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Research Article

Effect of GA_3 and other chemicals for increased seed yield of cms lines in rice

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Abstract
The WA cytoplasm which leads to CMS in rice poses problem of poor panicle exertion. Hence foliar application of gibberellic acid (GA_3) at the start of panicle emergence has been widely adopted as an essential technique for enhancing panicle exertion in China and has been recognized as an integral component of hybrid rice seed production. An experiment was conducted to study the effect of GA_3 and other chemicals to economize the dose of GA_3 for higher grain yield in CMS lines in rice. The highest seed yield of CMS lines can be obtained with the application of GA_3 30 g / ha + Nutragold. The same treatment also recorded the highest productive tillers per plant, panicle length, panicle exertion per cent and seed setting per cent. Application of GA_3 alone or in combination with boric acid, KH_2PO_4, Nutragold and Nutragold alone improves the expression of floral characters promoting better seed set on CMS parent.

Key words
Rice, GA_3, CMS

Introduction

Most of the commercial rice (*Oryza sativa* L.) hybrids are based on cytoplasmic male sterile (CMS) lines having WA cytoplasm. The CMS lines had poor panicle exertion
which is a major problem in hybrid rice seed production, associated due to physiological mechanism (Duan and Ma, 1992). Poor panicle exertion is caused by poor elongation of the last internode just below the panicle. Increased seed yield can be witnessed, if the panicle exertion is increased thereby facilitating more number of spikelets for seed setting. Shengqui (1988) proposed application of GA_3 for better panicle exertions in the CMS lines.

Foliar application of gibberellic acid (GA_3) at the start of panicle emergence has been widely adopted as an essential technique for enhancing panicle exertion in China and has been recognized as an integral component of hybrid rice seed production. Manipulation with chemical such as GA_3 is found to be successful in China (Pillai, 1996). High dose of GA_3 (180 g / ha) for seed production is being used in China to achieve an average seed yield of 2.8 tonnes / ha. The GA_3 which is a costly chemical, increases seed cost. In India 45 g / ha of GA_3 has been recommended for hybrid seed production to obtain 1.0 - 1.5 tonnes / ha of seed yield. This necessitates the need for optimizing the GA_3 dose to obtain economically viable seed yield levels of 2.0 - 2.5 tonnes / ha. Hence, identification of cost effective alternative is the prime need. Considering the importance of rice (*Oryza sativa* L.), the present investigation was undertaken with the objective of studying the effect of GA_3 and other chemicals for increased seed yield of parental line.

Material and methods

The experiment was conducted during the wet season-2007 at Main Rice Research Station, Anand Agricultural University, Nawagam, Gujarat. The material used in the study consisted of cytoplasmic male sterile (CMS) line IR 58025A of indica rice (*Oryza sativa* L.) and its maintainer line IR 58025B, in order to see the effect of GA_3 and other chemicals for its maintenance.

IR 58025A (A line) and IR 58025B (B line) were used as seed and pollinator parents, respectively for CMS seed multiplication. The experiment was conducted in randomized block design with three replications and a row ratio of 2 : 8 of maintainer and CMS lines was used. The net plot size was 3.0 x 1.90 m^2. The A lines were planted at a distance of 15 cm between two rows. The B lines were planted at a row to row distance of 30 cm. The distance between B line and first A line was kept 20 cms. The plant to plant spacing was kept to 15 cm in both A and B lines.

The following seven treatments were tested :

T_1 = Control
T_2 = GA_3 45 g / ha
T_3 = GA_3 30 g / ha + 1 % Boric acid
T_4 = GA_3 30 g / ha + KH_2PO_4 20 g / ha
T_5 = GA_3 30 g / ha + Nutragold
T_6 = Nutragold
T_7 = GA_3 60 g / ha

Nutragold is a growth promoter from Cippy Bio-international. Different concentration of GA_3 were applied in two splits i.e. 40 % at 10 - 20 % panicle exertion and the remaining 60 % on the next day. GA_3 requirement for each plot was calculated according to the treatment. It was dissolved first in 70 per cent ethanol @ 20 ml ethanol / g of GA_3 and the final volume was made with water.

Nutragold was sprayed at the dose of 4 ml solution for 1 liter water to the area of 1 m^2. Nutragold, boric acid and KH_2PO_4 were dissolved in water and sprayed as per the treatment. To avoid drift losses, spraying was carried out in the late evening hours. The observations from the CMS lines of the treated plots were recorded for the seven characters *Viz;* Flag leaf angle, Plant height (cm), Productive tillers per plant, Panicle length (cm), Panicle exertion (%), Seed setting (%) and Grain yield per 10 plants (g).

Result and discussion

Foliar spray of gibberellic acid increases panicle exertion and also alter the floral biology, which enhances seed setting and ultimately yield of CMS line (A line). The results of present study carried out on effect of different chemicals on traits favouring out crossing in CMS line IR 58025A are presented in Table 1.

In the present study, there was an increase of flag leaf angle from $42^0$36' in control to $66^0$17' in the treatment of GA_3 60 g/ha. Application of KH_2PO_4, boric acid and Nutragold in combination with GA_3 30 g/ha and GA_3 45 g /ha resulted in significant increase of flag leaf angle over untreated plot. Maximum plant height of 120.27 cm was recorded in the application of GA_3 60 g/ha followed by GA_3 45 g/ha (118.53 cm). Nutragold, boric acid and KH_2PO_4 with GA_3 30 g/ha also increased plant height over control. Combination of Nutragold and GA_3 30 g/ha recorded the highest productive tillers per plant followed by combination of GA_3 30 g /ha with KH_2PO_4 and GA_3 30 g /ha with boric acid. All the treatments of GA_3 i.e. GA_3 alone and 30 g /ha in combination with other chemicals recorded significantly higher panicle length than control. In CMS line 'IR 58025A' an average of 66-67% panicle exertion was observed. Application of GA_3 45 g / ha, GA_3 60 g /ha and GA_3 30 g / ha + Nutragold significantly increased panicle exertion. With the application of GA_3 30 g /ha + Nutragold, panicle exertion increased by 10 %. Highest seed setting per cent of 38.87 % was observed in GA_3 60 g / ha followed by GA_3 30 g / ha + Nutragold (38.47 %) and Nutragold (37.37%). GA_3 30 g /ha in combination with boric acid and KH_2PO_4 also increased seed setting per cent over control. Highest grain yield of 104.67 g per 10 plants was recorded in the application of GA_3 30 g /ha + Nutragold, followed by 93.67 g and 93.00 g from GA_3 60 g / ha and Nutragold alone, respectively. GA_3 30 g/ha + KH_2PO_4, GA_3 30 g /ha + boric acid and GA_3 45 g / ha also yielded significantly higher grain yield over the control plot.

In hybrid rice seed production transfer of pollen from the pollinator to seed parent is crucial to attain a higher seed set in the female parent. Rice being an autogamous plant, the normal outcrossing rate is low, varying from 0 to 6.8% in *Oryza sativa*. However, outcrossing up to 55.9% is known in the wild species of *Oryza* e.g. *O. perennis* and 0 to 44% in male sterile lines of rice (*O. sativa*) (Athwal and Virmani, 1972). Hence, to augment pollination in the CMS lines, rope pulling or shaking of pollinator rows with a bamboo stick is followed. These methods create a pollen mass over the pollinator rows, which is transferred through the wind to the adjoing seed parent row. Erect and long flag leaves act as a barrier to the pollen flow. To tackle this problem in seed production plots, flag leaf clipping is usually practiced.

However, this technique is labour intensive and costly, besides affecting the photosynthetic potential and enhancing the possibility of spreading diseases. Application of GA_3 elongates the cells in the upper side of the leaf at collar region which facilitates flattering of the flag leaf (Srivastava *et al.,*1972), thus allowing better movement of pollen, and it cause better seed set and directly increases the grain yield. The CMS lines have poor panicle exertion due to poor elongation of last internode just below the panicle. Application of GA_3 promotes panicle exertion (Yuan, 1977 and Shengqui, 1988).

In the present study, there was the highest flag leaf angle in the application of GA_3 60 g /ha. This contributed to a more even and smooth flow of pollen from pollinator to seed parent in GA_3 treated plots leading to a higher seed set. It was obvious that plant height was increased by GA_3 application and it was maximum at 60 g / ha. The increase in plant height with the application of GA_3 has been ascribed to elongation of cells in the three uppermost internodes (Li and Yuan, 2000). Sharma (1991) reported that the seed set in hybrid seed production plots was highly influenced by panicle exertion of CMS female parent. In order to enhance panicle exertion leading to higher grain yields, application of Gibberellic acid (GA_3) 30 g /ha + Nutragold gave the highest productive tillers per plant, panicle length and panicle exertion. Nutragold, a mixture of plant extracts in combination with GA_3 which has shown a synergistic effect in elongation of cells, leading to better panicle exertion than GA_3 @ 45 g /ha and 60 g /ha. There was an increase in percentage seed set with every incremental dose of GA_3 from 45 g to 60 g. Application of 30 g GA_3 in combination with nutragold represent the same seed set percentage as higher dose of 60 g GA_3 / ha. Also it has the highest grain yield than the application of GA_3 60 g / ha and other combined effect of 30 g GA_3 + boric acid, 30 g GA_3 + KH_2PO_4 and alone application of Nutragold and GA_3 45 g /ha. Thus, application of GA_3 30 g / ha + Nutragold is best among all the treatments as reflected by the highest grain yield, productive tillers per plant, panicle length, panicle exertion per cent and seed setting

per cent. Nutragold is cheaper than the GA_3, so it reduces the cost of seed production. Similar findings have been reported by Ponnuswamy and Prabagaran (1997), Ponnuswamy *et al.,* (1998), Singh (1999), Manzhong and Zaman (1999), Kalavathi *et al.,* (2000), Pandey *et al.,* (2003) and Jagadeeswari *et al.,* (2004). Thus, the present results are in confirmity with the work done by the earlier workers.

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Table 1. Effect of GA_3 and other chemicals on important traits in CMS line IR 58025A

Treatment	Flag leaf angle	Plant height (cm)	Productive tillers per plant	Panicle length (cm)	Panicle exertion (%)	Seed setting (%)	Grain yield per 10 plant (g)
Control	$42^0 36`$	110.82	7.20	24.00	62.68	22.50	76.24
GA_3 45 g/ha	$57^0 63`$*	118.53*	7.53	25.50 *	68.83 *	23.83	83.00 *
GA_3 30 g/ha + 1 % Boric acid	$58^0 23`$*	117.97*	7.93 *	24.80 *	66.57 *	32.77 *	85.33 *
GA_3 30 g/ha + KH_2PO_4 20 g /ha	$61^0 77`$*	116.70*	7.97 *	24.60 *	65.73 *	33.23 *	91.33 *
GA_3 30 g/ha + Nutragold	$58^0 60`$*	150.87*	8.83 *	25.80 *	71.77 *	38.47 *	104.67 *
Nutragold	$44^0 53`$	116.43*	7.73 *	25.63 *	63.53	37.38 *	93.00 *
GA_3 60 g/ha	$66^0 17`$*	120.27*	7.60 *	25.77 *	69.53 *	38.87 *	93.67 *
General mean	$55^0 31`$	116.37	7.82	25.15	66.94	32.43	89.61
CD value (p = 0.05)	3.98	1.54	0.38	0.57	2.14	3.85	4.57

* = Significant at the level of 5 %.