ISSN 0258-7122
Bangladesh J. Agril. Res. 38(1): 155-163, March 2013

EFFECT OF GA_3 AND ROW RATIO ON FLORAL TRAITS OF COMPONENT LINES OF BRRI HYBRID DHAN2

M.H. RAHMAN[1], M.M KHATUN[2], M. S. R. KHAN[3]
M. M. HAQUE[4] AND M.G. RASUL[5]

Abstract

Component lines (A and R lines) of BRRI hybrid dhan2 were assessed under treatment of GA_3 application and row ratio on days to 5% and 50% flowering, duration of opening of floret, angle of open floret, filament length, anther length, stigma length, panicle exsertion rate, stigma exsertion rate and outcrossing rate. The CMS line viz; BRRI 10A have been found to be usable female parents for hybrid rice seed production due to their stigma length, stigma exsertion rate, duration of blooming, anther length and filament length. The different between genotypic and phenotypic variation was not remarkable for most of the characters studied indicating negligible environmental influence on the traits. The maximum duration of opening of floret (158.10 min) and angle of floret opening (28.87^0) were obtained with the application of 350 g GA_3 ha^{-1}. The improvement in the floral traits with increased GA_3 level might be due to increased availability of GA_3 which enhanced floral traits. The CMS line can be used as potential female parent in hybrid rice seed production of BRRI hybrid dhan2.

Keywords: CMS line, restorer line, floral traits, GA_3 and row ratio, hybrid rice.

Introduction

The green revolution in rice producing countries enabled global rice production to meet the demand of the world's increasing population. Recent progress in plant breeding research indicated that a significant shift in the yield frontier could possible through hybrid rice technology. Hybrid technology in a self-pollinated crop like rice, with a yield advantages of 20% or higher over the best conventional varieties is no doubt a landmark in the history of rice breeding. This technology, now being adopted in over 58% of China's rice area, has helped the country during the last 15 years to advance its rice production by 45% (Virmani, 2006). It is worthwhile to mention that several Asian countries such as Bangladesh, India, Indonesia, Malaysia, Myanmar, Philippines, South Korea, Srilanka, Vietnam and Thailand have already started their own hybrid rice research and development (Virmani, 2004). Experiences of these countries had

[1]Scientific Officer, Plant Breeding Division, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, [2]Scientific Officer, HRC, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, [3]AEO, Khamarbari, Farmgate, Dhaka, [4]Professor, Dept. of Agronomy, [5]Professor, Dept. of GPB, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur-1706, Bangladesh.

shown that the success in the use of hybrid rice depends on the extent of heterosis and efficiency of the seed production techniques. In tropical countries like India, the cytoplasmic-genetic male sterility (CMS) and the thermosensitive genic male sterility (TGMS) systems are being used in hybrid program. The CMS with wild abortive (WA) cytoplasm is used extensively but later on TGMS system was found more effective in increasing grain yield and seed production efficiency (Yuan, 1998; Lu *et al*., 1998; Lopez and Virmani, 2000). The development of hybrid rice breeding technology involves improvement and evaluation of parental lines, evaluation of the degree of heterosis for yield and techniques for seed production. Customarily to produce hybrids on a commercial scale, it is essential to change the function of male and female reproductive systems of rice plants. A breakthrough came with the discovery and development of the cytoplasmic genetic male sterility system from a wild rice in 1964 (Yuan, 1966). The genetic tools essential for production of hybrid rice-cytoplasmic male sterile (A) line, maintainer (B) line and restorer (R) line-were developed in China and in 1976 the first batch of hybrid rice was released (Virmani *et al*. 1997).

In hybrid rice research and production, the success of the female seed production plays the decisive role in determining the cost of F_1 seed production for commercial rice production. The use of male sterility is a prerequisite for commercial exploitation of heterosis since rice is a self-pollinated crop. However, seed setting in a CMS line depends upon the extent of outcrossing which is a function of the floral morphology and flowering behavior of CMS lines and the male parents (Oka and Morishima, 1967). Therefore, the present study was carried out to evaluate of various floral traits in A and R lines of BRRI hybrid dhan2 influencing GA_3 and row ratio of restorer and CMS line.

Materials and Method

The experiment was carried out at the experimental farm of Bangladesh Rice Research Institute (BRRI), Gazipur, during November to May 2009-10. The restorer line (R) BRRI10R and CMS line (A) BRRI10A developed by the Bangladesh Rice Research Institute (BRRI), has been used as plant material in the experiment. The lines BRRI10R and BRRI10A matures after 150 days and 147 days, respectively. The experiment was laid out in a Randomized Complete Block Design with three replications. 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 40, 30 and 15 cm, respectively. Hill spacing for both R and A lines were maintained 15 cm. Transplanting was done on different dates as per experimental treatments. However, R lines were transplanted on 7 January, 2010 while A lines were transplanted 10 January, 2010 to synchronize flowering. The row ratio of R and A lines was 2:8, 2:10, 2:12, 2:14 and 2:16. To accommodate varying number of rows, plot size was also varied accordingly. Row directions were perpendicular to wind direction. Urea, TSP, MP, gypsum, zinc, borax and Cowdung were applied @ 370, 250, 370, 150, 20, 7 Kg/ha and 15 t/ha respectively. Urea, TSP, MP, gypsum, zinc, borax (250, 250, 250, 150, 20, 7 kg/ha) were applied at the time of final land preparation and cowdung was applied at the time of 1st land opening and was mixed thoroughly with soil. The rest of the urea and MP were applied as top dressed in two equal splits, at active tillering stage and panicle initiation stage (30 and 50-55 days after transplanting) respectively. Weeding was done twice by hand pulling on 15 and 30 DAT. To control the pests/ diseases, necessary measure was taken. Space isolation of 50m and a time isolation of 21 days were considered for hybrid seed production. Moreover, the experimental field was surrounded by an additional 20 rows of R lines to avoid any possibility of cross pollination. The off-type plants were removed by hand pulling during different growth stages. To ensure easy dispersal of pollen and higher cross pollination of panicles of CMS plant, flag leaf clipping is very important. At booting stage flag leaf blades were cut with the help of a sickle in such a way that two third of the flag leaf were removed. Supplementary pollination was done by shaking the pollen parents (R line) with bamboo sticks. This operation was done 4-5 times in between 9 AM to 11.30 AM for a period of 10 days. In experiment, data were recorded from 10 randomly selected hills excluding border rows per plot. Data were collected for the following parameters- days to 5% and 50% flowering, duration of opening of floret, angle of open floret, filament length, anther length, stigma length, panicle exsertion rate, stigma exsertion rate and outcrossing rate. The angle of lemma and palea at peak anthesis was measured in degrees when the floret was fully opened. In case of length and diameter measurement we used millimeter sketched graph sheet. Samples put on graph paper and data were collected. Angle was measured by angular scale.

Results and Discussion

Mean effect of GA_3 concentrations on different floral traits of component lines

The analysis of variance indicated significant effect of GA_3 doses and row ratio for almost all the characters studied except for days to 5% and 50% flowering GA_3 application and during of floret opening and angle of open floret for row ratio (Table 1). The lowest days to 5% flower opening (113.47 days) was recorded for control treatment, while the highest days to 5% flower opening (113.93 days) obtained from 350 g/ha of GA_3. The lowest days to 50% flower opening (115.27 days) was noticed from without application of GA_3, while the highest days (115.73 days) to 50% flower opening was recorded from 150 g/ha of GA_3. Chakraborty and Hajarika (1994) found similar results in rice. The maximum duration of opening of floret was (158.10 min) obtained when the application of GA_3 was 350 g/ha, while the minimum duration of opening of floret was (136.30 min) observed in control. The lowest angle (26.01^0) was recorded in control, while the highest (28.87^0) angle was observed from application of 350 g GA_3/ha which was statistically similar (28.65^0) to 250 g/ha. The highest stigma length (1.04 mm) was obtained from the application of GA_3 of 350 g/ha, while the lowest stigma length (0.88 mm) was found in the control. The other levels of GA_3 had intermediate effect on stigma length (Table 2). The variation in stigma length among the GA_3 level might be due to interaction between genotype and GA_3 levels. The improvement in the stigma length with increased GA_3 level might be due to increased availability of GA_3 which enhanced stigma length. The stigma length is favourable for outcrossing rate. The results were in close conformity with those of Sarial and Singh (1999). The highest stigma exertion rate was observed (58.31%) at the highest level of GA_3 and it was statistically similar (57.76%) with the level of GA_3 250 g/ha. The lowest stigma exertion rate (45.50%) was computed against control condition (Table 2). The highest duration (8.31 days) was obtained with the application of GA_3 @ 350 g/ha and it was statistically similar (7.96 days) with the level of GA_3 250 g/ha. The lowest duration of blooming (5.62 days) was computed against the control (Table 2). The longest anther length (1.98 mm) was recorded in the highest GA_3 level and it was statistically similar (1.95 mm) with the level of GA_3 @ 250 g/ha. The shortest one (1.73 mm) was in control and that was statistically similar with 150 g GA_3/ha (Table 2). Ashok *et al*. (1999) observed that long anthers were favourable for outcrossing during seed production. The longest filament length (9.07 mm) was observed in the application of GA_3 @ 250 g/ha and the shortest filament length (8.57 mm) was noticed in control. The filament length of the anther determines the degree of versatility of the anthers i.e., higher the filament length greater the degree of versatility of the anther and higher frequency of pollen dispersal and migration from the male parent to female parent. Therefore, the results confirmed the findings of Singh and Singh (1998).

Mean effect of GA_3 concentrations and row ratio on floral traits of component lines

Row ratio significantly influenced almost all the parameters studied except duration of opening floret and angle of open floret (Table 1). The lowest days to 5% flower opening (113.25 days) was recorded when the row ratio of restorer and CMS lines was 2:14. On the other hand, the highest values were obtained from row ratio of restorer and CMS lines 2:16. Results showed that the different row ratio of restorer and CMS lines was a genetical as well as environmental factor for the days to 5% and 50% flower opening (Table 3). The maximum duration of opening of floret was (150.92 min) obtained from the row ratio of

Table 1. Analysis of variance (mean sum square values) for different floral traits of component lines of BRRI hybrid dhan2.

Source of Variation	Degree of Freedom	Days to flowering at 5%	Days to flowering at 50%	Duration of opening of floret (min)	Angle of open floret (0^0)	Stigma length (mm)	Stigma exertion rate (%)	Duration of blooming (days)	Anther length (mm)	Filament length (mm)
Replication	2	1.667^{NS}	0.467^{NS}	21.117^{NS}	1.558^{NS}	0.392^{*}	288.800^{*}	1.038^{*}	0.005^{NS}	0.041^{NS}
GA_3 level (A)	3	0.578^{NS}	0.667^{NS}	1602.667^{*}	28.690^{*}	0.068^{*}	574.062^{*}	21.828^{*}	0.238^{*}	0.692^{*}
Row ratio (B)	4	1.933^{*}	1.525^{*}	41.350^{NS}	1.446^{NS}	0.041^{*}	7.686^{*}	2.112^{*}	0.216^{*}	0.279^{*}
Interaction (A x B)	12	0.633^{NS}	0.736^{NS}	48.972^{NS}	1.020^{NS}	0.015^{*}	22.166^{*}	1.154^{*}	0.062^{*}	0.083^{*}
Error	38	0.456	0.502	68.696	1.536	0.003	2.274	0.331	0.016	0.019

*= Significant at 5% level of probability, NS=Not Significant at P≤0.5

Table 2. Mean effect of GA_3 concentrations on different floral traits of parental lines of BRRI hybrid dhan2.

Concentration	Days to flowering at 5%	Days to flowering at 50%	Duration of opening of floret (min)	Angle of open floret (0^0)	Stigma length (mm)	Stigma exertion rate (%)	Duration of blooming (days)	Anther length (mm)	Filament length (mm)
0 g/ha	113.47	115.27	136.30c	26.01c	0.88c	45.50c	5.62c	1.73b	8.57d
150 g/ha	113.73	115.73	145.50b	26.89b	0.99b	50.22b	6.93b	1.77b	8.87c
250 g/ha	113.80	115.33	157.10a	28.65a	0.96b	57.76a	7.96a	1.95a	9.07a
350 g/ha	113.93	115.53	158.10a	28.87a	1.04a	58.31a	8.31a	1.98a	8.95b
CV (%)	0.59	0.61	5.55	4.59	5.19	2.85	7.99	6.77	1.57
SE (±)	0.25	0.29	3.03	0.45	0.02	0.55	0.21	0.05	0.05

In a column, the means having same letter(s) do not differ significantly but dissimilar letters differ significantly at 5% level of significance by Duncans's Multiple Range Test (DMRT). SE= Standard error of means.

Table 3. Mean effect of Row ratio of restorer and CMS lines on different floral traits of parental lines of BRRI hybrid dhan2.

Row ratio	Days to flowering at 5%	Days to flowering at 50%	Duration of opening of floret (min)	Angle of open floret (0^0)	Stigma length (mm)	Stigma exertion rate (%)	Duration of blooming (days)	Anther length (mm)	Filament Length (mm)
R_2:A_8	113.92ab	115.75a	148.08	27.35	0.93b	52.30b	7.00bc	1.68b	8.91b
R_2:A_{10}	113.83abc	115.75a	150.33	27.72	0.91b	53.05ab	6.67c	1.95a	8.76cd
R_2:A_{12}	113.42bc	115.17ab	150.92	27.79	1.02a	52.13b	7.80a	2.00a	8.85bc
R_2:A_{14}	113.25c	115.00b	146.58	27.15	0.94b	54.15a	7.30b	1.76b	8.68d
R_2:A_{16}	114.25a	115.67a	150.42	28.01	1.04a	53.10ab	7.25b	1.92a	9.08a
CV	0.59	0.61	5.55	4.59	5.19	2.85	7.99	6.77	1.57
SE (±)	0.28	0.29	3.38	0.51	0.02	0.62	0.23	0.06	0.05

In a column, the means having same letter(s) do not differ significantly but dissimilar letters differ significantly at 5% level of significance by Duncans's Multiple Range Test (DMRT). SE= Standard error of means. R= Restorer line. A= CMS (cytoplasmic male sterile) line.

restorer and CMS lines 2:12, while the minimum duration of opening of floret was (146.58 min) observed from row ratio of 2:14. The other row ratio took medium duration of opening of floret (Table 3). The lowest angle (27.15^0) was recorded in 2:14, while the highest angle was observed (28.01^0) from row ratio of 2:16. It seemed that duration of floret opening is variety specific trait and not affected by row ratio of restorer and CMS lines. The highest stigma length (1.04 mm) was obtained from row ratio 2:16, while the lowest stigma length was (0.91 mm) observed from 2:10 (Table 3).

The highest stigma exsertion rate (54.15%) was observed when the row ratio of restorer and CMS lines was 2:14 and it was statistically similar (53.05 and 53.10%) with the row ratio of 2:10 and 2:16, respectively. High frequency of stigma exsertion rate in CMS lines gave higher rate of outcrossing. The differences in stigma exsertion rate among the row ratio of restorer and CMS lines might be due to cytoplasmic factor. The highest duration of blooming days (7.80) was obtained from the row ratio of 2:12 (Table 3). The lowest duration (6.67) was observed from the treatment 2:10. The variation in duration of blooming days among the row ratio of restorer and CMS lines might be due to the differences in genetical constituents of the parental lines as well as environmental effects. The longest anther (2.00 mm) was recorded in 2:12 and the shortest one was (1.68 and 1.76 mm) observed from the row ratio 2:8 and 2:14, respectively (Table 3). The variation in anther length among the row ratio of restorer and CMS lines might be due to differences in genetical constituents of the parental lines as well as environmental effects. The longest filament length (9.08 mm) was observed when the row ratio of restorer and CMS lines were 2:16. The shortest filament length was (8.68 mm) found in 2:14. The filament length of the anther determines the degree of versatility of the anther i.e. higher the filament length greater the degree of versatility of the anther and higher frequency of pollen dispersion and migration from the male parent to female parent. Therefore, the results confirmed the findings of Singh and Singh (1998).

Interaction effect of GA_3 and row ratio of restorer and CMS lines on different floral traits

Interaction effect of different levels of GA_3 and row ratios of restorer and CMS lines significantly influenced on different floral traits of parental lines of BRRI hybrid dhan2 (Table 1). The highest stigma length (1.10mm) was found when the application of GA_3 was 350 g/ha and the row ratio of restorer and CMS lines were 2:12. On the other hand, the lowest stigma length (0.73 mm) was found without the application of GA_3 with row ratio of 2:14 (Table 4). The highest stima exsertion rate (61.14%) was found when the concentration of GA_3 was 250 g/ha and row ratio of restorer and CMS lines were 2:14, while the lowest stigma exsertion rate (43.13%) was found with control GA_3 and 2:8 row ratio (Table 4).

Table 4. Interaction effect of GA_3 and Row ratio of restorer and CMS lines on different floral traits of parental lines of BRRI hybrid dhan2.

GA_3 level (g/ha)	Row ratio level	Stigma length (mm)	Stigma exertion rate (%)	Duration of blooming (days)	Anther length (mm)	Filament length (mm)
	$R_2:A_8$	0.87ef	43.13h	6.00gh	1.53hi	8.87c-e
	$R_2:A_{10}$	0.87ef	46.07fg	5.0 h	1.93a-e	8.23h
0	$R_2:A_{12}$	0.93c-e	44.30gh	5.55gh	1.93a-e	8.60fg
	$R_2:A_{14}$	0.73g	45.37gh	5.55gh	1.63g-i	8.27h
	$R_2:A_{16}$	1.00a-d	48.63ef	6.00gh	1.60g-i	8.87c-e
	$R_2:A_8$	0.93c-e	46.50fg	7.55b-d	1.63f-i	8.97b-e
	$R_2:A_{10}$	0.93c-e	50.90de	6.110fg	2.03a-d	8.80d-f
150	$R_2:A_{12}$	0.97b-e	48.37ef	8.22a-c	1.90a-e	8.73e-g
	$R_2:A_{14}$	1.06ab	51.47cd	6.33e-g	1.43i	8.53g
	$R_2:A_{16}$	1.07ab	53.87c	6.44e-g	1.87b-f	9.10a-c
	$R_2:A_8$	0.90de	60.08ab	7.33c-e	1.73e-h	8.97b-e
	$R_2:A_{10}$	0.80fg	57.40b	7.55b-d	1.83c-g	8.97b-e
250	$R_2:A_{12}$	1.07ab	57.87b	8.44ab	2.01a-d	9.17ab
	$R_2:A_{14}$	1.00a-d	61.14a	8.44ab	2.03a-d	8.93b-e
	$R_2:A_{16}$	1.03a-c	52.30cd	8.00a-d	2.13a	9.30 a
	$R_2:A_8$	1.03a-c	59.50ab	7.11d-f	1.80d-g	8.83c-f
	$R_2:A_{10}$	1.03a-c	57.83b	8.00a-d	2.00a-d	9.03b-d
350	$R_2:A_{12}$	1.10a	58.00b	9.00a	2.10 ab	8.90b-e
	$R_2:A_{14}$	0.97b-e	58.63ab	8.89a	1.93a-e	8.97b-e
	$R_2:A_{16}$	1.07ab	57.60b	8.55ab	2.07abc	9.03b-d
CV (%)		5.19	2.85	7.99	6.77	1.57
SE (±)		0.04	1.23	0.47	0.10	0.04

In a column, the means having same letter(s) do not differ significantly but dissimilar letters differ significantly at 5% level of significance by Duncans's Multiple Range Test (DMRT). SE= Standard error of means. R= Restorer line. A= CMS (cytoplasmic male sterile) line.

The highest blooming (9.0 days) was obtained from 350 g/ha GA_3 with the row ratio of 2:12, while the lowest blooming (5.0 days) was obtained from control GA_3 with the row ratio of 2:10 (Table 4). The longest anther (2.13 mm) was recorded due to the in application of 250 g/ha GA_3 with the row ratio of 2:16. On the other hand, the shortest one (1.43 mm) was obtained from 150 g/ha GA_3 with the row ratio of 2:14 (Table 4). The longest filament length (9.30 mm) was observed from 250 g/ha GA_3 with the row ratio of 2:16, while the shortest one (8.23 and 8.27 mm) was found with control GA_3 with the row ratio of 2:10 and 2:14, respectively (Table 4).

References

Ashok, S. K., R. Singh., L. C. Prasad., R. M. Singh., D. K. Singh and S. K. Agarwal. 1999. Screening rice germplasm for floral attributes that influence outcrossing. *International Rice Research Notes* **23** (1): 7.

Chakraborty, S. and M. H. Hajarika. 1994. Estimation of various genetic parameters of yield and yield componenets of rice. *Oryza.* **31:** 226-227.

Lopez, M. T., and S. S. Virmani. 2000. Development of TGMS lines for developing two-line hybrids for the tropics. *Euphytica* **114:** 211-215.

Lu, X. G., S. S. Virmani, and Y. Rencui. 1998. Advances in two-line hybrid rice breeding. In *Advances in hybrid Rice Technology* (Ed S S Virmani, E. A. Siddiq, K Muralidharan). pp 89-98., IRRI, Manila, Philippines.

Oka, H. T., and H. Morishima. 1967. In: The ancestors of cultivated rice and their evolution. Japan: Department of Applied Genetics, National Institute of Genetics. pp 145-145.

Sarial, A. K. and V. P. Singh. 1999. Studies on stability of cytoplasmic male sterile lines and their floral traits influencing outcrossing in rice (*Oryza sativa* L.). *Indian Journal of Genetics and Plant Breeding* **59**(2): 149-157.

Singh, R. and B. Singh. 1998. Genetic variability in floral traits of 10 cytosterile lines of rice (*Oryza sativa*. L.). *International Rice Research Notes* **23**(3): 4.

Virmani, S. S. 2006. Hybrid rice. *Adv. Agron*. **57:**377-462.

Virmani, S. S. 2004. Prospects of hybrid rice in the tropics and sub-tropics. In: *Hybrid Rice Technology, New Developments and Future Prospects* (S. S. Virmani, ed). pp. 7-16. International Rice Research Institute, Manila, Philippines.

Virmani, S. S., B. C. Viraktamath, C. L. Casal, R. S. Toledo M. T. Lopes and J. O. Manalo. 1997. Hybrid Rice Breeding Manual. International Rice Research Institute. Los Banos, Laguna, Philippines. p: 1.

Yuan, L. P. 1966. A preliminary report on male sterility in rice. *Science Bulletin* **4:** 32-34.

Yuan, L. P. 1998. Hybrid rice breeding in China. In: *Advances in hybrid Rice Technology* (Ed S S Virmani, E. A. Siddiq, K Muralidharan). IRRI, Manila, Philippines. Pp 27-33.