Bangladesh Rice J. 19(1):57 – 61, 2015

Assessment of Appropriate Doses of GA_3 and Row Ratio for Better Seed Yield of a Promising Hybrid Rice Variety

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ABSTRACT

A field experiment was carried out at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur during dry season 2013-14 to find out the appropriate GA_3 dose and row ratio for hybrid seed production. GA_3 doses were applied @ 0, 80, 160, 240 and 320 g ha^{-1} with different row ratio. Results revealed that GA_3 application influenced the panicle exsertion rate only. The calculated optimum GA_3 dose was 302.4 g ha^{-1} with the highest PER (84.62%). Seed yield and OCR were influenced by row ratio. The highest OCR was observed with 2:12 row ratio while the highest seed yield was found in 2:14 row ratio.

Keywords: Row ratio, GA_3 doses, PER, OCR and F_1 seed yield

INTRODUCTION

Rice is the staple food of about half the world's population, of which more than 90% of the rice consumers inhabit in Asia (FAORAP and APSA, 2014). Therefore, rice plays an important role in ensuring food security, and contributing to poverty alleviation in Asia and the world. As the world's population continues to increase, there will be further increase of rice production to meet additional consumption.

Efforts to meet the rice needs can be done in two ways: expanding the rice growing area and increasing productivity, or both. But in the future, expansion will be more difficult and expensive. Substantial improvement can be done through the adoption of hybrid rice (Nguyen, 2010). Rice hybrids with a yield advantage of 20% were developed in China in the 1970s and are now cultivated in about 57% of the rice area in the country (Yuan, 2011). Hybrid rice has contributed significantly to food safety in China in the last 25 years. Following the success in China, Bangladesh has also started adopting hybrid rice technology since 1993 and able to develop own hybrid rice variety in 2001.

In Bangladesh, hybrid rice is developed following the three line systems. The weakness of this system is low level of F_1 seed production. The low rate of seed production due to lack of high panicle exsertion and low outcrossing rate of own developed CMS lines.

Application of GA_3 is an effective plant growth hormone, which stimulates the cells elongation. GA_3 is a key to obtain high seed yield in hybrid rice seed production. It can make increase panicle exsertion from the flag leaf, ncrease the rate of stigma exsertion, adjust plant height, increase the duration of floret opening and make the later tiller taller and productive (Virmani and Sharma 1993; Yuan *et al.*, 2003; Gavino *et al.*, 2008). Xu and Li (1988) reported 13% higher seed yield with application of GA_3 in rice.

Rahman *et al*., (2010) also reported similar results, while conducted experiments to study the influence of row ratio of restorer (R) and cytoplasmic male sterility (A) lines on seed production of hybrid riceTo enhance the efficiency of hybrid seed production, it is necessary to increase the yield of hybrid seed by improving the out crossing capacity of CMS lines (Shi-Hua *et al.*, 2006). The advantage of hybrid rice cannot be fully utilized unless a cost effective seed production system successfully developed. At present, use of Gibberellic acid (GA_3) is necessary for hybrid rice seed production, which increases the cost of hybrid seeds.Outside China this is quite expensive (more than US$ 1 per gram), because it is imported from China (Virmani *et al.*, 2007).

To overcome this problem, it is necessary to determine appropriate doses of GA_3 and row ratio for a promising hybrid rice combination for its commercial feasibility during seed production. The present study was undertaken to determine the appropriate doses of GA_3 and row ratio on hybrid seed production.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Bangladesh Rice Research Institute (BRRI), Gazipur, during dry season (November 2013 to May 2014). The restorer line (R) BRRI31R and CMS line (A) BRRI33A developed by the BRRI have been used as parent material.

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The line BRRI31R and BRRI31A mature after 148 days and 141 days respectively. The experimental design was factorial RCB with three replications. Thirty-day-old 3-4 seedlings of R and two seedlings of A lines were transplanted per hill. 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 2014, while A lines were transplanted on 8 January 2014 to satisfy the experimental requirements. Number of rows for different treatments was different, such as 2:6, 2:8, 2:10 2:12 and 2:14. To accommodate varying number of rows, plot size also varied accordingly. Row directions were perpendicular to wind direction. Urea, TSP, MP, gypsum, zinc, borax and cowdung were applied @ 270, 130, 120, 70, 10, 7 kg ha^{-1} and 15 t ha^{-1} respectively. One forth of urea and full doses of TSP, two third MP, full doses of gypsum, zinc, borax were applied at the time of final land preparation and cowdung was applied at the time of 1^{st} land opening and was mixed thoroughly with soil.

The rest of the urea were applied as top dress in three equal splits at 10-12 days after transplanting, active tillering stage and at panicle initiation stage with rest doses of MP (30 and 50-55 days after transplanting) respectively. Weeding was done as required of the field. To control the pests/diseases necessary measure were taken. Space isolation of 100 m 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. The GA_3 doses were applied @ 0, 80, 160, 240 and 320 g ha^{-1} respectively, at 5-10 and 30-35% of heading of parental lines as per treatment basis. 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. The crop was harvested when 80% of the seeds became golden yellow in colour. 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 panicle exsertion rate, out crossing rate and yield. Panicle exsertion rate and out crossing rate was measured using the following formula:

Panicle exsertion rate (PER)

$$PER(\%) = \frac{Length\ of\ exserted\ panicle}{Total\ length\ of\ panicle} \times 100$$

Outcrossing rate (OCR)

$$OCR(\%) = \frac{Number\ of\ filled\ grain}{Total\ number\ of\ spikelet} \times 100$$

RESULTS AND DISCUSSION

The analysis of variance indicated significant effect of GA_3 doses and row ratio for all the characters studied (Table 1). Panicle exsertion rate (PER), out crossing rate (OCR) and seed yield was significantly varied among the replications. This is in agreement with the findings of Biradarpatil and Shekhargouda (2006) and Tiwari *et al.,* (2011). Sharma and Virmani (1994) also recorded a positive effect of row ratio on outcrossing rate. Different row ratios of restorer and CMS lines significantly influenced the panicle exsertion rate, out crossing rate and seed yield of this hybrid combination. Interaction effect of level of GA_3 and different row ratios were also highly significant. The major limiting factors for economic hybrid seed production are low panicle exsertion and sufficient pollen availability at the time of anthesis (Soumia *et al.,* 2006).

Table 1. Analysis of variance for seed yield of a promising hybrid (BRRI33A / BRRI31R).

Source of variation	df	PER (%)	OCR (%)	Seed yield (t/ha)
Replication	2	7.32**	4.31**	0.227**
GA_3 level (A)	4	1292.13**	538.93**	9.89**
Row ratio (B)	4	61.64**	20.15**	0.21**
Interaction (A×B)	16	0.76**	2.03**	0.041**
Error	48	0.12	0.24	0.004

**Significant at the 1% level of probability PER (%)=Panicle exsertion rate; OCR (%)=Out crossing rate.

Panicle exsertion rate (%) increased with the increasing of GA_3 dose upto 240 g ha^{-1} then slightly decreased. However, the out crossing rate (%) and seed yield was not influenced by GA_3 doses. But different row ratios influenced the OCR and seed yield (Fig. 1). In control plot, panicle exsertion rate, out crossing rate and seed yield was the lowest. The application of GA_3 influenced panicle exsertion, spikelet opening angle and other floral traits, which increased outcrossing rate of CMS lines leading higher yield. Jagadeeswari *et al*., (1998) proposed that GA_3 application was inevitable but it should be applied with caution since higher doses are detrimental to seed quality.

The relationship between GA_3 application rate and PER (%) fit well in quadratic model (Table 2). The value of R^2 (0.95 to 0.98) indicated that 95 to 98% of the total variation in PER at different row ratio would be explained by the variation in applied GA_3 doses. However, the relationship between GA_3 with OCR and seed yield did not fit well in quadratic equation. The R^2 value for OCR ranged from 0.49 to 0.86 while for seed yield ranged from 0.38 to 0.79 (Table 2).

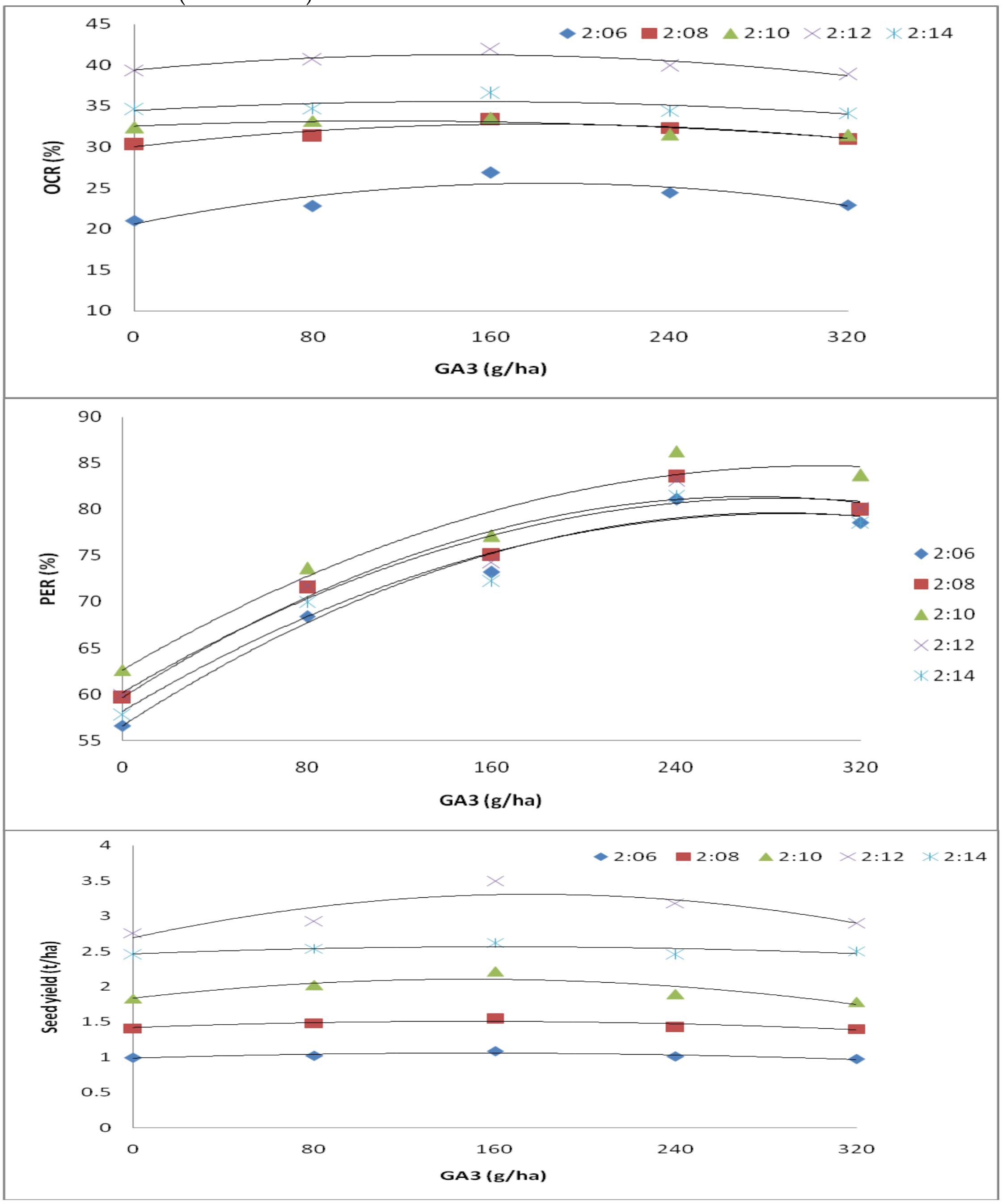

Fig. 1. Relationship between GA_3 rate and PER, OCR and seed yield at different row ratios.

Table 2. Quadratic regression equation for PER, OCR and seed yield.

Row ratio	Quadratic equation	R^2 value
	PER	
2:6	$Y=56.58714+0.16211x-0.00029x^2$	$R^2=0.97548$
2:8	$Y=59.68171+0.15918x-0.00029x^2$	$R^2=0.95653$
2:10	$Y=62.67029+0.14517x-0.00024x^2$	$R^2=0.95599$

2:12	Y=60.16571+0.14789x-0.00026x²	R^2 =0.94908
2:14	Y=58.13114+0.14870-0.00026x²	R^2 =0.94555
	OCR	
2:6	Y=20.66771+0.05339x-0.00015x²	R^2 =0.79186
2:8	Y=30.07114+0.03067x-0.00009x²	R^2 =0.86470
2:10	Y=32.52657+0.01079x-0.00005x²	R^2 =0.69414
2:12	Y=39.38286+0.02568x-0.00009x²	R^2 =0.83852
2:14	Y=34.43229+0.01577x-0.00005x²	R^2 =0.48774
	Seed yield	
2:6	Y=0.985429+0.00090x-0.000003x²	R^2 =0.788604
2:8	Y=1.414571+0.001186x-0.000004x²	R^2 =0.706939
2:10	Y=1.833429+0.003677x-0.000012x²	R^2 =0.781907
2:12	Y=2.462857+ 0.001191x-0.00000x²	R^2 =0.384052
2:14	Y=2.689714+0.007007x-0.000020x²	R^2 =0.751615

Table 3 presents calculated optimum dose of GA_3 in PER, OCR and seed yield coupled with estimated PER (%), OCR (%) and seed yield (t ha^{-1}). The calculated optimum level of GA_3 for PER at different row ratio ranged from 274.4 to 302.4 g ha^{-1} (Table 3). The highest GA_3 dose (302.4 g ha^{-1}) found in 2:10 row ratio with the highest PER (84.62%). Calculated optimum GA_3 dose for OCR at different row ratio ranged from 108 to 178 g ha^{-1}. The highest GA_3 dose (178 g ha^{-1}) found in 2:6 row ratio. However, the estimated OCR (%) was the highest (41.21%) with 2:12 row ratio.

Calculated optimum GA_3 dose for seed yield at different row ratio ranged from 148.3 to 175.2 g ha^{-1}. The highest GA_3 dose (175.2 g ha^{-1}) found in 2:14 row ratio with the highest (3.30 t ha^{-1}) seed yield. However, the quadratic relationships between GA_3 dose and OCR (%) as well as seed yield were poor (Fig. 1). The calculated optimum GA_3 dose for PER at different row ratio may be reliable, since the quadratic relationship was strong (R^2=0.95 to 0.98) (Table 2). From these equations the maximum estimated yield of 2:6, 2:8, 2:10, 2:12 and 2:14 row ratio were 1.05, 1.50, 2.11, 2.55 and 3.30 at 150.3, 148.3, 152.2, 148.8 and 175.2 g ha^{-1} respectively.

GA_3 play a key role in increasing the yield potential of hybrid rice seed production. Zheng *et al.,* (2011) found that suitable dosages of GA_3 application could improve the photosynthetic capacity, delay the leaf senescence increase PER and promote the rate of rice seed-setting. The major limiting factors for economic hybrid seed production are low panicle exsertion and sufficient pollen availability at the time of anthesis (Soumia *et al.,* 2006). Chowdhury *et al.* (2014) reported that GA_3 @100 ppm gave the highest fruit yield.

Table 3. Calculate optimum GA3 dose with estimated PER, OCR and seed yield at different row ratio.

Row ratio	Calculated optimum GA_3 dose for PER (g/ha)	Estimated PER (%)	Calculated optimum GA_3 dose for OCR (g/ha)	Estimated OCR (%)	Calculated optimum GA_3 dose for seed yield (g/ha)	Estimated seed yield (t/ha)
2:6	279.5	79.24	178.0	25.41	150.3	1.05
2:8	274.4	81.53	170.4	32.68	148.3	1.50
2:10	302.4	84.62	108	33.11	152.2	2.11
2:12	284.4	81.19	142.6	41.21	148.8	2.55
2:14	286.0	79.39	157.7	35.67	175.2	3.30

PER (%)=Panicle exsertion rate; OCR (%)=Out crossing rate.

CONCLUSIONS

Various levels of GA_3 application at different row ratio combinations significantly affected panicle exsertion rate. GA_3 dose did not influence the OCR and seed yield. However, different row ratios influenced the OCR and seed yield. Further research is necessary to confirm the present results.

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