International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 184-191

Received: 26-08-2020
Accepted: 02-10-2020

Ajay Kumar
Seed Technology Section, ANDUA&T, Kumarganj, Ayodhya, Uttar Pradesh, India

RDS Yadav
Professor/Head, Department of Genetics and Plant Breeding, ANDUA&T, Kumarganj, Ayodhya, Uttar Pradesh, India

Jai Prakash Gupta
Assistant Professor, School of Agriculture, ITM University, Gwalior, Madhya Pradesh, India

Corresponding Author:
Ajay Kumar
Seed Technology Section, ANDUA&T, Kumarganj, Ayodhya, Uttar Pradesh, India

Optimization of GA_3, DAP and boric acid for maximizing seed yield and its quality parameters in hybrid rice

Ajay Kumar, RDS Yadav and Jai Prakash Gupta

DOI: https://doi.org/10.22271/chemi.2020.v8.i6c.10767

Abstract
The investigation was undertaken with rice hybrid NDRH-2 by accommodating a number of treatments *viz*., IR58025A, IR58025B, NDR3026-3-1R, foliar application of alone and combination doses of GA_3 60,90 and 120 g/ha, DAP 1%, 2% and 3%, Boric acid 0.1%, 0.2% and 0.3% applied over CMS line days after anthesis (DAA) (10, 20, 30 and 40 days), seed treatment with thiram (2.5g/kg seed) at Student's Instructional Farm and Seed Testing Laboratory (STL) of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya during *Kharif* 2015-*Kharif* 2017. The experiment was laid out in Randomized Block Design (RBD) with three replications along with focusing observations on leaf numbers, plant height (cm), days to 50% heading, panicle exsertion (%), panicle length (cm), seed set (%) and yield (q/ha) were taken during the investigation. Application of GA_3@120g/ha+ DAP@2% +Boric acid@0.2% was optimized for maximizing the seed setting (32-33%), panicle exsertion (90-92%) and finally considerably seed yield (22-24 q/ha) which need to be experimented for CMS line IR58025A multiplication and hybrid seed production of rice hybrid NDRH2 in particular and as other promising hybrids in general.

Keywords: Hybrid rice, foliar application, NDRH-2

Introduction

Hybrid rice technology is likely to play a key role in increasing the rice production. In India during the year 2019, hybrid rice was planted in an area of about 3.0 million ha. Out of which more than 80% of the total hybrid rice area is in the states of Uttar Pradesh, Jharkhand, Chhattisgarh, Madhya Pradesh, Odisha and Haryana which is expected to spread in other States and Union Territory of the country. It's a matter of concern to note that area under hybrid rice remains @3 m.ha since 2016 and it may be due to unfavourable monsoons at the beginning of crop season (every year) besides factors like inadequate yield heterosis etc., Research efforts are intensified to address these challenges with the active involvement of public as well as private sector organizations.(Anon.-2019) [2] As rice is a key source of livelihood in eastern India, a considerable increase in yield through this technology has a major impact on household food and nutritional security, income generation, besides an economic impact in the region. In view of this, hybrid rice has been identified as one of the essential component under the National Food Security Mission (NFSM) launched by the Government of India (GOI). The approach is to bridge the yield gap in respect of rice through dissemination of improved technology and various management practices.

NDRH2 has been released in 1998 by State Variety Release Committee and notified by notification no. 425 (E8-6-1998). Its pedigree is IR-58025A as female parent and NDR-3026-3-1R as restorer parent. The duration of IR 58025 A is around 120 days whereas, the duration of restorer (NDR 3026-3-1 R) is around 130-135 days.

Thus the main constraint for hybrid seed production of $NDHR_2$ is non-synchronization of flowering between its parental lines. Secondly the panicle exsertion of CMS line (IR-58025A) rest around about 75% and thirdly, the storability of hybrid seed is comparatively poor. The background of NDHR2 exhibited 1 cm plant height, good threshebility, 250-275 fertile grain bearing panicle, profuse tillering, slight aroma present after cooking, 120-130 days maturity and producing grain yield 65-70 q/ha. (Anon.-2006) [1].

The need and importance of rice is increasing day by day due to the increase in human population. Conservative estimate indicated that by 2050, we need to enhance rice production by almost another 50 million tonnes, to current production level to meet the dietary requirement of ever growing population. It would be herculean task to meet the rice requirement of the future, in the backdrop of declining land, water scarcity, labour and environment concern. To meet this challenge, current level of the productivity i.e. 2.2 tonnes /ha has to be increased to the level of 3.0 tonnes/ha in irrigated ecosystem and from 1.0 to 1.5 tonnes/ha in stress environment. Therefore, enhancing the productivity of rice is crucial for national food security and also for economic development, we need to redesign, develop and grow the hybrids of rice.

Materials and methods

The experiment was conducted at Instructional Farm of Acharya Narendra Deva University of Agriculture & Technology Narendra Nagar (Kumarganj), Ayodhya during *Kharif* season 2015-2017. Geographically this place is situated at latitude 26.54^{0}N and longitude 81.83^{0}E and an altitude of 113 meter above the sea level. The Experimental materials consisted the parental lines of rice hybrid NDRH 2; wild abortive CMS line (IR58025A) along with its maintainer (IR58025B) in CMS multiplication and same CMS line with a restorer (NDR 3026-3-1). The nature of CMS line is wild abortive (WA) type, developed at IRRI, Manila, Philippine, which is used as female parent and the duration of its maturity is 110-115 days. Maintainer line (IR58025B) is an isogenic line of IR58025A but matured comparatively earlier to its A line. A promising fertility restorer *viz,.* NDR3026-3-1, developed at ANDUA&T Kumarganj, Ayodhya having medium duration (120-125 days). Healthy and uniform seeds of each line were presoaked in water over night and thereafter kept in shadow covered with wetted gunny bags to get seeds sprouted and broadcasted uniformly in well prepared wet nursery beds during *kharif* 2015. 21 days old seedlings were transplanted in synchronization behaviour between parental lines (A×B & A×R) planted on the basis of leaf growth rate were critically observed. in variably, seeding were prepared during first week of June every year and 21-25 days old seedings were transplanted by accommodating single seedling per hill in a planting ratio of 2:10 for A×B system and 2:12 for A×R system, in 2.65m×2.00m plot size for maintenance of CMS line (A×B) and 2.95m×2.00m for hybrid seed production (A×R) with the spacing (row and plant), row to row-male×male:30cm, male×female:20cm, female×female:15cm and plant to plant:10cm adopted perpendicular to wind direction in a randomized block design with three replications for both years. Fertilizers (NPK/ha)@120:60:40 and 25 Kg/ha $ZnSO_4$ were applied at proper stages of crops. Foliar spray is applied at panicle initiation stage GA_3 60, 90 and 120 g/ha, DAP 1%, 2% and 3%, Boric acid 0.1%, 0.2%and 0.3% alone and in combinations over female lines of A×B and A×R systems. An isolation distance kept for 400m from the adjoining rice experimental plots and nearby grown rice fields to avoid genetic contaminations and physical admixture of seed. Other agronomical practices such as weeding, rouging, plant protection measures and supplementary for pollination were followed time to time to raise an ideal crop.

Details about the treatments

Treatment	Treatment detail	Treatment	Treatment detail
T_0 (Control)	Control	T_{32}	2% DAP+0.2% BA
T_1	60g GA_3	T_{33}	2% DAP+0.3% BA
T_2	90g GA_3	T_{34}	3% DAP+0.1% BA
T_3	120g GA_3	T_{35}	3% DAP+0.2% BA
T_4	1% DAP	T_{36}	3% DAP+0.3% BA
T_5	2% DAP	T_{37}	60g GA_3+1% DAP+0.1% BA
T_6	3% DAP	T_{38}	60g GA_3+1% DAP+0.2% BA
T_7	0.1% BA	T_{39}	60g GA_3+1% DAP+0.3% BA
T_8	0.2% BA	T_{40}	60g GA_3+2% DAP+0.1% BA
T_9	0.3% BA	T_{41}	60g GA_3+2% DAP+0.2% BA
T_{10}	60g GA_3+1% DAP	T_{42}	60g GA_3+2% DAP+0.3% BA
T_{11}	60g GA_3+2% DAP	T_{43}	60g GA_3+3% DAP+0.1% BA
T_{12}	60g GA_3+3% DAP	T_{44}	60g GA_3+3% DAP+0.2% BA
T_{13}	90g GA_3+1% DAP	T_{45}	60g GA_3+3% DAP+0.3% BA
T_{14}	90g GA_3+2% DAP	T_{46}	90g GA_3+1% DAP+0.1% BA
T_{15}	90g GA_3+3% DAP	T_{47}	90g GA_3+1% DAP+0.2% BA
T_{16}	120g GA_3+1% DAP	T_{48}	90g GA_3+1% DAP+0.3% BA
T_{17}	120g GA_3+2% DAP	T_{49}	90g GA_3+2% DAP+0.1% BA
T_{18}	120g GA_3+3% DAP	T_{50}	90g GA_3+2% DAP+0.2% BA
T_{19}	60g GA_3+0.1% BA	T_{51}	90g GA_3+2% DAP+0.3% BA
T_{20}	60g GA_3+0.2% BA	T_{52}	90g GA_3+3% DAP+0.1% BA
T_{21}	60g GA_3+0.3% BA	T_{53}	90g GA_3+3% DAP+0.2% BA
T_{22}	90g GA_3+0.1% BA	T_{54}	90g GA_3+3% DAP+0.3% BA
T_{23}	90g GA_3+0.2% BA	T_{55}	120g GA_3+1% DAP+0.1% BA
T_{24}	90g GA_3+0.3% BA	T_{56}	120g GA_3+1% DAP+0.2% BA
T_{25}	120g GA_3+0.1% BA	T_{57}	120g GA_3+1% DAP+0.3% BA
T_{26}	120g GA_3+0.2% BA	T_{58}	120g GA_3+2% DAP+0.1% BA
T_{27}	120g GA_3+0.3% BA	T_{59}	120g GA_3+2% DAP+0.2% BA
T_{28}	1% DAP+0.1% BA	T_{60}	120g GA_3+2% DAP+0.3% BA
T_{29}	1% DAP+0.2% BA	T_{61}	120g GA_3+3% DAP+0.1% BA
T_{30}	1% DAP+0.3% BA	T_{62}	120g GA_3+3% DAP+0.2% BA
T_{31}	2% DAP+0.1% BA	T_{63}	120g GA_3+3% DAP+0.3% BA

Observations recorded
Ten competitive plants were selected at random in each plot for recording observations on leaf numbers, plant height (cm), days to 50% heading, panicle exsertion (%), panicle length (cm.), seed set (%) and yield.

Leaf numbers
The number of leaves per plant was counted by randomly selected 10 plants of each parental lines till flag leaf stage.

Plant height (cm)
The plant height of the plant was measured with the help of a scale from the ground to the tip of panicle on the main culm at maturity.

Days to 50% heading
The number of days taken from sowing to blooming in 50% of plants in each plot was recorded as days to 50% heading/flowering.

Panicle exsertion (%)
Ten panicle (one panicle from each hill) were randomly selected from each plot to determine the panicle exsertion (%). The length of panicle outside the flag leaf and total panicle length was measured using a scale. The percent of panicle exsertion was computed as:

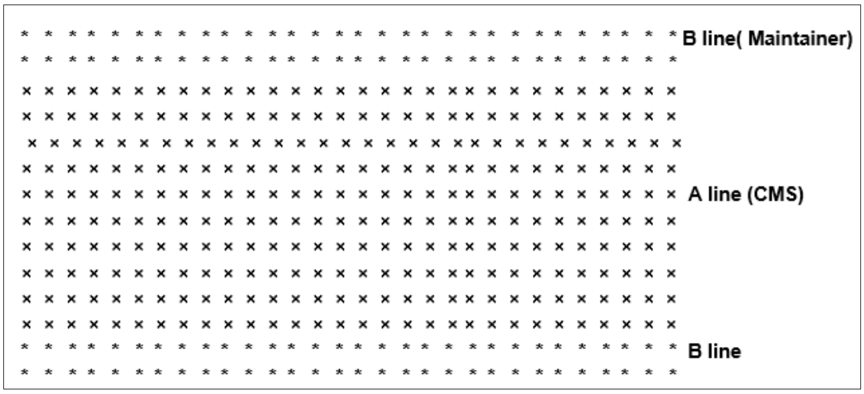
$$\text{Panicle excretion (\%)} = \frac{\text{Length of panicle emerged outside the flag leaf}}{\text{Total length of panicle}} \times 100$$

Panicle length (cm)
The ten spikes were randomly selected from previously selected plants and their lengths were measured in cm from the base of ear to the tip of the last spikelet and average values were recorded.

Seed set (%)
Ten panicles, one from each hill, were selected randomly from each plot. The number of filled spikelets and unfilled spikelets were counted separately and data were used to calculate seed set (%) as:

$$\text{Seed set (\%)} = \frac{\text{Number of filled spikelets}}{\text{Total number of spikelets}} \times 100$$

Seed yield (q/ha)
A, B and R line seed harvested separately and measured in q/ha.



Male × Male: 30 cm
Male × Female: 20 cm
Female × Female: 15 cm
Plant to plant: 10 cm

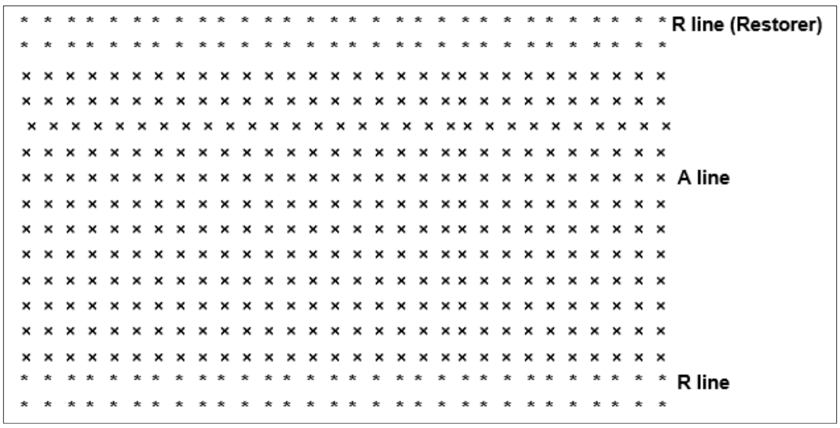


Fig 1: Figure, showing spacing and row ratio of 2:10 (CMS and Maintainer) and 2:12 (CMS and Restorer)

Results and Discussion
Since hybrid rice seed production has emerged as a major profit earning enterprise, it is worthwhile to explore ways to bring down the cost of seed production per unit area. GA_3 application promotes better expression of characters favoring better seed set in the female CMS line (Duan and Ma, 1992; Ponnuswamy and Rangaswamy, 1996; Jagadeeswari *et al*., 1998 and Pandey *et al*., 2003) [3, 4, 9, 7]. However, GA_3 is an expensive chemical and determination of its optimum dose of application and substituting its application wholly or partly

with other available cost effective chemicals can help the resource poor Indian farmers to reduce the cost of hybrid rice seed production.

Application of GA_3 had shown significant effect on the expression of various morphological and floral characters such as plant height, panicle exsertion, seed set and single plant yield in the present investigation. CMS parent IR 58025 A is shorter than its maintainer line IR 58025 B, on an average by 20 cm. Duan and Ma (1992) [3] reported a highly significant positive correlation between GA_3 dosage and plant height.

Leaf number of a genotype remains relatively stable over seasons and locations and between the parental lines. However, leaf growth rate varies widely with variety, stage of the crop, season and location (Viraktamath, 2004; Yadav *et al*., 2002) [13, 15]. As such, the CMS line IR 58025 A exhibited an average of 18.68 and 19.34 leaf number whereas it maintainer possessed 17.87 and 18.32 leaf numbers. Besides, the restorer NDR 3026-3-1 has 22.82 and 23.36 leaf number per plant for year *Kharif* 2015 and 2017. The results clearly revealed that there was a considerable difference for leaf number between IR 58025 A and NDR 3026-3-1 and relatively less between IR 58025 A and IR 58025 B. These leaf number differences have been employed in determining the seeding interval of these parental lines for getting perfect synchronization.

Plant height acts as a principal factor for enhancing the out crossing potential by aiding the easy pollen dispersal. As a rule, the seed parent should be shorter in comparison to pollen parent. Natural height difference of 15-20cm between seed and pollen parents had been emphasized by (Yadav *et al*., 2002) [15]. The CMS line IR 58025 A expressed its height as 86.94 cm whereas its maintainer showed 90.93 cm height. The restorer NDR 3026-3-1 attained its 113.14 cm plant height. Thus, these parental lines possessed their desirable plant height leading to enhance pollen dispersal.

Seeding intervals leading to synchronized flowering

Synchronization of flowering in hybrid seed production means that both the male and female parents come to flower at the same time, even though they differ in their growth duration. It is quite common that the parental lines of hybrids generally differ in their growth duration. It is rare to find the parental lines having the same growth duration. It is observed that in some cases, the extent of heterosis is quite higher when the parents differ significantly in their growth duration. In China, the difference in growth duration of some parental lines is more that 35 days. But for successful seed production, it is desirable that the difference in growth duration of parental lines is not more than 15 days. Besides, the synchronization in flowering date, synchronized anthesis is also equally important to ensure higher seed yields.

For better synchronization, we generally accord that the male and female parents should come to flowering at the same time. But in field, it is desirable if the female parent flowers a day or two days earlier than the male parent. This is because the stigma remains receptive 2-3 days after flowering so that it can receive pollens from the male parent even later. On the other hand, if male parent flower early, it sheds pollen and by the time the female parent comes to flower, most of the pollen are become either unviable or shed. Male parent coming to flowering much earlier than female parent is not an acceptable signal which should be avoided. Failure to obtain good synchronization may result in very low or no seed yield at all as the seed set on female parent, to a great extent depend upon the pollen supplied from the male parent. Hence, it is aptly said “half the success is achieved if one is able to get perfect synchronization in flowering between parental lines”.

Synchronization in flowering can easily be obtained by sowing and planting on the same day if parents have the same growth duration. But in other cases, if the parents are sown on the same day, they do not synchronize. When the parents differ in their growth duration, synchronization can be obtained by sowing the parental seed on different dates so as to come ensure that their flowering coincides perfectly. This is called staggered or differential sowing or seeding and it is the primary strategy to obtain synchronization in flowering.

When the parents are sown on the same day, they take different days for flowering. This difference in growth duration is called as seeding interval. It is necessary to precisely determine the seeding intervals between the parental lines before embarking on large-scale seed production. Seeding intervals can be determined by the three methods as growth duration differences, leaf number difference and effective accumulated temperature. The growth duration difference method is simple and most popular method for determining seeding interval used by the breeder as he has to deal in the several cross combinations. It is widely followed by the commercial seed growers. In this method, the seeding interval is calculated between the two parental lines in respect of number of days taken by them from date of sowing to date of flowering (initial or 50 per cent flowering). After determining the seeding interval, as a general rule, in the initial years, R-line is seeded two or three times at an interval of 3-4 days to ensure the supply of pollens from male parent to female parent for a longer period during flowering, while the A-line is selected only once at a seeding calculated from the second date of R-line sowing.

Accordingly, in the present investigation, the staggered seeding of NDR 3026-3-1 were determined. The second seeding of NDR 3026-3-1 was done on 4th day and third seeding on 7th day from its first seeding under A×R system. Besides, in the case of A×B system, the second seeding of IR 58025 B was done on 5th day from seeding of IR 58025 A line. Leaf number difference between two parents is also determined in same way as that of growth duration difference, which is indicated by the number of leaves, produced by earlier sown parent at a time when second parent is sown. In a 10-division method of counting leaves, the value for growing leaves an assigned with reference to the fully opened previous leaf. The ratings for the 3-division method are 0.2 for the leaf just emerged, 0.5 for half opened and 0.8 for fully opened leaf (Viraktmath, 2004) [12]. Hence forth, the seeding of the IR 58025 A was done at the stage when the NDR 3026-3-1 attained around two and half leaves for A x R system. Besides, under A x B, the seeding of IR 58025 B was done about at half leaf stage of IR 58025 A Viraktamath *et al*. (1998) [13] advocated about the leaf numbers as a reliable parameter for determining seeding intervals between parental lines in hybrid rice seed production. Further, Biradarpatil and Shekhargoud (2006) [6]; and Yadav *et al*. (1998) [16]; also utilized this parameter while conferring the synchronization in flowering of their respective hybrid combinations.

Standardization of optimum dose of GA_3 application and substituting with other chemical

The rice hybrids so far commercially developed in our country are generally based on wild abortive cytoplasmic male sterile (CMS) lines. Such CMS lines possess very short inter node below the panicle neck, which causes its low panicle exsertion. The CMS line IR 58025 A as involved in the present investigation does not exsert about 25 per cent of its panicles. To overcome this problem, different approaches such as splitting and open the leaf sheath manually, spraying of GA_3, DAP, Boric acid, etc. singly and or in combinations along with practices such as leaf clipping and rope pulling were tried earlier (Virmani *et al*., 1991; Yadav *et al*., 1998) [14, 16]. Out of these practices, application of GA_3 for making maximum panicle exsertion is only option. The Optimum dose and proper stages of its application are rather important. Therefore, in the present investigation 3 doses of GA_3, DAP and Boric acid along with controls were applied at three stages of crop growth namely, panicle initiation, boot leaf stage and 5-10 per cent heading stage. The days to 50 per cent flowering of IR 58025 A was found to be hastened maximum by increasing the doses of GA_3 applied at panicle initiation stage followed by boot leaf stage whereas its effect were measurable at 5-10 per cent heading stage. Similar results have also been reported by Yadav *et al*. (2002) [15]. Besides, the application of GA_3 with respect to the plant height was more when its applications were followed at an early stages of crop growth i.e. panicle initiation stage in comparison to late stage of growth i.e., 5-10 per cent heading stage. Whereas, slightly increasement for the number of productive tillers per plant was appeared when the various doses of GA_3 was applied at panicle initiation stage. Yadav *et al*. (2002) [15] also reported that the effect of GA_3 on plant height, panicle length and length & width of flag leaves of A lines.

The panicle length of the CMS line IR 58025 A was increased significantly with increasing the doses of GA_3 at all the stages of crop growth. The response of GA_3 was maximum at panicle initiation stage with the application of GA_3 @120g/ha+DAP@2%+boric acid@0.2% Whereas, it was comparatively low but quite considerable at 5-10 per cent heading stage. Increased panicle exsertion from flag leaf after the application of GA_3 has also been reported by several workers (Duan and Ma, 1992; Jagadeeshwari *et al*., 1998; Pandey *et al*., 2003; and Yadav *et al*. 2002) [3, 15, 7,]. The maximum percentage of seed set was observed at the dose of GA_3@120g/ha+ DAP@2%+ boric acid @0.2% applied at 5-10 per cent heading stage under both systems (table1 and 2) Almost similar results for the effect of GA_3 on percentage of seed set in IR 58025 A have been reported by Sarial and Singh (1999) [10], Kalavathi *et al*., (2000) [5], and Pandey *et al*., (2003) [7] Yadav *et al*. (2002) [15]. Further, the maximum seed set of IR58025A and NDRH2 were obtained by GA_3@120g/ha+DAP@2%+boric acid@ 0.2% applied at 5-10 per cent heading stage (table1 and2). The present finding confirmed the reports of earlier workers that the maximum seed yield is obtained when increasing doses of GA_3 are applied at 5-10 per cent heading stage (Singh *et al*., 2007; Ponnuswamy and Prabagaran, 1997; Jagadeeswari *et al*., 1998; and Pandey *et al*., 2003) [11, 8, 4, 7].

It is, therefore, inferred that the parental lines of hybrid NDRH2 possess the favourable flower traits which influenced the out crossing potential provided the synchronized flowering by adopting either techno measures based on either growth duration difference or leaf number difference method more preferably the later one. The optimum dose of GA_3 application is rather a continuing task. It is cleared that the percentage of seed set is proportionately related the dose of GA_3 being applied. After getting the perfect synchronization of flowering between the parental lines and the planting ratio is increased. The higher doses of GA_3 will also substantially require to obtain as much as higher seed of the hybrid rice.

Table 1: Influence of interaction among GA_3, DAP and Boric acid under A×B system

Treatment	Leaf numbers/ plant		Plant height (cm)		Days to 50% heading		Panicle exsertion (%)		Panicle length (cm)		Seed set (%)		Yield (q/ha)	
	2015	2017	2015	2017	2015	2017	2015	2017	2015	2017	2015	2017	2015	2017
$GA_3$1×DAP1×BA1	16.67	17.00	79.22	80.34	88.50	88.00	81.26	82.48	15.45	16.05	11.77	12.36	5.65	5.82
$GA_3$1×DAP1×BA2	17.00	18.50	79.95	81.15	88.00	87.00	82.50	83.72	17.60	18.20	26.07	26.66	6.19	6.40
$GA_3$1×DAP1×BA3	17.50	17.00	82.10	83.30	87.00	86.00	84.69	85.91	18.60	19.20	26.34	26.94	6.74	6.98
$GA_3$1×DAP1×BA4	18.00	17.50	82.10	83.30	87.00	85.00	84.68	85.90	18.60	19.20	26.30	26.89	6.97	7.18
$GA_3$2×DAP1×BA1	17.33	17.00	83.90	85.10	83.00	82.00	86.48	87.70	20.40	21.00	25.84	26.43	11.39	11.58
$GA_3$2×DAP1×BA2	17.50	17.50	81.80	83.00	85.00	84.00	84.38	85.60	18.30	18.90	26.34	26.93	11.85	12.02
$GA_3$2×DAP1×BA3	17.00	17.33	80.05	81.25	87.00	86.00	82.60	83.82	16.55	17.15	26.44	27.03	11.91	12.10
$GA_3$2×DAP1×BA4	17.33	17.50	84.60	85.80	83.50	82.50	87.17	88.39	21.10	21.70	26.53	27.12	12.05	12.22
$GA_3$3×DAP1×BA1	17.50	17.00	81.75	82.95	85.50	83.50	84.35	85.57	18.30	18.90	25.94	26.53	15.95	16.18
$GA_3$3×DAP1×BA2	17.50	18.00	82.60	83.80	86.00	85.00	85.20	86.42	19.15	19.75	28.34	28.97	16.39	16.56
$GA_3$3×DAP1×BA3	17.50	18.33	83.95	85.15	83.00	82.00	86.52	87.74	20.45	21.05	26.67	27.26	16.48	16.71
$GA_3$3×DAP1×BA4	17.50	17.00	83.75	84.95	84.50	83.00	86.35	87.57	20.30	20.90	26.80	27.39	16.51	16.68
$GA_3$4×DAP1×BA1	17.00	17.50	82.20	83.40	83.50	82.50	84.77	85.99	18.70	19.30	26.06	26.65	16.17	16.34
$GA_3$4×DAP1×BA2	18.00	18.50	84.10	85.30	82.50	81.50	86.64	87.86	20.60	21.20	26.99	27.58	17.36	17.53
$GA_3$4×DAP1×BA3	17.50	18.00	83.45	84.65	84.00	83.00	86.03	87.25	20.00	20.60	27.09	27.68	17.59	17.78
$GA_3$4×DAP1×BA4	17.00	18.00	85.95	87.15	84.00	83.00	88.54	89.76	22.50	23.10	27.19	27.78	18.12	18.33
$GA_3$1×DAP2×BA1	17.33	17.00	83.40	84.60	84.00	83.00	85.98	87.20	19.90	20.50	26.42	27.01	5.81	6.04
$GA_3$1×DAP2×BA2	17.00	18.00	81.30	82.50	87.00	86.00	83.88	85.10	17.80	18.40	26.98	27.57	7.22	7.39
$GA_3$1×DAP2×BA3	17.50	17.67	79.85	81.05	88.00	86.50	82.41	83.63	16.35	16.95	26.94	27.53	7.35	7.56
$GA_3$1×DAP2×BA4	17.33	18.00	84.20	85.40	84.50	83.00	86.75	87.97	20.70	21.30	27.08	27.67	7.41	7.58
$GA_3$2×DAP2×BA1	17.00	17.50	83.00	84.20	85.50	84.50	85.59	86.81	19.50	20.10	26.55	27.14	11.52	11.69
$GA_3$2×DAP2×BA2	17.50	17.00	83.00	84.20	85.50	84.50	85.58	86.80	19.50	20.10	27.15	27.74	12.12	12.31
$GA_3$2×DAP2×BA3	17.00	17.00	79.70	80.90	88.00	87.00	81.26	82.48	16.20	16.80	27.34	27.93	12.31	12.48
$GA_3$2×DAP2×BA4	17.00	18.50	79.95	81.15	85.50	84.50	82.50	83.72	17.60	18.20	27.48	28.07	12.45	12.62
$GA_3$3×DAP2×BA1	16.67	18.50	84.30	85.50	81.00	80.00	86.88	88.10	20.80	21.40	26.74	27.33	16.05	16.24
$GA_3$3×DAP2×BA2	17.50	17.33	82.15	83.35	85.50	84.50	84.73	85.95	18.65	19.25	27.40	27.95	18.55	18.76
$GA_3$3×DAP2×BA3	17.00	17.00	82.00	83.20	87.00	85.00	84.60	85.82	18.55	19.15	27.54	28.13	18.67	18.84
$GA_3$3×DAP2×BA4	17.50	17.50	85.25	86.45	84.00	82.50	87.82	89.04	21.75	22.35	27.68	28.27	18.78	19.01
$GA_3$4×DAP2×BA1	17.50	17.50	82.05	83.25	82.50	81.00	84.63	85.85	18.55	19.15	26.90	27.49	16.24	16.41

GA$_3$4×DAP2×BA2	17.33	18.00	82.80	84.00	84.00	82.50	85.40	86.62	19.35	19.95	27.82	28.41	18.84	19.03
GA$_3$4×DAP2×BA3	18.50	17.33	80.10	81.42	85.50	84.50	81.50	82.72	16.20	16.80	27.96	28.55	19.07	19.24
GA$_3$4×DAP2×BA4	17.00	18.50	85.80	87.00	81.50	80.00	88.38	89.60	22.35	22.95	28.10	28.69	20.44	20.67
GA$_3$1×DAP3×BA1	17.33	17.00	81.20	82.40	85.50	84.00	83.78	85.00	17.70	18.30	26.98	27.57	5.92	6.09
GA$_3$1×DAP3×BA2	18.00	18.50	85.10	86.30	85.50	84.50	87.70	88.92	21.65	22.25	27.42	28.01	7.96	8.20
GA$_3$1×DAP3×BA3	17.00	17.50	82.40	83.60	84.50	83.50	84.95	86.17	18.90	19.50	27.51	28.10	7.57	7.72
GA$_3$1×DAP3×BA4	18.00	17.00	84.95	86.15	84.50	83.50	87.51	88.73	21.45	22.05	27.54	28.13	7.68	7.89
GA$_3$2×DAP3×BA1	17.00	18.00	82.15	83.35	85.50	83.50	84.69	85.91	18.65	19.25	27.08	27.67	11.71	11.94
GA$_3$2×DAP3×BA2	17.33	17.50	80.55	81.75	83.00	81.50	83.10	84.32	17.05	17.65	27.58	28.17	13.37	13.54
GA$_3$2×DAP3×BA3	17.50	18.00	81.90	83.10	86.00	85.00	84.50	85.72	18.45	19.05	27.70	28.29	13.51	13.70
GA$_3$2×DAP3×BA4	17.00	17.33	84.55	85.75	84.50	83.50	87.13	88.35	21.05	21.65	27.81	28.40	13.65	13.86
GA$_3$3×DAP3×BA1	17.00	18.50	81.45	82.65	83.00	81.50	84.03	85.25	17.95	18.55	27.20	27.79	16.17	16.38
GA$_3$3×DAP3×BA2	17.00	17.50	82.20	83.40	84.00	83.00	84.80	86.02	18.75	19.35	29.78	30.41	20.15	20.33
GA$_3$3×DAP3×BA3	17.33	17.50	84.15	85.35	81.50	80.00	86.72	87.94	20.65	21.25	28.01	28.60	18.98	19.17
GA$_3$3×DAP3×BA4	17.50	18.00	83.95	85.15	82.50	81.50	86.55	87.77	20.50	21.10	28.04	28.63	19.01	19.18
GA$_3$4×DAP3×BA1	17.50	17.67	80.95	82.15	85.00	84.00	83.53	84.75	17.45	18.05	28.50	29.09	16.47	16.70
GA$_3$4×DAP3×BA2	17.00	17.50	83.75	84.95	83.50	82.50	89.30	90.52	20.30	20.90	28.99	29.57	20.76	21.08
GA$_3$4×DAP3×BA3	18.50	18.67	86.70	87.90	80.00	79.50	89.34	90.76	23.25	23.85	30.20	30.79	20.86	21.17
GA$_3$4×DAP3×BA4	18.00	18.50	86.45	87.65	80.50	79.50	86.35	87.57	23.00	23.60	29.77	30.36	20.36	20.57
GA$_3$1×DAP4×BA1	17.50	18.50	85.35	86.55	86.50	84.50	87.93	89.15	21.85	22.45	28.20	28.79	6.05	6.28
GA$_3$1×DAP4×BA2	17.50	18.00	84.35	85.55	81.00	79.50	86.94	88.16	20.90	21.50	28.39	28.98	7.84	8.01
GA$_3$1×DAP4×BA3	18.00	18.50	84.45	85.65	88.00	86.00	87.01	88.23	20.95	21.55	28.62	29.21	7.95	8.14
GA$_3$1×DAP4×BA4	17.00	17.00	79.85	81.05	84.00	82.50	82.41	83.63	16.35	16.95	29.15	29.74	8.08	8.25
GA$_3$2×DAP4×BA1	17.00	17.50	82.60	83.80	84.50	83.50	85.19	86.41	19.10	19.70	28.27	28.86	11.85	12.02
GA$_3$2×DAP4×BA2	17.33	17.00	82.60	83.80	84.50	83.50	85.18	86.40	19.10	19.70	28.87	29.46	13.77	13.94
GA$_3$2×DAP4×BA3	17.00	17.33	83.55	84.75	81.50	80.50	86.12	87.34	20.05	20.65	29.10	29.69	13.91	14.14
GA$_3$2×DAP4×BA4	17.50	18.00	83.35	84.55	83.00	81.50	85.95	87.17	19.90	20.50	29.47	30.06	14.05	14.24
GA$_3$3×DAP4×BA1	17.00	18.00	82.45	83.65	82.00	81.00	85.03	86.25	18.95	19.55	27.33	27.92	16.28	16.45
GA$_3$3×DAP4×BA2	17.50	17.50	83.20	84.40	83.50	82.00	85.80	87.02	19.75	20.35	28.44	29.03	19.39	19.62
GA$_3$3×DAP4×BA3	17.33	18.50	84.55	85.75	81.00	79.50	87.12	88.34	21.05	21.65	28.53	29.12	19.48	19.65
GA$_3$3×DAP4×BA4	17.00	17.50	84.35	85.55	82.50	80.50	86.95	88.17	20.90	21.50	28.56	29.15	19.78	20.13
GA$_3$4×DAP4×BA1	18.00	17.00	81.15	82.35	82.00	81.00	83.73	84.95	17.70	18.30	28.89	29.48	16.84	17.05
GA$_3$4×DAP4×BA2	17.50	18.50	85.70	86.90	86.00	84.50	88.25	89.47	22.20	22.80	29.41	30.00	20.65	20.82
GA$_3$4×DAP4×BA3	18.00	18.00	83.95	85.15	81.00	80.00	86.53	87.75	20.50	21.10	29.64	30.23	20.72	20.91
GA$_3$4×DAP4×BA4	18.00	18.50	81.65	82.85	81.00	79.50	84.23	85.45	18.20	18.80	29.24	29.83	20.25	20.44
S.Em±	0.67	0.70	2.35	2.35	2.32	2.35	2.35	2.35	2.35	2.35	1.12	1.15	0.58	0.59
C.D. at 5%	NS	NS	6.64	6.64	6.57	6.63	6.66	6.66	6.64	6.66	3.14	3.21	1.63	1.65

GA$_3$1 = 0 g/ha., GA$_3$2 = 60 g/ha., GA$_3$3 = 90 g/ha., GA$_3$4= 120 g/ha.
DAP1 = 0%, DAP2= 1%, DAP3 =2%, DAP4 =3% and BA1 = 0%, BA2= 0.1%, BA3 =0.2% and BA4 = 0.3

Table 2: Influence of interaction among GA$_3$, DAP and Boric acid under A×R system

Treatment	Leaf numbers/ plant		Plant height (cm)		Days to 50% heading		Panicle exsertion (%)		Panicle length (cm)		Seed set (%)		Yield (q/ha)	
	2015	**2017**	**2015**	**2017**	**2015**	**2017**	**2015**	**2017**	**2015**	**2017**	**2015**	**2017**	**2015**	**2017**
GA$_3$1×DAP1×BA1	18.33	18.67	82.06	82.77	88.67	87.67	83.22	84.08	17.43	17.73	13.80	14.23	8.12	8.30
GA$_3$1×DAP1×BA2	18.67	19.33	85.10	85.80	87.00	86.00	86.96	87.82	19.70	20.00	28.15	28.57	8.56	8.73
GA$_3$1×DAP1×BA3	18.67	19.67	85.20	85.90	87.00	85.33	87.06	87.92	19.80	20.10	28.43	28.85	9.13	9.30
GA$_3$1×DAP1×BA4	18.33	19.33	85.33	86.03	87.00	86.00	87.19	88.05	19.93	20.23	28.35	28.78	9.34	9.51
GA$_3$2×DAP1×BA1	18.33	19.00	85.43	86.13	86.67	85.67	87.31	88.17	20.07	20.37	27.88	28.30	13.76	13.93
GA$_3$2×DAP1×BA2	19.00	19.67	85.83	86.53	84.33	83.00	87.69	88.55	20.43	20.73	28.41	28.77	14.23	14.43
GA$_3$2×DAP1×BA3	19.00	19.67	85.96	86.67	84.00	83.00	87.83	88.69	20.60	20.90	28.49	28.90	14.27	14.45
GA$_3$2×DAP1×BA4	19.33	20.00	86.10	86.80	83.67	82.33	87.90	88.83	20.73	21.03	28.55	28.96	14.42	14.59
GA$_3$3×DAP1×BA1	19.00	19.33	86.03	86.73	84.67	83.67	87.87	88.73	20.63	20.93	27.96	28.38	18.34	18.51
GA$_3$3×DAP1×BA2	18.67	19.00	86.47	87.17	84.00	83.00	88.31	89.17	21.10	21.40	30.53	30.93	18.77	18.93
GA$_3$3×DAP1×BA3	19.33	19.67	86.53	87.23	84.00	83.00	88.40	89.26	21.17	21.47	28.75	29.13	18.85	19.02
GA$_3$3×DAP1×BA4	19.00	19.67	86.57	87.27	83.67	82.33	88.44	89.30	21.23	21.53	28.86	29.27	18.88	19.07
GA$_3$4×DAP1×BA1	19.33	19.33	87.23	87.93	83.67	82.67	89.09	89.95	21.83	22.13	28.11	28.50	18.54	18.75
GA$_3$4×DAP1×BA2	19.00	20.00	87.40	88.10	84.00	82.00	89.28	90.14	22.03	22.33	29.07	29.45	19.73	19.90
GA$_3$4×DAP1×BA3	19.00	19.33	87.63	88.33	83.67	82.00	89.51	90.37	22.27	22.57	29.15	29.52	19.96	20.13
GA$_3$4×DAP1×BA4	19.00	20.00	88.20	88.90	84.00	82.00	90.04	90.90	22.80	23.10	29.24	29.64	20.48	20.70
GA$_3$1×DAP2×BA1	18.67	19.67	84.90	85.60	87.33	85.67	86.73	87.59	19.50	19.80	28.45	28.86	8.16	8.41
GA$_3$1×DAP2×BA2	19.00	20.00	85.40	86.10	86.00	85.00	87.23	88.09	20.00	20.30	29.05	29.43	9.59	9.82
GA$_3$1×DAP2×BA3	18.33	19.00	85.50	86.20	86.00	84.67	87.33	88.19	20.10	20.40	28.97	29.36	9.72	9.91
GA$_3$1×DAP2×BA4	18.67	19.33	85.60	86.30	86.00	84.67	87.43	88.28	20.20	20.50	29.15	29.52	9.78	9.97
GA$_3$2×DAP2×BA1	18.67	19.67	85.57	86.27	87.00	85.67	87.44	88.30	20.20	20.50	28.60	29.00	13.89	14.06
GA$_3$2×DAP2×BA2	19.00	19.67	86.17	86.87	86.67	85.00	88.04	88.90	20.80	21.10	29.18	29.56	14.49	14.66
GA$_3$2×DAP2×BA3	18.33	18.67	86.37	87.07	86.00	85.00	88.23	89.09	21.00	21.30	29.38	29.78	14.68	14.85
GA$_3$2×DAP2×BA4	18.67	19.33	86.50	87.20	85.00	83.67	88.37	89.23	21.13	21.43	29.50	29.92	14.82	15.03

GA₃3×DAP2×BA1	19.00	19.33	86.10	86.80	84.67	83.00	87.97	88.83	20.73	21.03	28.76	29.18	18.42	18.63
GA₃3×DAP2×BA2	19.33	19.67	86.60	87.30	84.00	83.00	88.47	89.33	21.23	21.53	29.45	29.85	20.92	21.11
GA₃3×DAP2×BA3	18.33	19.00	86.73	87.43	84.00	82.33	88.59	89.45	21.37	21.67	29.61	30.00	21.04	21.23
GA₃3×DAP2×BA4	18.33	19.33	86.83	87.53	83.67	82.00	88.70	89.56	21.47	21.77	29.73	30.15	21.15	21.36
GA₃4×DAP2×BA1	18.67	19.33	87.27	87.97	83.67	82.33	89.16	90.02	21.97	22.27	28.95	29.34	18.60	18.78
GA₃4×DAP2×BA2	19.00	19.67	87.87	88.57	83.33	82.33	89.76	90.62	22.57	22.87	29.87	30.26	21.24	21.40
GA₃4×DAP2×BA3	19.67	20.00	88.13	88.83	84.00	82.67	89.99	90.85	22.73	23.03	30.03	30.40	21.44	21.67
GA₃4×DAP2×BA4	18.33	19.00	88.50	89.20	83.33	82.33	90.36	91.22	23.10	23.40	30.15	30.56	22.82	22.98
GA₃1×DAP3×BA1	18.67	19.67	85.00	85.70	87.33	85.67	86.83	87.69	19.60	19.90	29.03	29.42	8.28	8.50
GA₃1×DAP3×BA2	19.00	19.00	85.60	86.30	85.67	84.33	87.46	88.32	20.20	20.50	29.47	29.87	10.49	10.67
GA₃1×DAP3×BA3	18.67	19.33	85.70	86.40	85.33	84.33	87.56	88.42	20.30	20.60	29.57	29.95	9.92	10.13
GA₃1×DAP3×BA4	18.33	19.00	85.83	86.53	85.00	84.00	87.69	88.55	20.43	20.73	29.62	29.98	10.05	10.22
GA₃2×DAP3×BA1	18.67	19.33	85.77	86.47	87.00	85.33	87.63	88.49	20.40	20.70	29.13	29.52	14.08	14.29
GA₃2×DAP3×BA2	18.33	19.33	86.43	87.13	84.00	82.33	88.29	89.15	21.03	21.33	29.63	30.06	15.74	15.91
GA₃2×DAP3×BA3	19.00	19.00	86.57	87.27	84.00	82.67	88.43	89.29	21.20	21.50	29.75	30.18	15.86	16.07
GA₃2×DAP3×BA4	18.33	19.00	86.70	87.40	83.33	82.00	88.57	89.43	21.33	21.63	29.88	30.27	16.02	16.19
GA₃3×DAP3×BA1	18.67	19.67	86.23	86.93	84.00	83.00	88.09	88.95	20.87	21.17	29.25	29.65	18.54	18.71
GA₃3×DAP3×BA2	19.00	19.67	86.97	87.67	84.00	82.67	88.81	89.67	21.60	21.90	31.97	32.38	22.67	22.86
GA₃3×DAP3×BA3	18.67	19.67	87.03	87.73	84.00	82.33	88.90	89.76	21.67	21.97	30.10	30.45	21.15	21.34
GA₃3×DAP3×BA4	18.67	19.67	87.07	87.77	83.67	82.00	88.94	89.80	21.73	22.03	30.16	30.48	21.38	21.55
GA₃4×DAP3×BA1	18.67	19.33	87.53	88.23	83.33	82.00	89.39	90.25	22.13	22.43	30.56	30.94	18.84	19.03
GA₃4×DAP3×BA2	18.33	19.00	88.00	88.70	83.67	82.67	89.88	90.74	22.63	22.93	31.05	31.42	23.05	23.46
GA₃4×DAP3×BA3	19.67	20.00	89.20	89.90	82.33	81.33	91.04	91.90	23.63	23.93	32.24	32.65	23.15	23.48
GA₃4×DAP3×BA4	19.00	19.67	88.80	89.50	84.00	82.67	90.64	91.50	23.40	23.70	31.82	32.20	22.73	22.96
GA₃1×DAP4×BA1	18.67	19.00	85.10	85.80	87.00	86.00	86.93	87.78	19.70	20.00	30.25	30.64	8.45	8.59
GA₃1×DAP4×BA2	18.67	19.33	86.00	86.70	85.67	84.67	87.86	88.72	20.60	20.90	30.45	30.84	10.21	10.44
GA₃1×DAP4×BA3	18.33	19.00	86.10	86.80	85.33	84.33	87.96	88.82	20.70	21.00	30.68	31.05	10.32	10.55
GA₃1×DAP4×BA4	18.67	19.33	86.20	86.90	84.67	83.67	88.06	88.92	20.80	21.10	31.22	31.56	10.45	10.64
GA₃2×DAP4×BA1	18.33	19.33	85.90	86.60	85.67	84.67	87.77	88.63	20.53	20.83	30.32	30.70	14.22	14.39
GA₃2×DAP4×BA2	19.00	19.33	86.83	87.53	83.33	82.33	88.69	89.55	21.43	21.73	30.96	31.35	16.14	16.37
GA₃2×DAP4×BA3	18.33	19.33	86.97	87.67	83.67	82.00	88.83	89.69	21.60	21.90	31.16	31.55	16.28	16.49
GA₃2×DAP4×BA4	18.33	19.00	87.10	87.80	83.00	81.33	88.97	89.83	21.73	22.03	31.52	31.90	16.44	16.59
GA₃3×DAP4×BA1	19.33	19.67	86.33	87.03	84.00	82.67	88.20	89.06	20.97	21.27	29.40	29.77	18.65	18.84
GA₃3×DAP4×BA2	18.33	19.33	87.47	88.17	83.67	82.00	89.31	90.17	22.10	22.40	30.52	30.88	21.76	21.93
GA₃3×DAP4×BA3	19.00	19.67	87.53	88.23	83.33	82.00	89.40	90.26	22.17	22.47	30.58	30.97	21.85	22.02
GA₃3×DAP4×BA4	18.67	19.33	87.57	88.27	83.33	82.00	89.44	90.30	22.23	22.53	30.62	31.00	22.14	22.37
GA₃4×DAP4×BA1	18.67	19.67	87.90	88.60	83.00	82.00	89.76	90.62	22.50	22.80	30.94	31.33	19.20	19.38
GA₃4×DAP4×BA2	18.33	19.67	88.40	89.10	83.67	82.67	90.27	91.14	23.03	23.33	31.44	31.85	23.02	23.21
GA₃4×DAP4×BA3	18.33	19.00	88.63	89.33	83.33	82.33	90.51	91.37	23.27	23.57	31.72	32.15	23.10	23.28
GA₃4×DAP4×BA4	19.00	19.33	88.23	88.93	84.00	83.00	90.11	90.97	22.87	23.17	31.30	31.68	22.62	22.83
S.Em±	0.56	0.57	1.97	1.97	2.16	2.13	1.97	1.97	1.98	1.98	1.21	1.22	0.67	0.68
C.D. at 5%	NS	NS	5.52	5.52	6.04	5.96	5.53	5.53	5.53	5.53	3.37	3.42	1.88	1.91

Table 3: Analysis of variance for various parameters under A×B system during 2015 and 2017 of hybrid rice

		2015							2017						
Parameters	**d.f.**	**Leaf numbers**	**Plant height (cm)**	**Day to 50% heading**	**Panicle exsertion (%)**	**Panicle length (cm)**	**Seed set (%)**	**Yield (q/ha)**	**Leaf numbers**	**Plant height(cm)**	**Day to 50% heading**	**Panicle exsertion (%)**	**Panicle length (cm)**	**Seed set (%)**	**Yield (q/ha)**
Replicates	1	0.125	26.100	27.195	26.517	24.588	3.764	2.060	0.281	26.100	29.070	26.517	16.576	3.764	2.111
GA3	3	1.729	17.364	42.258*	19.167	16.576	16.244	1423.112**	1.000	17.364	45.029*	19.167	4.073	16.244	1426.434**
DAP	3	0.708	4.541	9.945	5.129	4.073	4.009	33.844	0.521	4.541	12.612	5.129	1.760	4.009	34.379
GA3*DAP	9	0.465	2.091	2.848	2.366	1.760	1.743	1.527	0.451	2.091	2.452	2.366	12.584	1.743	1.617
BA	3	0.521	11.953	7.383	12.889	12.584	11.210	53.365	1.500	11.953	8.195	12.889	5.862	11.210	53.558
GA3*BA	9	0.944	6.155	5.230	5.711	5.862	6.010	2.252	0.931	6.155	5.702	5.711	3.193	6.010	2.301
DAP*BA	9	0.229	3.505	3.640	3.622	3.193	2.203	2.697	0.896	3.505	2.813	3.622	6.808	2.203	2.735
GA3*DAP*BA	27	0.866	6.780	12.089	7.046	6.809	4.310	0.375	1.382	6.781	11.580	7.047	11.045	4.310	0.419
Error (C)	63	0.903	11.056	10.798	11.091	11.045	5.990	1.016	0.980	11.056	11.023	11.091	8.671	5.990	1.043
Total	127	0.819	8.764	10.379	8.916	8.671	5.366	24.772	1.015	8.764	10.491	8.916	20.141	5.366	24.869
General Mean		17.250	83.005	84.195	85.567	19.541	8.321	14.081	17.594	84.205	82.930	86.787	16.500	8.971	14.280
C.V.		5.508	4.006	3.903	3.892	17.007	29.414	7.159	5.626	3.949	4.003	3.837	12.230	27.283	7.153
C.D.5%															
Ai.-Aj.(GA3)		0.475	1.661	1.642	1.664	1.660	1.223	0.407	0.494	1.661	1.659	1.664	1.660	1.223	0.413
Bi.- Bj.(DAP)		0.475	1.661	1.642	1.664	1.660	1.223	0.407	0.494	1.661	1.659	1.664	1.660	1.223	0.413
AiBi-AiBj		0.949	3.322	3.283	3.328	3.321	2.446	0.814	0.989	3.322	3.317	3.328	3.321	2.446	0.825
AiBi-AjBi		0.949	3.322	3.283	3.328	3.321	2.446	0.814	0.989	3.322	3.317	3.328	3.321	2.446	0.825
Ci.- Cj.(BA)		0.475	1.661	1.642	1.664	1.660	1.223	0.407	0.494	1.661	1.659	1.664	1.660	1.223	0.413
AiCi-AiCj		0.949	3.322	3.283	3.328	3.321	2.446	0.814	0.989	3.322	3.317	3.328	3.321	2.446	0.825
AiCi-AjCi		0.949	3.322	3.283	3.328	3.321	2.446	0.814	0.989	3.322	3.317	3.328	3.321	2.446	0.825
BiCi-BiCj		0.949	3.322	3.283	3.328	3.321	2.446	0.814	0.989	3.322	3.317	3.328	3.321	2.446	0.825
BiCi-BjCi		0.949	3.322	3.283	3.328	3.321	2.446	0.814	0.989	3.322	3.317	3.328	3.321	2.446	0.825
AiBiCi-A.B.C.		1.899	6.645	6.567	6.655	6.641	4.891	1.629	1.978	6.645	6.635	6.655	6.641	4.891	1.651

Table 4: Analysis of variance for various parameters under A×R system during 2015 and 2017 of hybrid rice

		2015							2017						
Parameters	**d.f.**	**Leaf numbers**	**Plant height (cm)**	**Day to 50% heading**	**Panicle exsertion (%)**	**Panicle length (cm)**	**Seed set (%)**	**Yield (q/ha)**	**Leaf numbers**	**Plant height (cm)**	**Day to 50% heading**	**Panicle exsertion (%)**	**Panicle length(cm)**	**Seed set (%)**	**Yield (q/ha)**
Replicates	2	0.146	6.853	33.146	6.575	5.981	15.667	2.606	0.016	6.853	35.286	6.575	5.981	15.667	2.664
GA3	3	1.125	63.701**	71.561**	66.333	62.310**	62.601***	1417.948***	1.118	63.701**	77.172	66.333**	62.310**	62.601***	1420.115***
DAP	3	1.403	8.524	9.811	9.275	7.600	7.790	33.467	1.090	8.524	8.019	9.275	7.600	7.790	34.313
GA3*DAP	9	0.398	0.295	3.403	0.453	0.148	0.134	1.500	0.280	0.295	4.065	0.453	0.148	0.134	1.565
BA	3	0.458	11.230	15.991	12.310	10.105	10.289	53.026	0.299	11.230	17.741	12.310	10.105	10.289	53.434
GA3*BA	9	0.231	0.429	4.102	0.601	0.233	0.278	2.280	0.229	0.429	3.862	0.601	0.233	0.278	2.329
DAP*BA	9	0.269	0.133	0.204	0.247	0.072	0.070	2.817	1.146	0.133	0.616	0.247	0.072	0.070	2.943
GA3*DAP*BA	27	0.468	0.360	0.402	0.553	0.187	0.187	0.386	0.465	0.360	0.329	0.552	0.187	0.187	0.395
Error (C)	126	0.950	11.684	13.955	11.698	11.727	8.247	1.361	0.963	11.684	13.588	11.699	11.727	8.247	1.391
Total	191	0.784	9.182	11.503	9.306	9.103	6.921	24.920	0.818	9.182	11.399	9.307	9.103	6.921	25.007
General Mean		18.708	86.591	84.661	88.442	21.223	10.425	16.452	19.406	87.291	83.380	89.302	21.523	11.015	16.647
C.V.		5.210	3.948	4.413	3.867	16.136	27.549	7.091	5.056	3.916	4.421	3.830	15.911	26.073	7.084
C.D.5%															
Ai.-Aj. (GA3)		0.394	1.381	1.509	1.382	1.383	1.160	0.471	0.396	1.381	1.489	1.382	1.383	1.160	0.476
Bi.- Bj. (DAP)		0.394	1.381	1.509	1.382	1.383	1.160	0.471	0.396	1.381	1.489	1.382	1.383	1.160	0.476
AiBi-AiBj		0.787	2.762	3.018	2.763	2.767	2.320	0.942	0.793	2.762	2.978	2.763	2.767	2.320	0.953
AiBi-AjBi		0.787	2.762	3.018	2.763	2.767	2.320	0.942	0.793	2.762	2.978	2.763	2.767	2.320	0.953
Ci.- Cj. (BA)		0.394	1.381	1.509	1.382	1.383	1.160	0.471	0.396	1.381	1.489	1.382	1.383	1.160	0.476
AiCi-AiCj		0.787	2.762	3.018	2.763	2.767	2.320	0.942	0.793	2.762	2.978	2.763	2.767	2.320	0.953
AiCi-AjCi		0.787	2.762	3.018	2.763	2.767	2.320	0.942	0.793	2.762	2.978	2.763	2.767	2.320	0.953
BiCi-BiCj		0.787	2.762	3.018	2.763	2.767	2.320	0.942	0.793	2.762	2.978	2.763	2.767	2.320	0.953
BiCi-BjCi		0.787	2.762	3.018	2.763	2.767	2.320	0.942	0.793	2.762	2.978	2.763	2.767	2.320	0.953
AiBiCi-A.B.C.		1.575	5.523	6.036	5.527	5.533	4.640	1.885	1.585	5.523	5.956	5.527	5.533	4.640	1.905

Conclusion

On the basis of experimental results, it may be concluded that application of GA_3 @120g/ha+DAP@2%+boric acid@0.2% can be recommended for better seed setting,, maximizing panicle exsertion, increase panicle length and plant height but as we increase the doses of GA_3 alone or in combination with boric acid and DAP, it delays the days to 50% heading of CMS line under both AxB and AxR system of hybrid seed production.

Acknowledgement

Authors are thankful to Division of Genetics, IARI, New Delhi and Acharya Narendra Dev University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh for providing the experimental materials and other facilities related to the experiment.

References

1. Anonymous. Hybrid Rice NDRH2 Seed Production Technology. Hybrid Rice Bulletin 2006-I, Seed Technology Research Centre ANDUAT Kumarganj Ayodhya, 2006, 1-22.
2. Anonymous. Food and Agriculture Organization (FAO) regional office for Asia and the Pasific Bangkok. Statistical Year Book, 2019, 99-201.
3. Duan X, Ma HS. Effect of gibberellic acid (GA_3) application on seed yield and quality of hybrid rice. Seed Sci. & Tech 1992;20(2):209-214.
4. Jagadeeswari P, Kumar SS, Ganesh M, Anuradha G. Effect of foliar application of GA_3 on seed yield and quality in hybrid rice. *Oryza* 1998;36(1):26-30.
5. Kalavathi D, Ananthakaiselvi A, Vijaya J. Economization of GA_3 use in hybrid rice seed production by supplementing with other nutrients. Seed Res 2000;28(1):10-12.
6. NK Biradarpatil, M Shekhargouda. Synchronization studies in hybrid rice. Karnataka J Agric. Sci 2006;19(1):298-303.
7. Pandey S, Sharma SP, Dadlani M. Effect of gibberellic acid (GA_3) application on floral and morphological traits, seed yield and storability of parental lines in rice (*Oryza sativa*). Indian J Agric. Sci 2003;73(7):376-380.
8. Ponnuswamy A, Prabagaran SR. Determination of optimum growth stage for gibberellic acid (GA_3) application in hybrid rice seed production. Madras Agric. J 1997;84(4):231-232.
9. Ponnuswamy AS, Rangaswamy M. Factors influencing hybrid rice seed production. School of Genetics, TNAU, Coimbatore, 1996, 96-99.
10. Sarial K Ashok, Singh VP. Seed set potential and seed yield of A×R combination in rice (*Oryza sativa* L.). Seed Res 1999;27(2):140-145.
11. Singh S, Ahmed MI, Viraktmath BC, Ramesh MS. Relative effect of different chemicals and out pollination promoting techniques for increasing hybrid seed yield in rice (*Oryza sativa* L.) Indian J of Crop Sci 2007;2(1):29-31.
12. Viraktmath BC. Hybrid rice in India; *Int. Symp.* Rice: ‘From Green Revolution to Gene Revolution’ Oct.04-06. Hyderabad 2004;(1):32.
13. Viraktamath BC, Vijaya Kumar CHM, Ahmed MI, Singh S, Ramesha MS. Leaf number: a reliable parameter for determining seeding intervals between parental lines in hybrid rice seed production. IRRN 1998;23:25-26.
14. Virmani SS, Young JB, Moon HP, Kumar I, Flinn JC. Increasing rice yield through exploitation of heterosis. Hybrid rice seed production technology, DDR, Hyderabad 1991, 18-28.
15. Yadav RDS, Srivastava JP, Yadav DS. Standardizing GA3 application in hybrid rice seed production . Proc. Nac. Acad. Sci. India 2002;72B(3):342-345
16. Yadav RDS, Singh PV, Srivstava JP. Research Development and Challenges in hybrid rice seed production for 21st Century. Seed Tech. News 1998;28(4):16.