INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 16, No. 1, p. 93-106, 2020

RESEARCH PAPER OPEN ACCESS

Effect of growth stimulator on the yield of hybrid rice varieties in Boro season

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Key words: Growth stimulator, Hybrid rice, Yield.

http://dx.doi.org/10.12692/ijb/16.1.93-106 Article published on January 15, 2020

Abstract

Rice (*Oryza sativa* L.) is one of the main cereal crops and commonly grown all over the world for multiple purposes. The present investigation was undertaken for the improvement of yield of rice varieties through the manipulation of filled-grain percentage by plant growth stimulator. This experiment was comprised of two factors; Factor A: Rice varieties: BRRI hybrid dhan3 and BRRI dhan29, Factor B: PGS and fertilizer management: Recommended fertilizer dose (T_1), Recommended fertilizer dose + Akota + Global (T_2), Recommended fertilizer dose + Akota + Global + Calsol (T_3), Recommended fertilizer dose + Akota + Global + Magic Growth (T_4), Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth (T_5). In case of variety the highest filled grains panicle^{-1} (180.36) and grain yield (7.09 t ha^{-1}) was recorded from BRRI hybrid dhan3. In case of PGS and fertilizer treatment, the highest filled grains panicle^{-1} (168.7) and grain yield (6.99 t ha^{-1}) were recorded from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). Due to the interaction the highest filled grains panicle^{-1} (197.7) and grain yield (7.78 t ha^{-1}) were recorded from BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). So, BRRI hybrid dhan3 and T_3 (Recommended fertilizer dose + Akota + Global + Calsol) combinedly had outstanding superiority for yield over the other treatments.

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Introduction

Rice is the most important 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). In Bangladesh it covers about 80% of the total cropped area and contributes about 90% of food grains (BBS, 2009). Therefore, rice plays an important role in ensuring food security, and contributing to poverty alleviation in Asia special in Bangladesh. As the population of Bangladesh 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.

Adoption of hybrid rice is one of the major options for improvement of rice yield. Bangladesh has started adopting hybrid rice technology since 1993 and able to develop her own hybrid rice variety in 2001. Hybrid rice has contributed significantly to food safety in some country like China, India and Thailand etc. Among the rice growing countries, Bangladesh obtained third position in rice area and fourth position in rice production. Our farmers are cultivating hybrid rice varieties extensively. But the yield is not up to the mark.

In Bangladesh rice is cultivated all over the year as Aus, Aman and Boro. Among these transplanted cropping Boro is most important and occupied about 41% of rice cultivated land in 2009-10. The rest 46% is occupied by Aman, 9% by Aus and 4% by sown Aman. In Bangladesh the production of total rice is about 31.98 million metric tons where Boro rice cover about 18.06 million metric tons, which is the largest part among the total production.

In Boro season hybrid rice covers about 6.86 lac hectares area with production of 32.2 lac metric tons (BBS, 2010).

The population of Bangladesh is increasing at a high rate and the cultivable land is decreasing day by day due to urbanization and industrialization resulting in more shortage of food. The population growth rate of Bangladesh is two million in every year, it may increase by 30 million over the next 20 years. The growth of population demands a continuous increase in rice production in Bangladesh. Production of rice has to be increased by at least 60% to meet up food requirement of the increasing population by the year of 2020 (Masum, 2009).

Rice yield can be increased by various ways like developing new high yielding varieties and by using proper agronomic techniques to the existing varieties to achieve the potential yield. FAO has recognized hybrid rice technology as a key approach for increasing worldwide rice production. Hybrids rice are generally more vigorous and larger in size than their parent stock. The leaves of hybrid rice become long and the leaves becomes broad so that they can take up more nutrients thus they produce more grains. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter. This important component of soil is declining with time due to intensive cropping and use of higher doses of chemical fertilizers with little or no addition of manure.

Plant stimulators are chemical communicators, or agents, which helps to regulate a plant's development and its response to its surrounding environment. Remarkable accomplishments of plant stimulators such as manipulating crop yield have been actualized in recent years. Plant hormones are considered as yield boosting agronomic technique (Bakhsh *et al.*, 2011). Plant growth regulators are becoming popular to ensure efficient production and for other necessary activities of rice plant.

Global and Akota are two commercial growth stimulators available in market that imported from China by Akota Agro-product Ltd and Global Agro-vet Ltd. The importer companies claimed that these PGS show positive effect on reproductive growth in number of flower and fruit and yield. Our farmers use these growth regulators frequently. Highest number of effective tillers hill^{-1} was recorded from the 75% Urea as top dressing and 10% Urea with magic growth as foliar spray which was statistically similar with 100% Urea as top dressing and 10% Urea with magic growth as foliar spray and the lowest was observed from control treatment (Rabin *et al.*, 2016). The total grain panicle^{-1} found maximum in recommended fertilizer dose with Calsol at 7 days before panicle initiation.

However, much research information is available on the development and cultivation technology of hybrid rice varieties. But research work on improving yield of hybrid rice varieties through solving the spikelet sterility / poor grain filling problem is scanty or absent in Bangladesh. At present it is imperative to develop a way for exploiting maximum yield potential of the hybrid rice through maximizing spikelet fertility and solving poor-filled grain problem in hybrid rice. Under these circumstances, the present research proposal has been planned and designed to find out a way of lessening the unfilled-grain problem in hybrid rice varieties through using plant growth stimulator.

Materials and methods

Experimental site and soil of the experimental field

The experiment was carried out on the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, and Dhaka, Bangladesh. The soil of the experimental field is silt loam in texture belonging to the ago-ecological zone of Modhupur Tract (AEZ-28).

Planting materials, varieties and treatments of the experiment

In the present study, two high yielding rice varieties BRRI hybrid dhan3 and BRRI dhan29 were used as plant materials. This experiment consists two factors: 1) Rice varieties: BRRI hybrid dhan3 and BRRI dhan29. 2) PGS and fertilizer management: Recommended fertilizer dose (T_1), Recommended fertilizer dose + Akota + Global(T_2), Recommended fertilizer dose + Akota + Global + Calsol (T_3), Recommended fertilizer dose + Akota + Global + Magic Growth (T_4), Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth (T_5).

Layout and land preparation of the experiment

The experimental design was laid out in a Randomized Complete Block Design (RCBD) with two factors and three replicates for each treatment. The experiment was arranged in a Randomized Complete Block Design (RBCD) having PGS and fertilizer management in the main plots and varieties in the sub-plot. The total numbers of unit plots were 30. The size of unit plot was 3.0 m x 1.5 m. There were 10 treatment combinations. The distances between plot to plot and replication to replication were 0.5 m and 1m respectively.

Fertilizer application

Cow-dung was used as decomposed organic matter @ 5.0 ton /hectare before final land preparation. The recommended doses of chemical fertilizer were applied as Urea, TSP, MOP, Gypsum, and Zinc at the rate of 220, 165, 180, 70, 10 kg ha^{-1}. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Half of the rest two third of urea was applied after 20 DAT and the rest amount of urea was applied at 45 DAT.

Seed treatment and sowing

Seeds were treated with Bavistin at the rate of 0.2% to 0.3% of seed weight. Seeds were kept in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours. As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil.

Seeds were sown in the seed bed on 20 December, 2016 in order to transplant the seedlings in the main field. The plot selected for the experiment was opened in the first week of 24 January 2017 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilt. Weeds and stubble were removed, and finally obtained a desirable tilt of soil for transplanting of seedlings. The nursery bed was made wet by application of water one day before uprooting the seedlings.

The seedlings were uprooted on January 25, 2017 without causing much mechanical injury to the roots. The seedlings were transplanted in the main field on 25 the January, 2017 with a spacing 15 cm from hill to hill and 20 cm from row to row.

Intercultural operations

Some intercultural operations are irrigation and drainage, gap filling, weeding, top dressing, spraying of insecticides and fungicides, protection of crops from other pests.

Harvesting

The rice plant was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

Data collection

The following data were collected during the study period: effective tiller (%) hill^{-1}, panicles hill^{-1}, panicle length, filled grain panicle^{-1}, Total grains panicle^{-1}, Filled grain (%), 1000 grains weight, grain yield, straw yield, biological yield, harvest index (%)

Statistical analysis

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by Least Significant Difference (LSD) test at 5 % level of significance (Gomez and Gomez, 1984).

Results and discussion

Yield and yield contributing characters

Effective tiller (%) hill^{-1}

Effective tillers (%) hill^{-1} varied significantly variation among rice varieties, as shown in Table 1.

Table 1. Effect of different varieties and levels of fertilizer on yield and yield contributing characters of rice.

Treatments	Effective tiller (%)	Panicle hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1} (No.)	Total grains panicle^{-1}	Filled grain (%)	1000 grains weight (g)
Effect of variety							
BRRI hybrid dhan3	94.03 a	16.67 a	25.75 a	180.36 a	189.26 a	92.56	26.84 a
BRRI dhan29	91.77 b	15.45 b	23.29 b	127.54 b	141.15 b	88.62	19.52 b
$LSD_{0.05}$	0.58	0.91	1.18	9.29	9.47	NS	1.32
CV (%)	0.82	7.42	6.25	7.87	7.48	5.76	7.43
Effect of different levels of fertilizer							
T_1	90.10 e	14.45 d	23.0 c	141.4 c	154.9 c	87.61	21.56 c
T_2	92.94 c	16.12 bc	24.52 a-c	152.3 bc	163.5 a-c	90.59	23.16 abc
T_3	95.75 a	17.65 a	26.28 a	168.7 a	178.0 a	93.92	24.98 a
T_4	91.68 d	14.93 cd	23.67 bc	147.7 bc	159.6 bc	88.50	22.22 bc
T_5	94.03 b	17.17 ab	25.12 ab	159.7 ab	170.0 ab	92.32	23.97 ab
$LSD_{0.05}$	0.92	1.45	1.86	14.69	14.98	NS	2.09
CV (%)	0.82	7.42	6.25	7.87	7.48	5.76	7.43

T_1 = Recommended fertilizer dose, T_2 = Recommended fertilizer dose + Akota + Global

T_3 = Recommended fertilizer dose + Akota + Global + Calsol, T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth, T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth. NS=non-significant.

The highest (94.03 %) effective tiller was recorded from BRRI hybrid dhan3 whereas the lowest (91.77 %) was recorded from BRRI dhan29.

Effective tillers (%) hill^{-1} was significantly affected due to different PGS and fertilizer application at 5 % level of probability, as shown in Table 1. The highest value (95.75 %) of effective tiller was recorded from T_3, whereas the lowest value (90.10) was found from T_1 treatment. These results are in good accordance with those reported by Shafiee *et al.*, (2013).

Table 2. Interaction effect of different varieties and levels of fertilizer on yield and yield contributing characters of rice.

Treatment combination		Effective tiller (%)	Panicle hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1} (No.)	Total grains panicle^{-1}	Filled grain (%)	1000 seed weight (gm)
BRRI hybrid dhan3	T_1	92.35 d	15.13 bc	24.07 b-e	165.7 c	176.8 b	89.60 ab	25.33 b
	T_2	93.72 bc	16.43 ab	25.70 a-c	178.6 a-c	187.4 b	92.51 ab	26.50 ab
	T_3	97.00 a	18.13 a	27.77 a	197.7 a	204.5 a	96.23 a	28.90 a
	T_4	92.74 cd	15.75 bc	24.83 b-d	172.5 bc	182.3 b	89.54 ab	25.98 ab
	T_5	94.34 b	17.90 a	26.37 ab	187.3 ab	195.4 ab	94.91 a	27.49 ab
BRRI dhan29	T_1	87.86 f	13.77 c	21.94 e	117.2 e	133.0 c	85.62 b	17.79 d
	T_2	92.15 d	15.80 bc	23.33 c-e	125.9 de	139.6 c	88.66 ab	19.81 cd
	T_3	94.49 b	17.17 ab	24.80 b-d	139.8 d	151.5 c	91.61 ab	21.07 c
	T_4	90.61 e	14.10 c	22.52 de	122.9 de	137.0 c	87.47 ab	18.46 cd
	T_5	93.72 bc	16.43 ab	23.87 b-e	132.0 de	144.6 c	89.74 ab	20.46 cd
$LSD_{0.05}$		1.30	2.05	2.63	20.77	21.18	8.95	2.96
CV (%)		0.82	7.42	6.25	7.87	7.48	7.76	7.43

T_1 = Recommended fertilizer dose, T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol, T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth, T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth.

Table 2 shows the significant interaction between PGS and fertilizer levels and variety were found in effective tillers (%) hill^{-1}. The highest percentage (97.00 %) of effective tiller hill^{-1} was counted from the interaction of BRRI hybrid dhan3 × T_3 treatment. The lowest percentage (87.86 %) of effective tillers hill^{-1} was counted from the interaction of BRRI dhan29 × T_1 treatment.

Panicles hill-1

Statistically significant variation was observed in terms of the number of panicles hill^{-1} among rice varieties, as shown in Table 1. The maximum (16.67) number of panicles hill^{-1} was recorded from BRRI hybrid dhan3 and the minimum (15.45) number was recorded from BRRI dhan29.

Statistically significant variation was recorded in case of the number of panicles hill^{-1} due to different PGS and fertilizer applications, as shown in Table 1. The maximum (17.65) number of panicles hill^{-1} was recorded from T_3, which was similar (17.17) with T_5 treatment. On the other hand, the minimum (14.45) number was recorded from T_1 treatment. Soylu *et al.* (2005) and Kenbaev and Sade (2002) reported that foliar application of different micronutrients individually or in combination significantly increased in number of panicles m^{-2}.

Table 2 shows the significant interaction effects of PGS and fertilizer management and variety were found in producing panicles hill^{-1}. The highest (18.13) number of the number of panicles hill^{-1} was counted from the interaction of BRRI hybrid dhan3 × T_3, which was similar (17.90, 16.43, 17.65 and 17.17) with the interaction of BRRI hybrid dhan3 × T_5; BRRI hybrid dhan3 × T_2; BRRI dhan29 × T_3 and BRRI dhan29 × T_5 treatment respectively.

Table 3. Interaction effect of different varieties and levels of PGS and fertilizer on the yield characters of rice.

Treatment combinations	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index (%)	
BRRI hybrid dhan3 ×								
T_1	6.49	b-d	7.77	a-c	14.26	d	45.51	a-c
T_2	7.19	ab	8.63	ab	15.81	a-c	45.50	a-c
T_3	7.78	a	8.96	a	16.74	a	46.44	a
T_4	6.78	bc	7.92	a-c	14.71	b-d	46.11	ab
T_5	7.20	ab	8.83	a	16.03	ab	44.83	a-d
BRRI dhan29 ×								
T_1	4.87	f	7.11	c	11.98	f	40.60	c-e
T_2	5.30	ef	8.32	a-c	13.62	de	39.01	e
T_3	6.20	c-e	8.93	a	15.13	b-d	41.08	b-e
T_4	5.02	f	7.58	bc	12.60	ef	39.86	de
T_5	5.72	d-f	8.66	ab	14.38	cd	39.72	de
LSD $_{0.05}$	0.94		1.21		1.52		5.24	
CV (%)	8.78		8.53		6.11		7.12	

T_1 = Recommended fertilizer dose, T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol, T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth, T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth.

The lowest (13.77 and 14.10) number of panicle hill^{-1} was counted in the interaction of BRRI dhan29 × T_1 and BRRI dhan29 × T_4 treatment.

Panicle length

Table 1 shows the panicle length varied significantly between two varieties of rice.

The longest (25.75 cm) panicle was observed from BRRI hybrid dhan3, while the shortest (23.29 cm) panicle length was attained from BRRI dhan29.

Table 1 shows the panicle length of rice varied significantly due to different PGS and fertilizer applications. The longest (26.28 cm) panicle was found from T_3, which was statistically similar (25.12 cm) with T_5, while the shortest (23.00 cm) panicle length was attained from T_1 treatment. Same findings were reported by Zayed *et al.*, (2011) that the comparative foliar application treatment of Zn +Fe + Mn twice at 20 and 45 days after transplanting (DAT) gave the highest values of chlorophyll content and panicle length.

A significant interaction between PGS and fertilizer levels and variety were observed on panicle length of rice, as shown in Table 2.

The interaction result showed that the interaction of BRRI hybrid dhan3 × T_3 produced the longest (27.77 cm) panicle length followed by the interaction of BRRI hybrid dhan3 × T_5 and the shortest (21.94 cm) panicle length was counted in the interaction of BRRI dhan29 × T_1 treatment.

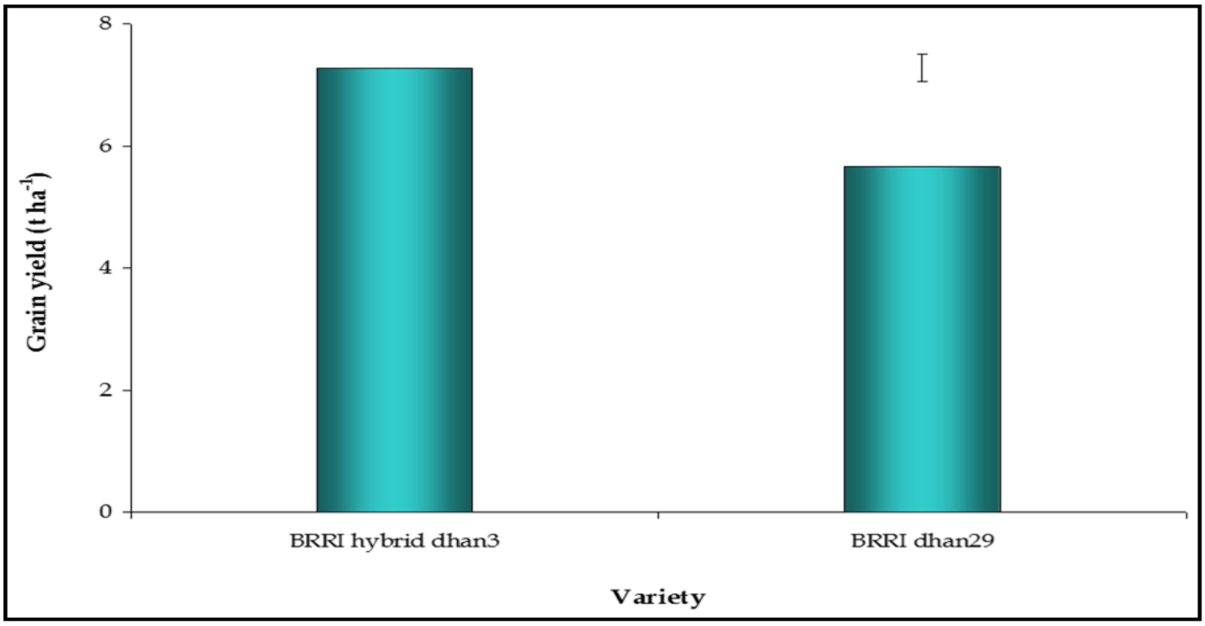


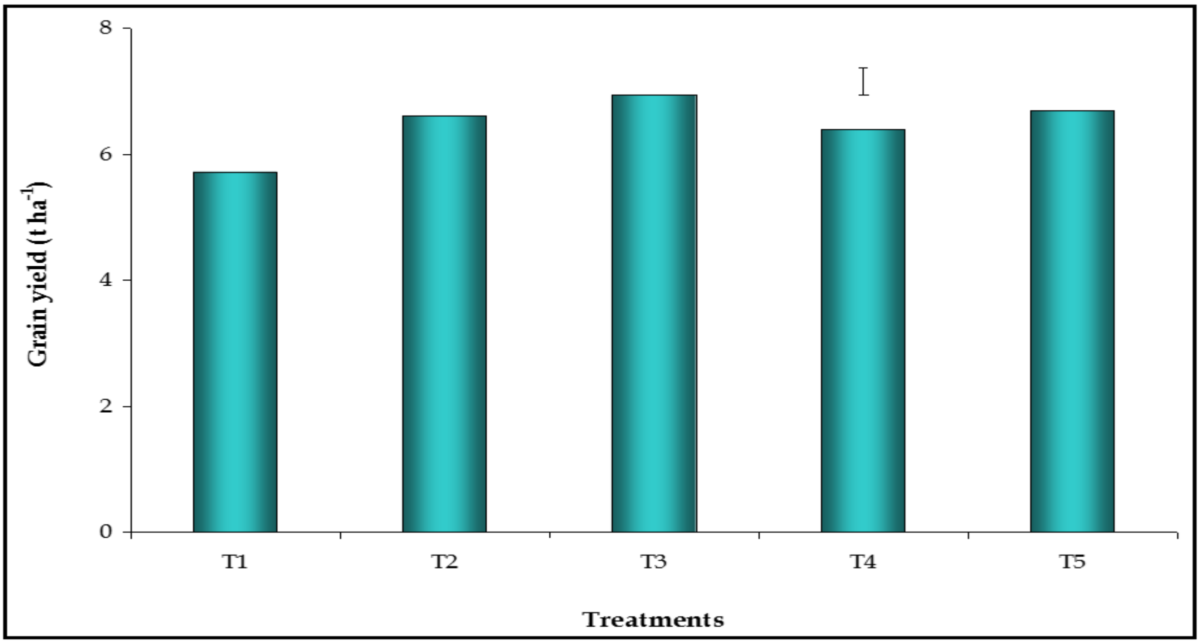
Fig. 1. Effect of different varieties on the grain yield of rice.

Filled grains panicle^{-1}

Table 1 shows the number of filled grains panicle^{-1} varied significantly among rice varieties. The maximum (180.36) number of filled grains panicle^{-1} was found from BRRI hybrid dhan3 variety and the lowest (127.54) number of filled grains panicle^{-1} was obtained from the BRRI dhan29.

The different PGS and fertilizer levels showed significant variation in case of the number of filled grains panicle^{-1}, as shown in Table 1.

The highest (168.7) number of filled grains panicle^{-1} was obtained from T_3, which was identical (159.7) with T_5 and the lowest (141.4) number of filled grains panicle^{-1} was obtained from T_1 treatment.



T_1 = Recommended fertilizer dose, T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol, T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth, T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth.

Fig. 2. Effect of different levels of PGS and fertilizer on the grain yield of rice.

The number of filled grains panicle^{-1} was significantly influenced by the interaction effect of different PGS and fertilizer levels and rice varieties, as shown in Table 2. The maximum (197.7) number of filled grains panicle^{-1} was recorded from the combination of BRRI hybrid dhan3 × T_3 and it was statistically similar (187.3) with the interaction of BRRI hybrid dhan3 × T_5. On the other hand, the minimum (117.2) number of filled grains panicle^{-1} was recorded from the combination of BRRI dhan29 × T_1 treatment.

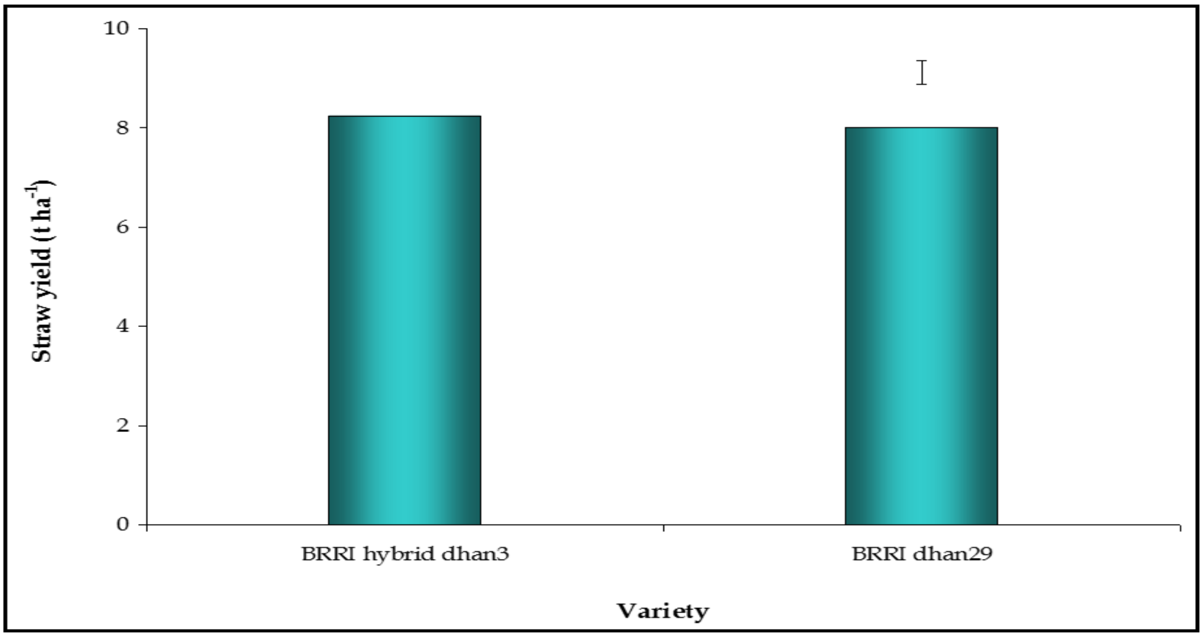


Fig. 3. Effect of different varieties on the straw yield of rice.

Total grains panicle^{-1}

Table 1 shows the varieties were differed significantly in production of the number of total grains panicle^{-1}. The highest (189.26) number of total grains panicle^{-1} was observed from BRRI hybrid dhan3. The lowest (141.15) number of total grains panicle^{-1} was obtained in BRRI dhan29.

Different levels of PGS and fertilizer showed significant variation on production of total grains panicle^{-1}, as shown in Table 1. The table showed that the maximum (178.0) number of total grains panicle^{-1} was obtained from T_3, which was identical with T_5 treatment, where the minimum (154.9) number of total grains panicle^{-1} was obtained from T_1 treatment. Similar results were observed by Pramanik *et. al.* (2015).

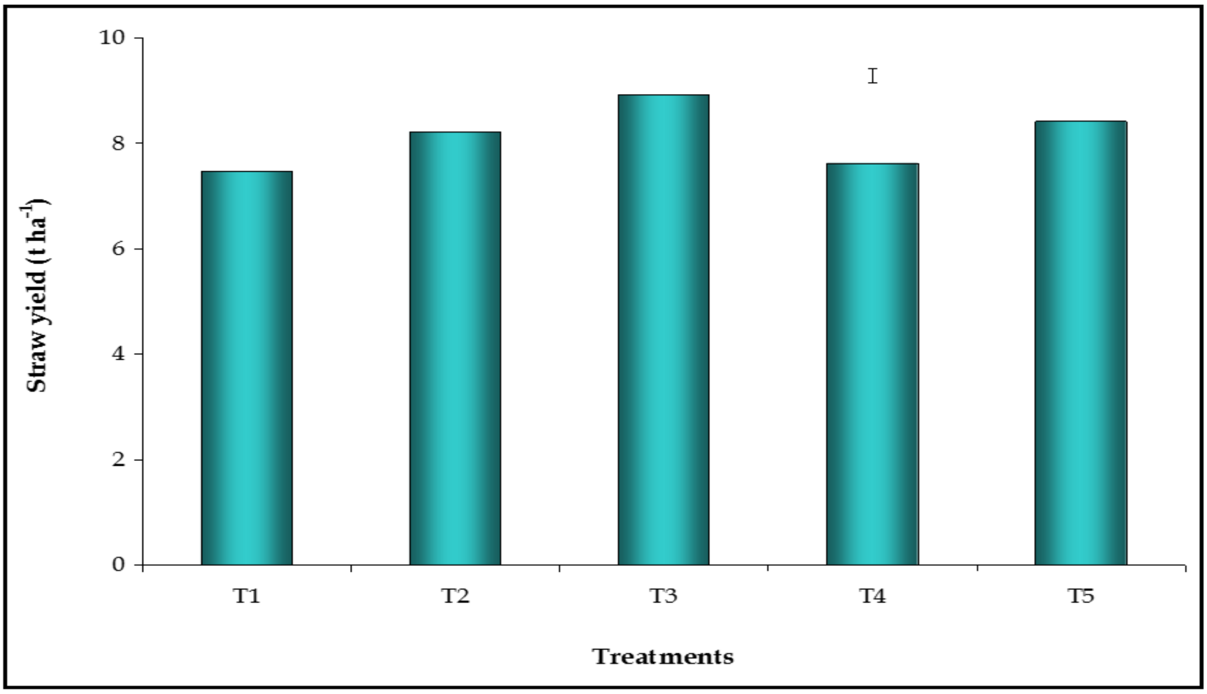
Table 2 shows the interaction effect of variety and PGS and fertilizer management showed significant variation was observed for number of total grains panicle^{-1} due to different PGS and fertilizer application.

The maximum (204.5) number of total grains per panicle was recorded from the interaction of BRRI hybrid dhan3 × T_3, which was statistically similar (195.4 and 187.4) with the interaction of BRRI hybrid dhan3 × T_5 and BRRI hybrid dhan3 × T_2 treatment.

The minimum (133.0, 139.6, 151.5, 137.0 and 144.6) number of total grains panicle^{-1} was recorded from BRRI dhan29 under all the fertilizer treatments.

Filled grain (%)

Variety exerted insignificant variation on filled grain (%) of rice. BRRI hybrid dhan3 showed the highest (92.56 %) filled grain and the lowest (88.62 %) filled grain was obtained from BRRI dhan29, as shown in Table 1.



T_1 = Recommended fertilizer dose, T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol, T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth, T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth.

Fig. 4. Effect of different levels of PGS and fertilizer on the straw yield of rice.

Table 1 shows the PGS and fertilizer levels exerted insignificant variation on filled grain (%). The statistically numerical highest (93.92 %) value of filled grain was recorded from T_3 treatment and the lowest (87.61%) filled grain was observed in T_1 treatment.

Table 2 shows the interaction between PGS and fertilizer levels and variety exerted significant effect on filled grain (%) of rice. The highest (96.23 %) filled grain was observed from the interaction of BRRI hybrid dhan3 × T_3 treatment, which was statistically similar with all the combined treatments except the combined effect of BRRI dhan29 × T_1 treatment. The lowest (85.62 %) filled grain was observed in the interaction of BRRI dhan29 × T_1 treatment.

1000 grains weight

Variety had significant effect on the weight of 1000-grains (g), as shown in Table 1. The highest (26.84 g) weight of 1000-grains was observed from BRRI hybrid dhan3 and the lowest (19.52 g) weight was observed from BRRI dhan29.

Different treatments of PGS and fertilizer excreted significant effect on 1000 grains weight (g), as shown in Table 1. The findings showed that the highest (24.98 g) 1000 grains weight was achieved from T_3 followed by T_5 (23.97 g), whereas the lowest (21.56 g) 1000 grains weight was recorded from T_1 treatment. Soylu *et al.* (2005) reported a significant increase in 1000 grain weight with the foliar application of micronutrients. The similar results were shown by Shafiee *et al.* (2013) and Gueins *et al.* (2003).

Table 2 shows the interaction effect of different treatments of PGS and fertilizer and rice varieties showed significant variation on 1000 grains weight (g). The highest (28.90 g) 1000 grains weight was found from the interaction of BRRI hybrid dhan3 × T_3 and it was statistically similar (27.49, 26.50 and 25.98 g) with the interaction of BRRI hybrid dhan3 × T_5; BRRI hybrid dhan3 × T_2 and BRRI hybrid dhan3 × T_4 treatment. On the other hand, the lowest (17.79 g) weight of 1000 grains was counted from the interaction of BRRI dhan29 × T_1 treatment.

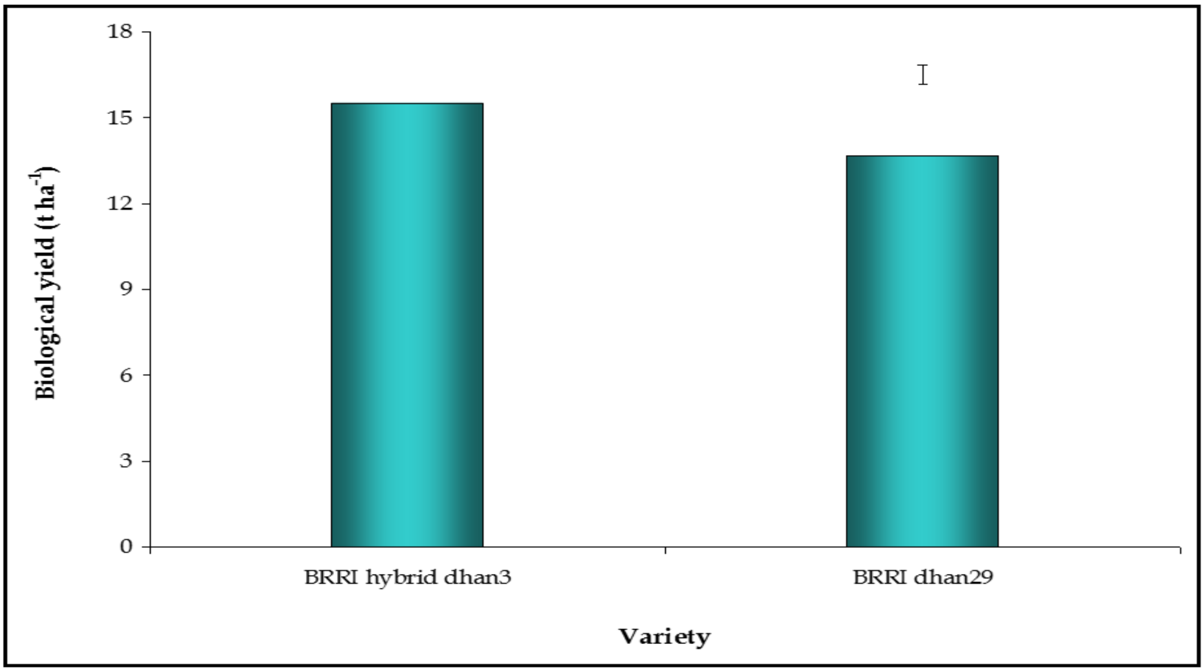


Fig. 5. Effect of different varieties on the biological yield of rice.

Grain yield

Fig. 1 shows the significant variation in case of grain yield (t ha^{-1}) between the rice varieties. Among the two varieties BRRI hybrid dhan3 showed its superiority in producing highest grain yield which was (7.09 t ha^{-1}). The lowest (5.42 t ha^{-1}) grain yield was found from BRRI dhan29.

Grain yield was significantly influenced by PGS and fertilizer management, as shown in Fig. 2. The maximum (6.99 t ha^{-1}) grain yield was obtained from T_3, which was statistically similar with T_5 (6.46 t ha^{-1}) treatment.

On the other hand, the minimum (5.68 t ha^{-1}) grain yield was recorded from T_1 treatment.

Grain yield influenced significantly by the interaction of PGS and fertilizer management and varieties, as shown in Table 3.

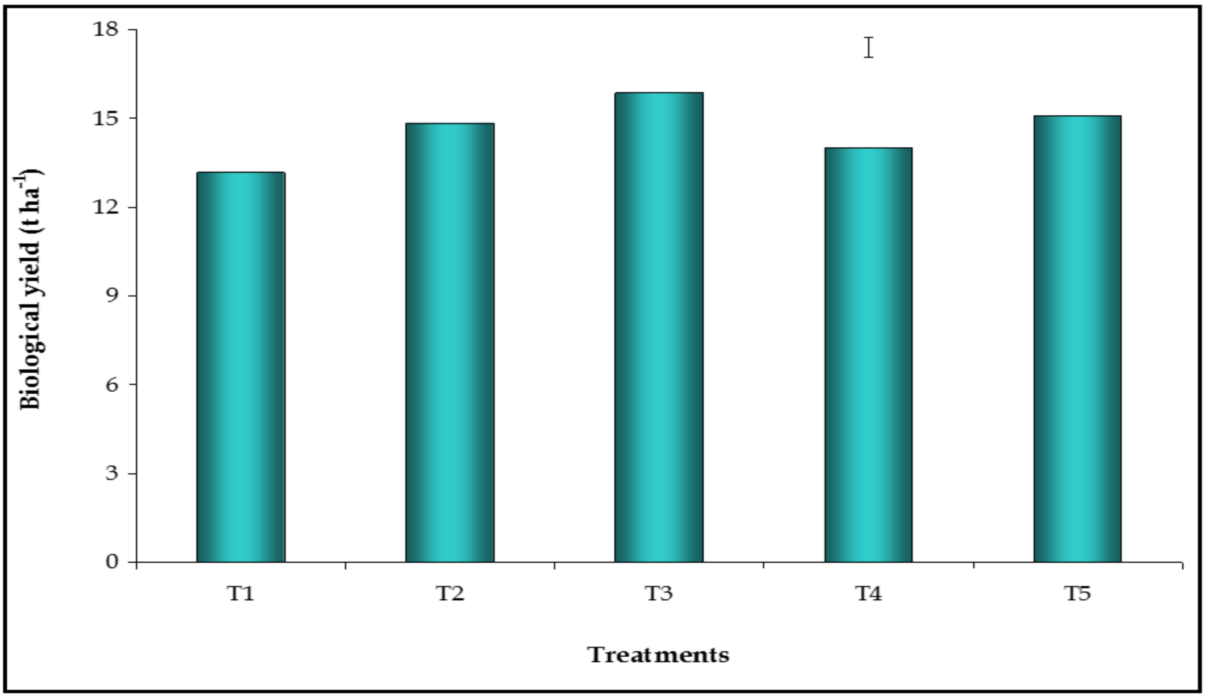
Among the interaction treatments, the highest (7.78 t ha^{-1}) grain yield was recorded from the interaction of BRRI hybrid dhan3 × T_3 followed by BRRI hybrid dhan3 × T_5 and BRRI hybrid dhan3 × T_2. The lowest (4.88 and 5.02 t ha^{-1}) grain yield was observed from BRRI dhan29 × T_5 and BRRI dhan29 × T_4 treatment.

Straw yield

Straw yield varied insignificantly among rice varieties, as shown in Fig. 3. BRRI hybrid dhan3 gave the highest (8.42 t ha^{-1}) straw yield whereas the lowest (8.11 t ha^{-1}) straw yield was found from BRRI dhan29. In the present study PGS and fertilizer management effect affected straw yield (t ha^{-1}), as shown in Fig. 4. It was found that significant variation of straw yield was seen among all the treatments. Results showed that the highest (8.85 t ha^{-1}) straw yield was achieved from T_3 treatment.

Table 3 shows the significant difference among the interactions of different PGS and fertilizer treatments and varieties in respect of straw yield (t ha^{-1}).

The maximum (8.96 t ha^{-1}) straw yield was found from the interaction of BRRI hybrid dhan3 × T_3, which are statistically similar with the interaction of T_5 and T_2 with BRRI hybrid dhan3 and BRRI dhan29 × T_3 and BRRI dhan29 × T_5, whereas the lowest (7.11 t ha^{-1}) straw yield was recorded from the interaction of BRRI dhan29 × T_1 treatment.



T_1 = Recommended fertilizer dose, T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol, T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth, T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth.

Fig. 6. Effect of different levels of PGS and fertilizer on the biological yield of rice.

Biological yield

Significant variation in biological yield was observed due to varietals difference and it ranges from 13.54 to 15.51 t ha^{-1}, as shown in Fig. 5. The highest biological yield was obtained from BRRI hybrid dhan3 and the lowest from BRRI dhan29, respectively.

Biological yield differed significantly due to the different treatments of PGS and fertilizer, as shown in Fig. 6. The highest (15.94 t ha^{-1}) biological yield was found from T_3 followed by T_5 treatment.

The lowest (13.12 t ha^{-1}) biological yield was recorded from T_1 treatment**.** The results were shown similarity with the results of Radwan *et. al.* (2015). Also similar to Gueins *et al.* (2003). Soleymani (2012) reported increase in biological yield for foliar application of zinc.

Table 3 shows the significant variation in biological yield (t ha^{-1}) was observed from the interaction effect of PGS and fertilizer management and varieties. The results showed that the interaction between BRRI hybrid dhan3 × T_3 gave the highest (16.74 t ha^{-1}) biological yield that was statistically similar with BRRI hybrid dhan3 × T_5 treatment. The lowest (11.98 t ha^{-1}) biological yield was found in BRRI dhan29 × T_1 treatment.

Harvest Index (%)

Significant difference was observed for harvest index (%) due to varietal differences, as shown in Fig. 7. The maximum (45.68 %) harvest index was observed from BRRI hybrid dhan3 and the lowest (40.05 %) harvest index was found from BRRI dhan29.

Fig. 8 shows the effect of different treatments of PGS and fertilizer exerted insignificant variation on harvest index. The maximum numerical (43.76 %) harvest index was observed from T_3 and the lowest (43.50 %) harvest index was obtained from T_1 treatment.

Harvest index was significantly influenced by the interaction effect of different treatments of PGS and fertilizer and variety, as shown in Table 3.

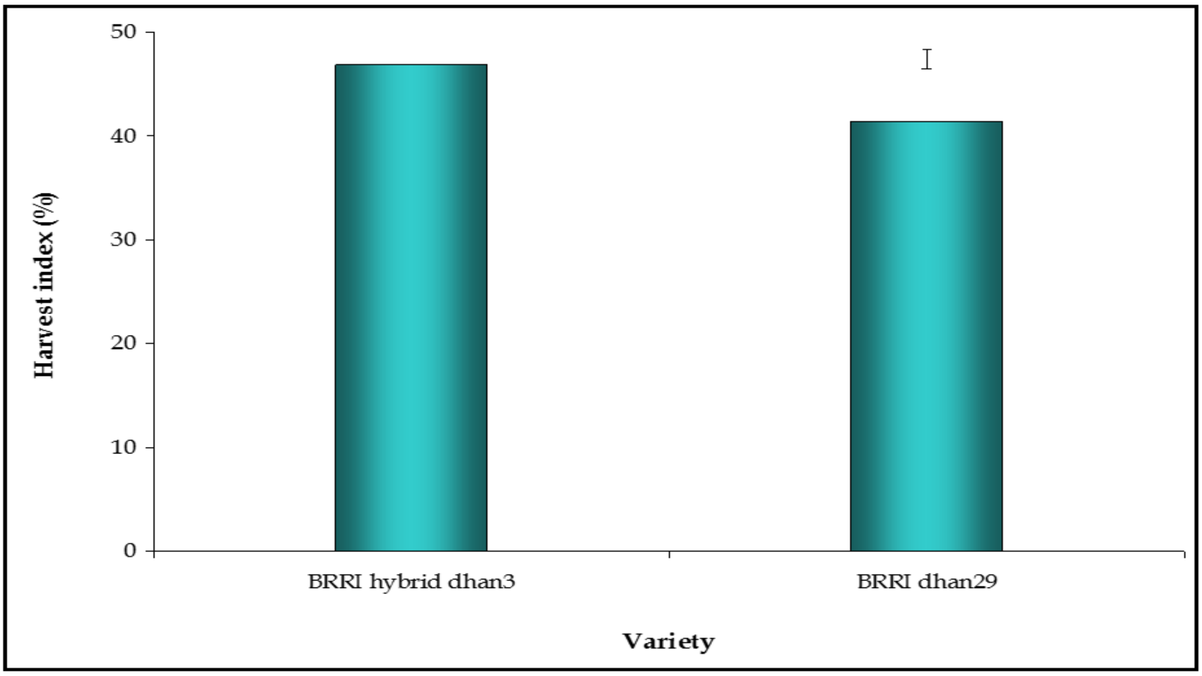
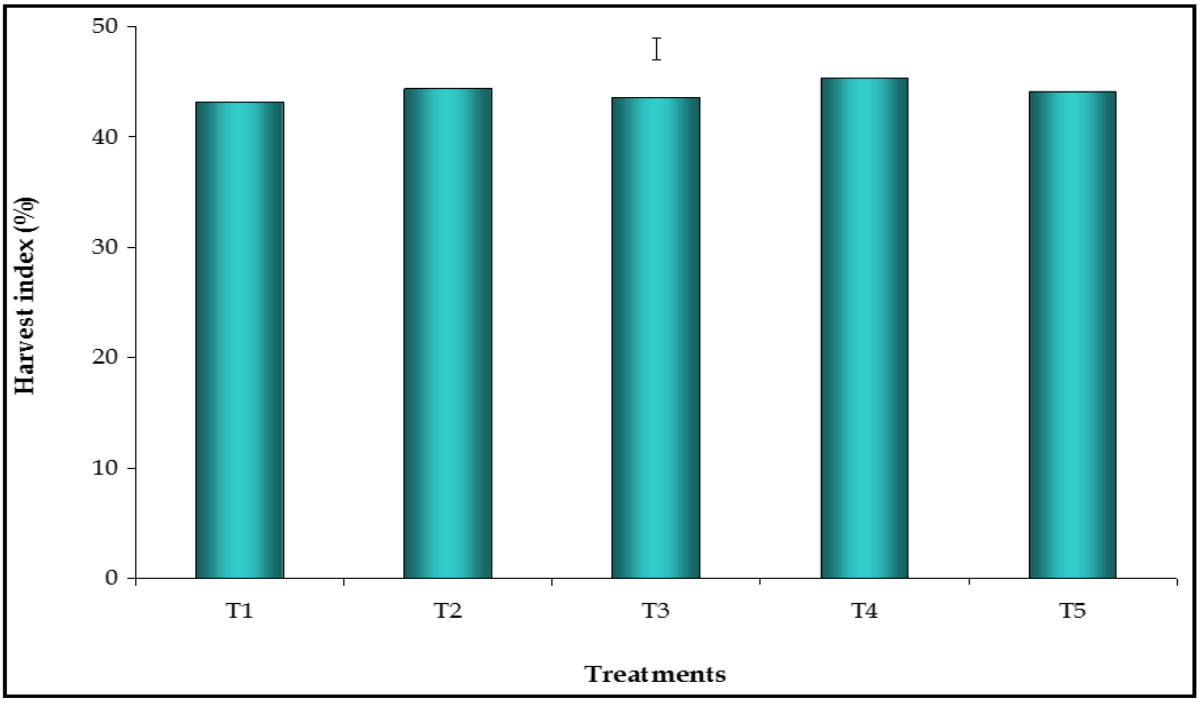


Fig. 7. Effect of different varieties on the harvest index of rice.



T_1 = Recommended fertilizer dose, T_2 = Recommended fertilizer dose + Akota + Global, T_3 = Recommended fertilizer dose + Akota + Global + Calsol, T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth, T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth.

Fig. 8. Effect of different levels of PGS and fertilizer on the harvest index of rice.

The maximum (46.44%) harvest index was observed from the interaction of BRRI hybrid dhan3 × T_3 that followed by BRRI hybrid dhan3 × T_4 treatment. The minimum (39.01%) harvest index was found from the interaction treatment effect of BRRI dhan29 × T_2 treatment.

Conclusion

On the basis of present research, it can be concluded that the combination of BRRI hybrid dhan3 and T_3

(Recommended fertilizer dose + Akota + Global + Calsol) treatment exhibited better growth and provided highest grain yield attributed by panicle hill^{-1}, 1000 grains weight, grain yield etc. T_3 (Recommended fertilizer dose + Akota + Global + Calsol) is more effective over the rest combinations. For getting higher yield, combination of recommended fertilizer dose, Akota, Global and Calsol should be used.

Acknowledgements

The authors would like to acknowledge my venerable research supervisor, co-supervisor and others concerned personnel of the department of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 for their constant inspiration, valuable suggestions, cordial help, heartiest co-operation and supports throughout the study period.

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