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Exploitation of heterosis for grain yield and quality traits in wheat

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Abstract
Wheat is one of the most important cereal crops in world, first rank of wheat in among cereal crops in all over world. it is a thermo stable and long day plants extensively cultivated with latitudinal distribution (Sahu *et al*., 2002). Wheat is prominently produced and consumed by the dense public domain in tropical and sub tropical areas. wheat mainly flourished at optimum temperature approximately 15-18 ^{0}C (Choudhury and Wardlaw, 1978). Wheat is the dominant crop in temperate regions that is being used by the human feed and livestock feed. Wheat contains the good protein approximately 8-11% and also contribute the mineral, vitamins, photo chemicals and dietary fiber to the human diet. but current scenario of wheat is not good due to more prone disease affected to wheat yield and resulting decreased yield (Shewry 2009). So how to overcome these problems, heterosis can be exploited in wheat crops. Heterosis is the superiority of progeny from both parents. Causes of heterosis is the dominance effects in progeny that is derived from the crossing between diverse parents. Heterosis in wheat due to complementary and dominance effects of gene interaction that Heterosis can be exploited in wheat. There are many problems to exploited heterosis in wheat that has been described in following and in this review we will be describe future exploitation of heterosis.

Keywords: Wheat, heterosis and future exploitation of heterosis

1. Introduction

Wheat is one of the most important cereal crops in world, first rank of wheat in among cereal crops in all over world. It is a thermo stable and long day plants extensively cultivated with latitudinal distribution (Sahu *et al*., 2002) [21]. Wheat is prominently produced and consumed by the dense public domain in tropical and sub tropical areas. Optimum temperature requirement for wheat is 15-18 ^{0}C (Choudhury and Wardlaw, 1978) [8]. Wheat is the dominant crop in temperate regions that is being used by the human feed and livestock feed. wheat contains the good protein approximately 8-11% and also contribute the mineral, vitamins, photo chemicals and dietary fiber to the human diet. But current scenario of wheat is not good due to more prone disease affected to wheat yield and resulting decreased to yield (Shewry 2009) [3]. Heterosis refers to the superiority of progeny over parents for anything or genetic expression in hybrid for superiority known as heterosis. The superiority of progeny based on dominance and overdominance as well as epistatic effects. But progeny having the additive effects that means there is no heterosis will be exploiting in plants. So for heterosis, dominance play indispensible role to exploitation of heterosis. Most of the heterosis can be exploit in the cross pollinated crops due to have heterozygotes nature, but in self pollinated species heterosis can not be exploited due to have homozygosity nature, it is clear that in cross pollinated exploitation of more heterosis due to hind the recessive allele but in self pollinated crops there is no hindrance of recessive alleles. The phenomena of inbreeding depression is another or opposite direction of heterosis. Inbreeding depression refers to loss of hybrid vigor due to increases of recessive alleles in crop plants. however inbreeding depression and heterosis mainly depend on gene action, which one gene action has been involved to expression of dominance and over dominance. On the other hand heterosis may be originate whenever genetic divergence in parents and reliable of dominance. The recovery of vigor in plants may be obtained remove of deleterious effects of recessive genes and may be nullification of epistatic genes (additive× additive gene effects). But yields contributing character governed by the polygene so they do not show the individual effects of any genes on heterosis. consequences may be increase if the heterozygisity originate differences in gene frequencies between the parents. if dominance can be exhibiting in progeny that means, heterosis to be fully exploited in crop plants. Heterosis may be inferior and superior in crop progeny, but hybrid vigor always to be superior.

Plant breeders describe that manifestation of heterosis will be, when any plants have as a greater vigor in height, leaf area, growth, accumulation of dry matter, and higher yield of the F_1 hybrid (where that is derived) in comparison with its parents (Allard 1960; Brewbaker 1964) [5]. All these characters are contributed by the quantitative characters and play an indispensable role for a final product as a yield (Allard 1960; Brewbaker 1964) [5]. Shull (1914) led the concept to allude that the characters observed in heterotic hybrids are not inherited as Mendelian traits. Therefore, most of the plant breeders have considered these characters as units and tried to explain their inheritance as quantitative characters. Eventually , this became an important part of quantitative genetics. However, most physiologists reviewed that the result of heterosis mainly depends on dominance or heterozygosity (Ashby 1937; Whaley 1952; Voldeng and Blackman 1973) [4, 29, 26].

2. Quantitative Basis of Heterosis

Quantitative basis of heterosis is based on mode of pollination such as self pollination and cross pollination that is mainly identified by the interaction of gene.

1. Dominance
2. Overdominance
3. Non- allelic interaction (Epistatic)

Moreover on the basis of gene interaction Melchinger *et al*., (2007a) [15, 16] reveals the dominance effects of each locus minus of the sum of the additive × additive epistasis will all other loci. these three interaction investigated used in generation mean analysis (Hallauer and Miranda, 1981) [12]. however gene reflections shows gene effects therefore negative and positive effects can be conceals by each other (Melchinger *et al*. 2007a) [15, 16]. There are some studies has been conducted on north Carolina design III by comstock and robinson, they revealed about that cumulative action of large no of dominant genes, this is the main reason of heterosis (Hallauer and Miranda, 1981) [12] however here epistatic is absent. So overcome this limitation one more design is triple test cross that given by the kearsey and jinks, this is the elegant extension of north Carolina design III. Nevertheless, even with a triple test cross design inferences the importance of epistasis are critical as non-significant epistatic variances can be attributable either to absence of epistatic effects or to the low power of the statistical tests with the sample sizes commonly employed in experimental studies. (Reif *et al*., 2012) [20].

Three categories have been defined based on the diversity presents in parents described here.

1. Intraspecific heterosis
2. Intersubspecific heterosis
3. Wide hybridization of heterosis

First, describe the intraspecific hybridization, in this, crossing between belonging the two different lines or parents from same species , intersubspecific heterosis crossing between two sub species, while wide hybridization means crossing between two species or different genera. there are many evidences to support to heterosis that if parents have diverse group, heterosis may be superior in progeny that has been reported in wheat (Krystkowiak *et al*. 2009) [13]. most of the breeders choice to intraspecific hetrosis because it is manipulated easily and resulting low costs and higher breeding efficiency and better seed sets compared then wide hybridization. Avoid the low level of heterosis, plants breeders classify the heterotic groups is based on both criteria physiological testing combining ability and molecular marker system. So each heterotic group can be combined and exhibit the different hybrid vigor. This interaction of hetrotic group combined the positive alleles in progeny and show the superior performance in wheat (Schon *et al*. 2010) [22]. Heterotic pattern and combination of parents allows the hybrid performance of parents by reciprocal crosses (Melchinger and Gumber 1998) [14]. The establishment of heterotic groups and patterns in crop species is dependent upon their evolutionary history and genetic diversity (Fu *et al*., 2014) [10].

3. Heterosis In Allopolyploid

Wheat is a self pollinated crop, it is derived from crossing among three different genomes (AABBDD) called the allopolyploid species. Allopolyploid species or interspecific cross is derived by the crossing between two inter species resulting in producing a new species that can generate interspecific heterosis and for higher genome stability. Heterosis fixed by the select of line of parents with normal chromosome during selfing. this can be holding higher diversity and higher ploidy level in allopolyploid such as in wheat (hexaploid) (Briggle 1963) [6] and octaploid triticale that is derived from the between wheat and rye and combine four sets of diverse genome (Goral *et al*. 2005) [11] this research support to further research and demonstrate to heterosis in allopolyploid species.

4. Observation of Heterosis

The conventional breeding method is totally based on phenotypic expression. The plant breeders select any genotype that have phenotypic expression of plants such as increased height, leaf area, growth, dry matter accumulation, early flowering, and higher yield. Analysis of all these characters will now be attempted.

4.a. Heterosis in leaf area: One of the most important things that show of greater leaf area for heterotic hybrids, accumulation of dry matter and yield also may be emphasis to heterosis (Watson 1952; Yoshida 1972) [28, 30]. Leaf area is a product of leaf number and the size of leaves. The size of leaves can be further divided into the length and width as its components.

4.b. Dry matter may be produced heterosis

The F_1 hybrids exhibit heterosis, in addition it is large in morphological form and shows greater morphology compared to their parents (Ashby 1930; Whaley 1952) [2, 29] Since this fact was recognized very early in the development of the concept of heterosis, there have been several attempts by plant physiologists to explain greater dry matter production in F, hybrids (Ashby, 1932;Voldeng and Blackman 1973; Donaldson and Blackman, 1973) [3, 26, 9]

4.c. Yield Components in Wheat

The main components of wheat that are contributed to yield such as number of spikes per plant, number of spikelets per ear, number of kernels per spikelet, kernel weight. Heterosis in wheat for grain yield has been a particular time but nowadays cultivation of hybrid wheat has not become a practical preposition due to additive gene effects in self pollinated crops. There are several practical difficulties in preparing hybrid seeds. Most of the plant breeders reveal that no heterosis has been recorded in the number of spikelets per ear or the number of grains per spike (Walton 1971; Singh and Singh, 1970) [27, 24] . but some amount of heterosis has been found in freshly harvested kernels weight. but in all these cases where yield components f1 hybrids along with their parents has been replicated clearly show that the hybrid followed one of the parents in the number of spikelets per ear and the number of kernels per spikelet. so this data clearly shows that This character with respect to heterosis has not been separated into that actual no of tillers produced and actual no of tillers survived. In such a character it is the ratio of the two that would be a more important trait. It would not be surprising if the hybrid did follow one of the parents in this character. In addition, this character is strongly influenced by the environment. But there is serious confusion. This character may or may not have high heritability. In the field one can obtain a large number of spikes by managing the population. In fact, most of the studies reported that if spacing between plants is reduced result has been recorded in a lowering of the percentage of heterosis also. The effect is largely due to an increased number of spikes per unit area in parents. Therefore, the heterosis based on this character is of much less consequence as compared to single-spike yield heterosis. The yield of some wheat genotypes which have about 600 spikes per square meter reaches the yield level equal to that reported for wheat hybrids (Jain *et al*., 1973). Therefore, heterosis in wheat will be successful only when the yield per spike increases. There are indeed possibilities for this if one could combine the spikelet number of some NP varieties with the kernel number per spikelet of a variety like KALYANSONA. Of course, this will have to be adequately supported by the photosynthetic system.

5. Exploitation of Heterosis

present discussion of heterosis in plants leads to following conclusion:

1. At the morphological level such as wider leaves, deep shoot, seedling vigor, plant height, leaf area, growth, accumulation of dry matter in plants, flowering and yields can be contribute in different components and show the simple mendelian dominance in f_1 (Nettevich 1968) [18].
2. The interaction of genes at the processes level, such as the components of photosynthesis, is complementary and provides only a limited advantage over the parents. However, the end products of complementary effects interact multiplicatively. It is this interaction that eventually makes the F, hybrids outstandingly superior to their parents. To be precise, characters such as height, leaf area, photosynthate avail ability, total nutrient uptake, and "sink" potential are the result of multiplicative effect of their component characters, which seem to behave as Mendelian traits. In the end the total photosynthate availability and the "sink" potential are complementary. Limitation in one of them would inevitably limit the expression of other (Nettevich 1968) [18].
3. There are many process such as starting from germination, photosynthesis and respiration can be divided in different component and that show the mendelian inheritance in fi generation, In heterotic hybrids the parents usually bring together contrasting but complementary characters that could have multiplicative effect. This leads to the kind of gene interaction that results in complementation of the physiological and biochemical processes. For example, during germination it would be true about water absorption, amylase activity, phytase activity, respiratory activity, and the number of leaf primordia. In photosynthesis, this could be between the carboxylases and cyclic and noncyclic photophosphorylation (Nettevich 1968) [18].
4. One more important components of heterosis is inbreeding depression, inbreeding depression may be originate continue selfing of progeny that is derived from two diverse parents. there are many components is involved in growth and yield but due to recessive allel fixation in progeny can be influence or decrease the yield (Nettevich 1968) [18]

6. Problems and Future Directons of Heterosis

There are many point of heterosis with hybrid breeding, first that hybrid combination of genes show not the heterosis due to unfavorable gene or low genetic diversity. So overcome to this problems, emphasizing the select of new diverse lines and wider genetic base. this is fact that negative heterosis may occur simultaneously in f_1 generation and it can be removed in f_2 or subsequent generation. Furthermore, as discussed, although the degree of heterosis tends to increase with increasing genetic diversity of the parents, this also increases the likelihood of meiosis abnormalities, such as poor chromosome pairing. Indeed, aberrant chromosomal rearrangements and transposon activations have been detected following wide hybridization (Chen and Ni 2006; Nicolas *et al*. 2007) [7, 19]. Hence the divergence of diffrent parents show the greater heterosis and influence the seed yield and give the suitable inheritance pattern to the agronomic trails. so utilization of heterosis some point must be need studied.

(1) identify and manipulate additional wide-compatibility genes to support stable genome compatibility between distant species; (2) identify and functionally characterize positive heterotic loci; (3) pyramid wide compatibility genes and positive heterotic loci into a common genetic background; (4) deepen our understanding of the mechanisms involved in genomic structural instability in the F_1, and (5) develop high efficient pollination control technologies on a species specific basis.

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