

EFFECT OF GA₃ DOSES AND ROW RATIO OF RESTORER LINE ON PERFORMANCE OF CYTOPLASMIC MALE STERILE LINE IN HYBRID SEED PRODUCTION OF RICE (*Oryza sativa* L.)

Hamad, H. Sh

Rice Research section, Field Crops Research Inst., ARC, Giza, Egypt

ABSTRACT

An experiment was conducted at the Experimental Farm of Rice Research Department at Sakha Agriculture Research Station, Field Crop Research Institute, ARC, Egypt, during 2015 and 2016 rice growing seasons to study the effect of GA₃ doses and row ratio of restorer Giza 178R and IR69625A cytoplasmic male sterile line (CMS) on different characters. Four levels of GA₃ doses, zero, 150, 200 and 250 g/ha and three row ratios 1R:10A, 2R:10A and 3R:10A for R and A lines respectively were used. The different doses of GA₃ showed highly significant influence on flag leaf angle (°), plant height, panicle exertion, panicle length, seed set (%), panicle weight, number of panicles/plant, grain yield, and harvest index when 3R:10A row ratio and 250g/ha of GA₃ were used in the first and second seasons. The highest seed yield 2.5 t/ha was obtained when 250 g/ha of GA₃ was applied with the row ratio of 3R:10A. The lowest seed yield (0.4 t/ha) was recorded without application of GA₃ (control) and row ratio of 1R:10A.

Key words: Hybrid rice, A line (CMS), R line, GA₃ application, row ratio and grain yield.

INTRODUCTION

In Egypt the average national yield level of rice has been increased by 25 – 30 % to meet the demands of the increasing population. This seems difficult considering the narrow gap between yield potential and actual yield (10.5 t/ha) in last season. Among available technologies to increase yield above the present ceiling, is the exploitation of heterosis in hybrid rice, which appears to be the practical approach for Egypt (Bastawisi *et al.* 1998). The cytoplasmic male Sterile (CMS) lines are utilized for developing the popular three line system. Success and sustain of hybrid rice depends on the efficiency and economic seed production technology besides the higher level of heterosis, which is a primary prerequisite (Virmani 2002). Some of the important components of seed production package, which need more study are isolation distance, of flowering date between parental lines, planting pattern, ideal row ratios, dose of GA₃ application and plant density (Zaman *et al.* 2002). Most of the hybrid male sterile parents are derived from wild abortive (WA) backgrounds.

Where, the panicle exertion from flag leaf sheath is a major problem for CMS lines, as 25 to 35% of the panicle remains inside the flag leaf sheath, thereby making these spikelet's unavailable for cross-pollination and resulting in low seed set. To overcome this problem different techniques were tried earlier, such as splitting open the leaf sheath manually; spray GA₃, urea and boric acid singly or combined and in combinations along with other practices, such as leaf clipping and rope pulling (Huang *et al.* 1998). Of all the practice applications, GA₃ was found to be the most effective and practically feasible. Besides, detailed study of different floral traits offers a guideline to promote outcrossing rate in CMS lines in obtaining more seed from the seed parent. Row ratio of parental lines (CMS, maintainer or restorer lines) plays an essential role in hybrid rice seed production. The objectives of this investigation are to study the effect of GA₃ application and parental row ratios on growth characters, yield and its components of production on the CMS line.

MATERIALS AND METHODS

Two experiments were conducted at the Rice Research Department at Sakha Agriculture Research Station, Field Crop Research Institute, ARC, Egypt, during 2015 and 2016 rice growing seasons to study the effect of four GA₃ application doses (zero, 150, 200 and 250 g/ha) and three row ratios, (1R:10A, 2R : 10A and 3R:10A) on restorer line (178R) and CMS line (IR69625 A) for growth, yield and its components on CMS line. A split-plot design in design with three replications was used. The main plot was devoted to row ratio of restorer lines, while the GA₃ applications were arranged in the subplots. Thirty days old seedlings of R and A lines were transplanted (3 - 4 seedlings and 2 seedlings per hill, respectively). The row spacing maintained for R-R, R-A and A-A lines were 20, 30, and 20 cm, respectively. Hill spacing for both R and A lines were maintained at 15 cm. Space isolation of 100 m and a time isolation of 21 days were considered for CMS seed production. Moreover, the experimental field was surrounded by an additional 20 rows of R lines to avoid any possibility of cross pollination. To ensure easy distribution of pollen and higher cross pollination of panicles of CMS plants Supplementary pollination was done by shaking the pollen parents (R line) with bamboo sticks. This operation was done 4-5 times, between 9 am to 11.30 am daily for a period of 10 days. The crop was harvested when 80% of the grains became golden yellow in color. Grains were sun-dried and adjusted at 14% moisture content to estimate grain yield. In the experiment, data were recorded from 10 randomly selected hills excluding border rows per plot. Data were collected for the following growth characters; flag leaf angle ⁽⁶⁾, plant

height (cm), panicle exertion rate, panicle length (cm), seed set (%) , panicle weight (g), number of panicles per hill , grain yield (t/ha) and harvest index.

The data were collected according to Standard Evaluation System of (IRRI 1998), for all the studied characters. All cultural practices were followed as recommended. The data were analyzed following the ANOVA technique and the mean differences were compared by the Duncan's Multiple Range Test (Gomez and Gomez, 1984) using a statistical computer package MSTAT.

RESULTS AND DISCUSSION

The results obtained from the present investigation in the two successive seasons of 2015 and 2016 are presented and discussed as follows:

Results in (Table 1). Revealed that, the effect of row ratio and GA₃ application, as well as, their interaction on growth characters, i.e., flag leaf angle, plant height, panicle exertion and panicle length. The results showed that the growth traits were not significantly changed by row ratio during the two seasons. Otherwise, there were highly significant differences among the GA₃ doses for flag leaf angle, plant height, panicle exertion and panicle length in both seasons. The highest values were; 46.36°, 117.44 cm, 94.20% and 23.16 cm for the four traits, respectively in both seasons using the dose of 250g GA₃/ha. But, the lowest values were obtained from control (without GA₃ application) for these traits in both seasons.

Table 1: Effect of row ratio and GA₃ doses, as well as their interaction on flag leaf angle (°), plant height (cm), panicle exertion (%) and panicle length (cm) during 2015 and 2016 seasons

Main effect and interaction	flag leaf angle (°)		plant height (cm)		panicle exertion (%)		panicle length (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016
Row ratio(R)								
1R:10A	34.54	35.53	88.34	91.47	72.36	71.95	19.01	19.05
2R:10A	34.60	35.46	88.32	91.05	70.52	71.80	18.63	18.82
3R:10A	34.78	35.39	88.68	90.94	70.33	71.29	18.39	18.37
F- Test	NS	NS	NS	NS	NS	NS	NS	NS
GA₃dose(D)								
0	20.95d	22.31d	64.83d	67.35d	29.43d	28.24d	14.70d	13.47d
150	34.40c	35.45c	76.30c	78.25c	77.39c	78.00c	17.41c	16.70c
200	38.90b	37.63b	97.24b	101.53b	83.84b	86.28b	20.39b	21.67b
250	44.68a	46.36a	115.42a	117.44a	93.62a	94.20a	22.60a	23.16a
F – Test	**	**	**	**	**	**	**	**
Interaction (Rx D)	NS	NS	NS	NS	NS	NS	NS	NS

** Highly significant at the 1% level of probability, NS not significant

These findings showed that, flag leaf angle, plant height, panicle exertion and panicle length were highly affected by applying different doses of GA₃, they (cm) increased with increasing GA₃ level might be associated with stimulating effect of GA₃ on various physiological process including cell division and cell elongation of the

rice plant. The data agreed with those obtained by Ponnuswamy *et al* (1998). The interaction between the row ratio and GA₃ doses was not significant for all traits in both seasons.

The results in (Table 2). indicated that, the 3R:10A row ratio with application of 250 GA₃ g/ha data revealed significantly highest values of flag leaf angle, plant height, panicle exertion and panicle length in both seasons. The highest values were 47.1°, 117.13, 94.46% cm and 24.60 cm for the four traits in second seasons, respectively.

Table 2. Flag Leaf angle (°), plant height (cm), panicle exertion (%) and panicle length (cm) as affected by the interaction between row ratio and GA₃ dose during 2015 and 2016 seasons

Row Ratio	GA ₃ dose g/ha	flag leaf angle (°)		plant height (cm)		panicle exertion (%)		panicle length (cm)	
		2015	2016	2015	2016	2015	2016	2015	2016
1R:10A	0	20.35	22.01	64.20	67.010	25.83	28.50	14.09	13.01
	150	33.17	35.18	76.26	79.30	77.70	78.70	16.90	17.10
	200	37.12	38.90	97.70	101.40	84.20	86.01	20.10	21.30
	250	43.53	46.50	115.20	118.20	93.60	94.01	22.10	23.10
2R:10A	0	20.71	22.02	64.79	67.34	26.16	28.80	14.53	13.40
	150	34.20	35.34	76.50	78.20	77.80	78.20	18.46	17.10
	200	37.82	39.90	97.00	101.09	83.86	86.70	20.22	22.01
	250	45.26	46.59	115.00	117.15	92.26	94.13	22.30	22.80
3R:10A	0	21.78	22.90	65.50	67.70	36.30	27.43	15.48	14.01
	150	35.84	36.11	76.13	77.26	76.67	77.12	17.86	16.90
	200	38.77	37.10	97.03	102.12	83.48	86.15	20.85	21.70
	250	45.27	47.01	116.07	117.13	93.01	94.46	23.40	24.60

NS not significant

While significantly the lowest values were detected as a result of 1R:10A row ratio with 0g GA₃/h interaction for four traits in both seasons. The data agreed with those obtained by Hamad *et al.*(2015) found that, the plant height character was highly affected by the doses of GA₃. The panicles under row ratio 2B:4A showed better exertion from the flag leaf sheath than the other row ratio 2B:8A. Similarly, the application with 300 g GA₃/ha resulted in the best exertion of panicles of A-line plants. The above given results are of high importance to encourage the cross pollination in hybrid seed production. Deshapande *et al.* (2003) found that, the application of 200 g NAA/ha resulted in the highest percentage of panicle exertion (88%).

Results in (Table 3). showed that, the effect of row ratios and GA₃ application, as well as, the effect of their interaction on seed set (%), panicle weight (g), number of panicle/hill, grain yield (t/ha) and harvest index. The results Revealed that, seed set (%) and panicles weight (g), number of panicles / hill, grain yield (t/ha) and harvest index

were highly significantly affected by row ratios in both seasons. The highest values were 33.98% for seed set, 2.71g for panicle weight, 19.05 for number of panicles/hill and 17.06% for harvest index in both seasons under row ratio 3R:10A. Otherwise, the highest value for grain yield was (1.710 t/ha) in the second season obtained from 3R:10A row ratio. While the lowest values were 19.97%, 1.46g, 9.57 and 11.60 for seed set (%), panicle weight (g), number of panicles / hill and harvest index in the first season, respectively, when using the row ratio 1R:10A. This might be due to insufficient availability of pollen which resulted in the lowest grain formation. On the other hand, the lowest value for grain yield obtained from row ratio 1R:10A. These results indicate that row ratio 3R:10A performed better than the other row ratios. This might be due to the optimum availability of pollen that led to the highest effective grain formation. Similar results were also found by Singh and Singh (1998) they conducted experiments during 1993-95 to determine the optimum row ratio of the pollen parent to the seed parent and the appropriate season for maximizing seed yields of male sterile lines and hybrid rice.

Table 3: Effect of row ratio and GA₃ doses, as well as their interaction on seed set % , panicle weight (g),No of panicles / hill, grain yield (t/ha),and harvest index (%) during 2015 and 2016 seasons

Main effect and interaction	Seed set (%)		Panicle weight (g)		No. of panicles/hill		Grain yield (t/ha)		Harvest index (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Row ratio(R)										
1R:10A	20.17c	19.97c	1.56c	1.46c	9.57c	10.79c	0.887c	0.900c	11.60c	12.50c
2R:10A	25.80b	28.60b	1.95b	2.00b	12.64b	14.77b	1.280b	1.390b	13.68b	14.80b
3R:10A	33.98a	32.47a	2.65a	2.71a	18.10a	19.05a	1.560a	1.710a	17.06a	16.50a
F- Test	**	**	**	**	**	**	**	**	**	**
GA₃(D)										
0	15.04d	14.44d	1.36d	1.45d	9.10d	10.59d	0.556d	0.650d	9.66d	10.30d
150	23.30c	22.83c	1.96c	1.93c	12.65c	13.87c	1.03c	1.106c	11.92c	13.96c
200	31.44b	30.00b	2.23b	2.20b	14.13b	16.83b	1.500b	1.663b	15.61b	16.20b
250	38.83a	35.80a	2.65a	2.51a	18.20a	20.55a	1.880a	1.920a	17.26a	18.93a
F- Test	**	**	**	**	**	**	**	**	**	**
Interaction (Rx D)	**	**	**	**	**	**	**	**	**	**

** Significant at level 1 % of probability. In a season, the values having the same letter(s) aren't significantly differ according to Duncan's multiple range test

The seed set (%), panicle weight (g), number of panicle/hill, grain yield (t/ha) and harvest index were highly significantly affected by GA₃ doses in both seasons. The most effective dose was 250g GA₃/ha, where the highest seed set %, the most heavier panicles, the highest number of panicles, the superior grain yield t/ha and the highest value of harvest index were produced, The highest values were 38.83% for seed set, 2.65g for panicle weight, 20.55 panicles/hill, 1.920 t/ha for grain yield and 18.93 for harvest index percentage in both seasons. While the lowest values were obtained without using GA₃ during the two seasons for pervious traits. Deshapande *et al.* (2003) found that, the application of 200 g NAA/ha recorded the percentage of seed set

(23.52-27.39%) and seed yield (1660-1795Kg/ha). Adequacy of GA₃ at 250 g/ha probably favored the proper cellular activates during panicle formation and development, which led to increase number of effective tillers/hill.

IRRI (1993) reported that the bearing tillers/hill was increased upon application of GA₃ due to late tillers converted into productive tillers. Adequate supply of GA₃ contributed to grain formation which increased the number of grains/panicle with increasing GA₃ level. These results were in compliance with those of Zhu et al. (1998) who reported the positive influence of GA₃ level on number of grains/panicle.

Results in (Table 4). Indicates the 3R:10A row ratio with 250g GA₃/ha interaction revealed significantly highest values of the seed set (49.90%) and (21.80) for harvest index in the first season. While panicle weight (2.71g), no of panicles (19.05) and grain yield (2.540kg t/ha)in the second season.

Table 4: Seed set (%), panicle weight (g), No. of panicles/hill, grain yield (t/ha) and Harvest index (%) as affected by the interaction between row ratios and GA₃ doses during 2015 and 2016 seasons

Row ratios	GA ₃ doses g/ha	Seed set (%)		Panicle weight(g)		No. of panicle/hill		Grain yield (t/ha)		Harvest index (%)	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
1R:10A	0	10.01	11.01	1.10	1.15	7.81	8.01	0.400	0.520	6.80	7.60
	150	19.40	17.20	1.50	1.40	10.86	9.11	0.800	0.810	11.70	12.30
	200	26.20	24.80	1.70	1.60	11.10	12.01	0.950	0.980	13.60	14.0
	300	27.10	26.90	1.95	1.70	13.50	14.04	1.400	1.300	14.30	15.60
2R:10A	0	16.01	17.10	1.40	1.50	9.09	10.01	0.510	0.630	10.01	11.30
	150	23.70	22.90	1.60	1.80	11.30	11.80	1.010	1.110	13.90	14.50
	200	30.01	29.60	2.10	1.90	14.40	13.70	1.700	1.810	15.12	16.20
	300	33.50	32.80	2.55	2.40	15.80	15.60	1.900	2.010	15.70	17.20
3R:10A	0	19.10	18.20	1.60	1.70	10.40	10.70	0.760	0.800	112.17	12.00
	150	27.80	28.40	2.40	2.60	16.80	17.70	1.300	1.400	16.18	15.10
	200	39.12	35.60	2.90	3.10	19.90	21.80	1.850	2.200	18.11	17.90
	300	49.90	47.70	3.05	3.25	25.30	26.01	2.350	2.540	21.80	21.01
LSD 0.05		0.012	0.014	0.020	0.014	0.027	0.024	0.014	0.014	0.011	0.010
LSD 0.01		0.018	0.020	0.030	0.020	0.040	0.036	0.020	0.022	0.017	0.016

* and **significant differences at 0.05 and 0.01 levels of probability respectively.

The significantly lowest values were detected as a result of the 1R:10A row ratio with (0 g GA₃/ha) interaction for the all traits in both seasons. The data were in agreement with Abo-Youssef (2009), who reported that the application of GA₃ at the higher dose (200gm/ha) gave the highest value of the seed set (32.95 %) comparing with no application of GA₃ which gave lowest one (17.34 %). Virmani (2002) found that, application of GA₃ increased seed set (45-50%) with 180-220g/ha, while, Gaballah (2004) mentioned that, the highest value of seed set (45%) was observed when rice plants of A- line were treated with 200g/ha of GA₃ while, the control treatment of GA₃ gave the lowest one (18.18%).

Zaman *et al.* (2002) reported that application of GA₃ at the rate of 200g/ha gave grain yield, 3.0t/ha for A/R. The interaction between the row ratio and GA₃ doses was highly significant for grain yield and harvest index (%) in both seasons. This might be due to higher outcrossing rate and panicle exertion as mentioned above. The data agreed with those obtained by Biradarpatil and Shekhargouda (2006), who found that, foliar spraying of gibberellic acid (GA₃) at 100 ppm, single super phosphate at 1.0 %, and KNO₃ at 1.0 % to A-line plant at panicle initiation enhanced the 50 % flowering by 3.7, 3.2 and 3.2 days, and increased the hybrid seed yield by 39, 32 and 28 %, respectively, over the control.

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تأثير إضافة حمض الجبريللين و نسب السطور في الأب المعيد للخصوبة على إنتاج تقاوي السلالة العقيمة الذكر السيتوبلازم في الأرز

حسن شحاته حمد

قسم بحوث الأرز - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر.

أجريت هذه الدراسة في المزرعة البحثية لمركز البحوث والتدريب في الأرز- محطة بحوث سخا - كفر الشيخ - مصر. خلال موسمي الزراعة 2015 و2016، واشتملت هذه الدراسة على السلالة العقيمة ذكوريا أي أر (69625 أم (و السلالة المعيدة للخصوبة جيزة 178 أب) لإنتاج تقاوي الأرز الهجين. صممت التجربة في القطع المنشقة في ثلاث مكررات. وكانت القطع الرئيسية تشتمل على نسب السطور بين الأب المعيد للخصوبة والسلالة عقيمة الذكر السيتوبلازم وهي 1 أب:10 أم، 2 أب:10 أم و 3 أب:10 أم بينما إضافة حمض الجبريللين كانت في القطع المنشقة وهي 0- 150 - 200 و 250 جرام/هكتار. وأوضحت النتائج أن أعلى القيم لطول النبات ومعدل خروج الدالية من غمد ورقة العلم وعدد السنابل الخصبة وطول ووزن الدالية و نسبة عقد الحبوب ومحصول الحبوب ومعامل الحصاد باستخدام حمض الجبريللين بمعدل 250 جم للهكتار مع معدل سطور 3 أب : 10 أم في كلا الموسمين. و محصول الحبوب كان 2.540طن/الهكتار باستخدام حمض الجبريللين بمعدل 250 جم للهكتار مع معدل سطور 3 أب : 10 أم في كلا الموسمين.