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The Causes, Mechanisms, and Treatments of Genetic Vulnerability in Advanced Crop Cultivars

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ABSTRACT: Plant breeding is one method of addressing the issue of bridging the increasing gap between food demand and availability. But plant breeding has its own detrimental side effects, despite the significance. Relocation of landraces with a number of genetically identical species makes genetic diversity less common and offers perfect circumstances for genetically vulnerable illnesses and insect pests. The ever-growing human population and consequently rising needs for more food are the major drive toward that limited genetic basis, on the one hand, and the success of initiatives such as the Green Revolution by adopting genetically unified variety in many areas of the globe on the other. It is essential, then, to understand the phenomena and prepare to reduce the dangers of hereditary susceptibility. The current plant breeding strategy, variety releases and certification procedures leading to genetic uniformity should be reconsidered under marginal conditions under which the resource-poor farmers are dominated and some level of genetic diversity should be deliberately maintained within the variety development programmes. Genetic variety may be introduced at many levels and in a range of methods including intra-varietal, inter-varietal, parental and inter-specific diversities. A systemic geographical and temporal application of genetics, the utilization of interspecific varietal mixes and the integration of horizontal and vertical resistors have been proposed as a method for specific adaptation rather than broad adaptation.

KEYWORDS: Agriculture, Cultivars, Genetic Vulnerability, Green Revolution, Plant Breeding.

1. INTRODUCTION

Crop production plays a vital function to feed the rapidly increasing population in global food supply. Nonetheless, agricultural plant production was often poor compared with forecasts. Genetic modification of crops and the cultivating environment via appropriate crop management and protection techniques including the use of large-scale agrochemicals are key means of bridging the gap between actual and anticipated yield. Modern plant breeding in its mature form may begin around the mid-1990s. Based on the efforts done to far, many improved varieties have been developed and distributed to growers which respond to cultural and crop management techniques. The genetic improvements in such cultivars have led to an enormous rise in agricultural production, at least in prospective regions during the last several decades. For example, 50% of the United States grain output is attributable to genetic enhancement. Dr Norman Borlaug, the father of the Green Revolution and winner of the 1970 Nobel Peace Prize, has repeatedly emphasized and mathematically demonstrated that, unless scientific progress was made in the last half of the century and a more fundamental level of achievement in the green revolution, life would have been nearly impossible with today's population level [1].

Typically, genetic diversity among (across) plant species characterizes traditional agricultural production. Genetic diversity within a particular species, i.e. the degree of individual differences within a species for inherited attributes may be denied continuously by selective breeding, adaptation of the environment and extinction of species, but the focus here is on denuding diversity through selective breeding as the unwanted side effect of scientific development. As far back as the 1840s, it was evident that sophisticated plant breeding, while essential, was also not immune to unwanted effects. The replacement of native land races with better genetic basis species has caused genetic erosion and a fast decrease in genetic diversity. The consequence of the later genetic homogeneity led, in turn, to so-called genetic fragility. The sensitivity of most farmed species to biotic as well as abiotic stressors owing to similarities in their genotypes may be described as genetic vulnerability. Without sure, depending on a limited genetic basis, at least as an important condition, would render crops susceptible to damaging epidemics, in particular. Recent research has shown that crop breeding continues to reduce the genetic basis of many crops, despite others arguing that plant breeding in some crops has not resulted in a denudation of genetic variety [2].

Global farming is at crossroads because the world's people are projected to grow to 8.3 billion in 2025, and there can be no further growth of the cultivated area, since cultivable land cannot be expanded forever. They may try to enhance their agricultural conditions, but it is now widely recognized that the farmer's own creative ability can only lead to a small improvement over existing methods, and only when farmers are backed by official research. With the number of people growing, the traditional methods and future improvements in food production cannot be limited to intensifying traditional practices, which entail replacing the land race with better varieties. In turn, the replacement of native lands with enhanced species of the limited genetic basis may lead to genetic vulnerability. Is there any way to reconcile these conflicting phenomena in future for sustainable development? Here we examined the major reasons and the genetic susceptibility mechanism and proposed solutions out of the related issues[3].

1.1 Genetic Vulnerability:

When modern cultivation started, the issue of pushing crop types to a very uniform condition with regard to the necessity of preserving some degree of genetic variation in the crop against the incidence of diseases, insect pests and climate flushes was not recognized. Later, the analysis of the causal foundation of some devastating effects such as the Irish Potato Famine in the 1840's showed, as hundreds of the traditional broader-genetic-based variants have still been cultivated, that using the genetically uniform varieties with a narrow genetic base lead to genetic risk.

In history, there are numerous horrific instances of the catastrophic consequences of depending on these limited genetic foundations. Most losses have traditionally been linked more with diseases than with insect pests because the latter have less possibility of mutation than the former. The Irish potato famine is a consequence of the proliferation of genetically homogeneous clones and an 80 percent decrease in the output of potato late blight. As a consequence, millions of Irish people died of hunger and two million others fled. Similar disadvantages of the uniform variety were apparent, especially in the United States, where genetically similar types were constantly used in production. The wheat rust caused by the destruction of wheat fields in 1917, the elimination by Victoria blight of all Victoria-derived oats in the mid-1940s and the southern maize blight resulted in an estimated 15% reduction in maize output or in a loss of one billion USD in the early 1970s could be given as a few examples. A number of additional instances are also accessible in Asian nations such as India's large Bengal famine of 1943 owing to a devastating rice disease. More than a century ago in France a prime example of destruction by insect pests occurred when grapevine was completely wiped out by assaults upon the root stocks of Phylloxera vertifoliae until a resistant variety was imported from the USA[3].

1.2 Genetic Vulnerability Causes:

1.2.1 Narrow Crop Species Genetic Base:

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The cultivated cultivars' narrow genetic basis is regarded as a direct source of genetic susceptibility. Natural populations normally suffer from natural disasters, but genetically speaking they are still more flexible in adapting or developing with disasters, whereas commercial cultivars are genetically consistent and their populations sufficiently rigid. Natural populations have either low genotype by environmental interaction, enabling them to perform under both stressful and optimal conditions, or genotype substitution can happen in a mixed population so that the plants that do not produce under certain circumstances produce well in different conditions. It might be argued that, in the natural population, the resistant individual generates more offspring than a vulnerable person, whatever is the current breed of the disease, causing the respective reproductive benefits. Therefore, every cycle of progression to the next progeny may lead to additional genetic improvement and adaptability. However, in a genetically uniform population no individual can have a relative reproductive advantage over the other, since they are all similar, and as long as there is no mutational change in pathogen, environment and/or host race is concerned no genetic change is anticipated[4].

The creation of hybrids by combining inbred lines with a high degree of genetic homogeneity has decreased the genetic diversity of plants like maize compared with open pollinated species. In addition, many high yield and disease resistance varieties are produced continuously by crossing and crossing the previously adapted standard varieties, and these methods significantly decrease the genetic basis of cultivars.

Genetic diversity-type crop production is usually steady in comparison to genetic uniformity for a variety of reasons. Firstly, the pathogen is hard to develop matching genes for many gene-specific resistance genes, as is the case with homogenous genotypes. In other words, the more resistance genes the host has, the less likely the pathogen can match all resistance genes. Second, it may be anticipated that the utilization of growth resources can be more efficient, based on spatial or temporal complementarities. Spatial and time complementarities may arise if the linked plants utilize re-sources in space and time efficiently. Thirdly, the buffering effects of mixed cultivar components may decrease the danger of stress, because all mixed cultivar components cannot be sensitive to stress at once. Fourthly, in the event that one component of a blended cultivar becomes vulnerable to stress, the other components may be compensated in part or in whole, since the latter would have access to additional resources for compensatory development. Fifthly, the reproductive advantage of mixed cultivar components resistant to stress may result in more of it in successive generations and so may lead to greater adaptation of each cycle of advancement to the next offspring. Six, sometimes mutual environmental change can lead to component crops as well as a mixed culture of faba bean and field pea in Ethiopia where faba bean is a physical support to field pea, thus facilitating aeration which reduces foliar diseases while field pea in turn suppresses weeds for faba bean. Simplified hypothesis scenarios show the comparative benefits of the intra-specific or inter-specific varietal mixes over its individual components. For example, a variety of potential situations for three intra-specific or inter-specific varietal mixes in the presence or absence of stress may be anticipated[5].

1.2.2 Dominant Varieties:

The narrow genetic basis of the cultivated types cannot always create genetic susceptibility when alone. The issue is exacerbated by the extensive usage across a broad hectare of one or a few of genetically homogeneous cultivars, which, in terms of the optimum state and susceptibility, is regarded another condition for widespread disease and insect pests. It is deceptive that uniform cultivars with a limited genetic basis are able to thrive for the first year or two after distribution, established on vast acres and then severe losses such unforeseen disease outbreaks. Continuous cultivation of a single variety of the same crop every year would promote disease outbreaks especially when the counteractive mutation of pests and pathogens defeats host plant resistance.

1.2.3 Vertical Resistance Failure:

In a shorter amount of time, varietal resistance may fail than it takes to create a new variety. Another reason of the genetic susceptibility associated with a limited genetic base is the failure of vertical resistance. Vertical resistance is thought to be achieved by one or a few genes rather than by horizontal resistance regulated by many genes. Therefore, it is very specialized and susceptible to changes in pathogens races. A disease or an insect pest is more easily able to overcome vertical resistance because one or several genes of a host may be defeated by mutations in the counteractive generation of the corresponding virulent genes[6].

1.2.4 Inadvertent Susceptibility Breeding:

An inadvertent breeding for susceptibility after infection exposure of a species not already recognized may also lead to unexpected disease susceptibility. One excellent example of accidental reproduction for susceptibility was the introduction of a novel maize genotype in the United States in the 1970s. Hybrids with this novel feature have several desirable characteristics, including resistance to the most prevalent maize diseases. However, they did not resist a formerly insignificant strain, the southern corn leaf blight, of a fungal disease. The TMS characteristic and genetic sensitivity to this disease were also shared by 90 percent of the maize planted in the US in 1970. The fungus met this whole area of vulnerable host and wiped out one fourth of the US maize harvest in 1970, a loss in output of over a billion dollars! If maize land had not been a monoculture, the fungus had not been able to spread so quickly, because genetically resistant varieties had faced obstacles.

1.3 Genetic Vulnerability in Africa:

There are no comprehensive studies showing adequate evidence of the genetic vulnerability of current crop cultivars in Africa. More concern is expressed about replacing land breeds with better variety as a significant source of genetic loss. For example, the FAO study (1996) warns of loss of important agricultural germplasm in many places across the globe, including Africa, where native barley has been reportedly suffering from severe genetic erosion and the loss of hard wheat by replacing landraces with modified species. It is obvious that enhanced cultivars of most crops have not yet been sufficiently produced, and efforts like the Green Revolution have not partially replicated in parts of Africa as the agrochemical requirements for soil fertility amendment and crop protection were not affordable for poor farmers in terms of resources. Although current cultivar varieties are least used, genetic vulnerability examples from African experiences may still not exist. The failure of hybrid maize compared to traditional cultivars in Zimbabwe as a reaction to drought years in the mid-80s is an excellent illustration of genetic fragility owing to the usage of limited genetic foundations in Africa. The cultivation of rapeseed was completely discontinued, a recent introduction to state farms in Ethiopia owing to pandemic outbreaks of blackleg disease. Failures in some crop types, such as maize and wheat, were found in Ethiopia immediately after distribution as a consequence of their vulnerability to severe illnesses, and many of them were soon outdated [7].

Africa is forced to progress towards scientific breakthroughs and modernization of agricultural output on adequate technical and socio-economic grounds. Technically speaking, plant breeding as a discipline appears to be evolving towards genetic homogeneity. Current technological advances, such as plant tissue and pollen crops, in breeding processes, contribute to the efficient production of genetically homogeneous cultivars. Cultivation, registration of varieties and certification processes in tropics have an impact on breeding experiences in temperate regions since less technological alternatives are available to enhance productivity while promoting the preservation of genetic diversity in improved plant cultivar. Africa is also one of the continents that benefit from the coordinated breeding efforts of the International Agricultural Research Consultative Group (CGIAR), which develops uniform and broadly adapted species [8].

Socio-economic aspirations are equally strong to improve scientific agriculture production in Africa. Firstly, agri-cultural development is not only a question of food self-sufficiency and security, but is also seen as a major economic sector in the area of fast industrialization by governments. Secondly, the population has continued to increase at an alarming pace and there's no reason why the growing need for food can't compel African nations in large geographic areas to adopt and produce the finest cultivar crops. Many nations encourage agricultural production to be mechanized, and this will certainly lead to a steady replacement of old cultivars with newly created uniform crops. Thirdly, varietal homogeneity gives developed-country producers, processors, packers and consumer's significant economic benefits. It should not be forgotten that many African countries pend their agricultural goods on the industrialized countries. Uniformity is of economic value here, because customers pay premium prices for uniform, high-quality products, and therefore farmers must cultivate many kinds to provide them with high financial returns [9].

As breeding plants have to comply with national requirements on the basis of genetic uniformity, the ongoing replacement of traditional land races with a few genetically uniform varieties reduces the risk of preventing the genetic diversity of land races, promotes uniformity and leads to genetic vulnerability. It is therefore easy to assume that genetic vulnerability issues once occurred in Africa would have more severe implications for both biophysical and socio-economic reasons. First, because of the fragile circumstances in which environmental deterioration is maximum, output is extremely marginal. Second, in tropical and subtropical areas in general as in Africa in particular, the causes of the genetic susceptibility such as illnesses and insect pests are harsher - causing comparatively more favorable circumstances like higher temperatures and relative humidity. Third, the economic potential of the most resource-poor farmers in Africa does not allow them to take the risk or utilize inputs acquired such as chemical products that provide crop protection [10].

2. DISCUSSION

New plant breeding methods often lead to large yields based on limited genetic foundations of different plants. Not only do research and development stakeholders have aspirations, but the desire of farmers is also a driving factor behind the replacement of genetically homogeneous land-races. Because agriculture is becoming competitive and competitive, no farmer can afford to not produce the finest and most productive crops available. The widespread adoption of one or few genetically homogeneous cultivars over vast geographical regions seems likely and offers perfect circumstances for diseases, insect pests and other natural catastrophes. As mentioned above, the risks of technological hazards once occurred are very serious especially for resource poor farmers in marginal areas where it is unlikely that not only environmental fluctuations, but also the economic potential of farmers, will allow the use of purchased inputs such as chemicals that confer crop protection. Genetic diversity diminishes when the overall number of variations is reduced, the area planted is grown to a limited number of preferred types or the genetic distance between those varieties decreases. The impact of genetic vulnerability should thus be reduced by the use of appropriate breeding techniques and by the systemic deployment of genes.

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No doubt, the highest priority must be acceptable income with less risk instead of high income with high hazards in favor of re-source impoverished farmers living in extremely susceptible conditions and risk aversion. In these regions, a method in which cultivars are adjusted to suit the environment rather than altering the environment to fit the cultivars is vital for sustainable agricultural growth. Specific adaptation to local circumstances, rather than wide adjustment, ensures that the various varied products are closer to the physical environment, to producer needs and to increase genetic diversity in a given area, where the problems of diseases, insects and environmental fluctuations and risks are significant. The earlier notion that breeding for prospective regions would also provide higher yields under marginal circumstances was not true for marginal settings and, of course, different breeding programmes are required for marginal areas and potential areas. Instead of wide adaptation, a specific adaptation to local conditions means that varieties are closer to the requirements of producers and improve the genetic diversity in a particular region. The availability of alternative kinds also makes it clear that they may replace the existing variety in the event of any failure.

Several writers have questioned the tendency of driving variations towards excessive homogeneity by contemporary plant breeding under marginal circumstances. In such circumstances it is preferable to think that uniformity is not essential or even desirable physiologically, but that variety may improve performance and stability at least occasionally. The interests of resource-poor farmers in the marginal regions are yield stability, disease resistance, insect and abiotic catastrophes, and minimal external reliance. Farmers intentionally accomplish this by generating intra-varietal and inter-specific genetic variation. Therefore, breeding efforts to address the group should build on farmers' practices to complement and not to replace their methods. The physical environment and price ratios of external inputs and farms do not permit the use of significant amounts of inputs, particularly agrochemicals, in vast sections of tropics and sub-tropics.

The purpose of crop production may be to improve output and productivity in prospective regions by using yield-enhancing technology such as high yield varieties and agrochemicals. Genetic variety may still be preserved in various ways via systematic genetic deployment without hindering the requirement for automation to minimize risks of genetic susceptibility. Some writers suggest that we should expand the selection of germplasm accessible to farmers instead of ensuring the use of one or more kinds in broad regions. Cultivating in varieties of various resistance genes closely located fields may spread the impacts of illnesses and insect pests. Similarly, in alternative years' other kinds with various vertical resistance genes may be employed to disrupt evolution of the pathogens. There is also some evidence that, if areas perpendicular to the wind are planted with alternative species with diverse genetic origins, each species may serve as a filter for the virulent path-type on its successor. However, pathogen migration along a particular route is not frequent.

3. CONCLUSION

Plant breeding is one method of addressing the issue of bridging the increasing gap between food demand and availability. But plant breeding has its own detrimental side effects, despite the significance. The substitution of soils for a number of genetically similar species reduces genetic diversity and offers the perfect circumstances for pests, illnesses and unfavorable climate changes. The expanding number of humans and the accompanying increase in food needs are the primary drivers for this limited genetic basis. It is essential to understand the phenomena and prepare to reduce the risks of hereditary susceptibility.

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We must neither avoid genetic uniformity completely or swing between genetic uniformity and variety. We ought to determine where to place what. Where automation in the prospective production regions is practicable and cost-effective, the benefits of genetic homogeneity resulting from formal breeding and seed production programmes should be very systematically used. We should rethink existing breeder methods which lead to genetic homogeneity in marginal regions where illnesses, insects and environmental variations and thus dangers are quite serious. Because risk aversion techniques shape the reactions of farmers to new choices, technology and regulations should confirm and strengthen these strategies. Some degree of genetic diversity in variety development efforts should be purposefully preserved. Farmers are to be encouraged by adequate technological and legislative assistance to preserve, develop and enhance locally-adapted and di-versed genetic materials.

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