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Hybrid Wheat : Problems and Prospects

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Wheat is a popular bread cereal used by man for centuries. Hybrid wheat is potential in production and productivity which needs for development of hybrid with selection of heterotic parents. In the development of hybrid, the problems are identified like limited choice of parental lines, low magnitude of heterosis, need to development of heterotic pool, recycling of maintainer and restorer lines; simultaneously these are to be rectified. New prospects CHAs (Chemical Hybridizing Agents) is an easy, cheap and reliable method as an effective substitute for emasculation in traditional breeding programme.

India has emerged as second largest wheat producer in the World after China. Indian wheat scientists during last 40 years have made tremendous efforts, which brought food self-sufficiency and promoted the buildup of buffer stock in the country. To keep pace with the burgeoning population and changing food habit of rural and urban populace, it is necessary to increase the productivity level.

However, to meet the wheat production targeted at 1000 million tonnes in the World against 500.62 million tonnes current production and 110 million tonnes in India against current production 76.5 million tonnes by year 2020. The current global productivity of wheat is 2.5 t/ha that must be increasing to 4 t/ha in 2020. Sustained research efforts are further needed to keep on the upward trends in wheat production well above population growth. Various plant breeding tools are increasingly becoming important in the changing scenario for further advancement of wheat; one of them is development of hybrids.

Wheat is one of the major food crops of the world. It has been described as the stuff of life or king of cereals for centuries. Wheat has originated from south-west Asia.

Major cultivated species of wheat in the world are :

Common Wheat or Bread wheat - (*T. aestivum*): A hexaploid species that is the most widely cultivated in the world.

Durum - (*T. durum*): The only tetraploid form of wheat is second most widely cultivated and used today.

Einkorn - (*T. monococcum*): A diploid species with wild and cultivated variants, one of the earliest cultivated, but rarely planted today.

Emmer - (*T. dicoccon*): A tetraploid species, cultivated in ancient times but no longer in widespread use.

Spelt - (*T. spelta*): Another hexaploid species cultivated in limited area.

The prime requirement of hybrid development in any crop is the presence of the extent of heterosis. This gives that opportunity for hybrid development. For development of hybrid wheat, selection of heterotic parents is the basic requirement. In wheat the assessed heterosis for yield ranges from 2.8 – 40.7% (Pricket, 1983). As wheat is strictly self pollinated crop, the search for the parents which have desirable features for enhanced outcrossing, is crucial and the traits like anther length, anther extrusion and pollen viability in male parents and stigma length and openness of florets in female parents is of utmost importance. In addition, the male sterility as well as effective fertility restoration system is needed for reducing cost of hybrid seed production.

For this purpose, suitable CMS lines in high yielding background are required which can be achieved through diversification of the available *timopheevi* based CMS lines. Outline of the **problems** that

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hindered the success and need to **rectify** are :

(1) Limited choice of parental lines : In wheat CMS system, the problems with female parents are by their maintenance behaviour and combining ability and in case of pollen parent by restoration ability. These limit the choice of parents. Joint study of the restore lines showed that only 15-24% were effective restorer and bulk of materials is partial restorer. The choice of parental lines can be greatly broaden by using EGMS or CHAs as we discuss latter.

(2) Low magnitude of heterosis: As compare to cross pollination crops, the magnitude of heterosis in self pollinated crops is much lower. To make hybrid technology commercially viable, it is better to channelize more diverse germplasm i.e. development of interspecific using *in vitro* techniques and wide compatibility genes. CIMMYT has developed some synthetic lines in wheat that gave 76% heterosis in wheat which may be used in hybrid wheat development.

(3) Need to develop heterotic pool : The development and improvement of maintainer and restorer lines by various breeding efforts or by growing F_1 s and identify superior cross for specific traits and harvested in bulk, this yields a diverse heterotic pool.

(4) Recycling maintainer and restorer lines : When these lines are become susceptible to any calamities, the back cross and pedigree method should be required for recycling. This is a long tern project which used other methods like GMS and CHAs.

Other constraints are (i) low seed yield (ii) high seed rate and (ii) low percentage of out crossing & cleistogamous nature.

Opportunities available for hybrid development :

Following methods are available for hybrid wheat development :

1. Cytoplasmic male sterility system : In wheat CMS was discovered during 1950s by Japanes scientists Kihara and Fukusawa when they crossed tetraploid durum wheat with bread wheat and related grasses. But in 1962, J.A. Willson and W.M. Ross at Kansas Agriculture Experimentation Station, USA reported stable CMS forms of wheat in *Triticum timopheevii*. In same year Schmidt *et al.* alsc reported the presence of fertility restorer gene provided necessary opportunities to develop commercially viable hybrid unlike other crops by 3 lines as :

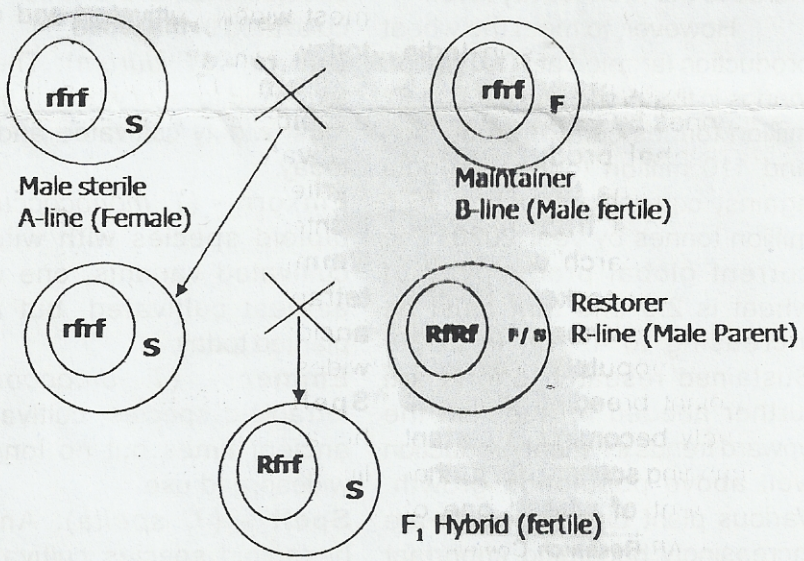
2. Chromosomal male sterility system (XYZ) : Discovered by Driscoll, 1971 in this method 3 lines viz., X=having deletion chromosome used as female sterile

Y=male fertile monosomic addition line

Z=male fertile disomic addition line and maintainer of Y line.

But this system requires heavy efforts and time that increased the cost of seed.

3. CHAs (Chemical hybridizing agents) : Since late 1970s, efforts have been made to use chemical hybridization agents or male gametocides for selective abolition of male sex. These chemicals selectively sterilized the stamens without much affecting the normal



function of female system of plant when applied at specific stage of growth and development and thus can be used to produce female parents for hybrid wheat production. Lang *et al.* (1989) proposed the use of CHAs in wheat.

CHAs have some advantages :

1. There is no need of maintenance of male sterile and restorer parent.
2. Sufficient large amount of seed can be produced.
3. Save the time needed for transferring male sterility to agronomically useful variety through back crossing.

The major problems associated with these are :

(i) Reduced female fertility : need extensive testing before utilization.

(ii) Doses and durability : required extensive testing before utilization.

(iii) Development stage specificity: CHAs are generally applied at PMC formation or pre-booting stage that's why they require critical observation. But in wheat, most suitable stage for CHA spray was 10-12mm of spike length, which is attained 50-60 days after germination in most of the genotypes. The CHA induced male sterilized line exhibited auto-induction of floret opening in wheat that promotes out-crossing.

(iv) Chronic spray required : to signify the results of CHAs, spray should be repeated.

(v) Phytotoxicity : caused epinasty, hybrid necrosis and lipid deterioration.

4. Other methods :

(A) Graham (1975) found that when wheat plants grown on Ca deficient soil, developed mini anthers with abortive pollens. This type of male sterility is little important in plant breeding because of yield losses up to 66% in calciferous soil.

(B) Saini and Aspinal (1982) reported that when wheat plant is treated to 30°C temperature for 3 days at time of meiosis this lead anther indehiscence and pollen abortion. But due to ovary damage there is low seed setting.

(C) Murai *et al.* (1991) suggested photo-sensitive cytoplasmic male sterility system (PCMS), using *Aeg. crassa* cytoplasm. PCMS line is maintained below 15 hr. day length. A fertility restorer gene for PCMS found on 7B chromosome in bread wheat that express at 30°C temperature and 15hr. day length. But due to instability of PCMS, it needs to identify the regions of suitable environmental conditions under which complete male sterility is expressed. The use of PCMS system in hybrid seed production is outlined as:

Out of the above method suggested, CHA is an easy, cheap and reliable method for inducing selective male sterility over diverse environment. CHAs can also become an effective substitute for emasculation in traditional breeding programme.

Location A
<30°C temperature
<15 hr. day length
↓ Selfing
↓
PCMS line (Male fertile)
(Maintenance of the line)

Location B
30°C temperature
15 hr. day length
↓
PCMS line ↓ X Male fertile line
(Male sterile)
Hybrid seed produced in PCMS line

Hybrid wheat – Indian prospect

In India, in the last 10 year, significant progress has been made under the network research on hybrid wheat towards development of gametocides based hybrid technology. Among 50 CHAs developed and evaluated by DWR, Karnal in collaboration with NCL Pune; CH 9701, CH 9702, CH 9078, CH 9831 and CH 9832 have been found promising (Mahajan *et al.* 2000).

Effective package for hybrid seed production comprising optimum doses and crop stages for CHAs application has been developed. The evaluation of near about 50 test hybrids produced by using CHAs revealed 3 (i.e. HM 99168, HM 99160 and HM 9997) to yield 15% higher than standard varieties.

Following institutions are involved in network research on hybrid wheat : IARI, New Delhi, DWR, Karnal, NCL, Pune, PAU, Ludhiana, CCHAU, Hisar. Besides this, MHYCO, a private seed company, has released two hybrids namely: Pratham 7050 and Pratham 7070 that gave

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1.50 tonnes more yield than high yielding variety in North-Eastern regions of India.

World prospect

Once the challenges that hindered the success of hybrid wheat are rectified, then hybrid wheat will have public acceptance and will become a reality. In the World countries are involved in hybrid wheat development are China, Australia and Argentina. Recently china has released some hybrids namely Lunxuan 987, Quantum 708, Quantum 7406, Quantum 7460, Quantum7504. Other countries are trying to enhance the efficacy of hybrids under trial that will be released soon in near future.

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