STUDIES ON EFFECTIVE METHODS FOR SYNCHRONIZATION OF FLOWERING IN PARENTS OF DMH-2 HYBRID MAIZE

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1. INTRODUCTION

Maize (*Zea mays* L.) is known as “King of crops and Queen of cereal” in view of its several uses. Maize is one of the world’s most widely grown cereals, having great significance as human food, animal feed and raw material source for large number of industrial products. In India, about 23 per cent of the maize production is consumed directly as food**,** 63 per cent as cattle feed, poultry, piggery and fishmeal, 10-12 per cent in starch and oil and about three per cent in dry milling. However, there is a shift towards the demand for industry-based maize products.

Maize is known as king of crops because of its high production potential and wider adaptability. In world, maize with a production of 517 million tonnes and productivity of 5.1 t per ha occupies an area of 159 million ha. In India, maize ranks third position among most important cereal crops next to rice, wheat with 19.73 million tonnes production grown on an area of 8.26 million hectares with productivity of 2.4 t per ha (Anon., 2010).

Karnataka is one of the major maize producing states in the country and ranks second in production. Total of 14 lakh hectares of maize was grown with a production of 35.80 lakh tonnes and an average productivity of 3060 kg per hectare. The average productivity of state is much higher than the national productivity. Area under maize is increasing rapidly in the state, because of better environment. Thus there is a greater scope to increase maize productivity to a global level (Anon, 2010).

Seed is the key input in determining crop establishment and yield in agriculture unlike the commercial grain production, the process of seed production is a difficult task. Advent of hybrids in maize, 1957 onwards with establishment of AICRP on Maize increased the importance of seed still more. Hybrid seed yield in any crop depends on synchronization of parental lines and their planting ratio and their yielding ability. Among the factors, major barrier in hybrid seed production is to get perfect synchronization of flowering between female and male parental lines; non uniformity flowering period causes a poor seed set due to non-availability of pollen at the time of stigma receptivity in female parent. To achieve proper synchronization of flowering of male and female parents, methods like staggered sowing and cultural practices such as application of nitrogen through soil, spraying of urea, gibberllic acid, ABA hydro priming and controlled irrigation are followed in hybrid seed production. DMH-2 is single cross high yielding hybrid having difference of about four to six days in flowering behavior of parental lines as stated by the breeder elsewhere. So there is a need and scope to increase the seed yield by improving the synchrony by seed technological and agronomical manipulations.

The ability of the variety to bring forward or delay the date of flowering is largely due to reduced or lengthened vegetative phase which depends on photoperiod and growth season. Thus, enhanced or delayed flowering in maize is largely a reflection of time of tassel initiation and subsequent silk development.

In the past, several methods have been adopted to overcome the said problem of non-synchronization of flowering. When the parental lines are more than the marginal, the only alternative is staggered planting which is not in practice in maize hybrid. In staggered planting the planting date’s of parents of hybrid are adjusted so as to make them to flower at the same time but success of this method is mainly dependent on the known information about the time of flowering of parents at different places and in different season, since planting ratio is involved in maize hybrid seed production.

Since maize is nitro positive crop, increased doses of nitrogen application has been in practice to hasten the flowering which also enables the parental lines to bridge the marginal gap in the flowering duration. The flowering behavior could also be manipulated by the use of different chemicals like gibberllic acid, foliar spray of nitrogen and pre-sowing hydration, which hasten the flowering.

Hybrid seed production of maize was carried out on hectares of land where staggered sowing of parents may pose the problem. Hence in this investigation efforts are made to synchronize the parental flowering during simultaneous sowing of parents where female is 4 to 6 days later flowering as compared to male parent.

So in the present study efforts were made to find out the effect of some physiological and agronomical manipulation with simultaneous sowing of both the parents, nitrogen application through soil, foliar spray on flowering of parental lines of DMH-2 and gibberllic acid hydration to seed for better synchrony to obtain higher seed yield.

Keeping the above points in view, the field and laboratory studies were initiated with the following objectives.

1. To study the effect of seed treatment, soil application of additional nitrogen and foliar spray of N to parents on synchrony and seed yield of DMH-2 maize hybrid.
2. To know the effect of time of sowing on flowering behavior and synchrony of parental lines of DMH-2 maize hybrid.

2. REVIEW OF LITERATURE

Synchronization in flowering between parental lines is a crucial factor in achieving higher hybrid or parental seed yields. The knowledge on flowering days of parental line is essential for adjusting sowing dates of parent. In spite of adjusting seeding dates of male and female parents based on their maturity duration, often we come across the problem of non-synchrony owing to differential behavior of the parental lines under different environmental conditions. Hence, it is essential to find out ways to manipulate flowering once flower initiation takes place.

In this chapter, an effort has been made to review the information mainly on synchronization of flowering and different methods adopted to know the flowering and different methods for fixing the sowing interval. Besides, all the available literature published to tackle this problem of non- synchrony in flowering and poor seed set through agronomic and cultural practices is also presented here. Wherever reviews on concerned concepts not available in maize crop, the work done in other related crops is also included.

2.1 Techniques for synchronization of flowering

Flowering date of parental lines can be adjusted by staggered planting or by application of nitrogen, GA3, hydro priming or ABA if the tassel and silk emergence stage of plant found non-synchronous.

2.1.1 Influence of staggered planting on synchronization of flowering

The staggered sowing of male parent either early or late is practiced to achieve the synchrony in flowering if the difference was more than 4 to 5 days.

Quinby *et al.* (1958) suggested that when the difference in flowering of parents is more than the marginal one, the only alternative to have effective synchronization is to adopt staggered planting. This has been in practice since the release of hybrids for commercial cultivation in crop plants. Similarly, freeman (1964) had suggested the staggered planting of one of the parents to coincide with the flowering of other parent.

Rao (1965) recommended the planting of early maturity parent a week later than planting of other parent in CSH-1 seed production to achieve higher seed yield in sorghum hybrid.

Mahadeshwaran *et al.* (1967) suggested that, the staggered planting of male parent (IS-84) eight days earlier than the female parent (MS-CK60A), in CSH-1 sorghum hybrid seed production to ensure continued supply of pollen and proper seed set.

Hussaini and Rao (1968) studied the flowering pattern in parental lines of CSH-1 and CSH-6. The seed production of CSH-1 was feasible without staggering in both *Kharif* and *Rabi* season as there was perfect synchronization of flowering between CK-60A and IS-84. In case of CSH-6 hybrid, the female line MS-2219A was earlier by one day in *kharif* and three days in *rabi* as compared to the male (CS-3541).

Synchronization study of flowering lines in seven sorghum hybrids at Madhira, Andra Pradesh was conducted by Narayan *et al.*. (1978). The results revealed that there was no problem of synchronization of flowering and hybrid seed production of CSH-1, CSH-7R, SPH-4 and SPH-16 and can be done during the regular season under the isolation condition in this area. Further they noticed that there was requirement of staggered sowing to adjust period of the respective parents in CSH-5, CSH-6 and CSH-8R.

Singh *et al.* (1979) advocated that female parent (MS-2219A) of CSH-6 should be sown 2 to 3 days after the male parent (CS-3541) as stigma of seed parent remains receptive for 5 days.

Mehta and Joshi (1970) based on the flowering behavior of CSH-5 parent under different dates of sowing suggested that, eight days prior planting of half quantity of male seeds and remaining half quantity along with the planting of female seeds in CSH-1 seed production is essential to get higher seed yield.

Kasam and Andrews (1975) concluded that each week delay in sowing, the vegetative phase was extended by 4-7 days, ear initiation by 2-3 days, heading by 1-8 days, head development by 0.5 days and maturity by 1.44 days.

Kunjamma and Menakshi (1979) studied the flowering behavior in the sorghum hybrid (CSH-5, CSH-6 and COH-2) at Coimbatore. In CSH-5, the flowering synchronization between the two parental lines was easier as differences in flowering was on an average only 3 to 4 days which can be adjusted by staggered sowing of parents. In case of CSH-6, the best nicking period falls for the parents sown during the beginning of the year as well as towards the middle of the year (February, March, June and July). The hybrid seed production in COH-2 was problematic due to the erratic flowering behavior of male parents (IS-3541).

Singh (1982) noticed that, sowing of monsoon season crop on 27th June escaped rain damage during the flowering and maturation period and produced better quality seeds in CSH-5, in terms of 100 seed weight, germination percentage and seedling vigour as compared to parents. The seed quality of parents sown on 20th June was good.

Umashankar and Bommegouda (1983) noticed the higher synchronization of flowering and seed set in CSH-5 sorghum hybrid by sowing female parent earlier by 10 days during November, 15 days during December and 20 days during January than the male parent under Bangalore conditions.

When five “A” male sterile lines and their corresponding B- lines were sown on three dates, significant differences in days to 50 per cent flowering were observed for all treatments and interaction in CSH-9 hybrid on an average, B-lines flowered one to three days earlier than their corresponding A lines for all the sowing dates. Nicking was satisfactory in 2077A and 2077B but 296A flowered 2-4 days later than 296B (Singh and Borikar, 1984).

Shekar *et al.* (1985) opined that CSH-9 seed production can be possible by 4 to 6 days late sowing of CS-3541 during *kharif* and 8 to 10 days late sowing during *rabi* season.

Staggering was suggested by Sastry and Krishnamurthy (1985) to be given for planting the parents of CSH-5 in Bangalore location. Simultaneous sowing of both male and female lines to be followed for June to August sowing crop while male parent to be planted 12-15 days late for October and November planted crop and 18-22 days late for December planted crop.

Lakshmaiah *et al.* (1990) while studying the flowering behavior in the parents of CSH-5, CSH-9, CSH-10 and CSH-11 at Podalkar sown from 6th October to 25th November revealed that synchronization of flowering in the parental lines of CSH-10 and CSH-11 was poor, while in CSH-5 and CSH-9 the flowering differences were 3-5 days when sown during second half of October. In CSH-9, the perfect synchronization was observed with the sowing of 6th October.

Krisnasamy and Ramakrishna (1993) reported that adequate staggered sowing of the parental lines had been found to be most effective in achieving synchronization of flowering in parental lines.

Tanwir Alam *et al.* (2007) observed proper synchronization in flowering of parents of Shaktiman -1 hybrid with two days staggered sowing of male parent (2 days late sowing of male parent than female) compared to the other helps to get synchrony and also high seed yield in maize.

Sudipta Basu Bhaumik *et al.* (2007) studied different maize hybrids for their field emergence, vegetative growth, flowering behavior synchronization pattern and seed yield of Ganga-1, Ganga-11, Ganga safed-2, PHM-1 and PHM-2 in monsoon, winter and spring-summer season. The result revealed the feasibility of seed production of hybrid PHM-1 and PHM-2 in all the seasons and of Ganga-1, Ganga-11 and Ganga safed-2, only in monsoon season and with adoption of flowering manipulation practices in winter and spring-summer season under North-East condition.

2.1.2 Effect of nitrogen on flower synchronization

Generally it is observed that additional application of nitrogen results in early flowering in maize, since it is nitro positive crop.

Bharat and Dass (1962) reported that foliar application of nitrogen resulted in greater production of dry matter, while Khuspe and Damber Patil (1963) noticed higher weight of the ear in sorghum.

Kishen Narayan (1967), observed better synchronization in flowering of hybrid sorghum CSH-51 parents with the increase in the dose of nitrogen to late maturing pollen parent (IS-84). The reduction in days taken for 50 per cent flowering was observed with the increase in the application of nitrogen.

Ramachandra Reddy and Mustafa Hussaini (1968), while studying the influence of nitrogen on CSH-1 sorghum hybrid under irrigated conditions reported that, increase in nitrogen levels from 112 kg to 196 kg per ha. has increased the plant height. The maximum plant height of 139.99 cm was obtained with application of 196 kg per ha.

Mukherjee and De (1968) reported that foliar application of nitrogen enhances the plant metabolic activities within a short time thus; it produces quicker results as compared to soil application.

Khot and Nerkhede (1970) reported that higher dose of nitrogen fertilization resulted in the increase plant height and weak stem structure. Similarly, Balanarasaiah *et al.* (1972) and Panda (1972) and Premsingh and Choubey (1972) while studying the effect of varying levels of nitrogen on the flowering behavior and yield of sorghum also observed the increase in plant height with increased nitrogen application.

Prabhakar *et al.* (1973) reported that the plant height was increased from 158 cms with 50 kgs N per ha. to 168 cms with 150 kgs N per ha. in CSH-1 sorghum hybrid.

Preliminary investigation carried out at IARI, New Delhi showed that a fair degree of synchrony in flowering of parental inbred lines of HB-5 could be achieved by different dose of application of nitrogen @ 40 kg per ha to seed parent, MS-5071 and 60 kg N to the pollinator, K-559 (Sharma *et al*., 1974).

Kudasomannavar (1974), obtained increase in leaf area per plant from 1252 cm to 1705 cm by increasing the nitrogen level from 50 kg to 200 kg per ha. He also noticed the same trend in leaf area index. Similar trend were also noticed in MS 2077A, a female parent of CSH-5 sorghum hybrid by Malali (1981) and in parents of CSH-8R sorghum hybrid by Patil (1978).

Vidhyabhushnm (1977) advocated that, the marginal difference in flowering of parental lines of sorghum hybrids can be reduced by the increased application of nitrogen through foliage.

Choudhari *et al.* (1977) reported that spraying of two per cent of urea at 30 days after sowing reduced the number of days for flowering significantly in sorghum.

Naik (1977) and Malali (1981) also observed the increase in plant height of CSH-5 sorghum hybrid with the application of additional nitrogen either to the soil or foliage.

Patil (1978) observed hastening of flowering in the parents of CSH-8R with the application of nitrogen through foliar spray.

Joshi (1976) and Pandusastry (1981) observed an early flowering in MS2077A by foliar application of nitrogen in sorghum.

Basavaraju and Bommegowda (1982) reported that planting ratio of 1:3 (Male and female) along with an application of 150 kg N per ha, the male and female lines of CSH-6 sorghum hybrid took 62 and 56 days respectively for flowering at Bangalore.

Vadivelu *et al.* (1983) observed earliness in flowering with two per cent urea spray to the parental lines of CSH-5 while Biradar Patil (1984) in the parental lines of DSH-1 sorghum hybrid compared to soil application and control.

Singh and Shelke (1984) conducted synchronization studies in two sorghum hybrids *viz*., CSH-5 and CSH-9 at sorghum research station, Parbhani. Along with recommended dose, 12 different doses of NPK fertilizer were applied which influenced the flowering in parental lines. Early flowering by 3 and 2 days in female parents of CSH-5 (MS-2077A) and CSH-9 (MS-296A) was observed with additional dose of 100 kg N plus 30 kg P / ha.

Vadivelu *et al.* (1984) found that spraying of GA @ 200 ppm and urea @ 2 per cent on female parental line (MS-2077A) of CSH-5 hybrid at primordial stage advanced flowering by 3 to 7 days, while treatment with CCC (Chloromequat) @ 300 ppm or malic hydrazide @ 500 ppm delayed the flowering of CS-3541 by 5 days over the untreated control.

Krishnaveni and Ramaswamy (1985) in a field experiment with the parental lines of COH-1 maize hybrid revealed that application of nitrogen significantly influenced the plant height, length of cob, width of cob, number of seeds per rows of cob, total number of seeds per cob, seed weight per cob, shelling percentage and seed yield. However, application of P and K significantly increased the seed weight percentage and seed weight per cob and seed yield only.

Yadav and Singh (2000) studied the effect of three fertilizer levels (90 kg N /ha + 45 kg P /ha, 120 kg N/ha + 60 kg P /ha and 150 kg N/ha + 75 kg P/ha) on seed production and quality of LM5 and LM6 inbred lines of single cross maize hybrid Paras. The results revealed that 150 kg N/ha + 75 kg P/ha gave highest seed yield and seed quality.

2.1.3 Effect of gibberllic acid on flowering synchronization

Naturally occurring hormones play an important role in the process of flowering. This is because of the fact the exogenous application of growth regulators like gibberllic acid is commonly used to promote flowering.

Allan *et al.* (1959) reported that height and internode length were increased with 100 ppm gibberllic acid application, where as 1000 ppm of gibberellic acid inhibited the growth in wheat.

Joe cherry *et al.* (1960) noticed the decrease in leaf area, increase in plant height and number of nodes per plant in single cross hybrid corn with foliar spray of gibberllic acid at seedling stage. Similarly, Kalina (1963) observed an enhanced plant height and dry matter production with the application of GA in corn.

Appalanaidu *et al.* (1961) noticed early flowering in Ragi with the application of gibberllic acid. Similarly, Im (1961) observed enhanced heading in Barley by four to five days with gibberllic acid treatment.

Early flowering was noticed with the application of gibberllic acid in ragi and in sorghum (Joshi, 1976 and Malali, 1981).

Freeman and Hadley (1963) in their study on response of milo-strains of sorghum to gibberllic acid application at the concentration of 100 ppm to 200 ppm reported that the treated plants flowered earlier than the untreated plants.

James and Lund (1965) noticed an accelerated floral initiation and development of short apices in barley with the use of potassium gibberllate (500 ppm).

Kirby (1971) opined that, gibberllic acid application at ear initiation and flower development stage in wheat has hastened the growth of actually growing plant parts.

Joshi (1976) reported that gibberllic acid spray to MS 2077A at 25 days after planting increased the plant height but spray at 50 days did not improve the plant height significantly. However, there was an increase in dry matter production and leaf area index.

Malali (1979) noticed decrease in plant height, leaf area and leaf area index at later stage of crop growth with the foliar application of GA3.

Gibberllic acid application at 200 ppm concentration induced early flowering by one day in February, by seven days in January and August in sorghum (Vadivelu *et al.*, 1984).

2.1.4 Effect of pre hydration sowing on flowering synchronization

Singh *et al.* (1984) reported that soaking the seeds of female parent (MS-2077A) of hybrid CSH-5 for 12 hour in water reduced the period of flowering by four days compared to control. This 4 days difference in flowering between 12 hours soaked and control seed was noticed in each sowing date. This indicated that male and female parents of CSH-5 can be sown simultaneously in *kharif* season by soaking female seed overnight.

2.2 Effect of time of sowing on flowering synchronization

Narayan and Reddy (1968) observed a difference of 42 days in flowering of CK-60A and IS-84 parental lines of CSH-1 sorghum hybrid in April sown crop, where as this difference of flowering was 31 days in May sown crop.

Simultaneous flowering of CSH-1 parental lines were observed by Venkateshwara Rao and Rama Rao (1969) when sown in January, where as in October sown crop, female parent flowered three days earlier to IS-84 and in February sown crop the flowering seen with difference of 6 days.

Shirwal *et al.* (1974) reported that the synchronization of CSH-2 sorghum hybrid was eliminated during sowing in August, September and November months at Hebbal, Bangalore.

Chopde *et al.* (1974) observed a difference of 8 days between female and male parents of sorghum hybrid, CSH-4 during kharif season at Parabhani, Maharastra.

Nayeem *et al.* (1976) observed at Parbhani that days to 50% flowering varied from 116 days in December sowing to 72 days in July sowing in female parent (MS-2077A) and from 73 days in June sowing to 91 days in November sowing in male parent (CS-3541) of CSH-5. The female parent flowered 6-8 days later than pollinator (CS-3541) during kharif, while during *rabi* planting there was 36-56 days difference between seed parent and pollinator. For the parents of CSH-6 there was gap of 0-9 days between July to September sowing.

Murthy and Venkat Rao (1976) revealed that the days to 50% flowering varied from 79-89 days in MS-2077A and from 65-71 days in CS-3541 during November to December sowing of CSH-5 hybrid and there was perfect and nearly stable synchronization observed between the parental lines of CSH-6 and CSH-1 hybrid respectively.

The female line of CSH-6 that is MS-2219A was earlier by three days in *kharif* 7-12 days in *rabi* and 10-12 days in summer season compared to male parent (Anon, 1978).

Meenakshi and Kunjamma (1979) studied the flowering behavior in the sorghum hybrid (CSH-5, CSH-6 and COH-2) at Coimbatore. In CSH-5, the flowering synchronization between the two parental lines was easier as differences in flowering was on an average only 3 to 4 days which can be adjusted by staggered sowing of parents. In case of CSH-6, the best nicking period falls for the parents sown during the beginning of the year as well as towards the middle of the year (February, March and June, July). The hybrid seed production in COH-2 was problematic due to the erratic flowering behavior of male parents (IS-3541).

Krishnasamy and Ramaswamy (1979) suggested that sowing of male and female parents of the sorghum hybrid CSH-5 at one month interval throughout the year, revealed that production of 50 per cent flowering was earlier in the male line sown during May, June, July and August while, it was earlier in the male line sown in the remaining months of the year.

Reddy (1979) studied the synchronization of flowering in the parental lines of CSH-5 hybrid sorghum by CSH-5 sowing male parent later than the female parent on five different dates during summer and winter seasons. Sowing male parent 20 days later during summer season and 10 days later during winter season compared to female parent, recorded higher hybrid seed yield.

Shinde *et al.* (1980) observed that male parent (CS-3541) of CSH-9 flowered 4 to 6 days earlier to female parent (296A) in *kharif* and 6 to 7 days earlier in *rabi* season.

Singh and Nayeem (1980) observed that female parent (MS-2077a) of CSH-5 had taken 67 days for flowering as against 65 days in male parent CS-3541. The differential flowering depends on the environmental conditions.

At Bangalore Pandusastry (1981) observed that female parent was late in 50 per cent flowering compared to male parent of CSH-5 sorghum hybrid. In June, July and August sowings the gap was lowest (8-10days), while in October, November, December and January the difference was 12 to 14 days.

Singh (1982) noticed that, sowing of monsoon season crop on 27th June escaped rain damage during the flowering and maturation period and produced better quality seeds in CSH-5, in terms of 100 seed weight, germination percentage and seedling vigour compared to parents. The seed quality of parents sown on 20th June was good.

Bommegouda and Umashankar (1983) noticed the higher synchronization of flowering and seed set in CSH-5 sorghum hybrid by sowing female parent earlier by 10 days during November, 15 days during December and 20 days during January than the male parent under Bangalore conditions.

Vanagmudi and Ramaswamy (1984) carried out the simultaneous sowings of parental lines of bajra hybrid KM-2 at monthly intervals from October to March and the sowing in March advanced the flowering by 7 days compared to October sowing.

Staggering was suggested by Krishnamurthy and Sastry (1985) to be given for planting the parents of CSH-5 in Bangalore location. Simultaneous sowing of both male and female lines to be followed for June to August sowing crop while male parent to be planted 12-15 days late for October and November planted crop and 18-22 days late for December planted crop.

Krishnaswamy and Ramaswamy (1987) reported that wide differences in the duration of flowering among parental lines of sorghum hybrid CSH-5, CSH-6, CSH-9 and Co-H-2 were observed where sown at fortnightly intervals throughout the year in Tamil Nadu. For achieving simultaneous flowering, the male lines of hybrids CSH-5, CSH-6 and CSH-9 should be sown simultaneously, 12 to 19 days and 4 to 7 days earlier in the monsoon season and in winter 7 to 10 days later, 3 days earlier and 5 to 7 days later than the respective female lines. CoH-2 seed production should not be undertaken during monsoon season since the interval in the flowering of the parental lines was too wide to effect pollination.

Nagesh (1987) reported that the male parent (CS-3541) of CSH-9 flowered 2 to 3 days earlier than female (MS-296A) at Bangalore during *kharif* season.

Vadivelu *et al.* (1989) reported that in male parental line of CSH-5, days to 50 per cent flowering ranged from 52 days at Coimbatore to 64 days at Palam. In female parent, it ranged from 56 to 72 days. They also reported that seed set depends not only on synchronization of flowering but also on the other factors like wind velocity and plant growth.

Lakshmaiah *et al.* (1990) while studying the flowering behavior in the parents of CSH-5, CSH-9, CSH-10 and CSH-11 at Podalkar sown from 6th October to 25th November revealed that synchronization of flowering in the parental lines of CSH-10 and CSH-11 was poor, while in CSH-5 and CSH-9 the flowering differences were 3-5 days when sown during second half of October. In CSH-9, the perfect synchronization was observed with the sowing of 6th October.

Zabeda Ahemed *et al.* (1993) conducted a study on parents of sorghum hybrids CSH-5 and CSH-9 at Seed Technology Research Project, Rajendranagar. Fortnightly sowings from June 15 to January 15 were taken up with the parents of CSH-5 (CS-3541) and (MS-2077A) and CSH-9 (CS-3541 and MS-296A). The differences in 50 per cent flowering of seed and pollen parent of CSH-5 were found to range between 12-14 days in mid September sowings whereas it widened to 16-19 days in advanced sowings. The pollen parent of CSH-9 was fairly stable in respect of days to 50 per cent flowering 66-68 days) and the seed parent 296A was late by 9-15 days in different sowing.

Sudipta Basu Bhaumik *et al.*.(2007) studied different maize hybrids for their field emergence, vegetative growth, flowering behavior synchronization pattern and seed yield of Ganga-1, Ganga-11, Ganga safed-2, PHM-1 and PHM-2 in monsoon, winter and spring-summer season. The result revealed the feasibility of seed production of hybrid PHM-1 and PHM-2 in all the seasons and of Ganga-1, Ganga-11 and Ganga safed-2, only in monsoon season and with adoption of flowering manipulation practices in winter and spring-summer season under North-East condition.

3. MATERIAL AND METHODS

The field experiment was carried out to know the influence of various treatments on the flowering behavior and synchronization in the parents and seed yield of maize hybrid DMH-2 during *kharif* 2010 at Main Agricultural Research Station, University of Agricultural Sciences Dharwad. Further seed quality attributes were tested in the laboratory of Seed Science and Technology, Agricultural College Dharwad. The details of the materials used and techniques adopted during course of investigations are given in this chapter.

3.1 Experimental site

The field experiment was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad in 'C' block, Plot No. 62 during *kharif* 2010 and the laboratory studies were conducted at Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Dharwad.

3.2 Location

Geographically, Dharwad is situated in the Northern Transitional Zone (Zone 8) of Karnataka State on latitude of 15^0 12′ N, longitude of 75^0 07′ E and at an altitude of 774 m above mean sea level.

3.3 Soil

The soil of the experimental site was deep black, clay in nature with 150 cm depth and 7.5 pH. The composite soil samples from upper 30 cm depth were analyzed for physico-chemical properties and presented in Appendix-I.

3.4 Climate

The data on weather parameters such as rainfall (mm), mean maximum and minimum temperature (^oC) and relative humidity (%) were recorded at Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during the experimental year (2010-11) and the mean of the last 60 years (1950-2010) are presented in Appendix-II.

The mean annual rainfall for the past 60 years was 810.55 mm and the maximum rainfall was received in the month of August (154.45 mm) followed by July (138.7 mm). The total rainfall during 2010 - April 2011 was 1122.45 mm and a maximum of 190.7 mm was received in August. January did not receive any rainfall during 2011. The mean maximum temperature ranged from 28.41^0C (June) to 28.15^0C (September) during year 2010-11. The months of October, February and March were hottest. While the mean maximum temperature during past 60 years indicated that, it was maximum in March (35.2^0C) followed by April (34.9^0C). The minimum temperature ranged from 12.5^0C (January) to 21.8^0C (June) during the 2010-11. The average of last 60 years indicated that the mean minimum temperature was maximum during June (21.8^0C) and minimum during January (12.5^0C). The relative humidity ranged from 44 (March) to 84 per cent (July) during 2010-11, the cropping period ranged from June 2010 to April 2011.

3.5 Previous crop in the experimental plot

On the experimental site, Bengal gram was grown during previous season with usual package of practices for seed production.

3.6 Description of parents

The description of the parents of DMH-2 is presented in Appendix III.

3.7 Experimental details

Experiment-I: Studies on effective methods for synchronization of flowering in parents of DMH-2 hybrid maize

The field experiment was laid out under RCBD with three replications and nine treatments at Main Agricultural Research Station, University of Agricultural Sciences Dharwad.

3.7.1 Treatments details

This experiment was consisted of parents of DMH-2 hybrid CI-4 as Female and KDMI-10 as male. The data on flowering of parents of DMH-2 revealed that there is a difference of 4 to 5 days between parents and female is late. Hence treatments were fixed to advance the flowering of female parent (except in T_8) when both the parents are sown simultaneously.

The treatments for present experiment were as follows:

T_1- Soil application 25 per cent N to female parent (CI-4)

T_2- Sowing of female parent four days early

T_3- Foliar spray of urea (2 %) to female before flowering

T_4- Soil application 10 per cent additional N + foliar spray of urea 2 per cent before flowering to female parent

T_5- Pre-sowing hydration of seed (6 hr.) + 10% additional N soil application to female parent

T_6- Pre -sowing seed treatment of female parent with GA_3 (100 ppm) for 6 hrs.

T_7- Pre-sowing seed treatment with GA_3 (100 ppm) 6 hrs + Foliar spray of Urea (2 %) before flowering in female parent

T_8- Pre-sowing hydration with ABA (2.5 ppm) 6 hrs in male parent seed

T_9- Simultaneous sowing both female and male parents of DMH-2 without any treatment (control)

3.7.2 Seed source

The seeds of both male and female parents of DMH-2 for the experiment were obtained from the Senior Maize Breeder ARS, Arabhavi.

3.8 Field experiment

The field experiment was carried out under rain fed condition during *kharif* season in the year 2010-11 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad.

3.8.1 Experimental design and field plan layout

The field experiment was laid out in a randomized complete block design in three replications and nine treatments. The plan and layout is furnished in the Fig. 2.

Plot size: Gross - 4 m x 9 m

Net - 3.6 m x 9 m

In net plot there were 12 rows with 12 plants in each row and planted in 4:2 planting ratio. The middle four rows, excluding two plants on either side were utilized for recording observations and final yield.

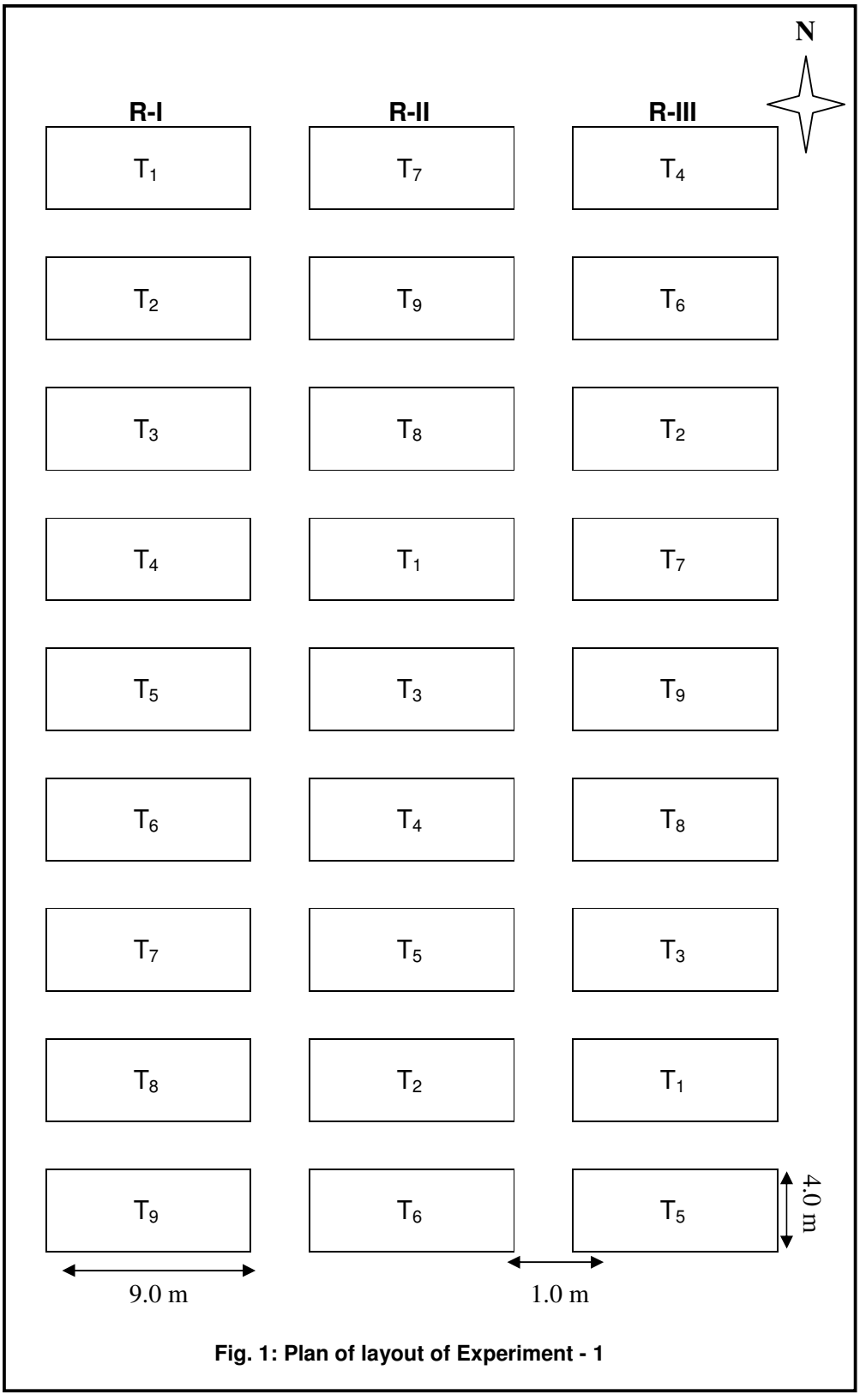

Fig. 1: Plan of layout of Experiment - 1

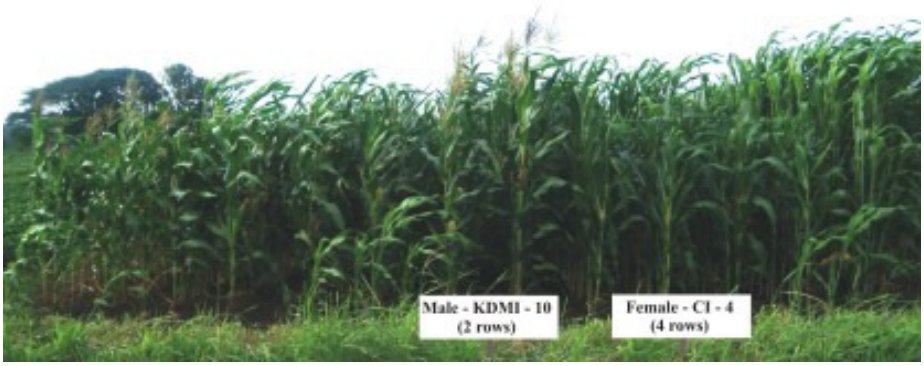

Plate 1: Photograph showing the general view of the experiment

3.8.2 Cultural operations

3.8.2.1 Land preparation

The land was prepared by deep ploughing, harrowing two times and soil was brought to fine tilth. The plots were laid with small bunds. Ridges and furrows were opened at 75 cm apart in each plot.

3.8.2.2 Fertilizer application

A recommended fertilizer dose of 150:75:37.5 kg NPK ha^{-1} of which 50 per cent N and full doses of P and K were applied as basal dose at the time of sowing and remaining dose of N was applied at 30 and 45 days after sowing as top dressing.

3.8.2.3 Isolation distance

To avoid cross pollination and to produce genetically pure seeds minimum isolation distance of 400 meters was provided between the experimental plot and other maize crops.

3.8.2.4 Imposing treatments

Seed treatments were imposed as per the treatments of the experiment.

3.8.2.5 Hydration

Pre-sowing hydration was given to the female seeds for 6 hours then dried under shade to the original moisture content and sown.

3.8.2.6 Pre-sowing hydration with GA_3

Pre-sowing hydration with GA3 100 ppm was given to the female seeds for 6 hours then dried under shade to the original moisture content and sown.

3.8.2.7 Pre-sowing hydration with ABA

Pre-sowing hydration with ABA 2.5 ppm was given to the male seeds for 6 hours then dried under shade to the original moisture content and sown.

3.8.2.8 Additional nitrogen application

Here applied additional nitrogen to female parent through soil 10 and 25 per cent extra that is 15 and 37.5 N kg/ha. on 35 days after sowing.

3.8.2.9 Foliar spray of Urea

Here applied additional nitrogen to female parent through foliar spray of 2 per cent extra that is 20g in 1 liter of water on 35 days after sowing.

3.8.2.10 Sowing

Sowing of both male and female parental seeds was done at same time as per the treatments on 3rd July 2010 two seeds per hill were dibbled on one side of the ridge with a spacing of 75 x 30 cm in the plot. After ten days thinning was done to retain single vigorous seedling per hill.

3.8.2.11 Planting ratio

In each treatment, 4 rows of female and 2 rows of male were planted (4:2) along with 2 rows of fodder sorghum as barriers to avoid cross pollination between treatments.

3.8.2.12 After care

The plots were maintained weed free throughout the growth period and earthing up was done on 30th day after sowing. In order to ensure effective control of stem borer Carbofuran granules (3%) were dropped in to leaf whorls at 35 days after sowing.

3.8.2.13 Gap filling and thinning

Gap filling was made on 10th day after sowing where the seeds failed to germinate. After 15 days of sowing, plants were thinned to maintain only one seedling per hill.

3.8.2.14 Removal of tassels

Tassels were removed as and when they emerged from female lines in all the plots. This was done to avoid mechanical admixtures.

3.8.2.15 Harvesting

The cobs were harvested after physiological maturity based on the visual observations of plant drying and husk turning to white colour after 115 days of sowing. Cobs from male parent were harvested first, then from female (F_1). The cobs were dried in isolation an threshing floor. Then shelled and kernels were separated by hand and dried to 12 per cent moisture content.

3.8.3 Field observations

The observations on crop growth and yield components were made on both male and female on 5 randomly selected and previously tagged plants from each treatment and each replication.

3.8.3.1 Plant height

Plant height was measured from the base of the plant to the base of the tassel and apical node of the labeled plants at harvest and expressed in centimeters.

3.8.3.2 Ear height

Ear height was measured from the base of the plant to the base of ear or cob.

3.8.3.3 Number of days to first tasseling

The number of days taken for first tasseling of male parent from the date of sowing in each plot was recorded and expressed in number.

3.8.3.4 Days to 50 per cent tasseling

The number of days taken for 50 per cent tasseling of male parent from the date of sowing in each plot was recorded and expressed in number.

3.8.3.5 Number of days to first silking

The number of days taken for first silking of female parent from the date of sowing in each plot was recorded.

3.8.3.6 Days to 50 per cent silking

The number of days taken for 50 per cent silking of female parent from the date of sowing in each plot was recorded and expressed in number.

3.8.3.7 Yield and yield components

The cobs from plants tagged for taking growth observations were used to record yield components as mentioned below.

3.8.3.7.1 Cob length

Cob length was measured from base to tip of the cob from tagged plants and the average length was expressed in centimeter.

3.8.3.7.2 Cob girth or diameter

Circumference of cob was measured at the base, middle and top of the cobs and mean circumference (girth) of the cob was calculated by using the formula given below and expressed in centimeters.

$$\text{Diameter of the cob} = \frac{\text{Circumference of the cob}}{\pi}$$

Where, $\pi = 3.142$

3.8.3.7.3 Number of seeds per cob

The number of seeds in each cob of the labeled plants were counted and recorded as mean number of seeds per cobs and expressed in number.

3.8.3.7.4 Number of seed rows per cob

The numbers of seed rows in each cob on the previously selected and labeled five plants were counted and the mean number of seed rows per cob was calculated.

3.8.3.7.5 Cob weight (g)

Cob weights of randomly selected plants were obtained in each treatment and replications and average was worked out in grams as cob weight per plant.

3.8.3.7.6 Seed weight (g)

The randomly selected plants were taken in each treatment with three replications and seed weight per cob was recorded and expressed in grams per cob.

3.8.3.7.7 Seed set percentage

The seed set was computed by using the following formula and expressed as seed set percentage.

$$\text{Seed set percent} = \frac{\text{Number of seeds filled}}{\text{Total number of seeds}} \times 100$$

3.8.3.7.8 100 seed weight (g)

The weight of the 100 seeds recorded in eight replications from each treatment as per the procedure given by ISTA (Anon., 1999a). The average weight was recorded in grams.

3.8.3.7.9 Shelling percentage

Shelling percentage was worked out with following.

$$\text{Shelling per cent} = \frac{\text{Grain weight}}{\text{Total weight (Grain weight + Pith weight)}} \times 100$$

3.8.3.7.10 Seed yield (q/ha)

The F_1 seed yield per plot was recorded in each treatment from three replications. The total yield per hectare was computed from net plot and expressed in q per ha.

3.8.3.7.11 Fodder yield (t/ha)

The weight of the stocks from net plot area was recorded after complete drying. This was expressed in tonnes per hectare.

3.9 Seed quality studies in laboratory

Seed quality was assessed in the laboratory at the Department of Seed Science and Technology, College of Agriculture, Dharwad on following parameters.

3.9.1 Seed germination percentage

Seed germination was determined by the standard germination test using between paper towel methods as prescribed by ISTA rules (Anon., 1999b). Hundred seeds of four replications each were tested. The germination counts on the fourth day and seventh day for I and II counts respectively were made on normal seedlings and total germination percentage was calculated.

3.9.2 Root length (cm)

The root length of ten randomly selected normal seedlings was measured on seventh day of the germination test. The average of ten seedlings was taken as root length (cm). The length of root was measured from the tip of root to the base of hypocotyl.

3.9.3 Shoot length (cm)

The shoot length of ten randomly selected normal seedlings was measured on seventh day of the germination test. The average of ten seedlings was taken as shoot length (cm). The length of shoot was induced from the base of hypocotyl to tip of plumule.

3.9.4 Seedling dry weight

Ten normal seedlings which were used for measurement of shoot and root length, were enveloped in paper packets and dried in an oven at $103^0C \pm 1^0C$ for 14 hours. After 14 hours paper packets were removed and weighed. The dry weight per seedling was expressed in mili grams.

3.9.5 Vigour index

The vigour index was calculated by adopting the formula suggested by Abdul Baki and Anderson (1973) and expressed as number.

Vigour index = mean germination (%) x [root + shoot length (cm)].

3.9.6 Electrical conductivity (dSm^{-1}) of seed leachate

Electrical conductivity was measured according to procedure described by Mathews and Powell (1981). Four replications of five grams of seeds of each treatment were weighed up to two decimal places. The seeds were then soaked in 25 ml distilled water and incubated at constant temperature of 25 ± 1^0C for 24 hours. The electrical conductivity of the seed leachates was measured by the digital conductivity meter (model sensitivity conductivity cell – CCS-811). After subtracting the electrical conductivity of distilled water from the value obtained from the seed leachates, the actual electrical conductivity due to electrolytes was measured and expressed in dSm^{-1} at 25 ± 1^0C.

3.10 Statistical analysis

The data was statistically analyzed as per the method outlined by Panse and Sukhatme (1967). Field experiment was statistically analyzed by RCBD. The level of significance used in 'F' test was P= 0.05 in field studies and P=0.01 for seed quality studies in laboratory.

Experiment- II: Effect of time of sowing on flowering behavior of parental lines of DMH-2 maize hybrid

3.11 Treatment details

In net plot there were 4 rows with 15 plants in each row and planted in 2:2 planting ratio. The middle two rows, excluding two plants on either side were utilized for recording the observations.

Genotype: Female CI-4

Male KDMI-10

Sowing of male and female parents as follows at an interval of 15 days

Treatments	Time of sowing
T_1	June 1st
T_2	June 15th
T_3	July 1st
T_4	July 15th
T_5	August 1st
T_6	August 15th
T_7	September 1st
T_8	September 15th
T_9	October 1st
T_{10}	October 15th
T_{11}	November 1st
T_{12}	November 15th
T_{13}	December 1st
T_{14}	December 15th
T_{15}	January 1st
T_{16}	January 15th

3.11.1 Seed source

The seeds of both male and female parents of DMH-2 for the experiment were obtained from the Senior Maize Breeder Agricultural Research Station, Arabhavi.

The field experiment was laid out in a complete randomized design in 16 treatments. The plan and layout is furnished in the Fig. 3.

Plot size: Gross - 2 x 2 m

Net - 1.8 x 2 m

3.11.2 Field observations

The observations on crop growth components were made on both male and female parents on five randomly selected and previously tagged plants in the plot from each treatment.

3.11.3 Plant height

Plant height was measured when 50 per cent plants in each treatment were flowered in plot. It was taken from the base of the plant to the base of the tassel and apical node of the labeled plants and expressed in centimeters.

3.11.4 Number of days to first tasseling

The number of days taken for first tasseling in male parent from each date of sowing in each plot was recorded.

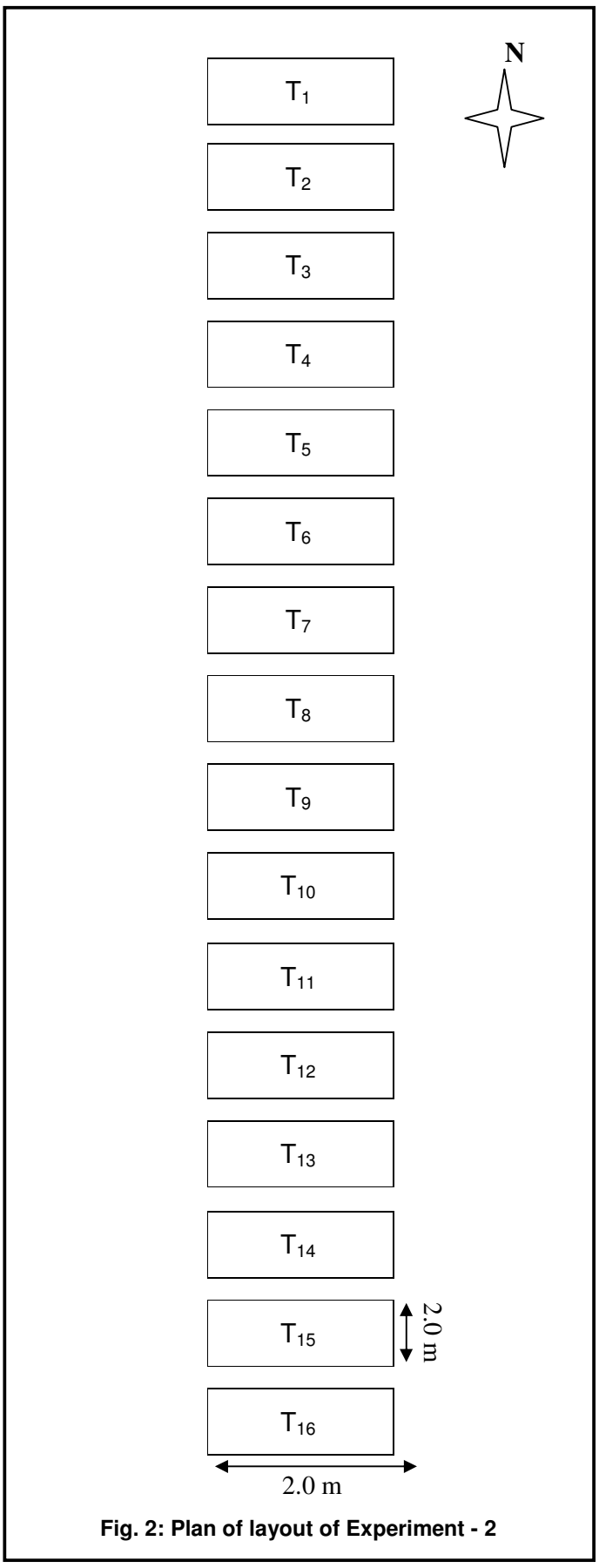

Fig. 2: Plan of layout of Experiment - 2

3.11.5 Number of days to first silking

The number of days taken for first silking of female parent from each date of sowing in each plot was recorded.

. 3.11.6 Number of days to 50% tasseling

The number of days taken for 50 per cent tasseling in male parent from each date of sowing in each plot was recorded.

3.11.7 Number of days to 50% silking

The number of days taken for 50 per cent silking in female parent from each date of sowing in each plot was recorded.

3.11.8 Days to complete tasseling

The number of days taken for complete tasseling of male parent was recorded from the date of sowing to complete tassel emergence in each plot was recorded and expressed in number.

3.11.9 Days to complete silking

The number of days taken for complete silking of female parent was recorded from the date of sowing to complete silk emergence in each plot and expressed in number.

3.11.10 Tassel length

The length of tassel in male parent was recorded after its complete emergence of tassel from the base of tassel to the tip of tassel and expressed in centimeters at complete tassel emergence.

3.11.11 Silk length

The length of silk in female parent was measured when after complete emergence of silk from the cob top and before it dried it was measured from base of silk to tip of silk and expressed in centimeters at complete silk emergence.

3.12 Statistical analysis

The data was statistically analyzed as per the method outlined by Panse and Sukhatme (1967). Field experiment was statistically analyzed by CRD. The level of significance used in ‘F’ test was P= 0.05 in the field studies.

4. EXPERIMENTAL RESULTS

The results of this investigation are presented in this chapter.

4.1 Experiment-I: Studies on effective methods for synchronization of flowering in parents of DMH-2 hybrid maize

Evaluation of parental lines for growth and floral characters

The results on plant height, ear height, flower opening, days to first tasseling, 50 per cent tasseling, days to first silking, 50 per cent silking yield and maturity recorded on DMH-2 hybrid parental lines at main Agriculture Research Station, University Agricultural Science Dharwad has and are presented here.

4.1.1 Growth parameters

4.1.1.1 Plant height (cm) of in female parent

The data on plant height of female parent at maturity are presented in Table 4.01.

No significant differences irrespective of treatment were noticed for the plant height. Numerically higher plant height was observed in soil application of extra 25% N to female parent in T_1 (190.93 cm) followed by pre sowing hydration with GA_3 (100 ppm) 6hour T_6 (190.33 cm) and pre-sowing hydration with GA_3 (100 ppm) 6 hour + foliar spray of urea 2% before flowering T_7 (189.00 cm). Numerically lowest plant height was observed in T_8 (185.60 cm) and overall mean plant height was (188.16 cm). Difference between maximum and minimum was 5.33 cm.

4.1.1.2 Ear height (cm) in female parent

Ear height in female at maturity is presented in Table 4.01. Ear height was also not influenced by the treatments. Mean ear height was 95.02 cm. Numerically higher ear height was observed in (T_1) soil application of extra 25% N (98.07 cm) followed by (T_4) soil application 10% extra N + foliar spray of urea 2% before flowering (96.93 cm), pre-sowing hydration with GA_3 (100 ppm) 6 hr + Foliar spray of Urea 2% before flowering T_7 (96.67 cm), pre sowing hydration with GA_3 (100 ppm) 6 hr. in female parent T_6 (94.93 cm) and the lowest ear height was observed in T_5 (92.67 cm).

4.1.2 Days to flowering

4.1.2.1 Days to first tasseling in male parent

The data presented in Table 4.02 revealed the non significant difference for the days to first tasseling in male parental line (KDMI-10).

The average number of days taken to first tasselling was (47.62). The maximum no of days were taken to first tasselling by the male was (49.33) in case of T8 where the seed treatment was given with ABA (2.5 ppm). Minimum number of days were taken to first tasselling (46.33) by T_7 which was followed by T_6 (46.67), T_3 (47.00), T_9 (47.00) and T_1 (47.67). The difference between maximum and minimum was 3 days.

4.1.2.2 Days to 50 per cent tasselling in male parent

There was non significant difference in days to 50 per cent tasselling in male parental line (KDMI-10) and the data are presented in Table 4.02

Number of days taken to 50 per cent tasselling by male parent of DMH-2 (KDMI-10) did not respond positively. The average number of days taken to 50 per cent tasselling was 55.92 days irrespective of any treatment. The maximum no of days taken to 50 per cent tasselling by male was (56.67) in case of T_8 which was given with ABA (2.5ppm). Minimum number of days taken to 50 per cent tasselling was (55.33) by T_7 followed by 56.67 days in T_1, T_2, T3, T_6 and T_9. The difference between maximum and minimum was 1.34 days.

4.1.2.3 Days to first silking in female parent

The data on first silking in female parent is presented in Table 4.02. It revealed significant difference in days to first silking in female parental line (CI-4).

Table 4.01: Effect of synchrony treatments on plant height and ear height of female parent of DMH-2 maize hybrid

Treatment	Plant height (cm)	Ear height(cm)
T_1	190.93	98.07
T_2	187.07	93.53
T_3	187.27	93.80
T_4	186.60	96.93
T_5	188.40	92.67
T_6	190.33	94.93
T_7	189.00	96.67
T_8	185.60	94.93
T_9	188.27	93.73
Mean	**188.16**	**95.02**
SE m±	2.26	2.48
C.D. at 5%	NS	NS

T_1- Soil application 25% N to female parent (CI-4)

T_2- sowing of female parent four days early

T_3- Foliar spray of urea (2%) before flowering to female

T_4-Soil application 10% extra N + Foliar spray of urea 2% before flowering to female parent

T_5- Pre-sowing hydration of seed (6 hr) + 10% extra N soil application to female parent

T_6- Pre sowing hydration of seed with $_{GA3}$ (100 ppm) 6 hr. for female parent

T_7-Pre-sowing hydration with GA_3 (100 ppm) 6 hr + Foliar spray of Urea 2% before flowering in female parent

T_8- Pre-sowing hydration with ABA (2.5 ppm) 6 hr in male parent seed

T_9-Simultaneous sowing both female and male parents of DMH-2 without any treatment (control)

NS – Non significance

Table 4.02: Effect of synchrony treatments on number of days to first tasselling and 50% tasselling in male parent and number of days to first silking and 50% silking in female parent of DMH-2 maize hybrid

Treatment	Male and Female parent			Male and Female parent		
	No. of days to first tasselling	No. of days to first silking	Difference	No. of days to 50% tasselling	No. of days to 50% silking	Difference
T_1	47.67	49.00	-1.33	55.67	57.67	-2.00
T_2	48.67	51.33	-2.66	55.67	58.00	-2.33
T_3	47.00	51.00	-4.00	55.67	58.67	-3.00
T_4	48.33	47.33	1.00	56.67	59.33	-2.66
T_5	47.67	49.00	-1.33	56.33	57.67	-1.34
T_6	46.67	48.00	-1.33	55.67	58.67	-3.00
T_7	46.33	49.00	-2.67	55.33	59.33	-4.00
T_8	49.33	52.33	-3.00	56.67	60.67	-4.00
T_9	47.00	49.67	-2.67	55.67	61.67	-6.00
Mean	**47.62**	**49.62**		**55.92**	**59.07**	
SE m±	0.56	0.71		0.67	0.45	
C.D. at 5%	NS	2.15		NS	1.37	

T_1- Soil application 25% N to female parent (CI-4)
T_2- sowing of female parent four days early
T_3- Foliar spray of urea (2%) before flowering to female
T_4-Soil application 10% extra N + Foliar spray of urea 2% before flowering to female parent
T_5- Pre-sowing hydration of seed (6 hr) + 10% extra N soil application to female parent
T_6- Pre sowing hydration of seed with GA_3 (100 ppm) 6 hr. for female parent
T_7-Pre-sowing hydration with GA_3 (100 ppm) 6 hr + Foliar spray of Urea 2% before flowering in female parent
T_8- Pre-sowing hydration with ABA (2.5 ppm) 6 hr in male parent seed
T_9-Simultaneous sowing both female and male parents of DMH-2 without any treatment (control)

NS – Non significance

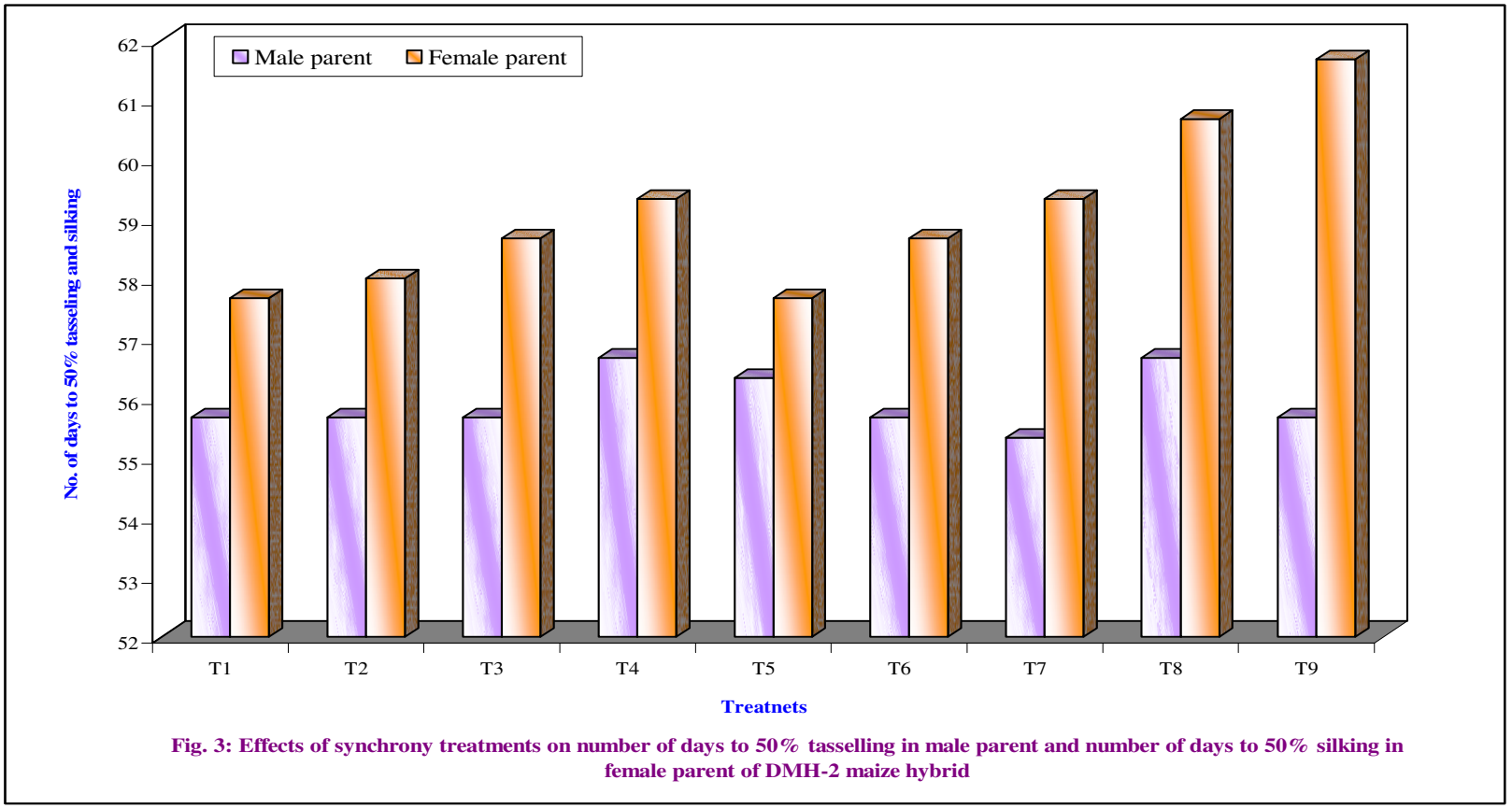

Fig. 3: Effects of synchrony treatments on number of days to 50% tasselling in male parent and number of days to 50% silking in female parent of DMH-2 maize hybrid

Fig. 3: Effects of synchrony treatments on number of days to 50% tasselling in male parent and number of days to 50% silking in female parent of DMH-2 maize hybrid

Number of days taken to first silking in female parent of DMH-2 (CI-4) has responded positively the average number of days taken to first silking was 49.62 days irrespective of any treatment the maximum number of days taken to first silking by female is (52.33) in case of T8 and minimum number of days taken to first silking was (47.33) by T_4 which was followed by T_6 (48.00), T_1 (49), T_5 (49) and T_9 (49.67) and lastly the difference between maximum and minimum was 5 days.

4.1.2.4 Days to 50 per cent silking in female parent

The data on 50 per cent silking in female parent is presented in Table 4.02 revealed significant differences in days to 50 per cent silking in female parental line (CI-4).

Number of days taken to 50 per cent silking in female parent of DMH-2 (CI-4) has responded positively. The average number of days taken to 50 per cent silking was 59.07 days irrespective of any treatment. The maximum number of days taken to 50 per cent silking by female was (61.67) in case of T9 and the minimum number of days taken to 50 per cent silking was (57.67) by T_1 which was followed by T_5 (57.67), T_2 (58), T_3 (58.67) and T_6 (58.67). Finally the difference between maximum and minimum was 4 days.

4.1.3 Yield components

Data on yield and yield components of DMH-2 hybrids with special reference to cob length (cm), cob diameter (cm), cob weight per plant (g) and shelling percentage of cob are presented in Table 4.03

4.1.3.1 Cob length (cm)

The data on cob length in female parent is presented in Table 4.03 revealed the non significant difference.

Average cob length of DMH-2 was 14.92 cm. The cob length did not differ significantly even though different treatments were imposed but numerically higher cob length was observed in T_3 (15.60 cm) which was given with treatment of foliar spray with urea 2% before flowering to female followed by T_1 (15.47 cm),T_4 (15.40 cm) and T_7 (15.20 cm) which were on par to each other and numerically lowest cob length was observed in T_9 control (14.13 cm) followed by T_8 (14.53 cm) and T_6 (14.80 cm) the difference between maximum and minimum was 1.47 cm.

4.1.3.2 Cob diameter (cm)

The data on cob diameter in female parent is presented in Table 4.03 revealed the significant difference for cob diameter (cm) among the treatments.

Average cob diameter of DMH-2 was 13.63 cm. The cob diameter significantly differed with different treatments. Significantly numerically higher cob diameter was observed in T5 (14.17 cm) which was given with pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_4 (14.07 cm), T_1 (14.07 cm) and T_2 (13.80 cm) which were on par to each other and the lowest cob diameter was observed in T_9 control (13.03 cm) followed by T_3 (13.07 cm) and T_8 (13.47 cm). The difference between maximum and minimum was 1.14 cm.

4.1.3.3 Cob weight per plant (g)

The data on cob weight per plant is presented in Table 4.03 revealed the significant difference.

Average cob weight per plant of DMH-2 was 136.95g. The cob weight per plant significantly varied with different treatments. Significantly higher cob weight (163.00g) per plant was observed in T5 was given with treatment pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_4 (159.33g) and T_1 (150.93g) which were on par to each other. Numerically the lowest cob weight per plant was observed in T_9 control (115.00g) followed by T_3 (122.40g) and T_8 (124.60g). The difference between maximum and minimum was 48g.

Treatment T_5

Control

Plate 2: Photograph showing the comparison best cob F1 v/s control

Table 4.03: Effect of synchrony treatments on cob length, cob weight, cob diameter and shelling percentage of DMH-2 F_1 hybrid maize

Treatment	Cob length (cm)	Cob weight per plant (g)	Cob diameter (cm)	Shelling percentage
T_1	15.47	150.93	14.07	67.73 (85.67)*
T_2	15.13	129.60	13.80	66.19 (83.74)
T_3	15.60	122.40	13.07	65.54 (82.89)
T_4	15.40	159.33	14.07	65.80 (83.23)
T_5	15.07	163.00	14.17	68.04 (86.05)
T_6	14.80	137.20	13.53	65.33 (82.61)
T_7	15.20	130.53	13.53	65.26 (82.52)
T_8	14.53	124.60	13.47	64.65 (81.71)
T_9	14.13	115.00	13.03	63.03 (79.47)
Mean	**14.92**	**136.95**	**13.63**	**65.73 (83.10)**
SE m±	0.54	8.67	0.28	1.27
C.D. at 5%	NS	25.99	0.85	3.80

* Figures in parenthesis indicate original values of transformed values

T_1- Soil application 25% N to female parent (CI-4)

T_2- sowing of female parent four days early

T_3- Foliar spray of urea (2%) before flowering to female

T_4-Soil application 10% extra N + Foliar spray of urea 2% before flowering to female parent

T_5- Pre-sowing hydration of seed (6 hr) + 10% extra N soil application to female parent

T_6- Pre sowing hydration of seed with GA_3 (100 ppm) 6 hr. for female parent

T_7-Pre-sowing hydration with GA_3 (100 ppm) 6 hr + Foliar spray of Urea 2% before flowering in female parent

T_8- Pre-sowing hydration with ABA (2.5 ppm) 6 hr in male parent seed ;T_9-Simultaneous sowing both female and male parents of DMH-2 without any treatment (control)

NS – Non significance

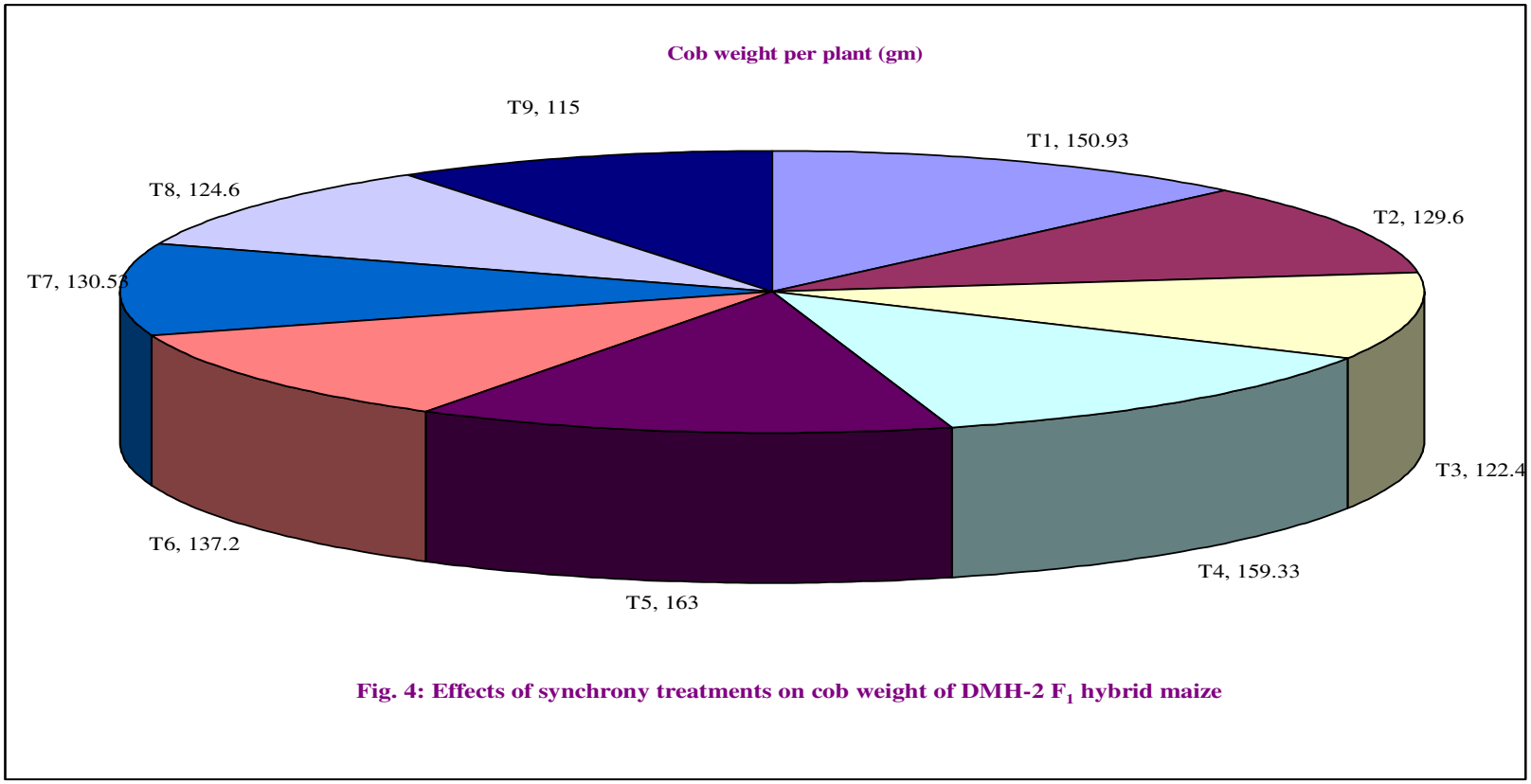

Fig. 4: Effects of synchrony treatments on cob weight of DMH-2 F_1 hybrid maize

Fig. 4: Effects of synchrony treatments on cob weight of DMH-2 F1 hybrid maize

4.1.3.4 Shelling percentage

The data on shelling percentage presented in Table 4.03 revealed significant difference shelling percentage

Average shelling percentage of DMH-2 was 83.10. The shelling percentage significantly differed with different treatments. Significantly higher shelling percentage was observed in T_5 (86.05) which was given with pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_1 (85.67) and T_2 (83.70) which are on par to each other. Numerically the lowest shelling percentage was observed in T_9 (79.47) followed by T_8 (81.71) and T_7 (82.52). The difference between maximum and minimum was 6.58 per cent.

4.1.3.5 Number of seeds per cob

The data number of seeds per cob was presented in Table 4.04 there was a significant difference for number seeds per cob. Average seeds number per cob of DMH-2 was 416.69g. The seeds number per cob significantly varied with different treatments significantly higher seeds number per cob was observed in T_5 (471.73) which was given with treatment of pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_1 (460.33) and T_2 (458.40) which are on par to each other. Numerically the lowest number of seeds per cob was observed in T_9 (364.53) followed by T_8 (383.40) and T_3 (394.07) the difference between maximum and minimum was 53.2.

4.1.3.6 Number of seed rows per cob

The data presented in Table 4.04 revealed the significant difference for numbers of seed rows per cob. Mean number of seed rows per cob DMH-2 was 13.51. The number of seed rows per cob significantly differed with different treatments. Significantly higher number of seed rows per cob was observed T_5 (14) which was given with treatment pre-sowing hydration (6hr) + 10% extra N soil application to female parent followed by T_2 (14) and T_1 (14) which are on par to each other. Numerically the lowest number of seed rows per cob was observed in T_9 (12.40) followed by T_6 (12.80) and T_8 (13.47) the difference between maximum and minimum was 1.6 seed rows.

4.1.3.7 Seed weight per cob (g)

The data are presented in Table 4.04.

The mean seed weight per cob significantly differed with different treatments. Significantly higher seed weight per cob was observed T_5 (132.07g) which was given with treatment of pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_1 (129.20g) and T_2 (120.60g) which are on par to each other. Numerically the lowest seed weight per cob was observed in T_9 (95.13g) followed by T_8 (104.07g) and T_3 (105.27). The difference between maximum and minimum was 36.94 g.

4.1.3.8 Seed set percentage

The data on seed set percentage are presented in Table 4.04.

Average seed set percentage DMH-2 was 85.06. The seed set percentage significantly different with differed treatments. Significantly higher seed set percentage was observed in T_5 (96.45) which was given with treatment pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_1 (93.94) and T_2 (93.55) which are on par to each other. Numerically lowest seed set percentage was observed in T_9 (74.41) followed by T_8 (78.24) and T_3 (80.41). The difference between maximum and minimum was 22.04.

4.1.3.9 100 seed weight (g)

The data are presented in Table 4.04.

The mean 100 seed weight of F_1 seeds was significantly different with different treatments. Significantly higher 100 seed weight was observed (29.79g) which was given with treatment pre-sowing hydration (6hr) + 10% extra N soil application to female parent followed by T_1 (29.22g) and T2 (28.93g) which are on par to each other. Numerically the lowest 100 seed weight was observed in T_9 (26.35g) followed by T_8 (26.98g) and T_7 (27.03). The difference between maximum and minimum was 3.44g.

Table 4.04: Effect of synchrony treatments on seed rows per cob, number of seeds per cob, seed set percentage, seed weight per cob and 100 seed weight of DMH-2 F_1 Hybrid maize

Treatment	Number seed rows per cob	Number of seeds per cob	Seed weight per cob (g)	Seed set percentage	100 seed weight (g)
T_1	14.00	460.33	129.20	75.72 (93.94)*	29.22
T_2	14.00	458.40	120.60	75.26(93.55)	28.93
T_3	13.60	394.07	105.27	66.19(83.74)	27.78
T_4	13.60	410.33	107.87	66.49(84.12)	28.31
T_5	14.00	471.73	132.07	79.11(96.45)	29.79
T_6	12.80	395.53	112.13	63.91(80.70)	27.35
T_7	13.73	411.93	112.40	63.70(80.41)	27.03
T_8	13.47	383.40	104.07	62.17(78.24)	26.98
T_9	12.40	364.53	95.13	59.59(74.41)	26.35
Mean	**13.51**	**416.69**	**113.19**	**68.02(85.06)**	**27.97**
SE m±	0.32	17.86	8.52	0.62	0.80
C.D. at 5%	0.96	53.57	25.56	1.86	2.42

* Figures in parenthesis indicate original values of transformed values

T_1- Soil application 25% N to female parent (CI-4)

T_2- sowing of female parent four days early

T_3- Foliar spray of urea (2%) before flowering to female

T_4-Soil application 10% extra N + Foliar spray of urea 2% before flowering to female parent

T_5- Pre-sowing hydration of seed (6 hr) + 10% extra N soil application to female parent

T_6- Pre sowing hydration of seed with GA_3 (100 ppm) 6 hr. for female parent

T_7-Pre-sowing hydration with GA_3 (100 ppm) 6 hr + Foliar spray of Urea 2% before flowering in female parent

T_8- Pre-sowing hydration with ABA (2.5 ppm) 6 hr in male parent seed ;T_9-Simultaneous sowing both female and male parents of DMH-2 without any treatment (control)

Table 4.05: Effect of synchrony treatments on seed yield and fodder yield per hectare of DMH-2 Hybrid maize

Treatment	Seed yield (q/ha)	Fodder yield (t/ha)
T_1	35.37	3.15
T_2	31.85	3.15
T_3	28.11	3.15
T_4	29.34	3.06
T_5	38.33	3.33
T_6	25.81	3.06
T_7	23.69	2.96
T_8	23.27	2.96
T_9	23.07	2.96
Mean	**28.76**	**3.09**
SE m±	2.37	0.24
C.D. at 5%	7.12	0.73

T_1- Soil application 25% N to female parent (CI-4)

T_2- sowing of female parent four days early

T_3- Foliar spray of urea (2%) before flowering to female

T_4-Soil application 10% extra N + Foliar spray of urea 2% before flowering to female parent

T_5- Pre-sowing hydration of seed (6 hr) + 10% extra N soil application to female parent

T_6- Pre sowing hydration of seed with GA_3 (100 ppm) 6 hr. for female parent

T_7-Pre-sowing hydration with GA_3 (100 ppm) 6 hr + Foliar spray of Urea 2% before flowering in female parent

T_8- Pre-sowing hydration with ABA (2.5 ppm) 6 hr in male parent seed

T_9-Simultaneous sowing both female and male parents of DMH-2 without any treatment (control)

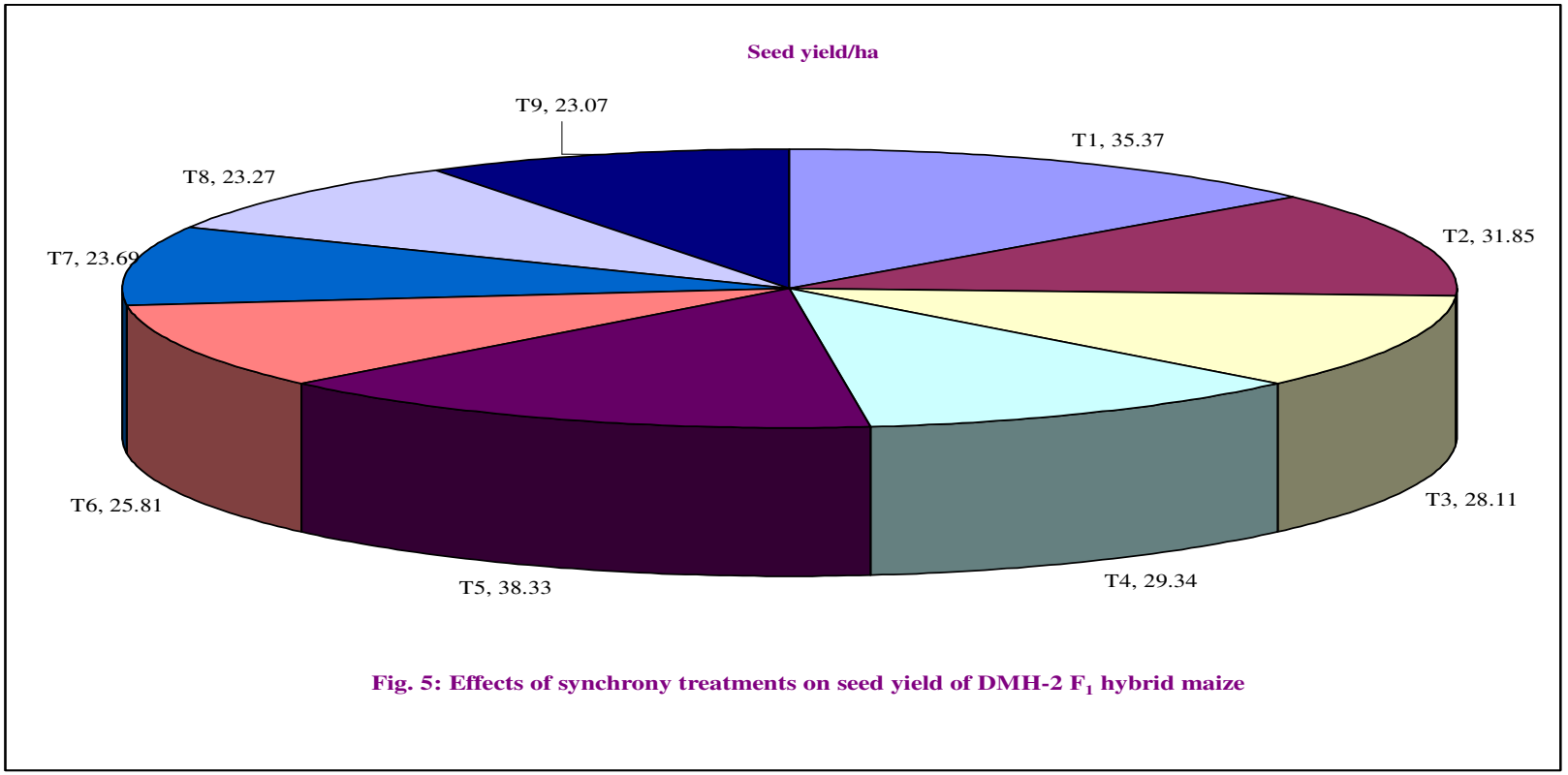

Fig. 5: Effects of synchrony treatments on seed yield of DMH-2 F_1 hybrid maize

Fig. 5: Effects of synchrony treatments on seed yield of DMH-2 F1 hybrid maize

4.1.3.10 Seed yield per ha (q/ha)

The data presented in Table 4.05 revealed significant difference seed yield per ha

Mean seed yield per ha of DMH-2 was 28.76q. The seed yield per ha significantly differed with different treatments. Significantly higher seed yield per ha was observed in T_5 (38.33q) which was given with treatment pre-sowing hydration (6hr) + 10% extra N soil application to female parent followed by T_1 (35.37q) and T_2 (31.85 kg) which were on par to each other. Numerically the lowest seed yield per ha was observed in T_9 control (23.07q) followed by T8 (23.27q) and T_7 (23.69q). The difference between maximum and minimum was 15.26q.

4.1.3.11 Fodder yield per ha (t/ha)

The data are presented in Table 4.05 revealed significant difference fodder yield per ha

Mean fodder yield per ha of DMH-2 was 3.09 t the fodder yield per ha significantly differed with different treatments. Significantly higher seed yield per ha was observed in T_5 (3.33t) which was given with treatment of pre-sowing hydration (6hr) + 10% extra N soil application to female parent followed by T_1 (3.148t) and T_2 (3.15t) which are on par to each other. Numerically the lowest fodder yield per ha was observed in T_9 control (2.96t) followed by T_8 (2.96t) and T_7 (2.96t) the difference between maximum and minimum was 0.37t.

4.1.4 Quality parameters

4.1.4.1 Seed germination percentage

The original and arc sine transformed data on seed germination percentage of F_1 DMH-2 maize seeds are presented in Table 4.06.

In this investigation average seed germination percentage DMH-2 was 96.78. The germination percentage did not differ significantly numerically higher germination percentage was observed in T_5 97.67 was given with treatment pre-sowing hydration (6hr) + 10% extra N soil application to female parent T_1 (97.67) soil application 25% N to female parent followed by T_2 (97.33) and T_3 (97.00) and T_4 (97.00) which were on par to each other. Numerically the lowest germination percentage was observed in T_9 (95.67) followed by T_8 (96.00) and T_7 (96.00) the difference between maximum and minimum was 2 per cent.

4.1.4.2 Root length (cm)

The data on seedling not length are presented in Table 4.06.

The average root length of DMH-2 was 20.98 cm. The root length did not differ significantly even though different treatments were imposed but numerically higher root length was observed in T5 (22.98 cm) which was given with treatment pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_1 (22.42 cm),T_2 (21.97 cm) and T_4 (21.85 cm) which were on par to each other. Numerically the lowest root length was observed in T9 (18.02 cm) followed by T_8 (19.55 cm) and T_7 (20.06 cm) the difference between maximum and minimum was 4.96 cm.

4.1.4.3 Shoot length (cm)

The data presented in Table 4.06 revealed non significant differences among the treatments for shoot length.

Average shoot length of DMH-2 was 19.61 cm. The shoot length did not differ significantly even though different treatments were imposed but numerically higher shoot length was observed in T_5 (21.39 cm) which was given with treatment of pre-sowing hydration (6 hr) + 10% extra N soil application to the female parent followed by T_8 (20.18 cm), T_2 (20.04 cm) and T_4 (19.64 cm) which were on par to each other. Numerically the lowest shoot length was observed in T_9 (18.37 cm) followed by T_8 (19.08 cm) and T_7 (19.09 cm) the difference between maximum and minimum was 3.02 cm.

Table 4.06: Effect of synchrony treatments on seed germination percentage, seedling root and shoot length, seedling dry weight, vigour index and EC of DMH-2 F_1 hybrid maize

Treatment	Germination percentage	Root length (cm)	Shoot length (cm)	Seedling dry weight (mg)	Vigour index	Electric conductivity of seed leachates (dSm^{-1})
T_1	81.19(97.67)*	22.42	20.18	400.00	4071.35	0.11
T_2	80.56 (97.33)	21.97	20.04	326.67	3968.42	0.12
T_3	79.99 (97.00)	21.61	19.42	280.00	3954.81	0.15
T_4	79.99 (97.00)	21.85	19.64	300.00	3964.82	0.13
T_5	81.19 (97.67)	22.98	21.39	410.00	4160.08	0.09
T_6	79.45 (96.67)	20.39	19.37	250.00	3945.87	0.16
T_7	78.43 (96.00)	20.06	19.09	240.00	3900.38	0.16
T_8	78.43 (96.00)	19.55	19.08	230.00	3861.02	0.16
T_9	77.96 (95.67)	18.02	18.37	223.33	3602.75	0.18
Mean	**79.69 (96.78)**	**20.98**	**19.61**	**295.55**	**3936.61**	**0.13**
SE m±	1.32	1.75	1.24	43.69	244.77	0.02
C.D. at 1%	NS	NS	NS	131.00	NS	NS

* Figures in parenthesis indicate original values of transformed values

T_1- Soil application 25% N to female parent (CI-4)

T_2- sowing of female parent four days early

T_3- Foliar spray of urea (2%) before flowering to female

T_4-Soil application 10% extra N + Foliar spray of urea 2% before flowering to female parent

T_5- Pre-sowing hydration of seed (6 hr) + 10% extra N soil application to female parent

T_6- Pre sowing hydration of seed with GA_3 (100 ppm) 6 hr. for female parent

T_7-Pre-sowing hydration with GA_3 (100 ppm) 6 hr + Foliar spray of Urea 2% before flowering in female parent

T_8- Pre-sowing hydration with ABA (2.5 ppm) 6 hr in male parent seed

T_9-Simultaneous sowing both female and male parents of DMH-2 without any treatment (control)

NS – Non significance

4.1.4.4 Seedling dry weight (mg/10 seedlings)

The data presented in Table 4.06 revealed significant difference seedling dry weight

Mean seedling dry weight significantly differed with various treatments. Significantly higher seedling dry weight (410 mg) was observed was given with treatment of pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_1 (400 mg) and T_2 (326.67 mg) which were on par to each other. Numerically the lowest seedling dry weight was observed in T_9 (223.33 mg) followed by T_8 (230 mg) and T_7 (240 mg) the difference between maximum and minimum was 186.67 mg.

4.1.4.5 Vigour index

The data presented in Table 4.06 revealed non significant difference vigour index

The mean vigour index differed with treatments. Numerically higher vigour index was observed T_5 (4160.08) in treatment of pre-sowing hydration (6 hr) + 10% extra N soil application to female parent followed by T_1 (4071.35) and T_2 (3968.42) which were on par to each other. Numerically the lowest vigour index was observed in T_9 (3602.75) followed by T_8 (3861.02) and T_7 (3900.38). The difference between maximum and minimum was 557.33.

4.1.4.6 Electric conductivity of seed leachates dS m^{-1}

The data on EC of seed leachate of DMH-2 F_1 seeds are presented in Table 4.06.

The mean electric conductivity of seed leachate did not differ significantly with various treatments. Numerically higher electric conductivity was observed in T_9 (0.18) that is simultaneous sowing of male and female parent followed by T_8 (0.15) and T_7 (0.16) and T_6 (0.16) which were on par to each other. Numerically the lowest electric conductivity of seed leachate was observed in T_5 (0.09) followed by T_1 (0.11) and T_2 (0.12). The difference between maximum and minimum was 0.07.

4.2 Experiment-II: Effect of time of sowing on flowering behavior of parental lines of DMH-2 maize hybrid

The performance of parental lines CI-4 (female) KDMI-10 (male) of DMH-2 hybrid was studied in periodical time of sowing with 15 days interval from July 1st to January 15th for vegetative growth and flowering behaviour

Evaluation of parental lines for growth and floral characters

The results on plant height 50% flowering both in male and female, flower opening, days to first tasselling, complete tasselling, days to first silking, complete silking and tassel length and silk length in DMH-2 hybrid parental lines at Main Agriculture Research Station, University Agricultural Science Dharwad has been presented here.

4.2.1 Growth parameters

4.2.1.1 Plant height (cm) of male parent at 50 per cent tasselling in

The result on plant height at 50 per cent tasselling in male parent is presented in Table 4.07

The mean plant height at 50 per cent tasselling in male parent was 144.42 cm. Significantly higher plant height at 50 per cent tasselling in male parent was observed in T_1 (152.4 cm) followed by T_2 (151.8 cm), T_{15} (150.6 cm),T_{16} (150 cm) T_9 (150.2 cm) and T_{10} (147.2 cm) which were on par with each other. Significantly lowest plant height was observed in September T_8 (134.60 cm) followed by T_7 (134.80 cm), T_6 (135.40 cm) and T_5 (136.00 cm) the mean difference between maximum and minimum was 17.8 cm.

4.2.1.2 Plant height (cm) of female parent at 50 per cent silking in

The result on plant height measured at 50 per cent tasselling in male parent are presented in Table 4.07.

Table 4.07: Effects of time of sowing on days to initiation of plant height at 50 per cent tasselling in male parent (CI – 4) and 50 per cent silking in female parent (KDMI 10) of DMH- 2 maize hybrid

Treatment	Time of sowing	Plant height (cm) at 50 per cent flowering	
		Male	Female
T_1	June 1st	152.40	149.00
T_2	June 15th	151.80	149.60
T_3	July 1st	155.60	151.00
T_4	July 15th	136.00	138.20
T_5	August 1st	136.00	138.20
T_6	August 15th	135.40	137.60
T_7	September 1st	134.80	137.40
T_8	September 15th	134.60	135.80
T_9	October 1st	150.20	135.20
T_{10}	October 15th	147.20	135.00
T_{11}	November 1st	146.20	141.00
T_{12}	November 15th	145.80	134.40
T_{13}	December 1st	142.40	133.00
T_{14}	December 15th	141.80	132.60
T_{15}	January 1st	150.60	149.20
T_{16}	January 15th	150.00	150.00
	Mean	**144.42**	**140.45**
	SE m±	3.81	2.74
	C.D. at 5%	14.31	10.30

Table 4.09: Effect of time of sowing on days to tassel emergence in male parent and silk emergence in female parent

Treatment	Time of sowing	Days to		Difference
		Tassel in male parent	Silk emergence in female parent	
T_1	June 1st	47.00	52.00	-5.0
T_2	June 15th	47.00	51.00	-4.0
T_3	July 1st	47.00	51.00	-4.0
T_4	July 15th	51.00	55.00	-4.0
T_5	August 1st	50.00	54.00	-4.0
T_6	August 15th	51.00	56.00	-5.0
T_7	September 1st	52.00	57.00	-5.0
T_8	September 15th	52.00	60.00	-8.0
T_9	October 1st	49.00	55.00	-6.0
T_{10}	October 15th	53.00	59.00	-6.0
T_{11}	November 1st	52.00	58.00	-6.0
T_{12}	November 15th	51.00	57.00	-6.0
T_{13}	December 1st	52.00	58.00	-6.0
T_{14}	December 15th	52.00	57.00	-5.0
T_{15}	January 1st	49.00	54.00	-5.0
T_{16}	January 15th	50.00	52.00	-2.0
	Mean	**50.31**	**55.37**	
	Difference	6	9	

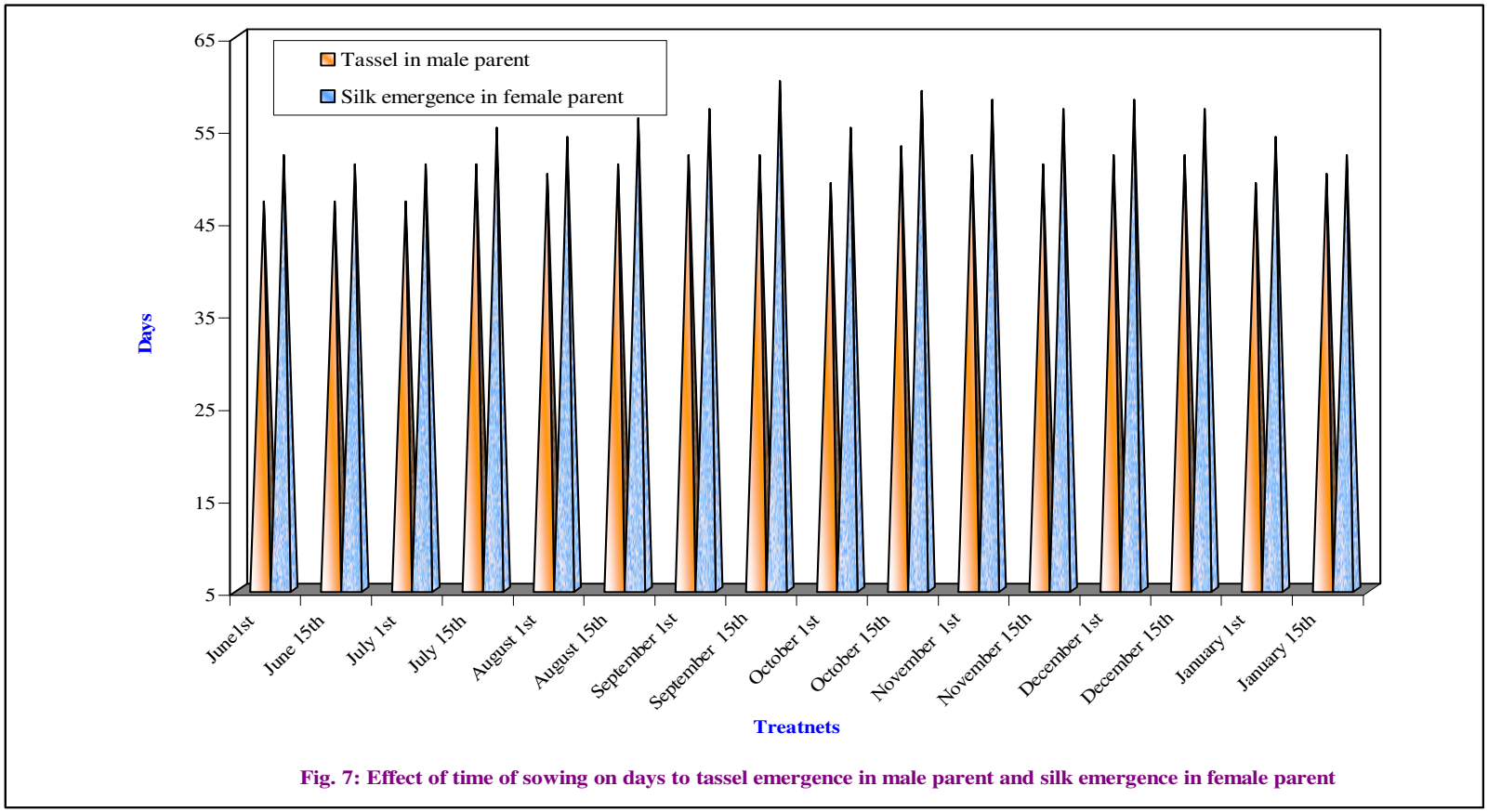

Fig. 7: Effect of time of sowing on days to tassel emergence in male parent and silk emergence in female parent

Fig. 7: Effect of time of sowing on days to tassel emergence in male parent and silk emergence in female parent

In present investigation mean plant height at 50 per cent silking in female parent was 140.45 cm. Significantly higher plant height at 50 per cent silking in female parent was observed in T_3 (151.00 cm) followed by T_{16} (150.00 cm), T_2 (149.60 cm), T_{15} (150149.20 cm) T_{11} (141.00 cm) and T_4 (138.2 cm) which were on par with each other. Significantly lowest plant height was observed in T_{14} (132.60 cm) followed by T_{13} (133.00 cm), T_{12} (133.40 cm)and T_{10} (135.00 cm). The mean difference between maximum and minimum was 18.4 days.

4.2.1.3 Days to emergence of tassel in male parent

The result on days to emergence of tassel in male parent is presented in Table 4.09

There was significant variation for days to tassel emergence in male parent sowing has given days difference with different treatment numerical highest number of days was taken for emergence of tassel in male parent. October 15th days taken for initiation of tasseling (53.00 days). The lowest number of days taken for initiation of tasseling was observed in June 1st and June 15th followed by July 1st (47 days) showing difference of 6 days during entire period of sowing.

4.2.1.4 Days to emergence of silk in female parent

The result on days to emergence of silk in female parent presented in Table 4.09

The time of sowing has given different with different treatment numerical highest number of days was taken for emergence of silk in female parent. October 15th days taken for initiation of silk (59.00). The lowest number of days taken for initiation of silking was observed in June 15th and July 1st (51.00) days show difference of 9 days during entire period of sowing time.

4.2.1.5 Days to 50 per cent tasselling in male parent

The result on days to 50 per cent tasselling in male parent are presented in Table 4.10

The time of sowing has given days difference with different treatment numerically higher number of days taken for 50 per cent tasseling in male parent. July 1st August 1st and August 15th was (60.00 days). The lowest number of days taken for 5o per cent tasseling was observed in December 1st and 15th (51.00) showing difference of 9 days during entire period of sowing time.

4.2.1.6 Days to 50 per cent silking in female parent

The result on days to 50 per cent silking in female parent are presented in Table 4.10

The time of sowing has given days difference with different treatment numerical higher number of days taken for 50 per cent silking in female parent July 15th and August 1st, September 1st and January 15th was 63.00 days showing difference of 4 days during entire period of sowing.

4.2.1.7 Days to complete tasselling in male parent

The result on days to complete tasselling in male parent are presented in Table 4.11

The time of sowing has given days difference with different treatment numerically higher number of days taken for complete tasseling in male parent. During July 15th and August 1st was (64.00 days). The lowest number of days taken for complete tasseling was observed in December 1st and 15th (55.00) showing difference of 9 days during entire period of sowing time.

4.2.1.8 Days to complete silking in female parent

The result on days to complete silking in female parent are presented in Table 4.11

The time of sowing has given days difference with different treatment numerical higher number of days taken for complete silking in female parent August 1st, followed by July 15th, August 15th, September 1st and January 15th was 67.00 days showing difference of 4 days during entire period of sowing. The lowest number of days taken for complete silking was observed in December 15th (63.00) showing difference of 5 days during entire period of sowing time.

Table 4.10: Effect of time of sowing on days to 50 per cent flowering in male and female parents of DMH-2 maize hybrid

Treatment	Time of sowing	Days to		Difference
		50 per cent tasselling	50 per cent silking	
T_1	June 1st	56.00	62.00	-6.0
T_2	June 15th	56.00	60.00	-4.0
T_3	July 1st	54.00	60.00	-6.0
T_4	July 15th	60.00	63.00	-3.0
T_5	August 1st	60.00	63.00	-3.0
T_6	August 15th	60.00	62.00	-2.0
T_7	September 1st	58.00	63.00	-5.0
T_8	September 15th	54.00	61.00	-7.0
T_9	October 1st	55.00	59.00	-4.0
T_{10}	October 15th	54.00	61.00	-7.0
T_{11}	November 1st	53.00	61.00	-8.0
T_{12}	November 15th	52.00	60.00	-8.0
T_{13}	December 1st	51.00	62.00	-11.0
T_{14}	December 15th	51.00	59.00	-8.0
T_{15}	January 1st	57.00	62.00	-5.0
T_{16}	January 15th	58.00	63.00	-5.0
	Mean	**55.56**	**61.31**	
	Difference	9.00	4.00	

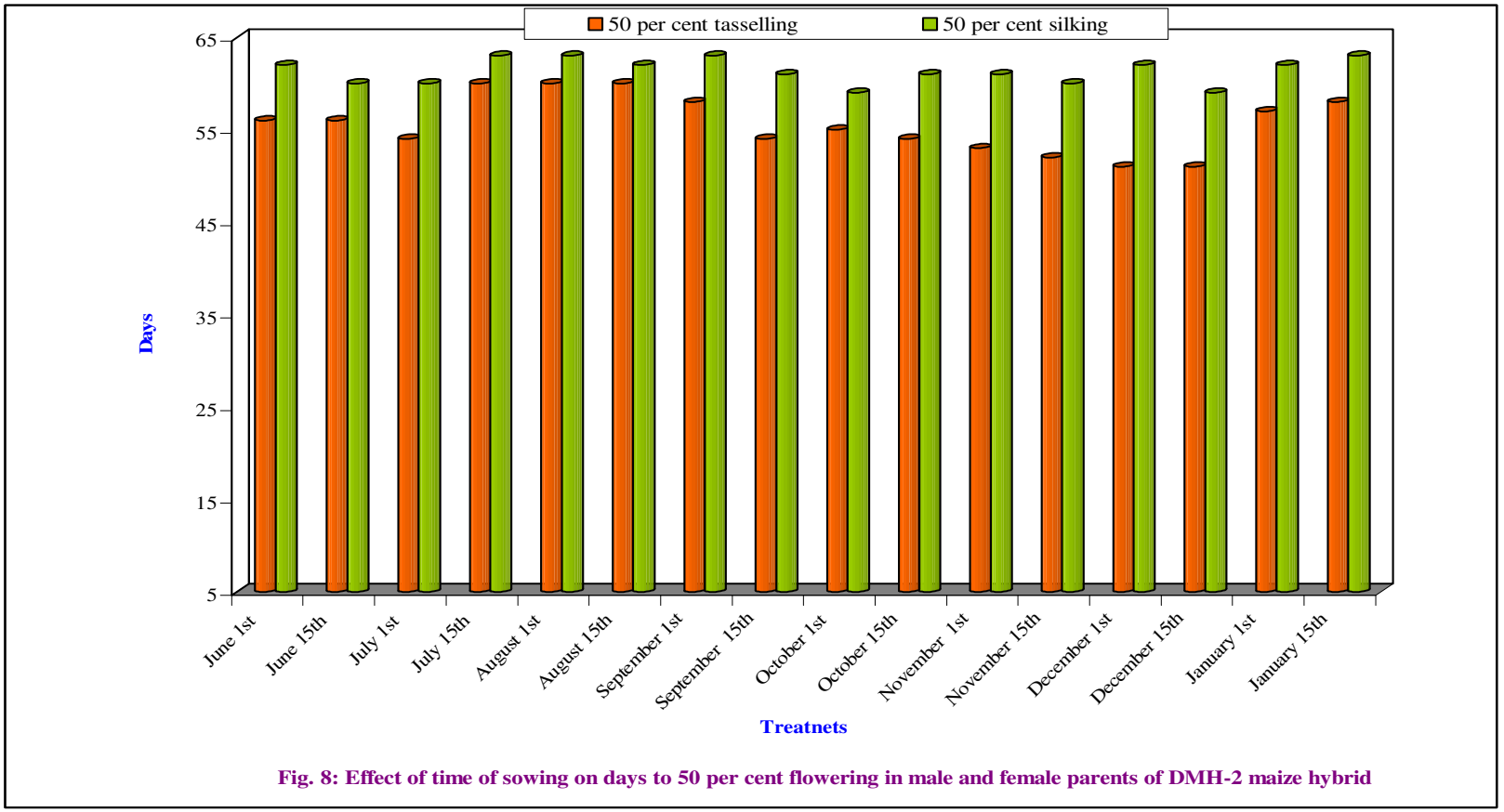

Fig. 8: Effect of time of sowing on days to 50 per cent flowering in male and female parents of DMH-2 maize hybrid

Fig. 8: Effect of time of sowing on days to 50 per cent flowering in male and female parents of DMH-2 maize hybrid

Table 4.08: Effect of time of sowing on tassel length in male parent (CI - 4) and silk length in female parent (KDMI- 10) of DMH-2 maize hybrid

Treatment	Time of sowing	Tassel length (cm)	Silk length (cm)
T_1	June 1st	35.80	32.00
T_2	June 15th	35.40	32.20
T_3	July 1st	34.80	34.20
T_4	July 15th	34.60	33.00
T_5	August 1st	34.60	32.80
T_6	August 15th	34.40	32.20
T_7	September 1st	33.60	32.40
T_8	September 15th	33.00	32.20
T_9	October 1st	35.40	33.00
T_{10}	October 15th	37.80	32.60
T_{11}	November 1st	37.80	32.60
T_{12}	November 15th	36.20	33.20
T_{13}	December 1st	34.80	32.20
T_{14}	December 15th	37.00	32.20
T_{15}	January 1st	33.60	31.60
T_{16}	January 15th	34.40	31.40
	Mean	**35.20**	**32.48**
	SE m±	1.40	0.70
	C.D. at 5%	5.26	2.65

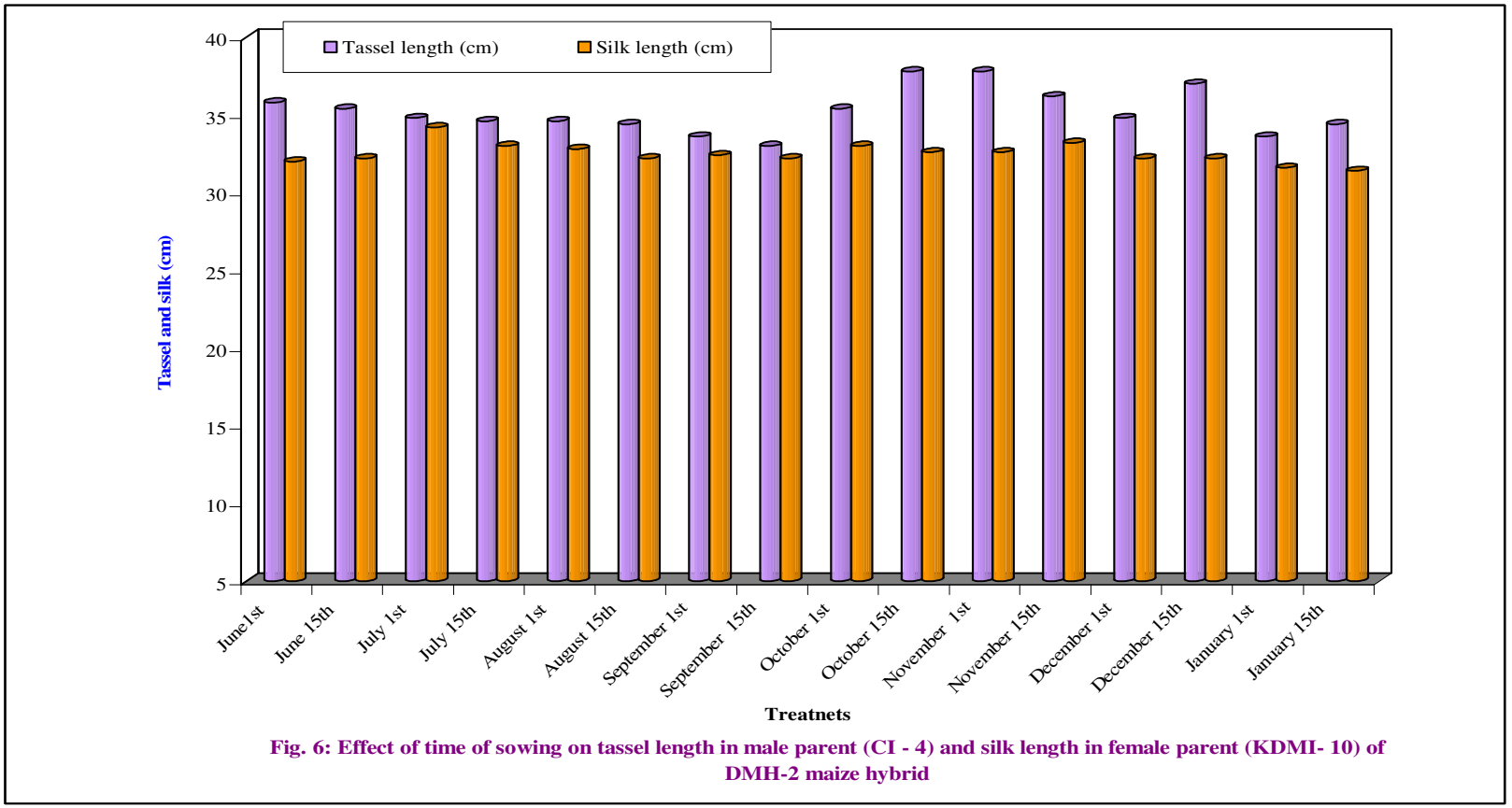

Fig. 6: Effect of time of sowing on tassel length in male parent (CI - 4) and silk length in female parent (KDMI- 10) of DMH-2 maize hybrid

Fig. 6: Effect of time of sowing on tassel length in male parent (CI - 4) and silk length in female parent (KDMI- 10) of DMH-2 maize hybrid

Table 4.11: Effect of time of sowing on days to complete flowering in male and female parents of DMH-2 maize hybrid

Treatment	Time of sowing	Days to complete flowering		Difference
		Male parent	Female parent	
T_1	June1st	60.00	65.00	-5.0
T_2	June 15th	60.00	66.00	-6.0
T_3	July 1st	58.00	64.00	-6.0
T_4	July 15th	64.00	67.00	-3.0
T_5	August 1st	64.00	68.00	-4.0
T_6	August 15th	63.00	67.00	-4.0
T_7	September 1st	62.00	67.00	-5.0
T_8	September 15th	58.00	65.00	-7.0
T_9	October 1st	59.00	65.00	-6.0
T_{10}	October 15th	58.00	64.00	-6.0
T_{11}	November 1st	57.00	65.00	-8.0
T_{12}	November 15th	56.00	64.00	-8.0
T_{13}	December 1st	55.00	66.00	-11.0
T_{14}	December 15th	55.00	63.00	-8.0
T_{15}	January 1st	62.00	66.00	-4.0
T_{16}	January 15th	61.00	67.00	-6.0
	Mean	**59.50**	**65.56**	
	Difference	9	5	

4.2.1.9 Tassel length in male parent (cm)

The result on Tassel length in male parent presented in Table 4.08

The time of sowing has a significant effect on tassel length of male parent. October 15th and November 1st sowing have recorded the highest tassel length (37.80 cm) followed by November 15th (36.20 cm). The lowest length of tassel was obtained in September 2010 and January 1st 2011 (33.60 cm). The tassel length ranged from 33.00 cm to 37.80 cm showing difference of 4.80 cm during entire period of sowing.

4.2.1.10 Silk length in female parent (cm)

The result on silk length in female parent are presented in Table 4.08

The time of sowing has a significant effect on silk length of female parent. July 1st sowing has recorded the highest silk length (34.00 cm) followed by November 15th (33.20 cm). The lowest length of silk was observed in January 15th 2011 (31.40 cm). The silk length ranged from 31.40 to 34.20 cm showing difference of 2.8 cm during entire period of sowing.

5. DISCUSSION

The development and release of the hybrid maize in India marked the beginning of the establishment of seed industry on a sound footing in the country. A good coverage with these hybrids was mainly due to their high yielding potentiality and the timely availability of hybrid seed at a reasonable cost.

Though the recent released hybrid DMH-2 has better yield potentiality, good grain quality and fodder yield than the presently recommended public hybrids, the coverage under this hybrid is not encouraging as the seed production of this hybrid has not become successful due to problem of synchronization in flowering between its parents during the seed production.

Hence, this problem is tackled through two experiments entitled study on the effect of seed treatment, soil application of additional nitrogen and foliar spray of N to parents on synchrony, seed yield of DMH-2 maize hybrid and the effect of time of sowing on flowering behavior of parental lines of DMH-2 are discussed in this chapter.

5.1 Effect of seed treatment, soil application of additional nitrogen and foliar spray of nitrogen to parents on synchrony, seed yield and quality of DMH-2 maize hybrid

In the present investigation with additional nitrogen, given to female parent through both soil and foliage, resulted in numerical increase of plant height, ear height and dry matter. Plant height of the female parent was influenced by additional N application. The soil application of 25 per cent additional N to female parent increased the plant height (190.93 cm) followed by pre-sowing hydration with GA_3 100 ppm 190.33 cm for 6 hours. In female parent and 189.00 cm pre-sowing hydration with GA_3 100 ppm 6 hrs. + foliar spray of urea 2 per cent before flowering in female parent compared to other treatments. Similar increase in plant height due to the application of nitrogen was also observed by Balanarasaiah *et al*. (1972), Prabhakar *et al*. (1973), Joshi (1976), Naik (1977), Malali (1979), Biradar Patil (1984) and Shivappa (1988) in sorghum hybrid. The additional dose of nitrogen helped in increasing the dry matter production thereby increasing the height of the plant which helped to get maximum photosynthates to store in turn led to maximum seed yield.

Ear height of the female parent was also influenced by additional N application. The soil application of 25 per cent additional N to female parent increased the ear height (98.07 cm) of the female parent followed by soil application of 10 per cent additional N + foliar spray of urea 2 percent before flowering (96.93 cm) to female parent and pre-sowing hydration with GA_3 100 ppm 6 hrs. + foliar spray of urea 2 per cent before flowering in female parent (96.67 cm) compared to other treatments. The increase in the plant growth is attributed to the continuous supply of nutrients to the photosynthetic region throughout the growth period. The soil and foliar application of nitrogen at the early stage might have led to the absorption and utilization of nutrients in the metabolism and thus resulted in early growth. Hence, continuous availability of nutrients particularly at the flowering primordial initiation stage might have caused the enhanced growth.

In the present investigation, even though complete synchronization of flowering was not achieved by additional application of nitrogen and seed treatment to the female parent, gap has been reduced for days to 50 percent flowering between two parents by 1.34 days, and reduction to 2 days where in soil application of 25 per cent additional N application and also staggered sowing of female parent by four days early has reduced gap between two parents by 2.33, since it induced early flowering in female parent. Thus it can be utilized to bridge the marginal gap in flowering of parents. The hastening of flowering in sorghum by additional application of nitrogen has also been reported earlier by Kishen Narayan (1976), Kudasommannavar (1974), Joshi (1976), Malali (1979), Pandusastry (1981), Basavaraj and Bommegouda (1982) and Vadivelu *et al*. (1984). Tanwir Alam *et al*. (2007) opined that in maize nitrogen manipulation alone cannot bring effective synchronization and it has to be supplemented with other means. So this helped to synchronization of flowering in parents of DMH-2 in (CI-4) female (KDMI-10) male parents.

Effect of T_4 and T_6 treatment imposed was reflected in early silking initiation and kept the same pace and resulted in advance 50 per cent silking which reduced the gap and brought closer synchrony between male and female parent. This would be due to hastening of seed germination and emergence coupled with additional nitrogen and GA_3 hydration application at approximate time fruitfully attained the nearer results. The next best treatment was T_1 followed T_5. Since staggered sowing of male parent by 4-6 days is somewhat problematic as seed production of maize hybrids will be taken hectares together. It will be sown simultaneously keeping in mind the manipulations for earliness of female parent of DMH-2, it would be induced by some seed treatment or additional nitrogen soil application or foliar spray. Partial success was achieved through one or two treatments in the present study.

5.1.1 Yield components

Final seed yield depends on yield components like cob length, cob diameter, cob weight per plant, seed weight of cob and shelling percentage

In the present study the mean cob length of DMH-2 observed was 14.92 cm. The cob length did not differ significantly even though different treatments were imposed but only numerically higher cob length was recorded with foliar spray of urea (2 per cent) before flowering to female (15.60 cm) followed by soil application of 25 per cent additional N to female parent (15.47 cm), soil application of 10 percent additional N + foliar spray of urea 2 percent before flowering to female parent (15.40 cm) and pre-sowing hydration with GA_3 100 ppm for 6 hrs. + foliar spray of urea (2 per cent) before flowering in female parent (15.20 cm) which were on par with each other. Numerically the lowest cob length (14.13 cm) was observed in simultaneous sowing of parents of DMH-2 (control) which was on par with pre-sowing hydration of male parent seed with ABA 2.5 ppm 6 hrs. (14.53 cm) and pre-sowing hydration with GA_3 100 ppm 6 hrs. in female parent (14.80 cm). It may be due to the additional application of nitrogen or seed treatment provided maximum area on cob to set seed which helped to get high seed yield.

Cob diameter of F_1 was significantly affected by different treatments. Numerically the higher cob diameter (14.17 cm) was observed in the treatment of pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent followed by soil application 10 per cent additional N + foliar spray of urea (2 %) before flowering to female parent (14.07 cm), soil application of 25 per cent additional N to female parent (14.07 cm) and sowing of female parent four days early (13.80 cm) which were on par with each other. Numerically lowest cob diameter was observed in simultaneous sowing parent's control of DMH-2 (13.03 cm). Better synchrony and seed set might have helped to develop large seed size on rind and resulted in more diameter in turn high seed yield through this synchronization effect. Similar results were also reported by Yadav and Singh (2000).

The average seed number per cob of DMH-2 was 416.69, the number of seeds per cob was also significantly differed with different treatments imposed for synchronization. Significantly higher (471.73) seed number per cob was observed in the treatment which was given with pre-sowing hydration for 6 hrs. + 10 per cent additional N soil application to female parent. This was followed by soil application of 25 per cent additional N to female parent (460.33) and sowing of female parent four days early (458.40) which were on par to each other. Numerically the lowest number of seeds per cob was observed in simultaneous sowing of parents of DMH-2 (364.53) followed by pre-sowing hydration with ABA 2.5 ppm (6 hrs.) in male parent 383.40 and foliar spray of urea (2 per cent) before flowering to female (394.07). The difference between maximum and minimum is 53.2g similar results were also found by earlier workers In maize (Singh and Yadav 2000).

In the present investigation average cob weight per plant of DMH-2 was 136.95g. The cob weight per plant significantly influenced by different treatments. Significantly higher cob weight (163.00g) per plant was observed in the treatment where seeds were given pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent followed by soil application (10 per cent) additional N + foliar spray of urea 2 percent before flowering to female parent (159.33g) and soil application of 25 per cent additional N to female parent (150.93g) which were on par to each other. Numerically the lowest cob weight per plant was observed in simultaneous sowing of parents of DMH-2 that is in control (115.00g) followed by foliar spray of urea 2 per cent before flowering to female 122.40g and pre-sowing hydration with ABA 2.5 ppm 6 hrs. in male parent (124.60g). The highest cob weight in pre-sowing

hydration 6 hrs. + 10 per cent additional N soil application to female parent was highest which might be due to better synchronization of flowering of both parents. Only small gap was 1.34 days. Close synchrony might helped the female parents to get maximum pollen grains and better fertilization resulted in higher seed set and seed weight.

Mean number of seed rows per cob of DMH-2 was 13.51. Though it is genetically controlled the number of seed rows per cob significantly differed with different treatments. Significantly higher number of seed rows per cob was (14.00) observed with pre-sowing hydration 6 hrs. + 10 per cent additional N soil application to female parent followed by sowing of female parent four days early (14.00) and soil application 25 per cent additional N to female parent (14.00) which were on par to each other. Difference between maximum and minimum is 1.6. This difference was due to poor cob development and poor seed set and improper seed rows due to poor synchrony.

Hundred seed weight was also significantly highest (29.79g) with treatment of pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent followed by soil application 25 per cent additional N to female parent (29.22g) and sowing of female parent four days early (28.93g) which were on par to each other. Numerically the lowest 100 seed weight was observed in simultaneous sowing parents of DMH-2 (26.35g) followed by pre-sowing hydration with ABA 2.5 ppm 6 hrs. in male parent (26.98g) and (27.03) the difference between maximum and minimum is 3.44g. Similarly, several workers have reported increased seed yield due to increased test weight Besides enhanced yield of maize with higher N level was reported by Yadav and Singh (2000). Thus, it is clear that pre sowing hydration and additional N application improved the synchrony and could enhance the yield components and the final seed yield as evidenced by the earlier results.

Average Shelling percentage of DMH-2 was 83.10 per cent. The shelling percentage significantly varied with different treatments. Significantly higher shelling percentage (86.05) was observed in treatment given with pre-sowing hydration + 10 per cent additional N soil application to female parent followed by soil application of 25 per cent additional N to female parent (85.67) and sowing of female parent 4 days early (83.70) which were on par with each other and numerically lowest shelling percentage was observed as 79.47 followed by 81.71 and 82.52. The difference between maximum and minimum was 6.5 per cent.

The higher seed weight 132.07g per cob was observed in the treatment which was given with pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent followed by soil application 25 per cent additional N to female parent (129.20g) and sowing of female parent four days early (120.60g) which were on par to each other. Numerically the lowest seed weight per cob was observed in simultaneous sowing of parents of DMH-2 (95.13g) followed by pre-sowing hydration with ABA 2.5 ppm 6 hrs. to male parent (104.07g) and foliar spray of urea (2 per cent) before flowering to female (105.27g). The difference in seed weight between maximum and minimum is 36.94g. Highest seed weight might be due to decreased gap between flowerings of both parents resulted in better seed set and seed yield.

Seed set percentage 96.45 was significantly higher with pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent, followed by soil application 25 per cent additional N to female parent (93.94) and sowing of female parent four days early (93.55) which were on par to each other and numerically lowest seed set percentage was observed in simultaneous sowing of parents (74.41) followed by pre-sowing hydration with ABA 2.5 ppm 6 hrs. in male parent (78.24) and foliar spray of urea (2per cent) before flowering to female (80.41). The difference between maximum and minimum was 19.56 per cent. This was attributed to better synchrony as the viability of earlier formed pollen might have been helped to high pollen for fertilization and seed set results. Induction of early flowering by simple hydration was also recorded by Singh *et al*. (2007) in maize.

Increase in all the yield components resulted in higher seed set and yield in the treatment which was received pre-sowing - hydration of seed along with 10 per cent additional N to soil. Higher yield parameters recorded in this treatment were attributed to reduction in days to silking of female parent which caused better synchrony that resulted in better pollination and fertilization, seed set, seed development and seed yield. Present results are in conformity with the work of Basavaraj and Bommegowda (1982). The next best treatment was soil application of 25 per cent additional N to female parent.

Significantly higher fodder yield per ha was recorded in the treatment which was given with pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent followed by soil application of 25 per cent additional N to female parent and sowing of female parent four days early which were on par with each other and numerically lowest fodder yield per ha was observed in simultaneous sowing parents of DMH-2.

5.1.2 Seed quality

Germination of seeds was seen to increase with the additional application of nitrogen and hydration treatments which was conformity with the results of Josh (1976) and Basavaraj and Bommegouda (1982). The seed quality parameters like germination percentage, root length, shoot length, seedling dry weight and vigour index (Table 4.6) have shown higher values with additional application of nitrogen treatment with hydration and growth regulators. The increase in these values was due to increased fertility level which was reflected in higher seed weight resulted in higher root/shoot length and dry weight of seedling. They had led to higher seed recovery percentage. The result of this investigation were in conformity with the findings of many workers who had reported that increased seed size increased the germination, coleoptile length and weight of seedling (Randhwa *et.al*., 1973) and seedling emergence and seedling dry weight. Krishnaswamy and Ramswamy (1979) also observed that larger seeds recorded increased germination, root-shoot length, dry weight of seedling and vigour index.

In the present investigation average germination percentage of DMH-2 was 96.67. The germination percentage did not differ significantly among treatments. Numerically higher germination percentage was observed in the treatment (97.67) which was given pre-sowing hydration of seed (6 hrs.) + 10 per cent additional N soil application to female parent followed by soil application 25 per cent N to female parent (97.67) and sowing of female parent four days early (97.33) and soil application 10 per cent additional N + foliar spray of urea 2 per cent before flowering to female (97.00) which were on par with each other. Numerically lowest germination percentage was observed in simultaneous sowing parents of DMH-2 (95.67) followed by no treatment for female (96.00) and pre-sowing hydration with GA_3 (100 ppm) 6 hrs. + Foliar spray of Urea 2 per cent before flowering in female parent (96.00). The difference between maximum and minimum was 2 per cent. Numerical decrease in seed germination with application of GA_3 or urea was also observed by Deshpande (1993) in hybrid seed production of rice.

In the present study average root length of DMH-2 was 20.98 cm. The root length did not differ significantly even though different treatments were imposed but the numerically higher root length was observed in pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent (22.98 cm) followed by soil application 25 per cent N to female parent (22.42 cm), sowing of female parent four days early (21.97 cm) and soil application of 10 per cent additional N + foliar spray of urea 2 per cent before flowering to female parent (21.85 cm) which were on par to each other. Numerically lowest root length was observed in simultaneous sowing both female and male parents of DMH-2 (18.02 cm) followed by no treatment to female parent (19.55 cm) and pre-sowing hydration with GA_3 (100 ppm) 6 hrs. + Foliar spray of Urea 2 per cent before flowering in female parent (20.06 cm). The difference between maximum and minimum was 4.96 cm.

The shoot length also did not differ significantly even though different treatments were imposed but numerically higher shoot length was observed in pre-sowing hydration of seed (6 hrs.) + 10 per cent additional N soil application to female parent (21.39 cm) followed by soil application of 25 per cent N to female parent (20.18 cm), sowing of female parent four days early (20.04 cm) and soil application 10 per cent additional N + foliar spray of urea 2 per cent before flowering to female parent (19.64 cm) which were on par to each other. Numerically the lowest shoot length was observed in simultaneous sowing both female and male parents of DMH-2 (18.37 cm) followed by no treatment to female parent (19.08 cm) and pre-sowing hydration with GA_3 (100 ppm) 6 hrs + foliar spray of urea 2 per cent before flowering in female parent (19.09 cm). The difference between maximum and minimum was 3.02 cm and average shoot length was 19.61 cm.

The mean seedling dry weight significantly differed with different treatments. Significantly higher seedling dry weight was observed in pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent (410 mg) followed by soil application 25

per cent N to female parent (400 mg) and sowing of female parent four days early (326.67 mg) which were on par to each other. Numerically the lowest seedling dry weight was observed in simultaneous sowing both female and male parents of DMH-2 (223.33 mg) followed by no treatment to female parent (230 mg) and pre-sowing hydration with GA_3 (100 ppm) 6 hrs. + foliar spray of urea 2 per cent before flowering in female parent (240 mg). The difference between maximum and minimum is 186.67 mg.

The mean vigour index differed with different treatments. Numerically higher vigour index was observed in pre-sowing hydration (6 hrs.) + 10 per cent additional N soil application to female parent (4160.08) followed by soil application of 25 per cent N to female parent (4071.35) and sowing of female parent four days early (3968.42) which were on par to each other. Numerically the lowest vigour index was observed in simultaneous sowing both female and male parents of DMH-2 (3602.75) followed by no treatment to female parent (3861.02) and pre-sowing hydration with GA_3 (100 ppm) 6 hrs. + foliar spray of urea 2 per cent before flowering in female parent (3900.38) .The difference between maximum and minimum was 557.33.

The mean electric conductivity did not significantly differed with different treatments. Numerically higher electric conductivity (0.18 dSm^{-1}) was observed with treatment which was given with simultaneous sowing both female and male parents of DMH-2 followed by no treatment to female parent (0.16 dSm^{-1}) and pre-sowing hydration with GA_3 (100 ppm) 6 hrs. + foliar spray of urea 2 per cent before flowering in female parent (0.16 dSm^{-1}). They were on par with each other. Numerically the lowest electric conductivity was observed in pre-sowing hydration of seed (6 hrs.) + 10 per cent additional N soil application to female parent (0.09 dSm^{-1}) followed by soil application 25 per cent additional N to female parent (0.11 dSm^{-1}) and sowing of female parent four days early (0.12 dSm^{-1}). The difference between maximum and minimum was 0.07.

5.2 Effect of time of sowing on flowering behavior of parental lines of DMH-2 maize hybrid

Male parent showed higher plant height than female during all the sowing intervals from June to January except in August 1st and 15th. Both the parents showed maximum plant height at 50 per cent flowering in June 1st and 15th sowing in male and January 1st and 15th in female minimum in September 1st and 15th sowing in male and in female December 1st and 15th (Table 4.07). Average plant height 144,42cm in male and mean in female height 140.45cm.

The number of days required to initiation of flowering varied in intervals of sowing in different months. In all the months sowing with 15 days interval, male parent (KDMI-10) flowered earlier than female parent (CI-4). The number of days taken for initiation of flowering increased from June 1st 2010 planting to January 15th. Both the parents took maximum days to initiation flowering in September 1st and 15th sowing and minimum in June 1st and 15th sowing (Table 4.09). Similarly, variation in days to flowering in different monthly planting was reported by earlier workers (Murthy *et al.,* 1964; Kishan Narayan and Chopde *et al.,* 1973; Krishnaswamy and Ramswamy, 1979; Malali, 1979 and Pandusastry, 1981). There was maximum difference between parents to initiation of flowering in September 1st and 15th sowing and minimum in June 1st and 15th sowing. The difference of number of days for tassel and silk emergence ranged from 2 to 8 days and it was found vary narrow (2.00 days) during January 15th the sowing and wide (8.00 days) during September 15th sowing. It was constant of 4 days different from July 15th to August 1st. The mean difference of days for tassel and silk emergence was (5.06) during entire period of experiment.

The number of days to 50 per cent flowering varied in 15 days interval of sowing in different months. In all the months of sowing male parent (KDMI-10) flowered earlier than female parent (CI-4). Both the parents took maximum days to 50 per cent flowering in December and November sowing and minimum in August sowing (Table 4.10).

The number of days to complete flowering varied in 15 days interval of sowing in different months. The number of days taken for complete flowering increased from June 1st 2010 planting to September 15th and then showed decreased up to October 1st to December 15th and January 1st and 15th 2011 again increased. Both the parents took maximum days to complete flowering in August sowing and minimum in December sowing (Table 4.11).

Similarly, variation in days to flowering in different monthly planting was also reported by earlier workers (Murthy *et al.,* 1964; Kishan Narayan and Chopde *et al*., 1973 Krishnaswamy and Ramswamy, 1979b; Malali, 1979 and Pandusastry, 1981).

From October to December sowing because of low night temperature prevailing during primordial initiation and development stage, the flowering might have been delayed. This is in accordance with the findings of Malali(1979) and Pandusastry, 1981). In the plantings, taken during the month of June, July, August and January delayed the flowering due to rainy days unavailability of sun shine due to photo period nature so flowering require particular day and night light and temperature and also maize is photosensitive nature of plant, since it is a short day plant. During the month of June, July, August and January when these plants entered in comes to primordial initiation stage, the duration of light may affect flowering during this period. This was true with both the parents. Present results are inconformity with findings of Quinby (1973). The early flowering in October to December monthly planting might be due to winter season due to plenty sunshine hours during that period (Shirwal *et al*., 1974).

In this present investigation mean tassel length in male parent was 35.20 cm and did not differ significantly due to sowing time in June to January but numerically higher tassel length of male parent was observed in November 1st (37.80 cm) followed by October 15th (37.80 cm),December 15th (37.00 cm),November 15th (36.20 cm) June 1st (35.80 cm) and June 15th (35.40 cm) which were on par with each other, Numerically the lowest tassel length of male parent was observed in September 15th (33.00 cm) followed by September 1st (33.60 cm),January 1st (33.60 cm)and January 15th (34.40 cm) among all these treatment, November 1st ,October 15th sowing has given highest tassel length in male parent had non significant effect on tassel length in male parent and the mean difference between maximum and minimum was 4.8 cm. Similar results were also recorded by Yadav and Singh (2000) increased tassel length in maize.

In present investigation mean silk length of female parent was (32.48 cm) significantly higher silk length of female parent was observed in July (134.20 cm) followed by July 15th (33.00 cm), August 1st (32.80 cm),November 1st (32.60 cm) September 1st (32.40 cm) and august 15th (32.40 cm) which were on par with each other and significantly lowest silk length in female parent was observed in January 15th (31.40 cm) followed by January 1st (31.60 cm), June 1st (32.00 cm) and June 15th (32.20 cm) among all these treatment, July 1st, July 15th sowing has given highest Silk length in female parent have significant effect on silk length and the mean difference between maximum and minimum is 2.8 cm Yadav and Singh (2000) also observed similar things during maize seed production.

The above data on tassel length and silk length revealed that the highest length of tassel length and silk length did not found in the same date of sowing during entire period of experiment from June 1st to January 15th.

Practical utility of results

1. Among the treatments pre sowing hydration (6 hrs.) + 10 percent additional nitrogen application to soil for female parent reduced the gap of 5-6 days into 1.34 days between male and female flowering so it helped to get synchrony in flowering of both male and female and also high yield and other supporting parameters to yield.
2. *Kharif* season is better than to *rabi* summer to get synchronization of flowering of parents of DMH-2.
3. In *kharif* season July 15th sowing is better as compared to other sowing dates because both initiation of flowering and completion of flowering are early in this treatment.
4. At Dharwad, for synchronization of flowering between the parental lines, male parent has to be sown 5-6 days late than female in *kharif* season.

Future line of work

1. The basic studies like floral biology, flowering habit and its behavior in female (CI-4) and male (KDMI-4) parents are to be studied for different agro climatic conditions.

2. Influence of growth regulators like Gibberellic acid and Absasic acid with higher dose on synchronization of flowering, seed set and seed yield in the parental lines.
3. The study on flowering behavior of female and male parents of pre released maize hybrids are to be conducted for various seed production areas before its release.
4. The application of additional dose of nitrogen through soil and foliage to the late flowering parent needs to study at different locations.
5. Effect of nitrogen application along with growth regulators on synchronization of flowering of parental lines of maize hybrid.
6. Influence of staggering dates with different levels of nitrogen management on seed production may be taken up.
7. It is necessary to initiate the studies on influence of planting ratio seed treatment and fertilization level on seed yield and quality in hybrid seed production.

6. SUMMARY AND CONCLUSIONS

The field investigation was carried out to study the effect of various treatments on synchronization between male and female parents of DMH-2 maize hybrid during seed production and sowing time of parents on flowering and synchrony (CI-4 × KDMI-10). With the release of many maize hybrids, the production of grain maize has increased tremendously. Supply of hybrid maize seeds at adequate quantity at reasonable price in time is a herculean task but the seed production of hybrid maize is not an easy task since it poses problem of non-synchrony of flowering between two parents due to difference in days to flowering. Unless synchronization of flowering is achieved, the hybrid seed production will not be satisfactory and hence will increase the cost of seed production. Since female parent of DMH-2 flowers 5-6 days late as compared to male, it poses problem of synchronization of flowering and results in poor seed yield. Hence efforts were made to get synchrony between parental flowering through seed treatment, with simple hydration, GA_3 or foliar spray of urea and soil application of additional nitrogen to the female to get early flowering. Keeping in view the above aspects, two field experiments were carried out from June 1st 2010 to January 2011 at Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* season of 2010-11. The laboratory studies were also conducted in the Department of Seed Science and Technology, College of Agriculture Dharwad. The results of the experiment are summarized in this chapter.

1. Application of 25 per cent additional N resulted in numerically higher plant height (190.93cm) and ear height (98.07cm) compared to rest of the treatments.
2. The soil application of 10 per cent additional N + foliar spray of urea (2%) before flowering to female parent (CI-4) hastened the first flowering in female parent (47.33days).
3. The pre-sowing hydration (6 hrs.) + 10% additional N soil application to female parent (CI-4) hastened the 50 percent flowering in female parent (57.67days), lowest number of days in male (KDMI-4) for flowering is 55.33days. The difference between male and female parents reduced due to this treatment. Highest synchrony achieved with a gap of 1.34 days.
4. The pre-sowing hydration (6 hrs.) + 10% additional N soil application to female parent increased the length of cob (15.07cm), cob diameter (14.17cm), cob weight per plant (163.00g) and resulted in increased value as compared to other treatments.
5. The pre-sowing hydration (6 hrs.) + 10% additional N soil application to female parent also resulted in high number of seeds per cob (471.73), number of seed rows per cob (14.00), seed weight per cob (132.07g), seed set percent (96.45) and 100 seed weight (29.79g) that resulted in increased value compared to other treatments.
6. The highest shelling percentage was (86.05) recorded where the treatment was given with pre-sowing hydration (6 hrs.) + 10% additional N soil application to female parent.
7. Planting DMH-2 parents with a treatment of pre-sowing hydration (6 hrs.) + 10% additional N soil application to female parent resulted in higher seed yield (38.33 kg) and fodder yield (33.33 kg).
8. The result of F_1 seeds obtained by the treatment of pre-sowing (6 hrs.) + 10% additional N soil application to female parent resulted during seed production showed numerically higher root length (22.98 cm) and shoot length (21.39 cm) seedling dry weight (410 mg) and ultimately resulted in higher vigour index (4160.08) compared to other treatments
9. Lowest electric conductivity (0.09dSm-1) was recorded in same treatment pre-sowing hydration (6 hrs.) + 10% additional N soil application to female parent.

The study of flowering behavior of parents as influenced by time of sowing has indicated that growth stages of the parents vary due to differential dates of sowing from June 1st to January 15th during 2010-11.

1. The plant height from June 1st 2010 planting to January 15th 2011. Of both the parents showed maximum plant height at 50 per cent flowering in June 1st and 15th sowing in male and January 1st and 15th sowing where as it was in female. Minimum in September 1st and 15th sowing in male and December 1st and 15th in female.
2. The number of days taken for initiation of flowering increased from June1st 2010 planting to January 15th. Both the parents took maximum days for initiation of flowering average in September 1st and 15th sowing and minimum in January 1st and 15th sowing.
3. The number of days taken for complete flowering increased from June1st 2010 planting to September 15th and it declined from October 1st to December 15th. Again increasing trend was observed during January. Both the parents took maximum days to complete flowering in August sowing and minimum in December sowing but the gap between male and female parent was least (3 days). Whereas it was moderate during August 1st and 15th sowing within 4 days.
4. October 15th and November 1st sowing has resulted in highest tassel length in male parent without any significant effect on tassel length in male parent and with an mean difference between maximum and minimum is 4.8 cm.
5. July 1st, July 15th sowing recorded significantly highest Silk length in female parent have significant effect on Silk length in female parent and the mean difference between maximum and minimum is 2.8cm.

Conclusions

1. Closer synchronization of flowering between parents (CI-4 × KDMI-10) of hybrid maize DMH-2 could be obtained by pre-sowing hydration of seeds of female parent and applied with 10 percent (32.55 kg/ha urea) additional nitrogen when both the parents were sown simultaneously. Further this treatment resulted in better yield components and high seed yield with better seed quality traits.
2. July and August sowing of parental lines was found to get closer synchrony between parents of DMH-2 when parents were sown simultaneously as per the package of practice.

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Appendix I: Physical and chemical properties of the soil of the experimental site

Sl. No.	Particulars	Values
I.	**Physical properties**	
1.	Coarse sand (International Pippette Method) (Piper, 1966)	6.10%
2.	Fine sand (International Pippette Method) (Piper, 1966)	13.14%
3.	Silt (International Pippette Method) (Piper, 1966)	28.00%
4.	Clay (International Pippette Method) (Piper, 1966)	62.76%
II.	**Chemical properties**	
	Available nitrogen (Alkaline permanganate method) Subbaiah and Asija, 1956)	0.0068%
	Available P_2O_5 (Olsen's method) (Jackson, 1967)	0.007%
	Available K_2O (Flame photometry method) (Jackson, 1967)	0.016%
III.	pH	7.5
IV.	Electrical conductivity (dS/m)	0.31

Appendix II: Monthly meteorological data for the experimental year 2010-2011 and the average of 60 years (1950-2010) at Meteorological Observatory, Main Agricultural Research Station, College of Agriculture, University of Agricultural Sciences, Dharwad

Months	Rainfall (mm)		Temperature (^{o}C)				Relative humidity (%)	
			Mean maximum		Mean minimum			
	2010	1950-2010	2010	1950-2010	2010	1950-2010	2010	1950-2010
January	0.8	0.062	29.67	28.2	15.4	14.07	63	64.81
February	0.4	0.547	32.20	32.4	17.3	16.56	50	54.41
March	Trace	15.65	33.73	35.6	20.3	19.71	49	64.24
April	43.8	39.27	36.00	37.6	22.0	20.11	55	78.05
May	63.1	68.39	34.41	35.7	22.4	20.95	63	75.78
June	63.4	108.51	28.77	31.2	21.8	21.68	75	86.29
July	155.0	138.70	28.64	27.7	20.8	20.85	84	89.18
August	190.7	154.45	26.92	27.9	20.7	20.16	84	88.60
September	164.9	135.23	28.15	27.9	20.2	19.96	83	86.68
October	177.0	94.43	30.13	29	19.5	18.65	77	79.40
November	92.8	52.49	29.67	28.4	19.0	15.93	79	73.62
December	0.6	2.83	28.94	27.4	14.1	13.18	65	69.24
January(2011)	0.0		29.2		12.5		59	
February	21.6		30.8		14.0		48	
March	00.8		35.2		18.6		44	
April	77.4		34.9		20.2		57	
Total	**1122.45**	**810.55**						

Appendix III: Description of the parents of DMH-2

Sl. No.	Characters		F_1 single cross (CI-4 × KDMI-10)	Inbred CI-4	KDMI-10
1	Plant height (cm)		169.40	143.33	151.00
2	Distinguishing morphological characters	Tassel	Open medium size	Compact to semi compact medium size	Open medium size
		Glume colour	Green with purple tinge	Green with purple tinge	Green with purple tinge
		Anther colour	Purple	Green and purple	purple
		Silk colour	Purple and green	Green and purple	Green and purple
		Empty pith	Mixture of white and purple	white	purple
3	Maturity (range in number of days)		110-115 days	110-115 days	110-115 days
4	Days to 50% flowering	50% pollen shed	56.80 days	63.00 days	61.00 days
		50% silking	58.00 days	64.00 days	62.00 days
5	Maturity groups		Late maturity	Late maturity	Late maturity

STUDIES ON EFFECTIVE METHODS FOR SYNCHRONIZATION OF FLOWERING IN PARENTS OF DMH-2 HYBRID MAIZE

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ABSTRACT

The present investigation was carried out to study the influence of seed treatment with hydration, gibberellic acid and soil application of additional nitrogen in combination with urea spray to female parent (CI-4) and only Abcisic acid seed treatment to male (KDMI-10) on synchronization of flowering between the parental lines, seed yield and quality of hybrid maize DMH-2 at MARS, UAS Dharwad during *kharif* 2010.

Female parent flowered late by six days than male with simultaneous sowing. Among the different techniques to achieve synchronization of flowering, pre sowing seed hydration(6hrs) + 10 % additional N soil application to female parent resulted in better synchronization of flowering (1.34 days) and resulted in significantly highest seed yield (38.33 q/ha) over simultaneous sowing control (23.07 q/ha). This treatment also hastened the first flowering in female parent (47.33 days) and increased the cob length, cob weight (163.00 g/ plant), number of seeds rows per cob (14.00), seed weight per cob (132.07 g), seed set % (96.45), 100 seed weight (29.79 g) and fodder yield (3.33 q) compared to other treatments.

The results of another field experiment conducted during 2010-11, to study the effect of time of sowing on flowering behavior of parental lines of DMH-2 maize hybrid revealed that, sowing dates influenced the flowering behavior of the parental lines. Sowing in mid July caused early initial and 50% flowering by 4 days and 3 days between female and male parents respectively and the difference was gradually increased up to January 1st sowings. None of the sowing did not give cent per cent synchrony and the flowering difference (50%) ranged from 3 to 11 days during June 1st 2010 to January 15th 2011 under Dharwad condition.