Oryza Vol. 46. No.2, 2009 (145-148)

Identification of chemicals to maximize seed setting in hybrid rice

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ABSTRACT

Ten different chemicals including gibberellic acid (GA_3), combinations of , respectively GA_3 with other chemicals and control (water spray) were first sprayed at 15% panicle emergence and 24hrs after the 1st spray on female parental lines IR 62829A and CRMS 32A of two promising rice hybrids CRHR 1 and CRHR 5, to find out a suitable substitute to GA_3 for better panicle exsertion and seed setting in hybrid rice seed production plots. In general, plant height, panicle length, panicle exsertion, seed setting percentage and seed yield increased significantly over the control with the application of different chemicals. The increase was recorded highest under GA_3 application as well as treatments with GA_3 combinations as compared to other treatments and control. Though GA_3 application was found invariably to be more effective in obtaining higher seed setting and seed yield, GA_3 alone could be substituted by GA_3 combinations with other chemicals cheaper than GA_3 to reduce the cost of hybrid seed production.

Key words: *Hybrid rice, seed production, GA_3, alternative chemicals*

Hybrid rice is the latest proven technology to improve rice productivity. The major limiting factor for economic hybrid seed production is low panicle exsertion at the time of anthesis causing low out crossing rate and low seed setting in the cytoplasmic male sterile (CMS) lines. Most of the CMS lines currently used in hybrid seed production have poor panicle exsertion. Since the CMS lines based on the wild abortive (WA) cytoplasm are having imperfect panicle exsertion, at least 25-30% spikelets remain enclosed in the flag leaf thus reducing the total number of spikelets available for out crossing. Erect flag leaf of the CMS lines also obstruct the pollen transfer from pollen parent to the spikelets of the female parent at the time of supplementary pollination. Foliar application of GA_3 at panicle emergence is widely adopted to overcome these problems in hybrid seed production (DRR 1994). Application of GA_3 helps in exsertion of panicles completely through elongation of cells and also prolongs the receptivity of the stigma. Virakthamath (1995) suggested that to have maximum effect, GA_3 should be sprayed for two consecutive days at the time of heading. It has also been reported that GA_3 when applied at 15-20% panicle emergence stage gave best effects (Rangaswamy and Ponnuswamy 1998). It has been observed that, GA_3 when applied @ 45 to 225 g ha^{-1}, the panicle exsertion, flag leaf angle, spikelet opening angle and its duration and the stigma exsertion are increased (Jagadeeswari *et al*. 2004). As it takes 5-7 days for the panicles to emerge from all the tillers in rice plant, frequent spray of gibberellic acid was observed to improve the synchronised panicle exsertion from all the tillers as well as increase flag leaf angle to facilitate pollen transfer from the pollen parent to CMS parent. Since the cost of GA_3 is very high, alternative chemicals cheaper than GA_3 are being attempted in the present investigation to find out a suitable substitute to GA_3 for better panicle exsertion and seed setting in hybrid rice seed production.

MATERIALS AND METHODS

Field experiments were conducted during wet season (WS) 2002 and dry season (DS) 2003 in a randomized block design with two replications and in a 2:4 row ratio of restorers and CMS lines. Fifty percent dose of GA_3 was applied as foliar spray at 15% panicle emergence stage and the remaining 50% was sprayed after 24 hrs. Ten treatments (including control) of different chemicals and chemical combinations *viz*. T_1- Control water spray; T_2- GA_3 (30ppm+30ppm); T_3- Spent wash (20ml/lit); T_4- Brassinolides (0.3ppm); T_5- Brassinolides (0.3ppm) + GA_3 (30ppm); T_6- KH_2PO_4 (500g/ha); T_7-

KH_2PO_4 (500g/ha) + GA_3 (30ppm); T_8- Salicylic acid (100ppm); T_9- Salicylic acid (100ppm) + GA_3 (30ppm) and T_{10}- DAP (2%) + KCl (1%) + $ZnSO_4$ (0.5%) + Boric acid (0.2%) were sprayed at 15% panicle emergence and after 24 hrs of 1st spray on CMS lines IR 62829A and CRMS 32A for the hybrid combinations of two promising rice hybrids, CRHR 1 and CRHR 5, respectively developed at Central Rice Research Institute, Cuttack for favourable rainfed lowland situations. The chemicals were selected based on earlier research works (Murthy and Murthy, 1984: Awan *et al*., 1989; Krishnan *et al*., 1999) for increasing spikelet fertility, grain development and grain yield in rice. While spraying, care was taken to avoid drifting of the chemicals to adjacent plots. IR 62829A and its restorer line Gayatri were grown in both WS and DS, while CRMS 32A and the restorer line IR 42266-29-3R were grown in DS only. Supplementary pollination through rope pulling was done twice a day at peak anthesis time (9.30-11.30 hrs) for a week. Plant height was recorded after completion of flowering. Panicle length, panicle exsertion %, seed set percentage were recorded at maturity from 10 representative panicles of CMS lines IR 62829A and CRMS 32A. The plants were harvested row wise and seed yield of CMS lines were calculated on m^2 basis.

RESULTS AND DISCUSSION

There was significant increase in the parameters *viz*. plant height, panicle length, panicle exsertion, seed set percentage and seed yield in both the years (except panicle length in WS 2002) as influenced by application of GA_3 and GA_3 combinations (Table 1 and Table 2). The application of GA_3 increased the plant height of CMS line significantly. Increase of plant height due to elongation of the cells in three uppermost internodes is known to be caused by the application of GA_3 (Li and Yuan 2000). The plant height and panicle length were the highest in GA_3 treatment followed by Brassinolides and GA_3 combination indicating their effect in increasing panicle exsertion.

Incomplete panicle exsertion in CMS lines is one of the major constraints in hybrid rice seed production. Panicle exsertion increased significantly with GA_3 as compared to that with application of other chemicals. It increased from 74 % in control to 87% in treatments. Significant increase in panicle exsertion and panicle length with gibberellic acid application was also reported by Jagadeeswari *et al*. (1998). Halaswamy

Table 1. Effect of different chemicals on plant height, panicle length, panicle exsertion, seed set and seed yield in IR 62829A, wet season 2002 and dry season 2003

Treatments	Plant height (cm)		Panicle length (cm)		Panicle exsertion (%)		Seed set (%)		Seed yield ($g\ m^{-2}$)	
	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS
Control	67.6	70.7	20.3	22.7	70.1	74.0	17.5	21.4	72.9	94.5
GA_3 (30ppm+30ppm)	79.3	88.3	22.6	25.2	78.5	83.3	26.4	33.2	115.1	141.5
Spent wash (20ml lit^{-1})	70.2	78.6	20.8	23.3	71.9	76.5	18.8	23.1	81.3	103.3
Brassinolides(0.3ppm)	68.3	81.3	20.5	24.1	73.0	76.1	20.3	29.0	92.7	139.4
Brassinolides (0.3ppm) + GA_3 (30ppm)	71.3	84.2	21.5	24.5	77.2	81.9	23.4	30.6	101.2	140.0
KH_2PO_4 (500g ha^{-1})	71.2	80.1	20.7	23.2	71.9	75.8	17.7	23.1	84.7	109.6
KH_2PO_4 (500g ha^{-1}) + GA_3 (30ppm)	69.8	82.9	20.8	23.8	75.4	79.6	20.2	25.4	90.9	137.5
Salicylic acid (100ppm)	70.3	73.9	21.8	24.0	72.7	77.2	18.2	24.6	85.2	132.9
Salicylic acid (100ppm) + GA_3 (30ppm)	70.5	77.2	21.1	24.4	76.7	81.3	20.0	27.6	97.1	137.0
DAP (2%) + KCl (1%) + $ZnSO_4$ (0.5%) + Boric acid (0.2%)	69.5	76.7	21.4	23.3	74.5	77.4	19.2	26.4	86.0	123.5
Mean	70.8	79.4	21.2	23.8	74.2	78.4	20.2	26.4	90.7	125.9
CV (%)	1.9	2.1	5.3	3.1	3.9	3.6	6.2	5.3	9.2	5.3
CD (P=0.05)	3.1	2.9	NS	1.3	5.0	4.9	2.8	2.4	18.6	11.5

Table 2. Effect of different chemicals on plant height, panicle length, panicle exsertion, seed set and seed yield in CRMS 32A, dry season 2003

Treatments	Plant height (cm)	Panicle length (cm)	Panicle exsertion (%)	Seed set (%)	Seed yield (g m^{-2})
Control	71.0	23.5	75.5	21.3	153.1
GA_3 (30ppm + 30ppm)	92.2	26.3	87.4	37.2	276.5
Spent wash (20ml lit^{-1})	79.5	24.6	80.1	26.9	155.3
Brassinolides (0.3ppm)	83.0	25.3	81.4	28.9	217.4
Brassinolides (0.3ppm) + GA_3 (30ppm)	89.1	26.2	85.1	32.0	256.6
KH_2PO_4 (500g ha^{-1})	79.7	25.1	78.3	23.8	160.7
KH_2PO_4 (500g ha^{-1}) + GA_3 (30ppm)	84.0	25.2	82.7	25.3	186.1
Salicylic acid (100ppm)	79.2	24.9	77.5	23.9	173.1
Salicylic acid (100ppm) + GA_3 (30ppm)	88.6	25.1	80.3	28.1	193.3
DAP (2%) + KCl (1%) + $ZnSO_4$ (0.5%) + Boric acid (0.2%)	84.9	25.0	77.8	25.1	182.4
Mean	83.1	25.2	80.6	27.2	195.4
CV (%)	3.2	4.0	6.0	7.6	14.1
CD (P=0.05)	4.6	NS	NS	3.6	47.3

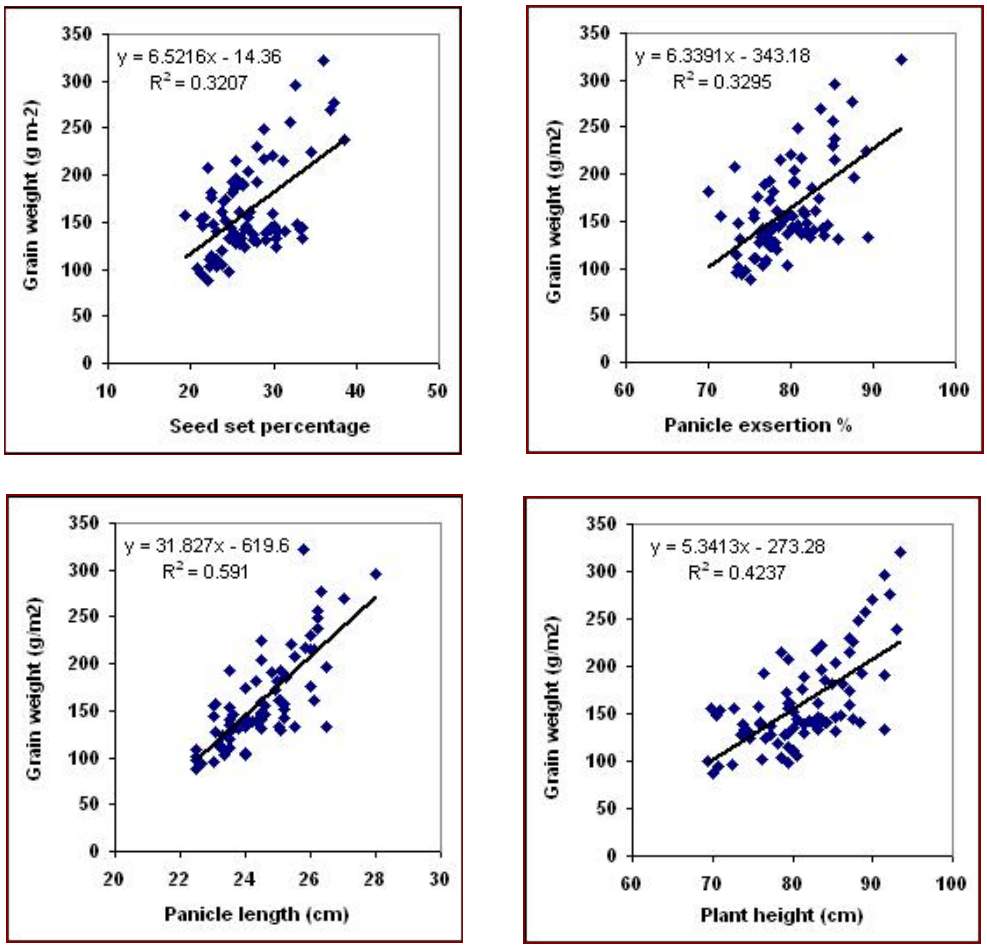

Fig 1. Correlation coefficient of seed yield with seed set percentage, panicle exsertion %, panicle length and plant height

et al. (1997) suggested that 60 ppm GA_3 at 50% flowering after clipping the flag leaf of 'A' line improved flowering synchronization between seed and pollen parent.

In general seed set percentage was low in all the treatments, but it was recorded significantly high in GA_3 as well as treatments with GA_3 combinations as compared to other treatments and control. However, maximum seed set percentage (37.2%) was observed in CRMS 32A during DS with GA_3 application. As compared to WS, seed set percentage was observed to be more in DS, which might be due to favourable weather conditions during dry season. During DS, maximum increase in seed set percentage was observed in GA_3 application which was 75% in CRMS 32A and 55% in IR 62829A. Increase in spikelet fertility or seed set percentage of CMS line due to GA_3 application was also reported by Jagadeeswari *et al*. (1998). Parmer *et al*. (1979) reported that stimulation of juvenile cells of the glumes by the application of GA_3 results in wider opening of the spikelet for longer duration leading to higher seed set percentage.

Significantly higher seed yield was obtained with GA_3 application followed by Brassinolides + GA_3 combination and then Brassinolides alone for both the CMS lines in both the seasons. However, seed yield increased up to 276 g in treatments as compare to 73 g in control and the increase over the control was higher in CRMS 32A (80%) than in IR 62829A (54%) (Table 2 and Table 1). Increase in seed set percentage and seed yield was due to better panicle exsertion, wide opening of the spikelet and increased stigma receptivity (Yuan and Virmani, 1988). Seed set percentage had a significant positive correlation with seed yield. Seed yield was also influenced by the extent of panicle exsertion, length of the panicle as well as height of the plant indicating positive correlations with these parameters (Fig 1), which corroborates with similar findings reported by Jagadeeswari *et al*. (2004).

From the above investigation it can be concluded that, though GA_3 application was invariably found to be more effective in obtaining higher seed setting and seed yield as compared to other chemicals, GA_3 alone could be substituted by GA_3 combinations with cheaper chemicals to reduce the cost of seed production in hybrid rice programme.

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