Forage Res., **38** (2) : pp. 65-73 (2012) **http://forageresearch.in**

ADVANCES ON HETEROSIS AND HYBRID BREEDING IN FABA BEAN (*VICIA FABA* L.)

S. K. BISHNOI*, J. S. HOODA, I. S. YADAV AND RAVISH PANCHTA

Department of Genetics and Plant Breeding
CCS Haryana Agricultural University,
Hisar-125004 (Haryana), India
*(email : sk_bishnoi@scientist.com)

(Received: 28 May, 2013, Accepted: 20 July, 2013)

SUMMARY

Faba bean, formerly broad bean, is gaining importance as a grain legume for protein security of demographically expanding and climatically changing world. Yield instability, however, remains major constraint in the cultivation of this important crop and it is contributing to significant decrease in acreage under this crop worldwide. Exploitation of heterosis has now long been established as a strategy not only to increase the yield but also to stabilize it in open pollinated crops. The cytoplasmic male sterility has already been discovered and positive and significant heterosis for seed yield component characters has been repeatedly demonstrated in the partially allogamous faba bean. Despite these developments, all the attempts for full exploitation of heterosis in the form of commercial production of F_1 hybrid have failed due to phenotypic instability of the cytoplasmic male sterility. The goal of development of hybrid varieties in this species remains unrealized yet, although partial exploitation of the heterosis in the form of synthetic varieties has been reported. The present review of research attempts to synthesize the literature on heterosis research in faba bean along with the description of current and future breeding objectives in context of the unique floral and pollination biology, CMS instability and constraints in hybrid breeding.

Key words : *Vicia faba*, faba bean, hybrid breeding, CMS, heterosis

Faba bean (*Vicia faba* L.), i also referred to as the broad bean, fava bean, horse bean or field bean, is a major food and feed legume (Gnanasambandam *et al.*, 2012). It is one of the oldest crops grown by man and used as a source of protein in human diets, as fodder and forage crop for animals and for available nitrogen in the soil (Maalouf, 2011). When grown for forage and biomass its average forage yields may reach more than 45 t $ha^{-1}$of green forage and nearly 13 t ha^{-1} of forage dry matter (Mihailoviæ *et al.*, 2006). However, it is conventionally grown as a grain legume, not as a forage crop (Patrick & Stoddard, 2010). The forage crude protein yields in spring faba bean cultivars may reach 2600 kg ha^{-1} (Mikiæ *et al.*, 2007). *Vicia faba* is known to have been cultivated since Neolithic times (Cubero, 1974) and it has been estimated to be domesticated around 8000 BC in the Near East (Cubero, 2011). *Vicia faba* does not cross with other Vicia species (Muratova, 1931) and the collections of *Vicia faba* represent the cultivated forms only (Gerard Duc *et al.*, 2010). Hence, it has been concluded that the wild ancestor of faba bean either remains undiscovered or has become extinct (Gerard *et al.*, 2010, Cubero, 2011).

Faba bean is cultivated over a latitudinal range from the equator to approximately 50 °N and 40 °S and altitude range from sea level to above 3000 m. The main faba bean producers are China (1.65 Mt), Ethiopia (0.61Mt), France (0.44 Mt), Egypt (0.29 Mt) and Australia (0.19 Mt) (FAOSTAT, 2009). In spite of the proven capability elsewhere, *Vicia faba* has been categorized as underutilized potential legume in the Indian sub-continent (Singh *et al.*, 2010; Cubero, 1974). They proposed that the evolution of the species accompanied expansion of its cultivation with selection for different interesting traits (seeds shape and size, various level of autogamy, winter tolerance). The long period of cultivation across very diverse environments has resulted in differentiation of germplasm into distinct groups based on seed size and regions of adaptation (Gnanasambandam *et al.*, 2012). The seed size based trait analyses have distinguished two distinct groups in this species: the small-seeded forms in South-Western Asia, including India, Afghanistan and adjoining regions of Bukhara and Kashmir; and large-seeded forms in the

West (Gerard *et al.*, 2010).

Vicia faba is represented by four subspecies viz. *V. faba paucijuga*, *V. faba minor*, *V. faba equina* and *V. faba major* (Cubero, 1974). Based on the region of adaptation the species *Vicia faba* is distinguishable in to winter, spring and mediterranean types. These three classes have different phenologies and the relative importance of vernalization, photoperiod and thermal time in the induction and maintenance of flowering also differ among them (Patrick & Stoddard, 2010). Despite numerous studies, little is known of the origin and domestication of faba bean (Maxted *et al.*, 1991). Cubero (1974) postulated the Near East as its center of origin. However, Ladizinsky (1975) reported the origin to be in Central Asia. According to Muratova (1931) and Maxted (1995) the center of origin for the genus Vicia is southeastern Europe and southwestern Asia which is supported by the study of Tanno and Willcox (2006). According to Cubero (1974), it entered to India through Mesopotamia. He suggested Afghanistan and Ethiopia to be the secondary centers of diversity for this species. The Arab traders introduced it into India (Singh *et al*, 2012).

Despite the huge importance of faba bean as a protein source for human and animals in ensuring food and nutritional security in context of global population increase and global climate change, its full potential remains unexploited due to the special breeding techniques required owing to a unique mixed mating system involving partial allogamy. Because of this intermediate mode of reproduction, the choice of the optimal breeding category in faba bean is difficult (Ghaouti, 2007). The positive impact of increased heterozygosity due to outcrossing in yield improvement and the existence of heterosis in yield component traits in faba bean is well established. The research on heterosis in faba bean started in early 1960s and it is continue till today. The heterosis in faba bean, however, remains unexploited because of many constraints imposed by pollination biology and unstable CMS which are to be discussed in the present review.

Pollination Biology and Impact of Out-crossing

Faba bean has very unique pollination biology in the sense that despite being a self pollinated crop by convention it involves significant levels of out crossing under natural conditions and it has been categorized as a partially allogamous crop. The levels of cross-pollination vary greatly between different cultivars (Suso *et al.*, 1996). The estimates of partial allogamy range from 2 to 84% with a mean of 32% (Bond and Poulsen, 1983). The specificity of partly allogamous and autogamous floral biology of faba bean raises the problem of how to choose the type of variety to be produced (Berthelem *et al.*, 1991). Bond (1987) reported the value of cross pollination to range from 10-70% whereas Berthelem *et al*, 1991 reported the most common values for allogamy as about 40% for winter and 60% for spring type faba beans. The rate of out crossing ranged from 4-89% depending on the genotype being used, environmental factors, row space and the number of pollinating insects, especially honeybees (Rashid & Bernier, 1994). G. duc (1997) concluded that outcrossing percentage in faba bean varies with geographical location and with the species and activity of pollinating insects at the time of flowering. The extent of cross pollination has been reported to be dependent upon occurrence of natural populations of honey bees and bumble bees, the pollinators of fababean. (Gnanasambandam *et al.*, 2012). Cross pollination has been associated with increased seed yields in faba bean. The honey bee mediated cross pollination accelerates the rate of set of bean pods and has been reported to result in significantly greater seed yields than self-fertilization (Wafa & Ibrahim 1960; Musallam *et al.*, 2004). Hence, in the countries with larger populations of honey bees and bumble bees, the extent of allogamy is supposed to be high and vice versa. The mixed mating system in faba bean means that breeding methods that are applied to self-pollinated crops are not suitable, or require modification, while the intermediate level of cross-pollination limits the applicability of breeding methods that are used for highly out-crossed crops such as maize (Briggs, 1967). Gnanasambandam *et al.*, (2012) is of the view that the partial cross-pollination introduces both challenges and opportunities for population development and breeding in faba bean.

In faba bean, the increased productivity and accelerated plant development caused by heterozygosity has been well documented (Link *et al.*, 1994). Musallam *et al.* (2004) reported an yield increase of 49% under cross pollinated conditions when compared to self pollinated conditions. Only 8-12% of flowers under self-pollination condition produce pods, where as this percentage increases to 16% under bee pollination condition. The use of honeybees has the potential to increase yields of faba beans by 19-52% (Somerville, 2002). The plants that were accessible to pollinators provided more pods per plant, more seeds per pods; the pods were longer and the seeds were heavier than the encaged (self polinated) plants (Malika *et al.,* 2008). It is evident that outcrossing in faba bean results into increased heterozygosity which has been postulated to enhance the plant development and yield.

Breeding Objectives

According to Link (2006), the breeding objectives for faba bean include the improvement of grain yield along with incorporation of grain yield stability and resistance against lodging, drought, frost (in case of winter bean breeding), fungi and other pathogens and pests. He also included the improvement in the grain quality in the form of increase in protein content and removal of anti-nutritional factors, as an additional objective. Apart from the yield instability, poor mechanization, susceptibility to biotic and abiotic stresses and presence of non-nutritional factors are other traditional constraints in faba bean cultivation (Cubero, 2012). Faba bean is susceptible to many biotic and abiotic stresses, which reduce yield and affect yield stability. The abiotic stresses such as drought and heat are the major constraints of faba bean production (Abdelmula *et al*., 2007; Amede & Schubert, 2003). It is affected by a range of biotic stresses, including foliar fungal diseases, soil borne pathogens, viruses, parasitic weeds, nematodes and bruchids (Gnanasambandam *et al*., 2012). However, many of them are of minor or local importance and are not major objectives in breeding programs. Chocolate spot and Rust are the important diseases worldwide. Viruses are one of the major enemy of this crop, mainly faba bean leaf roll virus (FBLRV) and faba bean necrotic yellow virus (FBNYV) (Maalouf, 2011). Traditional faba bean breeding involves crossing elite parents, multi-stage testing of progeny, identifying the progeny that outperform the parents for specific traits and the release of superior varieties (Gnanasambandam *et al.,* 2012). The yield potential, although remain unrealized in faba bean due to lack of success in hybrid breeding for exploitation of heterosis. Mahmoud, (2003) concluded that improvement in seed yield and yield stability addressed through the component traits, are the major breeding objectives in faba bean. The constraints in the cultivation of faba bean as described above should constitute the main objectives, while breeding for improved varieties is undertaken.

Yield Instability

The instability of yield is a major constraint in faba bean cultivation. Numbers of flowers and ovules formed greatly exceeds the resulting number of pods and seeds (Suso *et al.,* 1996; G. duc 1997). This indicates the inadequate fertilization particularly in the form of inadequate outcrossing is a major problem in this species resulting in low yields. This was experimentally proved by Rowlands & Bond (1983), who observed that in a field trial about 67% of total examined ovules had not been fertilized. They also found that single seeded pods were preferentially aborted under water stress conditions and suggested that in order to increase the number of seeds per pod, frequency of ovule fertilization should increase. The inadequate cross fertilization causing low and unstable yields in faba bean has primarily been attributed to the low number of (complete the sentence) A significant increase in harvest index, mean number of pods per plant, mean number of seeds per pod and mean seed weights was observed under bee pollinated conditions by Free and Williams (1976) and Somerville (2002). Numerous scientists have found that in faba bean the inbred plants will not set seed untill visited by insects, whereas the hybrids are able to set seed by self-fertilization (Musallam *et al.,* 2004). The yield and yield stability in faba bean are significantly improved by increasing levels of heterozygosity and heterogeneity achieved by breeding synthetic varieties (Link *et al* 1994a; Stelling *et al* 1994a). Economic yield of the faba bean depends on its adaptability to various environments (Confalone, 2009). Yield performance is often limited by the sensitivity of the crop to environmental conditions (especially cold and drought) and the high susceptibility to diseases and pests (Khan *et al.,* 2010 and Torres and Carmen, 2011). The reduction of acreage under faba bean is mainly attributed to its unstable yielding ability (Soon-Jae Kwon, *et al.,* 2010).

Male Sterility and Phenotypic Instability

The cytoplasmic male sterility was discovered independently by Bond in 1956 (Bond, 1957) (447 cytoplasm). However, soon it was realized that the cytoplasmic male sterility in *Vicia faba* is unstable as the cytoplasm appeared to shift from a sterile to fertile state, a phenomenon known as 'phenotypic instability' (Thiellement, 1982). Although maintainer and restorer lines for CMS-447 cytoplasm were found quite soon, but the high frequency of fertile revertants *i.e.* phenotypic instability during multiplication remains main problem in commercial utilization of CMS in faba bean (Bond, 1989). Both 447 and 350 cytoplasm suffers from phenotypic instability which results in disjunctions sterile/fertile in the course of backcrossing or while multiplying female lines (Berthelem *et al*., 1991).

Two new CMS systems designated as CMS 199 and CMS 297 were reported by Link *et al*., (1997). The maintainer and restorer lines for these both CMS systems were also identified soon. Out of these two, the CMS 199 cytoplasm was found to be relatively more stable than CMS 297 during backcross generations and across different environments and was reported to show great promise for hybrid breeding in faba beans. The research to uncover the mystery of occurrence of fertile revertants during multiplication resulting in the failure of hybrid seed production programmes started soon and the cytoplasmic spherical bodies (CSBs) associated with CMS were observed and confirmed in faba bean (Edwardson *et al*., 1976; Scalla *et al*., 1981). These purified CSBs which are uniquely and positively correlated with cytoplasmic male sterility, were shown to contain a high molecular weight double stranded RNA of 16.7 kb, always present in sterile plants but absent from the fertile revertants resulting in phenotypic instability. This CMS-associated RNA was successfully moved from donor sterile to fertile host plants through a dodder bridge (Grill and Garger 1981). After the successful transfer of this CMS-associated RNA the fertile plants exhibited a male sterile phenotype, as detected by visual examination of the flower, the pollen, morphological characteristics, and pollen staining ability. The role of cytoplasmic spherical bodies (CSBs) containing the high molecular weight double stranded RNA of 16.7 kb in conferring the cytoplasmic male sterility in faba bean was validated by this study. A stable CMS system in faba bean, however, still remains to be discovered for the successful production of F_1 hybrids for full exploitation of the reported and experimentally validated heterosis and eventually the yield potential in faba bean.

Hybrid Vigor and Inbreeding Depression

Heterosis, expressed as increase in vigor of the F_1 hybrid over the mid-parents or the better parent results from the combined action and interaction of allelic and interallelic genes. Hybrid vigor is effective in faba bean and improved yield can be obtained by hybrid combinations (Berthelem *et al*., 1991). The heterotic effects in *Vicia faba* may range from significantly positive to significantly negative for different traits depending on genetic makeup of parents (El-Hady *et al*., 2007). The yields of F_1 hybrids average 22% higher than the mean of their heavier-yielding inbred parents (Bond, 1989). The F_1 hybrids outyield their inbred parents mostly by more than 30% (Link, 2006). However, in the F_2 generation the heterosis was reported to be insignificant (EL-Hosary, 1988). The F_1 heterosis ranged from 30-50% over the mid parent in winter and spring type faba beans (Berthelem *et al.*, 1991). Selfing in faba bean is associated with marked inbreeding depression in grain yield and a reduction in auto fertility, while cross-pollination and heterosis are associated with hybrid vigor and improved seed yield (Frusciante & Monti, 1980; Link, 2006). The significant inbreeding depression in seed yield in faba bean indicates that observed heterosis in F_1 is a real one (Nassib 1982).

The significant inbreeding depression obtained for plant height, seed yield and winter damage in the open-pollinated faba bean population has been considered as a strong proof for heterotic effects in these traits (Gasim & Link, 2007). However, inbreeding depression in F_2 not always associated with heterosis in F_1 (Abdalla and Fischbeck,1983). Negative heterosis for some characters have also been reported in faba bean and significant negative heterosis relative to mid parents was found in number of pods per node, days to flowering and maturity time (Bond, 1966; EL-Hosary (1982). However, the superiority of the F_1 hybrid over F_2 not only in seed yield but also in early flowering and maturity was reported by Poulsen (1977). A highly significant positive inbreeding depression for 100-seed weight and seed yield and significant negative inbreeding depression for flowering date and number of seeds per plant was observed by EL-Hady *et al.* (1997). The positive and significant heterosis over mid-parent and better parent is exhibited by F_1 faba bean hybrids for seed yield, number of stems per plant, number of branches per plant, first fruiting node, podded nodes and seeds per plant, number of pods per plant, number of seeds per pod, number of pods per node and seeds per pod, seed weight, plant height, and maturity date which varied according to cross combinations and trait (Bond, 1966; Khalil, 1969; Cubero, 1970; Aabdalla, 1977; EL-Hosary, 1981; EL-Hosary, 1982; EL-Hosary, 1985; El-Hosary & Sedhom, 1988; Bargale and Billore, 1992; Torres *et al.* 1993; Alghamdi, 2009).

The yield components traits involved in yield increase due to heterotic combinations are reported to be number of pods per plant, seeds per plant, seed yield, number of branches, hundred seed weight (Abdalla (1977) tillering ability, number of fertile nodes per plant and number of pods per plant (Berthelem *et al.,* 1991). The superiority of hybrids over the mid and better parents for seed yield was found to be associated with manifestations of heterotic effect for yield components (Abdalla, 1977; El-Hady *et al.*, 2007). The high magnitude in seed yield per plant is mostly due to heterosis in number of pods per plant and a correlation between parental diversity and heterosis does not exist (Bargale & Billore, 1992). The greater part of the heterosis in yield is in the form of increase in number of pods per plant and not in pods (check the statement?) per plant and 100 seed weight (Mahmoud, 1977). Substantial heterosis is present in complex characters (seed yield) without significant heterosis in their component traits (Melchinger *et al.*, 1994). A positive increase for yield components over the mid parental values in the F_1 derived from cross between major and minor types faba bean was reported by De Pace & Filippetti, (1983). The F_1 hybrid produced from a cross between *Vicia faba* var. *minor* (100-seed weight =30g) and var. *major* (100-seed weight =170g) shoeds heterosis for pods per plant and seeds per pod and fruiting nodes per plant. Heterosis for yield components is more pronounced in the crosses between subspecies *V. paucijuga*, V. *equina* and *major* types of faba bean and less hetrotic response was obtained in hybrids between less divergent varieties (Abdalla, 1977). A 100 % and 158 % increase in seed yield over the better parent was obtained in the F_1 by Khalil, (1969) and Mahmoud (1977), respectively. The average significant heterosis for all characters except maturity date was reported by Ebmeyer, (1988) with average seed yield per plant heterosis as 75%, with a range of 34% and 148 %. A maximum value of 38.67% for F_1 heterosis was reported by EL-Hosary (1988). A heterosis range of 11.1 % to 52.9 % over the higher yielding parent and the inbreeding depression range from 4.7 % to 30.6 % was found by Ahmed & Kambal, (2005) in a study involving four faba bean cultivars and F_1 and F_2 generations derived from the crosses made between them. An increase of 30 % to 50 % in yield in F_1 above the mid parent was observed in spring and winter type faba bean by Berthelem *et al.* (1991) while an advantage of 21 to 54 % over the higher yielding parent in grain yield was reported by Stelling, (1997) in the F_1 hybrids of topless (determinate) type faba bean and an average heterosis of 50 % over mid parental value was observed for grain yield. Abd El-Aziz (1993) reported **s**ignificant heterosis for flowering date, over mid and better parent and a maximum advantage of 87.1% for seed yield. El-Badawy (1994) reported that F_1 hybrids showed a heterosis of 49.81 % for seed yield and were earlier to flower than better parent. Overwintering ability and yield were shown to exhibit a mid parental heterosis of about 32 % and 75 %, respectively in a study by Gasim & Link (2007). It is evident that the value of heterosis reported by various workers differ greatly and this difference in per cent heterosis might be due to genetic differences of the parents used and or non-allelic interaction which can either increase or decrease the expression of heterosis (Cress, 1966).

In a study by Abdelmula, (1999) for assessment of drought tolerance in twelve parental lines of faba beans and 27 F_1 hybrids derived from them, the mid-parent heterosis was found significant for Yd (yield under dry conditions) and Yw (yield under well watered conditions), but not for Yd/Yw and relative heterosis for Yd (52.0%) was greater than for Yw (39.3%). Heterosis for all traits except single seed weight is exhibited by the F_1 produced by crossing self fertile indeterminate and determinate var. *major* lines of faba bean (Filippetti and Ricciardi 1988). Heterosis is exhibited by F1 hybrids produced by crossing three Egyptian local genotypes i.e. Giza 2, Giza 402 and Rebaya 40 for all traits except number of branches per plant and 50% flowering **(**EL-Morsy, 1990). The number of pods per nod and number seeds per pod, however, remained unaffected by hybrid vigor (Berthelem 1991). Although heterosis for seed weight was reported by various workers (Habetinek *et al.*, 1985; Karim., 1987; Ibrahim, 2010) but Ahmed & IKambal, (2005) concluded that *Vicia faba* lacks heterosis in flowering time, plant height and 100-seed weight. Significant positive heterosis percentages relative to mid parent and better parent for seed yield per plant and 100-seed weight were reported by Ibrahim, (2010), including significant general (GCA) and specific (SCA) combining abilities. The heterosis for yield in interpool hybrids is superior to heterosis in intrapool hybrids and heterosis for yield components (Melchinger et al. 1992), however, 1000-seed weight and number of pods does not differ markedly between intra and inter pool hybrids Schill *et al.* (1995). Taking this fact into account heterosis and hybrid performance of 33 intra-pool and 66 inter-pool crosses were determined by Link *et al.*, (1996), from a factorial of six *V. faba* minor, six *V. faba* major and eight Mediterranean faba bean lines. Heterotic yield increase over the parental mean was largest for the inter-pool cross between European minor and Mediterranean amounting to 95% in the Mediterranean and 73% in German environments. Their results also confirmed the expectation of an increased heterosis in interpool over intra-pool hybrids. This emphasizes the importance of conservation of gene pools of *Vicia faba* for exploitation of heterosis. The mean weight of mature hybrid seeds produced by crossing two homozygous *Vicia faba* lines was demonstrably higher, revealing mid-parent heterosis and confirming embryo heterosis in faba bean (Meitzel et al 2011). Heterosis is dependent on the type of faba bean (winter or summer) and the origin of the parents In particular it is more important in winter type faba bean and is dependent on genetic distance between the parents of the hybrid (Berthelem et al., 1991). More genetically diverse faba bean parents show more heterosis upon crossing and more inbreeding depression upon selfing (Ahmed & IKambal, 2005). In a recent study by Obiadalla-Ali *et al.*,(2013) who used half diallel design to study heterosis in five Egyptian parental genotypes of faba bean, have reported significant heterosis estimates for better parent for earliness, vegetative, yield and yield components traits. It may thus be concluded that occurrence of significant and positive heterosis and inbreeding depression in F_1 *Vicia faba* hybrids has been well established by a magnitude of studies.

Constraints in Hybrid Development

Hybrid cultivars are not yet bred in *Vicia faba* because none of the several published CMS-systems (CMS447, CMS350, CMS297, CMS199) allows to be employed in practical breeding, mostly due to instability and spontaneous reversion to pollen fertility and thus, the commercial production of hybrid varieties for the full exploitation of heterosis is still unfeasible (Link et al., 1997; Ghaouti, 2007; Gnanasambandam *et al.*, 2012; Berthelem et al., 1991). Moreover, all attempts to obtain interspecific hybrids between *Vicia faba* L. and other species of the genus Vicia also remain unsuccessful. Even after thousands of pollinations attempts, no hybrid seed was obtained by crossing three morphologically similar wild vetch species with faba bean (Wijaya et al., 2004). The disparate chromosome numbers, size and DNA content (Bond, 1995) and postzygotic barriers (Wijaya *et al*., 2004), prevent the development of inter-specific hybrid embryos in *Vicia faba*. Plitmann & Zohary, however, produced slightly better pod and seed development in the interspecific combinations involving *V. faba*, *V. narbonensis* L. and *V. peregrine* (van der Maesen *et al.*, 2005). The development of hybrid varieties in faba bean therefore, remains unlikely due to the high cost of producing and growing very large seeds apart from the phenotypic instability (Gnanasambandam *et al.*, 2012). A large genetic variability has already been identified in *V. faba* in terms of floral biology, seed size and composition, and also tolerance to several biotic and abiotic stresses. (Gerard *et al.*, 2010) Screening of these *ex situ* germplasm collections for a stable CMS is highly desired. The better understanding of CMS may eventually lead to more easily managed forms, either through genetic manipulation or biochemical assays that breeders can use for screening for stability (Bond, 1989). Attempts should be made to introduce male sterility in faba bean through alloplasm and transgenics. Chemical hybridizing agents (CHAs) offer opportunity to develop hybrids in crops where stable cytoplasmic, genetic male sterile lines are not available. Ethrel at a concentration of 0.1, 0.2 and 0.3% has been reported to induce 100% male sterility which lasts for 15–25 days in two varieties of faba bean (Chauhan & Chauhan, 2003). A stable CMS cytoplasm which can result into successful production of F_1 hybrid, although, highly sought, still remain allusive in faba bean and constitutes the main constraint in hybrid breeding in this important crop apart from development of inbreds and identification of good combiners.

CONCLUSION

There occurs positive and significant hybrid vigor in faba bean and it has been well established now that the magnitude of expression of both heterosis and inbreeding depression is relatively high in yield, pod number and seed number and relatively low in weight of seed, plant height and days to flowering. Exploitation of heterosis could improv yield potential and its components in faba bean. The commercial production of hybrid varieties for the full exploitation of heterosis is still unfeasible, hence, the breeding of synthetic varieties has repeatedly been recommended to increase yield and yield stability of faba beans. The advantage of hybrids over composite populations has been reported to range from 3 to 18%. For achieving this objective much work has been done and more is needed to understand and control the phenomenon of phenotypic instability resulting into occurrence of fertile revertants during multiplication. Thus, yield traits and the traits contributing to drought avoidance, escape and tolerance are the main targets of heterosis breeding in faba bean apart from the exploitation of negative heterosis for some seed quality traits like tannin content. The production of inter-specific hybrid also remains a major challenge. Any success with inter-specific crossing would open the gate to new, very welcome allelic diversity.

The benefits of any new faba bean hybrid, which is produced by incorporation of a stable CMS by a novel method, cannot be realized unless sufficient quantities of pure seeds are commercially produced and sold at a cost affordable to the farmers.

The development of inbred lines and identification of good general and specific combiners also constitute the major objectives to be addressed in order to be able to utilize the reported high hybrid vigor. There is urgent need to develop high yielding and preferably hybrid varieties for this crop because as a highly diversified grain legume this crop has high potential to perform better under changing climate situation. Great hope is centered in the new techniques to bring some answer to the problem of phenotypic instability and successful exploitation of heterosis in this crop of future.

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