

Effect of staggered sowing and split application of nitrogen in seed production of pearl millet hybrid MH-946*

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Abstract: A field experiment was carried out during *Kharif* 2011 at the Regional Agricultural Research Station, Bijapur, University of Agricultural Sciences, Dharwad to investigate the effect of staggered planting and split application of N on synchronization of male and female parents of pearl millet hybrid MH-946 (GHB-558). The experiment comprised of twenty treatments with three replications in split plot design. The results revealed that sowing of male parent by 8 days earlier to female with 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS recorded less number of days for 50 per cent flowering in male (52.0 days) and female (51.3 days) and also recorded higher plant height (182.4 cm), ear length (19.0 cm), ear diameter (3.0 cm), ear weight per plant (28.3 g), number of seeds per ear (2658.0 seeds), seed weight per ear (21.0 g), seed set per cent (91.6 %) and 1000 seed weight (11.2 g) which resulted in increased value compared to other treatments.

Key words: Nitrogen application, Seed yield, Synchronization

Introduction

In India, pearl millet is grown in an area of 8.68 million hectares with a production of 8.61 million tonnes and the productivity of 991 kg per ha (Anon., 2011). With the establishment of AICRIP in pearl millet in 1961 by ICAR, New Delhi, the exploitation of heterosis was initiated, as a result of this first hybrid of pearl millet (HB-1) was released by AICRIP in 1961. Among the production factors, major barrier in hybrid seed production is to achieve perfect synchronization of flowering between female and male parental lines and the non uniformity in flowering period of male and female parent causes a poor seed set due to non-availability of pollen at the time of stigma receptivity in female parent due to the protogyny in pearl millet. To achieve proper synchronization of flowering of male and female parents, the methods like staggered planting and cultural practices such as application of nitrogen through soil, spraying of urea, gibberellic acid, ABA, hydro priming and controlled irrigation are followed in hybrid seed production of cereals and millets.

The pearl millet hybrid MH-946 (GHB 558) is a cross between ICMA 94555 × J 2290. The female parent (ICMA 94555) flowers 8 to 10 days earlier to male parent (J 2290). The period of staggered sowing in hybrid seed production of pearl millet can be reduced amicably by spraying either 2% urea or 2% DAP so that the late flowering parent meet synchrony and facilitate the simultaneous flowering which otherwise difficult under a longer period of staggered sowing. In the past, several methods have been adopted to overcome the problem of non-synchronization of flowering. When the parental lines are more than the marginal, only the alternative is staggered planting which is not in practice in pearl millet hybrid. In staggered planting, the planting dates of parental lines of hybrid is adjusted to make them to flower at the same time but the success mainly depends on the information about the time of flowering of both the parents at different places and in different seasons, since planting ratios are involved in pearl millet hybrid seed production.

Since pearl millet is nitro positive crop, increase in the 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 behaviour could also be manipulated by the use of different chemicals like gibberellic acid, foliar spray of nitrogen, phosphorus and pre-sowing hydration, which hasten the flowering. Hence, in the present investigation efforts were made to synchronize the parental flowering where flowering of male is 8 to 10 days later compared to the female parent.

Material and methods

The field experiment was laid out in a split plot design with two factors, Factor - I: staggered sowing (M), Factor - II: split application of nitrogen to male parent (S). Main factor consisting of sowing of male line at different dates *i.e.* M_1 -simultaneous sowing of male and female parents, M_2 -sowing of male parent by 4 days earlier to female, M_3 -sowing of male parent by 8 days earlier to female, M_4 -sowing of male parent by 12 days earlier to female, and M_5 -sowing of male parent by 16 days earlier to female. Hence, the treatments were fixed to advance the flowering of male parent (except in S_1) when both the parents were sown simultaneously. Sub plots of split application of nitrogen to male parent consisted of S_1 -50% N at the time of sowing and 50% N after 15 DAS S_2 -50% N at the time of sowing + 25% N at 15 DAS + 25% N at 25 DAS S_3 -50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS S_4 -25% N at the time of sowing + 25% N at 15 DAS + 25% N at 25 DAS + 25% N at 35 DAS. The seeds of both male and female parents of MH-946 (GHB-558) for the experiment were obtained from the Senior Pearl millet Breeder, Regional Agricultural Research Station, Bijapur. In each treatment, 4 rows of female and 2 rows of male were planted (4:2) along with 4 border rows of male parental seeds. The data of GHB-558 revealed that there was a difference of 8 to 10 days in flowering between the parental lines and the male parent being late.

Results and discussion

Among the five dates of staggered sowing, the male parent sown by 8 days earlier to female parent (M_3) recorded more

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Table 1. Effect of staggered sowing and split application of nitrogen for restorer line of pearl millet hybrid MH-946 on plant height (cm) at harvest in male and female parents

Treatment	Male parent (J2290R)					Female parent (ICMA 92555A)				
	S ₁	S ₂	S ₃	S ₄	Mean	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	179.3	177.0	178.0	178.0	178.1	95.3	95.3	94.3	95.0	94.5
M ₂	177.1	177.6	179.6	178.6	178.2	95.0	96.0	93.6	93.6	95.1
M ₃	179.9	180.5	182.4	181.2	181.3	93.0	94.3	103.0	102.0	98.0
M ₄	179.7	178.8	180.6	180.7	179.9	97.6	98.1	98.0	96.3	97.5
M ₅	178.8	179.9	179.8	178.0	179.1	96.0	95.3	94.3	95.0	95.5
Mean	178.9	178.8	180.1	179.31	179.3	95.4	95.8	96.6	96.4	95.8
For comparing the means of	S.E.m.±		C.D. (P= 0.05%)			S.E.m.±		C.D. (P= 0.05%)		
Staggered sowing (M)	0.58		1.69			0.57		1.67		
Split application of N (S)	0.26		0.78			0.45		NS		
Staggered sowing at same N levels	0.60		1.74			1.00		2.91		
Staggered sowing at same or different N levels	0.31		0.96			0.44		1.33		

NS - Non significant

Staggered sowings (M)

M₁: Simultaneous sowing of male and female parentsM₃: Sowing of male parent 08 days earlier to femaleM₅: Sowing of male parent 16 days earlier to female

Split application of N (S)

S₁: 50% N at the time of sowing and 50% N after 15 DAS to male parentS₂: 50% N at the time of sowing + 25% N at 15 DAS + 25% N at 25 DAS to male parentS₃: 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parentS₄: 25% N at the of sowing + 25% N at 15 DAS + 25% N at 25 DAS + 25% N at 35 DAS to male parentM₂: Sowing of male parent 04 days earlier to femaleM₄: Sowing of male parent 12 days earlier to female

plant height (181.3 cm) at harvest, which can be attributed to the favourable climatic and soil conditions during early staggered sowing. On the other hand, simultaneous sowing of female and male parent recorded lower plant height and it is probably related to erosion of congenial environment due to progressive delay in staggered sowing of male parent. Hence, it has resulted in sharp decline of plant height. These results are in confirmity with the findings of Pandusastry (1981), Biradar Patil (1984) and Shivappa (1988).

Irrespective of staggered sowings, the soil application of nitrogen did not exhibit marked variations on plant height. The soil application of 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent (S₃) recorded more plant height (180.1 cm) at harvest when compared to 50% N at the time of sowing and 50% N after 15 DAS (S₁) (178.9 cm).

Soil application of 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent recorded higher plant height and it can be attributed to readily available N nutrient in the source which might have modified morpho-physiological characteristics and enhanced the source availability to the developing sinks (seeds). Hence, 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent resulted in more plant height. Similar beneficial effect of nitrogen levels on growth parameters was also reported by Shivappa (1988), and Biradar Patil (1984) in sorghum.

The interaction effect between staggered sowing and soil application of nitrogen levels (MxS) on plant height was non-significant. However, higher plant height (182.4 cm) was observed at harvest.

Significant differences were observed for days to 50 per cent flowering due to staggered sowings irrespective of soil application of nitrogen. However, the sowing of male parent by

8 days before female parent (M₃) took relatively shorter period (57.8 days) for 50 per cent flowering as compared to sowing of female and male parent on same day (M₁) (63.1 days). The results indicated that staggered sowing did not show significant effect on flowering parameters due to shorter interval of staggered sowings. These findings are also in conformity with the results of Biradar Patil (1984) in and Shivappa (1988) in sorghum hybrid seed production, Varshney *et al.* (2006) and Tanwir Alam *et al.* (2007) in maize hybrid and Dhedhi *et al.* (2007) in Bajra.

Irrespective of staggered sowings, the soil application of nitrogen levels revealed significant variation on flowering parameters. However, number of days to 50 per cent flowering were relatively less (55.8) at 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS in (S₃) than in 50% N at the time of sowing and 50% N after 15DAS (S₁) (64.1days). Less days to 50 per cent flowering was noticed in soil application of 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS may be related to higher plant height, number of leaves, number of tillers per plant and number of ear heads per meter row length leading to faster growth of reproductive structures. Further, it was also related to greater availability and translocation of photosynthates at the metabolizing zone and it hastened flowering behaviour of the plants soil application of nitrogen levels with 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent over 50% N at the time of sowing and 50% N after 15 DAS to male parent plants. Similar findings were also reported by Pandusastry (1981) in CSH-5; Vadivelu *et al.* (1984), Shivappa (1988) in DSH-1; Dhedhi *et al.* (2006) in bajra; Varshney *et al.* (2006), and Tanwir Alam *et al.* (2007) in maize.

The interaction effect between staggered sowings and split application of nitrogen (MxS) showed significant variation for

Table 2. Effect of staggered sowing and split application of nitrogen for restorer of pearl millet hybrid MH-946 line on days to 50 per cent flowering in male and female parents

Treatment	Male parent (J2290R)					Female parent (ICMA 92555A)				
	S ₁	S ₂	S ₃	S ₄	Mean	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	66.0	64.0	58.0	64.6	63.1	55.6	55.0	53.6	57.0	55.3
M ₂	64.3	61.0	56.6	62.3	61.0	53.0	53.0	53.3	54.3	53.4
M ₃	64.3	61.6	52.0	53.3	57.8	54.0	53.6	51.3	52.0	52.7
M ₄	63.0	62.6	56.6	61.6	61.0	53.6	54.0	52.3	52.6	53.1
M ₅	63.0	64.0	56.0	62.0	61.2	54.0	53.6	53.0	52.3	53.2
Mean	64.1	62.6	55.8	60.8	60.7	54.0	53.8	52.7	53.6	53.5
For comparing the means of	S.E.m.±		C.D. (P= 0.05%)			S.E.m.±		C.D. (P= 0.05%)		
Staggered sowing (M)	0.40		1.1			0.45		1.3		
Split application of N (S)	0.62		1.8			0.47		NS		
Staggered sowing at same N levels	1.40		4.0			1.06		NS		
Staggered sowing at same or different N levels	0.47		1.3			0.49		NS		

Table 3. Effect of staggered sowing and split application of nitrogen for restorer line of pearl millet hybrid MH-946 on seed set per cent age

Treatment	Seed set percent age				
	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	42.3	43.0	52.3	43.0	45.1
M ₂	65.6	75.6	85.0	75.0	75.3
M ₃	75.3	81.5	91.6	86.6	83.7
M ₄	72.0	79.5	91.6	77.1	80.1
M ₅	74.4	75.3	87.0	75.5	78.0
Mean	66.0	70.8	81.5	71.4	72.5
For comparing the means of	S.E.m. ±		C.D. (P=0.05 %)		
Staggered sowing (M)	1.73		5.01		
Split application of N (S)	0.67		1.95		
Staggered sowing at same N levels	1.51		4.36		
Staggered sowing at same or different N levels	1.44		4.48		

Staggered sowings (M)

M₁: Simultaneous sowing of male and female parentsM₃: Sowing of male parent 08 days earlier to femaleM₅: Sowing of male parent 16 days earlier to female

Split application of N (S)

S₁: 50% N at the time of sowing and 50% N after 15 DAS to male parentS₂: 50% N at the time of sowing + 25% N at 15 DAS + 25% N at 25 DAS to male parentS₃: 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parentS₄: 25% N at the of sowing + 25% N at 15 DAS + 25% N at 25 DAS + 25% N at 35 DAS to male parentM₂: Sowing of male parent 04 days earlier to femaleM₄: Sowing of male parent 12 days earlier to female

days to 50 per cent flowering. However, the treatment combination of sowing of male parent 8 days before female sowing along with 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent (M₃S₃) recorded relatively less number of days (52.0) for 50 per cent flowering as compared to the simultaneous sowing of male and female parents with 50% N at the time of sowing and 50% N after 15 DAS to male parent (M₁S₁) took 66 days.

Significant differences for hybrid seed yield and yield components like ear length, diameter, ear weight, number of seeds per ear, seed setting percentage and seed weight per ear was observed due to staggered sowings irrespective of soil application of nitrogen levels. Among the dates of staggered sowings, the sowing of male parent 8 days before female parent (M₃) recorded significantly more ear length (16.9 cm), ear diameter (2.6 cm), ear weight (24.6 g), number of seeds per ear (2213),

seed setting percentage (83.7%), seed weight per ear (18.0 g) and hybrid seed yield per hectare (1946.1 kg /ha) as against sowing of female and male parent on same day (M₁) (12.9 cm, 2 cm, 15.6 g, 984, 45.1%, 10.3 g and 878.9 kg/ha, respectively). An increase in the hybrid seed yield per hectare was 1067.2 kg when male parent was sown 8 earlier to female parent. This increase in the hybrid seed yield might be attributed to higher seed setting percentage (83.7 %). Besides, the smaller differences in days to 50 per cent flowering noticed between the female and male parents has also caused better synchronization of flowering due to more availability of viable pollens at peak flowering period resulting in higher hybrid seed yield components like ear length, diameter, ear weight, number of seeds per ear and seed weight per ear as compared to simultaneous sowing of female and male parent which recorded less hybrid seed yield (878.9 kg/ha). This may be related to wider differences in days to 50 per cent

Table 4. Effect of staggered sowing and split application of nitrogen for restorer line of pearl millet hybrid MH-946 on ear diameter, ear length and ear weight

Treatment	Ear diameter (cm)					Ear length (cm)					Ear weight (g)				
	S ₁	S ₂	S ₃	S ₄	Mean	S ₁	S ₂	S ₃	S ₄	Mean	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	1.9	2.0	2.1	2.1	2.0	12.6	13.0	13.0	13.0	12.9	14.0	14.6	15.6	18.3	15.6
M ₂	2.4	2.3	2.5	2.2	2.2	14.4	15.4	14.7	15.4	15.0	18.6	21.3	25.3	24.3	22.4
M ₃	2.2	2.3	3.0	2.7	2.6	14.9	15.8	19.0	18.0	16.9	21.0	23.0	28.3	26.3	24.6
M ₄	2.3	2.2	2.6	2.3	2.4	15.6	15.8	16.0	15.6	15.7	25.0	24.6	25.0	23.3	24.5
M ₅	2.2	2.1	2.3	2.3	2.3	15.0	14.6	16.3	15.2	15.3	23.0	23.0	24.3	23.0	23.3
Mean	2.1	2.2	2.5	2.3	2.3	14.6	14.9	15.7	15.4	15.1	20.3	21.3	23.7	23.0	22.1
For comparing the means of	S.E.m.±		C D (P=0.05 %)			S.E.m.±		C D (P=0.05 %)			S.E.m.±		C D (P=0.05 %)		
Staggered sowing (M)	0.04		0.14			0.31		0.91			0.60		1.75		
Split application of N (S)	0.04		0.11			0.27		0.78			0.54		1.56		
Staggered sowing at same N levels	0.08		0.26			0.60		1.75			1.20		3.49		
Staggered sowing at same or different N levels	0.24		0.73			0.62		1.84			0.99		2.95		

Table 5. Effect of staggered sowing and split application of nitrogen for restorer line of pearl millet hybrid MH-946 on number of seeds per ear, seed weight per ear and thousand seed weight

Treatment	Number of seeds per ear					Seed weight per ear (g)					Thousand seed weight(g)				
	S ₁	S ₂	S ₃	S ₄	Mean	S ₁	S ₂	S ₃	S ₄	Mean	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	980	983	991	983	984	9.6	10.3	11.3	10.0	10.3	7.0	7.3	7.1	7.0	7.1
M ₂	1648	1877	2173	1942	1910	14.3	15.6	16.3	16.0	15.7	8.0	8.8	10.1	8.8	9.0
M ₃	1770	2053	2658	2371	2213	15.4	16.0	21.0	19.3	18.0	8.5	9.4	11.2	10.6	9.9
M ₄	2101	2062	2165	2073	2100	14.0	17.0	19.0	16.1	16.5	8.1	8.8	10.0	9.2	9.4
M ₅	2003	2019	2111	2038	2043	14.0	16.3	18.3	16.3	16.2	7.7	9.5	10.3	8.8	9.1
Mean	1701	1799	2020	1881	1850	13.5	15.1	17.3	15.5	15.3	7.8	8.8	9.7	8.9	8.8
For comparing the means of	S.E.m.±		C.D. (P=0.05 %)			S.E.m.±		C.D. (P=0.05 %)			S.E.m.±		C.D. (P=0.05 %)		
Staggered sowing (M)	59.11		170.74			0.43		1.25			0.17		0.52		
Split application of N (S)	48.96		141.42			0.30		0.89			0.16		0.46		
Staggered sowing at same N levels	109.48		316.22			0.68		1.98			0.35		1.03		
Staggered sowing at same or different N levels	10.49		31.19			0.82		2.46			0.46		1.38		

Staggered sowings (M)

M₁: Simultaneous sowing of male and female parentsM₃: Sowing of male parent 08 days earlier to femaleM₅: Sowing of male parent 16 days earlier to femaleM₂: Sowing of male parent 04 days earlier to femaleM₄: Sowing of male parent 12 days earlier to female

Split application of N (S)

S₁: 50% N at the time of sowing and 50% N after 15 DAS to male parentS₂: 50% N at the time of sowing + 25% N at 15 DAS + 25% N at 25 DAS to male parentS₃: 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parentS₄: 25% N at the of sowing + 25% N at 15 DAS + 25% N at 25 DAS + 25% N at 35 DAS to male parent

flowering noticed between female and male parent causing non-synchronization of flowering due to least availability of viable pollens at peak flowering period and it caused less seed setting as well as hybrid seed yield components. These findings are in agreement with those of earlier researchers in sorghum hybrid seed production (Shivappa, 1988) and in maize hybrid (Varshney *et al.*, 2006).

Similarly, hybrid seed yield and yield components differed significantly due to soil application of nitrogen levels irrespective of staggered sowings. In general, soil application of 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent (S₃) recorded significantly higher ear length (15.7 cm), ear diameter (2.5 cm), ear weight (23.7 g), number of seeds per ear (2020), seed setting percentage (81.5%), seed weight per ear (17.3 g) and higher hybrid seed yield per hectare (1863.7 kg/ha) as compared to 50% N at the time of sowing and 50% N after 15

DAS to male parent (S₁) with ear length (14.6 cm), ear diameter (2.1 cm), ear weight (20.3 g), number of seeds per ear (1701), seed setting percentage (66.0%), seed weight per ear (13.5 g) and seed yield (1443.4 kg/ha) (Table 6).

The soil application of 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent (S₃) has out yielded by recording 419.7 kg per ha. This increase in the seed yield may be attributed to high plant height and earliness in days to 50 per cent flowering, apart from greater availability of nutrients at metabolizing zone which hastened flowering period between the two parents. Further, smaller differences in flowering between female and male parent resulted in good synchronization of flowering between parents on account of more availability of viable pollens. Hence, this resulted in the higher seed setting (81.5%) and increased hybrid seed yield components as evident from the results of this study. Similar

Table 6. Effect of staggered sowing and split application of nitrogen for restorer line of pearl millet hybrid MH-946 on seed yield

Treatment	Seed yield (kg/ha)				
	S ₁	S ₂	S ₃	S ₄	Mean
M ₁	868.3	883.3	877.6	886.3	878.9
M ₂	1505.0	1671.6	2072.6	1653.3	1725.6
M ₃	1541.3	1780.3	2273.6	2189.3	1946.1
M ₄	1673.3	1687.0	2047.0	1625.0	1758.0
M ₅	1629.3	1664.6	2047.6	1643.0	1746.1
Mean	1443.4	1537.4	1863.7	1599.4	1611.0
For comparing the means of		S.E.m.±		C.D. (P=0.05 %)	
Staggered sowing (M)		43.14		124.62	
Split application of N (S)		36.69		105.99	
Staggered sowing at same N levels		82.05		236.99	
Staggered sowing at same or different N levels		8.04		23.89	

Staggered sowings (M)

M₁ : Simultaneous sowing of male and female parents

M₂ : Sowing of male parent 04 days earlier to female

M₃ : Sowing of male parent 08 days earlier to female

M₄ : Sowing of male parent 12 days earlier to female

M₅ : Sowing of male parent 16 days earlier to female

Split application of N (S)

S₁ : 50% N at the time of sowing and 50% N after 15 DAS to male parent

S₂ : 50% N at the time of sowing + 25% N at 15 DAS + 25% N at 25 DAS to male parent

S₃ : 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent

S₄ : 25% N at the of sowing + 25% N at 15 DAS + 25% N at 25 DAS + 25% N at 35 DAS to male parent

positive results of plant nutrients on hybrid seed yield components was also reported by Joshi (1976) and Patil (1978) in sorghum; Dhedhi *et al.* (2006) in bajra and Varshney *et al.* (2006) and Tanwir Alam *et al.* (2007) in maize.

The interaction effect between staggered sowing and soil application of nitrogen levels (SxN) was found to be significant for hybrid seed yield and yield components. However, numerically more ear length (19.0 cm), ear diameter (3.0 cm), ear weight (28.3 g), number of seeds per ear (2658), seed setting percentage (91.6%), seed weight per ear (21.0 g) and hybrid seed yield per hectare (2273.6 kg/ha) were recorded by sowing male parent by 8 days earlier to female and with 50% application of N

at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS to male parent as compared to 12.6 cm, 1.9 cm, 14.0 g, 980, 42.3%, 9.6 g and 868.3 kg/ha, respectively.

Closer synchronization of flowering between parents (ICMA92555A × J2290) of hybrid pearl millet MH-946 could be obtained by sowing of male parent by 8 days earlier to female along with application of 50% N at the time of sowing + 25% N at 25 DAS + 25% N at 35 DAS. Further, this treatment resulted in better yield components, higher seed yield and better seed quality traits. Sowing of MH-946 parental lines during July 4th week was best to get closer synchrony when they were sown simultaneously as per the package of practices.

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