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Research Article

A REVIEW ON HYBRID WHEAT: PROBLEMS AND PROSPECTIVE

Suresh* and Om Prakash Bishnoi

Department of Genetics and Plant Breeding CCS Haryana Agricultural University, Hisar (Haryana) – 125 004

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A B S T R A C T

Improvement in crop genotypes is the prime objective of any plant breeder. One of the best methods used for this purpose is development of superior hybrids. Heterosis breeding has improved yield of many cereal crops including maize and rice. In self-pollinated crops like wheat, hybrid development is a potential alternative to break yield platue. For any successful hybridization programme a system is required which can control self-pollination. Wheat is a highly self-pollinated crop and to exploit heterosis in yhis crop a number of methods are tried to control selfing including hand emasculation, male sterility systems and chemical hybridizing agents. But all of these systems have their own advantages and limitation. In this review, we have tried to focus on all aspects of hybrid wheat breeding and major problem occurring in hybrid development.

INTRODUCTION

Food is the basic need of every human. Cereals are the most common staple food all over the world. Among all cereals, wheat (*Triticum* spp. L.) is one of the most important staple food contributing to the nourishment of humankind.Wheat (*Triticum sp.*) is an annual cereal grown all over the world and used as a staple food in almost every country of the world. It is generally called '*the king of cereals*', which reveals importance of this crop. At present 749.46 million metric tons wheat is produced all over the world (FAOSTAT, 2016). But due to increasing population, the demand of wheat is expected to increase in the near future. If the population will increase with the same rate, global population will be around 9 billion in the year 2045 *i.e.* around 35% more than the present population (Bavel, 2013). To feed such a large population, we have to increase total production of wheat, which can be done by two ways; either by increasing area under wheat cultivation or by improving production per unit area. As area is limited and with increasing population, total area under wheat cultivation will be reduced, thus we have to focus on the second option. The productivity of wheat has increased from 1960s onward due to development of improved dwarf wheat and management practices. But this improvement is seized in the recent years because now days there are problem of lack of genetic variability in wheat. Breeders have already exploited most of useful genetic variability of wheat due to which a yield platue has reached (Ray *et al*., 2013). Under such situation, heterosis breeding can be an alternative to solve this problem.

Corresponding author:* **Suresh
Department of Genetics and Plant Breeding CCS Haryana Agricultural University, Hisar (Haryana) – 125 004

Freeman (1919) was the first scientist who successfully developedwheat hybrid. After this many scientists have reported significant heterosis in wheat (Singh *et al*., 2010;Longin *et al*., 2013; Mühleisen *et al*., 2014). But the problem in wheat hybrid development is that it is a highly self-pollinated crop. To develop a hybrid we have to emasculate wheat flowers, which is not possible for commercial hybrid seed production. The present review is focussed on various approaches which can beusedto develop hybrids in wheat and problems associated with them.

Conventional Method

Wheat is a bisexual crop and is a highly self-pollinated because of cleistogamous condition (Chelak 1989). In the conventional method of hybrid production, hand emasculation or removal of anthers is required. For the emasculation, plants should be selected at a proper stage. In wheat, flower maturation starts from middle and proceed both upward and downward. The plant which we want to use as a female parent is selected and emasculated when its spike is just to come out from flag leaf *i.e.* at booting stage. Spikelets of upper and lower portion mature late, so these are removed out. From remaining spikelets, middle floretsare removed first to make proper spacing for easy emasculation. Within a floret, glumes of are shortened by 2/3rd using scissors and all the three anthers are removed with the help of pointed forceps without touching stigma (Wells and Caffey, 1956). The emasculated spikes are bagged to avoid contamination with foreign pollens. In the next day morning, spikes from pollen parents are removed and spikelets are shortened in the same way as previously described. After five minutes exposure to sun, anthers will burst and pollen powder will appear which is dusted over emasculated females. The plants thus pollinated are again bagged and proper tagging in done. But, this process of hand emasculation and pollination is very laborious and time consuming process. It is only applicable in crop species which have large flowers and multiple ovules per floret. But in wheat, rate of success using this method is very low. In an alternative method, hot water (40-45°C) is used for the castration of female parent (Mukasa *et al*., 2007). But, again this method is not feasible under field conditions. These traditional methods are not suitable for hybriddevelopment in wheat due to their tedious, labor intensive nature. Seed setting is also a major problem when using emasculation technique. These methods are only suitable for small experiments but hybrid development is not economically using them.

Male sterility in wheat

In any crop species, hybrid development becomes easy if the female parent behave as a male sterile plant. Under such condition, the laborious process of emasculation is bypassed. In wheat a number of systemshave been tried including genetic male sterility, cytoplasmic male sterility and chemical hybridizing agents.

Genetic male sterility

The male sterility may be controlled by genes present in nucleus or cytoplasm. In the genetic male sterility system, the nuclear genes controlling male fertility are mutated. In wheat a large number of male sterile mutants are identified, out of them *Ms2*, *Ms3*, *Ms4* are dominant while *ms1a*, *ms1b*, *ms1c*, *ms1d, ms1e, ms1f* and *ms1g* are recessive in nature (Singh *et al*., 2010). Out of these, *ms1a* and *ms1b* are result of deletion in short arm of 4B chromosome due to ionization with radiations, while remaining are random spontaneous mutations (Singh *et al*., 2010). Genetic male sterility which is caused by recessive alleles is useful as it can be maintained by dominant counterpart but only half of the progeny of thisare sterile (Hermsen, 1965). Remaining 50 per cent of plants which are male fertile, have to rouged out in crossing block before flowering, making this system uneconomic and unreliable as even if a single fertile plant remains it will create problem of hybrid segregation. The differentiation between sterile and fertile plant can be done at early stage if sterility is found to be linked to some specific morphological or molecular marker.

Cytoplasmic-genetic male sterility

The second type of male sterility is caused by the cytoplasmic genes, especially due to some defect in mitochondrial genes (Chase, 2007). This system is called cytoplasmic-genetic male sterility because for the restoration of sterile plant, some fertile plant having restoration genes (*fms1* and *fms2*) in nucleus is required (Li*et al.*, 2006). The CMS is the result of defect in mitochondrial gene. This type of sterility was first found in wheat lines developed by substituting wheat cytoplasm with that of *A. caudate* (Kihara, 1951). In wheat, a number of CMS sources are available in related species. The most common of them is CMS-T identified from *Triticumtimopheevi* (Wilson and Ross, 1962). This system include three lines for a successful hybrid development programme *i.e.* a cytoplasmic male sterile line (A line), a maintainer line (B line) and a restorer line (R line). B line is isogenic to A line because the genetic composition of A and B lines are same except that B line has a fertile cytoplasm. When A and B lines are grown in isolation, seed developed on A line will be of sterile type and that developed on B line will be of maintainer line. The third line is R line, which has a nuclear dominant gene for restoration of fertility of A line. When A line is pollinated with pollen of R line, fertile hybrid progenies are formed.

However, this system again have some limitations including a laborious process of maintenance of three lines (A, B and R lines), incomplete or partial fertility restoration, break down of sterility and undesired side effects of alien cytoplasm (Singh *et al*., 2010). Due to these limitations, CMS system is used rarely in wheat breeding.

XYZ system

Driscoll (1972) developed this system using male sterile mutant of wheat and alien chromosome of rya (*Secale cereal* L.). The male sterile lines (Z line) in this system have the entire wheat chromosomes except a small deletion in 5B (Cornerstone mutant). For maintenance of this line, a line (Y line) having one alien chromosome (5R with *Ms*) from rye. The *Ms*gene is linked with a dominant mmarker, hairy peduncle (*Hp*). The Y line produces two types of pollens *i.e.*ms and msMsHp, while eggs of Z line have only ms type gamete. When Z line is pollinated with Y line, ms/msMsHp and ms/ms progenies will be produced. As fertile plants will not so hairy peduncule, these can be removed easily. The male parent used for fertility restoration and hybrid development is developed by addition of set of 5R chromosome from rye (Driscoll 1972). This system is somewhat useful but the marker gene express only in later stages of plant life.

Chemical Hybridizing agent

In self-pollinated crops like wheat, where crossing is very rare, transfer of genic or cytoplasmicg-genetic male sterility is very difficult task because for the transfer of these systems, regular back crossing is required. This problem can be overcome by using various chemicals, commonly known as chemical hybridizing agents (CHA), which interfere with the development of male gametes without affecting female reproductive part (McRae, 1985). When these chemicals are sprayed on a line at a particular stage, pollens are not formed and thus line behaves as a female line. A large number of chemicals have been tried in wheat for hybrid development including maleic hydrazide, DPX 3778 andEthrel(Hoagland *et al*., 1953).These CHAs are called first generation of CHA and for most of these controversy results are available (Parodi and Gaju, 2009).

Any CHA should have a few properties like it should not affect female reproductive system, do not cause any phytotoxic effects on the treated plants and its progenies, have broad applicability, effective at a wide range of plant stage and environment and it should not be carcinogenic (Pickett, 1993). But none of the chemical tried so far fulfil all these requirements.

Future Prospectus

As hybrid development is the only hope to sustain the productivity to feed the growing population, there is growing concern about hybrid development in wheat. But for large scale production of wheat hybrid, a reliable fertility control system is required in wheat. Using modern technique of tansgenics, a split-gene system in wheat has been developed in wheat male sterility was induced using *barnase* gene (Kempe*et al.*, 2014). But in developing countries like India, use of transgenics face several criticisms. Therefore, to save the future generation from broad spectrum hunger, there is quick need to work in this field.

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