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Seed Set as Affected by Male to Female Ratio, Male Direction and Different Flowering Date in Hybrid Rice Seed Production

Hamad, H. Sh.; E. E. Gewaily*; Neama K. El-Kholly and Haba A. Elsherbiny

Rice Research and Training Center (RRTC), Field Crops Research Institute, Agricultural Research Center, Giza, Egypt

ABSTRACT

Flowering synchronization between the restorer (R) line (Giza 178) and cytoplasmic male sterile (CMS or A) line (IR58025A) in hybrid rice seed production plot is very needed to achieve greater seed yield. Two-year experiment was carried out at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh, Egypt in the 2020 and 2021 seasons. This study aims to examine the effect of male to female ratio (2R:10A, 2R:12A and 2R:14A), male direction (one way and two ways) and differences in days in flowering between male and female (five, two days and without differences) on productivity of hybrid rice seed. A split split-plot design in three replications was utilized. The main plots were the male to female ratio, while male direction was arranged in the sub plot sand the differences in days to flowering were located in the sub-sub plots. The obtained results showed that plant height, panicle exsertion percentage, panicle length and flag leaf angle were not significantly affected by the male to female ratio, male direction and differences in days to flowering. On the other hand, the number of panicles hill^{-1}, panicle weight, seed set percentage, seed yield and harvest index (%) were highly significantly affected by the male to female ratio, male direction and differences in days to flowering. The highest values of seed yield (2.432 and 2.521 t ha^{-1}) were obtained when using the male to female ratio 2R:14A, two-way male direction and without differences in flowering.

Keywords: Hybrid rice, Male to Female ratio, Male direction, Differences in days to flowering, Seed yield**.**

INTRODUCTION

Rice viewed as perhaps the main cereal crops not only in Egypt but also across the whole world. Rice is cultivated in more than one-fifth of the total summer cultivated (0.600 million ha) area, which produced about 6 million tons of paddy rice with an average of 9.84 t ha^{-1}.

In Egypt, rice production should be increase by 25-30% to satisfy the needs of the developing populace. This appears difficult taking into account the narrow gap between yield potential and genuine yield (10.5 t ha^{-1}) in the last seasons (RRTC., 2016). Among existing technologies to upsurge yield, above the current ceiling, is the taking advantage of heterosis in hybrid rice, which seems to be a practicable approach for Egypt (El-Mowafi *et al.*,2016).

However, the success of hybrid seed production requires a higher crossing rate to achieve a maximum seed yield. Thus, the production of hybrid rice seed necessitates specialized techniques, which need to be thoroughly understood previous to starting this venture.

Among the factors that influence the extent of seed set and eventually the seed yield, is row ratio (proportion of rows of male parent to that of female parent in a seed production plot). To obtain higher seed yields, the row ratios should be such that the seed yields will be higher per unit area. The male and female ratio should be maintained in such a way that the male rows produce enough pollen to pollinate most effectively the female rows. Prior knowledge of the wind direction of the hybrid seed production area is essential. The row of seed production plots should be arranged in such a way that they are perpendicular to the wind direction during the flowering period. This will improve the natural cross pollination leading in increased seed yield (Bidhan and Vijay, 2013). Besides, row ratio, seed yields also, depend on row direction, panicle structure and the pollen load of restorer lines **(**Mao *et al*., 1996).

Production of hybrid seeds depends on the synchronization of flowering of the parental lines. By synchronization of flowering, the seed and pollinator parents flower simultaneously even though they may have dissimilar growth periods. Synchronization of flowering is very important because pollen grains from R line should be available to the A line throughout its flowering period. By adjusting the sowing dates of the parents in the seedbed, they flower at the same time in the field (Maurya, 1998 and Rahman 2012). Synchronization of flowering between the restorer line (Giza 178) and cytoplasmic male sterility line (IR58025A) assumes vital significance as the seed set on the female parent relies upon how much of pollen provided from the male parent throughout the flowering period. Inability to get the correct synchronization is generally experienced issue in hybrid rice seed production, which leads to exceptionally poor or no seed set at all. Knowing the flowering behavior of the parental lines that diverges with the sowing date is absolutely necessary to decide the precise difference in days to flowering between the parental lines. If there is a flowering gap, the issue of non-synchronization could be defeat by staggered sowing of the male parents in light of the data on days to flowering (Yuan, 1985). Although the sowing date is modified, sometimes the parents do not flower simultaneously due to the differential response of the parents to stress conditions (Mondo *et al*., 2016).

* **Corresponding author.**
E-mail address: sgewaily@yahoo.com
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The investigation aims to know the effect of male to female ratio, male direction and differences in days to flowering between male and female on growth and yield characteristics and its components on the production of hybrid rice seeds under the environmental conditions of Kafr El-Sheikh, Governorate, Egypt.

MATERIALS AND METHODS

A field experiment was layout at the Farm of Sakha Agricultural Research Station, Egypt, during the 2020 and 2021 rice growing seasons. A split split-plot design in three replications was utilized. The main-plots were dedicated to the male to female ratio (2R:10A, 2R:12A and 2R:14A), while male direction (one way and two ways) was organized in the sub plots and differences in days to flowering was placed in the sub-sub plots. The CMS line IR58025 (as the female parent) were broadcasted in the well prepared nursery on 1st May while the male parent Giza 178 R was sown on three different dates as follows, A- The male parent Giza 178 R was sown on 12th May which is nine days later than the CMS line IR58025 to get a proper synchronization of flowering (there is no difference between the male and the female line in flowering), B- The male parent Giza 178 R was sown on 14th May which is eleven days later than the CMS line IR58025 to get two days difference between male parent and female line in flowering), C- The male parent Giza 178 R was sown on 17th May which is fourteen days later than the CMS line IR58025 to get five days difference between the male parent and the female line in flowering (Figures 1 and 2). Rice seeds were soaked at 20 kg ha^{-1} (15 kg from the CMS line IR58025 (A) and 5 kg from the restorer line Giza 178 (R)) in freshwater for 24 hours, next drained and incubated for 48 hours to speed up germination. Pre-germinated seeds were sown according to treatments. The permanent field was properly prepared, *i.e.* plowed twice and well dry leveled. Phosphorous fertilizer was added in the form of single super phosphate (15.5% P_2O_5) at the rate of 36 P_2O_5 kg ha^{-1} before tillage. Nitrogen in the form of urea (46% N) at the rate of 165 kg N ha^{-1} was added (2/3 as basal dressing, and the rest at panicle initiation). Zinc sulphate (22 % $ZnSO_4$) at the rate of 50 kg ha^{-1} was added after paddling and before planting. Thirty days old seedlings of R and A lines were transplanted by 3 and 2 seedlings per hill, respectively. The row direction was perpendicular to wind direction. The row spacing kept up with for R-R, R-A and A-A lines were 20, 30, and 15 cm, respectively. Hill spacing for both R and A lines were kept up with at 15 cm. Isolation space of 100 m was considered for CMS seed production. Furthermore, the trial field was encircled by extra 20 rows of R lines to keep out from any chance of cross pollination. Each principal plot was detached by plastic hindrance (2.5m height) to keep away from any pollen transfer from treatment to another. Twice of GA_3 foliar application was done; the first spray (40% of GA_3) when A line was at 15-20% heading, and the other spray (60% of GA_3) was applied when A line was at 35-40% heading (five days subsequent heading). The pollen of restorer line Giza 178 (R line) was shaken by bamboo sticks to give supplementary pollination. This procedure was performed 2-3 times in between 9 am to 11.30 am for ten days. All cultural practices were practiced as recommended.

Data were collected for; plant height (cm), panicle exsertion (%), panicle length (cm), flag leaf angle, number of fertile panicles $hill^{-1}$, panicle weight (g), seed set (%), seed yield (t ha^{-1}) and harvest index (%). The yield was gathered when 80% of the grains became brilliant yellow in variety. Grains were sun-dried and adjusted at 14% dampness content to assess grain yield.

Panicle exsertion percentage was calculated according to the following formula:

$$\textbf{Panicle exsertion \%} = \frac{\textbf{Exserted panicle length (cm)}}{\textbf{Panicle length (cm)}} \times \textbf{100}$$

Seed set percentage was calculated according to the following formula:

$$\textbf{Seed set \%} = \frac{\text{Number of filled grains panicle-1}}{\text{Total spikelet number panicle-1}} \times 100$$

The data were collected according to the Standard Evaluation System of IRRI (2014) for all the studied characters. The data were analyzed via the ANOVA technique (Gomez and Gomez, 1984) and the mean differences were compared via the Duncan's Multiple Range Test (1955) using a statistical computer package COSTAT.

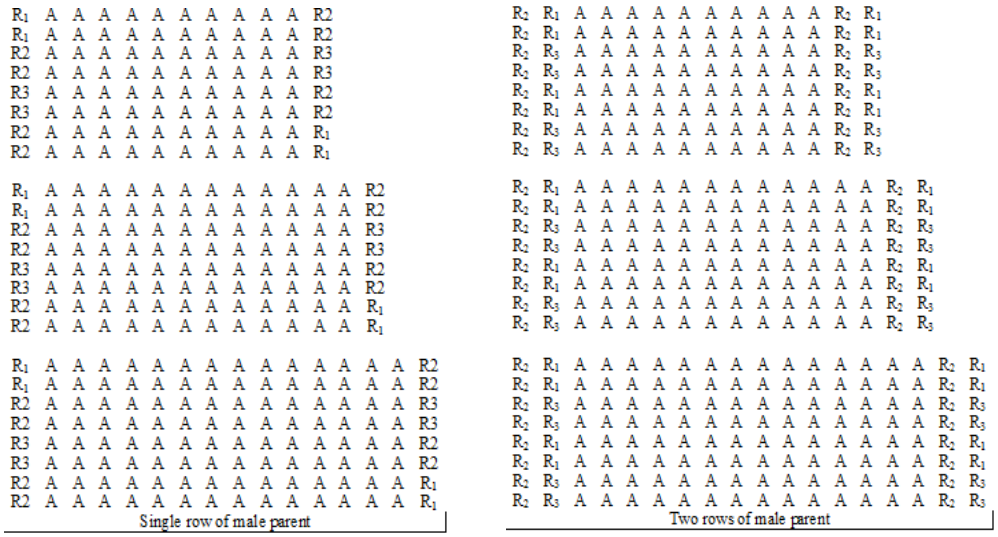

Fig. 1. Transplanting patterns of A and R lines operated in hybrid rice seed production plots

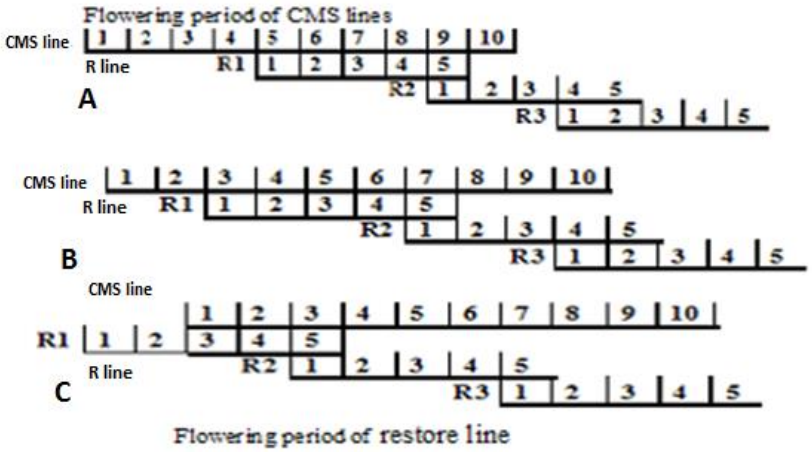

Figure 2. A = that the CMS line IR58025 was sown May 1st while the restorer Giza 178 R was sown on 12th May there is no difference between the male and the female line in flowering.
B = that the CMS line IR58025 was sown May 1st while the restorer Giza 178 R was sown on 14th May to get two days difference between male parent and female line in flowering.
C = the CMS line IR58025 was sown May 1st while the restorer Giza 178 R was sown on 17th May to get five days difference between the male parent and the female line in flowering.

RESULTS AND DISCUSSION

Effect of male to female ratio, male direction and difference in days to flowering as well as their interaction on plant height, flag leaf angle, panicle exertion and panicle length characters are given in Table 1.

Results in Table 1 showed that male to female ratio, male direction, the difference in days to flowering between male and female as well as their interactions were not significantly affected plant height, flag leaf angle, panicle exertion and panicle length during both seasons. The results are in concurrence with those reported by Rahman *et al*., (2012) who stated that the plant height, number of tillers and panicle exertion rate did not differ at various row ratios. The infect hereditary structure of a variety is accountable for manifesting the above-mentioned traits. Rather hereditary potentiality is fixed by an individual variety.

Table 1. Effect of male to female ratio, male direction and difference in days to flowering as well as their interactions on plant characteristics during the 2020 and 2021 seasons.

	Plant height (cm)		Flag leaf angle (^{0})		Panicle exertion (%)		Panicle length (cm)	
	2020	2021	2020	2021	2020	2021	2020	2021
				Male to female ratio (R)				
2R:10A	115.83	116.15	39.04	38.26	74.70	75.70	24.09	23.84
2R: 12A	115.94	115.99	38.59	37.81	74.18	75.97	24.00	23.85
2R: 14A	115.68	116.02	38.68	37.91	74.09	75.81	23.78	23.66
F-test	NS	NS	NS	NS	NS	NS	NS	NS
				Male direction (D)				
One way	115.78	116.05	38.92	38.14	74.15	75.07	23.91	23.82
Two way	115.85	116.07	38.62	37.84	74.56	75.80	24.07	23.74
F-test	NS	NS	NS	NS	NS	NS	NS	NS
				Difference in days to flowering (F)				
Five days	115.88	116.18	38.65	37.87	74.92	75.92	24.02	23.77
Two days	115.80	116.06	38.43	37.65	74.85	75.20	24.10	23.85
Without difference	115.77	115.95	39.23	38.45	74.60	75.08	23.90	23.72
F-test	NS	NS	NS	NS	NS	NS	NS	NS
				Interaction				
R× D	NS	NS	NS	NS	NS	NS	NS	NS
R × F	NS	NS	NS	NS	NS	NS	NS	NS
D×F	NS	NS	NS	NS	NS	NS	NS	NS
R×D×F	NS	NS	NS	NS	NS	NS	NS	NS

NS not significant at the 5% level of probability.

Effect of male to female ratio, male direction and difference in days to flowering between male and female as well as their interactions were a highly significant influences on the number of fertile panicles hill^{-1}, panicle weight, seed set, seed yield and harvest index characters as given in (Table 2).The effect of male to female ratio has a highly significant effect on the number of fertile panicles hill^{-1}, panicle weight, seed set, seed yield and harvest index. The male to female ratio 2R:12A gave the highest values (17.86 and 18.76) of the number of fertile panicles hill^{-1}, while the male to female ratio 2R:10A gave the highest values (2.74 and 2.49 g) of panicle weight and highest percent of seed set (32.12 and 33.48 %).While the highest seed yield (1.758 and 1.848t ha^{-1}) was obtained when the male to female ratio was 2R:14A in both seasons, respectively. This may be due to that 2R:14A had higher plant density which resulted in higher seed yield. Also, results showed that the male to female ratio 2R:10A recorded the highest values (18.94 and

19.84%) for harvest index in the 2020 and 2021 seasons, respectively. But, the male to female ratio 2R:14A produced the lowest values (16.59 and 17.54) for number of fertile panicles hill^{-1}, (2.45 and 2.20 g) for panicle weight, (29.32 and 30.68 %) for seed set and (17.81 and 18.71 %) for harvest index, while the male to female ratio 2R:10A recorded the lowest values (1.447 and 1.537 t ha^{-1}) for seed yield in the first and second seasons, respectively. The outcome are in conformity with those stated by Rahman *et al*., (2012) and Hamad *et al*., (2021).

Male direction has a highly significant effect on the number of fertile panicles hill^{-1}, panicle weight, seed set, seed yield and harvest index. The male direction in two ways produced the highest value (18.47 and 19.40) for the number of fertile panicles hill^{-1}(2.92 and 2.67g) for panicle weight, (32.27 and 33.63 %) for seed set, (1.834 and 1.924 t ha^{-1}) for seed yield and(19.65 and 20.55%) for harvest index in the 2020 and 2021 seasons, respectively. On the other hand, male direction one way gave the lowest values(16.04 and 16.94) for number of fertile panicles hill^{-1}(2.40 and 1.99 g) for panicle weight (29.07 and 30.43 %) for seed set, (1.380 and 1.470 t ha^{-1}) for seed yield and (17.24 and 18.14 %)for harvest index in the 2020 and 2021seasons,respectively.These results may be due to that planting the male in two directions way produced a higher number of fertile panicle, heavier panicle weight and maximum seed setting percentage which consequently gave higher grain yield. Similar results were also found by El-Mowafi *et al*., (2016) and Selim *et al*., (2018). Who stated that row of seed production plots should be arranged in such a way that they are perpendicular to the wind direction during the flowering period. This will improve the natural cross pollination leading to increased seed yield

Table 2. Effect of male to female ratio, male direction and difference in days to flowering as well as their interactions on panicle characteristics and yield during 2020 and 2021 seasons.

	Number of fertile panicles hill^{-1}		Panicle weight (g)		Seed set (%)		Seed yield (tha^{-1})		Harvest index (%)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Male to female ratio (R)										
2R: 10A	17.30b	18.20b	2.74a	2.49a	32.12a	33.48a	1.45c	1.54c	18.94a	19.84a
2R: 12A	17.86a	18.76a	2.55b	2.30b	30.57b	31.97b	1.62b	1.71b	18.59b	19.49b
2R: 14A	16.59c	17.54c	2.45c	2.20c	29.32c	30.68c	1.76a	1.85a	17.81c	18.71c
F-test	**	**	**	**	**	**	**	**	**	**
Male direction (D)										
One way	16.04b	16.94b	2.40b	1.99b	29.07b	30.43b	1.380b	1.47b	17.24b	18.14b
Two way	18.47a	19.40a	2.92a	2.67a	32.27a	33.63a	1.834a	1.92a	19.65a	20.55a
F-test	**	**	**	**	**	**	**	**	**	**
Difference in days to flowering (F)										
Five days	14.49c	15.39c	1.85c	1.60c	21.64c	23.00c	0.92c	1.00c	15.78c	16.68c
Two days	18.01b	18.97b	2.68b	2.43b	33.91b	35.27b	1.87b	1.96b	18.88b	19.78b
Without difference	19.25a	20.15a	3.21a	2.96a	36.46a	37.82a	2.04a	2.12a	20.67a	21.57a
F-test	**	**	**	**	**	**	**	**	**	**
Interaction										
R × D	**	**	**	**	**	**	**	**	**	**
R × F	**	**	**	**	**	**	**	**	**	**
D × F	**	**	**	**	**	**	**	**	**	**
R × D × F	**	**	**	**	**	**	**	**	**	**

**** Highly significant at the 1% level of probability.**

A difference in days to flowering between male and female lines has a highly significant effect on the number of fertile panicles hill^{-1}, panicle weight, seed set, seed yield and harvest index. Without difference between male and female lines produced the highest values (19.25 and 20.15) for the number of fertile panicles hill^{-1}, (3.21 and 2.96g) for panicle weight, (36.46 and 37.82 %) for seed set, (2.037 and 2.127 t ha^{-1}) for seed yield and (20.67 and 21.57 %) for harvest index in 2020 and 2021 seasons, respectively. By contrast, five days difference in flowering gave the lowest values (14.49 and 15.39 hill) for the number of fertile panicles hill^{-1}, (1.85 and 1.60g) for panicle weight, (21.64 and 23.00 %) for seed set, (0.915 and 1.004 t ha^{-1}) for seed yield and (15.78 and 16.68%) for harvest index in 2020 and 2021 seasons, respectively. The results are in agreement with those reported by Varma *et al*., (2018) who stated that the seed set on the female parent relies upon the pollen provided from the restorer parent throughout the flowering period. To accomplish good synchronization between parental lines, determination the sowing period of these lines is essential factor in hybrid seed production. Parental lines of the most hybrid combinations vary in duration of their growth, so the sowing of parental lines must be changed in such a way that it reaches flowering simultaneously.

All the interactions were highly significant for the number of fertile panicles hill^{-1}, panicle weight, seed set, seed yield and harvest index during both seasons.

The results in Table 3 indicated that the interaction between male to female ratio and male direction was highly significantly affected on the number of fertile panicles hill^{-1}, panicle weight, seed set, seed yield and harvest index in both seasons. Male to female ratio 2R:12A with two-ways male direction produced the highest values (19.21 and 20.11) for the number of fertile panicles hill^{-1}. While, male to female ratio 2R:10A with two directions produced the highest values (3.07 and 2.82 g) for panicle weight, (34.07 and 35.43 %) for seed set, (20.72 and 21.62 %) for harvest index in both seasons, respectively. On the other hand, the male to female ratio 2R:14A with two directions produced the highest values (1.996 and 2.08 t ha^{-1}) for seed yield in both seasons, respectively. However, the lowest values of the number of fertile panicles hill^{-1}(15.70 and 16.60), panicle weight (2.12 and 1.86 g), seed set(27.87 and 29.23 %) and harvest index (16.81 and 17.71 %) were obtained when male to female ratio

2R:14A with one-way male direction. While, the male to female ratio 2R:10A with one-way male direction produced the lowest values (1.181 and 1.271 t ha^{-1}) of seed yield in both seasons, respectively. This might be due to the optimal availability of pollen that resulting in the maximum efficiency of grain formation. The outcomes are in concurrence with those revealed by Abo-Youssef (2009) and Rahman *et al*., (2010) who reported that to multiply CMS lines and produce hybrid seeds, we should be planting maintainers and R lines, staggered to achieve optimized synchronization between CMS and R. Meanwhile, the key to increasing CMS/R seed production is to optimize synchronization at sowing date differences. Moreover, it increased seed yield remarkably compared to other sowing dates.

Table 3. Interaction effect between male to female ratio and male direction on panicle characteristics and seed yield during 2020 and 2021 seasons.

Male to female ratio	Male direction	Number of fertile panicles $hill^{-1}$		Panicle weight (g)		Seed set (%)		Seed yield (tha^{-1})		Harvest index (%)	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
2R:10A	One way	15.90e	16.80e	2.41d	2.15d	30.17d	31.53d	1.181d	1.271d	17.16e	18.06e
	Two way	18.71b	19.61b	3.07a	2.82a	34.07a	35.43a	1.714b	1.804b	20.72a	21.62a
2R:12A	One way	16.52d	17.43d	2.19e	1.94e	29.16e	30.52e	1.439c	1.529c	17.75d	18.65d
	Two way	19.21a	20.11a	2.91b	2.66b	31.98b	33.34b	1.793b	1.883b	19.42b	20.32b
2R:14A	One way	15.70e	16.60e	2.12f	1.86f	27.87f	29.23f	1.520c	1.610c	16.81f	17.71f
	Two way	17.48c	18.49c	2.79c	2.54c	30.77c	32.13c	1.996a	2.086a	18.81c	19.71b

Number in the same column followed by the same letter are not significantly different at 0.05 level

The results in Table 4 showed that the interaction between male to female ratio and differences in days to flowering was a highly significant effect on the number of fertile panicles $hill^{-1}$, panicle weight, seed set, seed yield and harvest index in both seasons. The male to female ratio 2R:12A without differences in flowering between male and female parents produced the highest values (20.07 and 20.79) of the number of fertile panicles $hill^{-1}$ and heaviest panicle weight (3.39 and 3.14 g) in both seasons. While the male to female ratio 2R:10A without differences in flowering between male and female parents produced the highest values (37.58 and 38.94 %) of seed set and harvest index (20.90 and 21.80 %) in both seasons. On the other hand, the male to female ratio 2R:14A without differences in flowering between male and female parent produced the highest values (2.232 and 2.321 t ha^{-1}) of the seed yield during 2020 and 2021 seasons, respectively.

Table 4. Effect of interaction between male to female ratio and difference in days to flowering on panicle characteristics and yield during 2020 and 2021 seasons.

Male to female ratio	Differences in days to flowering	Number of fertile panicles /hill		Panicle weight (g)		Seed set (%)		Seed yield (tha^{-1})		Harvest index (%)	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
2R:10A	Five days	14.23f	15.13f	1.92g	1.67g	22.95g	24.31g	0.855f	0.945f	16.40f	17.31f
	Two days	17.98c	18.88c	2.96c	2.71c	35.85c	27.21c	1.621d	1.711d	19.59c	20.49c
	Without difference	19.71ab	20.62ab	3.34b	3.09b	37.58a	38.94a	1.866c	1.956c	20.90a	21.80a
2R :12A	Five days	14.05f	14.95f	1.83h	1.58h	21.74h	23.10h	0.935ef	1.025ef	15.83g	16.73g
	Two days	19.46b	20.36b	2.44f	2.19f	33.42e	34.78e	1.900c	1.990c	19.05d	19.95d
	Without difference	20.07a	20.79a	3.39a	3.14a	36.57b	37.93b	2.014b	2.104b	20.83a	21.73a
2R :14A	Five days	15.20e	16.11e	1.81h	1.56h	20.24i	21.60i	0.953e	1.043e	15.12h	16.02h
	Two days	16.60d	17.66d	2.65e	2.40e	32.47f	33.83f	2.09b	2.180b	18.00e	18.90e
	Without difference	17.97c	18.87c	2.90d	2.65d	35.25d	36.61d	2.232a	2.321a	20.30b	21.20b

Number in the same column followed by the same letter are not significantly different at 0.05 level

On the other hand, the male to female ratio 2R:12A with five days differences in flowering between male and female line gave the lowest values (14.05 and 14.95) of number of fertile panicles $hill^{-1}$.While, the male to female ratio 2R:14A with five days' differences in flowering between male and female lines gave the lowest values (1.81 and 1.56 g) of panicle weight, seed set (20.24 and 21.60 %) and harvest index (15.21 and 16.02 %) in 2020 and 2021 seasons, respectively. While the male to female ratio 2R:10A with five days differences in flowering between male and female line gave the lowest values (0.855and 0.945 tha^{-1}) of seed yield during both seasons, respectively. Deciding the optimization male: female proportion is significant for getting an economically feasible, hybrid seed production program. The optimization row ratio not only lowers the fee of manufacture of hybrid seed but also helps in improvement usage of the available resources.

The results in Table 5 showed that the interaction between male direction and differences in flowering between male and female line was a highly significant effect on the number of fertile panicles $hill^{-1}$, panicle weight, seed set, seed yield and harvest index in both seasons. The male direction in two ways without differences in flowering between male and female line produced the highest values (20.79 and 21.69) of the number of fertile panicles $hill^{-1}$, panicle weight (3.54 and 3.29 g), seed set, (37.68 and 39.04 %) seed yield (2.206 and 2.296 t ha^{-1}) and harvest index (21.84 and 22.74 %) in 2020 and 2021 seasons, respectively. However, The male direction in one way recorded the lowest values(13.56 and 14.46) of the number of fertile panicles $hill^{-1}$, panicle weight (1.56 and 1.31 g), seed set (19.51 and 20.86 %),seed yield (0.652 and 0.742 t ha^{-1}) and harvest index (14.67 and 15.57 %) in 2020 and 2021 seasons, respectively when the differences in flowering between male and female line were five days. The determination of suitable seeding dates is the primary and foremost step in the successful synchronization of the parental lines (Huang *et al*., 2021). Actual practices for synchronization of flowering would have to be standardized for each hybrid and the location selected for hybrid seed

production. Sowing dates of male parents were found to be highly significant for seed yield (Hamad *et al*., 2020). Indicating the importance of seeding date in grain yield and related traits, and appropriate seeding time improved seed setting percentage and adjusted synchronization between multiplication cytoplasmic male sterile lines for hybrid seed production lines CMS/R (Schmitz and Ransom, 2021).

Table 5. Effect of interaction between male direction and difference in days to flowering on panicle characteristics and yield during 2020 and 2021 seasons.

Male direction	Difference in days to flowering	Number of fertile panicles hill^{-1}		Panicle weight(g)		Seed set (%)		Seed yield (tha^{-1})		Harvest index(%)	
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
One way	Five days	13.56f	14.46f	1.56f	1.31f	19.51f	20.86f	0.652f	0.742f	14.67f	15.57f
	Two days	16.84d	17.74d	2.28d	2.03d	32.46d	33.82d	1.620d	1.710	17.54d	18.45d
	Without difference	17.71c	18.61c	2.87c	2.62c	35.24c	36.60c	1.868c	1.958c	19.51c	20.41c
Two way	Five days	15.42e	16.32e	2.15e	1.90e	23.78e	25.14e	1.177e	1.267e	16.89e	17.79e
	Two days	19.18b	20.19b	3.08b	2.83b	35.36b	36.72b	2.120b	2.210b	20.21b	21.11b
	Without difference	20.79a	21.69a	3.54a	3.29a	37.68a	39.04a	2.206a	2.296a	21.84a	22.74a

Number in the same column followed by the same letter are not significantly different at 0.05 level

The results in Table 6 indicated that the interaction between male to female ratio, male direction and difference in days to flowering was a highly significantly affect on the number of fertile panicles hill^{-1}, panicle weight, seed set, seed yield and harvest index in both seasons. Male to female ratio 2R:12A with two way male direction without differences in the flowering day between male parent and female parent produced the highest values (22.12 and 23.02) of the number of fertile panicles hill^{-1} and the heaviest panicle weight (3.79 and 3.54 g).While male to female ratio 2R:10A in two directions without differences in the flowering day between male parent and female parent produced the highest values (39.03 and 40.39 %) of seed set and harvest index (22.84 and 23.73 %) in the 2020 and 2021 seasons, respectively. On the other hand, the male to female ratio 2R:14A in two directions without differences in the flowering day between male parent and female parent produced the highest values (2.432 and 2.521 t ha^{-1}) of seed yield in both seasons, respectively. However, male to female ratio 2R:12A in one way male direction when the difference in flowering day between male parent and female parent was five days produced the lowest values (13.03 and 13.96) of the number of fertile panicles hill^{-1}, panicle weight (1.52 and 1.27 g).The lowest seed yield (0.606 and 0.696 t ha^{-1}) was recorded when male to female was 2R:10A in one male direction when the difference in the flowering day between male parent and female parent was five days. While, male to female ratio 2R:14A with one direction when the difference in the flowering day between male parent and female parent was five days produced the lowest values (18.29 and 19.65 %) of seed set, and harvest index (14.12 and 15.03 %) in the 2020 and 2021 seasons, respectively.

Table 6. Effect of interaction among male to female ratio, male direction and difference in days to flowering on panicle characteristics and yield during 2020 and 2021 seasons.

Male to female ratio	Male direction	Difference in days to flowering	Number of fertile panicles /hill^{-1}		Panicle weight (g)		Seed set (%)		Seed yield (tha^{-1})		Harvest index (%)	
			2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
2R:10A	One way	Five days	13.43j	14.33k	1.52p	1.27p	20.50l	21.86l	0.606j	0.696j	15.06o	15.96o
		Two days	16.48g	17.38g	2.56i	2.31i	33.90f	35.26f	1.271h	1.361h	17.59k	18.49k
		Without difference	17.80ef	18.70ef	3.14e	2.89e	36.13c	37.49c	1.666g	1.756g	18.83h	19.73h
	Two way	Five days	15.03h	15.93i	2.32k	2.07k	25.40i	26.76i	1.105i	1.195i	17.74j	18.64j
		Two days	19.48c	20.38c	3.36c	3.11c	37.80b	39.16b	1.971def	2.061def	21.59b	22.49b
		Without difference	21.63a	22.53a	3.54b	3.29b	39.03a	40.39a	2.066cd	2.156c	22.84a	23.73a
2R:12A	One way	Five days	13.03j	13.96k	1.56op	1.31op	19.72m	21.08m	0.711j	0.801j	14.83p	15.72
		Two days	16.48g	19.36de	2.04n	1.79n	32.47g	33.83g	1.700g	1.790g	18.05i	18.95i
		Without difference	18.03de	18.93def	2.99g	2.74g	35.30d	36.66d	1.908ef	1.998ef	20.40d	21.30d
	Two way	Five days	15.04h	15.94i	2.32k	1.85m	23.76j	25.12j	1.160hi	1.250hi	16.82m	17.73m
		Two days	19.48c	21.36b	2.84h	2.59h	34.37e	35.73e	2.100cd	2.190cd	20.05e	20.95e
		Without difference	22.12a	23.02a	3.79a	3.54a	37.83b	39.19b	2.121c	2.211c	21.40c	22.30c
2R:14A	One way	Five days	14.21i	15.11j	1.60o	1.35o	18.29n	19.65n	0.640j	0.730j	14.12q	15.03q
		Two days	15.60h	16.50hi	2.25l	2.00l	31.02h	32.38h	1.890f	1.980f	17.00l	17.90l
		Without difference	17.31f	18.21f	2.50j	2.25j	34.29e	35.65e	2.032cde	2.121cde	19.30f	20.20f
	Two way	Five days	16.21g	17.11gh	2.03n	1.77n	22.19k	23.55k	1.267h	1.357h	16.12n	17.02n
		Two days	17.60ef	18.83def	3.05f	2.80f	33.92f	35.28f	2.290b	2.380b	19.00g	19.90g
		Without difference	18.64d	19.54d	3.30d	3.05d	36.19c	37.55c	2.432a	2.521a	21.30c	22.20c

Number in the same column followed by the same letter are not significantly different at 0.05 level

CONCLUSION

Rice production ought to be expanded to adapt to proceeding with populace development and the risk of ecological pressures. The cytoplasmic male sterility (CMS) technique is a worthy methodology for the commercial exploitation of heterosis and producing high-yielding hybrid rice. The seed set percentage on the female lines highly depends on synchronization between male and female line in the hybrid rice seed production plot. Male to female ratio 2R:14A in two directions without differences in the flowering day between male parent and female parent produced the maximum values of seed yield in both seasons

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تأثر نسبة العقد بنسب الأب إلى الأم واتجاه الأب و اختلاف التزهير بين الأب و الأم علي إنتاج تقاوي الأرز الهجين

حسن شحاته حمد ، السيد السيد جويلي ، نعمه كمال الخولي و هبة عبد الحميد الشربيني

مركز البحوث والتدريب في الارز- معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر

تزامن التزهير بين الأب الملقح جيزة ١٧٨(R) و الأم العقيمة ذكريا سيتوبلازميا IR58025 (A) في حقل إنتاج تقاوي الأرز الهجين ذو أهمية قصوي للحصول على أعلى محصول من بذور التقاوي. أجريت تجربة في المزرعة التجريبية بمحطة البحوث الزراعية بسخا ، كفر الشيخ ، مصر خلال موسمي ٢٠٢٠ و ٢٠٢١. لدراسة تأثير نسبة الأب إلى الأم (R٢ : A 10، R٢ : A 12 و R٢ : A 14) ، اتجاه الأب (اتجاه واحد و اتجاهين) والاختلافات في أيام التزهير بين الأب و الأم (خمسة أيام, يومين وبدون اختلافات) على إنتاج تقاوي الأرز الهجين. تم استخدام تصميم القطع المنشقة مرتين في ثلاث مكررات. تم تخصيص القطع الرئيسية لنسبة الأب إلى الإم ، تم ترتيب اتجاه الأب في القطع الشقية وتم ترتيب الاختلافات في أيام التزهير في القطع تحت الشقية. أظهرت النتائج عدم تأثر ارتفاع النبات, وزن وطول السنابل و وزاوية ورقة العلم معنويا بنسب الأب إلى الإم واتجاه الاب والاختلافات في أيام الإزهار. بينما تأثر معنويا عدد الداليات/ للجورة، وزن الدالية، نسبة العقد، محصول التقاى ودليل الحصاد بنسبة الأب الملقح إلى الأم واتجاه الأب و الاختلافات في أيام التزهير. أظهرت النتائج أن أعلى القيم لمحصول التقاوي (٢,٤٣٢ و ٢,٥٢١ طن هكتار-١) تم الحصول عليها عند استخدام نسبة الأب إلى الام ٢اب:٤١أم، زراعة الأب فى اتجاهين وبدون اختلافات في التزهيز بين الأب والأم .

الكلمات الدالة: إنتاج تقاوي الأرز الهجين, نسبة الأب الملقح إلى الأم العقيمة ذكريا, اتجاه زراعة الأب المعيد للخصوبة و الاختلاف فى يوم التزهير