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Agricultural Genetics and Plant Breeding in Early Twentieth-Century Italy

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To Daria, Angelo, Betti, and Marco

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Many years ago I read a poem by Jorge Luis Borges that began with these verses:

No one can write a book.
For a book truly to be
You require the sunset and the dawn,
Centuries, weapons, and the cleaving sea.

If I had to rewrite this list for this thesis, I would have to change some elements. The poetry would suffer a little, but I think that in this case the influence of weapons and the sea was negligible. Instead, I discovered that conducting research and writing a thesis is impossible without the help of others. I have worked and/or lived in three places during the last three years, and in each one there are many people to whom I owe thanks. I will inevitably forget someone and regret it later, but for now:

In Bologna, first and foremost I have to thank my supervisor, Prof. Giuliano Pancaldi. He believed I could write a good thesis at least a couple of years before I did. All the people at CIS (the International Centre for the History of Universities and Science) who helped me with their insights during discussions or in other ways: Dr Anna Guagnini, Matteo Serafini, Tommaso Panajoli, Armando Caracheo, Francesco Martini, Jan Cherlet and Giuditta Parolini. Elisa Arnaudo and Rupsha Banerjee helped me to see occasional setbacks and misfortunes as temporary and even funny things, and that always kept me going.

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Of course, without the help of my family and my friends in Reggio Emilia, especially Paolo Galli and Andrea Ferrari, none of this would have been possible.

Finally, this work is dedicated to Daria. I hope someday we will finally be able to live together somewhere. Despite the distance, you were always there to keep me sane and I miss you, each and every day I am not there with you.

INTRODUCTION

A casual encounter

This research was born out of curiosity about the story of an Italian plant breeder, Nazareno Strampelli, fuelled by the renewed interest of historians of science for agriculture and its relation to the history of biology[1]. I first heard about Strampelli from Dr Sabina Leonelli, who introduced me to a book written by Sergio Salvi[2]. Thus, despite being Italian and being a student interested in the history of biology, I had never heard of Strampelli before 2010. To hear the story of an Italian breeder for the first time in England was a curious experience.

The first thing I learned about Strampelli was that he organized a vast research programme, starting in the early twentieth century, that eventually resulted in the development of short culm and early-ripening wheat varieties. The second was that those highly productive varieties enjoyed a massive distribution after Strampelli joined the fascist party in 1925. Strampelli's plant breeding programme became a cornerstone of one of the most propagandized measures of the regime's agricultural policy: the infamous *battaglia del grano* or "battle for grain", a nationalistic attempt to achieve self-sufficiency in wheat production.

I began to think that my work had to focus on this fatal alliance. I had also found a possible, and reassuring, explanation of why I had not heard of Strampelli before 2010. Then, after some research, new elements convinced me that my original plan was flawed, and that things were going to be much more complex than I had originally thought.

First and foremost, the research programme that Strampelli developed began long before 1925. The fatal alliance came late in Strampelli's life and career, when he was already 59 and director of a national institute for cereal genetics in Rome. It was still crucial to explain why the alliance took place, but in order to do that it was necessary to start from the beginning, from a small itinerant chair of agriculture established in Rieti in 1903. Secondly, even if Strampelli died in 1942, his varieties remained in Italian fields for many years after the end of

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[1] As an introduction to the topic, I would recommend to the reader the oft-mentioned special issue of the *Journal for the History of Biology* edited by J. Harwood: vol. 39, no. 2 (2006). See also: Berris Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930" (Phd thesis, University of Leeds, 2011), which is online at http://ipbio.org/pdfs/papers/charnley-berris-agricultural-science-and-the-emergence-of-a-mendelian-system-in-britain-1880-1930.pdf.

[2] Sergio Salvi, *Quattro Passi Nella Scienza Di Nazareno Strampelli* (Pollenza: Tipografia S. Giuseppe, 2009).

the Second World War. Post-war oblivion could not be entirely justified by Strampelli's association with Benito Mussolini.

I soon discovered that a substantial part of the food products I was eating every day had been influenced in one way or another by Strampelli's work in Rieti and Rome. This experience is a common one: every day we interact with multiple objects without remembering their inventors or their stories. In the case of plants, however, I would argue that this phenomenon is even more intense: the general public often not only forgets about the key figures in the development of plants, but forgets the whole process too. When using an electric switch, no one doubts the fact that it was developed by someone and that electric switches have not always been there. When eating something that derives from wheat, however. It is easy to assume that the plant has always been there with its current characteristics. This process of naturalization is common among the general public while, as one might expect, it does not happen within communities that are more familiar with the vast world of agricultural research. Every agricultural scientist knows that plants have a long history of manipulation.

This is, however, not only a problem of scientific literacy: as I think everybody who has tried to reconstruct a piece of the story of a plant knows, varieties can be rather elusive subjects. It is not clear what a variety is (the name itself is now fading in the scientific community, where the word "cultivar" is used to refer to a botanical variety obtained under cultivation), and they can be extremely difficult to follow over the years due to streams of innovations and frequent changes of name[3].

From 2010 onwards, I began to find references to Strampelli's work, but my questions were still unanswered. Who was Nazareno Strampelli, and (perhaps a less historical question, but a poignant one for a PhD student) was there a story to be told worthy of a thesis? It will probably not surprise the reader to hear that I did find many stories, and that Strampelli's life and career soon ceased to be the only focus of the thesis. They were nevertheless an indispensable starting point for this research and points to which I would constantly return.

Following footsteps

Strampelli's story had been told before, but not by professionally trained historians of

[3] In this thesis, I have used the word "variety" because of its proximity to the Italian word *varietà*. Another reason for this choice is the difference of opinion among Italian breeders in the past about the actual nature of the breeding activity (i.e. whether breeders actually invent new plants or simply find them). Thus, it is reasonable to suppose that, at least to some breeders, the usage of two distinct words to designate a variety obtained in cultivation and another found in nature would have been questionable.

science. The only exception to this is a 2010 paper by Tiago Saraiva that focused on the relation between agricultural research on wheat and fascism[4]. This is not to say that the perspective of a professional historian of science is better than any other or that the available resources were not good: I would argue that they were trying to achieve something different from what this work seeks to accomplish, and with different instruments. In the following paragraphs I will give an overview of the main published works that were then available[5].

The most important contribution to the history of Nazareno Strampelli remains that of Roberto Lorenzetti, who has spent the last decade trying to preserve the memory and the material traces of Strampelli's work. In the most detailed book available on Strampelli to date, Lorenzetti reconstructed the institutional history of Strampelli's research programme, thanks to his work as an archivist in Rieti, where he found what was left of Strampelli's personal archive[6]. His book highlighted the relationships between the scientist, his scientific programme and the city that hosted it. At the same time, Lorenzetti documented the programme's growth, with sections devoted to the network of experimental stations established in Italy after the 1920s, Strampelli's visit to Argentina as a wheat expert and the use of Strampelli's wheat varieties outside Italy. The book also contains a chapter that tries to show the effect of Strampelli's varieties during the fascist *battaglia del grano*. Due to its focus on Rieti and institutional arrangements, the book does not analyze Strampelli's research programme in detail, and a comparison between European and Italian breeders is absent. These are not shortcomings of the book, but coherent results of the chosen point of view: for the same reason, many things that are discussed in Lorenzetti's work are not going to appear in this thesis. Unfortunately Lorenzetti's book (currently out of print) received an inadequate

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[4] T. Saraiva, "Fascist Labscapes: Geneticists, Wheat, and the Landscapes of Fascism in Italy and Portugal," *Historical Studies in the Natural Sciences* 40, no. 4 (2010): 457-98. Saraiva uses the work of Lorenzetti as his main source.

[5] I decided to limit this initial overview to articles and books that, no matter what audience they wanted to address, brought new information or new interpretation keys to the reader. It should be noted, though, that this literature has given birth to a small corpus of books and articles aimed at the general public, usually in an attempt to popularize the role of science in agriculture and subvert the naturalization process I sketched at the beginning of this chapter. See, for instance: Antonio Pascale, *Pane e pace: Il cibo, il progresso, il sapere nostalgico* (Milan: Chiarelettere, 2012).

[6] Roberto Lorenzetti, *La scienza del grano: l'esperienza scientifica di Nazareno Strampelli e la granicoltura italiana dal periodo giolittiano al secondo dopoguerra* (Roma: Ministero per i Beni e le Attività Culturali, Ufficio Centrale per i Beni Archivistici, 2000). The current situation of the Strampelli Personal Archive (APS) will be discussed in chapter **1** of this work.

English translation; another issue is that the indexing of Strampelli's private archive (see chapter 2) has changed, rendering Lorenzetti's references invalid. While a new edition of the book (which will take the new indexing into account) is currently being prepared, I do not know whether this new edition will be translated into English.

Another author who has dedicated many years to the memory of Strampelli is Sergio Salvi. With the help of his background as a biologist, Salvi tried at first to introduce a neglected scientist haunted by his close relation with a dictatorship (and a dictator) to the general public which, at least in Italy, is widely ignorant of the role of science in modern agriculture. Salvi started his historical work small by self-publishing books about Strampelli and his research programme, interpreted from a contemporary perspective. His work, still ongoing, has become more vast and ambitious: it now aims to instigate a complete re-evaluation of Strampelli's scientific work among scientists and non-scientists alike, through publications in Italian and international scientific journals. Recently, with Oriana Porfiri and Salvatore Ceccarelli, he highlighted the close similarity between Strampelli's breeding strategies and those of Norman Borlaug, both of which aimed to reduce the height of the wheat plant[7]. Salvi also collaborated with Mario Mosciatti in a short book on Strampelli's early years in Camerino[8]. As I wrote in the acknowledgements section above, Salvi's work was fundamental to this thesis: Strampelli's published works are scattered around Italian libraries and Salvi gave me a lot of advice when I was starting this research.

Then there are other authors who wrote about Strampelli, but attempting to put his story in a larger context, according to their aims. Gian Tommaso Scarascia-Mugnozza, a scientist and a breeder himself, tried to trace back a tradition of scientific plant breeding in Italy, linking his and Francesco D'Amato's work on neutron irradiation of wheat to Strampelli's research programme, considered by Mugnozza "the best of his time"[9]. Durum wheat became a thread that connected a Strampelli variety still cultivated today, *Senatore Cappelli*, to one of its most successful descendants, *Creso*[10]. Alessandro Volpone, in his history of early genetics in Italy,

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[7] S. Salvi, O. Porfiri, and S. Ceccarelli, "Nazareno Strampelli, the 'Prophet' of the Green Revolution," *The Journal of Agricultural Science* (2012): 1-5, doi:10.1017/S0021859612000214.

[8] Maurizio Mosciatti, *Là Dove Tutto Ebbe Inizio. Nazareno Strampelli a Camerino Tra Insegnamento e Ricerca (1891-1903), Con La Collaborazione Di Sergio Salvi*, (Camerino: Arte Lito, 2009).

[9] G. T. Scarascia Mugnozza, "The Contribution of Italian Wheat Geneticists: From Nazareno Strampelli to Francesco D'Amato," in *Proceedings of the International Congress: In the Wake of the Double Helix—From the Green Revolution to the Gene Revolution, 27-31 May 2003,* ed. R. Tuberosa, R. L. Phillips, and M. Gale (Bologna: Avenue Media, 2005), 53-75.

[10] Luigi Rossi, "Il miglioramento genetico del grano duro in Casaccia Il caso Creso," *Energia, Ambiente*

looked at Strampelli as one of the breeders involved with the spreading and use of Mendelism, which according to his interpretation, is the first force (Morgan's studies being the second) bringing together Italian scientists and technicians who, despite coming from different disciplinary fields, worked on research questions now generally categorized as proper of genetics[11].

With the exception of Scarascia-Mugnozza and Tiago Saraiva, the main sources about Strampelli were all written in Italian. This linguistic barrier often prevented interesting comparisons between the Italian case and those of other European and non-European countries which, currently, are discussed in English. The only paper about Strampelli published in an international history of science journal is Tiago Saraiva's[12]. Saraiva's paper, however, focuses on the use of Strampelli's varieties during the fascist regime; it does not try to place this period in the larger context of Strampelli's life and scientific career. Even if Italy cannot be considered a key country in the development of Mendelism, the rise of a vast state-funded plant breeding research programme based on hybrids is certainly of interest to scholars involved in the history of biology and agriculture. The Italian story did not participate much in the overall ongoing discussion about the history of plant breeding and Mendelism in the twentieth century.

After I completed a first period of research on archival sources at the Rieti State Archive, I began to think that there was much more to be said about Italian plant breeding in the early twentieth century than a simple reconstruction of Strampelli's scientific programme and career. Strampelli remained crucial to this thesis due to his historical importance and the availability of his archive, but other characters began to appear in the story I was trying to write.

Structure of the thesis

Chapter 1 is about the obstacles that I encountered while writing this thesis and the methodologies I used to overcome them. I explain the delicate situation of Strampelli's papers and the problems that I encountered when trying to find personal documents relating to other Italian wheat breeders. I advance the hypothesis that this difficulty in finding primary sources

e Innovazione 6 (Dicembre 2010): 46-52. *Creso* was not obtained directly with irradiation: it is actually a hybrid that has one *Cappelli* mutant as a parent. In 2001, after almost thirty years of cultivation, the radioactive origin of *Creso* provoked a debate in Italian and German newspapers. See: Daniela Monti, "Spaghetti con grano transgenico," *Corriere della Sera*, May 9, 2001.

[11] Alessandro Volpone, *Gli inizi della genetica in Italia* (Bari: Cacucci, 2008).

[12] Saraiva, "Fascist Labscapes" ref 4:11.

and manuscripts is connected with the lack of a common effort to preserve the memory of Italian agricultural research. Conservation of personal papers has been left to chance, and while some documents have survived (despite having a bureaucratically complex status), others have been lost or are difficult to find now. Plant breeding has not been considered a proper science and its memory has not been preserved with especial care. The lack of archival sources is one of the reasons why a proper history of plant breeding in twentieth-century Italy still remains to be written. What it was possible to do (and what I did) was instead to conduct a philosophically informed analysis of the available documents about Strampelli and other breeders. This analysis can constitute a first step towards such a history, providing useful ways of thinking about plant breeding, not as a minor science, but as a complex activity that has both practical and theoretical aspects.

Chapter 2 is an analysis of Nazareno Strampelli's life and career. This chapter looks at Strampelli both as a scientist and as an institution builder. Strampelli started the most important part of his career at 30, from a publicly-funded itinerant chair of agriculture in Rieti. The influence of G. Cuboni is analyzed both to understand Strampelli's 1907 decision to stake his scarce resources on his wheat hybridization programme and the knowledge available at the beginning of his programme.

What started as a small experiment in hybridization eventually became a systematic research programme that had a constant need for *growth* due to the methodologies chosen. The increasing demand for resources was satisfied through a breeding strategy that focused Strampelli's efforts on the wheat variety *Carlotta.* This choice can be explained with a metaphor: *Carlotta* became a lever that replaced publications as the mean to attract more support from the state.

This shift from publications to seeds is paralleled by an increasing distance between achievements that were happening in the field of genetics and innovations in breeding strategies. In 1919, Strampelli's national ambitions received recognition: a national institute for cereal genetics was founded in Rome and Strampelli was appointed as its first director.

The 1925 alliance between Strampelli's programme and the fascist regime remains a crucial point, but it is now explained with a careful reconstruction of what came before. Strampelli's programme received support from 12 Ministers of Agriculture between 1903 and 1919; nevertheless, Strampelli always tried to push for further support, expanding his programme.

Even with a national institute, the means available were not enough to accomplish Strampelli's project of a revolution in Italian wheat varieties. Reasons for the alliance with the fascist regime are suggested in the conjunction between the programme's structure, its short-term expected results, and a project that wanted to raise wheat production with a top-down approach based on intensive farming methods.

Chapter 3 is constructed around a comparison between the two most prominent Italian wheat-breeding programmes of the time: Todaro's and Strampelli's. This comparison has been done before to some extent, but with different research questions from those addressed in this chapter.

The starting point is an unexpected difference between the programmes, since both were claimed by their creators as part of the ongoing "Mendelian revolution". This theoretical consensus went hand in hand with different sets of practices. A way to solve this contradiction is to depict plant breeding as a practical activity that has no interest in theoretical debates.

This chapter proposes instead a different answer based on an analysis of the two breeding programmes that uses a conceptual tool developed in business studies side by side with a concept taken from aesthetics. This unusual juxtaposition of concepts developed in different disciplines comes from an actual argument between the two main characters of this chapter: should the breeder be considered an artist or is he just a businessman?

The two programmes are analyzed as *processes* according to the classic definition of T. Davenport. The rationale for using this definition is that a breeding programme is expected to produce varietal innovation in a systematic and reliable way: its overall organization is more important than a single wheat variety obtained from it. The outline of the steps involved in the development of a wheat variety is useful, but incomplete: I argue that it is also necessary to include an analysis of the assumptions that sustain those steps.

Plant breeders have their ideas about plants and their processes; however these ideas do not usually become proper scientific theories. To capture this partially implicit theoretical dimension, I propose a parallel with the notion of *poetic* used in aesthetics, notably by L. Anceschi. Concepts that sustain the processes of varietal innovation are analyzed: variety, chance, and the problems that the programme wants to address through its varieties. When both aspects (i.e. the process and the concepts that sustain it) are taken into consideration, two things happen: plant breeding appears as a complex activity that has practical as well as theoretical aspects and the differences between Todaro and Strampelli's programmes become evident.

This conception of plant breeding has the disadvantage of leaving the absence of more theoretical debates between breeders unexplained. An explanation is advanced that considers what both processes had in common: the need for an agriculture that was not based on self-sufficient farms. Mendelism allowed both Todaro and Strampelli to secure a separate scientific space for their programmes, with a definite function (development of seeds) that was opposed to traditional practices like seed swapping. There was no need to question the Mendelian umbrella, wide enough to accept under its shelter a set of different practices and concepts.

Chapter 4 is an analysis of technical proposals that were advanced at the beginning of the twentieth century by different actors to increase wheat production. The stakeholders were diverse: from small farmers to prominent landowners, from university professors to agricultural journalists.

The criterion of inclusion (or exclusion) chosen was the objective to raise wheat production: this technical objective, which implies a set of political choices, was not universal. Since the interest is common between the actors, one should expect to find a common strategy. What this chapter shows instead is a plurality of proposals and conceptions.

To make a comparison possible between the different positions, a framework is introduced, composed of *soil*, *seed*, *climate*, and *work*. These elements are conceived and explained as names for larger domains: *soil*, for instance, does not refer to the terrain alone, but also to the various elements that can be added to the soil to increase production.

In the framework, plant breeding programmes are obviously acting on the *seed* element of the framework; a deeper analysis, however, reveals a different strategy for the two breeding programmes already examined in chapter **3**. Francesco Todaro's programme is shown as an attempt to change *seeds* while leaving the other elements almost untouched. This approach made his offer extremely interesting to landowners in Bologna, since the promised increase in production was portrayed as relatively quick, economically viable, and low risk.

Strampelli started his work with a wide variety of different experiments before settling on wheat breeding, and even when the main element chosen became *seed*, he hoped to change agriculture at large by changing varieties, through the domino effect. The possibility of developing plant varieties with innovative characteristics (like early ripening) could change elements of *work* as well as introducing new varieties more resistant to adverse *climate* and capable of transforming a larger amount of *soil* inputs. It would be too much to say that the various elements were conceived by Strampelli as deeply correlated, but varieties were conceived as a much more dynamic element than in Todaro's programme.

Widespread adoption of Strampelli's varieties after 1928 was also favoured by the diffusion of a new protocol of fertilization that used high amounts of nitrogen fertilizers during the winter: the protocol needed early-ripening varieties to be successfully applied.

Plant breeding programmes are then compared with another voice, close to both technical elites and landowners: the technical advice given in the agricultural journal *Il Coltivatore* ("The Farmer") from 1903 to 1929. Even if, as one would expect, a journal includes a plurality of voices, the often unsigned recommendations and technical advice published in *Il Coltivatore* did present a coherent idea of agriculture that was different from that advanced by plant breeders. An example of this difference is the kind of selection recommended: not the selection developed by scientific breeders, focused around the need for *purity*, but a simple mass-selection based on the weight of seeds to increase their quality. The *elements* of the proposed framework, *seed*, *soil*, *climate*, and *work*, are scattered around the journal: what *Il Coltivatore* advanced was an idea of a *rational* agriculture that was tied to new scientific results as well as to old traditions. Suggestions for improvement in wheat cultivation, however, were not presented in any systematic way, or conceived as interrelated. The coherent idea developed itself into an inhomogeneous set of advice.

A notable exception that stands out when reading *Il Coltivatore* is a single article written in 1923 by Girolamo Azzi, which did not provoke any response. Azzi was the founder of a new discipline, named *Ecologia Agraria*, which wanted to redefine the concept of plant productivity, as relative to the balance between output and available resources. Azzi was a remarkable scholar now unfortunately forgotten despite his accomplishment and his wide international network of scientific collaborations. Azzi did conceive the various elements of wheat production as interrelated: his theories put into question the strategies followed by Italian plant breeders, who were accustomed to considering productivity as an absolute value. Azzi's critiques of Italian breeders are discussed in detail and found to be partially accurate. Despite the aim to increase resistances in plants, Italian plant breeding programmes were focused on increasing the maximum quantity of inputs tolerable to a plant. Azzi considered the various elements of production to be interrelated: *climate* was his starting point, but only because meteorological data could be used to choose *seeds* and then devise a correct protocol for *soil* preparation and *work* needed.

The conclusion shows that, between this group of actors who had a common objective, there existed a plurality of approaches that were only partially compatible. All of the approaches examined are adequately described by the proposed framework, despite its abstract nature. What emerges then is not a common plan of action towards an objective, but rather an ideal of agriculture that does not consider actual conditions of production as a relevant factor with a huge impact on production. The picture sketched is that of an agriculture without people.

In **Chapter 5** a comparison is attempted between Italian plant breeding and what was happening in other European countries, especially the UK and Germany. The strategy of the chapter is to compare specific aspects that have been highlighted in the available literature on plant breeding written by historians of science.

The first theme is the relation between wheat breeders and Mendelism: breeders who were later individuated as members of the "Mendelian revolution" began their work on wheat varieties before the arrival of Mendelian theories in Italy. This introduces a major difference between Italian wheat breeders and the Mendelian studies of Biffen and Bateson in the UK. At the same time, however, when Mendelism arrived, breeding programmes were still taking their first steps and agricultural research was far from matching the level of organization that could be found in Germany. There is a fundamental ambiguity in Italian plant breeding, which is reflected in the double function of Mendelism: a *practical* function, influencing breeding choices and a *rhetorical* one, attracting support by enforcing claims of control. This dualism is explained with a comparison with the French case.

The second theme concerns the strategy chosen by breeders in their programmes. In his recent book, Jonathan Harwood convincingly distinguishes a tension in the history of plant breeding between a *cosmopolitan* and a *local* strategy[13]. These strategies are presented to the reader along with a consideration of the model of control that is usually associated with them. I argue that research programmes that follow *cosmopolitan* strategies (i.e. strategies aimed towards the development of a variety that is expected to perform well wherever a certain amount of inputs can be granted) are connected with a need for *centralization*, while *local* strategies (i.e. the development of a specific variety in a specific environment, starting from traditionally cultivated varieties) tend to achieve a *decentralization* of the research process. Two examples are presented to prove the point: the unfinished varieties released by the Bavarian plant breeding station in Germany and Biffen's need for increased centralization of control when dealing with *rogues* in his wheat variety *Yeoman*.

Again, Italian plant breeders can be situated somewhere in the middle: in the case of Strampelli, *centralization* was constant, but his research programme was more *local* in its final aims, although it had a definite *cosmopolitan* phase. The choice to develop many varieties, while refusing to decentralize the research process, is shown to be a source of weaknesses. Even if it allowed a more flexible approach in the initial choice of varieties that had to be hybridized, it exposed the programme to increasing costs. Todaro started his

[13] Jonathan Harwood, *Europe's green revolution and others since : The rise and fall of peasant-friendly plant breeding* (London and New York: Routledge, 2012).

research programme in Bologna with a *local* approach, even if zones of origin were less important to him than a history of successful cultivation. Todaro did not try to *decentralize* his research programme either: he eventually managed to create a national institute that operated along lines more common in a *cosmopolitan* strategy. Todaro's choices allowed his programme to be profitable from early on, but it eventually lost ground to Strampelli's, partly because of the limits imposed by the refusal to use hybridization.

The conclusion of the chapter reflects on the various forms of financing that can be distinguished both in the Italian case and the European wheat breeding programmes. Public financing of plant breeding programmes in Italy was not part of any overall strategy before 1925. From that date, however, wheat breeding programmes became part of the fascist *battaglia del grano*. The social and economic consequences of that policy certainly played a role in the post-World War II oblivion of Italian plant breeding programmes. This, along with a lack of long-term goals and institutions' inability to replicate the results of their founding fathers, contributed to Italian plant breeders' failure to leave a strong legacy behind them.

The **conclusion** sums up the main findings of this thesis and suggests three directions in which this research could be expanded. The research brought to light previously unknown or neglected facts, giving a new perspective on the alliance between Rieti's plant breeding programme and the fascist regime. The main original contribution of the thesis, however, lies in the analysis of Italian plant breeding programmes as processes. These processes had a practical as well as a theoretical side, and involved various element of production. Although a complete history of Italian plant breeding still remains to be written, the Italian case can now be considered along with the case studies that other scholars have developed in the history of plant breeding. The hope is that this historical and philosophical analysis will contribute to the ongoing effort to understand the history of plants.

Chapter 1

WRITING THE HISTORY OF SCIENCE IN A WORLD OF MISSING DOCUMENTS: FILLING THE GAPS

Introduction

When I started the research for this thesis, I thought that this was going to be a work in the history of science, despite my training as a philosopher[1]. The instruments were going to be those of a historian: I was going to do a lot of archival research and present new evidence to the reader about Italian plant breeders of the early twentieth century. After all, I thought, the secondary literature available on Italian plant breeders was scarce, and scarcer still were papers about them written in English. This in spite of the impact that Italian plant breeders had on Italian agriculture before and after the 1920s: a change in wheat varieties that is sometimes compared to the so-called "green revolution" and is sometimes presented as one of the first examples of biodiversity erosion in Italy[2]. Someone had to fill the gaps.

This did happen to a certain extent: this thesis uses documents from Strampelli's private archive (APS) as evidence and some new facts did emerge from the research (e.g. the delicate financial situation between 1905 and 1907, see section **2.2.2**). What I learned from studying Strampelli's own documents was crucial in giving me an idea of the complexity that a plant breeding programme has to manage, a complexity that is easily overlooked due to the somewhat simple theoretical framework that was presented by breeders when seeking funds.

What I did not know at the time, however, was that I would have to come to terms with a series of gaps. Although this cannot be considered in any way an actor-network theory work, I still remembered (and liked) an actor-network theory mantra: "Follow the actors!", but my actors (their manuscripts) in many cases were nowhere to be found, missing in action[3]. At one

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[1] I should remind the reader that in Italy there are no departments dedicated to the history of science. History of science is mainly taught within philosophy departments.

[2] S. Salvi, O. Porfiri, and S. Ceccarelli, "Nazareno Strampelli, the 'Prophet' of the green revolution" ref 7:12. The effect of Strampelli's success on biodiversity is discussed briefly in Karl Hammer and Axel Diederichsen, "Evolution, Status and Perspectives for Landraces in Europe," in *European Landraces: On-Farm Conservation, Management and Use*, ed. M. Veteläinen and N. Maxted (Rome: Biodiversity International, 2009), 23-44 (see 34 for the passage on Strampelli).

[3] On Actor-Network Theory, see: Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2007). The main way in which this work differs from an ANT approach is that it does not treat humans and non-humans equally. I did, however, use a concept

point I did not think I had enough documents to write a PhD thesis on Italian breeders.

Then it came to me that I was making the very same mistake I was trying to address in the history of Italian plant breeding: given the scarcity of obvious theoretical contributions, I was considering breeding only as practical activity that had to be reconstructed with an abundance of historical data. Instead, I started to understand that wheat breeders, especially at the beginning of the twentieth century, when they could not rely on any pre-existing systematic data on wheat, had to be thinkers and managers at the same time. Historical research remained one of the main tools I had to use, but it started to be complemented by a philosophical analysis of the breeders' own processes of production and the concepts that were used to organize them. An example of the results of such an integrated approach can be found in chapter **2**: while few documents survive documenting the alliance between Strampelli's wheat breeding programme and the fascist regime, such an alliance can be shown to be essential to the programme once its structure has been analyzed and one is confronted with the strategies Strampelli used to advance his career.

This work is then somehow hybrid: rather than a single methodology, a network of strategies has been employed in its chapters and sections to address research questions to which answers could not be found with historical research alone. Though other questions, as I will explain in this chapter, still remain unanswered, this hybrid strategy did bear fruit.

Section **1.1** concerns the main primary source used in this thesis: the APS, currently housed at the Rieti State Archive (Rieti, Italy). Although the archive has proven to be vital for my research, the archival fund is peculiar: it is a fragment (67 boxes) of a much larger number of documents that due to various reasons (explained in this section) is not ready for historical research. The APS is not the only source of documents related to Strampelli; it is, however, the only archival fund that is ready for historians to investigate. An example is given of questions that arise from documents located in the APS that cannot be answered because potentially relevant documents are missing. At the moment the indexing of the APS is still provisional; if the state archive takes ownership of the remaining documents, the indexing will probably change. An index of the documents used can be found in the appendix of this work; should the retrieval of documents be complicated in future due to radical changes in the index, my own personal copies will help in tracing the originals.

If the provisional state of the APS can be a challenge at times, things can get much worse,

developed by Michel Callon (i.e. obligatory passage point) in chapter **4** to explain the attempt of an Italian scientist to found a discipline which he intended to stand in a brokerage position between breeders and the actual cultivation of their varieties.

as is shown in section **1.2**. Some key figures in the history of twentieth-century Italian plant breeding cannot be investigated at all by analysis of their personal documents. Their documents are either untraceable or lost in unfortunate circumstances (like Emilia's earthquakes in 2012). Scientists like Giuseppe Cuboni, Francesco Todaro, and Girolamo Azzi are remembered only through their publications. For example, Francesco Todaro seemed to accept Mendelism as a theoretical framework while refusing the usage of hybridization for his varieties, but this cannot be investigated further because his publications give no clue and his personal documents are lost.

In section **1.3** I argue that such a situation of missing documents cannot be ascribed to misfortune alone. Agricultural science has seldom been considered a proper science and its memory has not been preserved in a systematic manner. Some of the reasons are political: many agricultural scientists compromised themselves with the fascist regime, and their contribution has been evaluated according to the agricultural policies they supported, which in many cases (like in the infamous *battaglia del grano* which increased the resources available to breeders) were short-sighted and harmful to agriculture as a whole. Whatever the reason, it is a fact that many documents have not been kept by dedicated institutions as documents important to history at large; they have instead been kept either as personal treasure or left inside institutes with no historical aim. This can make documents extremely hard to find, or impossible to access due to arbitrary decisions of their gatekeepers. This arbitrariness can sometimes lead to a complete freedom of access, but I would argue that the game is not worth the candle, so to speak.

In the conclusion of this chapter, I argue that this lack of sources contributed to the general oblivion in which the history of plant science remains in Italy today. Varieties that were developed almost one hundred years ago inside complex scientific programmes are sometimes still cultivated and sold today with a "traditional" image attached to them. Old scientific results (which once fought against traditional practices, like seed swapping) are now opposed to newer scientific practices. A complete history of Italian plant breeding would be needed to explore and dissolve this paradox but, unfortunately, due to the lack of archival sources, this thesis is not that history. What this thesis does instead is apply philosophical analysis to fill the gaps, to tell a story that can interact with the work of other scholars who have in recent years rediscovered plant breeding and agriculture as an amazing source of insights for the history of science.

1.1 Archival Sources

As has been said, the main archival source for this thesis is Strampelli's private archive (APS), kept in the Rieti State Archive. Italy has a network of 134 state archives around the country[4]. What makes the APS peculiar is that the documents were not donated to the state archive while Strampelli was alive or by the family after the year of his death, in 1942. They were instead found many years later in the building that from the 1920s hosted Rieti's wheat experimental station[5]. Roberto Lorenzetti, now director of the Rieti State Archive, led the project to reorganize the documents. Lorenzetti still champions a project to valourize these documents and the other objects in the building by creating a museum in Rieti devoted to Strampelli and his work on wheat, unfortunately without success in sight[6]. In the meantime, some of the documents belonging directly to Strampelli have been moved to the Rieti State Archive, where I had the opportunity to study them, thanks to Lorenzetti's interest in my work.

Unfortunately, due to the complicated situation of the former experimental station and the relations between different actors involved, I obtained access to the other documents (those stored in the former experimental station) only late in 2012[7], despite the goodwill of the former station's staff, who were supportive towards me and my work in every way. The former station has a collection of more than 700 boxes containing many interesting documents; the index of the documents that is available at the station, however, is completely

[4] http://www.archivi.beniculturali.it/dga.html last access 28/9/2012.

[5] Some pictures of the documents can be seen in the MUSGRA website created by Roberto Lorenzetti and Jimmi Renzi: http://www.asrieti.it/PUBBLICAZIONI/strampelli/index-it.html

[6] Despite the potential riches of the Campomoro building in Rieti, where the experimental station was based. It is still possible to see Strampelli's herbarium (documenting the hybrid varieties obtained) and his seeds collection. No one is in charge of the conservation of these objects, although they are kept safely at the station. I would like to inform the reader that the museum project is not connected in any way with attempts to re-evaluate the agricultural policies to which Strampelli contributed with his varieties.

[7] At the time of writing, the building hosted a public institute devoted to agricultural research that was about to be suppressed. This, along with different views about the actual ownership of the documents, has complicated access to the complete archive of the station as well as gaining accurate information about it. The station archive is a big collection (more than 700 boxes of documents) of various collections, each one telling the story of the institution through its transformations from 1903 to the present day. The APS is a fragment of the whole that includes Strampelli's personal documents, but lacks other data that could be extremely interesting to historians (administrative documents, like financial statements could help explain in more detail the flow of resources that supported the scientific programme and help reconstruct a profile of the workers employed by the station). Without these documents, many interesting questions cannot be answered.

inaccurate. A reorganization and reindexing of the papers would be needed to make this impressive collection useful for historians; for this to happen, however, it will probably be necessary to reach a final arrangement on the actual ownership of the documents and find a financial sponsor. Thus, the APS remains the only viable primary source on Strampelli today.

The APS is a collection of personal (e.g. a receipt documenting the purchase of a used motorcycle) and professional (e.g. a map of an experimental field) documents relating to Strampelli and his work. Strampelli probably kept these documents for personal reference without thinking that they could become relevant for historians. One thing that is quickly learned while reconstructing the activities of a breeder is the constant need to plan the work by constantly tracing the work done so far (the past) and the intended outcomes (the future). In the APS there is no comprehensive collection of letters and the notes about Strampelli's research are often difficult to interpret. On the one hand, the absence of a museum-like filter means that one gets a glimpse of the difficulties and hard times that the research programme and its principal investigator faced[8]. On the other, the exact meaning of some documents remains a mystery[9]. The interval between Strampelli's death in 1942 and the creation of the archive also means that documents have been lost or damaged. Objects are not easier to study than documents: the former experimental station continued his activities (changing names and research topic) after 1942, and so it is extremely difficult to gain precise information from what is left there (books and scientific instruments). This is not an unusual problem for historians, but in the case of this thesis can become a big issue, even when the questions at hand are more philosophical or knowledge-related.

Take, for instance, Strampelli's notebook listing the varieties he used for his hybrids in 1904[10]. In this notebook each variety used has a two-page qualitative description. *Rieti*, the

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[8] See, in chapter **2**, the problematic transformation of the itinerant chair into an experimental station during the years 1905-1907.

[9] The most striking example of this is in APS box 20. The box contains a lot of diagrams annotated in a handwriting that is not Strampelli's. Prof. Staffan Müller-Wille suggested to me the possibility that these breeding schemas were not about wheat, but about animals. A closer analysis suggests that this is in fact the case: small annotations can be found mentioning "cages", "daughters", and "black versus yellow". It seems plausible that they concern crosses with rabbits. These documents are extremely interesting for two main reasons: they are the only proof of a link (at least ideal) between animal breeding and plant breeding at the Rieti station, and they seem to be about experiments aimed at investigating Mendelian mechanisms of inheritance in animals rather than immediate practical results.

[10] N. Strampelli, "Libro primo. Varietà servite per gli ibridi 1904," 1904, ASR, APS, Box 16, Folder 7. This example is about difficulties that cannot be solved, unlike those discussed in note 19, below. In that

key variety with which Strampelli's hybridization work started, can be found on the last page, cut and glued to the cover. In this way *Rieti*'s characteristics can be compared side by side with any other variety. This notebook is like no other document in the APS. Given that there is a chance that Strampelli might have missed the first Italian article about Mendel's laws, one could be tempted to argue that that notebook represents a non-Mendelian attempt to predict (through the use of botanical description alone) the possible outcomes of crosses. But what if other notebooks did exist and were simply destroyed or lost? The title *Libro primo* (first book) suggests that this is so. Perhaps the 1904 notebook, being the first one, was kept with special care, while the others did not have the same luck (and of course it should be taken into account that after 1919, Strampelli was working between Rome and Rieti, and thus it is possible that other documents were not kept in Rieti in the first place)[11]. This gap in the archive might seem irrelevant, and when reconstructing the history of the experimental programme it certainly is: there are already enough details to provide a reasonably precise timeline. However, when the questions become more philosophical and more closely related to questions about the kind of knowledge that is produced and used by breeders, these informational voids can start to be problematic.

Another difficulty, probably related to the unfulfilled museum project and the mixed nature of the APS documents, is that the current archive indexing of the APS is still *in progress*. The provisional indexing means that access to the archive is currently subject to approval of the state archive director. The numeration of some of the documents might change if the museum project is resumed or the remaining documents are donated to the state archive. Thanks to Roberto Lorenzetti, director of the Rieti State Archive, I was allowed to take photographs of the documents I studied; these photographs are only meant for personal use, however. To preserve the legitimacy of this work, an index of the documents cited is attached to this thesis, along with a short description of each and their current locations in the APS. Since I have in my possession personal pictures of the documents I used, it will be possible to trace the original document, or (at least) its copy, should the indexing of the APS change again[12]. In any case, the provisional indexing should remain valid for the next few years, while the fate

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case, sociological and economical questions cannot be answered for the time being due to bureaucracy, but they will eventually be open to historical investigation, sooner or later.

[11] The institute in Rome faced similar transformations as that at Rieti, though it seems reasonable to suppose that interesting documents about Strampelli's work were kept in the national institute in Rome, at the moment there is no archive or known historical material there.

[12] I am confident that, should the indexing change, I will be allowed to share the photographs for research purposes, if asked.

of the remaining documents stored in the former experimental station is less certain.

1.2 From missing documents to missing archives

If the uncertain status of Strampelli's various documents is not ideal for a researcher, one should always remember that things could be much worse, as in the cases of Giuseppe Cuboni and Francesco Todaro, two key figures in the history of Italian agricultural research on plants during the early twentieth century.

Giuseppe Cuboni, a plant pathologist born in Modena in 1852, became famous among Italian farmers thanks to his work on preventing downy mildew[13]. His work as a researcher was complemented by intense activity as a public lecturer addressing farmers, landowners, and politicians about agricultural problems and possible solutions. Cuboni was the first Italian scholar to visit Svalöf on behalf of the International Institute of Agriculture based in Rome; when he came back he started to diffuse the new term "Mendelism" in public conferences, private meetings, and written articles. He quickly became the link connecting all Italian agricultural researchers who tried to apply the new principles of Mendelism to plants. Alessandro Volpone has remarked that comparisons made by Cuboni's pupil Traverso between Cuboni and Bateson now appear exaggerated. Cuboni did not contribute directly to the new science of genetics with experiments or scientific results, nor did he have any significant role in the academic institutionalization of the discipline (in Italy, as in France, that happened much later in the century)[14]. However, it is certainly thanks to Cuboni's intense activity as an advocate for Italian agricultural research that public projects focusing on hybrids were financed by the state. Cuboni believed that the development of new plant varieties could be an answer to the problem posed by the different regional climates within Italy.

Despite Cuboni's crucial position in the development of Italian agricultural research, it seems that no collection of letters or personal papers is available today. This complicates the exact reconstruction of the relations between Strampelli and politicians which, in the beginning, were facilitated by Cuboni[15]. Cuboni appears to have occupied a brokerage

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[13] Giuseppe Cuboni, *Scritti scelti Cuboniani*, ed. Giovanni Battista Traverso (Rome: Prem. Tip. Succ. F.lli Fusi, 1924).

[14] Volpone, *Gli inizi della genetica in Italia* ref 11:13.

[15] See chapter **1** for additional details. Cuboni, along with Italo Giglioli, supported Strampelli's requests for funds and laws for the transformation of the itinerant chair into a proper experimental station, connecting him with Luigi Rava.

position between breeders working on different kinds of plants and politicians, but it is impossible to elaborate further on his role without primary sources.

Another character central to this thesis, and sharing the same fate, is Strampelli's rival the Bologna-based plant breeder, Francesco Todaro. The consequences of Todaro's work with wheat plants can be easily found in Bologna: the society he created, Società Produttori Sementi, is still active today, and Todaro taught for many years in what is now the faculty of agricultural sciences. In 1921, his successful work with landowners in Bologna allowed him to create a national institute of plant breeding based in Bologna (Istituto di Allevamento Vegetale).

Todaro is considered a minor figure in the history of agricultural sciences; during his lifetime his varieties were often considered inferior to those developed by Strampelli and his legacy as a breeder is not recalled as often as that of Strampelli. Today this is usually traced back to his refusal to use hybridization in the development of his varieties. Todaro maintained that the best way to improve Italian wheat varieties was a programme of single plant selection (see chapter **3**)[16]. What makes Todaro important for this thesis is the unusual relation between his refusal to use hybridization and his ideas on Mendelism.

One would expect to find in Todaro a strong connection between the two: if hybridization is refused, one of the main arguments could be theoretical (i.e. a cautious scepticism regarding the effective possibility of reducing a plant to a set of combinatory characters that display precise mathematical ratios in their offspring when crossed). Instead, Todaro had nothing against Mendelism: he explained it to his students in his lessons at the University of Bologna, demonstrating familiarity with the so-called "Mendel's laws" and with the Punnett square[17]. In 1913 Todaro opened his first lecture quoting from a speech made by Cuboni about the ongoing "Mendelian revolution" in biology that could become as important to agriculture as chemistry had been some years before. And yet Todaro's Mendelism was a strange one, a Mendelism without crosses. Hybrids were never used by Todaro, not even when Strampelli started to release his first early-ripening varieties, putting Todaro's varieties

[16] It should be noted that his refusal to use hybridization makes Todaro a less effective example when trying to prove the point that scientific manipulation of plants is not a new practice. However, it could easily be argued that a strict selection protocol like that employed by Todaro is by no means less artificial than a plan of systematic hybridization like that conducted by Strampelli.

[17] Francesco Todaro, *Adattamento Selezione e Incrocio delle Piante Coltivate. Sunto di Lezioni tenute dal Prof. Francesco Todaro nell'Università di Bologna Anno Scolastico 1913-1914* (Bologna: Societá tipografica già compositori, 1914).

in the shadows[18]. Todaro sold to Bologna's landowners what he called the "Svalöf Method" without ever mentioning something he perfectly knew: that in Svalöf single-plant selection and hybridization were both used successfully[19].

Thus, reading Todaro's letters and documents could be very interesting. Todaro could be a perfect example of what is easily suspected once plant breeding programmes that the authority of science are investigated more closely: that Mendelism offered a direction for breeding programmes, but at the same time it was also a powerful rhetorical device used to attract funds and support for those programmes and their leaders[20]. If some historians of science have questioned the actual impact of Mendelism on breeding practices, in the Italian case one thing is clear: after Mendelism, plant breeding in Italy became a field for scientific institutions, a new kind of actor not present in the network of wheat production during the nineteenth century[21].

Unfortunately, no collection of Todaro's documents or letters is available today. Studies undertaken by contacting Todaro's descendants have not been successful[22]. The society that Todaro founded in Bologna, Società Produttori Sementi, used to have a historical archive; unfortunately, the building in which the documents were kept collapsed last summer during the Emilia earthquakes. As puzzling as it seems, all that is left in Bologna are a couple of letters currently missing in action, despite the fact that in Bologna Todaro was not only professor at the university, but also founded a prominent society of seeds producers, a

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[18] It can be useful to remind the reader that back in 1920s Italy there was no law granting any patent-like right to breeders for their varieties. There was no legal obstacle preventing Todaro from crossing his varieties with Strampelli's, thus developing his own early-ripening wheat. Not surprisingly, this was done by his former society in Bologna, Società Produttori Sementi, almost immediately after Todaro's resignation.

[19] L. Hugh Newman, *Plant Breeding in Scandinavia* (Ottawa: Canadian Seed Growers' Association, 1912); online version at http://www.biodiversitylibrary.org/bibliography/31003.

[20] In Strampelli's case, the promissory nature of Mendelism certainly helped to sustain state funding for a programme that produced its first (provisional) significant results almost ten years later.

[21] See, for instance the controversial classic paper by P. Palladino, "Between Craft and Science: Plant Breeding, Mendelian Genetics, and British Universities, 1900-1920," *Technology and Culture* 34, no. 2 (1993): 300-23. About Palladino's paper, see also the Introduction of Berris Charnley's PhD thesis, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930", ref 1:9.

[22] To be more precise, at the time of writing, I was able to locate two descendants of Todaro, but they both said when questioned that they were not in possession of any historical documents relating to their ancestor.

laboratory devoted to seed testing, and a scientific institute for plant breeding[23]. Like Strampelli, Todaro was appointed senator by the fascist regime in 1934.

Chapter **4** includes a section on the Italian plant scientist Girolamo Azzi, the founder of a discipline that challenged the projects of Italian plant breeders. According to the available sources, Azzi, thanks to his vast knowledge of languages, had a remarkable international network of contacts. His ideas about the interrelatedness of various environmental elements which have to be considered when trying to improve plants makes him extremely close to contemporary views and an outsider in his own time. Unfortunately, so far all attempts to find a collection of documents have been unsuccessful.

1.3 Why are these documents missing?

It could be argued that luck is a factor that cannot be underestimated in the conservation of historical documents. Some of the circumstances I have just described (an earthquake, the struggle to locate and gain access to existing documents trapped in bureaucratic limbo), can be ascribed to misfortune. However, the recurring pattern of missing documents and complicated access that any scholar interested in the history of twentieth-century Italian agricultural research has to face leads to the suspicion that something more than misfortune is involved. Agricultural scientists, even those who attained prominence during their lifetime, have not been considered very important by historians, and this lack of consideration appears to be mirrored by the lack of primary sources. In the case of breeders, this happened despite the daily contact with the (often literal) fruit of their research programmes.

The ties that many Italian agricultural technicians had with the fascist regime certainly did not help the memory of their work[24]. In the case of Strampelli, there is also the fact that his results, today considered good, were incorporated into an agricultural policy that has been

[23] The existence of these two letters (along with a lab notebook) is documented by a pdf presentation of Prof. A. Lovato on the history of the LaRAS lab for seeds analysis in Bologna, where they can be seen on slides 6 and 7. Unfortunately, at the moment these letters and the notebook are missing and it was not possible to retrieve them, nor to confirm that they are still there. See: http://www.agrsci.unibo.it/agr/biblioteca/Presidi/PRES_A.Lovato.pdf. I would like to thank Prof. Lovato and Dr Enrico Noli for helping me with researching these letters.

[24] On these ties, see the essays collected in *Competenza e politica: economisti e tecnici agrari in Italia tra Otto e Novecento*, ed. Giancarlo Di Sandro and Aldino Monti (Bologna: Il Mulino, 2003).

judged by leading historians both harmful to peasants and to Italian agriculture[25]. There is no doubt among scholars that the social and agricultural costs of the autarky obsession were too high to celebrate the rise in wheat production, which did actually happen, as a success. At the same time, the propagandistic nature of the *battaglia del grano* made it urgent for historians to deconstruct the myth by highlighting the actual shortcomings of the wheat autarky project[26]. However, politics is not enough to explain the current situation[27].

When papers were kept, they were not in general kept as historically relevant material, but as either personal treasure of a private individual or a fragment of the memory of a particular institution. This has contributed to a general difficulty in finding materials (which are not indexed or advertised anywhere since they do not belong to an institution with historical aims) and in gaining access to them. If conservation is not done for historical purposes, access can become arbitrary. Sometimes this can grant the historian complete freedom of action if this is the desire of the gatekeeper, or it can be extremely difficult to gain access, to find the documents, or even to understand which physical person should be approached for authorization to study them. Some documents could be (or not be) somewhere in the dusty attic of an old building: obtaining assistance or even simple access to such an attic can prove to be a real challenge, and always relies on the goodwill of people whose work does not officially involve dealing with historical materials.

Conclusion

One of the outcomes of the current state of affairs (a lack of organized historical materials that can be investigated by historians) is a widespread obliviousness of the story of plants and agricultural research from which only a few articles in popular science magazines have escaped (and of course some among those who work in the sector of agricultural research

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[25] Although, as seems to be generally true for “improved” varieties, they needed favourable conditions and an adequate amount of inputs to reach the impressive yields they became famous for.

[26] See: P. L. Profumieri, “La battaglia del grano: costi e ricavi,” *Rivista d’agricoltura* n. 3 (1971), 153-72; A. Staderini, “La Politica Cerealicola Del Regime: I’impostazione Della Battaglia Del Grano,” *Storia Contemporanea* 9 (Dec. 1978), 1027-79; M. Legnani, D. Preti, and G. Rochat, *Le Campagne Emiliane in Periodo Fascista: Materiali e Ricerche Sulla Battaglia Del Grano* (Bologna: Cooperativa libraria universitaria, 1982); Luciano Segre, *La “battaglia del grano”: depressione economica e politica cerealicola fascista* (Milan: CLESAV, 1982).

[27] I would like to remind the reader again that the Rieti museum project is not connected with any revisionist attempt (occasionally still made in Italy among far-right groups) to celebrate the agricultural policy of the fascist regime.

today). From time to time, restaurants and food shops connected with the organic farming movement advertise bread or pasta made with "traditional" varieties. Sometimes they are varieties developed by Strampelli (like *Senatore Cappelli* or *Mentana*) or Todaro (*Inallettabile*) inside complex research programmes[28]. There is no need for advertising to be historically accurate, however, it is strange to find past examples of scientific and technical achievements in agricultural research championed under a "traditional" flag.

A complete history of plant breeding in Italy during the twentieth century and its consequences for the twenty-first still remains to be written. Such a history should not only analyze the role of breeders and their stories, but also the details of their institutes and their commercial networks. Since plant breeding is an activity that was (and sometimes still is) considered closer to an art than a science, more details about the people employed by those programmes (which sometimes gave work to hundreds of peasants and dozens of assistants) would be needed. If breeding is an activity with a lot of embodied components, then questions about the people actually involved and the strategies employed to transmit knowledge inside those institutes can become relevant. Plant breeding appears to be an amazing effort to gain knowledge about plants and trying to project this knowledge for the future while always being capable of tracing every choice back to the starting point[29]. This is rather unusual in science and definitely different from the new conception of heredity advocated at the beginning of the twentieth century by people like Wilhelm Johannsen[30]. Such an analysis, however, is not possible at the moment due to the lack of primary sources, and it is not clear if things will improve in the future.

In the meantime, I tried to conduct historical research with the documents available, while complementing it with a philosophically informed analysis of the processes of production and theories used by Italian breeders. I think that such an approach can help to reconstruct breeding programmes and research strategies, even explaining alliances and choices made by the breeders themselves during their careers when documentary evidence is not enough to draw definitive conclusions. Plant breeding is not a minor science: it is a complex activity that has practical as well as theoretical aspects.

The story of Italy in the twentieth century is a story of huge changes at all levels. This

[28] I personally ate some bread made from *Mentana* (a variety developed by Strampelli in the 1920s) in a popular chain of Italian high-quality supermarkets in Bologna, where it was advertised as an ancient traditional wheat variety.

[29] See the conclusion of this thesis for a brief elaboration of this point.

[30] W. Johannsen, "The Genotype Conception of Heredity," *The American Naturalist* 45, no. 531 (1911): 129-59.

thesis can be an opportunity to rediscover the story of something (wheat) that is usually conceived of as a natural entity and that instead underwent dramatic changes through the work of researchers and farmers who changed the network of seed production and use. At the same time, the thesis has been written with the objective of participating in the ongoing conversation between historians of science about the history of plant breeding in the twentieth century, a conversation that I think can only benefit from the increased availability of local histories which will make it easier to draw comparisons and highlight differences between breeders, research programmes, and national policies.

Chapter 2

NAZARENO STRAMPELLI, WHEAT BREEDER

Introduction

In early twentieth-century Italy a large research programme on wheat hybridization was established, a programme that resulted in production of early-ripening, semi-dwarf wheat varieties that became popular during the second half of the century. Trying to understand this research programme, begun in 1900, and its creator, Nazareno Strampelli (1866-1942), is not an easy task. Nazareno Strampelli is a crucial figure in the history of Italian agriculture: in the first years of the century we find him among the early Mendelians, when crucial changes in plant breeding were taking place in Italy and elsewhere; in the 1920s we find him again, this time as the director of a national institute (the first Italian institution to have the word 'Genetics' in its name), providing wheat varieties that were employed by the fascist regime during the infamous *battaglia del grano*[1].

Endorsement of Strampelli's programme by the fascist regime, and a general lack of interest in the history of Italian agrarian research, has left Strampelli's story unknown to the general public after the Second World War[2]. Even if the relations between Strampelli and the fascist regime remain a crucial point in the development of Strampelli's research, a bigger picture is needed to understand why and how the alliance between a research programme and a dictatorial agricultural policy began. This chapter tries to reconstruct Strampelli's career strategy until the 1920s, *before* his commitment with the fascist regime[3].

Reconstructing Strampelli's career is difficult: he did not publish a lot (stating that his true publications were his seeds) and he did not leave any comprehensive collection of letters. The director of the Rieti State Archive, Roberto Lorenzetti, who has written the most detailed

[1] On Strampelli's wheats during fascism, see T. Saraiva, "Fascist Labscapes: Geneticists, Wheat, and the Landscapes of Fascism in Italy and Portugal" ref 4:11.

[2] A continued effort towards a realistic image of Strampelli and his often forgotten legacy can be found in the work of Sergio Salvi. See: Salvi, Porfiri, and Ceccarelli, "Nazareno Strampelli, the 'Prophet' of the Green Revolution": 12. Salvi authored many earlier publications on Strampelli in Italian, among these, see Salvi, *Quattro Passi Nella Scienza Di Nazareno Strampelli*, ref 2:9.

[3] One could argue that this is a typical elephant-in-the-room situation, but I think there are two good reasons to begin with this preliminary analysis. The first is a purely biographical one: Nazareno Strampelli was born in 1866; his support for the fascist regime came late in his career and his life, a life in which involvement with politics was constant but often indirect. The second is that in order to understand what changed after 1925, we need to know what took place before.

book on Strampelli, found what was left of Strampelli's personal archive in Rieti[4]. The greater part of it consists of notebooks documenting crosses and tables summarizing experimental results.

Two intertwining threads can be recognized in Strampelli's own story: his profile as a scientist, mirrored by his research programme, and his profile as an institution builder. Due to his lack of theoretical contributions to the new science of genetics, Strampelli has sometimes been considered no more than an empiricist, or a talented manager of research organizations[5]. Instead, the scientific aspect of his work, although substantial, cannot be understood without considering the organizational framework that contained it. This chapter tries to do justice to both those aspects, while collecting a first set of instruments that can be useful to explain the alliance between Strampelli's programme and the fascist regime.

Structure

Section **2.1** introduces the reader to Nazareno Strampelli. A member of a small *elite* of graduate agricultural technicians, he was initially employed by universities and technical institutes. His initial profile seems to be that of a teacher rather than a researcher, but includes elements (like his interest in hybrids and emphasis on practical experiences) that were developed later into his research programme. Two events in 1900 mark the ideal end of this phase: his marriage, which probably improved his social status, and his first experiment in wheat hybridization. Although only scarce details about the latter have survived, it shows Strampelli's initial aims and goals.

In section **2.2** the proper beginning of Strampelli's research programme is analyzed in detail, both from an institutional and from a scientific point of view. Rieti's itinerant chair of agriculture, created in 1903, was not intended as an experimental institution. It eventually became one due to Strampelli's own intentions and his ability to attract resources for his experimental programme. In the first years of the Rieti chair, there was a clear divide between Strampelli's own projects and his available resources and thus a significant risk. It is not possible to understand why this risk was taken without introducing (section **2.2.1**) Giuseppe Cuboni, the town crier of Mendelism in Italy. Cuboni's 1903 paper (the first Italian account of

[4] See: R. Lorenzetti, *La scienza del grano*, ref 6:11. At the time of writing, the indexing of the APS was still provisional. Additional information about the APS can be found in the methodological chapter of this thesis.

[5] See: Volpone, *Gli inizi della genetica in Italia*, ref 11:13. Volpone rejects the idea that Strampelli was just an empiricist, highlighting his talent as a manager, as well as his role among the early Italian Mendelians.

Mendel's laws) is explained because it sums up all that Strampelli could have known about Mendelism at that point. After 1904 (section **2.2.2.**) Cuboni supported Strampelli: Cuboni's connections with the ministry of agriculture were crucial in granting Strampelli additional resources and a new institutional framework (a proper experimental station). Why did Strampelli need additional resources? In the same section a brief account of his initial research programme is given, showing why its organization implied a progressive need for inputs and a central focus on wheat. Although the programme was guided by practical aims, the initial results were mainly publications (section **2.2.3**) meant to attract further support for the programme, which initially could not claim any specific wheat variety as a result.

Section **2.3** follows the story of *Carlotta*, the first important wheat variety released by Strampelli into the Italian market. Strampelli's method produced many promising (though untested) wheat varieties. In this section I argue that the choice to focus on *Carlotta* was a strategy motivated by the location of Strampelli's main resources and his project to use *Carlotta*'s success as a lever to gain additional resources. Two peculiarities of the research method (the division of the work in two phases, and the use of different experimental fields as *model environments*) are explored to explain the constraints that contributed to this choice. Strampelli's strategy worked, even if a somewhat unexpected vulnerability to high temperatures did cast some shadows on *Carlotta*'s success.

Carlotta's place in Strampelli's strategy was taken after 1920 by *Ardito*, his first early-ripening/short culm variety (section **2.4**). *Ardito* was the result of crosses that included the Japanese variety *Akakomughi*. Such a cross was possible thanks to a fortunate circumstance (the *Akakomughi* seeds came to Strampelli as a gift) and to a research framework that accepted the combinatory conception of plants supported by Mendelism. Work on *Ardito* was paralleled by an effort to gain enough support to found a national institute for wheat breeding. Strampelli's national ambitions became explicit, although they were already embedded in his research programme. The 1919 foundation of the Istituto Nazionale di Genetica per la Cerealicoltura, the pinnacle of Strampelli's scientific career, thus happened before the 1925 alliance between Strampelli and the regime. However, three things must be considered: 1) the actual diffusion of Strampelli's varieties was limited; 2) the resources granted were insufficient for Strampelli's ambitious project; and 3) The research method became somewhat fixed, without any major innovation.

The conclusion underlines the continuity of political support that Strampelli received during his career from 1904 to 1919, when the alliance took place. Some elements are given to put that alliance into a more correct perspective. Strampelli's programme was planned to be public from the beginning, making political support necessary (although to different degrees) in every part of his story. The year 1925, when Strampelli joined the fascist party and was appointed by Mussolini to the permanent committee of the *battaglia del grano*, can still be considered a watershed, but now appears less puzzling. A massive research programme, which promised a radical improvement of Italian wheat culture joined a dictatorship that promised all the means necessary to accomplish that purpose. The accomplishment of the goal (increase in wheat production) did not prevent the failure of a shortsighted agricultural policy and the subsequent oblivion of one of its actors, even if the wheat varieties themselves survived long after the end of the Second World War.

2.1 Early years: from Crispiero to Camerino

Who was Nazareno Strampelli? Born in 1866 into a family of small landowners in Crispiero (Castelraimondo, Marche, central Italy), he belonged to one of the first generations of agricultural scientists trained after Italy's unification (1861)[6].

His file in the Senate archive (he became a member in 1929) does not say much about his family: his father, Francesco Strampelli, is simply listed as *possidente* (property owner) without any additional information, while nothing is said about his mother, Luigia Ottaviani[7]. Sergio Salvi has written that they were both landowners[8]. After *liceo* (secondary school) in Camerino, in 1885, Strampelli enrolled in the faculty of Law at the University of Camerino[9]. However, changed his mind after a year, enrolling in the Portici School of Agriculture (Naples). The school, founded in 1866, offered a curriculum of scientific and technical studies[10] which could be completed after another three years in a faculty of agricultural sciences, as Strampelli did at the University of Pisa, graduating in 1891.

Strampelli belonged to a small elite of agricultural technicians: in 1885 two of the main

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6 Sergio Salvi, "La 'Rivoluzione Verde' Di Nazareno Strampelli," *Agricoltura – Istituzioni – Mercati* no. 3 (2009): 107-22.

7 Unfortunately, the file in the Senato archive is not a completely reliable source. For instance, only Benedetto Strampelli is listed as a son (while he also had a daughter, Augusta) and Strampelli himself is listed (wrongly) as former professor at the University of Camerino.

8 On Nazareno Strampelli, see also: Sergio Salvi, *Viaggio nella Genetica di Nazareno Strampelli* (Pollenza: Tipografia S. Giuseppe Pollenza, 2008).

9 M. Mosciatti, *Là dove tutto ebbe inizio,* ref 7:12

10 F. De Stefano, "Manlio Rossi-Doria e la Scuola di Portici" in G. Di Sandro, A. Monti (eds) *Competenza e politica*, ref 24:30.

agricultural schools, Portici and Milano, enrolled between them only 97 students[11]. This in a country where agriculture was still the main sector of employment. To give a comparison, thanks to D'Antone's work, in the same year in Berlin, 481 students of agricultural sciences were enrolled, 82 in Paris, and 887 in Gembloux.

Strampelli's dissertation was on the Eurasian smoke-tree culture in Camerino. Not much has been preserved from this period; however from his *attestato* we know that he graduated with full marks and that he was particularly skilled in chemistry[12]. Some notebooks from the Portici years have been preserved[13]. From these notebooks it is possible to see that a great part of the main agriculture course was devoted to the study of wheat. One of the most interesting notebooks has a red cover and is entitled *Appunti non di scuola presi per mio uso e consumo in biblioteca* ("Non-school notes taken in the library for my own use"). The notebook is about grafting: even if there is no strong evidence that the idea of grafting had a role in the development of Strampelli's interest for hybrids, grafting was of great importance in the fight against grape phylloxera during the nineteenth century[14]. The long-known idea that resistance to a parasite could be somehow transferred from one plant to another may have been a source of inspiration for Strampelli.

After his graduation, Strampelli was employed by the University of Camerino as a chemistry lab technician from 1891 to 1892[15]. As Mosciatti has written, it is probable that, despite this official qualification, his actual work included some teaching of University courses as well. In the same year he founded a Società Operaia di Mutuo Soccorso[16]. He then

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[11] L. D'Antone "L'intelligenza Dell'agricoltura: Istruzione Superiore, Profili Intellettuali e Identità Professionale," in *Storia Dell'agricoltura Italiana Contemporanea*, vol. 3 ed. P. Bevilacqua (Venice: Marsilio, 1991), 391-426.

[12] Archivio di Stato di Rieti (ASR), Archivio Privato Strampelli (APS), Box n. 1, Folders n. 2 and 3.

[13] N. Strampelli, Notebooks 1-11, 1888-1889, ASR, APS, Box 2.

[14] On the fascinating story of phylloxera in Europe, see: G. D. Gale Jr., *Dying on the Vine: How Phylloxera Transformed Wine* (Berkeley: University of California Press, 2011). The story is still widely known among agronomists and farmers: in the nineteenth century, the arrival of American vine specimens in Europe led to diffusion of this parasite, deadly to European vines. European wine production was seriously threatened. One of the solutions found was growing European vines on American vines, through grafting. Unlike European vines, American vines were more resistant to the parasite.

[15] M. Mosciatti, *Là dove tutto ebbe inizio,* p. 17, ref 8:12.

[16] A mutual organization, it was one of the few created for farmers. This form of mutual assistance was usually established among factory workers, and consisted of a self-financed common fund that could provide assistance to workers or their families in times of need. See: L. Tomassini, "L'associazionismo

left Camerino for two years, working as the head of Argentario mines chemistry lab. When Strampelli returned to Camerino in 1894, he resumed his previous occupation at the University while also teaching at the local *liceo* and joining Camerino's *Comizio Agrario*[17]. In 1896 he started publishing articles on agriculture in the *comizio*'s bulletin and, about a year later, in the local newspaper *Chienti e Potenza*. In 1899 he started teaching Agronomy at Camerino's Scuola Normale Femminile, a secondary school for girls that trained primary school teachers.

The profile that emerges from an overview of the Camerino years is not that of a young scientist concerned with the advancement of the natural sciences. Rather, it is that of a teacher and an experimenter concerned with the diffusion of agricultural knowledge among farmers and the effectiveness of their practices. His publications were not meant for scientists but for farmers and landowners. In 1897, for example, Strampelli wrote an article for *Chienti e Potenza* on results obtained through the use of different fertilizers, something that clearly cannot be seen as a breakthrough, but can be perceived as important once the prevalence of traditional methods of farming at the time and the lack of reliable data on the real benefits of fertilizers from trustworthy sources is taken into consideration[18]. In agriculture, teaching often means showing: Strampelli requested permission to use the Scuola Normale's garden for experiments that could complement his lessons at the local Istituto Tecnico per Agrimensori (Technical Institute of Agriculture). Before leaving Camerino in 1903, two important events took place: his marriage and his first hybridization experiment with wheat.

Strampelli married Carlotta Parisani (1868-1926) in 1900. Carlotta was the fifth daughter of Count Giuseppe Parisani and Emilia Gabrielli, descendant of Lucien Bonaparte. Nazareno Strampelli always wrote about his wife as his first and most precious assistant[19].

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operaio: il mutualismo nell'Italia liberale" in *Tra Fabbrica e Società. Mondi operai nell'Italia del Novecento*, ed. S. Musso (Milan: Fondazione Giangiacomo Feltrinelli, 1999).

[17] Established after Italy's unification, these local associations were supposed to help spread technical knowledge among farmers. Membership was voluntary and the availability of experts needed to accomplish the intended tasks was not always granted. Some of these associations, like the one in Camerino, were used by farmers to obtain lower prices for instruments and raw materials through collective purchasing. See: M. Zucchini, *Le cattedre ambulanti di agricoltura* (Rome: G. Volpe, 1970).

[18] N. Strampelli, "La fertilizzazione del suolo a mezzo di concimi chimici", *Chienti e Potenza*, 9 January 1897.

[19] See: N. Strampelli, "I miei lavori", in *Origini, sviluppi e risultati* (Rome: Lacroix, 1932). Unfortunately, it is not possible to assess properly from archival sources the role Carlotta Strampelli had in the development of the new hybrid wheat varieties. Marriage with a member of the Parisani family

In 1900 Strampelli also made his first experiment in wheat hybridization, crossing the two wheat varieties *Noè* and *Rieti*. The details of this first attempt are not completely clear: considered by Strampelli the true starting point of his work, this experiment was later remembered by his students and collaborators almost as a founding myth, a tale of pure genius[20]. It is certainly true that Strampelli started his hybridization experiment unaware of 'Mendel's laws': the aim of the cross was simply to merge two useful traits into a new improved wheat variety. *Rieti* was a landrace traditionally cultivated in the Rieti valley: Italian farmers praised it for its resistance to a family of plant diseases called *ruggini* (rusts)[21]. *Rieti* seeds were sold all over Italy, but they always (at least the legitimate ones) originated from the Rieti valley[22]. Outside the valley, for reasons unknown at the time, *Rieti* used to lose its resistance after a couple of generations. The main weakness of *Rieti* was considered its susceptibility to lodging[23]. Strampelli choose *Noè* for its resistance to lodging: the result he hoped for was a new wheat variety that could resist both lodging and rusts.

The first hybrid generation *Noè x Rieti* had the requested traits, but the supposed accomplishment vanished in the second year, when the hybrid seeds grew into many different forms. The experiments with wheat were thus suspended, but not for long: in 1904 Strampelli started again, in another place and with a slightly different approach[24].

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probably increased Strampelli's social status and his access to higher social circles, but it is not possible from the available archival sources to define those advantages in detail.

[20] See: B. Strampelli, "Un grande reatino di elezione Nazareno Strampelli," in *Sabina. Periodico dell' E.P.T di Rieti* II (1957): 8-14. Written by Strampelli's son, Benedetto, the article must be intended as a celebration of his father and not as a historical account. Every claim that Strampelli had somehow 'anticipated' Mendel can usually be traced back to this article.

[21] The word "Rieti" will be written in italic when referring to the wheat variety, in order to distinguish it from references to the city.

[22] The commerce in *Rieti* seeds was notoriously plagued by frauds. See: R. Lorenzetti, *La scienza del grano*, pp. 14-16, ref 6:11.

[23] The word *allettamento* (lodging) was used to describe the condition of a plant with a bent stem, due to adverse atmospheric events sometimes combined with an excessive growth in height. Lodging could mean harvest losses if it occurred before full maturation. The problem was exacerbated by the enhanced growth in height produced by the use of fertilizers.

[24] On Strampelli's first hybridization experiment, see also: S. Salvi, "I primi incroci di frumento in Italia: le esperienze di Nazareno Strampelli e Napoleone Passerini," *Rivista di diritto agrario* no. 2 (2011), 105-11. Salvi argues that Strampelli used a different method (cross-pollination by close contact) for this first cross. There are good reasons to believe that this may have been the case, but unfortunately (as Salvi himself wrote in his paper), no conclusive evidence is available about the exact procedure followed.

2.2 Rieti: From the Itinerant Chair to the Experimental Station (1903-1907).

Rieti's itinerant chair of agriculture was founded in 1903, thanks to Rieti's MP Domenico Raccuini and Minister of Agriculture Guido Baccelli[25], despite the previous existence of a similar position nearby, in Poggio Mirteto. Though nearby, Poggio Mirteto is outside the zone of production of the *Rieti* wheat variety (Rieti valley) and this boundary of production was used to legitimize the foundation of the new chair, publicized as a new institution specially dedicated to wheat culture.

In 1903, Strampelli was already in his late 30s, close to the average life expectancy of his generation[26]. Strampelli had a much longer life: he died in 1942. However, it is useful to highlight the position of the most historically interesting part of his life (1903-1942) in his biographical timeline (1866-1942). In 1903, when he became director of the itinerant chair of agriculture in Rieti, he was not a young inexperienced researcher, and in 1925, when he joined the fascist party, he was already 59.

Itinerant chairs of agriculture were positions aimed at the diffusion of agricultural knowledge among farmers[27]. The first chairs were created in Italy in the 1880s; initially founded by local institutions, they were later supported directly by the state. In the early twentieth-century, the chairs' financial support came both from the state and local institutions. The professor in charge had to deliver public lectures (at least 80 every year), publish an agricultural newspaper, and generally act as an adviser to the local community of farmers. The amount of funding could be very different from chair to chair: while the state contribution was standard, the degree of funding received by local institutions (municipality, banks, landowners) could differ greatly.

Itinerant chairs were formally controlled by the Ministry of Agriculture. In Rieti the administrative board included two representatives of the Ministry: Prince Lodovico Potenziani and Cavaliere Francesco Canali. Centralized control from the state, however, generally remained loose, to the point that professors were forced to send an annual report only from 1907.

In 1903, all that Strampelli received from the Rieti municipality was a wooden chair.

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[25] See: R. Lorenzetti, *La scienza del grano*, ref 6:11. Before the First World War, the Italian Ministry of Agriculture was part of the larger "Ministero di Agricoltura, Industria e Commercio" (Ministry of Agriculture, Industry and Trade).

[26] Giovanni Vecchi, *In ricchezza e in povertà: il benessere degli italiani dall'unità a oggi* (Bologna: Il Mulino, 2011).

[27] See: M. Zucchini, *Le cattedre ambulanti*, ref 17:40.

Things soon changed for the better thanks to local aristocrat and prominent landowner Lodovico Potenziani, who gave Strampelli permission to use two of his fields as experimental sites. In his first years of activity, Strampelli had to organize the chair from scratch, acquiring agricultural instruments and seeds, setting up a basic chemistry lab, and moving, not without difficulty, the local weather station into the chair's rooms provided by the local bank[28]. Despite local support, the chair started to lose money from 1904[29]. The reason behind this can be deduced from the answers Strampelli gave to minister Luigi Rava's questionnaire sent in 1904 to all the itinerant chairs: while the minister's questions were all focused around the role of the chairs as teaching institutions, Strampelli's answers were aimed at showing the amount of experimental activities that he had conducted[30]. The newly founded chair could already claim the establishment of several experimental fields (dedicated to wheat selection, experiments with fertilizers, and study of foreign wheat varieties) and the growth of a large number of potted plants, both for experiments with fertilizers and other substances, and for hybrids[31].

In his answers to the questionnaire, the research on wheat hybrids was downplayed: Strampelli wrote about a 'small number' of potted plants. From the papers in the Strampelli archive, it is clear that from 1904 onwards Strampelli tried to acquire a lot of different wheat seeds: letters were sent to agricultural institutions or individuals in England, France, Serbia, Denmark, Eritrea, Netherlands, the US, and Lebanon[32]. The reason Strampelli gave to some of his correspondent was the intention to undertake a comprehensive comparative study between different wheat varieties. There is no evidence that this was not the initial reason behind this collecting effort; however it is interesting to note that the seeds Strampelli asked for were not all the known varieties, but only those which in their place of origin were cultivated successfully and considered the most viable. It can also be useful to remember that in its first stages a hybridization programme can be rather inexpensive. Even if screening and

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[28] N. Strampelli, "Copia di lettera di Nazareno Strampelli al Ministero di agricoltura industria e commercio," 28 Sep 1903, ASR, APS, Box 10, Folder 4, and N. Strampelli, "Cronaca della Cattedra Sperimentale di Granicoltura in Rieti," 1904, Box 5, Folder 8.

[29] N. Strampelli, "Promemoria," 1906, ASR, APS, Box 11, Folder 3.

[30] N. Strampelli to Luigi Rava, "Notizie riflettenti l'attività di questa Cattedra," 1904, ASR, APS, Box 5, Folder 7.

[31] As already stated, Rieti's itinerant chair was created with the improvement of wheat culture in mind. However, it seems clear that no one was expecting such a large experimental programme.

[32] These requests are kept in ARS, APS, Box 16, from Folder13 to Folder 26. A detailed analysis of these short letters is beyond the purpose and scope of this chapter.

comparison of different types across generations can soon lead to a quick scaling up of resources needed, the first steps can be executed with a place for storing at least two potted plants, a brush, some parchment, and a pair of tweezers. However, something that happened in 1903 suggests that the downplaying was not entirely honest, and that the hybridization programme started with a higher degree of ambition.

2.2.1 Mendel explained to farmers: Giuseppe Cuboni (1852-1920)

In 1903, Giuseppe Cuboni was already an accomplished scholar and the first director of the Stazione di Patologia Vegetale (Plant Pathology Station) in Rome, created in 1887[33]. Cuboni had been a pioneer in the fight against grape downy mildew both through publications aimed at farmers and experiments. He became popular in Italy and Europe after demonstrating that one of the remedies employed, *bordeaux mixture*, retained its effectiveness if diluted to 1% concentration. Concerned by the state of agriculture in Southern Italy, Cuboni became one of the first Italian academics involved in the spreading of Mendelism. Cuboni was also the first Italian scholar to visit the famous Svalöf experimental station in Sweden, on behalf of the International Institute of Agriculture. After his return, he published a paper that is the first account of "Mendel's laws" and its consequences in Italian[34]. Titled *Le leggi dell'ibridismo secondo i recenti studi* ("Hybrid's Laws According to Recent Studies"), it appeared in 1903 on the bulletin of the Società degli Agricoltori Italiani, (Society of Italian Farmers)[35]. The choice of this particular journal reveals Cuboni's hopes that the new knowledge gained through the rediscovery of Mendel's work could change Italian agriculture for the better.

The Società degli Agricoltori Italiani was an association created in 1896 as the result of a ministerial project led by Nicola Mitraglia. The society declared itself to be apolitical and of scientific purpose. Its members were mainly important landowners (aristocrats and not) but the society also included renowned agronomists, like Cuboni. Ties with the Minister of Agriculture remained strong and the society is considered by Malatesta to have been a protector of landowners' interests. By publishing an account of Mendel's laws on the society's bulletin, Cuboni could hope not only to spread what he thought was a huge scientific

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[33] On Cuboni, see: G. Cuboni, *Scritti scelti Cuboniani*, 27. See also: A. Volpone, *Gli inizi della Genetica in Italia*, ref 11:13; A.V. Agnello Gagnotto, "Cuboni, Giuseppe," in *Dizionario Biografico degli Italiani*, (Rome: Istituto della Enciclopedia Italiana "G. Treccani", 1985).

[34] G. Cuboni, "Le leggi dell'ibridismo secondo i recenti studi," *Bollettino quindicinale della società degli agricoltori italiani* VIII (1903): 554-64.

[35] On the society, see: M. Malatesta, *I signori della terra. L'organizzazione degli interessi agrari padani (1860-1914)* (Milan: Franco Angeli, 1989).

achievement, but also to reach an audience that could implement the new knowledge in an applied research programme.

Cuboni's paper is ten pages long, divided into five sections. The first is an introduction in which the traditional tale of Mendel's rediscovery is told and celebrated as one of the most important achievements in biology. According to Cuboni, the distribution of traits in hybrids was previously considered to be chaotic and unreliable; knowledge of Mendel's laws could lead both to improvements in practical results and theoretical knowledge. The second section is a summary of Mendel's results integrated with a partial account of De Vries' studies: Cuboni describes the seven traits studied by Mendel in the pea plant and explains two laws that can be deduced from his work. The laws are those still taught in almost any undergraduate course of genetics: the first states that the entire offspring of a cross between two plant varieties with antagonist traits (like smooth seeds versus rough) displays just one of the traits; the second states that in the second generation (obtained by self-pollination of the hybrids) 3/4 of the offspring displays one trait (the dominant one) while the remaining 1/4 displays the other (the recessive one). The laws are then explained again by Cuboni, this time using probability.

In the third section, after some brief theoretical remarks, Cuboni introduces two practical consequences for plant breeders that he considers fundamental:

1. To obtain a certain combination of traits, the breeder has to study the offspring of the self-pollinated hybrids across many generations.
2. All the traits of a certain plant variety can be obtained in all possible combinations. Cuboni acknowledges that some problems and limits are going to appear in actual practice; nevertheless, he states that the breeder can in principle obtain new combinations of traits at will.

The last two sections consist of a brief summary of De Vries' theory of mutation and a conclusion where Cuboni predicts a future of mathematical certainty for the creation of new plant varieties through hybridization.

2.2.2 A new hybridization programme: growing

Given Strampelli's early interest in hybrids, and the kind of readers the bulletin could reach, it seems plausible to assume that he had the opportunity to read Cuboni's paper; however, there is no conclusive evidence that this actually happened. Fortunately, this uncertainty is not crucial to our attempt at understanding the development of the Rieti chair into an experimental station: we know for sure that Giuseppe Cuboni visited Strampelli in Rieti in June 1904 and also that Strampelli had resumed his hybridization experiments in

1904[36]. Whether the 1904 experiments were conceived with a long period of types screening in mind or simply as another attempt after the one made in 1900, Strampelli had the opportunity that same year to share his results with someone who was later remembered by his pupil as 'the town crier of Mendel in Italy'[37].

Strampelli obtained 53 hybrids in 1904, 35 if we subtract the 18 hybrids that did not survive the winter. Almost all had *Rieti* as one of its parental plants[38]. The importance of *Rieti* as a starting point is confirmed by a notebook kept in the Rieti State Archive[39], wherein all the varieties used for the 1904 crosses are described in detail. For each one Strampelli listed various traits (e.g. seed type, ear type, whether the plant was aristate or not) and its susceptibility to rusts. Each variety takes a separate page, but the page dedicated to *Rieti* has been cut and glued to the last page, making it possible to juxtapose it to all the others for quick comparison[40].

The wheat hybridization programme will be discussed in detail in another paper; for the time being some remarks on the dynamic of growth that such a programme imposes over the research structure that hosts it will suffice. After all, hybridization was not the only research project of the chair: a selection programme on *Rieti* was also taking place, along with many different experiments (on chemical substances, methods of cultivation, the effects of electricity on plants, etc.). Furthermore, Strampelli worked on many other plants, like maize, sugar beet, and castor oil plant. Is it a legitimate choice, then, for the historian to highlight the wheat hybridization programme, while saying very little about the rest?

The answer is 'yes': not only because all the other activities were suspended or reduced from 1907, but also because the dynamic of growth pushed Strampelli's position to its limits,

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[36] Cuboni praised Strampelli's activities in a paper published in the bulletin: G. Cuboni, "Le esperienze di granicoltura a Rieti," *Bollettino quindicinale della società degli agricoltori italiani* X (1905), fasc. 9. On hybridization experiments carried out by Strampelli from 1904 to 1907, see: N. Strampelli, *Alla ricerca e creazione di nuove varietà di frumenti a mezzo dell'ibridazione* (Roma, Tipografia dell'Unione Cooperativa Editrice, 1907).

[37] G. Cuboni, *Scritti scelti Cuboniani*, ref 13:27.

[38] N. Strampelli, *Alla ricerca e creazione di nuove varietà di frumenti*, pp. 8-9, ref 36:45. The only two crosses made without *Rieti* are in the group of 18 hybrids that did not survive the winter.

[39] N. Strampelli, "Libro primo. Varietà servite per gli ibridi 1904," 1904, ASR, APS, Box 16, Folder 7.

[40] This is the only notebook found in the Rieti archive with these characteristics. Information on hybrids was later collected and managed with library-like files. Whether this is due to a change in the research method, or the randomness involved in the conservation and loss of historical materials, is difficult to say.

forcing a choice between expansion or failure[41].

To understand this dilemma, let us imagine a greatly simplified abstract system, a system that starts with two stable varieties of a plant, landrace *a* and landrace *b*. The meaning of 'stable' in this context is that the offspring of each *a* and *b* obtained by self-pollination is always parent-like. In this system, the expected outcome is *c*: a new stable plant variety that has certain characteristics found in *a* and *b* in a new combination. For the first artificial cross, some exemplars from variety *a* and *b* are enough (even one plant *a* and one *b*): at the end of the process hybrid seeds *ab* are created. According to classic Mendelian theory (which Strampelli was using), these *ab* seeds are going to develop into an uniform F1 generation with a combination of the parental traits: *their offspring*, however, are going to be greatly diversified. Thus, *ab* is not a variety, and nor is its offspring, *abXab*.

According to Mendelism, the *ab* plants, despite looking the same, are in fact different. Our objective, *c*, has to be found in the progeny of one of the different combinations created by the self-pollination of hybrids. If every trait comes in two alternatives (tall culm versus short culm, aristate versus non-aristate) for each couple of traits *n*, we will have 2^n possible types. Many of them will look the same but lead to different results in reproduction: to reach stability it is necessary to keep each plant separate and to track its offspring across many generations.

Note that before the screening point three years have already passed (one for the parental plants to grow, one for the first hybrid generation to grow, and another for the offspring of the hybrids). While some potted plants were enough for the first cross, to make all the possible combinations appear (and thus have a better chance of finding promising types) the breeder is going to need a large number of plants, plus enough land and resources to grow them. He has to set up a sufficiently large *space of possibilities* where his desired outcome can appear. It is a game of chance where the breeder's own abilities and intuition (sometimes called the "breeder's eye") can reduce costs, but only up to a certain point[42]. With every new generation the breeder can choose the plants that he considers to be promising and eliminate the others: every time, however, the total number of plants he has to grow will probably increase. Consider that this work is usually conducted with many crosses in parallel, the reality is

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[41] On the suspension, see N. Strampelli, report, Mar 1910, ASR, APS, Box 11 Folder 5.

[42] For an interesting opinion on the breeder's eye in contemporary practice, see: M. Timmermann, "The breeder's eye – theoretical aspects about the breeder's decision-making," in *Proceedings of the COST SUSVAR Workshop on cereal crop diversity: Implications for production and products, 13-14 June 2006, La Besse, France*, ed. H. Hoestergard and L. Fontaine (Paris: ITAB, 2006), 118-23.

usually more complicated than our imaginary system and, finally, that no profit at all is expected at this stage. Even when stability is reached, no reliable data on the actual behaviour of the new *c* variety is gained. It should be more than enough to understand that an early twentieth-century research programme on wheat hybrids could easily turn into the perfect recipe for a complete economic disaster.

This almost happened in 1906: in a document titled *Promemoria* (memorandum), Strampelli explains the critical financial state of the chair in 1906[43]. From this document we learn that Strampelli successfully obtained endorsements from Cuboni and another prominent agronomist of the time, including Italo Giglioli, head of the Portici School of Agriculture. Giglioli and Cuboni expressed their support, sending two reports to the Minister of Agriculture, Luigi Rava. Their efforts convinced Rava that the itinerant chair had to be transformed into a proper experimental station, and increased funding from 1905. The Treasury Minister, however, blocked the operation, claiming that a special law was required for the change to take place. Rava assured Strampelli that the problem would be solved quickly so Strampelli kept the research programme running. Given the new picture, local institutions withdrew their financial support, leaving Strampelli in a delicate position. Some funding was expected the following year, giving Strampelli some relief. In 1907, the requested special law was approved, and the Rieti experimental station was officially born.

2.2.3 First results of the hybridization programme: publications

In 1907, Cuboni presented to the Accademia dei Lincei a preliminary note written by Strampelli about his results in Rieti[44]. This publication does not describe Strampelli's methods in detail; it does, however, make clear what the goals were and the main results achieved[45]. Strampelli wanted to develop wheat varieties that could benefit from the artificially increased soil fertility. According to Strampelli, susceptibility to *rusts* was the main obstacle preventing the use of wheat varieties already developed in other countries,

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[43] N. Strampelli, "Promemoria," 1906, ASR, APS, Box 11, Folder 3.

[44] The Accademia was, and still is, a prestigious science academy based in Rome. Despite a two century-long hiatus (1630-1847), the academy is considered to be the ideal heir of the one founded by Federico Cesi in 1603.

[45] N. Strampelli, "Esperienze di selezione e ibridazione sul frumento e sul granturco," *Rendiconti dell'Accademia dei Lincei. Classe di scienze fisiche, matematiche e naturali* vol. 16 (1907). Strampelli had previously published, in 1906, a short note about his experiments on the plant disease provoked by *Ustilago carbo*. See: N. Strampelli, "Esperienze intorno alla malattia del frumento dovuta all'ustilago carbo," *Rendiconti dell'Accademia dei Lincei. Classe di scienze fisiche, matematiche e naturali* vol. 15 (1906).

while *lodging* was a problem for the resistant varieties already cultivated, like *Rieti Originario*. Strampelli linked lodging to the structure of the culm, finding that the number and length of fibres influenced susceptibility.

Later that year Strampelli published a small book documenting his results and methods, this time in detail[46]. It is interesting to note that this publication, although far more rich in details than the previous one, does not mention the correlation between culm structure and resistance to lodging made in the former publication[47].

In the second 1907 publication Strampelli described his method of artificial pollination, along with the precautions he used to avoid the infection with *Ustilago carbo*. The description was complemented by a series of photographs documenting the ideal flowering point of the pistils.

On pages 13-14, Strampelli gave a table of *dominant* and *recessive* traits. Starting from Biffen's work, he listed 25 couples of traits. The distinction between *dominant* and *recessive* was considered relative to a specific cross and not absolute. Strampelli also shared his classification system for hybrids and his field division.

This publication was meant to show the structure of a research plan that in 1907 could only offer partial results. None of the hybrids obtained could yet be considered a viable variety. The publication contained valuable knowledge for a wheat breeding programme, however that knowledge was impossible to put into practice without the initial collection of wheat varieties made by Strampelli at the beginning of his work and without a good supply of land and resources. Those factors, along with the public nature of the work made the sharing of information safe. It was in fact a good way to persuade landowners and politicians that the approach followed made sense and that results would follow given enough time and resources. Later, the balance between publications and seeds changed: the main levers used to gain resources became the wheat varieties released. It should not come as a surprise, then, that we have to wait until 1918 to find another publication by Strampelli in the Lincean Academy's journal, when the first important hybrid wheat variety was released: *Carlotta Strampelli*.

[46] N. Strampelli, *Alla ricerca e creazione di nuove varietà di frumento,* ref 36:45. Compared with the previous note, this publication is clearly meant for another kind of audience. See the following discussion of its content.

[47] Two types of straw fibres were listed as a couple of traits, but no explanation was given about the relationship between these characteristics and lodging.

2.3 Wheat as a lever: Carlotta Strampelli

Named after Strampelli's wife, the wheat variety *Carlotta* was first presented to the general public during the 1914's Mostra delle Novità Agrarie (the National Agricultural Exhibition) in Rome[48]. *Carlotta* was not the only wheat shown by the Rieti experimental station; other four hybrids (one named after Mendel) were also on display, along with the outcomes of a selection programme on different varieties like *Rieti* and *Gentil rosso*. Nevertheless, *Carlotta* was the first outstanding result of the hybridization programme, one that made Strampelli famous in Italy when in 1919 the Lincean Academy decided to award him the Santoro prize. What kind of wheat was it, and how did Strampelli obtain it?

Carlotta Strampelli was type number 637 from the cross *Rieti* x *Massy* made in 1905[49]. Strampelli presented it as a variety resistant to lodging, resistant to rusts, highly productive, and suited for bread making. Strampelli considered it one of his most important results, remarking in the notes written for the exhibition that

> Results achieved through genealogical selection are certainly beautiful and useful, but the hybridization work is the most moving. Through hybridization, the ancestral types are shaken, providing the selectioner with a broader and safer field. If he keeps fixing his creations, without rushing, and guiding the choice in the desired direction, he will certainly achieve what he wants[50].

Carlotta was chosen because Strampelli believed he had obtained a homozygous plant. Its characteristics were exploited through a careful choice of resource management.

In 1910, Strampelli wrote a report with some requests to the Minister of Agriculture, Luigi Luzzatti, and in July of the same year, a short reminder to his successor, Giovanni Raineri[51]. In the report Strampelli gave an overview of the work done in Rieti since 1903, highlighting a crucial change that had taken place in 1906, when Lodovico Potenziani took back the two

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[48] N. Strampelli, "La R. Stazione Sperimentale di Granicoltura in Rieti alla Mostra delle novità agrarie dell'anno 1914," 1914, ASR, APS, Box 18 Folder 10.

[49] N. Strampelli, "Genealogia del frumento *Carlotta Strampelli*," *Rendiconti della R. Accademia dei Lincei* vol. 27 (1918).

[50] N. Strampelli, "La R. Stazione Sperimentale", ref 48:50. Author's translation. The original Italian is: *I risultati conseguiti con il lavoro della selezione genealogica sono bellissimi ed utilissimi indubbiamente, ma il lavoro che più commuove è quello dell'ibridazione, per esso, provocandosi lo scuotimento dei tipi ancestrali, viene offerto un campo molto più vasto ed anche molto più sicuro al selezionatore, il quale se senza fretta persevererà pazientemente nel fissare le sue creazioni e nel guidarne la scelta nel senso voluto, potrà arrivare indubbiamente ad ottenere ciò che vuole*.

[51] N. Strampelli to Giovanni Raineri, "Campi sperimentali necessari per la costituzione di razze di frumenti atte alle diverse regioni italiane," 19 Jul 1910, ASR, APS, Box 11, Folder 4.

experimental fields (*S. Pastore* and *Setteponti*) he had lent Strampelli for free since the first years of the itinerant chair. Strampelli relocated his experiments to another field owned by Potenziani, in *Torretta*, this time paying rent[52]. The new field was not homogeneous in its composition. This was crucial because, in his report, Strampelli introduced an important distinction he saw in his work between a *botanical* and an *agronomic* phase.

In this context, *botanical* refers to the screening of different types resulting from a cross, tracing their offspring across generations. This phase ends when a fixed variety is reached. At this point, the breeder has a set of seeds that can grow into plants with consistent traits. What the breeder is missing is reliable information on actual performances of the variety once cultivated on a large scale in different places: that is what the *agronomic* phase is supposed to find out. In this phase, homogeneity of the terrain becomes crucial for the quality of data.

Homogeneity was a necessary, but insufficient, condition. Strampelli asked for additional fields in Rieti, Foggia, and Leonessa, a plateau not far from Rieti. Those fields were intended as a way to test the performances of new wheat varieties: they were *models* of different environments where wheat was cultivated in Italy. Fields in Rieti were supposed to be similar to fields in plains and hills in northern Italy, fields in Leonessa to the ones in mountainous regions, while those in Foggia could be used in the search for varieties that could resist arid climates[53]. Every location had to include a space devoted to seeds multiplication which could provide a starting point for a large distribution.

The availability of fields in different locations was crucial for finding out what had been obtained through artificial crosses. Varieties could not be considered viable without reliable data about their ideal environment. Unlike landraces, hybrids did not come with a relation to specific environments. The link had to be created anew through trial and error.

Some of the requests were granted the following year, thanks to Rieti's MP, Antonio Solidati-Triburzi[54]. Bernardino Giovannelli and Giovanni Dall'Aglio were officially employed as assistants; fields in Rieti, Leonessa, and Foggia were established; the research station's legal status was changed to that of a non-profit organization.

Another significant event took place in 1911. According to documents in the Rieti archive, Strampelli had the opportunity to travel across Europe, visiting Svalöf, Norwood

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[52] *Torretta*, *S. Pastore*, and *Setteponti* were names of small areas near Rieti.

[53] Strampelli had started experiments in Foggia in 1906 thanks to Raffaele Cappelli, politician and director of the aforementioned Società Italiana degli Agricoltori, who offered him land and complete coverage of related costs.

[54] R. Lorenzetti, *La scienza del grano*, ref 6:11.

Woburn, Reading Agricultural College, and Sutton farms, Kew Botanical Garden, Rothamsted, Gartons farms in Warrington, Aynsone, and Cambridge to see work on wheat conducted by Biffen and Bateson[55]. Strampelli also visited France: Fontainebleau, Mendon, Vilmorin in Paris, and the breeder Emile Schribaux. The actual journey was a reduced version of a broader one suggested to Strampelli in 1903 by the aforementioned professor Italo Giglioli. Despite the significance of this tour in Strampelli's life, there is nothing in his personal archive that can document precisely what kind of influence these experiences had on him. It is not possible to point to any specific change in the research method resulting from this tour of breeders. The only trace left seems to be the tickets themselves and the paper presented at the 4th International Conference of Genetics[56]. The paper was about the possibility of creating a new variety through selection of exemplars with peculiar characteristics. From the paper it is clear that already in 1911 Strampelli had reasons to believe that early ripening could be considered a Mendelian trait.

Back to *Carlotta*, there is something that can be deduced from the information collected so far:

1. Unlike the *botanical* phase, where working with different hybrid types at the same time is mandatory, in the *agronomic* phase the work can (and should) be separated for each variety. To collect reliable data, many seeds are required for trials in different places, including third-party agricultural institutions.
2. Suspension of the work is always possible at every stage (storing the seeds away), but makes more sense when the type is fixed and a variety is created (although without information on its actual performances)[57].
3. Resources granted after 1911 were of great help to the institute, but still not enough for a massive trial of the types found during the *botanical* phase.

Carlotta was just one among the 1,086 types that were considered promising by

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[55] N. Strampelli to F. S. Nitti, "Viaggio all'estero," 6 Aug 1911, ASR, APS, Box 18, Folder 9.

[56] See N. Strampelli, "De l'étude des caractères anormaux présentés par les plantules pour la recherche des variétés nouvelles," in *IV Conférence Internationale de Génétique. Paris 1911. Comptes Rendus et Rapports*, ed. Ph. De Vilmorin (Paris: Masson, 1913), 237-46.

[57] With the term "fixed" I refer to the belief (justified or not) that a certain plant will give a parent-like offspring when self-pollinated. Both T. Saraiva (*Fascist Labscapes*, ref 4:11) and Boggini et. al. have remarked that Strampelli's varieties were not completely stable. From archival sources, however, this appears to be a byproduct of Strampellli's method and not an intentional strategy, since Strampelli never wrote about it. See: G. Boggini, M. Cattaneo, M. Corbellini, M. Perenzin, A. Brandolini, and P. Vaccino, "Le varietà di frumento tenero costituite da Nazareno Strampelli," in CD-ROM n.8, *Collana di ipertesti di agricoltura e comunicazione del Centro di collegamento ricerca-divulgazione del CRA-ISC* (Sant'Angelo Lodigiano, 2004).

Strampelli, a result obtained by elimination from a starting point of 4,775 fixed types, the outcome of 306 crosses[58]. Strampelli did not stop working on other wheat varieties; however, he decided to focus the greater part of his available resources on *Carlotta*, a wheat that could fit in the same niche of *Rieti*, where he had more resources. After the 1914 exhibition, with the aid of minister Giannetto Cavasola, Strampelli started a limited distribution of *Carlotta* seeds among Italian agricultural schools, itinerant chairs, and some private farms. This distribution was intended as a way to collect a vast amount of data, to prevent 'any damage to Italian wheat culture'[59]. Thanks to Cavasola, Strampelli had the opportunity to gain data on *Carlotta* from an extensive network of experimental fields distributed in every Italian region. Since the fields were managed by teaching institutions, the trials also provided good advertising for the new varieties.

In Rieti, an agreement was signed with the Unione Produttori to ensure the required amount of seeds were produced[60]. The members had to sign an agreement that provided strict cultivation rules to prevent any contamination with other varieties, and set a fixed price, based on a standard increase of *Rieti*'s[61]. The experimental station had the right to perform inspections to guarantee that the rules were followed. A fixed amount was reserved for the experimental station: at least 1,000kg, in order to prepare samples that could be sent to research institutions that required it, in Italy and abroad. The extensive trials were conducted during the First World War, when wheat in Italy became scarce[62].

Carlotta was also at the centre of a set of special dispositions during the war, in 1917, when the government imposed the confiscation of wheat for rationing[63]. *Rieti* seeds selected via a mechanical procedure by the experimental station (viable for sowing) could be sold,

[58] N. Strampelli, "Miliani," 1917-1919, ASR, APS, Box 5, Folder 17. The item (undated) appears to be a draft for a letter addressed to the Minister of Agriculture Giovanni Battista Miliani, who was minister from 30 October 1917 to 17 January 1919.

[59] N. Strampelli to G. Cavasola, "Relazione sui risultati del nuovo frumento 'CARLOTTA STRAMPELLI' conseguiti nei campi regionali di prova," 23 Aug 1915, ASR, APS, Box 26, Folder 27.

[60] Lodovico Potenziani was the president of this association of Rieti's seed producers.

[61] N. Strampelli, "Per la moltiplicazione ed il commercio del nuovo frumento Carlotta Strampelli," ASR, APS Box 19, Folder 2. Rules included: the prohibition of cultivating *Carlotta* seeds that did not come from the experimental station; careful surveillance of the surrounding fields; the use of a single thresher.

[62] Reliance on imported wheat had considered a structural weakness of the Italian economy since the 1880s.

[63] F. Girolami, disposizioni, 15 Aug 1917, ASR, APS, Box 9 Folder 10. From other handwritten items found in the same archival folder, it seems clear that the dispositions signed by the special commissioner were developed by N. Strampelli himself.

while the non-selected seeds had to be handed over to the rationing committee. All *Carlotta* seeds had to be sown: all of the product obtained had to be given to the experimental station.

The results of the trials were largely positive: *Carlotta* became a lever that Strampelli could use to advance further requests for his research programme. The popular success of the new variety is attested not only by the reports the experimental station received, but also by agricultural newspapers of the time[64]. Demand repeatedly exceeded supply, marking a related decline in the sale of *Rieti*. *Carlotta* was so successful that, according to Strampelli, it started to be grown even in ill-suited environments. Although *Carlotta* was always meant to be a wheat for fertile plains, its use in arid environments and the subsequent poor performances threatened Strampelli's reputation, at least until the commercial release of *Ardito*, his first early-ripening variety.

2.4 A national institute and Ardito: a partial victory?

From 1913 onwards Strampelli started to work on early-ripening wheat varieties[65]. The starting point was a Japanese wheat variety, *Akakomughi*, that was sent as a gift to Strampelli by F. Ingegnoli, an important seeds man based in Milan[66]. *Akakomughi*, a semi-dwarf variety, was considered worthless in itself, but its early ripening awakened Strampelli's interest. In 1920, he released the new variety *Ardito*, the name of the Italian elite storm troops during the First World War[67].

Strampelli had, on many occasions, spoken and written of the breeder as an artist, or as a mosaicist[68]. He maintained that, thanks to Mendelism, the breeder could design a plant

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[64] ASR, APS, Box 23. The box is composed of two folders containing articles from Italian agricultural newspapers about *Carlotta* (Folder 1) and *Ardito* (Folder 2). A more detailed study of wheat in Italian agricultural newspapers during the years 1900-1929 is currently in progress.

[65] N. Strampelli "I miei lavori" p 91, ref 19:40.

[66] N. Strampelli, notes, undated, ASR, APS, Box 19 Folder 3.

[67] "Ardito" means "daring" in Italian. In the publication describing the new wheat, Strampelli wrote that the name was chosen to describe and praise the behaviour of the Minister of Agriculture, Vincenzo Riccio, who was in charge during 1919. Strampelli named one of his varietyies after him to express his gratitude, and ended the article with an appeal to the new minister, Giuseppe Micheli, asking for additional resources and promising the creation of *Arditissimo* (extremely daring) and *Micheli*. These varieties were never created. See N. Strampelli, *Altre varietà di frumenti ottenute nella stazione di granicoltura di Rieti* (Piacenza, Federazione Italiana dei Consorzi Agrari, 1920).

[68] See the aforementioned notes in ASR, APS, Box 19 Folder 3. See also: N. Strampelli, "Breve riassunto dei lavori della R. stazione di granicoltura sperimentale di Rieti," *Bollettino degli agricoltori italiani* no.10/11 (1918).

according to a specific need. With enough time, every trait could be recombined with any other. This conceptual shift is important because here the breeder is not thinking of himself as an improver who has to work within strict social and natural boundaries, such as cultivation practices already in place or varieties traditionally sowed. Here the breeder considers himself a creator, someone who can redesign agriculture according only to environmental conditions.

The early-ripening quality and the short culm were conceived, according to Mendelism, as traits that could be taken and recombined in other, more valuable varieties. From a technical point of view, the cross that generated *Ardito* was no different from any other carried out by Strampelli in Rieti. However, it is only with this cross that we have a clear example of a result that could not be achieved inside a research programme based on selection alone, without hybridization. This cross demonstrates once more the combinatorial conception Strampelli had of plant varieties, a mechanism which, no matter how tangled and difficult to manipulate, could always be bent to one's will with time and patience. Time and patience were not only used to bend manipulate the hybrids: as Roberto Lorenzetti stressed in 2000, Strampelli was working both on the early-ripening wheat and on the Italian government, trying to create a national institute of genetics for wheat[69]. The institute was seen by Strampelli as a way to give his research programme the national status that was implicit in its organization. The varieties obtained (but not tested) during the Rieti years were going to be the starting point for the new institute, founded in 1919 with the name of Istituto Nazionale di Genetica per la Cerealicoltura. The possibility of large trials in different locations, and the 'national' label could be used by Strampelli to bypass regional problems created by his aim to replace *Rieti* landrace and advance his project to 'give every Italian region it's own wheat'[70].

What could be seen as Strampelli's triumph, however, had some disadvantages too, which could help explain the subsequent alliance between Strampelli and the fascist regime after 1925. The first thing to consider is that *Carlotta* and *Ardito* were the only two varieties obtained by Strampelli which enjoyed some relevant distribution before fascism. Another chapter of this thesis (chapter **4**) will show that varieties were seldom considered as a key factor for increasing production by Italian landowners and agricultural technicians.

The second thing is the increase in resources available to Strampelli after 1919. Even though it was substantial, legitimizing Strampelli's national ambitions, it was not enough to accomplish the massive project of changing all the traditional varieties cultivated in Italy that Strampelli had in mind.

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69 R. Lorenzetti, *La scienza del grano,* p 62, ref 6:11.

70 N. Strampelli, "Miliani," 1917-1919, ASR, APS, Box 5, Folder 17.

The third is connected with the fact that, although rich in terms of seeds released, the years after the First World War were poor in term of publications. Strampelli's activities as a breeder left little time for his other scientific goals. This can tell us something about the kind of knowledge produced in this period. The time required for developing new varieties was reduced: when *Carlotta* was considered "ready" in 1918, 14 years had passed since the cross. *Ardito*, on the other hand, was released after seven years. This can be ascribed to an improvement in the resources available, but also to general progress in expertise. In his 1932 publication, a book that was meant as a celebration of the national institute, Strampelli acknowledged his lack of publications, making the statement that his real publications were his varieties, even if they did not carry his name[71]. The distance between production and theoretical knowledge, between achievements in genetics and his breeding programme increased. If 1904 can be considered the point of minimum distance, 1932 can be taken as the maximum: in his closing remarks, Strampelli wrote that, based on his personal experience, he doubted the existence of mutations in wheat, a statement that is, at the very least, puzzling in 1932.

Conclusion: hybrids before fascism

From 1903 to 1919, Italy had a total of 12 Ministers of Agriculture. Although it is possible to pinpoint those who were in charge when the major changes in the institutional forms and resources happened, they were all involved with Strampelli's research programme, and no one decided to suspend it or reduce its size.

The public dimension of Strampelli's research programme was unavoidable for at least three reasons:

1. As a result of Strampelli's own approach to his research, seen by him as a public service for Italy, and more generally as a way to improve wheat production everywhere (although one can detect a strong degree of nationalism in Strampelli, he always sent and offered his wheat to agricultural research institutions outside Italy).
2. As a result of the great resources and years required for his programme to succeed, with the slow fixation of traits and the creation of a large number of varieties without reliable data on their performances, the experimenter Strampelli was bound to a massive agronomic phase and it is almost impossible to scale down. This phase is not sustainable through profits in the seeds market.

[71] See: N. Strampelli, "I miei lavori," p. 104, ref 19:40. This can be understood both as a reference to the problems of controlling biological innovation, and to the fact that Strampelli never chose his own name for a variety.

3. As a result of Strampelli's 'top-down' approach, where control of the research programme and subsequent production of seeds is absolutely centralized and research conditions are kept almost unchanged to maintain quality.

Despite the continuity that emerges from this picture, 1925 can be considered a watershed. After 1919, the new minister, Micheli, declined to grant Strampelli the additional resources he asked for. The institute was founded, but did not have all the means that Strampelli considered necessary for his work. With hindsight, it is easy to see that Strampelli's varieties promised an increase in production (allowed by the new varieties' increased tolerance for inputs like chemical fertilizers) with a lower impact on the composition of the agricultural world than other innovations (e.g. mechanization).

When Mussolini decided to put Strampelli's wheat at the centre of his *battaglia del grano* (a nationalistic effort aimed towards an increase in wheat production), the varieties developed by the scientist enjoyed a dramatic increase in distribution, covering, in some regions, over 80% of the total wheat acreage. The relationship between Strampelli's wheat and the fascist regime is not a simple one: on the one hand, the institute in Rome had a huge increase in funding and the opportunity to expand Strampelli's *model* fields into proper experimental stations, achieving the long-sought national scale; on the other, Strampelli's seeds became a vehicle for political propaganda, starting with their names, which were approved by Mussolini himself[72]. Italian wheat production did increase, but the social and economic price paid for that increase makes it hard to look at this event as a scientific or technical achievement.

In this chapter, fascism might appear as the classic elephant in the room. However, I strongly defend the choice to reconstruct some of the preceding events in order to understand how it was possible for it to enter in the first place. With this metaphor, we can now have a clearer picture of the status of Strampelli's research programme before 1925: an applied, state-funded research programme partially stuck due to a lack of resources needed for an extensive trial of the fixed varieties. Results obtained with *Carlotta* and *Ardito* could be used to substantiate the claim that many other wheats were only waiting for the testing phase, promising further results soon. Plus, the research structure was centralized, offering a strong degree of control and the possibility of propaganda through naming practices.

Despite technical improvements (like the use of refrigerators), and the availability of new research structures, the core of the research programme changed only slightly between 1903 and 1932. The description of hybridization that can be found in Strampelli's 1932 summary of his entire work is taken almost verbatim from his 1907 publication. What once was a new

[72] There were, among others, wheat varieties called *Bruno* (named after Mussolini's son), *Edda* (Mussolini's daughter), and *Tiriamo Dritto* (a slogan used by Mussolini).

strategy in plant breeding became a large and slow research programme, as systematic it was as resistant to any strong innovation.

Centralized control, a conservative attitude, untapped potential: these features are not enough to explain how a hybridization programme became the core of a dictatorial agricultural policy; however, I believe they can be a starting point for an attempt to understand what happened to Italian agriculture, and agricultural research, after 1925.

In 1925, two elements merged: a dictatorship that wanted to massively increase wheat production with a top-down, input-intensive approach, and a national institute that was developing wheat varieties through a large hybridization programme and hoping to replace the old varieties cultivated in the country with new ones. As mentioned, Strampelli was 59 at the time, towards the end of his career. He became a senator in 1933 and died in 1942, before the end of the Second World War. He helped to raise Italian wheat production, but though his varieties proved to be effective, the agricultural policy of the fascist regime was a complete failure, and Strampelli is today largely forgotten, even if some of his varieties are still cultivated.

Chapter 3

PROCESSES OF PRODUCTION IN ITALIAN WHEAT BREEDING

Introduction

When it comes to plant breeding and Mendelism, each country has its own story filled at the same time with parallels trajectories and peculiarities. The role of the state as a sponsor of agricultural research and the difficulties in “making seeds travel” (i.e. not only to physically move them from one place to another, but to successfully grow them outside of their place of origin) probably contributed to the establishment of research and development programmes for new plant varieties in many countries. Comparisons between historical studies on different national stories have proven to be fruitful, showing common trends[1]. This chapter will instead attempt to discuss a peculiarity of the Italian case, and to advance a certain idea related to plant breeding to explain a situation that, to my knowledge, has no obvious parallels in the European landscape.

While the academic institutionalization of genetics in Italy was very slow, agricultural scholars and agricultural research institutions were quicker to adopt the new science of Mendelism[2]. When wheat breeding is analyzed in detail, however, the following situation appears: inside the Mendelian consensus, different competing practices existed, developed by researchers who all equally claimed to be Mendelians. These practices, performed inside complex breeding programmes, competed with each other almost silently. Each criticism was expressed only subtly, each possible debate never expanded into a proper dialogue. Why?

The usual answer is that plant breeding is a practical activity which has little interest in theoretical debates. This answer has the advantage of explaining why theoretical discussion between breeders does not develop, but I think it gives an inaccurate image of plant breeding as an almost theory-free activity. In this chapter, I will contend that this is not the case, and try to give a different answer.

The conception of plant breeding that emerges from such an analysis utilizes both the concept of *process* in its definition advanced by T. Davenport, and a theoretical analysis that uses Luciano Anceschi’s concept of *poetics*, although in a slightly different way. Besides giving a more accurate picture of plant breeding, this conception can explain why theoretical debate between Italian Mendelians did not happen, despite the relevant differences between their practices and concepts.

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[1] See: J. Harwood’s special issue of the *Journal of the History of Biology*, ref 1:9.

[2] A. Volpone, *Gli inizi della Genetica in Italia*, ref 11:13.

Structure

Section **3.1** presents the "Mendelian revolution" as it was portrayed by Giuseppe Cuboni. Deciding whether Mendelism was actually a revolution is not important here: the main point is to show that a group of Italian plant breeders were labelled as "Mendelians" and presented as revolutionaries. No one among the breeders mentioned refused the label; an analysis of the work by two of the most prominent wheat breeders mentioned, Francesco Todaro and Nazareno Strampelli, is proposed to explore this apparent theoretical uniformity in more depth.

A brief profile of Francesco Todaro is given in section **3.2**: after obtaining his degree in agricultural sciences in Pisa, Todaro, like Strampelli (see section **2.1**), began to teach in various agricultural schools until he was appointed to Modena's experimental station of agriculture. In 1903, Todaro became professor at the Scuola Superiore di Agraria in Bologna, later the faculty of agricultural sciences. Todaro considered the improvement of wheat varieties a priority following his experimental work in Modena.

In Bologna (section **3.2.1**), Todaro started his wheat selection programme, based on a theory of subspecies, with the support of prominent local landowners. The programme was successful, as was the cooperative Todaro founded to manage it. One of the first results was the bypassing of natural monopolies by permanent adaptation of already cultivated varieties that had to be imported each year. Todaro did not use hybridization in Bologna, however, it is evident from his published university lecture notes that he was well-acquainted with its methods and theories. A notable difference between a selection programme and a hybridization programme is found in the different degree of risks that have to be taken and the amount of time required to obtain results.

Todaro's interest in wheat varieties put him in direct competition with Strampelli, both in the market and in the search for public funding: their rivalry, however, introduced in section **3.2.2**, always remained subtle. In 1919, Todaro wrote an article that criticized Strampelli's ideas about the role of hybridization in plant breeding, but it did not start a proper theoretical debate as one might expect. A possible reason for the absence of such a debate is the limited importance of theoretical concepts in plant breeding: after all, Todaro's argument was that he and Strampelli were doing practically the same things, with the exclusion of one small step (artificial pollination). Although two initial objections to this view are given, the hypothesis is kept on the table, and an analysis of both Todaro and Strampelli's processes of varietal innovation is started in the section below.

Section **3.3** explains what will be the focal point of the analysis: following a definition of *process* common in business literature, the emphasis will not be on the final products (wheat varieties) of the two research programmes, but on the activities that made both Todaro and Strampelli's programmes capable of producing new varieties in a systematic and reliable way.

Todaro's process of production is explained in section **3.4**: the goals of his research programme are explained, as well as the six steps that were used to produce new wheat varieties. The process started with varieties already cultivated successfully in Bologna, which were subjected to *selective breeding*, *observations*, *test multiplication*, *territorial tests*, *adaptation tests*, and *conservative multiplication*.

In section **3.4.1**, I argue that such an analysis of Todaro's process, based on Todaro's own suggestion (that the breeder is a businessman) is incomplete: the process produces and uses *concepts* as well as seeds. Following Strampelli's suggestion (that the breeder is an artist), I propose to analyze these concepts, which can be implicit or explicit, in a way inspired by the philosopher Luciano Anceschi (1911-1995). Three questions (on variety, chance, and hybridization) are asked to examine more closely the assumption of Todaro's process. Todaro's conception of a wheat variety as a subspecies is related to the role of chance in the process (a disturbance in data collection) and to his refusal to use hybridization (a source of uncertainty). His conceptualization of problems (and thus of his goals) is also peculiar: resistances (to rusts and lodging) were conceived of as *relative* characteristics influenced by elements that were not entirely in the breeder's area of control.

The same kind of analysis is developed in section **3.5**, this time focusing on Strampelli's process. Strampelli's division of work into two phases (*botanical* versus *agronomic*) is further specified to keep the analysis comparable with that of Todaro's programme. The steps individuated are *hybridization*, *selection*, *testing*, and *multiplication*.

The process followed by Strampelli was different from Todaro's: in section **3.5.1** this difference is analyzed on a conceptual level. In Strampelli's programme, a variety is not a subspecies, but a stable combination of traits. Rather than being relegated to a disturbance in the data-collection phase, chance (through hybridization) is at the core of the process. Hybridization was not conceived as a source of uncertainty (or variation), but rather as a means to achieve certain combinations, even if the degree of control claimed by Strampelli when presenting his programme now appears exaggerated. Problems were also conceived differently: both rusts and lodging resistances were treated as Mendelian traits, and thus reduced to a single cause (plant conformation).

The conclusion of chapter **3** presents the main results of the analysis: plant breeding is a practical process with a theoretical side, and the actions that compose this process can have different meanings according to the overall organization. This conception, while presenting a more accurate image of plant breeding, has the disadvantage of leaving the absence of theoretical debates between Todaro and Strampelli unexplained. An explanation is thus advanced asking how the two competitors could consider themselves to some extent allies. Both their processes of production shared a characteristic: they could not survive inside an agriculture where the farm was a self-sufficient entity. Strampelli and Todaro were both trying to change wheat culture in Italy by claiming a definite scientific space of action that occupied a certain function (production of varieties). Mendelism, interpreted as a loose framework that comprised a plurality of practices, became a useful tool to advance both Strampelli and Todaro's research programmes without imposing particular limitations on them. The Mendelian umbrella remained a comfortable shelter it was not convenient to question.

3.1 Mendelism as Revolution

On 7 June 1914, the famous plant pathologist Giuseppe Cuboni made a speech at the Royal Lincean Academy in Rome[3]. The topic chosen by Cuboni was the revolution he thought was happening in biology: Darwinism was being replaced by Mendelism[4].

Mendel's laws were bringing mathematical certainty into a world, that of heredity, previously dominated by disorder, transforming it into a real experimental science. Cuboni said that the turning point dividing the old and the new was, in a nutshell, the idea of different independent units in the sexual cells governing heredity[5].

Cuboni had to admit that mutations were still an open field for inquiry and research, and

[3] G. Cuboni, "Una rivoluzione nella biologia. Dal Darwinismo al Mendelismo," *Atti R. Acc. Lincei* vol. 2 (1914). The article was later reprinted along with other papers in G. Cuboni, *Scritti scelti cuboniani*, pp. 161-169, ref 13:27.

[4] With his use of the word "Darwinism", Cuboni was not referring to evolutionism: he maintained that evolution was the only theory that could guarantee the advancement of science, without having to resort to hypotheses that "escape control and experimental verification". However, according to Cuboni, natural selection could no longer be considered the necessary and sufficient condition for explaining evolution and the origin of species.

[5] It is not surprising to the contemporary reader that immediately after this depiction of Mendelism as the bearer of mathematical certainty in biology, the speech continues with a praise for its universality that begins with diseases and ends with a reference to American *eugenics*: from the colour of plants to the Hapsburg lip, the power of Mendelism was considered by Cuboni absolute. Nothing, not even psychological characteristics was expected to resist a Mendelian explanation for long.

that the theory, no matter how effective, was incomplete. He thought, however, that this did not limit the usefulness of the theory for practical purposes: Mendelism was going to bring a radical transformation to agriculture, an impact that Cuboni thought comparable to that made by chemistry with the introduction of chemical fertilizers during the nineteenth century. Pioneered by Nilsson in Sweden, the new methods were spreading to Germany, Austria, England, and the US[6].

The speech ended with a plea for Italian agricultural research. Science could promise a solution for the problems of Italian agriculture (especially in the south), but only if the necessary resources were granted to researchers, and experimental institutes founded devoted to the improvement of plants. Cuboni mentioned Ottavio Munerati, Napoleone Passerini, Leonardo Angeloni, Francesco Todaro, and Nazareno Strampelli[7].

Ottavio Munerati was working on sugar beet in Rovigo; Leonardo Angeloni on tobacco in Scafati; Napoleone Passerini, a botanist and a pioneer of agricultural education, had created a wheat hybrid in Scandicci. However, the two most extensive applied research programmes on wheat at that time (then still considered cultivation par excellence) were Francesco Todaro's in Bologna and Nazareno Strampelli's in Rieti. They both praised Cuboni, and both could consider themselves as part of the ongoing revolution, at least of its practical side. These breeders represent an ideal terrain for a deeper analysis of their work. The analysis will reveal differences that are not captured by the image of the Mendelian revolution, showing that theoretical uniformity was only apparent.

The story of Nazareno Strampelli (the first part) has already been told in chapter **2** of this work[8]. I will now give a brief biographical profile of Todaro before discussing the main point of this chapter.

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[6] Cuboni considered the US Ministry of Agriculture as an ideal model of organization. G. Cuboni, "Come è organizzato un ministero di agricoltura moderno," *Bollettino della Società degli Agricoltori Italiani* 15, no. 7 (1910).

[7] Few years earlier, in a speech on the theoretical and practical meaning of Mendel's work, Cuboni mentioned only Angeloni and Strampelli. G. Cuboni, "L'opera dell'abate Mendel e il suo significato teorico e pratico," *Atti Società Italiana per il Progresso delle Scienze* 4, (1911).

[8] See also: S. Salvi, O. Porfiri and S. Ceccarellli, "Nazareno Strampelli, the 'Prophet' of the green revolution," ref 7:12; R. Lorenzetti, *La scienza del grano*, ref 6:11.

3.2 The breeder as a businessman: Francesco Todaro

Francesco Todaro was born in Cortale (Catanzaro) on 17 February 1864[9]. He graduated in agronomy at the University of Pisa, with Girolamo Caruso[10]. After graduation, Todaro taught for more than 15 years in various technical schools: Catania, Grigenti, Melfi, Viterbo, and Modena[11]. In 1895, he was appointed director of the experimental station of agriculture in Modena. In 1889, he married Elvira Marescotti. In 1903, the University of Bologna assigned him the agronomy chair in the Scuola Superiore di Agraria (superior school of agricultural sciences), later the faculty of agricultural sciences. That same year, Todaro founded a laboratory for seed analysis.

In 1905, Todaro published in a short book detailing the results of his trials with different wheat varieties during the period 1901-1904 in Modena[12]. The first pages of the book are dedicated to the state of Italian experimental stations: according to Todaro, although they were born to do experimental work, the diffusion of fertilizers and frauds among farmers had transformed those institutions into laboratories devoted to chemical analysis and quality control. This workload was preventing experimental stations from accomplishing the goals for which they were intended.

Among those goals, Todaro considered the improvement of wheat crucial. Varieties, he maintained, were subjected to a spontaneous decay in quality when left to themselves. "Improvement" was meant as a process *specific* to a particular environment and *continuous*. *Specific* because the ideal conditions were different from place to place and the improvement sought had to be stated precisely; *continuous* because all the improvements obtained could soon vanish if the varieties were not sufficiently controlled.

As Strampelli did after him, Todaro started his work on wheat with trials of foreign varieties; unlike Strampelli, however, Todaro did not start his own collection of seeds by contacting institutions and schools of agriculture. Todaro relied instead on a set of seeds provided by the Milanese seeds man Ingegnoli. These seeds did not perform well, which

[9] Senato della Repubblica Italiana, Archivio Storico, 'I Senatori d'Italia' http://notes9.senato.it/web/senregno.nsf last access March 29 2012.

[10] F. Todaro, "Onoranze al prof. Girolamo Caruso," *Annuario del Regio Istituto superiore agrario di Pisa per l'anno accademico 1925-1926* (1926).

[11] Comitato per le onoranze nazionali a Francesco Todaro, *Commemorazione Nazionale* (Bologna: Università degli studi di Bologna, 1953).

[12] F. Todaro, *Esperienze e Prove di Coltivazione fatte nella Regia Stazione Agraria di Modena dal 1901 al 1904* (Modena: Soc. Tip. Modenese, 1905).

Todaro considered to be a proof that a successful selection programme had to start with varieties that were already cultivated in the chosen environment, whether or not they were landraces.

With the term "landraces" I refer to plant varieties traditionally cultivated in a certain area: Todaro saw landrace varieties as an impure mix of many "small races". This mix was held responsible for the general decay and unreliability in yield figures. Apart from the improvement of landraces, the other goal Todaro considered achievable was the 'complete' adaptation of foreign varieties that were already cultivated, but had to be renewed after a number of years.

3.2.1 Bologna's wheat selection programme

From 1908, Todaro started to use selection in Bologna: his first achievement was the appropriation of the variety *Hatif Inversable* sold by Vilmorin company in France[13]. The variety was renamed *Inallettabile*.

During the academic year 1913/1914, Todaro introduced selection to his students, dividing selectors in two categories: Darwinian and Jordanian[14]. "Jordanian" referred to German entomologist Karl Jordan, who advocated the legitimacy of subspecies, though Todaro considered the practice older than the theory[15]. Todaro considered himself a Jordanian, along with breeders like Le Couteur, Shirreff, Hays, Von Lochow, Hopkins, and Nilsson.

Selecting means choosing which seeds from among a certain number of plants will be used for sowing. It can be argued that this activity is as old as agriculture itself; however, the criteria that inform the selection can vary greatly. Jordanian breeders had a clear method that was already practised with success by Hjalmar Nilsson in Sweden[16]. In contrast with pedigree methods, Jordanian selectors made a single selection, considering continuous selection and selection of a set of plants useless.

The argument can be summarized as follows: since what is actually cultivated in the field

[13] F. Todaro, *Il perfezionamento agrario delle piante, Relazione del Prof. Francesco Todaro sui lavori che vinsero il concorso al premio quadriennale 'Cesare Zucchini'* (Bologna: Cassa di Risparmio, 1917).

[14] F. Todaro, *Adattamento Selezione e Incrocio delle Piante Coltivate,* ref 17:28.

[15] See: J. Mallet, "Subspecies, semispecies, superspecies," in *Encyclopedia of Biodiversity*, ed. Simon A. Levin (New York: Elsevier, 2007), 1-5.

[16] Todaro does not seem to acknowledge Nilsson's ambiguity towards pedigree methods discussed by E. Ȧkerberg, "Nilsson-Ehle and the development of plant breeding at Svalöf during the period 1900-1915," *Hereditas* 105 (1986): 1-5.

as a single wheat variety is in fact a mix of different subspecies, what the breeder has to do is isolate a single plant with the intended characteristics. The plant must then be reproduced "in purity" (i.e. separated from all the others), growing its seeds in a dedicated parcel of land. After a number years of reproduction of individuals by self-pollination, the breeder will have a sufficient number of seeds that have a clear origin (they all descend from the plant initially selected) and that can be considered a "pure" variety. If the result is really a subspecies, further selection will be ineffective, provoking only a return to the mean of the subspecies. Selection of an "elite" group of plants could not guarantee the separation of subspecies, and was also considered ineffective[17].

Along with improvements in landraces, the process could also guarantee what Todaro called the "permanent" adaptation of a variety. The aforementioned French wheat variety *Hatif Inversable* was already being cultivated with success in Bologna because of its resistance to lodging. Adaptation was not considered complete because seeds had to be imported from France each year. Achieving purity meant the possibility of ending natural monopolies determined by zones of origin. If the characteristic sought was not dependent on a certain environment but was inherent to the variety itself, purity could guarantee the reliable reproduction of that characteristic.

This possibility of bypassing natural monopolies can be thought as one of the main reasons for the peculiarity of the institutional organization of Bologna's plant breeding programme. Work conducted in Bologna in 1908 became the foundation for the cooperative formed in 1911 by Todaro, with the help of the Società Agraria (the local landowners' society), and Cassa di Risparmio (the local bank)[18]. Named Società Produttori Sementi, the cooperative still exists today, sometimes known by the shorter name Prosementi.

Todaro could promise landowners both the end of natural monopolies and a general improvement in the productivity and quality of their wheats, while also increasing reliability of results. The method had already been successful in Sweden and the preliminary studies conducted in Bologna were considered promising.

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[17] "Jordanian" selection as described by Todaro was thus different from what was known as the "Hallett" method. Hallett, a nineteenth-century plant breeder, advocated continuous single-plant selection. See: J. A. Harris, "Hallett's method of breeding and the pure line theory," *American Breeders' Magazine* 4 (1913): 32-4.

[18] On the foundation of the Società Produttori Sementi, see: E. Felice, *La Società Produttori Sementi (1911-2002). Ricerca scientifica e organizzazione d'impresa* (Bologna: Il Mulino, 2004). On page 23, Felice lists the initial division of the shares: 46.7% were controlled by the Società Agraria, while the others were divided into smaller amounts among prominent landowners.

The kind of innovation proposed by Todaro could be presented as safe: a breeding programme based on single-plant selection can indicate the intended result *from the start*. The research process is aimed at obtaining plants that are similar to the one initially chosen, again and again; even if in practice this task is far more complex than it sounds in theory, it has the advantage of being able to show, at any stage of isolation and multiplication, exemplars with the intended characteristics. It is not possible to find in this programme an equivalent of the uncertainty experienced by the breeder using hybridization.

In the same academic year, Todaro also explained to his students the process of artificial hybridization in wheat. One of his sources, besides studies by Fruhwirth and Punnett, was Nazareno Strampelli's 1907 publication[19]. The method, however, was introduced as a solution to be recommended only if selection had failed to produce the desired type. In Bologna the success of selection meant that there was no necessity to use hybridization[20].

3.2.2 Todaro and Strampelli: a subtle rivalry

In 1919, Todaro denied that there was a strong difference between researchers using hybridization and those using only selection. The point was made in response to an earlier article published by Strampelli[21]. Strampelli had written that hybridization offered the experimenter the possibility of creating new plant varieties with a degree of freedom similar to that enjoyed by artists. Breeders using selection alone could instead be compared to archaeologists: they could discover only what was already there.

Todaro argued that it was incorrect to make such a strong distinction between breeders. Every breeder had to use selection, which remained the fundamental activity: it did not matter much if selection was performed over a pre-existing variability found in the local environment or over an artificially induced one. Despite these claims, Todaro never used hybridization in Bologna, and even if his article did not start a proper debate (Strampelli refused to reply), the issue was still considered a sensitive one during the commemoration held in Bologna in the 1950s[22].

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[19] N. Strampelli, *Alla ricerca e creazione di nuove varietà*, ref 36:45.

[20] F. Todaro, *Adattamento Selezione e Incrocio delle Piante Coltivate*, ref 17:28.

[21] F. Todaro, "Ibridatori e Selezionatori," in *Giornale di Agricoltura della Domenica*, March 2 1919.

[22] Comitato per le onoranze nazionali a Francesco Todaro, *Commemorazione Nazionale*, p. 46, ref 11:64. Mario Bonvicini, one of Todaro's assistants, wanted to make clear in his commemorative speech that Todaro never prohibited hybridization in Bologna. However, the speech hints at an episode where hybridization experiments were started there in secret, concealed from Todaro. Hybridization work was officially started at Prosementi by Todaro's former collaborator Cesare Orlandi, soon after Todaro left the

The rivalry between Todaro and Strampelli was subtle. There was no extensive public debate, and both recognized the importance of the work done by the other. They both claimed to be Mendelian, and they both considered their work to be related to what scientists like Cuboni were doing. The contrast between selection and hybridization was presented by Todaro as a practical matter, a decision influenced only by environmental conditions and goals that every breeding programme had to consider.

This explanation also resonates well with the common conception of breeders' knowledge: breeders are generally not considered proper scientists, and their work is perceived as far from theoretical debate and scientific problems. This is sometimes reinforced by the self-representation that breeders themselves use when they write about their work. But is this self-representation faithful?

The question shall remain open; for now it will suffice to raise some objections to this view. If the choice whether or not to use hybridization was just a practical decision, one that had nothing to do with how the plant is conceived according to the ongoing Mendelian revolution advocated by Cuboni, then why did the division between the two programmes remain so strong, even after the 1920s? In 1926, the main reason behind Prosementi's decision to start producing hybrids was the concern that isolation of pure races had reached a plateau with regards to the improvement of plant performances[23].

In the same year, Strampelli's variety *Ardito* started to become popular among farmers and landowners: it had characteristics that originated from a Japanese wheat variety considered worthless in itself, *Akakomughi*. Its short stem and early maturation were characteristics that were impossible to obtain in a selection programme that did not use hybrids.

3.3 Varietal innovation processes in Italian wheat breeding

This chapter attempts to prove that differences between Todaro and Strampelli were not purely practical. They involved different conceptualizations of problems and a different relation to chance. The analysis will try to unveil the theoretical side of their practices. I will claim that the same actions (namely hybridization and selection) had a completely different meaning. If this is true, then the question to answer becomes the following: Why did they

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cooperative. This choice did not prevent future collaborations between Todaro and Prosementi: relations remained good. Bonvicini's speech also alludes subtly to Strampelli when he praises Todaro for never being considered a magician (Strampelli was nicknamed "the wheat wizard" by Italian newspapers).

[23] E. Felice, *La Società produttori sementi*, ref 18:66.

both claim to be Mendelians, while doing and thinking completely different things?

To answer this question, I will consider the research programmes led by Strampelli and Todaro as processes: ordered ways of doing things. The word *process* has many possible definitions: to make the analysis a little less abstract I decided to follow Todaro's own suggestion. In his aforementioned 1919 article, Todaro reminded Strampelli (who had described the breeder as an artist) that the final goal of their work was related to business: through their varieties they were both trying to secure profits for farmers. Thus I propose to use a classic definition of *process* that comes from business literature, advanced by Thomas Davenport in 1993. According to Davenport:

> In definitional terms, a process is simply a structured, measured set of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on *how* work is done within an organization, in contrast to a product focus's emphasis on *what* [sic].
> A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action[24].

Davenport's definition is adequate for describing what will be considered in the following sections. The focal point will not be the wheat varieties developed by Todaro and Strampelli (the what), but the processes that they organized to produce many new wheat varieties in a systematic and reliable way (the how).

The two programmes (and their processes) will, for the sake of this analysis, be considered stable: instead of following the organizational and institutional changes that affected both and all the historical details, their methods will be described as reliable processes aimed at constant results within a specific organizational framework.

This is of course an abstraction and, like all abstractions, bears, along with enhanced clarity, the risk of overlooking complex issues. However, I believe that the risks in this particular case are marginal: a more detailed historical analysis, like the one conducted in chapter **2**, shows that processes of production like that organized by Strampelli tend to maintain the work method unchanged, even when scaling up considerably. This is also true in Todaro's case: innovations introduced into the processes of Italian programmes aimed at varietal innovation in wheat during the first half of the twentieth century were only marginal after the first pioneering decades.

I will introduce Todaro's process of production in Bologna and then turn to Strampelli's in Rieti. Then I will discuss again problems and solutions, taking the comparison forward and

[24] Thomas H. Davenport, *Process Innovation: Reengineering Work Through Information Technology* (Boston: Harvard Business Press, 1993), p. 5.

drawing from it the conclusion.

3.4 Francesco Todaro's process of production

From his days spent at the experimental station of agriculture in Modena, Todaro considered it crucial for the improvement of plants to know exactly what kind of improvement was sought. Wheat in Modena needed to be more productive while resisting rusts and lodging. Those requirements did not change from Modena to Bologna: both areas were (and still are) part of the larger Po Valley. Todaro had written in 1917 that plants, just like machines, could become obsolete, needing to be replaced with new ones[25].

Todaro uses the word "lodging" to mean the condition of a plant that, due to harsh weather or excessive growth in height, had a permanently bent stem. As is widely known, wheat varieties in the early twentieth century were generally higher than the cultivars now in use. Chemical fertilizers increased the problem, correlated with the amount of nitrogen in the terrain. Rusts referred to a plant disease provoked by fungi of the family named *Puccinia graminis*[26]. The popular name of the disease derives from the colour of the rust-like spots that can be found covering stems and leaves of infected plants. During Todaro's time, there were no effective methods of preventing infections though it was known that not all wheat varieties were equally vulnerable. *Rieti Originario*, a landrace variety traditionally grown in the Rieti Valley, was known for its resistance; unfortunately that characteristic was not inherited in *Rieti*'s offspring cultivated outside the Rieti Valley[27].

The goals of Todaro's production regime were thus straightforward:

1. Increasing yield.
2. Developing (or keeping) rust resistance.
3. Developing (or keeping) lodging resistance.

The process was composed of six steps: *selective breeding*, *observations*, *test multiplication*, *territorial tests*, *adaptation tests*, and *conservative multiplication*[28].

As already discussed, the starting point for the processes were varieties already cultivated:

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[25] F. Todaro, *Il perfezionamento agrario delle piante coltivate*, ref 13:65.

[26] "Stem rust," in *Dictionary of plant breeding*, ed. Rolf H. J. Schlegel (Boca Raton, FL: CRC press, 2009).

[27] Despite being in the centre of Italy, the peculiar position of the Rieti Valley makes its environment similar to the Po Valley.

[28] Todaro's description of his process of plant improvements remained more or less consistent over the years. For this analysis, however, I will follow the shorter version found in F. Todaro and M. Bonvicini, *La Coltivazione del Grano* (Rome: Opera Nazionale Combattenti, 1929), 74-82.

seeds were chosen by Todaro and his assistants from wheat plants already cultivated in Bologna. During the *selective breeding* phase, each group of seeds obtained by each selected plant was grown separately in a small parcel. Spontaneous cross-pollination was (and still is) considered to be an extremely unlikely event in wheat: the separate parcels were initially isolated using rye plants, a practice later abandoned by Todaro[29]. Seeds chosen from exemplars belonging to the same landrace were not expected to produce plants with different macro characteristics (like the shape of the ear or the plant colour); what was expected to be different was what Todaro called *physiological* characteristics, like the length of the vegetative cycle or the degree of resistance to rusts.

Selective breeding allowed the collection of data about the behaviour of a pure line. Purification (i.e. establishing a clear and unique origin for each plant) was already achieved after the first step. Subsequent *observations* could determine which pure lines were promising and which could be abandoned. *Test multiplication* was nothing but another phase of data collection, this time from a larger area (up to 20mq). *Territorial* and *adaptation tests* followed, where the chosen lines could be tested by selected agricultural institutions or schools.

Each phase of the process could act as a sieve: lines that did not perform well could be abandoned, preventing almost unmanageable growth like that described in chapter **2**. We can think about the entire process as a competition that becomes more strict which each level. The final result was usually a variety given a name and a number (e.g. *Inallettabile 96*), where the name referred to the original landrace or imported variety and the number to the established pure line.

The breeder's work, however, was not finished here: to prevent decay, a *conservative multiplication* had to be established. Pure lines could easily lose their purity: a small cultivation had to be established under the breeder's control where all the possible precautions were taken to keep plants from changing.

From Todaro's account it seems that he did not consider multiplication and distribution a proper part of his work. This seems to be confirmed by his career building strategy: in 1921, Todaro managed to found a dedicated institute in Bologna, named Istituto di Allevamento Vegetale (institute for plant breeding). The institute, financed by Prosementi, was supposed to be a place where research could to be conducted autonomously, while its products could be distributed and sold by the cooperative.

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[29] F. Todaro, *Memoria letta alla società agraria della provincia di Bologna* (Bologna: Tip. Paolo Cuffini, 1912).

3.4.1 Concepts in the process: variety, selection, chance, and problems

So far, we have seen a practical plan of action, a repeatable process that, starting from some exemplars of a recognized landrace, can end with a reliable production of improved seeds: seeds that are supposed to perform better according to specific criteria (yield, rust resistance, resistance to lodging). This process of production, however, also uses and produces concepts that have a role in its organization. Along with Todaro's suggestion (the breeder as businessman) it can be useful to also follow Strampelli's conception of the breeder as artist. The sometimes implicit conceptual side of practical processes such as the one described bears much resemblance with what can be found in the study of an artist's own poetics[30]. Luciano Anceschi argued that every artist has some "theory" about his or her art. Reflection can be implicit or explicit, but since choice is involved in artistic practice, the artist, inevitably, thinks. The breeder, while organizing production, thinks too, even if the result of his thinking cannot be considered a proper scientific theory[31].

To define these concepts it is sufficient to ask, now that the process has been outlined, three questions that are meant to capture the assumptions that sustain it: What is a wheat

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[30] See: Luciano Anceschi, *Le Poetiche Del Novecento in Italia: Studio Di Fenomenologia e Storia Delle Poetiche* (Milan: Marzorati, 1961) and Tommaso Lisa, *Le poetiche dell'oggetto da Luciano Anceschi ai Novissimi: linee evolutive di un'istituzione della poesia del Novecento* (Florence: Firenze University Press, 2007).

[31] To further clarify the concept of poetics, I will translate here a definition given by Anceschi in his 1961 book, *Poetiche del Novecento in Italia*, later reprinted in T. Lisa, *Poetiche dell'oggetto*, 83-4. Anceschi's Italian is a philosophically dense and extremely precise language: the translation inevitably loses much of the nuance and detail of the original author's thought:

"Born with poetry, poetics […] represents the reflection that artists and poets make on their actions, pointing to their technical systems, operative rules, methodologies, ideals […].[…] In any case, (poetics) is an effort aimed at poetry, and whether it is manifested explicitly in treatises or hidden within statements in the discourse of the poem itself, or even when it has to be made explicit from an implicit form that presents itself in its irreparable definitiveness, poetics establishes a specific relation between poetry and poetics that brings us inside the secret of poetical gestation."

For this thesis three things have to be taken into consideration: 1) the reflection that an artist makes on his/her activity, although crucial, can remain implicit; 2) such a reflection is inevitable due to the choices (of methods, technical systems, etc.) that are involved in creating art; and 3) examining this reflection means entering inside a creative process. The hypothesis I am following in this chapter is that the same holds true for other kind of makers. A plant breeder has to make choices too, and those choices imply reflection. Even when this reflection is not developed in a proper scientific contribution, it is nevertheless linked to a definite explicit practice, expressed in the actualization of the research programme.

variety, according to the process of production just outlined? What relation does this regime have with chance? What role could hybridization have had?

In Todaro's regime of production, a wheat variety is a subspecies already being grown successfully, albeit mixed with other plants. As such, it exists already. No hypothesis needs to be made. The breeder has to transform outstanding individual plants in replicable results.

In this kind of process, chance is only relevant as a disturbance during data collection. Observations must be careful and repeated multiple times in different conditions to make sure that results have really been achieved. Apart from that, chance has no role at all.

In this particular regime of production, "to select" means really "to sort out". Hybridization could only introduce another element of uncertainty, while increasing the time needed for the development of a wheat variety. If a variety is a subspecies, sorting becomes much more difficult if it must be done while trying to achieve stability in the offspring (something that when working with landraces or with already cultivated varieties is taken for granted). From this point of view, Todaro's decision to avoid hybridization in Bologna can be seen in a new light, not only as a practical strategy influenced by the socio-economical context, but also as a meaningful choice intertwined with the theoretical assumptions (either explicit or implicit) of the breeder.

The same theoretical assumptions have a role in the conceptualization of problems: while yield is taken as simply a measure, rusts and lodging can be conceived in different ways. For Todaro, rusts and lodging were broad problems, depending on a wide set of conditions and thus impossible to consider in absolute terms. There was nothing like a complete lodging-immune plant: given harsh enough conditions, every stem could bend[32]. Todaro considered lodging a complex phenomenon: the plant itself was just one of the factors involved. Lodging was also influenced by the environment and cultivation practices. While some of the components were under the farmer's control (like the choice of the seeds or that of the preceding culture, to avoid an excess of nitrogen in the terrain) others were not (e.g. climatic conditions). Likewise, no wheat plant was completely immune to rusts: some varieties just became infected later in their vegetative cycle and sustained less damage. The attribution of rust resistance to a subspecies left open the possibility of developing this characteristic through the years, almost like an acquired character.

Resistances to rusts and lodging were thus claimed to be *relative* characteristics, and not absolute results. Todaro never conceived of them as Mendelian traits. Could Mendelism help selection, according to Todaro? There seems to be an affirmative answer to this question: in

[32] F. Todaro and M. Bonvicini, *La Coltivazione Del Grano* p.96, ref 28:70.

his 1913-14 lectures, he made brief reference to the idea of *correlation*[33]. When a hereditary unit could be related to more than one trait, the breeder could use this knowledge to shorten the time required for the development of new varieties. For instance, in some fruits, colour and bitterness could be reduced to a single factor, the amount of tannins. From this remark, it seems that Todaro thought of traits as a reality much more complicated than is suggested by the table on wheat hybrids that he nevertheless published on page 68.

3.5 Nazareno Strampelli's process of production

In his 1907 note to the Lincean Academy, Nazareno Strampelli stated once again the goals of his wheat hybridization programme, started in 1904[34]. Diffusion of chemical fertilizers increased soil fertility, but the varieties cultivated could not take complete advantage of the new situation. Foreign varieties developed in other countries where productivity was far greater could not be used directly, due to their susceptibility to rusts. His hybridization programme was thus aimed at the development of new varieties that could exhibit high productivity, resistance to rusts, and resistance to lodging.

Unlike Todaro, Nazareno Strampelli had started an autonomous collection of wheat varieties. Instead of relying on seeds merchant, he simply wrote to individuals and agricultural institutions asking for wheat seeds[35]. This choice does not imply a different relationship with seed merchants to Todaro, but shows a difference in aims and methods. Strampelli wanted to have a complete picture of the best wheat varieties cultivated, and an idea of their performance in the Rieti Valley. Experiments showed that the results obtained with foreign varieties in their zone of origin were impossible to achieve by merely importing and planting them[36].

Why hybridization? Since 1903, Mendel's laws had spread in Italy thanks to a paper by Giuseppe Cuboni[37]. Even according to this highly simplified theory of heredity, the development of stable hybrids was supposed to be a long and expensive project. There are at least two reasons that can explain this choice:

[33] F. Todaro, *Adattamento Selezione e Incrocio delle Piante Coltivate*, ref 17:28.

[34] N. Strampelli, "Esperienze di selezione e ibridazione sul frumento e sul granturco", ref 45:48.

[35] This correspondence is in ARS, APS, Box 16, from Folder 13 to Folder 26.

[36] Seeds were sent to Strampelli from England, France, Serbia, Denmark, Eritrea, the Netherlands, the US, and Lebanon. From a 1919 exchange of letters between Strampelli and Dr Giovanni Rossi, it seems that Strampelli become convinced of the impossibility of obtaining good results by sowing in southern countries seeds developed in the northern ones. The exchange is collected in ASR, APS, Box 12, Folder 8.

[37] G. Cuboni, "Le leggi dell'ibridismo secondo i recenti studi", ref 34:44.

1. Strampelli's personal fascination with hybridization as a way of combining useful traits, already shown by his first (failed) attempt to produce a stable hybrid between wheat varieties *Noé* and *Rieti* in 1900[38].
2. The decision, implicit in the creation of the itinerant chair (whose complete name included a reference to wheat culture) of using the landrace *Rieti Originario* as a starting point. *Rieti* was considered an excellent variety that suffered from an excessive tendency to lodge.

Along with his hybridization programme, Strampelli started a selection programme on *Rieti*. Unlike Todaro, however, he followed a slightly modified version of Hallett's method[39]. Strampelli's selection was thus continuous, but the distance between plants recommended by Hallett was decreased[40]. After some struggles, the modified version of Hallett's method seemed to increase *Rieti* seeds' performance, but no results were achieved regarding resistance to lodging. If, as Strampelli wrote in the same 1907 note, susceptibility to lodging was influenced by the kind of fibres that formed the plant's culm, there was no way of changing this conformation through selection alone.

It was economically viable to start a research programme on hybrids thanks to support from the state and the initial interest of landowner Lodovico Potenziani (later a prominent member of the fascist party in Rome), and the local banks. Despite the mix between public and private funding, Strampelli's programme always relied heavily on the state, even before becoming a crucial part of the fascist regime's agrarian policy. Unlike Todaro's programme, Strampelli's in Rieti could not guarantee quick results or even show conclusively that results would come at all: in 1904 Mendelism in Italy was still new.

As in Todaro's case, it is possible to divide the research and development process of the new wheat varieties Strampelli followed in steps: this division was not made by Strampelli himself, however. The only distinction Strampelli introduced into his work was between a *botanical* and an *agronomic* phase. To keep the account of Strampelli's production regime comparable to Todaro's, we will explain and keep Strampelli's distinction, while adding a subdivision between *hybridization* and *selection*, and *testing* and *multiplication*. *Hybridization* and *selection* are part of the *botanical* phase while *testing* and *multiplication* are part of the *agronomical* phase.

Hybridization was the first step. The process has already been described, following

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[38] N. Strampelli, *Alla ricerca e creazione di nuove varietà*, ref 36:45.

[39] N. Strampelli, "Esperienze di selezione", ref 45:48.

[40] According to Strampelli ("Esperienze di selezione": 137-8, ref 45:48), short distances between plants provoke late maturation, which increases susceptibility to rusts.

Strampelli's own account, by Tiago Saraiva in 2010[41]. Plants chosen for crossing were (partially) synchronized through the use of south-facing walls and basements. Crosses were always done between potted plants to prevent any possible contamination[42].

Every plant chosen to act as female had their anthers removed, and pollination was done with a little brush with the pollen taken from the chosen male plant. The choice of which plant to use as a male and which to use as a female was considered to have no effect whatsoever on the final result[43]. From 1904 to 1907, Strampelli's rate of success with artificial pollination increased from 40% to 96.85%[44]. The vast majority of the crosses were the offspring of a *Rieti* parental plant.

Selection was the second step, where Mendelian theory had the biggest influence. According to Mendelism, the first generation of hybrids is always uniform in its external appearance. First generation plants have *dominant* traits, while *recessive* traits seems to disappear. Strampelli followed a personalized version of Biffen's table of characters[45]. Strampelli took into consideration ten characters described as Mendelian by Biffen, and then added 15 more. However, he maintained that the distinction between *dominant* and *recessive* traits, no matter how useful, could not be taken as absolute. The distinction depended on the varieties chosen, and thus was considered to be *relative*. Nevertheless, Mendelism was crucial for the calculation of the number and probability of types for each hybrid.

The breeder had to choose which traits to consider for each cross: that could depend both from his objectives or from the differences between the varieties that he decided to cross. For instance, Strampelli wrote that in the cross between *Rieti* x *Vittoria d'Autunno* the couple of antagonist traits were five. Following Mendelian theory, this meant a total of 2^5 possible types, each one with its own probability of appearing according to his dominant/recessive ratio.

For each first-generation hybrid, Strampelli took an ear that he stored in his herbarium.

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[41] Saraiva, "Fascist Labscapes", ref 4:11.

[42] As is widely known, wheat is a self-pollinating plant. Spontaneous hybridization was and still is considered a very unlikely event. Nevertheless, Strampelli took every possible precaution to prevent it in *Rieti* (e.g. by using parchment cylinders).

[43] So, a cross between varieties *Rieti* and *Square Head* was supposed to give the same results whether *Rieti* was chosen as a female and had its anthers removed while being pollinated with pollen from a *Square Head* plant or vice versa.

[44] N. Strampelli, *Alla ricerca e creazione di nuove varietà*, ref 36:45.

[45] R. H. Biffen, "Mendel's Laws of Inheritance and Wheat Breeding," *The Journal of Agricultural Science* 1, no. 1 (1905): 4-48.

Seeds obtained from a single ear, named *Aiuola Spiga*, were cultivated separately in a small parcel while the other seeds were cultivated in a larger parcel and named *Aiuola Massa*. Plants in the *Aiuola Spiga* parcel were separated with gauze to prevent spontaneous re-hybridization. All the hybrids were thus left to self-pollinate in a controlled environment. After the first year, this procedure of separation was repeated, this time for each different type that appeared in the offspring.

Distinction between different types was made on the basis of a choice, made by Strampelli individually for each cross, about how many couples of antagonist traits had to be taken into account. The total number of possible types was considered to be 2^n, where n is the number of couples. In such a scheme, adding or subtracting a couple has a strong impact on the scale of the experimental work that the process has to manage. To control this complexity, Strampelli used two different strategies: a classification system and the choice to decide how many couples of antagonist traits had to be considered for each cross. The classification system was composed of different levels (class, division, section, subsection, category, subcategory, group, sub-group, type, sub-type): each level of the classification was numbered, always starting from number 1 for each level. With this system, Strampelli could express all the different characteristics of a certain plant using a number.

Strampelli's discussion of probability did not take into account any distinction between *genotype* and *phenotype*. Since the text is from 1907 this is not surprising: the distinction was made later by W. Johannsen[46]. However, this has direct implications for breeding: not considering alleles in the calculation changes the probabilities. If we consider five characteristics, the total number of combinations is 32 (2^5). In this number both the all-dominant type and the all-remissive type count for one. When calculating probabilities however, applying the 3:1 Mendelian ratio gives for these two types different probabilities of appearing in the field, though only the all-remissive type is guaranteed to breed true (being homozygous). Even if the all-dominant form was supposed to appear in the field more often, disjunction was still possible.

In the description of the wheat hybrid *Carlotta Strampelli*, Strampelli tells that this variety was obtained via selection of a particular type from the offspring of f1 *Rieti* x *Massy* plants. Selection was motivated by the presence of good characteristics (like the conformation of culms) that were all considered to be recessive. Thus, Strampelli thought that he had found a

[46] W. Johannsen, "The genotype conception of heredity," ref 30:32

homozygous plant[47].

The end of the *selection* phase corresponds to the end of the *botanical* phase as distinguished by Strampelli. The *botanical* phase was complete for a type when disjunction in further forms was no longer observed, and the result could be considered stable[48]. Strampelli does not explain this distinction between the two phases in detail; from the context, however, it seems clear that the main point was a shift from stabilization to data collection. If this hypothesis is correct, the word *botanical* must not be intended in its literal sense. Of course, even during this initial phase, the main goal (the one that guides the choices of the breeder) is still a practical one: crosses and characters, and later types, are chosen because the breeder thinks that they will have good chances of being successful in the field. However, the main priority is to obtain plants with certain characteristics that do not segregate into further types when self-pollinated. It is thus not necessary in this phase to provide conditions (like homogeneity of the terrain) that are vital for collecting reliable data on the actual performances of the stable hybrid.

This process of data collection, which I have called *testing*, was the core of the *agronomic* phase. Strampelli did not require only homogeneity of the terrain to draw comparisons between varieties: he also developed a system based on three *model* environments. Unlike landraces, hybrids did not come with a definite connection to a specific geographical position. The link had to be created anew: from the initial cross there was no reliable way to predict with certainty the kind of environment that was best suited to the new variety. After 1925, when Strampelli's programme was heavily endorsed by the fascist regime, resources were granted to establish a vast network of experimental stations that could experiment with new varieties[49]. Before 1925, Strampelli used the resources available to establish experimental fields in three different environments: the fertile Rieti valley, the high plateau of Leonessa (rigid weather), and Foggia (high temperatures, drought). The project already had national ambitions before 1925 (see chapter **1**). Nevertheless, the first successful variety, wheat hybrid *Carlotta*, was released only after an extensive two-year trial conducted by agricultural schools and institutions in Italy. The trials were considered by the Minister of Agriculture, Giannetto Cavasola, after the variety was presented at the 1914 National Agricultural Exhibition in

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47 N. Strampelli, "Genealogia del frumento Carlotta Strampelli," ref 49:50.

48 N. Strampelli to Giovanni Raineri, "Campi sperimentali necessari per la costituzione di razze di frumenti atte alle diverse regioni italiane," 19 Jul 1910, ASR, APS, Box 11, Folder 4.

49 Istituto nazionale di genetica per la cerealicoltura in Roma, *Origini, sviluppi, lavori e risultati*, ref 19:40.

Rome.

Unlike Todaro, it seems clear that Strampelli thought of production and distribution as proper parts of his work. After the release of *Carlotta*, he asked for further resources to establish the three experimental fields of different environments described above. The network of agricultural schools and institutions was only supposed to conclusively certify the usefulness and safety that had already been tested (as far as possible) by Strampelli himself. Strampelli formed an association of landowners in Rieti to organize multiplication of seeds on a vast scale while maintaining purity[50]. Just like the research programme, the entire production phase was designed with what we could call a top-down approach: all of the fundamental decisions were made by the scientist at the top of the process.

3.5.1 Concepts in the process/3.5.2 Variety, selection, chance, and problems

The process of production outlined above is manifestly different from that organized by Todaro in Bologna. The use of hybridization forces the experimenter to establish a procedure for stabilization that has no obvious parallel in a programme limited to selection alone. However, just as in Todaro's case, once the regime has been described in its entirety it is possible to analyze its conceptual side with the same questions: What is a wheat variety, according to the process of production just outlined? What relation does this regime have with chance? What role could hybridization have had?

In Strampelli's production process, a variety is not a subspecies. A variety is a stable combination of traits. How many traits does a variety have? As many traits as the experimenter chooses to take into consideration. The choice is not determined by botanical criteria alone, but also follows practical criteria, like the degree of complexity it is possible to manage with the available resources. If division into subtypes is done only on the basis of the characteristics that the breeder considers important, it is possible to imagine cases in which what could be considered two varieties according to botanical criteria alone will be considered one by the breeder.

In this production process, to select means *to find*. Crosses are planned with a certain outcome in mind: a certain combination of useful traits that cannot be found in landraces and varieties already cultivated. The process for which this new combination is the hoped-for outcome has chance at its core. The larger part of the *botanical* phase is constructed in order to govern chance, to ensure enough resources for the intended outcome to actually appear in the experimenter's fields.

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[50] R. Lorenzetti, *La scienza del grano*, ref 6:11.

In his 1918 paper, Strampelli made a comparison between the work of artists and breeders[51]. The article claims a degree of control that today cannot be considered realistic. However, in the context of this regime of production, hybridization is not a blind source of variability that the breeder has to select in subsequent steps; the process is instead the combination of traits that the breeder has already chosen. It is due to the lack of methods for more direct control that the process has to cope with uncertainty, using Mendelian probabilities and the breeder's expertise as the only guidelines.

The reduction of the wheat plant to a set of combinable traits was done in two ways. On the one hand, characteristics already recognized as traits were considered as units and could act as an organizing principle for a set of crosses. For instance, from 1913 Strampelli started a series of crosses using the Japanese wheat variety *Akakomughi*, as has been said[52]. Those crosses were done with the intention of obtaining early-maturing wheats (a characteristic of *Akakomughi*) while discarding all the other traits of *Akakomughi* which rendered the variety worthless according to Strampelli. On the other hand, problems the production process was supposed to solve, like achieving resistance to rusts and lodging, were defined as Mendelian traits: when Strampelli wrote of lodging in his 1906 publication, he did not consider it the complex phenomenon that Todaro described, but rather the result of a particular conformation of the plant's culm (length and number of fibres)[53]. As such, a certain conformation could be exploited in a series of crosses, generating new varieties that could include resistance to lodging as a proper characteristic[54].

Conclusion: Mendelism, tradition, and the theoretical side of breeding

The comparison between Todaro and Strampelli, conducted through the analysis of their production processes, can help us reconsider the differences between them. Todaro's argument, that he and Strampelli were actually engaging in the same actions, still holds, but no longer proves his point (no major distinction between their work). The same procedure, like the selection of a particular plant, can have a totally different meaning depending on the production process in which it takes place.

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[51] N. Strampelli, "Breve riassunto dei lavori della R. stazione di granicoltura sperimentale di Rieti," ref 68:54.

[52] N. Strampelli, "I miei lavori," in *Origini, sviluppi e risultati*, ref 19:40.

[53] N. Strampelli, "Esperienze intorno alla malattia del frumento dovuta all'ustilago carbo," ref 45:48.

[54] It can be interesting to point out that lodging is a complex phenomenon, and so Todaro was right in his description of it as something that can only partially be controlled. However, the somewhat reductionist approach taken by Strampelli achieved better results in the fields.

Production processes are ordered ways of doing things: they are composed of people, practices, and objects, but also have a theoretical side. The ideas involved do not constitute a proper scientific theory, and breeders do not claim that this is the case. Nevertheless, these ideas are implicit in their work and are a major part of the regime of production. They are the rationale behind certain decisions and can help us understand why certain choices were made while others were discarded. This can explain why sometimes a certain alternative is not implemented or a certain achievement is not possible within the constraints of a certain regime. Todaro's wheats competed with Strampelli's varieties for many years, but in the end the exclusion of hybridization from the regime prevented certain characteristics (like early maturity) from being developed.

Why did these differences never develop into a true theoretical debate? Why did both breeders decide to stay under the Mendelian umbrella? When looking at the two regimes of production in detail, the role of genetics in daily practice appears to be less relevant than one would initially expect. In Todaro's case, it can be considered a scientific legitimation of a method (selection) that was chosen because of results already achieved elsewhere (in Svalöf). For Strampelli, it was limited to an extensive use of the Mendelian ratios to organize work; even if the word 'genetics' was in the name of the national institute founded in Rome, there was very little genetics in his programme. No further analysis of the genetic composition of wheat was done apart from the table of characters that was (not always and not in the same way) followed for planning crosses and sorting results.

One possible answer to this puzzle is that plant breeding is a practical project aimed towards economically viable results. As such, its practitioners are not interested in theoretical debates. When those breeders also happened to be academics, they were teaching and researching agriculture. Interest in genetics could only go as far as principles and suggested practices could claim immediate relevance to application in the fields.

I tried to prove that this solution is not satisfactory: it fails to consider that processes of production, no matter how practical, also have a theoretical side. Breeders have theories too, even if those theories are not defined and structured as clearly as what we usually call science. But if the purely practical nature of breeding is questioned, then how can the uncritical adherence to Mendelism be explained? And why did breeders with different regimes of production not engage in a theoretical battle?

My suggestion is the following: since we are looking at a strange alliance, we should ask who the enemy is. How could competing processes of production march together under the flag of the Mendelian revolution?

An answer can be found in a book published by Todaro in 1917 on the Bologna selection programme[55]. Todaro opened his discussion with a comparison between plants and machines. His point, however, was not about structure, as one might expect. Todaro wrote instead that plants, just like machines, could become obsolete: while ploughs had improved a great deal over the centuries, plants remained the same. Todaro seems here to consider plants as the bottleneck that was preventing major increases in production from occurring. We already know of his solution (i.e. his selection programme), but what was the cause of this stasis? Todaro mentioned the scarcity of state-financed structures, before addressing something else he saw as a problem: the diffusion and prevalence among farmers of traditional practices like the swapping of seeds, and beliefs about how a farm should work.

Swapping seeds was a common practice between farmers: it was a widespread belief that the exchange and mixture of seeds could prevent plants from becoming weak. It should now be clear that such a practice was in direct contrast with the almost obsessive striving for purity of both Todaro and Strampelli's production processes.

More threatening than practices, however, were ideas about how a farm should work and the relationship a farm should have with its surrounding environment. The traditional belief, reported by Todaro, was that farms needed to be self-sufficient[56]. Within this traditional framework, a process of production that controls and manages varietal innovation, no matter whether using hybridization or not, has no place at all. A process of production can be considered as a unit for the sake of analysis, but is not self-sufficient: it needs buyers (or at least receivers) at the end of the cycle. Obviously, buyers cannot be self-sufficient either.

This observation is not related to a judgement of value: self-sufficiency is not a value per se and a farm can (or cannot) achieve better results in this new role as a customer and producer rather than having to play all the parts by itself.

No matter how this change is judged, the alliance between Italian agricultural scientists and Mendelism created a space where certain parts of agriculture could be considered scientific. As Alessandro Volpone has shown, the academic institutionalization of genetics was slow in Italy; at the same time, however, agricultural scientists like Todaro and

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[55] Francesco Todaro, *Il Perfezionamento Agrario Delle Piante, Relazione Del Prof. Francesco Todaro*, ref 13:65.

[56] It can be interesting to point out that similar beliefs were also widespread elsewhere. A good example can be seen in B. Theunissen, "Breeding without Mendelism: Theory and practice of dairy cattle breeding in the Netherlands 1900–1950," *Journal of the History of Biology* 41, no. 4 (2008): 637-76. However, I do not think that in the Italian case these beliefs came with a definite moral dimension attached.

Strampelli were gaining increasing recognition and academic positions[57]. Mendelism, and the results claimed and obtained by Mendelians in Europe and elsewhere, was instrumental in backing up the claims of scientific accuracy and progress. Todaro and Strampelli were rivals, but from another point of view they were both trying to change traditional agriculture by introducing new varieties that came with new prescriptions about their use and another view of the farm. The long-term objective was the same; there was no need to question a framework as successful as Mendelism, especially when such a framework was so loose as to accept a plurality of practices under its umbrella.

[57] A. Volpone, *Gli inizi della genetica in Italia*, ref 11:13.

Chapter 4

SOIL, SEED, CLIMATE, AND WORK: HOW TO RAISE WHEAT PRODUCTION IN EARLY TWENTIETH-CENTURY ITALY

Introduction

At the beginning of the twentieth century, Italian wheat production was generally considered to be low, even if the wheat acreage was considered by economists to be excessive[1]. What technical solutions were proposed and/or tried in the discussion of the problems of production, and what role did varieties have? The question might seem irrelevant at first: Italy was far from being at the forefront of scientific and technological innovation that was taking place in agriculture elsewhere. However, due to this gap in productivity, many different proposals were advanced to improve production and induce change. I would argue that it is precisely this lack of results and these efforts aimed at changing the current state of affairs that makes this specific context interesting.

Actors and stakeholders were diversified: from university professors to members of the technical elite, from small farmers to large landowners. Here I will not attempt to investigate the social components of the early twentieth-century wheat production cycle: I will look instead at technical solutions that were proposed and experimented with by different stakeholders[2].

The common problem informing the landscape is what could be called "the problem of production". Italian wheat production was generally considered to be very low, being around 11hl/hectare[3]. Production was also far below consumption, forcing strong wheat imports from other countries. This was not universally seen as a problem per se. For instance, in 1902 economist and politician Edoardo Giretti argued against import duties that were meant to protect national wheat production[4]. According to a polemical article published by *Il Coltivatore*, when someone replied that, without import duties, no one would cultivate wheat in Italy, Giretti answered that Italy could then be transformed into a beautiful garden,

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[1] Staderini, "La Politica Cerealicola Del Regime" ref 26:31.

[2] In this chapter, I will use some of the results of a study I conducted on the issues of the agricultural journal *Il Coltivatore* from 1900 to 1929. Some details of this journal, and why I think it is worth considering, will be discussed later in the chapter.

[3] C. Mancini, "La produzione granaria nazionale," *Il Coltivatore* vol. 2 (1901): 257-62. In the same article, French production was estimated to be over 16 hl/hectare and English above 20 hl/hectare.

[4] Unknown Author, "Faremo dell'Italia un bel giardino," *Il Coltivatore* vol. 1 (1902), 564.

increasing tourism.

This little story should serve as a reminder: a problem that appears to be technical in its nature (how is it possible to raise wheat production?) has, at least in its background, choices and ideas that cannot be conceived as technical at all. How much wheat should a country produce? Should a country fulfil all of its food requirements by itself? Should a country's agriculture be managed to some degree by the state, according to national needs, or should decisions about what to cultivate and how be left to the market? What kind of relations should be established with other countries? These are clearly not technical questions.

These questions are of course far beyond the scope of this chapter; however, thinking about them can be useful to draw a first line connecting all the actors that I will analyze in the following pages and to give an initial criterion for inclusion or exclusion: no matter whether they be farmers, technicians, or professors, all actors examined here considered low wheat production to be a problem, strong reliance on imports undesirable, and all thought that the solution had to be technical. Since the word "technical" can be vague, I should make clear that I am referring to solutions that distinguished a key element of the production process to improve wheat production.

According to this criterion, scholars who were considering wheat production in a much larger (and complete) economic picture, like Arrigo Serpieri, or scholars who were sceptical about the actual possibility of raising wheat production appropriately through technical measures will not be considered here.

Structure

In section **4.1**, I will begin the analysis with the introduction of a framework that will be useful to explore and compare strategies aimed at production increase. This framework is composed of four elements: *soil, seed, climate*, and *work*. Although this framework is certainly abstract, it allows a bird's eye view of the production process that can help to distinguish the differences between technical proposals that are often considered together due to the shared interests of their proponents. The elements are explained and conceived as broad categories that comprise more than their dictionary meaning: for instance *soil* refers in this framework not only to the terrain, but also to the substances that could be included (or not) in the terrain, like chemical fertilizers.

In section **4.2**, the Bologna plant breeding programme led by Francesco Todaro is discussed as an example of a technical intervention aimed at increasing wheat production. According to the established framework, Todaro's programme can be seen as a kind of technical intervention that focuses exclusively on a single element (*seed*) without changing the others. This focus on a single element can have advantages as well as disadvantages: on the one hand the programme received support from Bologna's landowners due to its narrow focus; on the other, the isolation of the *seed* element meant that the others were often conceived as boundaries for what was and what was not achievable through the use of new wheat varieties.

Section **4.3** compares Todaro's approach with his main rival, Strampelli. Strampelli's itinerant chair of agriculture in Rieti was created with wheat improvement in mind, but it was not clear from the start which instrument had to be used to achieve that goal. From 1903 to 1907, a number of different experiments were tried before he decided to invest the majority of his resources in the growing hybridization programme already described in chapters **2** and **3**. Unlike Todaro's, I argue that Strampelli's programme had the ambition to tackle various elements at once through the use of hybridization. A radical change in the *seed* element could influence the other elements as well, and did happen to a certain extent. The opposite is also true: diffusion of Strampelli's wheat varieties was helped by the endorsement that the fascist regime gave to a new protocol of soil fertilization developed by Dante Gibertini (a modification of *work*, according to the proposed framework).

Section **4.4** introduces a voice that was extremely close to landowners interested in growing wheat: that of the weekly agricultural journal *Il Coltivatore*, published in Italy from 1855. For this chapter, the research was limited to issues from January 1900 to December 1929. Along with articles from agricultural scientists and technicians, *Il Coltivatore* also published many unsigned articles that gave practical advice to farmers. The journal also published data about wheat varieties and their performance, but without any systematization. Some of the advice frequently given are analyzed: an ideal of *rational* agriculture emerges that is different from a purely *scientific* one, as is evident from the example of selection. According to the framework, the editorial board of *Il Coltivatore* saw the solution to the problem of production as composed of many elements, with a particular stress on *soil* (the need to use an increased amount of fertilizers). This need was used by both Strampelli and Todaro, who presented their plants as capable of transforming an increased amount of inputs. The different elements of production, however, apart from the correlation between varieties and fertilizers, were not conceived as interrelated, with the remarkable exception of a 1923 article, written by the plant scientist Girolamo Azzi, that was completely ignored in the following issues of the journal.

This exception is explored in section **4.5**, where Girolamo Azzi's work is presented to the reader as well as his critique of Italian plant breeding programmes. Azzi, a polyglot and scientist initially interested in botany, and later professor at the University of Perugia, was the founder of a peculiar discipline named "agricultural ecology". The name meant something different from what a contemporary reader might expect: the central concept of Azzi's discipline was the productivity of plants, conceived in a *relative* way, as a balance between a potential output and the amount of inputs required to achieve it. According to his proposal, yield was not sufficient to judge the merit of a variety: resistance to harsh conditions had to be taken into account too. Azzi's critique of breeders is analyzed and found to be partially correct. The environment (*climate* combined with *soil* and *work* in the framework) had to be taken by breeders as a starting point to develop their new varieties (*seed*): Azzi proposed a classification of varieties suited to different environments according to his meteorological data. It is important to note that Azzi's critique was not addressed at Mendelism or genetics, but to the kind of reduction that he felt had been effected, turning complex phenomena (like resistance to dry weather) into single factors instead of connecting them with a set of actual plant characteristics (like the size of the leaves). Azzi's, then, is one of the few examples of a conception of wheat production that not only considers many elements at the same time, but problematizes their interrelation too. His attempt at founding a discipline that was meant to become an obligatory passage point, to use Callon's term, was not successful.

The conclusion of the chapter shows that among stakeholders who had a common interest (the rise of Italian wheat production) there were a plurality of approaches that were not necessarily compatible. Varieties were generally overlooked by landowners, while breeders seldom considered the role of varieties in the larger picture of interrelated elements of production. Stakeholders, however, did share a picture of agriculture that is striking for what is not included in it: while the proposed framework is adequate for representing the plurality of approaches to the problem of production, it mirrors the stakeholder's neglect for the actual workers involved in the production. Productivity was never considered to be linked with work conditions and contracts, sketching an image of agriculture rich in technical improvements but without people in it.

4.1 A tentative framework for understanding wheat production in early twentieth-century Italy

In order to understand attempts at improvement of Italian wheat culture, it can be useful to analyze the components of this production. Agriculture is a complex activity: I am not claiming that it can be summarized in a simple scheme. I propose instead a framework in which the main components that I believe influence production can be taken into account and listed. This will be used later as a tool to describe and compare different approaches that were meant to obtain the same result (i.e. an increase in production) and to put some of their problems into perspective. The role of varieties will emerge in each analysis thanks to the evaluation of the different factors in each strategy.

The components considered are four: *soil, seed, climate*, and *work*. They should be understood as placeholders that are meant to stand not only for themselves but for larger domains that I will describe in the following paragraphs. If we can consider wheat culture as a process that ends with a certain amount of product, these factors can be thought of as the main influencing forces that are active between the start and the end of the process.

With the word *soil*, I refer not only to the natural conditions of the land, but also to all the substances, whether or not obtained through the use of chemical synthesis, which can be added to the soil. It is the soil prepared to receive and nurture the seed. Not all soils are equal, and the degree of intervention required can vary greatly from place to place. The soil can be considered a starting point, since it can influence the decision on the opportunity of growing wheat in the first place.

With the word *seed*, I refer to the problems of both seed quality and variety. As for every plant, there are (and were) many different types of wheat: which one should be grown in a specific place? Some wheat varieties were known for their resistance to pests and lodging; others for their high productivity or for their endurance when faced with harsh conditions. Another problem in this domain is the choice between self-production of seeds and reliance on the market. Self-production was traditionally linked to a set of practices (like the swapping of seeds between farmers) that later stood in direct contrast to new recommendations coming from researchers involved with the early results of genetics. These new recommendations were in explicit contrast with traditional beliefs about how a farm should be managed (should the farm be a self-sustaining circle or a function that buys inputs and sells outputs?)[5].

With the word *climate*, I refer to the sum of environmental conditions: temperature, humidity, the amount and types of precipitations, etc. Italy is a country that extends in latitude rather than longitude: this, along with its complicated political history, led Stefano Jacini to famously state in his inquiry on Italian agriculture that there were many different "agricultural

[5] Todaro, *Il Perfezionamento Agrario Delle Piante, Relazione Del Prof. Francesco Todaro*, ref 13:65. A similar point has been made by B. Theunissen, "Breeding Without Mendelism: Theory and Practice of Dairy Cattle Breeding in the Netherlands 1900–1950," ref 56:82. As I have already written, I do not think that these traditional beliefs were linked with a clearly defined moral dimension in the Italian context.

Italies"[6]. This diversity sometimes fostered the establishment of specific projects: one of the aims of Strampelli's research on wheat varieties was finding types that were highly tolerant of arid climates.

Finally, the last element that I will consider in this framework is *work*. In this element I would like to include both the specific operations that are meant to counterbalance other factors (e.g. a specific arrangement of seeds during sowing to counter potential damages of strong winds) and the normal set of practices that every farmer who wanted to grow wheat had to follow. This element is different from the others, because it is the one involving people more directly than things. Even a technical improvement – like the decision to use a mechanical harvester – can greatly alter the human composition of this element, and thus be considered positive, or not, according to a specific context. Changes in *work* do not need to be technical in their nature: a change in this element can involve, for instance, changes in the type of contract between workers and the landowner (if the change was expected to influence production).

This simplified framework can be used to remind us of what research programmes or knowledge diffusion efforts had to consider in their answer to the problem of production. Now it is possible to further elaborate on it, looking at our four different cases in detail.

4.2 Francesco Todaro's landrace purification programme in Bologna

Francesco Todaro started his research programme based on selection in 1908. According to Todaro, while innovations were developed and adopted in technical instruments and practices, the same was not true of plants themselves. He called available plants old machines, no longer useful[7]. The idea that plants, *seeds* in the proposed framework, were the main untapped potential that could increase production was a constant in Todaro's career. Todaro was a strong supporter of German quality-control procedures on seeds and started a laboratory dedicated to seed analysis at the University of Bologna[8].

Todaro imported into Bologna what he presented to local landowners and bankers as the Svalöf method of selection. His project was commercially sound, promising an increase in profit almost without risks; Svalöf's reputation was used to substantiate the claims of

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[6] Alberto Caracciolo, *L'inchiesta agraria Jacini* (Torino: Einaudi, 1973).

[7] Todaro, *Il Perfezionamento Agrario Delle Piante, Relazione Del Prof. Francesco Todaro*, ref 13:65.

[8] According to Todaro, the lack of quality-control institutions in Italy was also a major bottleneck preventing agricultural experimental station from achieving notable results. Experimental stations were frequently used by farmers as public laboratories to help prevent fraud through analysis.

potential production increase. Todaro proposed to start from varieties already cultivated in Bologna; he and his assistants would choose promising plants and then grow their seeds *in purity*; that is, separating each group of seeds in order to prevent mixing and be able to track every plant to his exact parent. The procedure seems to be related to the concept of the *pure line* advanced by Wilhelm Johannsen[9]. When Todaro had to explain the concept, however, he referred only to the German naturalist Karl Jordan and to the Svalöf station[10]. Even if Todaro was familiar with the procedures and theory of wheat hybridization (practiced in the same Svalöf station that he wanted to emulate) he considered it an unnecessary step – at least in Bologna. Why? Although some answers to this question have already been given on the basis of a more detailed analysis of his programme (see Chapter **3**), some additional answers can be found by looking at how Todaro's programme fits in the proposed framework.

If we consider the practice of wheat culture as a square, with *work, seeds, soil*, and *climate* as the corners, Todaro's approach promised results while changing only the seed element, in the space of a few years and with limited resources. Even if we cannot describe his programme as quick, the length was not determined by probability (as in a hybridization programme), but by the time required to produce a sufficient amount of *pure* seeds and to obtain reliable data on their performances, as only years of trials could exclude the effects of peculiar climatic conditions.

With his programme, Todaro secured a new space in Bologna's agricultural landscape: a scientific institute (founded in 1921) focused on the development of plant varieties through the selection method. This positioning, as a source of seeds before commercial reproduction, changed some of the links previously established both inside and outside the country between zones of origin and zones of use. Todaro's method allowed local reproduction of varieties that, albeit used successfully in Bologna, had to be frequently re-imported from their zones of origin, in order to prevent decay and the loss of important characteristics, like rust-resistance[11].

Remarkably, however, Todaro's approach touched other points of the framework proposed

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[9] W. Johannsen, *Ueber Erblichkeit in Populationen Und in Reinen Linien: Ein Beitrag Zur Beleuchtung Schwebender Selektionsfragen* (Jena: G. Fischer, 1903).

[10] Todaro, *Adattamento, selezione, incrocio, delle piante coltivate*, ref 17:28. According to Todaro, the theory behind his selection method was the theory of small species. Within what was called a landrace, and thus considered a single variety, there was often a multitude of smaller varieties, which could be isolated and grown in purity to replicate plants with certain characteristics with certainty.

[11] Two varieties that were subjected to the procedure, and thus said to be completely adapted afterwards, were *Rieti* and *Inversable*.

only marginally: his work was aimed at increasing production while leaving *soil*, *climate*, and *work* almost untouched. A possible reason for this can be the local environment in which Todaro was already working in satisfactory conditions (for the purposes of obtaining high production), where plants could be considered an element lagging behind others. The other elements also served as boundaries for what was possible to achieve through the use of new plants and, conversely, what could not be achieved. For instance, Todaro rejected the idea that it was possible to find a wheat variety immune to lodging. Lodging was conceived as a complex phenomenon involving not only the plant, but also the climatic conditions, the preparation of the soil, and the cultivation practices adopted by farmers.

Todaro was certainly aware of the complex set of elements involved in wheat cultivation, but his solution to the problem of production was to start with better seeds, seeds obtained through purification practices. Varieties were central to his strategy, but they were conceived of in isolation from the other elements of production and as almost stable entities. Varieties could be improved, but not completely changed.

4.3 Nazareno Strampelli's varietal innovation programme

In the history of Italian agricultural research, Todaro's name is always linked to that of Nazareno Strampelli. A biographical sketch of Strampelli, who was a contemporary and rival of Todaro, has already been given in chapter **2**; here some brief notes about his research programme will be added, along with some reminders.

After a first, unsuccessful experiment in 1900, Strampelli started a hybridization programme on wheat in the Rieti Valley, from a minor and underfunded position (professorship of an itinerant chair of agriculture). The connection between Strampelli and Rieti has been explained both by his early interest in wheat hybridization and the presence in Rieti of one of the best known (at the time) Italian wheat varieties: landrace *Rieti Originario*[12]. The programme expanded as Strampelli's career gained momentum, first with the foundation of an experimental station in Rieti and then, in 1919, with the birth of a national institute for wheat genetics in Rome.

Even if no one could expect in the early years of the twentieth century that Rieti's itinerant chair was going to be transformed into a major source of varietal innovation, wheat production was the main reason for the creation of this initial position. It was not obvious at first how the chair would help local production. Strampelli conducted many experiments on

[12] Lorenzetti, *La scienza del grano*, ref 6:11.

chemical fertilizers, cultivation practices (both conventional and not, like the use of electricity). From 1907, however, he focused his resources, which were slightly increased, entirely on the hybridization and selection programme, even if the first major results only came during the First World War.

As already noted (see section **1.3**), Strampelli's first success was the highly productive *Carlotta Strampelli*: this wheat variety was considered capable of using higher inputs (fertilizers) without lodging *and* being rust-resistant. It is not surprising that, in the framework, Strampelli and Todaro appear to be similar: they both worked on varietal innovation, on seeds. I will now try to highlight some similarities along with some major differences.

After a few years of experiments, Strampelli's choice to focus on hybridization reveals that he considered plants to be the most important component of the production formula. There is also evidence that when Strampelli had the opportunity to introduce mechanization into the chair's fields he quickly decided against it, fearing hostile reactions from the peasants[13]. The difficulty of acting directly on the *work* element is confirmed also by Strampelli's opinion on green manure: Strampelli praised it as a convenient means of enriching the soil, but suggested the minister donate the seeds required to farmers[14].

What I want to suggest is that Strampelli thought of changing plants as a means to improve wheat culture at large, through the possible effects of this change on the other elements of the framework. Plants could be used to leave a certain part of *work* unchanged, raising production without changing cultivation practices radically. At the same time, other parts of *work* could be changed indirectly: when Strampelli released his first early-ripening varieties in the 20s, harvesting could be anticipated, preventing some illnesses and allowing for other cultivations to follow immediately in the same fields.

A seed could not adapt to climate; however through the combined use of selection and hybridization it was possible to search for varieties more resistant to arid climates, diseases, and adverse events that produced unwanted effects like lodging. When the first successes of *Carlotta Strampelli* were contested, and its vulnerability to high temperatures discovered, *climate* became one of the main reasons to focus the research programme on early-ripening

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[13] N. Strampelli, letter to G. Pasqui, (1904), Archivio di Stato di Rieti, Archivio Privato Strampelli, Box 5 Folder 6.

[14] N. Strampelli, letter to the Minister of Agriculture, (1910), ASR, APS, B18 F7. Green manure, *sovescio* in Italian was the practice of growing and then ploughing under the soil a particular crop, usually leguminosae.

varieties which could avoid the temperature peaks of July.

Finally, development of new seeds through hybridization could promise an increase in the use of fertilizers, thus changing the way *soil* was prepared: lodging-resistant varieties, in particular the semi-dwarfs produced using the Japanese wheat *Akakomughi*, could use more inputs, raising the maximum production that it was possible to achieve[15].

As in Todaro's case, varieties were the main element of Strampelli's strategy; however, they were clearly considered a much more dynamic element. Varieties could be completely changed and designed according to the experimenter's needs[16]. The other elements of production were considered secondary, but they could nevertheless be influenced through the introduction of new plants. It is then somewhat ironic that what finally contributed to the widespread adoption of Strampelli's varieties was not only favourable legislation, but a change in *soil* and *work*[17].

In 1928, the Confederazione degli Agricoltori (the Confederation of Farmers) organized a visit to the itinerant chair of agriculture in Brescia, led by Professor Dante Gibertini[18]. In Brescia, Gibertini was experimenting with a different use of nitrogen, based on the idea that wheat could store nitrogen during winter (this idea was also developed by A. Draghetti in Modena). Gibertini's method was based around three main elements[19]:

1) Sowing only from November (December in the south).
2) An abundant but fractionated use of nitrates during the winter (January and February) and then again in April (but not in March).
3) The use of early-ripening varieties (developed by Strampelli) to avoid high temperatures and, as Roberto Anderlini has written, to counter the lengthening of the vegetation cycle induced by nitrogen.

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[15] Even if, as recognized by Strampelli himself, this maximization of production was only possible in optimal conditions.

[16] This according to Strampelli. Today it seems clear that claims about the power to design plants were at least exaggerated. Nevertheless, a careful examination of the approach followed by Strampelli in his work suggests that the ability to shape plants was not only a claim made to obtain funds and increase his reputation, but also an ideal to pursue.

[17] The legislation has been described by Lorenzetti. During the *battaglia del grano*, diffusion of "elected races" of seeds was encouraged both through propaganda and economic measures (half the costs of establishing seeds stations dedicated to reproduction of elected seeds were paid by the state).

[18] Roberto Anderlini, "Gibertini, Dante," *Dizionario Biografico Degli Italiani* vol. 54 (Rome: Treccani, 2000). Gibertini had been appointed to the chair due to his ties with the fascist party.

[19] Dante Gibertini, *La Nuova Tecnica Frumentaria*, Biblioteca Per L'insegnamento Agrario Professionale (Piacenza: Federazione Italiana dei Consorzi Agrari, 1930).

The results obtained in Brescia were considered so promising that the method was recommended by the permanent wheat committee from the following year, leading to an tremendously increased diffusion of Strampelli's varieties.

4.4 Agricultural advice for landowners: Il Coltivatore

Founded in Casale Monferrato (Piedmont) in 1855 by Giuseppe Antonio Ottavi (1818-1885), *Il Coltivatore* was a journal dedicated to practical agriculture. It was intended to be a source of information and practical advice for small and medium landowners. The journal was probably inspired by the French *Journal d'Agriculture Pratique* that was published in Paris from 1837. While the political stance of the journal was always from the landowners' point of view, the articles published were often about technical improvements and readily employable innovations. The journal was published weekly, with some modifications in frequency during wartime.

Although in Italy there were many other agricultural journals at the time, *Il Coltivatore* was peculiar: according to Agostino Bignardi, Giuseppe Antonio Ottavi was one of the first true Italian "agricultural journalists"[20]. Ottavi was not a scientist, but a teacher and a powerful advocate for the popularization of agricultural science. He was among the first to propose itinerant teaching as a means to spread technical knowledge. Even when many other agricultural publications started to spread in Italy, thanks to the itinerant chairs of agriculture, *Il Coltivatore* remained an important source of practical advice and technical information for readers all over the country[21]. Strampelli, Todaro, and Azzi published articles in it, along with many other prominent Italian agronomists, like Domizio Cavazza, Napoleone Passerini, and Tito Poggi. The journal was strongly committed to wheat production (supporting import duties), but against the technical stagnation that was usually associated with that culture. According to various writers in the journal, Italy had to raise wheat production to reach the figures that were common in other countries[22]. This approach did not change over the years: after Edoardo Ottavi's death in 1918 (one of the sons of Giuseppe Antonio Ottavi), Tito Poggi

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[20] Agostino Bignardi, "Per Una Storia Del Giornalismo Agricolo in Italia," *Rivista Di Storia Dell'agricoltura* (1971): 30-50.

[21] Among the obligation of the itinerant chairs of agriculture was the publishing of an agricultural journal. These publications were thus aimed at a particular local audience, while *Il Coltivatore*, despite an obvious preference for its local surroundings, aimed at a national diffusion.

[22] See, for instance: E. Petrobelli, "Perché il frumento ha reso poco?" *Il Coltivatore* vol. 2 (1904): 44-6.

was appointed director[23].

4.4.1 A journey through a journal

Like the French *Journal d'Agriculture Pratique*, the issues of *Il Coltivatore* were meant to be collected in two volumes at the end of the year, together with an index of the main topics. The pages were numbered accordingly, progressing from one issue to the next. A volume was typically around 800 pages long. Since for the purposes of this chapter the exact chronological details of the articles quoted are not important (i.e. the month in which the article was published), I decided to refer to them using a year/volume/pages format. A good argument in favour of this system is that libraries that keep the journal in their historical archive always store it in the volume format. This should make retrieving articles easier, since *Il Coltivatore* is not available in any digital format.

I examined the volumes of *Il Coltivatore* published between 1900 and 1929. I did not have enough time to read each volume cover to cover; the index that can be found at the end of each volume was thus used to identify the articles about wheat. This method is not entirely satisfactory, since it lacks the completeness that an electronic search on a digitalized text corpus could offer. However, the level of detail achieved is adequate for our purposes.

Agostino Bignardi recalls a methodological observation by historian Luigi Dal Pane that is also relevant for this section: writing a journal's biography is more difficult than writing a person's. In a journal, many voices are presented together at the same time. In *Il Coltivatore* this situation is further complicated by the number of articles that are not signed. These are usually short notes giving advice on technical procedures and general suggestions on farming or summaries of interesting news published in other journals or countries. While it is plausible that the chief editor in charge is the author, it is safer to assume rather that the opinions expressed are considered representative of the editorial line of the journal. The journal's plain style and the regularity of the advice (following the seasons) tended to create in these unsigned notes a common *voice*.

4.4.2 Technical advice for landowners

Il Coltivatore can be considered a voice close to both landowners and the technical elite of agricultural scientists to which both Todaro and Strampelli belonged. Not surprisingly then,

[23] Poggi, born in 1857, was credited as the first itinerant professor of agriculture in Italy. Poggi, like many agricultural scientists and technicians of the time, openly endorsed the regime, becoming a member of the committee leading the *battaglia del grano*, and senator in 1929.

the public initiatives of the Rieti experimental station were praised, not only when the first varieties were released after the First World War, but also in the early years when plant pathologist Giuseppe Cuboni was trying to highlight the need for new plant varieties obtained through hybridization[24].

From an analysis of the issues between 1900 and 1929, however, it does not seem that the editorial board considered varieties as the key factor in determining an overall increase in Italian wheat production. Small notes about varieties and their performance appeared frequently, often praising *Noé* and *Rieti*, but there was a lack of systematization and it was impossible to compare data and rely on them; the journal published many results of trials on different varieties, but they were never developed inside the journal, and never meant to be systematic of definitive[25]. Varieties were seldom seen as a crucial element.

It is true that the journal often encouraged farmers and landowners to select their seeds, but which kind of selection where those articles praising and recommending[26]? Two complementary approaches were considered to be useful: a choice of the best plants to use in reproduction and a mechanical selection of seeds in order to isolate and use only the heaviest.

This kind of selection, which looks similar to the *elite* one described by Jonathan Harwood in Germany, had nothing to do with the concept of *purity* which was fundamental to both Strampelli's and Todaro's research programmes[27]. Without the need to establish and maintain purity, there was no need to track each plant back to his ancestor, or to use separated instruments to avoid contamination.

The final outcome of this group selection was considered to be a constant improvement of seed quality. The desired outcome was still independence: producing (and perhaps selling) seeds inside the same farm system that was going to use them.

The value of scientific research programmes was not questioned, but the objective of the journal seems to be a generalized (even if numerically small) improvement of yields through incremental steps, and not the achievement of the highest production possible in a

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[24] A. Marescalchi, "Nuovi Orizzonti," *Il Coltivatore* 1 (1905): 705-7.

[25] Nor did they come when published with a particular endorsement of the journal. They were treated as communications, and never commented upon.

[26] *Il Coltivatore* frequently published small articles about selection. For our purposes, see: Unknown Author, "La selezione del frumento," *Il Coltivatore* 1 (1902): 794; and Unknown Author, "È il momento di selezionare il frumento," *Il Coltivatore* 1 (1903): 816.

[27] J. Harwood, "The Reception of Genetic Theory Among Academic Plant-breeders in Germany, 1900-1930," *Sveriges Utsädesförenings Tidskrift* 107 (1997): 187-95.

few select areas[28]. What was advanced in the pages of *Il Coltivatore*, then, was not a model of *scientific* agriculture (which, as we have seen with both Todaro and Strampelli, tends to add another actor to the picture – a scientific institute as a source of seeds) but a more pluralistic, and less defined, model of *rational* agriculture. The rational landowner involved in wheat culture had to use a flexible mixture of tradition, personal experience, and science. He had to use chemical fertilizers, but also sow early, according to the proverbs. Some varieties were recommended for their high productivity, but the farmer's own experience with his particular field was considered more certain.

According to this view, Italian wheat production did not need a magic bullet to solve its problems, but a combination of practices, mechanization, fertilizers, and selection. This advice was frequently repeated over the years, due to the nature of the journal (organized to follow the agricultural cycle of the year) and to a perceived resistance towards these basic assumptions.

Where does *Il Coltivatore* stand within our framework? Looking at the various pieces of advice given, from fertilizers to varieties, from economic ideas to observations about the climate, it might seem that this journal was among the few considering the problem of wheat production in its complexity. However, if the interests at stake favoured a cautious approach, open to innovations but sceptical of supposed miracles, this never evolved into a systematic approach. The idea that it was in fact possible to raise production was always advanced, but at the same time, perhaps because production was very low, it was considered sufficient to give the same advice every year.

Rational agriculture meant an increase in production, but not subversion or radical change in agriculture. *Work* had to be changed with the introduction of specific machines and practices (and perhaps new work contracts), but at the same time there was no ambition to redesign agriculture completely or to improve the peasant's life. *Climate* was accepted as a source of uncertainty that was beyond man's power to control[29]. *Seeds* were considered important, but more because of their quality than their botanical characteristics. *Soil*, instead was considered by *Il Coltivatore* to be the most important variable: chemical fertilizers could greatly improve yields. This stance can explain a strategic move that both Todaro and Strampelli used to attract support: one of the promises made and directions explored in

[28] Improved varieties had a reputation for requiring special care and inputs.

[29] This might seem obvious, but in fact towards the end of the nineteenth century and the beginning of the twentieth, there were many experiments, also described in detail in *Il Coltivatore*, aimed at controlling the weather using cannons.

research was a struggle to find plants that could use more chemical inputs.

Here, a clear link between two elements, *seeds* and *soil*, was established; but their relationship was not problematized or analyzed in detail as a complete system, nor were the other elements not conceived of as interrelated. In the history of the journal there is only one exception: an article, that did not provoke any follow-up, published in 1923 by Girolamo Azzi (which will be analyzed in the next section).

In the strategy of rational agriculture, then, varieties always remained a secondary element, at least until 1925[30]. Improved varieties needed higher inputs to obtain noteworthy results, while varieties already known and grown were perceived as less risky. *Quality* of seeds was considered more important, a quality which, from the point of view of the farm, could be attained both with external sources of seeds or with internal procedures and machines.

4.5 Girolamo Azzi's Agricultural Ecology

Girolamo Azzi was born in 1885 in Ponticelli (Imola, Emilia-Romagna)[31]. He graduated from the faculty of Natural Sciences in Bologna in 1908, having written his thesis on botany. According to one of his former students, Prof. Androkli Baltadori, Azzi knew several languages (Italian, English, German, Spanish, Portuguese, Russian, and Swedish). Thanks to his remarkable linguistic abilities, he gained a place at the international institute of agriculture in Rome[32]. At the institute, Azzi supposedly helped compile the review of worldwide agricultural research that was published in one of its monthly bulletins.

Thanks to this work, Azzi became acquainted with the work of Petr Ivanovic Brounov, a Russian meteorologist. Azzi's early works, influenced by Brounov, were in the field of agricultural meteorology, proposing to transpose Russian methods and organizational structures to the study of the Italian climate. Later, however, he developed his own approach,

[30] In 1925, when the *battaglia del grano* was started by the fascist regime, director Tito Poggi became a member of the permanent committee on wheat. The journal then started to devote a much larger space to wheat; many articles were written by Poggi himself, who had a long personal experience in science popularization. From then on, the journal was expressing the committee's advice.

[31] The only biographical source on Azzi seems to be a small volume published in 500 copies by Imola's Pro-Loco (an association for promotion of the territory). See: *Girolamo Azzi, il fondatore dell'Ecologia Agraria*, ed. A. Baltadori and G. I. Pinnola (Imola: La Mandragora, 1994).

[32] Unfortunately, no traces of an Azzi archive have been found to the present day, and so it is not possible to confirm this detail or explain how, when, and where his linguistic proficiency was obtained.

which was named *ecologia agraria* (agricultural ecology). Azzi managed to establish a meteorological service in Italy and, in 1924, a professorship at the University of Perugia in the newly founded discipline; in 1934, however, the discipline was replaced by *ecologia* (ecology)[33].

Despite the widespread use of the term *ecology* today, Azzi's agricultural ecology had little to do with our popular conceptions of this word, usually tied with efforts to preserve the environment. In his 1928 textbook, Azzi defines the discipline as "the study of the bio-environmental conditions in relation with productivity"[34]. Productivity was the core of Azzi's *ecologia agraria*, but this productivity was conceived of in a peculiar way.

Instead of considering productivity as a characteristic of the plant itself, for Azzi productivity had to be understood as a *relative* property: a result of the relationship between the plant's potential output and its resistance to adverse atmospheric conditions. To prove his point, Azzi frequently made comparisons between two varieties usually considered equivalent: *Luigia Strampelli* and *Capinera*. He demonstrated that these two varieties performed differently according to the quantity of water available: *Luigia Strampelli* could use a larger quantity of water effectively, increasing its product far beyond that of *Capinera*; however when water was scarce, *Capinera* performed much better. Which variety should be considered the more productive? An answer was only possible through detailed analysis of data concerning both the plant and the environmental conditions surrounding it. In arid climates, *Capinera* was clearly a better choice.

According to Azzi, this double aspect of productivity had been taken into account in Svalöf; elsewhere, programmes based on selection and hybridization had failed to consider the relationship. Hybridization had also frequently forgotten to consider other characteristics of wheat, like its gluten content and the flour quality. Azzi's critique was not aimed at genetics in general, a subject to which he devoted a chapter of his textbook, but to Italian plant breeders, including Strampelli: improved varieties like *Carlotta Strampelli*, according to

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[33] Azzi did not lose his professorship, but *ecologia* became an optional course (while *ecologia agraria* had been a mandatory one). To explain this change, Baltadori and Pinnola (*Girolamo Azzi*, 13) emphasise Azzi's close ties with Soviet Russia; this explanation is not entirely satisfactory, since Azzi's relationships with Russian scientists and institutions were well known from the beginning of his career. These relationships did not prevent the regime from supporting Azzi: in 1927, the preliminary edition of his magnum opus, *Le Climat du Blé dans le monde*, was published for the international conference on wheat held in Rome "under the patronage" of Benito Mussolini. See: G. Azzi, *Le Climat du Blé dans le monde* (Rome: Institut International d'Agriculture, 1927)

[34] Girolamo Azzi, *Ecologia Agraria* (Torino: UTET, 1928).

Azzi, had only been selected for their higher output, neglecting resistances.

Azzi's attack was not entirely fair: one of the main criteria behind the selection process Strampelli followed was resistance to certain plant diseases, such as *rusts*; an isolated part of his scientific programme was conceived with the objective of developing wheat varieties resistant to arid climates, in Foggia. There were, however, at least two points in Azzi's critique that were correct.

First of all, productivity was indeed conceived by breeders like Todaro and Strampelli in *absolute* terms. *Lodging*, the condition in which the stem is permanently bent due to adverse atmospheric events, was considered by Strampelli and other breeders as the main problem, along with *rusts*, preventing an increase in production. While *rusts* were a family of diseases, *lodging* was not only a condition related to a certain structure of the plant's culm, but also a limit imposed over production. The degree to which the plant was subjected to *lodging* put constraints on the maximum amount of chemical fertilizers that it was possible to use on that particular plant. *Demand* for improved varieties was first and foremost demand for plants that could use more inputs (from landowners or farmers who could afford them) in order to raise the maximum production achievable in optimal conditions. The necessity for good conditions was clear to both Strampelli and agricultural journals like *Il Coltivatore*, but this did not prevent an unwise use of *Carlotta* in unsuitable climates, a choice that soon revealed the shortcomings of this variety[35].

Second, selection and hybridization programmes did not consider environmental conditions in their initial phase. Todaro's programme did not have to: his improved varieties were selected in the same environment in which they would subsequently be used, starting from successfully cultivated varieties that only needed *purification* as a means to stabilize better-than-average results and avoid imports. Strampelli, on the other hand, considered the environment with his system of *model* fields, but only at the end of his varietal innovation cycle. Environmental conditions were conceived of as *tests* meant for collecting information on the actual performance of varieties and finding their ideal conditions. Strampelli's hybrids did not come with a strong connection to a certain land; the link had to be created anew through trials. According to Strampelli's own division of his work in two phases (*botanical* and *agronomical*, see chapter **2**), environment was only considered in passing in the first phase (which ended with a fixed type).

Azzi believed that breeding programmes had to use his extensive meteorological data

[35] See Azzi, *Ecologia Agraria*, p. 51, ref 34:100. *Carlotta* was discovered to be particularly vulnerable to high temperatures.

analysis method, which assigned to every variety optimal and limit values for each environmental factor, like humidity or temperature[36]. The first result of this approach was a classification of varieties according to their characteristics: unlike those employed by breeders, Azzi's classification was not based around botanical criteria or Mendelian factors, but on resistances and productivity. These characteristics were not conceived of in absolute terms, but in relation to the particular region in which the variety was cultivated. A wheat variety could be considered resistant to low temperatures in a certain area but not in another.

Azzi's classifications were not conceived of by their author only as an aid in choosing the right variety for a specific area: they could also offer directions to breeders, highlighting shortcomings and needs. His tables gave a complete evaluation of the strengths and weaknesses of each variety. An extensive knowledge of environmental values was indispensable for a breeding programme to succeed:

> "A plant's characteristics are the result of a reaction between a genetic factor or a group of genetic factors, and an environmental value, or a group of environmental values. How is it possible to find a product without knowing one of the two factors?" [37]

It is interesting to point out that, while trying to stress the importance of environmental conditions, Azzi was not criticizing Mendelism *per se*, but its application to agriculture. He maintained that the decision to consider complex characteristics like *productivity* or *resistance to arid climates* as single factors had led to an impasse. A theory of multiple genetic factors influencing those characteristics was used to hide a pre-Mendelian set of practices in which *effects* rather than genetic factors were combined and selected[38]. This aspect of Azzi's critique could offer some insight into the reasons why Italian wheat breeding programmes, despite being successful in the fields and in their institutionalization, did not follow closely or contribute to new discoveries in genetics[39].

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[36] G. Azzi, *Ecologia Agraria,* p. 17, ref 34:100.

[37] G. Azzi, *Ecologia Agraria,* p. 17, ref 34:100. Author's translation. The original Italian is: "I caratteri di una pianta sono il risultato di una reazione tra un fattore genetico o gruppo di fattori genetici, e un valore ambientale, o gruppo di valori ambientali. Com'è possibile individuare un prodotto senza conoscere uno dei due fattori?"

[38] For instance, according to Azzi, resistance to arid climates had to be analyzed instead according to the plant structures that enabled it, like a reduction in the leaf surface, a reduction in the number of stoma, a reduction in their degree of opening, etc.

[39] Although, as C. Bonneuil has written analyzing the French case, Mendelism still had a definite effect

According to the framework proposed, Azzi considered *climate* the most important factor in wheat production, followed by *seeds*. He worked towards a redefinition of plant properties based on their relation to environmental values. This attempt had the remarkable side-effect of reserving a space for his newly founded discipline, *ecologia agraria*. Accepting Azzi's arguments meant considering *ecologia agraria* as an obligatory passage point to cross in order to develop and use plant varieties and gain meaningful information about their performances[40]. The different path taken by Italian agriculture after the *battaglia del grano* in 1925 and after the diffusion of the combination between Strampelli's varieties and Gibertini's method, could help explain the decline of *ecologia agraria*. Azzi's approach is the only one among those considered in this chapter that acknowledged a complex interaction between different factors to the point of redefinition. Varieties were much more important for Azzi than for *Il Coltivatore*; however, unlike both the journal and plant breeders, Azzi questioned the idea that complex properties like productivity could be considered as simple characteristics located in the plant or the direct result of an increased amount of inputs.

Conclusion: exploring a plurality of approaches

The picture that emerges from this preliminary analysis based on the proposed framework is not uniform as one might expect. Despite a common involvement of the considered actors with wheat production, and the shared opinion that production had to be raised, the method proposed and the strategies followed were different. Such a difference was not only limited to the solutions proposed, but also represented a difference in the way the factors of production where considered.

The radical changes that have happened to Italian agriculture in the twentieth century (especially mechanization) have usually left varieties in the shadows when it comes to

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on breeding practices. Azzi seems to forget that starting selection from the F2 generation obtained through self-pollination of hybrid plants (and expecting to eventually reach stability) was definitely a Mendelian practice. See: C. Bonneuil, "Mendelism, Plant Breeding and Experimental Cultures: Agriculture and the Development of Genetics in France," *Journal of the History of Biology* 39, no. 2 (2006): 281-308. It is true, however, that Strampelli's wheat varieties developed in Foggia to enhance resistance to arid climates, like *Senatore Cappelli*, were obtained by selection alone.

[40] Michel Callon, "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay," in *Power, Action and Belief: A New Sociology of Knowledge?*, John Law (London: Routledge, 1986), 196-223.

analysis[41]. *Seeds* were not only overlooked by historians later, but also by many contemporary actors: while highlighting the need for quality seeds, the editorial board of *Il Coltivatore* did not think that varieties could become a key factor in raising production, at least until the *battaglia del grano* changed the landscape. Even after the declaration of the "battle", a prominent agricultural scientist like Azzi could argue that breeding programmes had failed and that a new discipline based around the study of both plants and climate was needed to improve results.

Breeders like Strampelli and Todaro, on the other hand, were trying to increase the use of their improved varieties and promote the importance of *seeds*. As has already been stated in chapter **3**, they used the rhetorical arsenal of Mendelism to gain support and funding for their activities, later legitimized by effective (but not overwhelming) results. Strampelli went further, picturing the breeder as a creator who could design plants according to specific needs.

With the notable exception of Azzi, no one really considered the possibility that the various elements could be deeply interrelated to the point of mutual definition. However, what really strikes one as an impressive feature of this plurality is not what is there, but what is missing. The proposed framework is abstract and schematic and, with the use of only four elements (seeds, work, climate, and soil), misses many important parts of the complex process of agriculture. Nevertheless, it seems to capture well all the positions expressed by the main actors who wanted to increase Italian wheat production in the first half of the twentieth century. What is missing then? People. *Seeds, work, climate*, and *soil* are always considered, despite a lack of consensus and a difference in the importance assigned to each. The idea that production could be influenced by the way the land was distributed at the time, by the conditions that peasants were experiencing, and by the type of contracts, they had never taken centre stage. This could help explain, for instance, the lack of widespread adoption of *rational* methods that *Il Coltivatore* kept repeating year after year with more and more frustration.

The proposed framework captures the debate, but sketches a strange picture that was somehow shared by the actors: a picture of an agriculture made of objects and practices, but unpopulated

[41] This reflects not only the well-known difficulty in assessing properly the influence of a determined variety over production, but also, I think, a widespread cultural habit that considers the plant as the natural element in agriculture, overlooking the process by which the plant was obtained.

Chapter 5

CENTRALIZING THE LOCAL: ITALIAN VERSUS EUROPEAN PLANT BREEDERS

Introduction

This chapter is not aimed towards a reduction of complexity through the analysis of common themes between different stories. I would argue that one of the main results obtained by historians of science interested in early twentieth-century plant breeding has been to replace the uniform narrative of a common Mendelian revolution with a much richer polyphony of different national cases, each one with its own peculiarities. What this chapter will do instead is compare specific aspects of plant breeding between different stories, highlighting the differences between Italian breeders and their European counterparts.

The local specificity of the diverse social and agricultural contexts is one of the main reasons for suggesting a cautious approach when trying to juxtapose different national cases. I decided to keep a strong focus on the Italian case (and more specifically on wheat breeders) in this thesis. Since it is the case I am more familiar with, I thought it would inevitably influence my understanding of other stories and I decided to make this influence evident, using it to make more accurate claims. An argument in favour of focusing on wheat breeders is the dimensions of their projects, usually relevant. In Italy, wheat breeding programmes expanded far beyond their initial local dimension in the course of the century. My aim is to use other national cases as a source of inspiration and guidance while presenting the Italian story in a way that can be related easily to what was happening at the same time elsewhere.

While my knowledge of Italian breeders is strengthened by access to archival sources, what I know about other plant breeding related histories is thanks to secondary sources. I decided to limit the main comparisons to Germany, France, Great Britain and, to some extent, Sweden[1]. Such a broad field means that my knowledge of each case will be limited and I may

[1] Sources will be acknowledged and discussed in the body of the chapter. However, I would like to inform the reader that my main sources for the German case are Jonathan Harwood's articles and his most recent book *Europe's green revolution and others since : The rise and fall of peasant-friendly plant breeding* (London and New York: Routledge, 2012), along with T. Wieland, "Scientific Theory and Agricultural Practice: Plant Breeding in Germany from the Late 19th to the Early 20th Century," *Journal of the History of Biology* 39, no. 2 (2006): 309-43. For the French case, I used mainly papers and books published by Christophe Bonneuil, such as (with Frédéric Thomas) *Gènes, pouvoirs et profits: Recherche publique et régimes de production des savoirs de Mendel aux OGM* (Editions Quae, 2009); and J. Gayon and D. T. Zallen, "The Role of the Vilmorin Company in the Promotion and Diffusion of the Experimental

miss authors and sources that could contribute to the debate. I hope to compensate for that with the aforementioned focus on the Italian case and with precise comparisons about strategies and programmes that are described in detail in the sources I used.

Structure

Section **5.1** introduces two main obstacles that stand in the way of the kind of comparison attempted in this chapter. The first concerns sociological and technological differences. Not only can they make comparison complex between different countries: Italy's non-uniformity in agricultural conditions (both due to environmental and political factors) can make the attempt even more complicated. To overcome this obstacle, the analysis will focus only on wheat breeding programmes, without considering the uneven state of Italian agriculture. The second obstacle is related to the divide between breeding programmes and the overall conditions of agriculture at large. Due to this form of isolation it is extremely difficult, when looking at the Italian case, to shift from a perspective focused on individual stories to an overall trend or a movement like those convincingly distinguished in the UK and in Germany by other scholars. Although there is no obvious way around this obstacle, it does not make a comparison between programmes impossible.

Section **5.2** is about the influence of Mendelism on Italian wheat breeders. As happened elsewhere, in Italy wheat hybrids started to be developed outside the framework of Mendelism. Although written in 1903, Napoleone Passerini's account of the development of his hybrid wheat is clearly pre-Mendelian, as are the first attempts at hybridization of Strampelli and Todaro's experiments with mass-selection. Unlike what happened in the UK, Italian Mendelian wheat breeders did not start their work as Mendelian enterprises. This should put Italian wheat breeders closer to Germany and its story of hybrids developed outside a Mendelian framework; a closer comparison, however, reveals a huge difference in the development of breeding programmes achieved before the arrival of Mendelism. Pre-Mendelian programmes in Italy were isolated and still in a provisional state when Mendelism arrived.

Section **5.3** argues that Mendelism's arrival had a double function. The first was a

Science of Heredity in France, 1840–1920," *Journal of the History of Biology* 31, no. 2 (1998): 241-62. For the English case, I refer mainly to Charnley's thesis, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930." These sources are limited in number and I am not claiming that they are the only things that a scholar interested in the topic of plant breeding in Europe should read or know. However, these authors speak a common language that makes comparisons possible and fruitful.

practical function, particularly evident in the work of Strampelli where tables of alternative characters and calculations of traits distribution can be found. The second function, the *rhetorical*, is introduced by looking at Mendelism in France: as Bonneuil pointed out for the Vilmorin Company in France, it is possible to ascribe some specific practices followed by Italian breeders (e.g. starting selection in f2) to Mendelism. However, the claims that breeders usually made about their degree of control were greatly exaggerated. Discrepancies between Mendelian theories and actual practices, found both in the work of Nazareno Strampelli and that of Francesco Todaro, fuel the hypothesis that an idea of a "Mendelian revolution" was used to attract support and funding for research programmes that were much more complex than a simple application of the principles of Mendelism. An example of this discrepancy is found in the comparison between Biffen's work and Strampelli's (who is often cast as one of the main Italian Mendelians).

An aspect that cannot be understood by looking at theoretical principles alone lies in the research strategies used by Italian and European breeders. Section **5.4** exemplifies these strategies through the use of two categories identified by Jonathan Harwood as recurring in the history of plant breeding: a *cosmopolitan* versus *a local* approach. *Cosmopolitan* and *local* both refer to the plant variety developed (i.e. whether the plant is expected to perform well in every environment where a certain amount and quality of inputs is available or if the plant has been developed with a tie to a specific geographical location). I argue that this is usually reflected in a *centralization* versus a *decentralization* of the research process. A *decentralized*, *local* research strategy can be found in the story of the Bavarian station told by Harwood: an institute that also released unfinished varieties (for free) that could be further selected in the target environment by smaller institutions or farmers.

This *decentralization* is opposed, in section **5.4.1**, to the need for control of Mendelian system builders in the UK, where Biffen was developing a *cosmopolitan* wheat variety, *Yeoman*. The problem of *rogues* (out of type plants), although marginal from an economic point of view, became extremely important to British Mendelians due to their claims about purity. Having a system means that a problem in one of its parts can have an impact on other parts as well: a practical problem that could have effects on the theory was addressed with an increase in *centralization* and control. The problem was framed as one of contamination and treated accordingly.

Section **5.5** discusses where categories like *centralization, decentralization, cosmopolitan*, and *local* can be found in the work of the two most prominent Italian wheat breeders: Todaro and Strampelli. Strampelli's development of *Carlotta* can be seen as an example of a *centralized*, *cosmopolitan* strategy; however, I argue that, as was explained in chapter **2**, the *cosmopolitan* approach was a temporary strategy for Strampelli to gain enough resources to pursue his project of substitution of Italian wheat varieties that was more *local* in its aims. His programme, however, always remained strongly *centralized*, like that of his competitor Francesco Todaro. Todaro started his work with a more *local* approach, even if it was applied to varieties already cultivated in Bologna without especial care for their zone of origin. In Todaro's work, many elements can be found that are more akin to *cosmopolitan* strategies. The effects of those mixed strategies are discussed, highlighting their advantages as well as their shortcomings.

The conclusion shows that although a mix between private and public funding for plant breeding programmes was common in Europe, in the Italian case public funding was not guided by a coherent strategy before 1925; after 1925 there was a coherent strategy, but an economically and socially disastrous one. Breeding programmes were already in a late stage of development and while their increased resources made the release of varieties faster, it did not produce any major breakthrough. Support of agricultural technicians for the fascist regime contributed to the history of Italian plant breeding after the Second World War being consigned to dustbin of history. Italian plant breeders left varieties as their legacies, but the institutes they founded were either closed or reappraised, failing to preserve a memory of varietal innovation that still survives in other countries.

5.1 Obstacles

A first obstacle in the development of such comparisons is the non-uniformity of the Italian case. As was famously stated by Stefano Jacini in his 1884 post-unification enquiry on the conditions of Italian agriculture, there existed at the time many "Agricultural Italies"[2]. Differences were in fact broad: both from a sociological and technological point of view. An analysis of those differences (far beyond the scope of this chapter) would have to consider both the different political histories up to Italy's unification and the environmental conditions due to the country's extension in latitude rather than longitude. Agriculture in the fertile northern plains has been traditionally considered as productive and developed as the most advanced European counterparts, while southern agriculture has been generally considered by historians and contemporary actors as backward and underdeveloped, due to intertwined

[2] A. Caracciolo, *L'inchiesta agraria Jacini*, ref 6:89.

political and technological reasons[3]. In his 2007 paper, G. Federico made an effort to measure various objections to this traditional view that have been raised by some historians of agriculture; his data, however, seems to confirm this perceived gap in the productivity and development of agriculture between the north and the south of the country. The need to raise productivity was a constant theme in the discussion among agricultural scientists in agricultural journals (see chapter **4**). The differences between different climatic areas of the country were used as an argument, notably by G. Cuboni, to stress the importance of plant breeding for the development of new varieties that could better resist adverse conditions[4].

This obstacle can be overcome by focusing not on agriculture at large but on wheat breeding programmes. The two main programmes presented to the reader (chapter **3** and **4**) started as local enterprises, but soon developed national ambitions, giving a term of comparison that can be counterpoised with what was happening elsewhere. Nevertheless, an element of distortion should be acknowledged: with some relevant exceptions, the overall state of Italian agriculture was still backward. Looking at Italian breeding programmes from a wider perspective would probably result in an impression similar to that of G. Pancaldi when looking at the technical successes of Italian wartime chemistry: "…elites dancing on the quicksand of under-development"[5].

A second obstacle, connected to this impression, lies in the differences between what could be called *collective* and *individual* stories. In Jonathan Harwood's account of German plant breeding, for instance, we can see a galaxy of various actors, from local to regional associations, from individual commercial breeders in the north to the southern stations that proposed a more decentralized and peasant-friendly approach to plant breeding[6]. Harwood tells a long story that begins long before the twentieth century and can comfortably stand without mentioning Mendel once. Charnley, on the other end, begins with individuals like Bateson and Biffen, but since they are convincingly treated as system-builders, the individual narratives are soon accompanied by the story of the various institutions and associations that were part of Britain's Mendelian system[7]. If the Italian case could perhaps be represented as a

[3] G. Federico, "Ma L'agricoltura Meridionale Era Davvero Arretrata?" *Rivista Di Politica Economica* 97, no. 3/4 (2007): 317.

[4] Cuboni, *Scritti scelti Cuboniani*, ref 13:27.

[5] G. Pancaldi, "Wartime Chemistry in Italy: Industry, the Military and the Professors," in *Frontline and Factory: Comparative Perspectives on the Chemical Industry at War, 1914-1924*, ed. Roy Macleod and Jeffrey Allan Johnson (Dordrecht: Springer, 2006).

[6] Harwood, *Europe's green revolution and others since*, ref 13:18.

[7] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain,

failed attempt to constitute such a system, it is not possible to reconstruct it as a collective effort. In the early twentieth century, plant breeding was not treated by the Italian state as a strategic field, and research was both under-funded and poorly coordinated. It is true that before 1922, when the fascists took political power, there existed two institutes focused on wheat research, and others involved with other plants, like the Regio Istituto Sperimentale per la Coltivazione dei Tabacchi (Royal Experimental Institute for Tobacco Cultivation) directed by Leonardo Angeloni, but the plurality of research stations did not develop into a network or evolve into a system. Instead of a national project aimed towards varietal innovation in general, what can be found in the history of Italian plant breeding is the growth of individual projects that are backed by the state to different degrees, often with some discontinuity due to political instabilities. In his history of early Italian genetics, Alessandro Volpone lists plant breeders among the first group interested in Mendelian studies; however, the relationship between Italian plant breeders and Mendelian studies was more ambiguous than in the UK[8]. I see no obvious way around this obstacle, but I think that the focus on individuals and their programmes does not prevent a comparison with more the collective efforts that happened elsewhere, once this factor has been taken into account.

5.2 Mendelian and pre-Mendelian wheat hybrids in Italy

It is difficult to track varietal innovation across history: on the one hand, the concept of *variety* itself is not clearly defined and, as the *Telegraph/Telephone* story told by Charnley shows, the question "When can something be considered a (new) variety?" can (and did) become a poignant one for commercial breeders[9]. On the other hand, the memory of the work

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1880-1930" ref 1:9. Charnley uses (and extends) the concept of "system" developed by T. P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1993),

[8] Volpone, *Gli inizi della genetica in Italia,* ref 11:13.

[9] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930." pp. 126-133, ref 1:9. In 1878, seed firm Carter's introduced what was presented as a new pea variety, named *Telephone. Telephone* was supposedly obtained by selection made on another pea variety, private breeder William Culverwell's *Telegraph*. Culverwell claimed that *Telephone* was not a new variety, but simply a collection of the wrinkled *Telegraph* peas (some *Telegraph* peas being wrinkled and some smooth). The controversy, eventually won by Culverwell, could not be settled until proper tests on *Telephone* seeds could be organized (i.e. *Telephone* seeds were shown to produce both wrinkled and non-wrinkled peas, being in fact *Telegraph* seeds). In his thesis, Charnely uses the controversy between Carter and Culverwell to highlight the *moral economy* of plant breeding and the crucial role of reputation in it;

of specific breeders usually has a shorter life than the diffusion of the variety developed[10]. In the Italian case, it is difficult to gain information about pre-Mendelian wheat breeders, but a quick analysis of those who were later remembered among the pioneers of Mendelian studies in Italy is revealing.

Napoleone Passerini (1862-1951) is usually credited as the first Italian to obtain a wheat hybrid[11]. According to his 1903 description of his hybridization experiments, two things are clear:

1) The experiments were conceived without any theoretical purpose in mind: the goal was to obtain a new variety that could keep the good characteristics of traditional *Gentil Rosso* wheat with the resistance to lodging of *Noé.* It was not intended as a source of knowledge about the dynamics of heredity in plants.
2) The experiments were not conceived of or interpreted in a Mendelian way[12]. Passerini tells the reader that he obtained 50 different "forms" of wheat and that from among these he selected four. According to his description, the forms were individuated according to quantitative criteria, like the length of the ear, the average weight of the seeds, among others. Passerini does not use any Mendelian concept: he does not list any couple of alternative characters and he does not say anything about disjunction problems, only warning the reader that an adequate selection will be needed to keep the characters sought. Resistance to lodging was considered as the consequence of a definite ratio between two measurable characteristics of the plant and not as a binary alternative[13].

What about other Italian wheat breeders? In the same years, Nazareno Strampelli, unaware of Mendel's laws, was trying to obtain a wheat hybrid that was both resistant to lodging and rusts by crossing *Noé* with *Rieti*. The experiment failed due to what Strampelli later interpreted as segregation of characters in the F2 generation[14]. Francesco Todaro was instead experimenting with mass-selection and foreign varieties, concluding that a selection

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nevertheless, it is also a good example of the fact that boundaries between varieties could be questioned.

[10] A good example of this phenomenon is grape variety *Italia*, developed in the early twentieth century by the horticulturalist Alberto Pirovano. *Italia* can be easily found on the shelf of any Italian supermarket today, while Pirovano's name has been entirely forgotten.

[11] S. Salvi, "I primi incroci di frumento in Italia: le esperienze di Nazareno Strampelli e Napoleone Passerini," ref 24:41.

[12] The first Italian publication about Mendel's laws is thought to be G. Cuboni, "Le leggi dell'ibridismo secondo i recenti studi," ref 34:44. The methodology used by Passerini seems to suggest that he was not familiar with Mendelism at the time.

[13] Napoleone Passerini, "Prove Di Fecondazione Incrociata Sul Frumento Eseguite Presso l'Istituto Agrario Di Scandicci (Firenze)," *L'Agricoltura Italiana* 29, no. 14 (1903): 417-20.

[14] See chapter **2**. See also: S. Salvi "I primi incroci di frumento" ref 24:41.

programme on varieties already cultivated in the Po Valley (versus importation of foreign wheats) was the best and safest way to improve wheat cultivation[15].

The starting point for these Italian (and later somewhat Mendelian) wheat breeders, then, was not connected to the beginning of a new science, as happened in the UK. In the UK, wheat hybridization was used before Mendelism, but when Mendelism arrived in wheat breeding it did so through new research programmes. Charnely writes that Biffen's work on wheat in Cambridge was conceived from the start as Mendelian research[16]. Far from being isolated, Biffen's work was from the beginning a piece of a larger picture. It is significant that one of the first actions of the Mendelian system builders in Cambridge was founding a journal[17].

The Italian case might thus seem more similar to the German, where breeders like Rimpau and Von Lochow were already developing their own systematic approach to plant breeding without resorting to a well-structured pre-existing knowledge[18]. However, there are two major differences with German breeders. The first difference is chronological: Rimpau and Von Lochow were born in the 1840s, while Passerini (the oldest in the group of Italian breeders considered) was born in 1862. When Mendelian studies arrived in Italy, wheat breeding programmes that aimed to become systematic were still small and provisional. The second difference is that Italy did not have many plant breeding stations devoted to testing and development of new varieties like those described by Harwood in chapter 2 of his recent

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[15] Todaro, F., *Esperienze e Prove Di Coltivazione Fatte Nella Regia Stazione Agraria Di Modena Dal 1901 Al 1904* ref 12:64. Mass selection (as opposed to single-plant selection) can refer to a wide set of practices that share a common characteristic: each year a group of plants (considered the best) is chosen as a source of seeds for the following cultivation cycle. In single-plant selection, the choice is instead individual, that is, a specific plant is chosen as a starting point. Single-plant selection is usually credited to the Svalöf plant breeding station, which was the main example Todaro used while proposing the method to landowners in Bologna some years later. Single-plant selection requires a careful tracking of an individual plant's offspring grown in separation (often called *purity*) and time (since an adequate amount of seeds with a single common ancestor needs to be produced). Mass selection requires only an evaluation of the harvest to find a group of plant for reproduction, whose seeds can later be grown without any special procedure.

[16] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930", ref 1:9.

[17] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930", p. 45, ref 1:9.

[18] Wieland, "Scientific Theory and Agricultural Practice", ref 1:105.

book[19]. One of the Italian breeders, Francesco Todaro, frequently mentioned Germany as a model for its plurality of research structures and the mechanisms of quality control on seeds established[20]. Italy had a vast number of agricultural research stations, but according to Todaro and others, those institutions that were originally meant to produce scientific research were paralyzed by an overwhelming activity as public laboratories of analysis against frauds[21].

Italian plant pathologist Giuseppe Cuboni is usually credited as the first to publish an account of Mendel's laws in Italian, in 1903[22]. Cuboni, who was also the first Italian scholar to visit the Svalöf station for plant breeding, complemented his activity as a researcher (in Conegliano and later in Rome) with an intense effort as an advocate for public funded scientific research in agriculture. Cuboni thought that Mendelism could be used to improve agriculture at large, by making the work of breeders faster and more reliable[23]. In his speeches he lamented the difference between other countries' response to the new revolution in biology and Italy's, where he mentioned only a few names of researchers involved in the ongoing revolution: Ottavio Munerati, Nazzareno Strampelli, Leonardo Angeloni, Napoleone Passerini, and Francesco Todaro.

During his lifetime, Cuboni was sometimes greeted as an Italian Bateson[24]. Today, as A.

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[19] Harwood, *Europe's green revolution and others since* Chapter 2 pp 34-56, ref 13:18.

[20] Todaro, *Il Perfezionamento Agrario Delle Piante*, ref 11:64.

[21] Todaro, *Il Perfezionamento Agrario Delle Piante*, ref 11:64. For an overview of Italy's research stations, see: Volpone, *Gli inizi della genetica in Italia*, pp. 89-100, ref 11:13. Of course, Todaro, Strampelli, and Passerini were not the only ones trying to develop new wheat varieties and there were other researchers working at the same time with other plants. I decided to focus on these men because their varieties enjoyed a good diffusion and success. Todaro and Strampelli managed also to found research institutes that became significant on the national level and took a part in the agricultural policy of the fascist regime from the 1920s. A good source of information on Italy's agricultural research station in the early twentieth century is Silvio Fronzoni, "La Sperimentazione Agraria in Italia Tra Otto e Novecento. Appunti Per Una Storia," in *Competenza e Politica. Economisti e Tecnici Agrari in Italia Tra Otto e Novecento*, ed. Aldino Monti and Giancarlo Di Sandro (Bologna: il Mulino, 2003), 447-72. Since the primary sources available documenting the research conducted in these stations were usually published by the stations themselves, it is difficult to properly assess the value of those results.

[22] G. Cuboni, "Le leggi dell'ibridismo secondo i recenti studi", ref 34:44.

[23] Cuboni, *Scritti scelti Cuboniani* pp. 157-159, ref 13:27.

[24] See the introduction by Cuboni's pupil, G. B. Traverso, in *Scritti scelti Cuboniani*, ref 13:27 and Alessandro Volpone, *Gli inizi della Genetica in Italia*, ref 11:13 for another opinion on Cuboni versus Bateson similar to that expressed in this chapter.

Volpone has written, it seems clear that those statements were overrating Cuboni's contributions to the new science of genetics; however, there are other differences that are more striking than the measure of scientific achievements. According to Charnley and his sources, Bateson "brought Mendel's work to Britain […] from a precarious position at Cambridge University"[25]. Mendelism for Bateson was thus a research agenda as well as a strategic field for building a stable academic career. Cuboni instead brought Mendelism to Italy later and from a stable position as director of the Royal Station for plant pathology in Rome. In his speeches, Cuboni always referred to the theoretical revolution that Mendelism had brought to biology at large, but presented it mainly as a tool to improve plants and agriculture that could be readily used with enough patience and a systematic approach. This choice is further demonstrated by the type of journal in which Cuboni published his first account of Mendel's laws: the journal of an association of landowners.

5.3 The double function of Mendelism in Italy

In Italy, Mendelism became a tool with a double function: *practical* and *rhetorical*. The *practical* function is evident in the work of Nazareno Strampelli, who later affirmed his debt to Mendel by naming one of his varieties *Gregorio Mendel*. Although the extent to which Strampelli's breeding programme can be considered "Mendelian" is questionable, the promise of stability granted by Mendelism had an important role in convincing Strampelli that his hybridization programme was solid enough to bet all the (few) resources of his itinerant chair of agriculture on it[26]. The influence of Mendelism is evident in both Strampelli's calculation of possible forms, based on couples of antagonist traits, and his reasoning about the probability of finding a truly stable hybrid[27].

To introduce what I called the *rhetorical* function, a comparison with two different stances about the influence of Mendelism on breeding practices in France can be useful. In explaining the role of the Vilmorin Company in the early diffusion of Mendelism in France, Gayon and

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[25] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930.", ref 1:9.

[26] As said in chapter **1**, Cuboni was crucial in obtaining governmental support that finally made possible the legal transformation of the itinerant chair position into an experimental station dedicated to wheat culture.

[27] Nazareno Strampelli, *Alla ricerca e creazione di nuove varietà di frumenti a mezzo dell' ibridazione*, ref 36:45.

Zallen highlighted the absence of a definite change in research and development methods that can be directly traced back to Mendelism[28]. Bonneuil instead proposed to look more closely at breeding method, finding some strategies that can be directly correlated with Mendelism, like selection from the F2 generation; looking at breeding practices, however, soon reveals that breeders often overstated their power of designing and manipulating plants[29]. What can be found in the Italian case is a discrepancy between what breeders said and what they did. This can be found in the work of both Todaro and Strampelli, but it is more evident in the former. In his lectures at the University of Bologna, Todaro quoted Cuboni's speech on the "Mendelian revolution" and made clear that he considered his work a part of it[30]. His course on plant breeding at the university included a section on Mendelism in which he explained how to obtain wheat hybrids. In his practice as a breeder, however, Todaro rejected the use of hybrids, claiming that single-plant selection was still the best way to improve wheat in Bologna. This is interesting because it shows that Todaro viewed hybridization as a source of variation and not as a source of control. For him, hybridization was not the consequence of definite mathematical control on plant characteristics, but a potential source of uncertainty. From his lectures it seems that he considered research aimed at finding correlation between traits to be more promising. Nevertheless, the rhetoric of the "Mendelian revolution" was very useful: on the one hand, Mendelism justified his procedure of single-plant selection; on the other, it supported the idea that plant breeding was a scientific activity that had to be organized by professionals. Unlike German academic plant breeders, Todaro did not use theoretical concepts to make his academic position stronger[31]. Instead he used a combination of his practical results as a breeder and theoretical concepts to claim plant breeding as a scientific activity that had to be researched by professionals in a systematic way. Unsurprisingly, his polemical target was the set of traditional practices, like seed swapping between farmers, and traditional beliefs about the farm's economy[32].

Nazareno Strampelli is usually presented as a counter to Todaro as an example of a plant breeder who based his success on the principles of Mendelism. Strampelli's work on wheat

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[28] Gayon and Zallen, "The Role of the Vilmorin Company in the Promotion and Diffusion of the Experimental Science of Heredity in France, 1840-1920", ref 1:105.

[29] Bonneuil, "Mendelism, Plant Breeding and Experimental Cultures", ref 39:102.

[30] Todaro, *Adattamento, selezione, incrocio, delle piante coltivate*, ref 17:28.

[31] Wieland, "Scientific Theory and Agricultural Practice", ref 1:105.

[32] The same belief that Todaro attacked, the idea that the farm should be conceived of as a self-sustaining system that does not have to rely on the market, could also be found in the Netherlands, as explained by Theunissen, "Breeding Without Mendelism", ref 56:82.

was almost entirely based on hybridization, and although it is not clear when exactly he became aware of Mendel and Mendelian results (see chapter **2**), they definitely had an influence in his 1907 decision to bet his scarce resources on his hybridization project. It is true that the classic tools of Mendelism can be found in Strampelli's work: tables of alternative characters, probability notions, the conception of the plant as a set of decomposable parts. However, a closer look at his work in comparison with other Mendelian breeders reveals a more complex picture: for instance, while Biffen, according to Mendelian theories, stopped data collection after f3, Strampelli went usually on and on, testing (and probably selecting) his varieties for ten and more generations[33]. At the same time, his research in Apulia aimed at obtaining drought resistance was a classic selection programme, similar to Todaro's in Bologna. Strampelli also considered the *dominant* versus *recessive* distinction as relative to a specific cross, something that does not sound Mendelian at all. It would be unfair to agree with Girolamo Azzi, who said that Mendelian theory was used to cover pre-Mendelian practices, but beyond the rhetoric of the revolution there were nevertheless strong elements of continuity in what breeders actually did[34].

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[33] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930" ref 1:9. It is true that Strampelli considered his varieties *fixed*, however contemporary sources like Saraiva and also Boggini et. al. have remarked that Strampelli's wheat varieties were not entirely stable. It is not clear whether this was an intended or unintended result. See Saraiva, "Fascist Labscapes" and G. Boggini et al., "Le varietà di frumento tenero costituite da Nazareno Strampelli", in CD-ROM n.8, *Collana di ipertesti di agricoltura e comunicazione del Centro di collegamento ricerca-divulgazione del CRA-ISC* (Sant'Angelo Lodigiano: CRA, 2004).

[34] Azzi, *Ecologia Agraria*, ref 34:100 See chapter **4**; in the early twentieth century, Azzi tried, with mixed results, to found a new science, based on a *relative* conception of productivity. Unlike plant breeders, who tended to consider productivity as an absolute value, Azzi conceived of it as a balance between the maximum yield achievable and the plant's resistance to harsh conditions. This shift meant constructing a link between the plants and the environment through data collection. After some initial success, Azzi did not have a strong influence on Italian plant science. It should be noted that Azzi's criteria implied a strong critical stance towards Italian plant breeders. High yielding varieties (usually considered the top achievement of a breeding programme) could be judged unfavourably due to their intensive need for adequate inputs. A variety that was usually considered less productive could, in Azzi's system, be better for a specific environment due to better performances in a resources scarce environment. As I stated in chapter **3**, Azzi's critique of Italian plant breeding programmes, though it raises some interesting points, is not entirely fair.

5.4 Strategies: centralization versus decentralization

Despite the different degrees of influence that Mendelism had or did not have on European plant breeders, there are elements of their activities that cannot be captured with disciplinary or theoretical categories alone. One of these elements, which I am referring to with the general term "strategy," is illustrated in the difference that Harwood proposes between processes that follow a *cosmopolitan* strategy versus those that follow a *local* strategy[35]. Harwood finds what he calls a tension between the two approaches, which can also be interpreted as a leitmotif in the history of plant breeding.

According to Harwood, a *cosmopolitan* plant breeding strategy is focused on the development of a single outstanding variety, environmentally undifferentiated. These varieties are usually highly productive when a certain schema of inputs and conditions can be replicated. From the point of view of the *cosmopolitan* strategy, the initial environment that originated the plant is not important. This indifference towards location, however, does not guarantee that the variety will perform better than more traditional ones in every environment, especially where methods of intensive farming are not applied. The *cosmopolitan* strategy was followed by German commercial plant breeders, who were advocates of intensive cultivation methods[36]. The alternative strategy, explored in southern Germany from the 1890s, considers it more efficient to develop many improved varieties, each one suited to a particular environment, starting with a selection programme on *local* varieties already cultivated. In Germany, the *local* strategy was followed by breeding cooperatives, which improved rye and other plants thanks to local programmes of mass-selection. The lower costs of this strategy meant that the improvement was achievable for small farmers[37]. This approach was also followed by state-funded agricultural stations, like the Bavarian plant breeding station opened in 1902 in a political and economic climate where containing small farmers' discontent was a priority.

[35] Harwood, *Europe's green revolution and others since,* 42-50, ref 13:18.

[36] Harwood, *Europe's green revolution and others since,* p. 46, ref 13:18.The sub-optimal response of local varieties to mineral fertilizers described by Harwood also has a parallel in Italy.

[37] The final results of these selection programmes (seeds) were less expensive not only to buy, but also to grow (not being bred with a high-input system in mind). For details on why such a strategy is less expensive, see: Harwood, "The Reception of Genetic Theory Among Academic Plant-breeders in Germany, 1900-1930", ref 27:97. In this paper, Harwood does not use the words *cosmopolitan* versus *local*, but he stresses the point that mass selection required far less resources and less specific knowledge than hybridization.

To this division between a *cosmopolitan* and a *local* strategy made by Harwood, I would add a small detail that is evident from Harwood's treatment of the German case, even if it is not explicitly stated. *Cosmopolitan* strategies were connected with *centralized* models of research while *local* strategies could afford to *decentralize* part of the research process. On the one hand, these strategies are related to the final outcome of their research: the final (improved) variety, which is either *cosmopolitan* (i.e. meant to be cultivated in many different environments) or *local* (i.e. meant for a limited distribution in a specific environment). On the other hand, this is reflected in the organization of the research. Who should develop the new (improved) plant variety? The *cosmopolitan* strategy is connected to a pyramid-like view: the commercial breeder develops it inside his centralized programme and later sells it to farmers; he controls the whole process. The *local* strategy instead requires a distributed approach to plant improvement. Since the tie between variety and environment is never broken, the research process has to be *local* as well. It must be conducted at least partly inside the target environment in which the plant will actually be cultivated. An example of this is the choice of the Bavarian station to distribute "unfinished" varieties: while a central institution is present, the research process extends beyond it[38]. Rather than a single *cosmopolitan* variety, a set of promising lines was distributed (for free). The set could then be further selected in the target environment by local actors.

5.4.1 UK system builders and their need for control

This *decentralization*, which implies a lack of control, can ideally be opposed to the need for control of Mendelian system builders in the UK, as is evident from the story of Biffen's *rogues*[39]. *Rogues* are plants that do not conform to the norm, displaying characteristics that are different from those expected. As Charnley writes, no complete solution was found to this problem, and a (small) number of out-of-type plants is today acknowledged as inevitable[40]. The persistence of the problem means that its interpretation in the history of plant breeding has changed over the years; however, the interesting point raised by Charnley is that rogues were particularly dangerous for British Mendelians. Seeing it from a practical point of view, the problem of rogues appears an economic one: some seeds develop into out-of-type plants, generating (eventually) a loss in profit that should be reduced if it is significant. But since

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[38] Harwood, *Europe's green revolution and others since*, p. 65, ref 13:18.

[39] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930." pp. 123-162, ref 1:9.

[40] Charnley, "Agricultural Science", p. 88, ref 1:9.

Mendelians claimed that their methods guaranteed *purity* of varieties while denying mechanisms that were formerly used as an explanation for out-of-type plants, like reversion, rogues could also become a theoretical threat. One of the various response strategies explained by Charnely is blaming distribution and framing the problem as one of contamination[41]. For the same reasons, threshing machines were also considered responsible for an accidental mix of different seeds in the fields, and special means (like sealed bags) were used with the aim of increasing control on the chain that went from the experimenter to the farmers. Purity was thus safeguarded with an increase in *centralization* of control. This could be thought of as one of the potential disadvantages of building a system: since its parts are strongly connected, a problem in one area can move into another, evolving into a more general problem. Increasing control usually means increasing centralization; a *cosmopolitan* breeding strategy is more common in such an approach because the need for control gives far fewer opportunities to delegate parts of the research process.

5.5 Centralization and decentralization in Italy

If southern German breeding stations and Biffen's research programme can be considered extremes, Italian breeding programmes could be located somewhere in the middle, with one breeding programme closer to Germany (Todaro's) and another to Biffen (Strampelli). One can, however, identify some major differences. I will start with Strampelli and then turn to Todaro. In this section I will not discuss the work of Napoleone Passerini because, although his wheat hybrid did enjoy some diffusion, his experiments did not evolve into a vast research programme. As should be evident from the preceding chapters, both Todaro and Strampelli's programmes started as regional but soon developed national (and in the case of Strampelli, international) ambitions.

Strampelli's story as a breeder was already explored in chapter **2**, above. I would just remind the reader here that his experiments were started with the aim to improve a popular Italian variety*, Rieti Originario* (sometimes called simply *Rieti*). Strampelli soon became convinced that hybridization could be the instrument to develop new wheat varieties that could replace those already in cultivation. His first result was *Carlotta Strampelli*, a hybrid variety that was more productive than *Rieti* while retaining *Rieti*'s resistance to rusts and adding resistance to lodging[42]. The strategy followed by Strampelli in this phase seems to be a

[41] Charnley, "Agricultural Science", p. 155, ref 1:9.

[42] Lodging was the main problem in *Rieti*. See chapters **1** and **2** for more detail.

classic example of a *cosmopolitan* strategy, and has strong aspects of centralization. *Carlotta* was meant to be an outstanding variety that could enjoy wide success due to its higher tolerance for intensive-like inputs. Although Strampelli conceived of his research as a public service for the country at large, the characteristics of *Carlotta* were those sought by practitioner of high-input farming methods. Being resistant to lodging meant a better transformation of inputs through the plant's improved capacity to accept chemical fertilizers. The variety had the classic shortcomings often found in *cosmopolitan* outcomes: a weakness in harsh conditions (*Carlotta* was vulnerable to high temperatures) and a greater need for resources to express its potential[43].

The aspect of public service is important and should not be overlooked: Strampelli did not think that his variety had to be grown everywhere. Although it could be argued that *Carlotta*'s vulnerability to high temperatures was not anticipated (despite many years of trials before releasing it), Strampelli always recommended it only for fertile plains and did not fuel the enthusiasm that spread after the first successful years of distribution. As I wrote in chapter **2**, *Carlotta* was used by Strampelli as a lever with a specific entry point into the range of Italian wheat varieties. Strampelli decided to release a single variety not because of a *cosmopolitan* strategy, but because *Carlotta* could replace *Rieti*, a wheat that was popular in the country's fertile plains. Strampelli had the majority of his resources located in the same environmental niche of *Rieti*, so he had enough experimental fields with the right climate needed to develop an alternative[44]. Strampelli used his experimental fields to test the new variety as accurately as was possible. Later, thanks to the Minister of Agriculture, who saw his hybrid at an exhibition in 1914, he managed to organize a network of agricultural schools and experimental stations that could try the new wheat across the country. *Carlotta* gave Strampelli enough of a reputation as a breeder to attract additional resources and continue to develop other varieties, using experimental fields located in different places (which later became controlled sub-experimental stations) as *models* of the various environments. Strampelli's final goal was to obtain a set of varieties, each one suited to a specific environment. While the entire process of research, development, testing, and distribution was *centralized*, it was not conceived of as *cosmopolitan*. In Strampelli's project, professors of

[43] This equivalence between the productivity of the plant and the productivity of the plant in the best environmental conditions possible was exactly the main point of Azzi's critique of Italian breeders. See: Azzi, *Ecologia Agraria,* ref 34:100.

[44] See chapter **1** for more details. Strampelli worked in the Rieti valley, and there are good reasons to think that he choose Rieti because the traditional variety *Rieti Originario* was grown there. See also: Lorenzetti, *La scienza del grano* ref 6:11.

itinerant chairs of agriculture had to help farmers choose from a pool of varieties (developed by him) that was better suited to their local conditions.

This unlikely blend of centralization and *non-cosmopolitan* (although not entirely *local*) strategy had its strengths as well as its weaknesses. On the one hand, it permitted the introduction of strong innovations thanks to the use of varieties (like Japanese *Akakomughi*) that were alien to the traditional landscape. On the other, hybrids had to be tested. Since they were often a blend of varieties that were not cultivated in the area, it was not possible to establish beforehand a definite link between the plant and its ideal environment. This link had to be created anew with tests, slowing the development process and making it strongly connected to the personal abilities of *one* breeder, a sort of commander in chief. In this process, *rogues* could become a problem due to their negative influence on the breeder's own reputation. Strampelli issued strict guidelines for his network of seed makers, using the same instruments that were used by British Mendelians: sealed bags, strict rules of cultivation to avoid contamination, the use of a separate specific thresher. These dangers for the breeder's reputation, however, were never conceived of as theoretical problems: Strampelli was not developing Mendelism in Italy, and despite the word *genetics* in the name of his national institute in Rome, he was not contributing to genetics at large. Instead, he was developing (with a remarkable ability) new wheat varieties, within a project of an overall change of wheat culture in Italy. Purity was thus enforced, but only to a certain point.

The breeding strategy of Francesco Todaro was already explored and compared with Strampelli's in chapter **3** of this work. In the early twentieth century, Todaro managed to persuade landowners in Bologna that a selection programme (presented as "the Svalöf method") could quickly improve wheat varieties already cultivated with success in Bologna[45]. Todaro started his work by selecting single plants that were later cultivated in separation from others (purity) to start what could be called, as Johannsen does, a *pure line*[46]. His initial strategy was thus *local*, but later evolved in directions that were more typical of a *cosmopolitan* strategy, with strong elements of centralization. A first element of difference between a *local* approach and Todaro's was the choice to use as a starting point varieties already cultivated in the area, no matter where they originally came from. One of the first results was the selection of a line obtained from a variety developed and sold by Vilmorin in France. *Inversable* soon became Todaro's *Inallettabile*, which prevented landowners in

[45] Felice, *La Società produttori sementi (1911-2002)*, ref 18:66.

[46] Although it is useful to use Johannsen's concept to explain what Todaro actually did, it is important to note that he never used the former directly.

Bologna from having to buy *Inversable* seeds from Vilmorin each year[47]. The same selection procedure was applied to traditionally grown varieties like *Gentil Rosso*. Todaro's approach did produce good results for landowners in Bologna, and his society (unlike Strampelli's research programme) became soon profitable. Although more *local* than Strampelli's approach, when Todaro managed to attract enough resources and support for his research, he did not think about extending this *local* model to other environments. Instead he tried, and succeeded in 1921, to detach his research programme from the society of seeds producers that he had created, founding an institute for plant breeding (Istituto di Allevamento Vegetale). The institute had to work in a *centralized* and *cosmopolitan* way: it had to develop new varieties of plants that later could be commercialized by the society of landowners that Todaro had started earlier to begin his work on wheat improvement.

On an economic level, blending *cosmopolitan* and *local* strategy produced mixed results according to the chosen blend. Todaro's model of business was more sustainable, being backed up by his society's profits from new seeds. Single-plant selection did not require huge investment, while Strampelli's programme constantly required more and more resources every year, being exposed to losses due to Strampelli's idea that a great number of varieties had to be created for Italian agriculture. On the other hand, when Strampelli's first short culm early-ripening varieties started to appear on the Italian market, Todaro's varieties started to lose ground: he could not reproduce the same results without hybridization and he did not replicate his *local* model of research elsewhere, trying instead to push his varieties obtained in Bologna elsewhere[48].

Conclusion: breeders and their legacy

As is evident from chapter **2** of this work, agricultural research can quickly become expensive and time-consuming. Even if the ability of the breeder can help cutting costs, research programmes based on hybridization required a vast amount of land and resources to

[47] *Inversable* seeds that arrived in Bologna had a tendency to lose their precious characteristics in a few generations, making a return to the original source necessary.

[48] Lorenzetti, *La scienza del grano,* ref 6:11. See also Comitato per le onoranze nazionali a Francesco Todaro, Associazione provinciale dottori in scienze agrarie Bologna, *Commemorazione Nazionale : Universita Degli Studi Di Bologna, 11 Gennaio 1953* (Bologna: Arti Grafiche, 1953), http://sol.unibo.it/SebinaOpac/Opac?action=search&thNomeDocumento=UBO2109760T.

be successful[49]. The relationship between biological innovation and intellectual property is too complex to be considered here; however, the impossibility of maintaining complete control on new plants is often mentioned, along with high entry barriers, as explanation of the prominence of public funding for agricultural research in the early twentieth century[50].

Funding, however, can differ in degree, kind, and returns. In Britain, Biffen could count on a consistent number of private and public funding. Cambridge was at the centre of what Charnley calls "a sprawling Mendelian empire" that comprised many other institutions[51]. Institutions like the John Innes Centre relied on private funds, and from 1911 Mendelian studies were further helped by the newly established Development Commission, leading to the birth of two new institutes related to plant breeding[52]. In Germany, while northern breeders operated according to commercial strategies, Harwood points to the political function of public investments in agriculture in the south: improving plants through policies favourable to small farmers became a useful tool to prevent social unrest and political change[53]. The mix of private and public funding can also be found in Sweden, where financing for the Svalöf plant breeding station came, according to Newman, thanks to "membership fees, government grants, county grants, contributions from the Agricultural Societies, fees from the Swedish Seed Company on account of stock seed sold the said company and for the inspection and control by the Association of the commercial product"[54].

Italian plant breeders received financing in a similar way. Strampelli started his research programme from a public position (granting him a small salary), integrating it with private resources gathered from a prominent landowner in Rieti. Strampelli, both in his aims and the structure he gave to his research programme, was always overextending the resources available and pressing for more public involvement. His position, however, was initially

[49] I agree with C. Bonneuil's argument, that the breeder is somehow playing a lottery. See: Bonneuil, "Mendelism, Plant Breeding and Experimental Cultures." ref 39:102. On the advantages of selection over hybridization, see: Harwood, "The Reception of Genetic Theory Among Academic Plant-breeders in Germany, 1900-1930" ref 27:97.

[50] Giovanni Federico, *Feeding the World: An Economic History of Agriculture, 1800-2000* (Princeton: Princeton University Press, 2010). On the vast topic of intellectual property in the biosciences, I would recommend the reader visit the IPBIO network homepage at http://ipbio.org/.

[51] Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930" ref 1:9.

[52] Charnley, "Agricultural Science" pp. 62-64, ref 1:9.

[53] Harwood, *Europe's green revolution and others since*, 28 and p. 50. ref 13:18.

[54] Newman, *Plant Breeding in Scandinavia*, ref 19:29.

funded and meant to improve the *Rieti* variety, and a local dimension was thus expected. His research was backed by the state, but it was only in 1919 that the national dimension of his programme was recognized, with the creation of a national institute. Todaro was a professor in what later became the agriculture faculty of the University of Bologna. He raised resources for his selection programme by involving local landowners in a cooperative. When he wanted to separate his research from the society, he had to rely also on the state to establish his plant breeding institute (which could also count on the financial support of local landowners who had benefited from the commercialization of the improved varieties)[55].

Both Todaro and Strampelli's institutes were financed by the state before 1922, but a remarkable increase of resources (especially in Strampelli's case) and support came after the fascist regime decided to put wheat culture at the core of its agricultural policy, for reasons that had little to do with economics[56].

When this support came, however, both Todaro and Strampelli were already well-known plant breeders at the end of their careers. The increase in resources did not change research methods or provoke any radical change, except in scale: in Strampelli's case it allowed testing and distribution of varieties already developed within his research programme. The connection between achievements in genetics and achievements in plant breeding had been lost somewhat along the way. Thus, even if plant breeders were included into a coherent (but pernicious) agricultural policy after 1925, this policy, and the breeder who endorsed it, did not have complex scientific or academic goals on their agenda.

The support that agricultural technicians gave to the regime certainly contributed to the subsequent disappearance of the history of Italian agricultural research after World War II[57]. Italian institutions that were producing cutting-edge results in plant breeding at the beginning of the twentieth century failed to maintain this prominence after the war. Major innovations in Italian wheat culture after WWII did not come from the institutes founded by Todaro or Strampelli[58]. Strampelli's varieties did enjoy some international distribution, but even though the directions pursued by Strampelli (height reduction and early maturity) can be found much later in the work of N. Borlaug, this seems to be only a coincidence[59]. I explored in chapter **1** some of the issues that must be faced when trying to reconstruct a piece of Italian agricultural

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[55] Felice, *La Società produttori sementi (1911-2002)*, ref 18:66.

[56] Saraiva, "Fascist Labscapes", ref 4:11

[57] Di Sandro and Monti, *Competenza e politica*, ref 24:30.

[58] Scarascia Mugnozza, "The Contribution of Italian Wheat Geneticists.", ref 9:12

[59] Salvi, Porfiri, and Ceccarelli, "Nazareno Strampelli, the 'Prophet' of the Green Revolution": ref 7:12.

research history.

This failure of Italian breeders to establish a strong legacy despite the diffusion of their varieties contrasts with their European counterparts: while the Vilmorin company still exists in France, like the John Innes Centre in Britain, the Italian institutes did not survive or, when they did, they did not achieve results that were comparable with those of their originators. Efforts to preserve the historical memory of biological innovations are slowly growing, but remain few to date. This could be related to the failure of Italian Mendelians to establish a proper system. The reliance on practical aims alone prevented the introduction of major innovations in the methods followed by Todaro and Strampelli after the first pioneering years. Their processes, once established, became rigid protocols that did not change and that depended on the presence and skills of their "founding fathers." Varietal innovation in Italy did happen again, notably in the 1960s, but the link between old and new plant breeders was a wheat variety (Strampelli's *Senatore Cappelli*) and not an institute.

CONCLUSION

This chapter will recapitulate the main findings of this thesis and propose future directions in which this work could be extended. Throughout the previous chapters, Italian breeders have been considered as researchers, institution builders, creators of processes; they have been compared with other scientists and technicians who were advocating the increase in wheat production that breeding programmes were supposed to grant, and their activities have been juxtaposed with those of their main European counterparts.

What was wheat breeding in early twentieth-century Italy? Having examined breeders from various angles, a possible answer is: a complex process that acted on a plurality of interrelated elements, and had a theoretical as well as a practical side. More than anything else it was the establishment and refinement of processes meant to produce varietal innovation reliably. The focus needs to be on the process rather than on a particular variety, because both Todaro's and Strampelli's programmes were trying to establish their research as a continuous source of varietal innovation. The fact that a description of the steps composing the process is possible does not grant reproducibility. The production processes examined in this thesis are straightforward, but in the process some steps are related to individual choices of the breeder that are impossible to reduce to a simple criterion. If the comparison with artists may appear to exaggerate the creative power of breeders, breeding can nevertheless be considered a craft in which the skills, intuition, and ideas of the artisan are crucial elements.

As is explained in the first chapter of this work, this thesis started as a historical study, but eventually took a different direction. Nevertheless, new elements have emerged from the historical part of this research as well as from the analysis. I will underline in this section what I think are the main original contributions of this thesis.

As I wrote in chapter **1**, Strampelli's story has been told before, but certain elements of the story did not emerge in the available literature. The emphasis in the available literature on Strampelli's ability to attract financial and political support for his research programme often overlooked the delicate financial position that Strampelli had to face between 1905 and 1907. As is explained in chapter **2**, this is not a minor point but a sign of something that has a profound implication; that is, the constant need for the research programme to expand due to Strampelli's aims and his chosen research method. This dynamic of growth has been individuated for the first time in this work: research methods and career strategy were deeply intertwined as the "wheat as a lever" story shows in section **2.3**. If this analysis alone cannot resolve the questions that surrounds Strampelli's choice to ally himself and his programme with the fascist regime in 1925, it nevertheless gives a new set of possible explanations that are consistent with the actual life cycle of Strampelli's research programme.

That said, I think that the main original contribution of this thesis is to be found not in the historical reconstruction of plant breeding, but in the analysis of plant breeding as a process, mainly developed in chapter **3**. The analysis uses the stories of two Italian breeders and their rivalry as an excuse to explore in detail the way in which new seeds were produced: a similar analysis conducted on other breeders could bring interesting results. Plant breeding emerges as an art and a process: on the one hand, it is an activity that is repeatable and codified in a set of steps; on the other, these steps rely on personal skills and contribute to theoretical concepts. Different answers can be given to the question "What is a variety?" depending on the particular research programme that is being examined. The same holds true for the conceptualization of problems that breeding programmes were supposed to solve. This plurality may be hidden in the definitions that are explicitly given or agreed upon by breeders, but it is evident from the choices that are made by the breeder in the organization of his programme. An explicit consensus on a scientific theory was used as an instrument by researchers who had different aims and conceptions.

This thesis is also a first attempt at showing a plurality of approaches that existed among advocates of an increase in wheat production. The proposed framework that is used shows that while actors involved in the production of wheat in early twentieth-century Italy definitively had something in common, the solutions they proposed to the problem of production were different and sometimes irreconcilable. One contribution is the framework itself, a set of elements (soil, seed, climate, and work) that can help capture the nuances of a debate that are often lost when looking at interests alone. The second contribution of this chapter lies in the fact that for the first time the ideas of Girolamo Azzi are re-evaluated and presented in their context to a contemporary audience. Azzi's conception of production as *relative* to the relationship between plants and environmental conditions already underlined shortcomings in Italian plant breeding programmes in 1923, when Strampelli's early-ripening varieties were starting to become more and more popular. Although Azzi's main ideas are examined in this work, I think that Azzi deserves further historical research. He was a pioneer with an impressive network of connections with international scholars. Unfortunately, so far attempts to find Azzi's personal papers have been unsuccessful.

Despite the obstacles, chapter **5** presents specific aspects of plant breeding in early twentieth-century Italy in a way that makes comparison with other European programmes easier. The analysis underlines a fundamental ambiguity of Italian plant breeding programmes towards Mendelism that had already been suggested in chapter **3**. This ambiguity between a rhetorical and a practical function is not derived from an idealization of Mendelism, but from the fact that practices that do not make sense according to Mendelian theories (e.g. continuous selection) were still used by breeders. A general picture of continuity rather than revolution emerges in the analysis of Italian wheat breeding programmes. The second contribution of this chapter is the proposed connection between plant breeding strategies analyzed by Jonathan Harwood (*cosmopolitan* versus *local*) and the way the programmes are managed: *centralized* versus *decentralized*. As the Italian case shows, this connection can be reversed, but at a price. Strampelli's partially successful attempt to develop location-specific varieties through the use of a mixed strategy is seen as a source of strengths as well as weaknesses: the introduction of new characters absent in the wheat varieties cultivated in Italy at the time proved to be hugely successful, but the strategy increased costs considerably.

Future directions

There are at least three directions in which this research could continue: in this section I will give an overview of the various aspects that could not be entirely developed in this work. Those aspects are: *knowledge in breeding*, *memory*, and the *seed/land/hybridization relation*.

As is explained in chapter **1** of this work, it is difficult to find reliable archival sources for the history of plant breeding in Italy at the moment. Even if those sources were available, however, there are aspects of plant breeding that cannot be easily grasped by reading written documents. Those aspects are briefly mentioned in chapter **2** of this work with the expression "the breeder's eye". A breeder who runs his programme with limited resources has to make choices about how to employ them. Which plants are the most promising? This is also a problem of data interpretation: the breeder in his fields does not have complete control of the experimental conditions, since they are exposed to natural variance. A common strategy used was to collect data for many years, but this method does not relieve the breeder from the burden of a risky choice. Nevertheless, the ability of certain breeders to develop successful varieties over and over suggests that, although it is difficult to describe it, this is a form of knowledge rather than the gambler's luck. Knowledge in breeding, and especially knowledge that is not completely described, is difficult to analyze; however, traces of it remain. I would suggest that they must be found in the way data about varieties were collected. On the one hand, this shows what was perceived as important to the breeder; on the other, when other people had to assist the breeder in this collection of data, the kind of instruction given and the instrument used could reveal something about the elements that comprise "the breeder's eye". I would argue that when breeding programmes scale up, some elements that were implicit must become explicit due to the need to delegate tasks. The strong link between the programme and the breeder could mean that there are limits to the amount of information that can become explicit.

The idea that *memory* in breeding could be a future direction for this research comes from the famous 1911 article authored by Wilhelm Johannsen, in which he presented to an American audience his distinction between genotype and phenotype[1]. In his article, Johannsen maintains that his new conception was "ahistoric" and akin to the chemical view: a chemical compound is fully described by its formula, its characteristics are known without having to know its history.

This stance is in direct opposition with one of the main practices of breeding: keeping records of plants through the years. If Mendelian combinations could be used to project into the future possible results of hybridization processes, there remained practices that allowed the breeder to know the past of a plant as well. Both Todaro and Strampelli developed numbering systems that allowed a quick description of the plant while keeping the possibility of tracing back the plant's history. Unsurprisingly, due to the complexity derived from hybridization, Strampelli's system was more developed. The progressive numbers was a condensed way to describe all of the plant characteristics, as he explained in his 1907 publication[2]. Nevertheless, this ahistorical view was always accompanied by the inclusion of information about the parental varieties in the new plant description. For Strampelli, this was not a minor point, since he considered *dominance* as relative to a specific cross. It would be fruitful to look at these memory systems in detail and also to see if this double need to consider the past as well as the future can be found (as I suspect is the case) in other plant breeders too.

The third direction I think could be further developed is the relationship between plant and territory, and how it is changed by hybridization. I suggest that it would be interesting to develop this direction by searching common themes between different stories, but I will stick to the Italian case to make my point clearer to the reader.

It is somewhat ambiguous to talk about the relationship between a plant and a territory: as the work of Vavilov showed, seeds have always travelled between different places[3]. Seeds

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[1] Johannsen, "The Genotype Conception of Heredity", ref 30:32.

[2] Strampelli, *Alla ricerca e creazione di nuove varietà di frumenti a mezzo dell' ibridazione*, ref 36:45.

[3] A collection of Vavilov's main works translated into English was compiled by A. A. Filatenko, see: Nikolaĭ Ivanovich Vavilov, *Origin and Geography of Cultivated Plants* (Cambridge: Cambridge University Press, 1992).

thus cannot be considered a static element. However, it is also true that the memory of those movements is often lost, and concepts of "traditional varieties" or landraces tend to appear, in which a plant is identified through a special relation to a physical place. An example of this is *Rieti Originario*: a variety whose zone of origin is in its name and is first and foremost identified through its provenance.

The use of hybridization breaks this link between the plant and the territory in two ways. First, it uses as a starting point for the cross varieties chosen on the basis of their characters and not of their zone of origin. It does not matter if the varieties chosen are considered inadequate for the environment in which the hybrid will eventually be grown, as long as intended characteristics that the breeder wants to recombine are present. Second, the final outcome of the cross, the hybrid, has no definite geographical collocation but only hypotheses regarding its ideal environment. The hybrid needs to be tested because there is no link between it and the territory given in advance. This explains the shorter development cycle that Todaro established thanks to his refusal to use hybridization in his programme.

The missing link between hybrid and territory is the reason behind the processes of *territorialization* that were developed by Strampelli to find the ideal environment for his new varieties. The use of *model environments* was one among many strategies employed to speed up this process.

More interestingly for our times, I would argue that this missing link with a definite environment made the hybrid an alien entity, and raised the first concerns about its *safety* that are today more and more important in the way food is produced and sold. *Safety* concerns at the time of Strampelli were not like those that are more common in our day to day reality, which appear to me more related to health dangers. There were two concerns about *safety* of the hybrids: a purely economic concern and another that was more related to food.

Hybrids did not have a long history of successful cultivation: establishing economic safety meant conducting many years of testing to be sure that large-scale cultivation of the new variety would not do any harm to Italian agriculture at large.

At the same time, concerns were raised about the quality of the new varieties, and whether their flour was adequate for bread-making. This was not yet a health-related concern, but it is nevertheless a first example of a wheat variety having to prove its safety through analysis and documents. The story of how something so apparently common as a wheat variety ceased to be considered entirely safe in principle would be quite a story to tell or to be told, but it was far beyond the scope of this thesis to write it.

APPENDIX

Strampelli's private archive (APS)

Strampelli's private archive (APS) is currently kept in the Rieti State Archive, as explained in chapter **1**. Studying the traces that Strampelli left of his own research has been equally challenging and fascinating. Despite the insights that I gained through studying each document of the APS, due to the hybrid nature of this thesis and the administrative difficulties surrounding access to these documents, I decided to use only a small number of documents directly, those I felt to be the most important. The Box/Folder indication reflects the indexing of the APS in March 2011. This indexing was done by Dott. Roberto Lorenzetti, director of the State Archive. The progressive number is a unique identifier that I assigned to each document or a specific group of documents cited in this thesis, to make an eventual retrieval of photographic evidence easier.

INDEX N.	YEAR	AUTHOR	TITLE	TYPE	FROM/TO	BOX	FOLDER
1		vv. aa.		Academic certificates		1	
2	1888-1889	N. Strampelli	Appunti non di scuola	Notebook		2	10
3	1888-1889	N. Strampelli	II Agricoltura	Notebook		2	2
4	1903	N. Strampelli	Copia di lettera di Nazareno Strampelli al Ministero di agricoltura industria e commercio.	Letter	N. Strampelli to Luigi Rava	10	4
5	1904	N. Strampelli	Cronaca della Cattedra Sperimentale di Granicoltura in Rieti	Note		5	8
6	1906	N. Strampelli	Promemoria	Note		11	3
7	1904	N. Strampelli	Notizie riflettenti l'attività di questa Cattedra	Letter	N. Strampelli to Luigi Rava	5	7
8	1904	N. Strampelli		Seed request	N. Strampelli to Isaia Baldrati	16	13
9	1904	N.		Seed	N. Strampelli	16	15

INDEX N.	YEAR	AUTHOR	TITLE	TYPE	FROM/TO	BOX	FOLDER
		Strampelli		request	to T. Allsops (Reading)		
10	1904	K. Hansen		Seeds sent	K. Hansen (Lyngby) to N. Strampelli	16	16
11	1904	N. Strampelli		Seed request	N. Strampelli to Hugo Devries (Amsterdam)	16	18
12	1904	?		Seeds sent	from ? (Belgrade) to Nazareno Strampelli	16	20
13	1904	?		Seeds sent	From ? (Wagenigen) to N. Strampelli	16	22
14	1904	Vilmorin-Andrieux & C.ie		Seeds sent	Vilmorin-Andrieux & C.ie (Paris) to N. Strampelli	16	23
15	1904	N. Strampelli		Seed request	N. Strampelli to Presidente del Commissariato Italiano per l'esposizione di St. Louis	16	24
16	1904	N. Strampelli		Seed request	N. Strampelli to Abbot Luigi	16	25

INDEX N.	YEAR	AUTHOR	TITLE	TYPE	FROM/TO	BOX	FOLDER
					? (Rome)		
17	1904	N. Strampelli		Seed request	N. Strampelli to T. Allsops (Reading)	16	26
18	1904	N. Strampelli	Libro primo. Varietà servite per gli ibridi 1904	Notebook		16	7
19	1910	N. Strampelli		Report	N. Strampelli to the Minister of Agriculture	11	5
20	1906	N. Strampelli	Promemoria	Note		11	3
21	1914	N. Strampelli	La R. Stazione Sperimentale di Granicoltura in Rieti alla Mostra delle Novità Agrarie dell'anno 1914	Booklet brochure		18	10
22	1910	N. Strampelli	Campi sperimentali necessari per la costituzione di razze di frumenti atte alle diverse regioni italiane	Letter	N. Strampelli to Giovanni Raineri	11	4
23	1911	N. Strampelli	Viaggio all'estero	Letter	N. Strampelli to F. S. Nitti	18	9

INDEX N.	YEAR	AUTHOR	TITLE	TYPE	FROM/TO	BOX	FOLDER
24	1917-1919	N. Strampelli	Miliani	Draft	N. Strampelli to G. B. Miliani	5	17
25	1915	N. Strampelli	Relazione sui risultati del nuovo frumento *Carlotta Strampelli* conseguiti nei campi regionali di prova	Report	N. Strampelli to G. Cavasola	26	27
26	?	N. Strampelli	Per la moltiplicazione ed il commercio del nuovo frumento *Carlotta Strampelli*	Rule book		19	2
27	1917	F. Girolami	Disposizioni	Bylaw		9	10
28	vv.	vv. aa.	Collection of articles about *Carlotta*	Newspapers		23	1

INDEX N.	YEAR	AUTHOR	TITLE	TYPE	FROM/TO	BOX	FOLDER
29	vv.	vv. aa.	Collection of articles about *Ardito*	Newspapers		23	2
30	?	N. Strampelli	Untitled	Notes		19	3
31	1919	N. Strampelli	untitled	letter	N. Strampelli to G. Rossi	12	8
32	1919	G. Rossi	untitled	letter	G. Rossi to N. Strampelli	12	8
33	1904	N. Strampelli	untitled	letter	N. Strampelli to G. Pasqui	5	6
34	1910	N. Strampelli	untitled	letter	N. Strampelli to the Minister of Agriculture	18	7

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