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KG Kugashiya
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

PR Chaudhari
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

YA Viradiya
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

DK Patel
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

TA Desai
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

PO Vaghela
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

BK Chaudhari
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Corresponding Author:
KG Kugashiya
Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Effect of staggered sowings on crop growth, flowering parameters and hybrid seed yield on castor hybrid cv. GCH 8

KG Kugashiya, PR Chaudhari, YA Viradiya, DK Patel, TA Desai, PO Vaghela and BK Chaudhari

Abstract
A field experiment was carried out during *Kharif* 2019 and 2020 at the Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to investigate the effect of staggered sowing on hybrid seed yield of castor hybrid GCH 8 during seed production. The experiment comprised of five staggered sowing treatments and analysis was carried out with Completely Randomized Design. The results revealed that sowing of male parent (DCS 89) by 10 days earlier to female parent (JP 96) recorded higher number of effective branches per plant in female parent (22.69), total number of capsules on primary raceme of female parent (56.69), hybrid seed yield per plant (209.95 g) and hybrid seed yield (1148 kg/ha).

Keywords: Castor, staggered sowing, hybrid seed yield

Introduction
Castor (*Ricinus communis* L., 2n=20) is one of the most important non-edible oilseed crops of India. Castor belongs to monospecific genus *Ricinus* of Euphorbiaceae family. In world, India ranks first in respect to area, production and productivity contributing about 70% of the global requirements. Gujarat, Andhra Pradesh, Rajasthan, Tamil Nadu, Karnataka, Madhya Pradesh, Uttar Pradesh, Maharashtra and Orissa are the main castor growing states in the country. It is extensively cultivated in Gujarat and ranks first in area and production. Gujarat contributing about 80% of the country's area and production. Hence, it was considered as one of the priority areas of research for hybrid seed production. Recently, new high yielding castor hybrid GCH 8 was released and recommended for commercial cultivation. Therefore standard technique of quality hybrid seed production of GCH 8 castor hybrid is necessary and important for castor seed producer of country.

Differential flowering period cause a poor seed set due to insufficient supply of pollens at the time of stigma receptivity in female parent. To achieve proper synchronization of flowering of male and female parents the simple agronomic manipulations like staggered sowing being followed in hybrid seed production programme. In staggered sowing method the male and female parents are sown at different dates depending on the differences in their flowering days to coincide the flowering of male parent with that of female parent. It is being practiced widely by the seed growers to get proper synchronization of flowering of male and female parents during flowering period. Usually staggered sowing technique is adopted to bridge difference in flowering of male and female parents at least by five days and more. Hence, systematic research works are to be initiated to find out the effect of staggered sowings on the seed setting in female parental line (JP 96) of new released castor hybrid GCH 8 to achieve better synchronization of flowering for higher seed setting and yield of hybrid seed.

Research procedure
The field experiment was conducted to study the effect of staggered sowings on crop growth, flowering parameters and seed yield in female parental line (JP 96) of new released castor hybrid GCH 8 at Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India during *kharif* 2019 and *kharif* 2020 season. The field experiment consisted of five staggered sowings treatment *viz.* S_1: 10 days early sowing of male parent than female parent, S_2: 15 days early sowing of male parent than female parent, S_3:10 days early sowing of female parent than male parent, S_4: Same day sowing of male

parent and female parent and S_5: Same day sowing of male parent and female parent and nipping of primary raceme of female parent. Sowing of female parent and male parent was carried out in ratio of 3 row of female: 1 row of male parent (3:1) and two border row of male parent to provide sufficient pollen load to female parent. The observations were made on days to flowering of female parent and male parent, days to maturity of primary raceme of female parent, number of nodes up to primary raceme in female parent, plant height up to primary raceme in female parent (cm), number of effective branches per plant in female parent, total number of capsules on primary raceme of female parent, total length of primary raceme of female parent (cm), hybrid seed yield per plant (g) and hybrid seed yield (kg/ha). The data obtained from various periodical observations were subjected to statistical analysis. The experimental data of *Kharif* 2019 and 2020 were used for combined analysis to arrive best staggered sowing treatment combination effect to get higher hybrid seed yield.

Result and Discussion

The results obtained from the present investigation have been discussed in the following sub heads:

Flowering parameters

In both the years of experiments and combined year analysis, the effect of five staggered sowings was found non-significant for the flowering parameters studied for both female and male parent are presented in Table 1. The overall mean data for days to flowering of female parent and male parent revealed that female parent JP 96 flowered earlier than male parent DCS 89. Similar findings were also reported by Patil and Goud (1980) [7], Biradar Patil (1984) [2] and Shivappa (1988) [9] in sorghum and Varshney *et al*. (2006) [11] and Alam *et al.* (2007) [1] in maize hybrid.

Growth parameters

The data presented in Table 2 revealed that days to maturity of primary raceme of female parent and total length of primary raceme of female parent (cm) was non-significant during *Kharif* 2019, *Kharif* 2020 and in pooled result.

The data presented in Table 3 for number of nodes up to primary raceme in female parent and plant height up to primary raceme in female parent (cm) showed that the number of nodes up to primary raceme in female parent JP 96 was differing significantly during *kharif* 2019. Higher number of nodes up to primary raceme was recorded in S_1 (19.18) during *kharif* 2019.While looking to the plant height up to primary raceme in female parent JP 96 was significantly differed during *kharif* 2019 only. Higher plant height up to primary raceme was observed in S_1 (95.42) during *kharif* 2019, while during *kharif* 2020 and in pooled analysis the result was non-significant. These results are in conformity with those of earlier researchers like Pandusastry (1981) [6], Biradar Patil (1984) [2], Shivappa (1988) [9], Lakkappan (1999) [4] and Shivashekhar Patil (2001) [10] in sorghum hybrid.

Hybrid seed yield and yield parameters

Significant differences for hybrid seed yield components like number of effective branches per plant in female parent, total number of capsules on primary raceme of female parent, hybrid seed yield per plant (g) and hybrid seed yield (kg/ha) due to staggered sowings in both years of experiment as well as pooled analysis are presented in Table 4 and 5 and Plate 1.

The data presented in table 4 for number of effective branches per plant and total number of capsules on primary raceme of female parent indicated that the number of effective branches per plant in female parent significantly differed in both the years and in pooled result. During *kharif* 2019, higher number of effective branches per plant in female parent JP 96 were observed in S_1 (23.0) and was statistically at par with S_2 (22.52), while during *kharif* 2020, higher number of effective branches per plant in female parent JP 96 were observed in S_1 (22.38) and was statistically at par with S_2 (21.90). In pooled analysis, higher number of effective branches per plant in female parent JP 96 was observed in S_1 (22.69) and it remained statistically at par with S_2 (22.21). While looking to the result on total number of capsules on primary raceme of female parent indicated staggered sowing of male and female parent exerted significant influence on total number of capsules on primary raceme during individual years (*kharif* 2019 and 2020) and in pooled analysis. Significantly higher number of capsules of female parent JP 96 was observed in S_1 (56.20) and it remained statistically at par with S_2 (55.14) during *kharif* 2019, while during *kharif* 2020 and in pooled analysis significantly higher total number of capsules on primary raceme of female parent JP 96 recorded in S_1 (57.18 and 56.69, respectively). The result indicated that 10 days early sowing of male parent DCS 89 than female parent JP 96 had positive influence on development of capsules on primary raceme of female parent JP 96. This might be due to synchronization of male and female flower, thus availability of ample viable pollens from male parent DCS 89 during receptivity of female flower of female parent JP 96.

The data presented in table 5 for hybrid seed yield per plant (g) and hybrid seed yield (kg/ha) showed that hybrid seed yield per plant was significantly differed during *kharif* 2019, *kharif* 2020 and in pooled result. During *kharif* 2019 in S_1 (220.60 g) remained statistically at par with S_2 (210.80 g). Whereas during *kharif* 2020 and in pooled analysis significantly higher hybrid seed yield per plant was recorded in S_1 (199.30 g and 209.95 g, respectively) than all the staggered sowing treatment. The treatment of staggered sowing of male and female parent exerted significant influence on hybrid seed yield during individual years (*kharif* 2019 and *kharif* 2020) and in pooled analysis. Significantly higher hybrid seed yield during *kharif* 2019 and in pooled analysis were recorded in S_1 (1191 kg/ha and 1148 kg/ha, respectively) than all the staggered sowing treatment, while during *kharif* 2020 it remain statistically at par with S_2 (1060 kg/ha). The yield superiority in S_1 seems to have resulted from higher values of yield attributing characters like number of effective branches per plant, total number capsules on primary raceme and seed yield per plant in female parent. On the contrary, the female parent sown 10 days before male parent sowing (S_3) has recorded less hybrid seed yield per hectare (855 kg/ha) in pooled result which may be related to less availability of viable pollens from male parent to female parent showing less seed setting as well as hybrid seed yield components. Similar findings were also confirmed by earlier researchers in sorghum hybrid (Shivappa, 1988; Lakkappan, 1999; Shivashekhar Patil, 2001) [4, 9, 10] and in maize hybrid (Varshney *et al*., 2006 and Hipparagi, 2011) [11, 3].

Table 1: Days to flowering in female parent JP 96 and Days to flowering in male parent DCS 89

Treatment Name	Days to flowering in female parent			Days to flowering in male parent		
	2019	2020	Pooled	2019	2020	Pooled
S_1: 10 days early sowing of male parent than female parent	57.60	58.20	57.90	61.80	63.00	62.40
S_2: 15 days early sowing of male parent than female parent	57.80	57.40	57.60	61.60	62.40	62.00
S_3:10 days early sowing of female parent than male parent	58.80	57.20	58.00	62.40	62.60	62.50
S_4: Same day sowing of male parent and female parent	57.40	58.80	58.10	61.20	62.60	61.90
S_5: Same day sowing of male parent and female parent and nipping of primary raceme of female parent	58.40	57.80	58.10	62.80	62.40	62.60
S. Em. ±	0.58	0.57	0.58	0.67	0.60	0.50
C.D. at 5%	NS	NS	NS	NS	NS	NS
CV %	3.15	3.12	3.14	3.42	3.05	3.23

Table 2: Days to maturity of primary raceme of female parent JP 96 and Total length of primary raceme of female parent JP 96 (cm)

Treatment Name	Days to maturity of primary raceme of female parent			Total length of primary raceme of female parent (cm)		
	2019	2020	Pooled	2019	2020	Pooled
S_1: 10 days early sowing of male parent than female parent	134.80	135.60	135.20	71.42	70.84	71.13
S_2: 15 days early sowing of male parent than female parent	133.00	134.00	133.50	73.76	71.60	72.68
S_3:10 days early sowing of female parent than male parent	135.80	134.80	135.30	69.56	70.46	70.01
S_4: Same day sowing of male parent and female parent	132.00	133.00	132.50	70.62	68.74	69.68
S_5: Same day sowing of male parent and female parent and nipping of primary raceme of female parent	-	-	-	-	-	-
S. Em. ±	1.98	1.96	0.98	1.49	1.55	1.22
C.D. at 5%	NS	NS	NS	NS	NS	NS
CV %	4.68	4.61	4.64	6.60	6.96	6.78

Table 3: Number of nodes up to primary raceme in female parent JP 96 and Plant height up to base of primary raceme in female parent JP 96 (cm)

Treatment Name	Number of nodes up to primary raceme in female parent JP 96			Plant height up to base of primary raceme in female parent JP 96 (cm)		
	2019	2020	Pooled	2019	2020	Pooled
S_1: 10 days early sowing of male parent than female parent	19.18	18.64	18.91	95.42	86.66	91.04
S_2: 15 days early sowing of male parent than female parent	16.74	19.30	18.02	88.74	87.34	88.04
S_3:10 days early sowing of female parent than male parent	17.12	19.10	18.11	81.46	82.66	82.06
S_4: Same day sowing of male parent and female parent	17.78	19.04	18.41	79.94	85.28	82.61
S_5: Same day sowing of male parent and female parent and nipping of primary raceme of female parent	17.82	18.94	18.38	83.34	82.64	82.99
S. Em. ±	0.28	0.30	0.58	2.05	2.39	2.57
C.D. at 5%	0.78	NS	NS	5.85	NS	NS
CV %	4.91	5.06	5.00	7.57	8.91	8.26

Table 4: Number of effective branches per plant in female parent JP 96 and Number of capsules on primary raceme of female parent JP 96

Treatment Name	Number of effective branches per plant in female parent JP 96			Number of capsules on primary raceme of female parent JP 96		
	2019	2020	Pooled	2019	2020	Pooled
S_1: 10 days early sowing of male parent than female parent	23.00	22.38	22.69	56.20	57.18	56.69
S_2: 15 days early sowing of male parent than female parent	22.52	21.90	22.21	55.14	52.58	53.86
S_3:10 days early sowing of female parent than male parent	17.58	17.16	17.37	43.60	42.80	43.20
S_4: Same day sowing of male parent and female parent	20.30	19.34	19.82	49.60	47.74	48.67
S_5: Same day sowing of male parent and female parent and nipping of primary raceme of female parent	14.76	13.64	14.20	-	-	-
S. Em. ±	0.47	0.46	0.36	1.33	0.91	0.92
C.D. at 5%	1.35	1.30	1.01	3.81	2.63	2.61
CV %	7.62	7.68	7.65	8.22	5.79	7.13

Table 5: Hybrid seed yield per plant (g) and Hybrid seed yield (kg/ha)

Treatment Name	Hybrid seed yield per plant (g)			Hybrid seed yield (kg/ha)		
	2019	2020	Pooled	2019	2020	Pooled
S_1: 10 days early sowing of male parent than female parent	220.60	199.30	209.95	1191	1104	1148
S_2: 15 days early sowing of male parent than female parent	210.80	187.70	199.25	1078	1060	1069
S_3:10 days early sowing of female parent than male parent	156.20	151.40	153.80	890	819	855
S_4: Same day sowing of male parent and female parent	188.80	176.80	182.80	1005	956	981
S_5: Same day sowing of male parent and female parent and nipping of primary raceme of female parent	160.00	151.70	155.85	962	829	896

S. Em. ±	4.15	4.10	3.31	25	25	20
C.D. at 5%	11.82	11.68	9.31	71.18	71	56
CV %	7.00	7.48	7.23	7.71	8.30	8.00

Conclusion

From this investigation, it is concluded that closer synchronization of flowering between parents (JP 96 × DCS 89) of castor hybrid seed production of GCH 8 could be obtained by sowing of male parent ten days earlier to female parent to obtain higher hybrid seed yield.

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