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Genetic Engineering Technology in Plant Breeding and Respect for the Environment

by

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Abstract

The aim of this thesis is that of considering whether the application of genetic engineering to plant breeding can be deemed as a practice that respects the natural environment. Drawing on the constructivist approach elaborated by Andrew Feenberg, the idea is supported that genetic engineering, as any other technology, is not value-neutral but embodies values. Consequently, genetic engineering cannot be regarded merely as an alternative method to obtain agricultural products, but has to be assessed taking into account the values involved in its possible applications.

Since there is not a shared idea neither of what respect for the environment means nor of what a respectful attitude to it should imply, different conceptions of respect will be taken into account. Two of the four conceptions considered, biocentrism and what will be called the naturalness approach, condemn genetic engineering as a technology that is inherently disrespectful, precluding therefore any of its possible applications. Whereas the other two, anthropocentrism and ecocentrism, do not see this technology as inherently disrespectful, leaving space to some possible designs of genetic engineering in accordance with their views of respect for the natural environment.

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Introduction

The Gene Revolution can be considered the third of the main changes that invested the history of plant breeding since, about 12,000 years ago, human communities in the Middle East initiated to domesticate the first species of plants. That was the first revolution, also known as the Neolithic Revolution, and coincided with the outset of agriculture and the consequent human departure from the hunting-gathering system of subsistence that characterized the first forms of human life.

Plant breeding was essentially conducted by means of craft technology. With the passing of millennia, more and more complex tools were developed with the purpose of selecting and cultivating species most suitable for humans needs. But we have to wait until the first half of the twentieth century if we want to appreciate another really significant step in breeding technology. That is, when plant breeding met for the first time the science of genetics. The 1930s are the years when the genetic laws of Segregation and of Independent Assortment, published by Gregor Mendel in 1866, were rediscovered and applied to agriculture. These two laws enabled farmers to hybridize sexually related plants on the base of their phenotypical characters in order to suppress or develop some specific traits.

It was only forty years after that last major technological progress that the Gene Revolution took place. In 1973 the biochemists Herbert Boyer and Stanley Cohen tuned up a technique called recombinant DNA and created the first genetically engineered organism by inserting a piece of foreign DNA into a bacterium. An event that was made possible by the incredible developments of molecular biology after the discovery of the structure of DNA by James Watson and Francis Crick in 1953. DNA is a nucleic acid that encodes all the instructions necessary for the development and the function of any living organism. The minimum segment of information contained in DNA is called gene. Roughly, at any gene corresponds a specific biological heritable trait. Once this method to transfer genes from an organism to another was discovered, researchers were offered the chance to create new plants by looking for genes that could express a desired trait into the genome of whatever organism. Even of organisms not necessarily belonging to the vegetable kingdom. Ten years were needed after Boyer and Cohen's successful experiment to finally present the first application of recombinant DNA technique to agriculture, with the development of an antibiotic resistant tobacco plant.

As we can imagine, the potentialities opened by this new technique are enormous. Whenever a desired trait is found in an organism not sexually compatible with the plant we want to 'improve', it may be transfered applying genetic engineering. However, genetic engineering has been, so far, the most controversial application of technology to agriculture. Together with its potentialities rose a series of ethical concerns that can be summarized in the following three main categories; the third of which will be the focus of the present thesis.

Firstly, food safety. Due to the fact that genetic engineering allows genetic combinations that would hardly or never occur in nature, it is argued that plants modified using this technology could have undesirable effects on human and animals' health.

Secondly, socio-economical implications. Developing and releasing a genetically engineered plant does not only require great scientific knowledge and technical expertise, but involves also high costs. Generally, those that can afford such costs are only big multinationals. Multinationals that are driven by the foreseeable profits they could make thanks to the patent regime that protects the development of a new product. This whole situation, and here lies the reason of concern, implies a power shift from farmers to the technocracies and multinationals that develop engineered plants.

Finally, impact on the environment. The employment of genetic engineering in plant breeding has opened a vivid debate about the risks that this technology poses to the environment. Debates on environmental risks are not new in agriculture. Also some traditional practices, like the use of chemicals, have been criticized for their harmful effects on the environment. However, given its enormous potentialities of altering the behaviors of crops, and consequently their interaction with the surrounding nature, genetic engineering is being accused of being an inherently risky technology.

All these three concerns are in some ways related. The solution to an environmental issue, for instance, can be questionable for its socio-economical impacts and *vice versa*. The problem of a possible contamination of wilderness could for example be solved by adopting the so called 'terminator' technology. That is, inserting into the plant a gene that makes its seeds sterile, which would avoid its spreading into the wild. Yet, this answer to an environmental issue has a side-effect on the socio-economical level as farmers who adopt this technology cannot store their seeds any more; becoming *de facto* dependent on their supplier company.

Unravelling the controversies surrounding the adoption of genetic engineering in plant breeding requires a profound analysis that cannot avoid to take into account and connect all the three levels of the debate. The aim of this thesis is however decisively more circumscribed and focused only on the third of the mentioned concerns: the impact of genetic engineering on the environment. As the issues on food safety and the socio-economic aspects of this technology play a pivotal role for its assessment and eventual development, the intent is not therefore that of giving a conclusive argument for opposing or advocating the use of genetic engineering.

Neither will be attempted to decide whether the environmental risks genetic engineering poses is worth its adoption. Much of the debate around this technology is based on a cost-benefit analysis in which advocates and opponents try to demonstrate the validity of their positions on the base of scientific facts. Yet, the scientific community, as it will be pointed out, is everything but unanimous in evaluating these risks. Moreover, the debate on this respect would turn on how to evaluate and regulate technology in a situation of uncertainty. An aspect that will not be developed here.

Instead, without forgetting the environmental risks posed by the adoption of genetic engineering, this thesis attempts to evaluate the technology in connection with the idea of respect for the natural environment[1]. In specific, the question addressed here is: *can plant breeding that makes use of genetic engineering technology respect the environment?*

What is investigated is whether, from an environmental perspective, there is something inherently wrong with the application of this technology. Drawing on the constructivist approach to technology elaborated by Andrew Feenberg, it is maintained that genetic engineering, as any other technology, is not value-neutral but embodies values. Some of those values are part of its essence, whereas others can be tailored during its design process accordingly to the values shared by the society that adopt this technology.

It is therefore necessary to evaluate whether genetic engineering can embody respect for the natural environment as one of its own values. In order to do so, four conceptions of respect for the environment will be taken into account. The first one is the anthropocentric view for which the respect due to the environment derives from the respect other human beings deserve. The second is the biocentric conception for which any individual living being has to be considered intrinsically valuable and thus deserve the same grade of respect. The third is the ecocentric position that considers disrespectful any form of human behaviour that threatens the preservation of biodiversity and the stability of ecosystems. Finally, a conception that will be called the 'naturalness approach' which, supporting an idea of partnership between humans and nature, links the respect for the environment to the promotion of natural occurring processes.

1 The expression 'natural environment' is used here to signify the totality of biotic and abiotic entities present on earth, excluding human beings. For convenience it will be mostly referred to as simply 'environment'.

Once we have delineated these conceptions of respect it will be possible to evaluate if the use of genetic engineering can be compatible with them or not. By matching these four with the constructivist view of technology, it is argued that whether genetic engineering can be considered as a disrespectful practice will depend on which of the four conceptions of respect will be taken into account. In particular, genetic engineering inherently represents a form of disrespect for the environment for both the biocentric and naturalness approach. Therefore its application to plant breeding cannot be considered as a feasible alternative to other agricultural practices. Differently from these two positions, either anthropocentrism and ecocentrism do not completely exclude the chance of applying this technology to plant breeding. Whether its use in agriculture could count as a respectful practice will depend, from these two latter perspectives, on a case by case evaluation of its possible applications.

The thesis is structured as follow. *First chapter*: introduction to the technology, its environmental risks and the debate within the scientific community. *Second chapter*: presentation of Feenberg's constructivist approach to technology. *Third chapter*: summarization of possible ways to intend respect for the environment in environmental ethics. *Fourth chapter*: evaluation of genetic engineering technology on the base of the different conceptions of respect for the environment.

First Chapter

Genetic modification: terminological disambiguation

Until now we have talked of genetically engineered organisms. Yet, the common name to refer to those organism is 'Genetically modified organism'. This latter is, however, a quite unhappy expression whose *signifier* does not make justice of its *signified*. In fact, when we speak of genetically modified organisms we do not simply refer to an organism that has undergone a modification of its genome, but also and foremost to the process that has led to such a modification. In specific, with 'genetically modified organism' is meant an organism that has been genetically modified by means of genetic engineering techniques (also known as recombinant DNA technology). It is good to notice that, strictly speaking, it is erroneous to say that a crop is a 'genetically modified' simply because it has undergone a genetically engineered modification. All crops are in fact genetically modified as a result of human domestication (see Doebley *et al.* 2006).

Genetic engineering allows the alteration of organism genotypes by asexual transfer of a new sequence of DNA. Basically, it consists in the manipulation of the DNA outside the organism in order to isolate a gene or a set of genes of interest and in its reinsertion by means of a vector (the most common vector used for plants is a bacterium called Agrobacterium Tumefaciens) in a host organism that we want to modify. If the gene transferred comes from the same species, the modified organism is said 'intragenic', whereas if it has its source in a different species it is called 'transgenic'. Other differentiations, depending on the source of the gene, are: 'famigenic' (same family); 'linegenic' (same phylogenetic lineage); and xenogenic (the gene does not exist in any organism, but has been synthesized in laboratory) (Nielsen 2003). All these last definitions would be more appropriate. However, unless essential for the argumentation, they will be mostly overlooked in the present text and the more general designation of 'genetically engineered' will be preferred. This said, the very presence of all these differentiations shows the major novelty in recombinant DNA techniques: they permit the genetic modification of crops by using any genetic source; including plants not sexually related, as well as viruses, bacteria and animals (potentially, even human animals).

Genetic engineering vs. traditional breeding

Genetic engineering is based on the assumption that whenever a gene expressing a desired trait has been individualized and isolated, it is possible to move it into another organism so that it will develop the desired trait[2].

Trying to make a crop develop a desired trait is not a novelty in agriculture. Traditional practices attempt to realize hybrids which combine characteristics of different varieties by crossing plants sexually related on the base of their phenotypical aspects. Since many generations may be necessary before the desired combination of traits will be found, this is a process that requires the investment of lots of time. While, adopting genetic engineering to transform an existing variety into one with some new desired traits takes generally less than one year (Rommens *et al.* 2007: 399).

The major problem in developing new desired traits by using conventional cross-breeding is that the gene responsible for the desired trait is rarely known (Clark and Pazdernik 2009: 399). Traditional crossing, in fact, involves the movement not only of the gene of interest but, together with it, also of several other genes that cannot be monitored (Lemaux

2 This assumption is only partly true. Or better, it oversimplifies the real situation. Genes, in fact, operate contextually with their surrounding environment. Once the environment has changed, the gene could express different traits (see Holdrege and Talbott 2008: 59). That does not means that it never expresses the traits engineers where looking for; rather that it could happen that those traits are not present in the receiving organism because of the recontextualization of the gene.

2008: 774). Under this respect, as stated in the FAO report 'The State of Food and Agriculture 2003-2004', genetic engineering is surely “both a more precise extension of breeding tools that have been used for decades and a radical departure from conventional methods” (2004: 5).

As already said, with GM technology it is possible to look for genes that could express desired traits not just in sexually related plants, but in all the living realm, or even to synthesise in laboratory completely new genes. This chance allows humans to develop crops with characteristics that otherwise would never occur in nature and that would be difficult or impossible to obtain by means of conventional breading.

Examples of applications

The potentiality offered by genetic engineering to agriculture have been mostly employed with the purpose of developing resistance to pests, herbicides and diseases, to enhance nutritional traits, to improve performance in hostile environments, and to increase yields.

Among the most known genetically engineered crops there is the so called 'Flavr Savr' tomato. It became particularly famous as, appearing on the market in 1994, it was the first commercialized genetically modified food. These genetically engineered tomatoes were developed by inserting a gene able to slow down the ripening process. This would permit tomatoes to ripen in the sun before picking, giving them a better taste. On the side of producers and distributors, the conveniences were that the modified crops would not force farmers to pick them when green, as well as a long life in the shelf[3].

Another famous example of genetically engineered food is 'Golden Rice', which was

3 However, Flavr Savr tomatoes did not meet their expectations and were withdrawn from the market in 1997. Beside the marketing controversies and financial troubles of Calgene (the firm that developed the Flavr Savr), the reason for their failure was that, even though the rotting process was slowed down, the skin of the tomatoes continued to ripe becoming soft. This made the new tomato susceptible of damages when managed with traditional harvesting equipment which were studied to work with the harder skin of green tomatoes (Martineau 2001).

developed with the purpose of alleviate the deficiency of vitamin A in developing countries diets. Especially in Asia, where rice constitutes the main aliment. This quality of rice was obtained by the insertion of three genes, two of which extracted from the DNA of a plant (daffodil) and the other one from a bacterium. Grains modified in this way contain an increased amount of beta-carotene that, when in the body, will be converted in vitamin A. Technically, Golden Rice has been definitely more successful than the Flavr Savr. Nutritionists found that when included in diets poor of vitamin A, illnesses due to deficiency of that vitamin were effectively alleviated (FAO 2001; and Grusak et al. 2009)[4].

So far, the plantations that have been more invested by the development of genetic engineering technology are maize, soya, rapeseed and cotton. These crops represent, at the moment, the four most cultivated genetically engineered plants on earth. Their modification is aimed above all at the development of resistance to herbicides and pests. This with the purpose to rationalize better the use of both herbicides a pesticides. In the case of herbicides, they are unable to differentiate between the crop and the weeds farmers want to eliminate. Therefore, in conventional breeding weaker herbicides are used in order not to harm the crop. Yet, this solution requires several applications of herbicide before weeds will be eliminated. Growing up a genetically engineered plant with a herbicide resistance trait would allow farmers to use a stronger product able to eliminate weeds in one or few applications without the risk of damaging the crop. Resistance to pests, instead, is obtained by inserting into the genome of a plant a BT toxin noxious to insects. Once the plant develops the resistance the use of pesticide will be reduced drastically.

4 Nonetheless, experts are divided on considering Golden Rice the most appropriate solution to the dietary deficit of vitamin A that afflict some developing countries. Indeed, some of them argue, this boosted rice is only one of the opportunities to solve the problem, but not necessarily the most feasible for the socio-economical situation of those countries for which it is destined (see Mayer 2005 and van Wijk 2002).

Benefits and risks

It is clear that, differently from the examples of the Flavr Savr and the Golden Rice, developing traits such as herbicide and pest resistance has direct repercussions on the environment. Diminishing the use of harmful products such chemicals would surely be considered beneficial.

Other potential benefits for the environment of this technology are directly linked to the chance of increasing yields. The obvious advantage is that this would imply the preservation of natural habitats as less land would be required for the purpose of cultivating the necessary crops (Wolfenbarger and Phifer 2000: 2091).

Moreover, genetically engineered plants can be modified in order to enhance their phytoremediation properties; that is their capacity of restoring soil quality from pollution due to toxic substances such as heavy metals (*ibidem.*).

But the advent of genetic engineering in plant breeding did not only bring positive expectations. Critics of this technology tend, indeed, to underline its potential risks rather than its potential benefits. Among the most common cited risks there is the chance that in the long run those that are believed as advantages for the environment will turn out to have harmful consequences. The worry is that inducted genetic modifications could have unexpected consequences such as the development of 'super-weeds' that will become resistant to strong herbicide. With the result that the elimination of weeds will be more difficult than it was before and will require massive applications of herbicides. And the same argument has been made in relation to the use of pesticides (FAO 2001: 20).

Another foreseeable problem is the possible effects on non-target organisms such as insects that are not pests. The most famous example are Monarch butterflies which seem to be threatened by the presence of Bt toxin in genetically engineered crops.

All these risks are furthermore amplified by the potential invasiveness of genetically engineered crops. That is to say, the chance that non-enginereed crops will be contaminated by the new plants. As we have already noticed in the introduction above the chance of contamination could be avoided with the development and application of technologies such as the introduction of 'terminator' genes which make the plant sterile. However critics are sceptic about the result of those solutions and claim that the risks of invasiveness can still remain.

It is obvious that most of what is disputed about the potential benefits and risks of this technology can be solved, if at all, only on scientific grounds (Thompson 2007: 8,166). The problem is that there is no general agreement within the scientific community about the likelihood of either benefits and risks. What seems to be clear is that, whenever empirical data are presented in order to support the evidence of some beneficial or harmful impacts of genetic engineering, the scientific methodology used for assessing those impacts will be criticised by other scientists (see Verhoog 2004 and 2007). Furthermore, to make the situation even worse, there is the fact that field experiments in ecology could take years before some valid results can be gathered (FAO 2001: 19).

Deciding whether the application of genetic engineering to plant breeding is detrimental or has positive effects on the environment requires two levels of philosophical analysis. The first one deals with the values at stake in the development of technology. The second concerns risks assessment in cases of scientific uncertainty. These two levels are hierarchically related since the second one depends in some ways on the first level. What constitutes a risk is in fact a matter of value. As noted by Alan Raybould, part of the controversy surrounding risk assessment is due to the confusion about what should be protected (2006: 120). That is to say the confusion depends on what should be considered valuable.

It is important to notice that in technology assessment the first level of analysis is required also in cases where we face substantial scientific agreement. On this respect Peggy Lemaux pointed out that we cannot take for granted “that people possessing the same scientific understanding will necessarily make the same choices [...], because different people have different values ” (Lemaux 2008: 773).

The contribution of this thesis to the debate on genetic engineering in plant breeding, has to do with the first of these two level of analysis. In the following chapter a constructionist conception of technology will be presented with the purpose of supporting the idea that not all the values at stake depend on how genetic engineering is used. Some of them are in fact part of its essence whereas others can be shaped into the technology during its design process. This latter will reflect the values shared by the society that decides to adopt the technology.

Second chapter

Technology embodies values

In contemporary philosophy of technology the idea that technology is not neutral but embodies cultural and ethical values is generally shared. This position denies the assumption that every technology can be employed indifferently for beneficial or harmful purposes. Certainly, someone could argue, especially thinking of technologies just in terms of tools, at least some of them can be used both in a beneficial and a harmful manner: a hammer can be employed either to drive a nail into a wall or to kill someone smashing his or her head. The same consideration has been made in relation to the terrorist attack on 11 September 2001, when a passenger aircraft has been turned into a weapon (Denton, 2005). It seems that all depends on how the user interprets the device. Nevertheless, not all interpretations are possible and, most of all, these interpretations are guided or at least suggested by technological design. If a hammer was intended as an instrument of offence in a combat, it would probably have a handle more suitable for a safe grip during a fight. Even its head would surely be different. Most likely it would be more regular in order to allow an efficient stroke from any angle. In sum, it would be a different tool. The situation is slightly different for the aircraft used during the 11 September attacks. Its design would hardly let us think of it as an proper missile. Size, speed and manoeuvrability of a passenger aircraft make it too easy to be intercepted by the enemy before it could hit its target. It would be necessary to completely reshape the device if we would like to have an efficient military device. Yet, the success of the Twin Towers attacks in catching the American defence unprepared was due exactly to the unconventional use of a passenger aircraft as a missile. A different design, more open to an interpretation as a military weapon, would not had had the same result. As anyone who has undergone airport controls after 2001 knows, the way society sees passenger aircraft has changed. Those attacks made explicit an interpretation that was not manifested in the design of the technology. The result was that it has been necessary to redesign all passenger control systems in order to make aircraft still embody the value of safety.

Different interpretations lead to different choices and any choice reflects, in turn, some values. As said before, the interpretations of a given technology are limited. Therefore choices are not only up to the user but are proposed or suggested, if not even imposed, by the technology itself in virtue of its design. A design that nonetheless is, still within some limits which depend on the potentiality offered by the technology, also the fruit of human choices and of the values that these reflect.

The values expressed by technology are partly inherent to the technology itself, partly due to the choices that humans – if they accept to employ it – made during its design process. In order to make this aspect clear, the philosopher Andrew Feenberg (1992, 1999, 2003, and 2005) has argued that it is first of all necessary not to fall into three common misconceptions of technology: instrumentalism, determinism, and substantivism.

Instrumentalism

The instrumentalist view is the conception that sees technology exclusively as an instrument used by humans in order to fulfil their needs. Nothing more than a means to achieve some ends. Since these ends depend, at last, on humans, technology is seen as intrinsically value-neutral. Or better, the only value it can express is efficiency; that is, the capacity to be more or less appropriate to accomplish a specific goal. Instrumentalism tends to decontextualize technology limiting the analysis to its usefulness (Feenberg 1999: 1-9, 2003, and 2005: 49-51).

To discredit this position it is sufficient to have a look to whatever object stays around us.

Most probably it does not even need to be subjected to any profound hermeneutic scrutiny before starting to reveal to us something more than the way it can be employed. Let us take as an example a chair. How many shapes, sizes, materials, colours can we think of? Not all of them have to do with ergonomics. Mostly they will concern values that have nothing to do with the capacity to receive a sitter; that is the main end for which chairs are designed and the characteristics that make of an artefact a chair. Its design will disclose a wider set of values other than efficiency, such as aesthetical or ethical ones. A throne, for instance, will immediately refer to certain social relationships within a specific culture. Technology does not exclusively express the ability to reach a goal. It embodies a series of values which are the values of the society that decided to make use of it.

Determinism

The second misconception Feenberg warns us to avoid is determinism. This position assumes that technology is not under human control. Instead, it has an autonomous logic which is indifferent to society. Even if it has a huge impact on society, technology is seen as essentially neutral. Humans have to shape their daily lives in accordance with technological standards. But these are the results of progress. And the advancement of technology is not guided by any judgement of value, if not the only one consisting in the promotion of progress; which still pertains to humans.

This view is based on two premisses; both false. The first one assumes that technological progress follows a unilinear course from less to more advanced stages, any of which is the necessary consequence of the antecedent. While the second premise states that once society has accepted any given technology, the former must inevitably conform to the latter. That, said in other words, means that technology influences society but not *vice versa*. Given these premises, determinism leads to two main related conclusions. Firstly, the western biases that the status of our technological development (which is assumed to be the more advanced) is universal; hence, other cultures cannot find different solutions but can only try to adapt to our standards. Secondly, humans cannot escape from the sole possible future designed by the technological progress. (Feenberg 1992, 1999: *passim* and esp. 77-78, 2003).

Determinism, looking at the past, misleadingly tends to draw the history of technology as an ascendant progress line which inevitably leads till the current standards. This way of representing history misses all the branches that characterized the development of any given technology. Any branch represents a choice. And behind any choice there are values; that, moreover, are not always linkable to the mere efficiency. When, for example, at the end of the seventies the first home video recording devices were developed, consumers had to deal with two format options: Betamax and VHS, developed respectively by Sony and JVC. Even though the performances of the first device were considered by experts qualitatively superior, a more successful marketing campaign operated by JVC decreed the adoption of the second one, which became the standard.

The future of our technological development is questionable and can be directed accordingly to our preferences. Technological progress does not mean a complete abandonment to fatalism, as determinism implies, but involve conscientious choices concerning what kind of technology to employ and how to shape its design in order to reflect our values.

Substantivism

Similarly to determinism, substantivism affirms the autonomy of technology. Yet, contrary to it, this conception denies the neutralist thesis. Technical devices are not only a means that can more or less efficiently achieve an end. They bring with themselves a specific way of life, a *weltanschauung*. Whereas both instrumentalism and determinism individualize in efficiency the only value; substantivism affirms that the use of a technology commits its users to a whole set of values that go far beyond the ability to reach an end. Following this view, those values are inherent to the essence of technology. Whenever a new technology is introduced, some corresponding values are introduced as well. Humans can decide about its introduction, but cannot shape it in order to reflects values different from those expressed by its essence (Feenberg 1999: 1-9, 2003, and 2005: 49-51). A classical and strong example is that of nuclear weapons. The introduction of this technology does not only changes the diplomatic equilibria betweens countries, establishing tensed relations of power, but open the door to a future where humanity could be responsible for its non existence. Once the atomic bomb was introduced, words such as fear and destruction gained a new shade. Humans have no way to intervene into the design of this technology with the purpose of introducing some more peaceful values.

What is not satisfactory in the substantivist account is that, assuming that all technology are of the type of the atomic bomb, it does not recognize the capacity of humans to reshape technology in conformity with their own values. But the fact that there are technologies that hardly permit, during their design process, the embodiment of values other than those belonging to their essence, does not mean that all of them are of this type.

Any technology is open to different interpretations, each of which is linked with different values. Values that can, in turn, be reflected into technology during its design process. However, not all technologies show the same grade of openness to interpretation. Some, as nuclear weapons, have very little. Others, as will be shown for genetic engineering, can have definitely more.

Constructivism

What we need in order to appreciate the implications and potentialities of technology is, as Feenberg suggests (1992, 1999, 2003, and 2005), a constructivist theory. The main advantage of this view is that it recognizes the chance that humans have to intervene during the design process in order to embed their own values.

Constructivism holds that technological development does not follow necessary stages. Instead, it is possible to choose among a set of variables in conformity with the goals humans wish to achieve. At any stage of the technological development humans are provided with a raw technical material that, joined with the scientific knowledge available, suggests some possible solutions. What will be a new technology and how it will be employed, depends in part on how they interpret these suggestions. Any suggestion is a chance to intervene into the design in order to reflect values that are still unexpressed by the current standard. At the heart of constructivism stays what the sociologists Wiebe Bijker and Trevor Pinch call 'interpretative flexibility' (see Feenberg 1999: 79). That is, the capacity of any technology to respond to the different demands posed by society. A capacity whose potentiality can be realized during the design process.

Technology and society influence and model each other. Feedbacks of new technological devices on the society that employ it give as a result a resettlement of the latter to the former. On the other hand, society tends to model technologies so that they could better satisfy its demands. The case of the value of privacy in relation to information technologies is a clear example. Such technologies are changing the boundaries of what is public or private. Society, however, is not passively adapting itself to the impact of these devices. Instead, it tries to redesign these technologies to make them reflect, as far as possible, the conception of privacy it cares for.

What a device 'is' depends both on the potentialities of a raw material of technical functionalities and on the meaning given to it by society during the design process. Feenberg calls ' technical code' the result of the relation between these two aspects (1992, 1999: 88, 2005: 52). Balancing the opportunities offered by a device with the needs and values of a society, the technical code represents the established standard of that device for that specific society. “[A] technical code – Feenberg writes – is a criterion that selects between alternative feasible technical designs in terms of a social goal. 'Feasible' here means technically workable. Goals are 'coded' in the sense of ranking items as ethically permitted or forbidden” (2005: 52).

Third Chapter

Premise

The aim of this chapter is that of presenting some general ideas of those that in environmental ethics can be considered as the most common attitudes of respect for the natural environment. The intent is not therefore that of giving an exhaustive review of all the possible conceptions developed in the field of environmental ethics. Neither is the intend to put into question the justifiability of the theories developed in that field. Considering the limits of space and the purpose of this thesis, the scope is simply that of drawing some general traits of the discipline in order to allow the further discussion about the chance that an employment of genetic engineering in plant breeding could be done respecting the environment.

Since it was necessary to choose a criterion to schematize the possible attitudes of respect, it has been decided to contrast anthropocentrism with non-anthropocentrism and to subdivide this latter in biocentrism and ecocentrism. Taking for granted that humans have a *prima facie* moral obligation to respect all those entities which have intrinsic value, for any of these category of theories will be specified which entities can be considered to have intrinsic value and what a respectful attitude towards these entities should require.

Furthermore, at the end of the chapter, an attitude of respect for the environment will be taken into account, that will be called 'naturalness approach'. Since this approach does not directly follow from any specific theory of value, it cannot be precisely collocated in any of the categories that have been just mentioned. However, as it is often employed in the discussion about the application of technologies to plant breeding, it has been considered opportune to include it as a possible attitude of respect for the environment.

Anthropocentrism vs. non-anthropocentrism

Assumption of every environmental ethics is that we cannot use the natural environment as we please. There are some limits that, when crossed, turn the human use of nature into a morally reprehensible abuse. We respect the environment when we do not harm it; that is, when we take into account its value and treat it with the due deference.

First prerequisite to show respect is that of recognizing some sort of value in the natural environment. Following a Kantian distinction, it is possible to distinguish two senses in which something can be said to be valuable: *instrumentally* and *intrinsically*. In the first sense the value of a thing depends on its usefulness, on its capacity to be a means to pursue some other ends. While, in the second sense, a thing is valuable as an end in itself, regardless of its ability to be a means for other ends.

In the development of environmental theories the concept of intrinsic value has played an important role in deciding which entities deserve direct moral respect and which not. It is generally assumed that the characteristic of being intrinsically valuable confers to entities or to communities of entity (see below the distinction between individualism and holism) moral standing (or, that is the same, moral status). And when we say that something has moral standing we also assume that we have a *prima facie* moral obligation to respect it. That is to say, when an entity has moral standing we have a duty to respect it, unless we do not find ourselves in a situation of conflicting duties with the presence of a stronger duty. In that case the stronger duty will prevail.

In the field of environmental ethics the distinction between instrumental and intrinsic value is used to characterize and distinguish ethical theories on the base of two possible attitudes towards the environment: *anthropocentrism* and *non-anthropocentrism* (see Brennan and Yeuk-Sze 2009).

Anthropocentric theories consider human beings as the only entities having intrinsic value. For whom supports this conception the answer to the question 'why should the environment be respected?' is simply: because it is in our own best interest. Our survival on earth depends, in fact, on a healthy environment. Any form of pollution or an excessive exploitation of natural resources can compromise the very existence of our species. Since the real concern is for present and future generations of human beings, the respect deserved to the environment is only indirect. The environment is seen just as a resource for human purposes. As long as these purposes are not threatened by the use made of the environment, there are no reasons for concern.

Anthropocentrism is a pragmatic approach that fights against pollution and resources depletion not because they harm the environment but because they represent a potential harm to humans, now and in the future. Even the preservation of wilderness areas (that is, areas on the planet where humans presence is intentionally left outside in order to permit nature to take its course), which is a leitmotiv in ethical discussion about the environment, is not supported by any believe that these areas could have some sort of intrinsic value. Virtually human life will be possible even without such areas. The anthropocentric reason for respecting wilderness areas lies in their instrumental value to be recreational refuges that humans can appreciate for their aesthetic qualities.

Non-anthropocentric theories, on the other hand, believe that human beings are not the only entities possessing intrinsic value. Therefore, from this set of theories, other entities beside humans are worthy of being respected directly; that is, as ends in themselves.

We could say that the non-anthropocentric perspective is the one that is genuinely pertinent to the field of environmental ethics. In fact, since the first developments of the discipline, about forty years ago, the main occupation of philosophers involved has been that of trying to extend the class of entities having intrinsic value with the purpose of including entities other than human beings (Light 2002: 426-430). The major worry has been that a mere anthropocentric perspective might not be sufficient for developing, on theoretical grounds, an ethic capable of entitling the environment to the respect it deserves (see Brennan and Yeuk-Sze 2009). It was in the Seventies that humans started to be conscious about the fact that the use they were making of natural resources was causing an environmental degradation. A degradation whose moving cause, in the eyes of some environmental ethicists, could be found exactly in the anthropocentrism which were at the base of the ethical codes that had been developed till then (see Sapontzis 1995).

Notwithstanding the common premise of widening the circle of beings having intrinsic value, non-anthropocentric theories are all but in agreement on which entities have intrinsic value and which have not (see Light 2002; Brennan and Yeuk-Sze 2009). Moreover, there is disagreement also on how to justify the fact that, in some circumstances, the respect due to these entities can be violated in order to permit human life (*ibidem*). The consequence of this sort of dispute within the discipline has been that upon the general idea that humans should respect the environment not just because it is in their own interest, a series of different theories has been developed.

As said in the premise above, the intent here is not that of giving an exhaustive exposition of all the ramifications on which environmental ethics has evolved, but simply that of presenting some general attitudes of what can be considered a respectful attitude towards the environment. For this purpose, within non-anthropocentrism, the biocentric approach will be differentiated from the ecocentric one.

Biocentrism vs. ecocentrism

Within the non-anthropocentric approach it is possible to distinguish two different groups of theories, depending on whether they extend the sphere of entities having intrinsic value to individuals or wholes of entities. In the first case we speak of *individualistic* theories, whereas in the second case we talk of *holistic* theories.

Individualism. This approach extends the sphere of entities possessing intrinsic value to individual living beings. Usually it has been supported by the animal liberationist movement with the argument that animals show to be sentient beings having interests on their own. Besides animal liberationists there have been philosophers, such as Paul Taylor (1986), that have broadened the circle of entities possessing intrinsic value, and thus moral standing, also to non sentient beings, including all individual living beings in nature[5]. Generally, for environmental ethicists that endorse this type of individualism, an entity is intrinsically valuable if it shows a goal-oriented behaviour whose end is not for the sake of other entities but for its own. The fact that all living beings, sentient or not, show to have at least a tendency to survive and reproduce themselves is, for who advocates this perspective, enough to demonstrate that they have a good of their own.

Holism. The individualistic approach has been criticized by most of the philosophers interested in environmental ethics because, giving equal moral standing to any single goal-oriented living being, it fails to support those that are the central themes of the discipline. That is, the safeguard of ecological wholes such as ecosystems and wilderness, and endangered species (see Light 2002; Brennan and Yeuk-Sze 2009). Since the protection of wholes could require the suppression of individual organisms, as, for example, when their presence jeopardizes the equilibrium of an ecosystem or the existence of an endangered species, many environmental ethicists decided to opt for a holistic view. This latter is essentially a consequentialist approach in which individual organisms are important as long as they can contribute to the integrity and stability of wholes. This does

5 Note that Taylor employs a slightly different terminology that, in order to avoid confusion, will not be taken into account here. It is however necessary to point out that the concept of 'intrinsic values' used here corresponds, in Tailor's vocabulary, to that of 'inherent worth' (cf. Taylor 1986: 73-75).

not necessarily means that individuals lack intrinsic value. But that such a value, when recognized, can be overlooked for the sake of the whole (see Rolston 2003). On this regard holism seems to pose some sort of hierarchy between entities that gives priority to wholes[6].

Differently from individualists, who put the emphasis only on individual living beings, advocates of the holistic approach are generally concerned also with wholes such as ecosystems that include not only living organisms but not living entities like soil and water too. In virtue of this difference, the former is also referred to as *biocentric*[7], whereas the latter is usually called *ecocentrism* (ibidem).

Attitudes of respect for the environment.

Now that some general approaches of valuing the natural environment have been individualized, will be pointed out what, for each of them, can be deemed as a respectful attitude for the environment. Then, in the next chapter, the implications that these attitudes of respect have for plant breeding will be taken into account and the chance of tailoring an application of genetic engineering accordingly.

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6 It is good to note that the possibility that wholes could have moral standing can be quite debatable. It is in fact hard to think of an ecosystem as having a good of their own (Comstock 1995: 8-11). And the same is true for species. As Taylor wrote: “[A]lthough a species-population can be benefit or harmed, a species itself cannot. [...] The term 'species' is a class name, and classes themselves have no good of their own, only members do”. (1986: 69, n.5).

7 Note that *biocentric* theories can be also holistic if they recognize the moral standing of species. Since however most of the philosophers that affirm the moral standing of species (as, for instance, Holmes Rolston III and Baird Callicott do), generally claim also the moral standing of ecosystems (which include abiotic entities too), biocentric holism will not be considered as an approach distinct from ecocentrism. Taking into account only this latter will in fact permit to examine the impact of genetic engineering on species as well, without complicating the discussion with a further environmental ethics approach.

Anthropocentrism. Since anthropocentrism does not recognize any sort of intrinsic value in the natural environment, the respect due to this latter is, for who advocates this standpoint, only indirect. That is, since we have a *prima facie* obligation not to harm our fellow human beings, indirectly we have also an obligation to respect the environment because the life of human beings depends on it. What this respect will require is neither more nor less than a wise use of the environment that can permit the flourishing of present and future generations of humans.

Biocentrism. For who endorses an individualistic point of view, it is possible to manifest direct respect towards a living entity that shows a goal-oriented behaviour by acting or declining to act in relation to the end that it pursues. What biocentrism substantially requires is therefore the promotion of individual life and, accordingly, also of all those conditions that could make that life a better life[8].

Ecocentrism. Ecocentrism fixes in the famous precept of the father of land ethics, Aldo Leopold, the moral limits of a respectful human behaviour towards wholes such ecosystems: “[a] thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise” (Leopold 1970: 262). Since the integrity and stability of the biotic community is proportional to the species diversity (Comstock 1995: 6), preservation of biodiversity becomes a matter of central concern. That, consequently, implies the safeguards of every single species integrity as such. And this is one of the reasons that explain why, for who advocates a holistic standpoint, the safeguard of wilderness areas has been considered of vital importance: to maintain the

8 Even for organisms that do not have feelings or interest it is possible to talk of a better or worse life condition. A basilicum plant, for example, would surely have a better life if watered regularly. As Rolston, with the purpose of explaining the biocentric view, wrote: “Though things do not matter for trees, a great deal matters for them. We ask, 'What's the matter with that tree?' If it is lacking sunshine and soil nutrients, we arrange for these, and the trees goes to work and recovers its health. Suck organisms do 'take account' of themselves; and we should take account of them” (2003: 522).

integrity of wild species wild, and protect them from the contamination of domestic relatives (Callicott 1998). For some environmental ethicists such as Holmes Rolston, however, the reason for preserving species and wilderness cannot be limited to the fact that those wholes are functional for the purpose of increasing biodiversity. Instead, species and wilderness have to be preserved for they intrinsic value. An intrinsic value that in the cases of species consists in the fact that they, transmitting their specific biological lineage over generations, show to have a goal-oriented behaviour whose end is that of maintaining their species genetic integrity (Rolston 2003: 523). While, in the case of wilderness, its intrinsic values lies in that fact that nature, when let alone, develops spontaneously, careless of what could be its instrumental value for human beings. This shows, in the eyes of thinkers like Rolston, that nature is not here as an instrument to satisfy human needs, but as an end in itself, which therefore deserves respect (Rolston 2001). Respecting nature means, in this case, protecting, as much as possible, wilderness areas from external contamination in order to permit the autonomous development of wild species.

Naturalness approach in agriculture

In addition to the previous attitudes of respect, will be take into consideration a further one that even if not directly ascribable to any specific environmental ethics theory, it is quite common in the evaluation of agricultural practices and has been endorsed by the organic farming movement. This further attitude of respect makes use of the concept of 'naturalness' to determine when the use of the environment becomes an abuse.

In order to make their position clear, supporters of naturalness warn us that when we talk of nature in the context of plant breeding we should not have in mind nature as pristine nature. Simply because in that case any form of human intervention should be forbidden (Verhoog *et al.* 2007: 338). In agriculture nature has, instead, to be seen in relation with its opposite pole, namely, culture. The two concepts, nature and culture, are in a dialectical relationship that permits us to distinguish grades of more or less naturalness (*ibidem*: 339). Respecting the environment implies acting in a way that the pole of culture is reduced as much as possible. The idea is that of a partnership between human and nature in which the former does not force the latter but tries to reach its goals by making use of natural occurring processes. A respectful practice is that which allows the maximum independence of nature. That, in practical terms, means that agriculture should avoid the use of synthetic substances, stimulate the self-regulating abilities of plants and ecosystems, and respect the specific characteristics of species (*ibidem*).

Fourth Chapter

Anthropocentrism

From an anthropocentric perspective humans are the only beings having moral standing. The natural environment is considered just for its instrumental value, as a resource that humans can use in order to satisfy their needs. Yet, that does not means that we are exempted from any obligation with regard to the environment. The respect owed to our fellows humans (present and future generations) indirectly constrict us to an attitude of respect for the natural resources from which they depend. The way we treat the environment has to be compatible with the chance that any human being could enjoy its (instrumental) value as we do.

Respect for the environment requires the preservation of ecosystems equilibria, biodiversity of species and wilderness areas. However, for whom assumes an anthropocentric standpoint, this should not be done because any sort of intrinsic value could be recognized in them. But because the more they are preserved, the more are the food, goods and services that they can supply.

Accordingly, agricultural practices will be compatible with the anthropocentric attitude of respect for the environment if they do not compromise the ability of humans to take advantage of natural resources. From this perspective, the application of genetic engineering to plant breeding can substantially be considered as a new chance, in the history of agriculture, to control and modify natural resources with the purpose to fulfil human needs. As plants, either as individuals and as species, are not regarded as having any good of their own, the modification of their genome by means of genetic engineering cannot be considered in itself as a disrespectful intervention. As long as the new properties of the engineered plants do not lead to a harm to human beings there is no reason for concern.

From its beginning the purpose of plant breeding has been that of providing humans with safe, edible products. With its development, agriculture has repeatedly tempted to select and to cultivate those plants that could be, as much as possible, rich in taste and nutrients, and that could lead to the maximum yield at the minimum costs. Genetic engineering is nothing more than a refinement of the techniques employed in agriculture in order to achieve those objectives. Objectives to which, from the moment the possible detrimental effects of agriculture on ecosystems equilibria became clear in the second half of the previous century, humans had to add that of respect for the environment.

As noted in the first chapter, genetic engineering can be employed in order to develop plants with traits that potentially could have beneficial environmental impacts. The way pest and herbicide resistance could reduce the employment of noxious chemicals has already been cited, as well as the possibility to develop plants with traits that could help restoring contaminated soils by phytoremediation methods. In the first chapter we have however also noted that there is a general disagreement within the scientific community about the efficiency of all those potentialities. And on the scientific community lies, in the end, the burden of deciding whether the consequences of cultivating plants by using genetic engineering could have positive or negative effects on the environment. A decision that needs to take into account any single application of this technology and evaluate case by case the eventuality to allow or forbid its use on the base of its environmental impact. In fact, the effects of genetically engineered plants on the environment change in relation to the trait or set of traits that have been developed.

The task of determining possible side-effects of genetically engineered plants is furthermore complicated by the fact that the development of new traits could be obtained by using genetic resources that come from completely unrelated species, or could even be synthesised in laboratory. The unexpected outcomes of a genetically engineered plant becomes more and more difficult to predict in connection to the extent of how its genotype differs from those previously observed in the natural environment. However the point here is not that of establishing how to deal with a situation of uncertainty, but simply to determine whether the application of genetic engineering to plant breeding can be consistent with an attitude of respect for the environment.

Anthropocentrism, recognizing humans as the only beings having intrinsic value, does not preclude any application of genetic engineering to plant breeding as long as it does not turn into a harm to humans. Deciding whether this would be the case is being the object of a heated debate within the scientific community. But *per se*, the chance of intervening into the genome of plants by inserting some external genetic material, does not represent a disrespectful use of the environment. Even if the mixing of genetic materials that come from different species could complicate the prediction of possible outcomes and side-effects, it cannot be considered as a use of natural resources that is inherently wrong. From an anthropocentric point of view, the only limits in crossing species barriers is that of not making use of human genetic material. Indeed, respect for the intrinsic value of humans beings could not be compatible either with the chance that their bodies could count as a possible resource where one could find genetic material; or with the fact that, when the plants are intended for food, the presence of humans genes would lead to some sort of cannibalism.

Biocentrism

Following the biocentric idea of respect for the environment, it is possible to manifest direct respect towards a living individual that shows a goal-oriented behaviour by acting or declining to act in relation to the end that it pursues. Generally who endorses this point of view and tries to apply it in the contest of agriculture, faces the problem of having to justify the fact that taking into account plants for their instrumental value is inherent to any agricultural practice. Plants are cultivated not for their own sake, but because they have been judged, in virtue of their instrumental value, particularly suitable to satisfy human needs. Furthermore plant breeding requires the elimination of all those living organisms that could interfere with the management of the cultivar. The elimination of weeds can be considered as a paradigmatic example of the difficulties that the biocentric position has to overcome. Indeed, it is not clear how it is possible to maintain at the same times that every living being is intrinsically valuable, and deserve the same grade of respect, and then to make a distinction between plant that are crops and plant that are weeds. All in all, weeds are nothing more than a plant in the wrong place.

Lammerts Van Bueren and Struik, who advocate the adoption of a biocentric approach in agriculture, recognize these difficulties, and rebut them by stating that "non-crop plants are allowed when and where they do not interfere with the natural aim of crop plants" (2005: 490). "[T]here are" – they continue – "some trade-off between the plant rights and the objectives of the farmer in the exploitation of plants" (*Ibidem*: 491). However, the attempt of Lammerts Van Bueren and Struik to deal with the problems that biocentrism encounter when applied to agriculture, are not really satisfactory. They in fact assume that there is a priority to protect crop plants from the interference of weeds. What determines such a priority is however only the instrumental value that such plants have to satisfy human desires. An instrumental value that, on the base of humans needs, permits to distinguish plants that are cultivars and those that are weeds. Even admitting that the biocentric position could consistently allow the human cultivation of plants (at the conditions that will be stated below), what continues to be problematic is that there are some plants, weeds, towards which any sort of moral consideration, and thus of respect, is denied simply because humans do not recognize in them even an instrumental value.

Notwithstanding these problems of consistency, which can be considered as marginal here, what is of interest is to clarify what, from a biocentric perspective, can be the requirements for an agricultural practice that wants to respect the environment.

Lammerts Van Bueren and Struik hold that a biocentric attitude of respect for the environment requires to consider plants not only for their instrumental value, but also for their intrinsic one (*Ibidem*: 481). The management of plants, which is unavoidable in agriculture, not necessarily leads to a disrespectful use them. The condition is however that plants will be managed taking into account not only the needs of humans but also those of the cultivated plants. And taking into account the needs of cultivated plants means to allow them to follow, as long as the practices of domestication permit to grow products suitable for humans, their autonomous and self-regulating development (*Ibidem*: 482). What makes this development possible is the preservation of plant integrity; which consists in not violating their wholeness, species-specific characteristics and functions.

With the purpose of making the concept of integrity suitable for a careful assessment of which agricultural practices could be allowed in plant breeding, Lammerts Van Bueren and Struik individualized four different levels on which the integrity of a plant is manifested: (i) the plant ability of self-regulating its biological functions; (ii) its ability to autonomously interact with its surrounding environment; (iii) the specific character of its genome, which defines its life form and cycle, ontogeny, morphology, metabolism, and reproductive strategies; and (iv) its phenotypical aspect, which reveals the health of the plant and its balance with the surrounding environment (*Ibidem*: 482-483; cf. also Lammerts Van Bueren *et al.* 2003: 1925).

Any of these levels can be violated if, respectively: (i) the plant cannot autonomously perform its biological function, as when for example human intervene in altering its metabolism; (ii) the plant cannot perform its functions interacting with the organisms and abiotic substances normally present in the natural environment, as when it is cultivated on an aseptic and artificial media; (iii) humans modify the structure of the plant genome; and (iv) the plant cannot develop in a healthy status (Lammerts Van Bueren and Struik 2005: 482-484; and Lammerts Van Bueren *et al.* 2003: 1925). Specifying the concept of integrity, these four levels permit to examine plant breeding practices considering all those aspects that can count as a violation of the integrity of plants. And thus to assess whether those practices respect the intrinsic value of plants or not.

Evaluating genetic engineering in order to establish whether, from a biocentric perspective, it can be a technology admissible in plant breeding does not require a profound scrutiny. In fact, its application would surely violate the first three levels of integrity recognized by Lammerts Van Bueren and Struik; and in some circumstances even the fourth. Inherently genetic engineering interferes with: (i) the ability of plants to self-regulate their biological function (e.g. changes in metabolism); (ii), the chance of plants to interact with the surrounding environment (since, at least during the developing process, the plant has to be treated in laboratory); and, evidently, (iii) the composition of plants genome.

The use of genetic engineering will not necessarily cause imbalances in the phenotypical structure and composition that could compromise the capability of plants to lead their lives in a healthy status (level (iv)). Indeed, some applications of this technology are specifically intended for boosting the fitness of plants. Nevertheless, since integrity is preserved when none of its four levels are violated, the violation of a single level is sufficient for considering an agricultural practice as disrespectful. And as it has been noted, genetic engineering unavoidably violates the integrity of plants at a least three of its levels. Therefore, it cannot be considered as an admissible practice.

Ecocentrism

Ecocentrism holds that a respectful attitude towards the environment requires the preservation of the integrity and stability not of individuals but of wholes. In specific, the wholes that are matter of concern are ecosystems and species.

An ecosystem is a whole constituted by a specific portion of the biosphere in which biotic and abiotic entities interact with each others. Key requisite for maintaining the integrity and stability of ecosystems is the preservation of biodiversity. Ecosystems are in fact dynamic systems in which the interaction among species, and between species and abiotic substances, contributes to the achievement of an equilibrium that allows the maintenance of life-cycles. Since the stability (which is tantamount to the health) of an ecosystem is proportional to its biodiversity, it is possible to affirm that the more the species, the more stable the ecosystems (see Comstock 1995: 6). In order to permit the conservation of a stable ecosystem it is furthermore essential to avoid its contamination with polluting substances. These, as they cannot be integrated into the life-cycle processes, determine a reduction of species biodiversity with consequently unbalances in the ecosystems dynamics.

It is necessary to note that farmlands are inherently unbalanced ecosystems. Not because farming necessarily requires the use of pollutants but because, as pointed out by Comstock, its purpose, "the characteristic that distinguish it from hunting and gathering, is the systematic attempt to 'control', that is, to kill, indigenous plants that compete with crops" (1995: 6). In a farm, efficiency requires to circumscribe the breeding of plants to a few species, which in virtue of their characteristics, are selected among others. Natural occurring dynamics of the ecosystem and life-cycles have therefore to be managed by farmers in order to permit an intentional unbalance in favour of the cultivars. Even if there are ecocentrists that, for this reason, seem to disapprove any form of agriculture (see Comstock 1995: 6-7), most of them have however a more positive view on agricultural practices. What these latter require is that the needs of humans to control nature can be compatible with the preservation of biodiversity and wild areas (Rolston 1999). Since in a farmland some species are preferred among others, the biodiversity within cultivated fields is unavoidably diminished. It is however possible to maintain an overall biodiversity by practising crop rotation (i.e., the cultivation of different variety of crops following the changing of seasons) and limiting the extension of the field dedicated to specific varieties. That is, by avoiding the practice of monoculture. This latter, even if more remunerative, dedicates to a single variety a vast expanse of land which could otherwise be used for the cultivation of other varieties.

As far as the preservation of wilderness is concerned, the ecocentric view claims that recognizing the intrinsic value of other species, humans cannot consider themselves as the masters of the planet. Respecting the environment involves the chance that there could be some places on earth where nature can take its course independently from human activities and interests. Preserving wild ecosystems means substantially two things: to avoid any form of human interference that could compromise the internal equilibria of the ecosystem, such as pollutants contamination; and to permit that wild species stay wild. It is therefore of vital importance that the human engagement in activities do not contribute to the production of pollutants, but also that the crossing of wild species with domesticated relatives is impeded. And this latter could be obtained by including buffer zones (uncultivated fields) between wild areas and farmlands.

What is now necessary to clarify is whether an application of genetic engineering could involve a decrease of biodiversity and a menace to ecosystems equilibria and wilderness conservation.

Strictly speaking a genetically engineered plant is nothing more than a new species of plants that has been created by humans. Under this respect, since a new species is added to the already existing ones, the genetically engineered plant could hypothetically be considered as an enrichment in biodiversity. But is it really so? From a non-anthropocentric standpoint what permits to appreciate the intrinsic value of entities is the fact that these can be considered as end in themselves. And this is not the case for genetically engineered plants; because they have been created for the mere purpose of fulfilling humans needs. From this perspective an engineered plant is nothing more than a human artefact and cannot count as an enrichment in natural biodiversity.

But also non-engineered cultivated plants can be considered as artefacts. They, in fact, do not only have been selected by humans for their instrumental value, but are also the result of millennia of domestication. A domestication that has altered their genetic composition in a way that barely permits us to retrace their wild ancestors. What could distinguish them from engineered plants is that their genetic modification is the result of crossing processes that, at least in theory, could have been occurred in nature. However, also some applications of genetic engineering could lead to a genotype that, at least in theory, could have been the result of natural occurring processes. Intragenic techniques, in fact, alter the genome of plants by using genetic material which comes from the same species that has to be modified. The outcome, as for the case of domesticated plants, is a species whose genetic composition could have been present in nature as well.

Since, in both cases, we are facing a genetic modification that, although driven by humans, could have been also the result of natural occurring processes, it is not clear what, from an ecocentric perspective, could differentiate the value of a domesticated plant from an intragenic one. Unless the speed of processes and technologies employed in the two methods does count as a discriminating factor, but this can be the case only if the ecocentric conception is combined to the 'naturalness approach' (see below next paragraph), the value of the two should, from a mere ecocentric perspective, be the same.

The possibilities are two. Either domesticated plants, too, do not have intrinsic value, and in that case only wild species should be preserved; or intragenic plants have to be considered intrinsically valuable as well, and in that case they would be an enrichment in biodiversity.

Regardless of the value of genetically engineered plants, it is possible to affirm that, even if the presence of engineered plants cannot count as an enrichment of biodiversity, neither it can count, in itself (that is, if their presence allows the coexistence of other species), as a reduction of biodiversity. Moreover, if also domesticated plants are nothing more than human artefacts, their preservation does not seem to be particularly relevant from an ecocentric perspective. While the safeguard of wild species will require the same precautions that are necessary for traditional agricultural practices; unless there is prove of a major risk of invasiveness of genetically engineered plants (see below).

Admitting, for the sake of the argument, that not only wild but also non-engineered domesticated species have to be preserved, the worry with genetically engineered plants is their potential invasiveness; that is, the chance that they could outcross with non-engineered crops and wild varieties. Plants engineered with traits such as pest and herbicide resistance have in fact more adaptive fit than their non-engineered relatives. Thus they have a higher probability to spread their genes, contaminating non-engineered domesticated and wild varieties. As noted in the first chapter, it is however possible to get round this problem by creating sterile plants. This would avoid the chance of outcrossing with other varieties and thus the integrity of existing species would be preserved.

According to Anders Melin (2004), what, from an ecocentric standpoint, could determine the diminished value of genetically engineered plants is exactly the fact that this technology allows the creation of non self-sufficient species (483-484). And as pointed out in the previous chapter, species are considered intrinsically valuable because of their ability to reproduce themselves. If the trait of sterility is introduced into a species, this does not show any form of goal oriented behaviour and thus there is no source of intrinsic value to be taken into account. That however engineered species could not have intrinsic value is not a problem here. On the contrary, if the intrinsic value of species is proportional to their adaptive fit, from an environmental perspective it could be even desirable that they have none. If they have no capacity to spread there is no risk of contamination.

Another concern which regards the preservation of biodiversity end stability of ecosystems is that, since developing engineered plants involves great costs, the application of this technology could encourage monoculture; which is the most productive and efficient way to get the invested money back. Yet, the problem of monoculture, that, as said, concerns agriculture as such, could not be directly referable to technology itself but to the system of agricultural production in industrialized societies. Whether the management of development costs of genetically engineered plants could avoid the adoption of monoculture, or not, is a problem that falls into the socio-economical implications of this technology and cannot be tackled here.

As long as existing species are preserved, the use of genetic engineering does not seem to pose particular problems for the preservation of biodiversity. What could be matter of concern is the chance of side-effects on non-target species. Some traits could in fact be noxious for some species that, as in the case of the Monarch butterfly cited in the first chapter, not interfering with the breading of the cultivars, are considered part of the farm ecosystem. As we have already noted, within the scientific community there is great disagreement about the likelihood of these side-effects. Nevertheless, it is without any doubt that whenever the worry of some side-effects would turn to be an effective danger to some species, from an ecocentric perspective the application of genetic engineering cannot be admissible. However, since the possibility of side-effects, and the likelihood they actually occur, will depend on the specific application of genetic engineering, such a worry cannot be generalized to the technology itself, and has to be evaluated case by case. And the same is true for the chance that applying genetic engineering to plant breeding could involve an increase or a reduction of polluting substances in agriculture. In the first case it would admissible, whereas in the second case, as it would destabilize the equilibria of the ecosystem, not. But again, this is a matter of scientific debate that cannot be solved here.

To conclude, genetic engineering technology, from an ecocentric conception of respect for the environment, does not seem to be an inherently disrespectful practice. The only exception being those applications that, as a result of empirical studies, compromise ecosystems equilibria and the chance to safeguard biodiversity.

Naturalness Approach

Discussing the implications of the ecocentric view in plant breeding, it has been noticed that any cultivated plant could be considered as nothing more than a human artefact.

Moreover, a plant engineered with intragenic methods, could, hypothetically, have the same genetic composition of one obtained by using traditional agricultural methods. Since the effects on the natural environment will be the same in both cases, from a mere ecocentric perspective, there do not seem to be problems inherently ascribable to the genetically engineered one.

This situation of substantial equivalence between the two would change if the idea of respect for nature belonging to ecocentrism is combined to what has been called the 'naturalness approach'. As said in the previous chapter, this approach recognises the intrinsic value of the environment, without however being directly linked to any specific conception of what the source of this value could be, and without clarifying which entity should be considered intrinsically valuable. This does not therefore exclude that it is possible to support this approach either from an individualistic[9] and a holistic perspective.

The naturalness approach claims that respecting the intrinsic value of the environment involves establishing a relation of partnership between nature and humans. A relation that does not mean an exceptionalness obligation to refrain from any human interference with nature. Instead, what it requires is that humans do not force nature in order to obtain products that it could not obtain thanks to natural occurring processes. As Verhoog *et al.* affirm: “One needs to work together *with* nature instead of fighting *against* nature” (2007: 341). And working together with nature means not to pervert, with our technological tools, the autonomous capacity of plants to offer their products. According to this view, as Verhoog wrote, “genetic engineering is seen as a technology which forces the organisms to do what humans want, instead of eliciting a reaction in which the natural entity retains its relative independence as a partner” (Verhoog 2007: 397).

Since according to the naturalness approach what counts is not only the result of our

9 As it is possible to note from what will be said, the naturalness approach leads to the same conclusions as the biocentric position. It would be good to point out that what distinguishes the two is that while for the latter only individual living beings are worthy of respect, for the naturalness approach what deserves respect are natural occurring processes as such. Regardless of whether living or non-living being, wholes or individuals are involved.

actions, but, and most of all, the process by means of which humans obtain such a result, no application of genetic engineering can be considered as an agricultural practice respectful of the environment. Even if, such in the case of intragenic modification, it would lead to genetic combinations that would also have been occurred as a consequence of natural processes. The difference between the intragenic method and other traditional practices which endorse the idea of partnership with nature is that, while these latter *stimulate* the natural occurrence of some specific traits, genetic engineering *imposes* those traits, regardless of how the plants could have independently developed in virtue of its self-regulating abilities.

Designing genetically engineered plants.

The constructivist approach delineated in the second chapter allows us to avoid the so called 'modernist fallacy' often employed for advocating the introduction and application of new technologies (see Thompson 2007: 63-65). The fallacy consists in overlooking the ethical concerns involved in the use of technology by making use of the argument that even if there are unwanted consequences, these are the price to pay in order to permit the progress of human societies.

According to the modernist fallacy, whatever the ethical concerns involved in the application of genetic engineering to plant breeding are, refusing its introduction would mean arresting the advance of progress. Yet, using the argument of progress for advocating genetic engineering is equivalent to endorse a deterministic conception of technology. That is, to presume that the progress of technology is nothing more than a linear concatenation of stages any of which inevitably follows from the previous one. But, as noted in the second chapter, this assumption is simply false. From a constructivist perspective genetic engineering has to be considered just as one of the options humans have to breed plants. An option that, when it clashes with the ethical values endorsed by the society, can be rebutted without the worry of missing the train of progress.

For constructivism, technological progress does not necessarily involve the application of the newest and more efficient technology available. On the contrary, the introduction of any new technology requires a careful assessment in which the value of efficiency cannot be considered as the only criterion of choice.

In order to decide about the application of genetic engineering to plant breeding what has to be taken into account is not only the capacity of this technology to supply humans with the best agricultural products at minimum costs. The assessments of genetic engineering should be made by considering all the possible values at stake in its application. Values that, as noted in the introduction of this thesis, have to do with safety, socio-economic implications, and impact on the environment.

Whether engineered plants could embody respect for the environment in their design, which is what is of interest here, will depend on which conception of respect will be taken into account. Of the four conceptions that have been considered here, two of them, biocentrism and the naturalness approach, do not allow any form of application of genetic engineering to plant breeding. For these two, genetic technology inherently embodies a form of disrespect for the natural environment.

According to the biocentric view, which recognises in the intrinsic value of individuals the source of respect, a complete rejection of genetic engineering is due the fact that this technology inherently violates the integrity of plants. As the violation of plants integrity is part of the essence of genetic engineering, there is no possible design that could avoid this violation.

For the naturalness approach, instead, the reason of the rejection is that this technology forces plants to do what they would not have done otherwise; if they would be allowed to develop independently from human interference. Necessary for showing respect is a human attitude of partnership towards plants. But the very essence of genetic engineering embodies the idea not of humans as partners, but as masters who force plants to satisfy their needs.

Differently from these two, anthropocentrism and ecocentrism do not see in genetic engineering an inherently disrespectful technology that – if carefully designed – could cause problems substantially dissimilar from those involved in traditional agricultural practices.

A conception of respect for the environment that does not seem excessively constraining is the anthropocentric one. As said, this conception refers respect for the environment to the respect that is due to our fellow human beings and to posterity. Genetic engineering, with its several potentialities of applications, represent a new promising option to manage the environment in order to satisfy human purposes. The only limit is represented by the chance that any of its possible application would turn into a harm to humans. Whether this would be the case depends on the results of empirical research. And when empirical research is at stake, it is up to the scientific community to choose what could be possible technical codes (see second chapter). That is, to establish when – and if – the potentialities of genetic engineering of providing humans with more suitable agricultural products can be developed without causing any harm to other human beings.

Respecting human beings means also respecting other world-views. That is, respecting the fact that there could be other fellow humans (future generations included) that, for whatever reason, want to have access to non-engineered agricultural products. Technical codes have to take into account the chance that genetically engineered cultivations could coexist with other forms of agricultural practices. Some strategies such as inducted sterility of engineered plants and buffer zones that could prevent the contamination of non-engineered species have already been mentioned. Whether these could be feasible solutions is, again, a matter of scientific research.

As healthy ecosystems are essential for the survival of human beings, workable applications of genetic technology will depend on whether they contribute to the preservation of biodiversity and on whether their design could involve a growth in the use of pollutants or not.

It has to be noticed that when anthropocentrism is properly inclusive, that is, when it includes in the safeguard of biodiversity and ecosystems stability also the wild, its implications for a respectful use of natural resources tend to tally with the ethical requirements of the ecocentric attitude of respect for the environment. Even if the source of respect differs, both positions maintain that human behaviours should not compromise the stability of ecosystems and should preserve species biodiversity. Technical codes developed from these two perspectives will lead to the same types of possible applications of genetic engineering to plant breeding.

Conclusion

The practices adopted by humans in plant breeding will reveal something about how they conceive the natural environment and the respect due to it. As far as we have seen, either from a biocentric perspective and following the naturalness approach, the use of genetic engineering in plant breeding cannot be considered as a feasible practice to obtain agricultural products. This technology, in its essence, clashes with the ideas of respect for the environment endorsed by these two conceptions. Accordingly, it does not matter how genetically engineered plants will be designed, they will continue to embody a disrespectful attitude of humans towards the environment.

If instead the conception of respect for the environment endorsed is an anthropocentric or an ecocentric one, the employment of genetic engineering in agriculture does not seem to represent an inherently disrespectful practice. On the contrary, the application of this technology could offer the chance of designing plants with traits that could even promote the values supported by these conceptions. The potentiality of genetically engineering plants with the purpose of increasing the yields, for instance, beside the evident advantage it could give to farmers, represent, from an ecocentric perspective, the chance to reduce the use of land necessary for agriculture and consequently reserve more territory for the preservation of wilderness.

Whether genetic engineering could be considered as a respectful agricultural practice will depend on the attitude of respect that will be endorsed. Nonetheless, even if the technology is not considered *per se* disrespectful, the verdict of the scientific community about the impact and possible side-effects of an application of genetic engineering is crucial in order to decide if it could be considered as a feasible application or not.

Furthermore, respect for the environment is just one of the several concerns that rise in relation to a possible application of genetic technology to plant breeding. The decision about whether it could be considered as an acceptable technology and, if so, how it could be designed, cannot overlook any of these concerns. The considerations exposed here represent therefore only a minimum part in the assessment of a technology whose implications concern not only its impact on the natural environment, but also the safety of agricultural products and the socio-economical organization that stays behind their production.

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