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Agronomists and accounting. The beginnings of capitalist rationalisation on the farm (1800-1850)

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1. INTRODUCTION

> *Figures are said to govern the world: when on earth are we going to understand more generally that the agricultural sphere must take this maxim seriously? […] When on earth are we going to understand that knowing how to count is the ultimate in agricultural experience? When are we going to admit that the latest word of agriculture to have been erected as industry is a figure?* (Lecouteux, 1870-1871: 1.369).

At the dawn of the nineteenth century, numerous debates took place about the development of capitalist agriculture and about the ways of making as much profit as possible from landed property. The analysts of the period, however, scarcely examined the management techniques that went hand in hand with such an ambition. This fact was at odds with what was observed in the commercial and industrial spheres, for which the links between the diffusion of double-entry accounting and the spread of commercial and industrial capi-

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talism was better known[1]. Nonetheless, a literature did already exist between 1800 and 1850 that aimed to reform the administration of large and medium-sized estates. This literature was to be even more successful during the second half of the nineteenth century. This article sheds light on these subjects, which have been little examined so far and which are specific in that they at once pertain to the economic history of agriculture, to the history of agronomy and to the history of managerial thinking. Essentially, our contribution aims to highlight the usages of double-entry accounting for running agronomic tests in the first half of the nineteenth century, as well as the valorisation of their results and the way these were debated.

Rural historians have examined farmers' accounting practices mostly as sources. When concerning long series, rural accounting offers invaluable references with regard to production orientations, farm profitability, savings, money flows, etc. (Hubscher, 1981; Garnier and Hubsher, 1984; Moriceau, 1994, Moriceau and Postel-Vinay, 1992). As appositely shown by Antoine (2000, 2009), «small accounting», though piecemeal and unpolished, is very interesting for a microeconomic approach to the functioning of farms. In some cases, a mere school notebook filled with accounts (Moriceau, 1995) or a pocket *agenda* (diary) kept on a regular basis (Joly, 1997; Madeline and Moriceau, 2010) is enough to approach the farmers' material lives and notice traces of change. Research on such accounting is generally not so much concerned with the bookkeeper's reasoning as with collecting information for documenting such or such a research question. In this line, when studying the transformations of accounting practices initiated by the physiocrats, Jean-Claude Perrot wonders «what accounting archives» these practices can «offer to the history of rural economy» (Perrot, 1978: 559). While he is concerned with the economic reasoning implemented in agricultural accounting, his aim is mostly to discover its biases, as they might distort the historian's reading. Actually, anthropologists, sociologists and historians have only recently focused on the farmers' ways of writing, counting and measuring so as to discern practical rationalities at work (Coquery, Weber and Menant, 2006).

In addition, an extensive literature has long been devoted to the description of «good» accounting practices with a view to orientating economic conducts. Since agronomic writings first appeared, their authors have always urged landowners to keep accounts and to make their estates yield a profit, as is indicated in the treatises from antiquity[2] or, closer to us, the *Livre des prouffitz champestre et ruraulx*, *La maison rustique*, or the *Théâtre d'a-*

1. For a summary, see Carruthers and Espeland (1991); Hopwood and Miller (1994); Chiapello, 2007.
2. For instance, Caton's and Xenophon's writings, as well as Gaulin (1994) and Minaud (2005).

griculture et mesnage des champs (Beutler, 1998). The texts we will examine here belong to this didactic tradition, which still remains largely unexplored. Just like the documents studied by Rossi (2007, 2013) in nineteenth-century Italy, they deal with profit-making. We will show how, in the early nineteenth century, French agronomists, who established close relationships with one another, adopted the techniques of double-entry accounting for managing their model farms and conducting their experiments. After indicating the authors' social characteristics and the sources we mobilised, we will analyse the effort at quantification undertaken during the period under consideration with regard to three areas of experimentation: plants, animals, and the use of a paid workforce. Our aim is to highlight the authors' justifications and the role played by bookkeeping in the elaboration of economically rational knowledge and reasoning[3]. Thus we will bring to light two mechanisms which are common to this movement of accounting quantification: data tabulation and the inclusion of this data in balance sheets, making it possible to compare inputs and outputs in the processes of production. We will finally discuss the impact of the mind-sets which the agronomists attempted to popularise during the first half of the nineteenth century and which participated in the construction of new technical, economic and managerial rationalities on the farm.

2. A VERY ACTIVE COMMUNITY OF PRACTISING SCHOLARS

At the beginning of the nineteenth century, agronomists living in various places in Europe developed a passion for experimentation. Sinclair in England, Thaer in Germany, De Fellemberg in Switzerland and Mathieu de Dombasle in France[4] exchanged ideas about the means to hasten progress in agriculture and about their respective works. They endeavoured to convince the leaders and large landowners in their respective countries that rational agriculture, that is, economically rational, could generate profits, at a time when «spending money in manure […] [came] to no capitalist's mind» (Anon., 1834: 4). These scholars, as well as their followers, were called *agromanes*[5]. They gave priority to the technique of double-entry accounting, which had to date been the preserve of merchants and factory owners. This practice led them to subject the tests they conducted to the demands of accounting measurement.

3. For reasons of lack of space, we will mention very briefly the probable effects this effort at quantification had on the individuals' conceptions of management and practices. In contrast, the consequences of such accounting techniques on economic results do not come within the scope of our research.

4. On Mathieu de Dombasle's relationships with his European counterparts, see Knittel (2010).

5. Most of them were notables or *cultivateurs* (large landowners) subscribing to agricultural societies and shows. For more detailed information on the sociological profile of these *agromanes*, see Désert and Specklin (1976); Gaboriaux (2008); and Vivier (2009).

These men of science shared three social characteristics. First of all, they decided to distance themselves from speculative science. As agronomy was undergoing institutionalisation (Denis, 2007), they advocated the search for practical solutions: tillage techniques, crop rotation, tool improvement, etc. As they were imbued with an engineering culture (Vatin, 2008), «optimal» profitability was their gospel. Then, some of these scholars took charge of model farms. They used lands under contracts, benefiting from private or public capital investments. This administrative task, as performed for third parties, required of them faultless management practices. Lastly, the agronomists provided training. They imparted their knowledge to wealthy young men or to mere stewards at the agricultural institutes usually adjoined to experimental farms, or again, they taught rural economy at the first state-run, agricultural further-teaching establishments (Grignon, Grand-Jouan) or at the Centre national des arts et métiers (CNAM). As teachers, they were led to formalise their accounting method so as to teach it. Later on, their students were to be the best propagators of an «intellectual practice» of agriculture.

The sources selected for this article have varied forms: agronomic treatises, rural economy and accounting treatises, letters, annals of model farms, accounting lessons from professional journals, etc. Most of these sources combined scientific and professional objectives, as they were designed for a readership familiar with academies and societies of agriculture, but also with farming practice. Thus we examined the *Journal d'agriculture pratique*, the *Annales de Roville*, *Le Cultivateur*, *L'Agronome*, the *Bulletin des sciences agricoles et économiques* and – as we are concerned with animal feeding too – the *Recueil de médecine vétérinaire*, the most important veterinary review of the period under consideration. Concerning the manuals and more general books dealing with agronomy and rural economy, as well as the treatises discussing specifically agricultural accounting[6], we have contented ourselves with studying publications by agronomists working with teaching institutions and model farms.

3. THE VALUE OF CROP ROTATION

At the beginning of the nineteenth century, the issues raised by agronomists were set within the context of a general scientific move: a move towards systematic measurement in most sectors of human activity and of nature. As recalled by Dujarier (2010: 137), «[the] measurement of time, space, populations and markets expanded simultaneously with the

6. We selected books specifically devoted to accounting based on the references provided by the *Bibliographie méthodique des ouvrages en langue française parus de 1543 à 1908 sur la science des comptes* (published in 1909) and the *Bibliographie agronomique ou dictionnaire raisonné des ouvrages sur l'économie rurale et domestique et sur l'art vétérinaire* (published in 1810).

monetarisation of the economy». Thus arises the question of the construction of market value and of its institutionalisation (Vatin, 2008) in industry as well as in agriculture[7].

As the heirs to eighteenth-century engineers, the «practising» agronomists sought management optimums. They hardly distinguished between what was connected with technique and what pertained to economics. This is clearly expressed by Thaer's *The Principles of Agriculture*:

> *The most perfect agriculture is, evidently, that which produces, by application of labour, the largest and the most permanent profit in comparison with the means employed. Systematic agriculture ought, then, to teach us all the circumstances by means of which we may derive the most considerable profit by the practice of the art.* (Thaer, 1844 [1809]: 1).

Research on crop rotation was without a doubt a major economic issue:

> *Notwithstanding the multitude of books on agriculture, there is scarcely an author, who, prior to the middle of the last century, seems to have formed any just ideas, either of the importance of judicious rotations, or the principles on which they ought to be regulated* (Sinclair, 1832 [1818]: 376).

In France, De Gasparin agreed with Sinclair's view when he advanced the idea that the rules of cultivation of crop rotation must not be separated from economic rules. But how to establish the value of a crop rotation? How to know whether such or such a crop succession is more profitable than another? How to anticipate labour costs and weed management-related problems, which will require varied answers? On all these points, De Gasparin advocated the systematic bookkeeping of receipts and expenses:

> *To manage in advance a cropping plan with regard to soil cleanliness, [the farmer] has to know exactly the number of working days that will be required for each season of the year as well as the number of working days when it will be possible to work during these seasons. The latter knowledge might result in the examination of weather tables, but [farmers] rarely possess [such tables] and it is rather through the perusal of well-kept accounting that [they] will make up for it, as [they] will indicate the number of working days per average year* (De Gasparin, 1843-1848: t. 5, 61).

7. As early as the mid-eighteenth century, the landed aristocracy was nonetheless concerned with knowing what their lands brought in and Lavoisier's accounting already provided the basis for comparative statistics (Lavoisier, 1862 [1792]).

In Germany and in France, the «agronomo-metric» current endeavoured to tackle the tricky issue of soil fertility. In the 1820s and 1830s, the fact that certain plants exhaust the soil more than others was already known, but at that time there were no precise figures of this mechanism. Although with the help of the first analyses conducted by the chemist Einhof, Thaer did offer to distinguish between classes of plants according to their soil-exhausting nature, his proposals were not satisfactory: De Valcourt (1841: 526), one of the great French specialists in ploughing implements, deemed these were «quite vague facts on data that were subject to controversy». Before the advances that were to be made in chemistry, the temporary solution to this problem came from one of Thaer's followers, namely, the German agronomist De Voght. After twelve years of experiments, he had enough data to develop an agronomo-metric scale.

In the sixth issue of the *Annales de Roville*, Mathieu de Dombasle praised his German counterpart for his «truly Germanic» patience. De Voght modestly stated that he had only «interrogated nature and recorded its answers», but De Dombasle noted that by so doing, De Voght (1830: 251) «forced [nature] to answer him with figures, for he interrogated it in this language». Just as one counts a till or calculates the receipts-expenses situation of a shop, De Voght wrote down an account of the situation of each plot on his estate, for which, year after year, he modified crop and manuring conditions. The numeric unit, which was arbitrarily decided on at the beginning of the experiment (theoretical estimation of soil «fecundity»), was refined by subtraction of the accounting results, by setting three series of data against one another: i) the land's level of «fecundity», ii) the fertiliser's level of «richness» and iii) the harvests obtained.

French commentators judged the process admirable, but too complex[8]. For Mathieu de Dombasle (1830a: 259), studying the relationships between series of numbers requires «tact and integrity of judgement which are not very accessible to farmers, even when picked from the highest ranks of this class». Before Liebig imposed «the reign of the laboratory» and the unique reference to the nitrogen unit, practising agronomists had hardly any choice other than to keep their accounts. Thus in his *Cours d'agriculture*, De Gasparin set out the results of almost forty years of research. These results were displayed in «reference value» tables concerning the chemical composition of plants[9] and the feed intake of the cattle[10]. The agronomist overtly despised «routine-minded farmers who do

8. For more detailed analysis of this doctrine, see Vatin (2006) on J.-E. Briaune. This agronomist and landowner followed Mathieu de Dombasle and Bella in making agronomo-metrics known in France.

9. De Gasparin compiled data from a score of his contemporaries, most of whom were Frenchmen and Germans.

their calculations by number of manure carts and assume all have the same value, since most often this comes down to likening a sack of debased coins to a sack of crowns» (Mathieu de Dombasle, 1830a: 78). Though, he deemed it was necessary to provide landowners with «rational instruments», so as to encourage the most educated to make their crop rotation choices on the basis of these value tables. Thanks to the double-entry technique, farmers learned to write down in their books the initial fertility of a plot of land to the debit of the value attributed to a terrain and to the credit of capital or inventory; then they learned to extract from balance sheets the crop combinations that were sources of profit or loss. That was at least the type of reasoning practising agronomists wished to spread by means of their writings, whether they considered plants or – as we shall see – cattle breeding and labour force management.

4. LIVESTOCK DIET

With respect to livestock feeding, the first half of the nineteenth century witnessed the junction of two distinct types of quantification which, apparently, had been separate before: on the one hand, the economic quantification of livestock feeds and products and, on the other hand, the chemical and physiological quantification of the substances passing from feed through the animal to its products.

4.1. Nutritional and economic value of feeds

At the beginning of the nineteenth century, farmers had essentially two means to compare the value of the feeds they could give to their livestock. The first one of course referred to monetary value. However, exclusive focus on this criterion and systematic search for lowest cost were gradually questioned by agronomic writings that attempted to take livestock from the status of «necessary evil» – which had to be undergone at the lowest cost possible – to that of productive element – from which as much profit as possible must be drawn (Bailly, Bixio and Malpeyre, 1849: 435; Moll, 1845 [1835]: 189). Now what was important was no longer minimal expense, but maximal profit.

According to these agronomists, empirical observations did show that for the same price and weight, feeds were more or less suitable for livestock. Thus the cheapest feed

10. For instance, he provided data taken from a study of the chemical composition of the feeds fed to twelve oxen, twenty milking cows and eight horses on his farm, from which he estimated the composition of the manure added to the soil.

was not necessarily the most profitable. For the first time in 1809 Thaer published feed tables with values expressed in hay equivalents. He built such tables as follows: he chose a reference feed (most often hay), then he stabilised the weight of an animal using this feed only. Lastly, he merely had to find out, by trial and error, the appropriate quantities of the various feeds required for achieving the same result, that is, the animal's stabilised weight. Thaer's followers justified the proliferation of such tables arguing that it was not necessarily possible to generalise the results obtained for a given animal and for a specific task. Along this line, Masson-Four embarked upon setting up tables based on the same type of experiment (Masson-Four, 1837: 75).

With this movement of quantification, the transformations of chemical techniques for analysis that had taken place since the beginning of the nineteenth century made it possible for several scholars to publish detailed compositions of specific feeds, and even tables comparing the composition of several feeds, most often with regard to nitrogen content[11].

For instance, with a view to taking farmers away from comparisons between weights or weight-for-weight substitutions, Humphry Davy, a chemist, provided them with a particular index for comparing the efficiency of feeds that was based on the nutritional material-feed total weight ratio[12]. For some agronomists, these chemical equivalents remained purely speculative reflections. Mathieu de Dombasle cautioned agronomists against taking an exclusively speculative interest for such issues, which would thus be disconnected from agricultural practice, that is to say, from economic exploitation (Mathieu de Dombasle, 1833). Levelling criticism at Davy's previously mentioned book, De Dombasle did not hesitate to state that, taken to extremes, such works yield only «absurd results», though they are presented as «sufficiently exact for agricultural research» (Mathieu de Dombasle, 1828: 148, underlining in the original)[13]. In De Dombasle's view, the only possible way of estimating «quite exactly the economic properties» of livestock feeds is to compare the results provided by chemistry with the data derived from experimentation.

11. On nutrients, see Orland (2010). On the history of the chemical techniques of organic compound analysis, see Holmes (1971).
12. See Chaptal (1823) and Boussingault (1836).
13. To do justice to Davy, we nonetheless need to specify that he related his experiments with more qualification than De Dombasle admitted. He considers as only «probable» the fact that the quantities of nutritious substances should provide indications for the use of feeds in agriculture and he insists on the fact that «these quantities cannot be regarded as absolutely indicating their value» (Davy, 1819).

4.2. Input and output

According to De Dombasle, one would need to «measure and estimate the financial value of all material flows that move from one place to another on the farm, so as to become aware of the improvements to be made in the administration of livestock. Each item has its own accounting book, with receipts and expenses» (Boulaine and Legros, 1998: 75). In the specific case of livestock, it is appropriate to keep accurate accounts, systematically debiting feed to animal and crediting the products obtained, such as working hours, manure, etc. (Mathieu de Dombasle, 1830b).

But De Dombasle came up against a problem already raised by other writers: how to set up accounts, expressed in financial value, of the flows of organic matters between feeds, livestock and the products derived? Thaer himself admitted that «without a doubt it is absolutely necessary to reduce all elements to one common measure, and it would hardly be possible to decide on any measure other than money», while recognising that in the case of agriculture it was very hard to attribute a price to things «which cannot be carried out immediately» (Thaer, 1844 [1809]: 205).

Aiming to overcome such an obstacle, Louis Moll proposed using a *livre de notes*, a notebook, for accounts in kind (Moll, 1841). Just like «accountant» farmers, authors of manuals of accounting applied to agriculture were faced with the same issue. In his *Agenda de comptabilité agricole*, Joubert noted that keeping double-entry accounting on purely economic bases is accessible to a tiny bunch of farmers while, paradoxically, «it is quite certain that, today, order is as essential to farmers as it is to bankers» (Joubert, 1846: 2).

Despite practical difficulties, the 1830s and even more the 1840s saw a large body of research set up balances for livestock feed intake, economically comparing the income and expenditure of the animal production process. The authors of these balance studies used two distinct techniques: either they took an inventory of the diets empirically given to livestock and drew up the related balance so as to find the best of them, or they themselves carried out experiments so as to find the diet which, at the lowest cost, yielded maximum product (Wohlfart, 1841; Anon., 1836; Anon. 1837; Dailly, 1838).

Alongside the proliferation of financial balances and the reform in agricultural accounting as applied to livestock, agronomists trained in chemical analysis as well as in economic exploitation were to resolve the tricky issue of equivalents between feeds and animal products. To this aim, they combined equations which had to date been written as separate items: financial accounting and animal production material with chemical analysis of feeds and compilation of practical experiments.

As early as 1831, Mathieu de Dombasle sensed that it was necessary to unify economic balances and chemical analysis of animal products to ensure the smooth running of agriculture. Thus, «by subjecting all animal products to a common scale, we would cast a brilliant light into the darkest corners of rural economy» (Mathieu de Dombasle, 1831: 147).

While the best agronomists versed in animal chemistry did manage to mix financial balance with chemical balance without discrimination, like Royer, for instance, in his *Note sur la question économique de l'engraissement du bétail* (Royer, 1840a), the chemists dealing with agriculture were those who massively answered De Dombasle's call. In the mid-nineteenth century, jobs available in «pure» chemistry were not numerous enough, so that a number of chemists turned to resolving agronomic issues. Among these agronomists was Jean-Baptiste Boussingault.

One of the first realisations in this line was Boussingault's drawing up of purely chemical balances, as against what agronomists did at that time. We do not say here that Boussingault was the first to draw up chemical balances of a physiological process; he was the first to stamp agronomists' minds on such a long-term basis. Thus he showed, just as De Dombasle suggested, that animal products are the direct equivalent of feeds consumed: nothing is miraculously created by the animal or taken by it from ambient air[14]. The logical consequence of such research is that chemical units would, just like monetary unit, make it possible to draw up balances a posteriori and, most importantly, to anticipate the livestock feed intake required.

5. WORK ACCOUNTS

As the vast majority of them managed large estates, the «practising» agronomists and their followers managed their personnel as true capitalist entrepreneurs. The way they considered the acquisition, cost and supervising of workforce broke with the practices in use at the time: «While work is one of the main objects of agriculture, [farmers] have too often failed to take note of it and to calculate its cost», Thaer said (1844 [1809]: 202). Royer (1840b: 12), a former postmaster, a steward and accountant[15], even suspected that

14. The experiments were first published in 1839 (Boussingault, 1839). They were popularised by a course Dumas delivered at the Medecine school, as this course was published in article form in 1841 and in book form in 1842. On this point, see Depecker (2014). For a detailed analysis of Boussingault's experiments in the scientific context of the time, see McCosh (1984) and Aulie (1970).
15. Then he became a professor of rural economy at Grignon (from 1838 to 1840) and a general inspector of agriculture in 1843.

landowners were losing «quite considerable amounts of money in certain petty work operations without being aware of it». To begin with, introducing order into the administration of an estate required the daily recording of work operations. Agronomic treatises of the first half of the nineteenth century stated that this is the only means to know the true cost a day worked by servants and piece-workers, women and children.

5.1. How much does a working day cost?

The small landowner using family workforce focused his economy on the quantity of work to be done. In contrast, the large landowner had to resort to outside workforce; he did not consider labour in terms of task rate, but in terms of hour rate. Thompson (2004, [1967]) reports that in the mid-eighteenth century landowners assessed their workforce needs in «working days», and this procedure is without a doubt older[16]. In *The Code of Agriculture*, Sir John Sinclair devoted a few pages to the hours worked by animals and men. According to soil quality and the techniques in use, he also mentioned calculations of the time required for ploughing among landowners of various counties in England. In Germany, Thaer signalled the references offered by the manuals of agriculture and political economy of the second half of the eighteenth century[17]. Translating these two famous agronomists, Mathieu de Dombasle too endeavoured to study the length of time required by each of the tasks to be performed on his «exemplary» farm of Roville:

> *As earnestly and precisely as possible, I have provisionally assessed the cost of an hour worked by a man, a horse, etc. The balance of my accounts then shows me whether I have been mistaken and thus indicates quite accurately the true price of the working hour and, consequently, the expense actually entailed by each type of work I entrust my teams with* (Mathieu de Dombasle, 1824: 119).

As he had a great liking for detail, De Dombasle gave several instances of underestimated costs, such as that of the horse-using hour (initially estimated at 15 *centimes*, then at 20 *centimes*) and of overestimated expenses, such as bread consumption on his estate.

Work standards are never set once and for all and are rarely mechanically translatable from one farm to another, insofar as a number of factors are to be considered: men, techniques, climate. However, practising agronomists set out to develop such standards and

16. In his 1967 article «Time, Work-Discipline and Industrial Capitalism», Thompson refers to Markham's treatise, *The Inrichement of the Weald of Kent* [tenth edition, 1660].
17. On this point, (Thaer, 1844 [1809]: 100) extols the perfect accuracy of the economic calculations worked out by Count de Podewills at Gusow.

endeavoured to spread them across Europe. In his *Principles of Agriculture*, Thaer employed a particularly accurate method for describing agricultural activity. He split farming operations up into as many tasks as appropriate and assessed the optimal length of time required for each of them. Sometimes he made a few remarks on the expected quality of work[18]:

> *Spreading the dung on the land. It is generally admitted that a woman can spread an acre and a quarter per day, and a man an acre and a half or two acres per day. But this depends much on the quantity of manure which is to be spread, and on the state of it, and on the care which is taken to divide it as much as possible and distribute it equally. This last mentioned point is of so much importance, that no pains should be spared in attending to it. Manure containing much straw often requires to be thrown into the furrow with a rake or pitchfork, and this operation requires a man for two ploughs, and sometimes even for one* (Thaer, 1844 [1809]: 102-103).

This detailed inventory was repeated for each activity, considering the characteristics of the crops grown and hectares worked. The inventory was made possible by keeping records which provided an accurate image of the time men and animals spent doing the varied farm operations. Choosing the hour as his unit, Thaer assessed the working days of one horse, of two spare oxen and of workers (men and women) and, step by step, set out work standards (in terms of quantity and cost) that applied to the whole crop cycle. In his *Principles of Agriculture*, Thaer provided his readers with long tables of numbers that made it possible to anticipate the acquisition of labour, as the cost of workforce could increase considerably when hands were becoming scarce at certain times of the year.

The quantification of working times is interesting in that it does much more than merely permit a «forward-looking management of jobs». These work metrologies went hand in hand with new possibilities of control. At the Roville Institute, the foreman was charged with filling personnel auxiliary books, which enabled him to control the work done by each employee of the farm. Mathieu de Dombasle (1824: 133) recommends to give each man «always a fixed and determined task». Favourable to the development of large farms, he did find several advantages to such work division[19]:

18. For manures, among other items, the agronomist distinguishes between the following operations: carrying outside the cowsheds, unloading, heaping up, turning and watering. He does this for six other work items.
19. For this he based himself on a sugar factory established on his estate, which went bankrupt before he moved to Roville.

> *This is the only means to ensure that everyone will take interest in his task and get used to performing it with the utmost care. This is also the means to devolve some responsibility on those who have been charged with the execution of each task* (Mathieu de Dombasle, 1824: 134).

Royer (1840b: 10), for his part, deems it is «perfectly useless to know which day worker has done such or such work», preferring to rely on the careful observation of the crop supervisor or of the steward to sanction bad workers. On the other hand, he considered accounting to be very useful for controlling employees as a whole. While the idea of constant control has to be abandoned, accounts prove that «time has not been lost» (Royer, 1840b: 10). This approach, Taylorist before its time, attempts to rationalise productive resources but stops along the way, since one can hardly contemplate pinning workers down to one task, after the fashion of factories (Mathieu de Dombasle nonetheless recommends this for day workers).

Most of Thaer's and De Dombasle's correspondents and followers took such work quantification even further. *La Maison Rustique du XIX*e published the costs of a working day for a servant, a horse and an ox, as worked out on five experimental farms –Valcourt, Roville, Grignon, Hoffwyl, Vorages – (Malepeyre, 1836: 527). In his *Mémoires sur l'agriculture*, De Valcourt (1841) reviewed the references established at Roville, Grignon, Grand-Jouan, Hoffwyl and those he had drawn up on his own estate. De Gasparin, for his part, adopted quite a different method, as he proposed a calculation independent of productive activity. Within the context of strict reproduction of the workforce, he aimed to fix the price of a working day based on annual family income. He reasoned based on the father's, mother's and three children's income, so that he had to consider numerous statistical items: for instance, he used Montferrant's infant-mortality tables so as to work out the optimal number of children a family needed to have for replacing one adult worker (Valcourt, 1841: 52); Riedefel's works on sheep «maintenance feed intake» (Valcourt, 1841: 53); Cato's writings on the feeding of slaves in ancient Rome (Valcourt, 1841: 53); the data concerning ascetic monks and soldiers and expressed in nitrogen percentages; etc. Furthermore, De Gasparin worked out his own statistics on the basis of the accounts he kept on his estate. Thus he estimated the weight of wheat a worker consumed every day (Valcourt, 1841: 54) and his expenses for food, rent, clothes, heating, lighting, tools and utensils (Valcourt, 1841: 57). As an ardent advocate of the large property, De Gasparin deployed considerable energy for calculating the «fair» price of a working day, as he sought to avoid any wage excess.

5.2. Calculating the useful effort

During the 1840s and 1850s, the efforts towards quantification took a new direction, revealing how agronomists believed in figures. They introduced the concepts of «useful effort» and «tiredness» into their vocabulary, along with the results from experiments carried out by eighteenth-century engineers, such as Vauban, Coulomb, Lavoisier, de Saussure, Quetelet, etc. Thanks to his persistence, the mechanic De Valcourt, who had an estate at Toul, adjusted the «dynamometer» to ploughing implements[20], thus achieving a breakthrough in the knowledge of animal-traction capacities. Concerning human traction, experiments conducted by the Génie engineers, notably J.-V. Poncelet's, gave rise to true competition in the agronomic sphere. Their results were disseminated by means of publications designed for a wider public, such as *L'année agricole, almanach illustré des comices, des propriétaires et des fermiers*[21]. The useful effort, calculated to the second and related to the number of hours worked, made it possible to determine the quantity of daily work that could be required of an animal or human being in extremely well defined situations: «a labourer raising the ground level by an average height of 1.6 m with a spade […] a 360-kg horse harnessed to a 500-kg cart loaded with 940 kg of materials and walking on a good metalled road»[22]. The publishers who popularised the results of these mechanical studies deemed they would be useful to farmers. The latter were advised, among other things, to be perfectly aware of the slopes along the paths that led to their farms, so as to adjust the load of their carts as appropriate and enquire as to the conditions of roads:

> *One can see the interest the farmers have in maintaining the farm pathways in good condition, as the effort is of 33 kilograms on a very well maintained road, of 80 kilograms on a correctly maintained road and of 125 kilograms on appropriately placed gravel*[23].

Here again, De Gasparin back (1843-1848: t. 3, 39) distinguished himself by the large number of references he considered for defining the useful effort, including the measurements worked out by Buffon, Régnier, Rausom and Péron concerning the strength of wrists and Quetelet's results for these same items with respect to sexes and age groups (De Gasparin, 1843-1848: t. 3, 39); Schulze's measurements of the walking speed of a

20. The dynamometer is a resistance-measuring instrument initially devised to measure the resistance of the steam machine and of hydraulic wheels. Following a series of technical adjustments made by De Valcourt, the first dynamometer was presented at the Grignon show on the 16 June 1832.
21. Heuzé (1862).
22. Barral (1861-1862: 1.029, 1.031).
23. Barral (1861-1862: 1.033).

pedestrian (De Gasparin, 1843-1848: t. 3, 41); Coulomb's and Poncelet's calculations of lifting strength (De Gasparin, 1843-1848: t. 3, 43-45).

6. CONCLUSIONS

The first half of the nineteenth century was the scene of agronomic experiments that, in a new fashion, called on the technique of double-entry accounting at several points across Europe. Double-entry accounting was applied to the circulation and transformation of material flows in various branches of the farm (the unit was, for instance, the cowshed, fattening pigs or such or such a cereal crop). During the nineteenth century, certain agronomists – those who were closest to chemists (Jas, 2001) – also applied this technique to the study of physiological and biological processes of production. They did not examine or compare the interest of fallow with that of continuous cropping, or of sheep breeding with that of oxen in such or such a cropping system (which would involve keeping a record of the flows of manure, cereals, fodder, work, etc. between each branch of production so as to monitor their transformations and measure, in the end, their profitability). Instead, they thought about biological units (for example a cow, a grain) as machines to convert with a view to understanding the natural mechanisms, input and output flows through which oxen produce their grease, the grain produces its ear, and to managing them in the most economical manner.

In François Dagognet's words, in the mid-nineteenth century the aim was to found a «plant, animal or even human science» which can be reduced to:

> *a game of hide-and-seek: watching out for what enters the organism, also measuring what is eliminated from it, that is, estimating the difference thereof, so as to discover, by subtraction, what is incorporated and what this becomes in the living organism […] Animals and plants are no more than machines to convert: it is important to accurately calculate inputs and outputs and draw up a balance of them so as to know, afterwards, what one must give [to animals and crops]* (Dagognet, 1973: 138).

The accounting techniques that practising agronomists attempted to adjust to the context of agricultural production and the knowledge developed with the help of such tools did not assert themselves, by the mere strength of their efficiency or evidence. On the contrary, the implementation of the accounting models we have studied met with much resistance. The templates these models put forward, and more importantly the types of reasoning they required for being applied or at least heard, were far too remote from the

reasoning of the vast majority of farmers, including that of large landowners. The latter stuck to their habits and calculated the value of work and the wealth of a farmer based on criteria other than those of strict economic rationality. Moreover, a large majority of peasants farmed very small tenures, and a significant number did not master more than the basics of reading, writing and counting. The objective of the reform of accounting practices – and, in the background, of the farmer's relation to work, to the market and to the economy – would need over a century to materialise. Scholarly elites particularly committed to this objective at the beginning of the nineteenth century provided the first guidelines for management. These guidelines were retranslated, simplified and reformulated, so that a discipline of numbers and writing gradually emerged on the farms (Joly, 2011), owing to multiple socialisations: on school benches, in vocational training establishments and in agricultural domestic economy schools, in the company of agricultural teachers, itinerant schoolmasters, popularisers and agricultural advisers.

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