Advances in Crop Science and Technology

Review Article Open Access

Influences of founder effect on crop evolution; Causes, Mechanisms and Remedies in the case of Ethiopia

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Abstract

The founder effect is an occurrence when a new colony of crop with few in number is causes for a genetic drift. A large number of genetic resources are losted their genetic variation in this world because of this event. This universe is reach in having ample amounts of genetic resources and the earth has 370,000 - 500,000 species of higher plants out of which approximately 369000 have been described. Now a day several species of plant genetic resources are not known by science whereas a third of the available genetic resources are at a risk of extinction because of the events of the founder effects. This phenomenon is happening when small group of individuals is isolated from the diversified populations as a result of selection of the most preferred crop for specific purposes, domestication and introduction of the crops from abroad and creating of the distances within the selected and the overall population in order to prevent inbreeding providing the new population becoming genetically distinct over the time. Even if the founder effects basically from domestication consisting a fraction of genetic variability of the parental lines it is so important that and can contribute a significant role in domestication and the genetic improvement of the crop whereas the problem is when a preferred traits are intentionally selected from the larger population while ignoring of others is takes place that resulted in loss of genetic diversity within the massive crop species as a result of wide spread adoption of the elite or selected genotypes substituting the existing land races and wild cultivars and colonizing of their natural habitats. Even if the exotic crop is dominated for a given period of time, however it will be fallen after a period of time under a harsh circumstance due to the constraints like climate changes, biotic and abiotic factors as a result of it doesn't have a resistant gene that enables it to overcome the aforementioned constraints. Even if crop introduction is inevitable, it is very valuable and it needs to be to protect the indigenous crop plants in order to prevent them from extinction as a result of the effects of the founder effects. Since indigenous crops are gifted in polygenic in nature it serves as a source for resistant genes that enable to withstand the harsh environmental circumstances and also it is very important to play a vital role in providing gene of interests in crop improvement that uses as a means of supporting in maintaining the genetic diversity of the crop population. As crop plant is displaced from its original agroecologies as a result of various means of agents then the crop is enforced to alter their gene pool that causing to the genetic bottle neck simply because of domestication and founder effects and it is that is why in the field of breeding work any selection imposes causes for reduction of genetic diversity because of in selection it favors the best genotypes while ignoring of the rest of the population than conserving to use for the other purposes. Therefore, the objective of this paper is to review on the influence of founder effects on the crop evolution and to understand its causes, mechanisms and the existing remedies to overcome the problems [1, 2].

Keywords: Founder effect; Crop; Evolution; Influence

Introduction

Founder effect is the mechanism of reducing the genetic diversity of the crop when a population is descended from small number of colonizing ancestors and the loss of genetic variation is happening when a new population is established by a very small number of individuals from a huge number of population (Cowling., et al 2009). Introduction and domestication of a crop is one of the breeding methodologies which consists of selection that contribute to create genetic variation that used as a pillar in a crop improvement in the course of breeding program. As far as a crop plant is transported from its center of origin to the other places through different means of agents then the crop may alter their gene pool causing a genetic bottle neck because of domestication and founding effect. Once the crop is domesticated to its non-center of origin only favorable haplotypes are remained around selected genes resulting in creating genetic valley with extremely low genetic diversity that resulted in allowing deleterious alleles to come to fixation and therefore in a breeding system any selection imposes a reduction of genetic diversity through favoring of a preferred genotypes (Smykal et al., 2018) [3].

Founder effect is therefore can be influenced through narrowing of the genetic variability in the crop population as compared to its wild progenies. Natural hybridization between two different genotypes of the same crop can be presented by various isolating techniques and gene flow and if it's exist is more effective in direction from the cultivated to the wild population, founder effect in crop plant evolution conveys that the value and the breeding quality of the genetic variability stays in its wild relatives (Meyer., et al 2012). Selection of a target individual plant is led to a founder effect and that is why the domestication bottle neck increasing the linkage disequilibrium in which a large spread of phenomenon in a genomic studies of annual crop (Olsen,K.M and Wendel,J.F,2013). When a number of wild species is brought into cultivation and conducting of further selection pressure as well as domestication it is accompanied by a genetic bottle neck that leading to minimize the genetic diversity of the crop in relation to its wild

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Received: 01-Sep-2023, Manuscript No: acst-23-113874, **Editor Assigned:** 04-Sep-2023, pre QC No: acst-23-113874 (PQ), **Reviewed:** 18-Sep-2023, QC No: acst-23-113874, **Revised:** 22-Sep-2023, Manuscript No: acst-23-113874 (R), **Published:** 29-Sep-2023, DOI: 10.4172/2329-8863.1000623

Citation: Chifra W (2023) Influences of founder effect on crop evolution; Causes, Mechanisms and Remedies in the case of Ethiopia. Adv Crop Sci Tech 11: 623.

progenitor (Schaal, 2001). Domestication and intensive breeding is one of a causative agent in narrowing a genetic bases of a germplasm of a crop (Bergougnoux 2014). Which reveals that only a subset of genes and alleles in the wild progenitor gene pool are still present among crop cultivars (Olsen and Wendel, 2013) [4].

In a wild population plant breeding and domestication are a key to local adaptation. As far as crops cultivated either in garden or in the fields and as it distributed to different agro-ecologies of the new areas, the discrete population will be founded from relatively small number of founders (Ladizinsky 1985). According to Ladizinsky (1985) report, introduction of crop plant could be driven a unique adaptation in relative to wild progenitors including genomic changes related with demographic transitions and gene flow of which resulted in the creation of another bottle neck due to a trade from place to places and also when the crop is improved for specific uses and this resulted in addition to the demographic effect of more over it alleviated a breeding population material exposing to genetic drift. Human selection of a crop for different purpose and crop improvement through removal of allelic variants of genes that conferring to undesirable traits for production is also causes for alleviation of a genetic diversity of a domesticated crop (Allaby et al., 2008). The most huge genetic differences found in the wild progenitor of most of the crop as compared to domesticates implies as most of the cops derived from a single or a few crop plants through a domestication phenomenon (Meyer & Purugganan, 2013) [5].

Founder effect which comes basically from domestication pertaining of a fraction of a genetic variability of the parental population can play a significant role in domestication and crop genetic improvement whereas the bottle neck is when a desired traits are intentionally selected through ignoring of others that resulted in loss of genetic diversity within the crop because of the wide spread of adoption of the elite genotypes replacing the existing landraces and wild cultivars and replacing their natural environments (Olsen & Gross 2008). Therefore, the objective of this paper is to review on the influence of founder effects on the crop evolution and to understand its causes, mechanisms and the existing remedies to overcome the problems [6].

Literature review

Causes of founder effect

Founder effect is a phenomenon happening when a new colony of a crop is started by a few members of the original population that causes for a genetic drift which causes for a huge loss of genetic variation for small population implying that the colony may have minimized a genetic variation from the original population. And it is estimated that the earth has 370,000 - 500,000 species of higher plants out of which approximately 369000 have been described (world's plants report,2017). Until now several species of plant genetic resources are not known by science whereas a third of the available genetic resources are at a risk of extinction (Pimm,S.L and Joppa,L.N,2015). Phenomenon that happened when small groups of individuals is isolated from a huge population and the distance obstacles between the two population causes for preventing inbreeding resulting in the new population becomes genetically distinct over a time.

According to a finding of FAO and FAOSTAT(2015) founder effect may occur due to food preferences as human depends on a few collection of crop plants for their dietary intake, reporting that only less than 20 plant species collectively gives about 95% of the world calories; recognizing for instances as banana, cassava, maize, millet, potatoes, rice, sorghum, soybean, sugarcane, sweet potatoes, wheat, legumes (lentil, pea and chickpea) revealing that depending on a few species of crop plant is a key causes for vulnerability of the world wide food delivering to the impacts of climate change causing in the creation of a new serious of plant diseases and pests which resulted in loss of genetic variability.

Mechanisms of founder effects influencing crop evolution

One of a major agent in influencing crop evolution is a founder effect. The mechanisms of founder effect in influencing crop evolution is through; primarily through wild harvesting and then conscious and unconscious selection of the crop that targeted to upgrade crop behavior and at the end consciously selected plants are subjected to adopted at specific area and then the plant finally loses the ability to survive by their own independently without human interference for their care to be survive (Harlan,J.R et al,1992). Molecular analysis conveys that convergent phenotypic evolution is often relied on a molecular change in orthologous genes or pathways. Mechanism of domestication is happened in separately on a different continents using different cultural methods representing a set of parallel trial from which to infer recurrent processes of which crops have been subjected to similar selection pressures and developed identical adaptation in different regions that leading to convergent evolution (Lenser, T. and Theiben, G.,2013) [7].

On the other part Vavilov had stated the law of homologous variation implying that closely related species and genera are categorized as a similar homologous serious in their genetic variability of which is consistent with the idea of domestication syndrome and also with the view of convergent evolution (Genet.,1922). Fuller, D.Q, Allaby, R.,(2009) reports that the best defined and studied domestication syndrome is for the grain crops such as cereals, pulses, and oil seeds. Furthermore Purugganan, M.D. and Fuller, D.Q., (2009) reports as this insisting loss of germination inhibition, seed size enlarges, linking to successful early growth of planted seeds and loss of natural seed dispersal. In most of seed of a crop, shattering is one of a mechanism in losses of fruit that has been under selection. In wild plants shattering is regarded as a basic trait to assure seed dispersal and the evolution of non-shattering could either being under conscious or unconscious selection as a by-product of harvesting higher proportion of non-shattering variants which were then sown in higher frequency (Ray, A., and Chakraborty, D.,2018).

Influence of crop introduction and its founder effect on crop evolution

As crops are moved from a center of origin to other locations during domestication and then the founder effect is happening causing altering of gene pool of the crop and the estimates of the number of loci under selection in the domestication process will have a huge range (Ladizinsky, G.,1998). In several crops domestication syndrome is managed by a few numbers of major genes under monogenic recessive genes while the others are tending to be only loosely linked genes (Gepts, P.,2004). Beyond the bottlenecks, as far as crops grown across a large environment their census population size will expands while in most broad acre crops with low out crossing rates is difficult to compensate the lost genetic diversity within the crop because of domestication bottle neck. For instance, in the diversity of chick pea,100 fold decreased as compared to C. reticulatum even if the crop distribution is far wider than its wild progenitor (Vonn Wettberg, E.J.B.et al., 2018). If population distribution is accompanied with

introgression, they may provide additional alleles into a defined crop population that can be happen if a compatible wild relatives co -occur in the new environments (Mathew, L.S.et al., 2015) [8].

In crops with significant introgression or hybridization like North African dates or citrus and in out crossing perennials like most of tree crops, their genetic diversity remains high in their cultivated population when compared with wild relatives and furthermore the occurrence of mutation is very vital and the influence of epigenetic changes remain substantially unexplored in several of incompatible crops like several of fruit trees (Miller, A.J. and Gross, B.L,2011). Grafting may preserve heterozygosity within the individual while providing very low population stage variation (Warschefsky, E.J.et al., 2016).The alleviation of diversity because of the bottle neck and through selection process can be causes for inbreeding between domesticates and local wild population which resulted in primary slowed domestication and makes the mobilization of crop from outside of center of origin has provided reproductive isolation resulting in better modification of the crop and admixtures substantially complicates the evaluation of the timing and location of domestication (Larson, G.et al., 2014). In addition to this, this author also defines as the diversity of domesticated crop species and their wild relative is exploited through breeding and production and this diversity is stored in germplasm collection at the level of the world but most of the crop species in the seed banks are poorly characterized and it is difficult to utilize in crop improvement.

High amounts of nutrients and higher level of antinutritional compounds like phytic acid is largely found in wild relatives while selection for palatability and advancing of the yield potential of the crop through domestication as well as when post domestication divergence exacerbated the low nutrient levels of several crops. And this resulted in lack of genetic diversity within modern germplasm which imposes a larger influences in limiting the capacity to breed for higher nutrient level and this is a place where knowledge of domestication along several crop taxa should be provide the required insights to breed for advanced nutritional crops in a rapidly developing worlds and in addition to the maintenance of diversity of crop species in human diets that are very vital in sustainable amendments in human nutritional values (White, P.J. and Broadley, M.R.,2005) [9].

Major causes for crop introduction and its founder effect on crop evolution

Increasing of demand for high quality food

Currently the fasting growing rate of human population throughout the world with declining of domestical crop nutritional quality constituent limits causes for the raising of the demands for high quality food that happened in connection with the climate change and due to a shrinking of resource bases like arable lands, N, P and the like creates the perfect storm for the society where agriculture is being requested to produce more from less to meet the emerged challenges and agriculture need to deploy all the tools at its disposal. In the view of crop advancement identifying and exploiting all the useful genetic diversity that were exists in our crop gene pools as well as widening of our vision to domesticate new crops should be seriously viewed. Crop water requirement is the most vital requirement for crop genetic diversity improvement and despite of their potential it is not utilized to the required level in a breeding program (Dulloo, M.E. et al., 2013). Breeders are always nervous in diluting elite domestic gene pools with wild traits when represented international gene banks are available (Maxted, N. and Kell, S.,2009).

Increasing of demand for high yield

Among the several of significant trait's, yield, quality and adaptation are the most important that are controlled by several of genes within a very complicated population advancement approaches that are required to identify and could be able to be applied in agricultural crop species breeding (Huang, B.E. et al., 2012). Homogenization of agricultural habitat is one of the major decisive approaches in rapidly driving of evolutional system and therefore high density of domesticated species is significantly required for the seck of maximization of production and productivity and that is why agricultural practices have been used over years and have developed strong selection both on crops and wild selection (Barrett, S.H,1983). As far as a breeding practice is mainly focused on yield in order to achieve the maximum production, more or less optimum cultivation circumstance's seems likely that abiotic stress tolerance traits have been lost (Van Der Knaap., 2007). This shows that the potential gained in heat tolerant level from the cultivated germplasm is likely low and that of the wild plant population gives higher genetic variability than the domesticated varieties (Koenig et al. 1990). This truth conveys that a stronger founder effects in the domestication process could affect the wild populations (Ladizinsky 1985), and which could be able to eroded a valuable genetic variability of the crop species (Debouck and Tohme 1989) [10].

Summary and Conclusion

As long as the finding of different several authors reveals, a founder effect is one of a principal component in exposing the genetic materials to be lost. When a new colony is established by small number of original population then the occurrence of founder effect will be happening. This will be happening when the founder effect causes for the loss of genetic variation as a result of a new population is founded by a few numbers of individuals than from huge number of populations. In this case the number few populations conveys that as the colony have been minimizing the genetic variation as compared to the original population. And these forms of occurrences will be happening in either of when this few numbers of individual are introduced or domestically improved few individuals is isolated from a huge population. As a result of this cases the distance between the two population prevents the action of interbreeding among the population and finally causes for the new population becomes genetically distinct over a time. It is because of preferences for Yield, quality, early maturing, the color and the others best performing characters that makes a few numbers of individuals to be selected and makes them to be isolated from population causing the population to be colonized. Hence, as a result of this action the consequences resulted in genetic drift that causes for a huge loss of genetic variation within the existing population. Over increment of human population is one of among the major driving forces for the introduction of plants in order to fit the food demands requirements domestically. This brings for the indigenous plants gradually forced to be out of cultivation and finally eliminated resulting in loss of genetic variation.

Although the introduced crop is dominated for a while period it will be fallen under very harsh condition because of climate changes, biotic and abiotic factors since it lacks resistant genes to overcome these challenges. Generally, even if crop introduction is inevitable, it is very useful and it needs to be protected the indigenous crop plants in order to save them from disappear as a result of a cases of founder effect. Since they are polygenic having lots of genes in nature it serves as sources of resistant genes to withstand for harsh environment and also it is very pertinent in research as one of a core component of starting material as an initial parental line in using as a source of very interested

traits for crop improvement for supporting in maintaining genetic diversity of the crop species. Therefore, conservation of the existing available resources of crop species like land races, wild cultivars, released varieties, and any other species is very important in either of research system or in the crop population genetic diversities habitats that can be used as a source of gene of interests and in maintaining to keep the races in the agroecological niches of the crop and preventing of the influence of the founder effects in order to save the crop species from extinction is one of the most valuable action to be done in any of crop species in order to lightning of the future more.

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