Response of Different Sources of Phosphate Fertilizers and Homo-brassinolide on Total Chlorophyll Content, Yield Attributes and Yield of Hybrid Rice under Lateritic Zone of West Bengal, India

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Abstract

A pot culture experiment was conducted during *kharif* season of 2009 and 2010 at Agricultural research farm, Visva-Bharati, Sriniketan, Birbhum. The experiment was laid out in CRD with two sources of phosphatic fertilizers, viz. DAP and SSP, two hybrids, viz. PHB71 and 25P25 and two sprayings of homo-brassinolide, viz. panicle initiation (PI) and PI+flowering. The crop was fertilized with respective dose of 150:60:60 NPK kg ha^{-1}. Between the hybrids, PHB71 recorded significantly higher total chlorophyll content, number of effective tillers hill^{-1}, panicle length, test weight, number of filled grains panicle^{-1}, fertility%, straw and grain yield hill^{-1} and harvest index as compared to rice hybrid 25P25. The percentage increase in grain yield of PHB71 as compared to 25P25 was 28.32. Application of DAP significantly increased total chlorophyll content, number of tillers hill^{-1}, panicle length, test weight, number of filled grains panicle^{-1}, fertility(%), straw and grain yield hill^{-1}. Two spraying of homo-brassinolide at PI and flowering significantly increased yield attributing parameters, fertility%and grain yield hill^{-1} as compared to one spraying of homo-brassinolide at PI stage

1. Introduction

Rice (*Oryza sativa* L.) is the staple food providing about two-thirds of the calories for more than two billion people in humid and sub-humid Asia and one-third of the calorie intake of nearly one billion people in Africa and Latin America. It feeds more than half or world population. It has been estimated that the world will have to produce 40% more rice by 2030 than what it produced in 2011. Therefore, to increased production of rice plays a very important role in food security and poverty alleviation. Theoretically, rice still has great yield potential to be tapped and there are many ways to raise rice yield, such as building of irrigation works, improvement of soil conditions, cultural techniques and breeding of high yielding varieties. Among them, it seems at present that the most effective and economic way available is to develop hybrids based on the successful experience in China. Hybrid rice has potential of yielding 20-25% more than the best inbred varieties grown under similar conditions (Meena et al., 2002).

Plants do not grow normal due to limiting of phosphorus (Sircar and Sen, 1941) and yield is depressed. Apart from contributing greatly to high rice yield, phosphorus is necessary in several other ways. Phosphorus is an essential nutrient for plants because of its vital role in better root development, photosynthesis and several energy transformation processes. Phosphorus application showed advantage because it favored early tillerinw. Likewise, phosphorus application increased yield of hybrid rice (Mandal, 1982). Most of the soils in Asia are low in native P. Therefore, attention is increasingly turned to efficient use of P under cultivation. Brassinolide (BL), considered to be the most important homo-brassinolide (HBR) playing a pivotal roles in the hormonal regulation of rice plant growth and development, and its ability to induce disease resistance in rice plants was analyzed by Nakashita et al., (2003). The available information on P and HBR for inbred varieties may or may not be suitable for rice hybrids.

2. Materials and Methods

A pot culture experiment was conducted during *kharif* season of 2009 and 2010 at Agricultural research farm, Visva-Bharati, Sriniketan, Birbhum. The soil was sandy-loam in texture with high percentage of sand and low percentage of clay. The soil was slightly acidic (pH 5.9), low in soil available nitrogen (136 kg ha^{-1}), phosphorus (11.50 kg ha^{-1}) and medium in potassium (160.5 kg ha^{-1}). The experiment was laid out in CRD. Two sources of phosphatic fertilizers, viz. DAP and SSP, two rice hybrids, viz. PHB71 and 25P25 and two sprayings of homo-brassinolide @ 0.2 ppm (double @ 0.5 ml l^{-1}, Godrej Agrovet) at PI (panicle initiation) and PI+flowering stage. Seedlings of the two hybrids were raised separately in nursery. In all, treatments were replicated three times. The earthen pots (25 cm diameter) were filled with unsterile soil (10 kg pot^{-1}) and dose of fertilizers on the basis of soil weight according to treatments. The crop was fertilized with respective dose of 150:60:60 NPK kg ha^{-1}. Crop was sown in 5th July, 2009 and 9th July, 2010 and the harvesting was done in the 25th November, 2009 and 30th November, 2010 respectively. Observations were recorded on total chlorophyll content, number of tillers $hill^{-1}$, length of panicle, panicle weight, test weight, number of filled grains $panicle^{-1}$, grain yield $panicle^{-1}$, fertility (%) and grain yield $hill^{-1}$.

2.1. Chlorophyll estimation

Total chlorophyll content was measured adopting the method of Hiscox and Israelstam (1979), using dimethyl sulfoxide (DMSO) with the following procedure. Leaf material of 50 mg was taken from fully emerged leaf and placed in a test tube, and 10 ml of DMSO was added. This was kept in an oven at 65°C for about 4 h. After 4 h the chlorophyll was expressed in the liquid form without any grinding. The extract was taken in a measuring cylinder and final volume was made up to 10 ml by using DMSO. The absorbance of the solution was read at 663 nm and 645 nm using spectrophotometer against the DMSO blank. The chlorophyll content was determined by using the formula given by Arnon (1949) and expressed as mg g^{-1} of fresh leaf. Arnon's formula estimates total chlorophyll as follows:

$$\text{Total chlorophyll} = [20.2(D645)+8.02(D663)] \times \frac{V}{1000 \times W}$$

Where, D=Absorbance, V=Final volume of DMSO (ml), W=Weight of fresh leaf (g)

3. Results and Discussion

3.1. Total chlorophyll content

Data on total chlorophyll content in leaf affected by rice hybrids, source of phosphatic fertilizers and HBR are presented in Table 1. Total chlorophyll content was higher in second year as compared to the first year. Rice hybrid PHB71 recorded significantly higher chlorophyll content in leaf as compared to rice hybrid 25P25 in both the years at all the crop growth stages. Application of DAP significantly increased total chlorophyll content in leaf as compared to SSP at all the growth stages of crop in both the years. Two spray of HBR at PI and PI+flowering significantly increased total chlorophyll content as compared to one spray of homo-brassinolide at PI stage at 80 DAT and at flag leaf stages. This might be due to root system with consequent supply of nitrogen from soil. It has been evidenced that there is a positive correlation between nitrogen and total chlorophyll content. The results are conformity with those of De Geus (1954), Datta and Mistry (1958), Nakashita et al. (2003), and Bera and Pramanik (2010).

3.2. Effective tillers $hill^{-1}$

Significant differences in number of effective tillers $hill^{-1}$ were observed between two hybrids (Table 2). The numbers of effective tillers $hill^{-1}$ were higher in the second year than first year. Hybrid PHB71 produced higher numbers of effective $tillers^{-1}$ at harvest (22.46, 25.00) as compared to 25P25 (19.29, 21.80). Effective tillers $hill^{-1}$ of rice hybrids also varied significantly due to source of phosphatic fertilizers (Table 2). Application of DAP produced the highest numbers of effective tillers $hill^{-1}$ (22.25, 24.99) which was statistically significant than application of SSP (19.51, 21.28). This might be due to more solubility as well as availability of phosphorus from DAP which help rice plants to accelerate the phosphate absorption for increased tillering. Similar kind of results was reported by Katyal (1978), and Matsuo et al. (1995). Spraying of HBR did not show any variation in respect of production of numbers of effective tillers $hill^{-1}$ during both the years.

3.3. Panicle length

Significant differences in respect of panicle length were observed between two hybrids (Table 2). The longest panicle was observed from PHB71 (24.78 cm) and the shortest from 25P25 (22.81 cm). Phosphorus had significant role in increasing the panicle length. Application of DAP produced the longest panicle (24.95 cm) as compared to SSP application (22.65 cm). Similar results were reported by Sahar and Burbey (2003). The longest panicle (24.30 cm) was produced in hybrid rice receiving twice spraying of HBR at panicle initiation (PI)+flowering stage number and shortest panicle length (23.30 cm) with one spraying at flowering stage. The results are conformity with Nakashita et al. (2003).

3.4. Filled grains $panicle^{-1}$ and fertility%

Hybrid PHB71 produced the maximum number of filled grains $panicle^{-1}$ (112.1) which was statistically significant with 25P25 (106.7). Hybrid PHB71 produced 5% higher filled grains over 25P25. However, fertility percentage was at par between two hybrids. Filled grains $panicle^{-1}$ as well as fertility percentage was also significantly affected by different sources of phosphorus application (Table 2). Application of DAP produced highest number of filled grains $panicle^{-1}$ (113.2) and fertility (91.58%) and it was statistically significant with SSP application (105.6, 89.29%). DAP produced 7% higher filled grains over SSP. The findings are in agreement with those of Fageria and Barosa-Filho (1982). Sahar and Burbey (2003) showed that phosphorus compound significantly affected the grain numbers $panicle^{-1}$. The highest number of filled grains $panicle^{-1}$ (111.5) and fertility

Table 1: Total chlorophyll content (mg g^{-1} of fresh leaf) of rice hybrids as influenced by different sources of phosphatic fertilizers and HBR

Treatments	20 DAT		40 DAT		60 DAT		80 DAT		Flag leaf	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Rice hybrids										
PHB71	1.63	2.22	2.90	3.02	1.99	2.71	1.80	2.02	0.79	0.95
25P25	1.25	1.76	2.68	2.61	2.22	2.32	1.25	1.46	0.46	0.55
SEm±	0.06	0.08	0.04	0.08	0.07	0.06	0.07	0.07	0.05	0.06
CD (*p*=0.05)	0.18	0.24	0.12	0.24	0.21	0.18	0.21	0.21	0.15	0.18
Source of phosphatic fertilizers										
DAP	1.68	2.37	3.00	3.13	2.43	2.68	1.72	1.94	0.73	0.88
SSP	1.21	1.61	2.58	2.48	1.78	2.33	1.33	1.54	0.53	0.63
SEm±	0.06	0.08	0.04	0.08	0.07	0.06	0.07	0.07	0.05	0.06
CD (*p*=0.05)	0.18	0.24	0.12	0.24	0.21	0.18	0.21	0.21	0.15	0.18
Spraying of HBR										
PI	1.45	2.01	2.80	2.83	2.10	2.50	1.34	1.55	0.52	0.63
PI+flowering stage	1.42	1.97	2.78	2.78	2.11	2.52	1.72	1.93	0.73	0.88
SEm±	0.06	0.08	0.04	0.08	0.07	0.06	0.07	0.07	0.05	0.06
CD (*p*=0.05)	NS	NS	NS	NS	NS	NS	0.21	0.21	0.15	0.18

Table 2: Numbers of effective tillers hill^{-1}, panicle length, numbers of filled grains panicle^{-1} and fertility (%) of rice hybrids as influenced by different sources of phosphatic fertilizers and HBR

Treatments	Number of effective tillers hill^{-1}		Panicle length (cm)			Number of filled grains panicle^{-1}			Fertility (%)		
	2009	2010	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
Rice hybrids											
PHB71	22.46	25.00	24.07	25.00	24.78	109.41	114.70	112.10	90.08	91.33	90.70
25P25	19.29	21.80	22.30	23.32	22.81	104.34	109.16	106.05	89.91	90.41	90.16
SEm±	0.18	0.07	0.18	0.17	0.12	0.58	0.72	0.47	0.46	0.27	0.38
CD (*p*=0.05)	0.54	0.21	0.54	0.51	0.35	1.74	2.16	1.36	NS	0.78	NS
Source of phosphatic fertilizers											
DAP	22.25	24.99	24.24	25.65	24.95	110.46	115.95	113.21	91.33	91.83	91.58
SSP	19.51	21.81	22.13	23.16	22.65	103.28	107.92	105.60	88.66	89.91	89.29
SEm±	0.18	0.07	0.18	0.17	0.12	0.58	0.72	0.47	0.46	0.27	0.38
CD (*p*=0.05)	0.54	0.21	0.54	0.51	0.35	1.74	2.16	1.36	1.33	0.78	1.10
Spraying of HBR											
PI	20.80	23.36	22.71	23.89	23.30	105.18	109.32	107.25	89.16	90.00	89.58
PI+flowering stage	20.96	23.43	23.67	24.93	24.30	108.56	114.54	111.55	90.83	91.75	91.29
SEm±	0.18	0.07	0.18	0.17	0.12	0.58	0.72	0.47	0.46	0.27	0.38
CD (*p*=0.05)	NS	NS	0.54	0.51	0.35	1.74	2.16	1.36	1.33	0.78	1.10

(91.29%) was recorded in crop receiving twice spraying of HBR at PI+flowering stage.

3.5. 1000-grain weight

Hybrids showed significant response on 1000-grain weight (Table 3). The maximum weight of 1000-grain was recorded with the hybrid PHB71 (22.37 g, 22.45 g) and the lowest from 25P25 (21.24 g, 21.33 g). Grain weight of rice hybrids also varied significantly due to phosphorus fertilizer application. The

Table 3: 1000-grain weight, grain and straw yield hill^{-1} and harvest index (%) of rice hybrids as influenced by different sources of phosphatic fertilizers and HBR

Treatments	1000-grain weight (g)		Grain yield hill^{-1} (g)			Straw yield hill^{-1} (g)			Harvest index (%)		
	2009	2010	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
Rice hybrids											
PHB71	22.37	22.45	51.32	57.96	54.64	61.39	65.45	63.42	45.24	46.73	46.00
25P25	21.24	21.33	39.96	45.20	42.56	54.09	60.23	57.16	42.19	42.71	42.45
SEm±	0.07	0.08	0.55	0.60	0.41	0.88	0.86	0.61	0.45	0.41	0.29
CD (p=0.05)	0.21	0.24	1.67	1.82	1.18	2.67	2.61	1.76	1.36	1.24	0.84
Source of phosphatic fertilizers											
DAP	22.14	22.23	52.27	57.84	55.06	61.94	66.08	64.01	45.53	46.42	45.98
SSP	21.47	21.55	39.01	45.31	42.16	53.55	59.59	56.57	41.92	43.02	42.47
SEm±	0.07	0.08	0.55	0.60	0.41	0.88	0.86	0.61	0.45	0.41	0.29
CD (p=0.05)	0.21	0.24	1.67	1.82	1.18	2.67	2.61	1.76	1.36	1.24	0.84
Spraying of HBR											
PI	21.67	21.73	41.88	47.95	44.91	55.92	60.65	58.29	42.44	43.86	43.16
PI+flowering stage	21.95	22.04	49.00	55.20	52.30	59.56	65.02	62.29	45.01	45.57	45.29
SEm±	0.07	0.08	0.55	0.60	0.41	0.88	0.86	0.61	0.45	0.41	0.29
CD (p=0.05)	0.21	0.24	1.67	1.82	1.18	2.67	2.61	1.76	1.36	1.24	0.84

highest 1000-grain weight (22.14 g, 22.23 g) was recorded with application of DAP as a resource of phosphatic fertilizer. The lowest weight of 1000-grain (21.47 g, 21.55 g) with SSP. The highest 1000-grain weight (21.95 g, 22.04 g) was observed with twice spraying of HBR at PI+flowering stage. However, the lowest test weight (21.67 g, 21.73 g) was observed in crop receiving one spraying of homo-brassinolide at panicle initiation stage.

3.6. Grain yield hill^{-1}

The rice hybrids were different significantly in respect of grain yield hill^{-1} (Table 3). The hybrid variety PHB71 produced the highest grain yield hill^{-1} (54.64 g) which was statistically significant with the hybrid 25P25 (42.58 g). The yield increase by PHB71 was 12.06 g hill^{-1} which was 28.32% over the hybrid 25P25. The yield advantage was mainly due to more filled grain panicle^{-1} and largest panicle length. The impact of phosphorus on grain yield hill^{-1} was significant. Grain yield hill^{-1} of rice hybrids also varied significantly due to use of different sources of phosphatic fertilizers application. The highest grain yield hill^{-1} (55.06 g) was observed in hybrid receiving DAP. However, the lowest grain yield hill^{-1} (42.16 g) was with application of SSP fertilizer as a source of phosphorus. The increase in grain yield by the use of DAP was 12.90 g hill^{-1} and which was 30.60% over the application of SSP as a source of phosphatic fertilizers. Higher grain yield with DAP might be due to higher filled grain panicle^{-1} and largest panicle length as well as higher chlorophyll content of leaves was an important index. DAP enhanced the photosynthetic efficiency thus increased the grain yield of hybrid rice. Application of DAP could enhanced the absorption of phosphate through physiological changes in plants and receiving NH_4±N has been attribute to stimulate uptake of $H_2PO_4^-$ or HPO_4^{2-} to balance a greater cation uptake and potassium by hybrid rice. The results are conformity with those of Ghosh and Chatterjee (1979), Bhowmick and Nayak (2000), Bera and Pramanik (2010). Spraying of HBR at different stages also showed significant different in grain yield hill^{-1}. The highest grain yield hill^{-1} (52.30 g) was recorded with twice spraying of HBR at PI+flowering stage. However, the lowest grain yield hill^{-1} (44.91 g) was observed in crop receiving only one spraying at panicle initiation stage. The grain yield increase with twice spraying of HBR was 16.45% over the one spraying of HBR at PI stage. The findings also supported by Pramanik and Bera, 2011 and Bera and Pramanik, 2012). This might be due to more number of filled grains panicle^{-1} and largest panicle length.

3.7. Straw yield hill^{-1}

Significant differences in straw yield hill^{-1} were observed between two hybrids. The hybrid PHB71 produced the highest straw yield hill^{-1} (63.42 g) and the lowest (57.16 g) from the hybrid 25P25. The increase in straw yield with PHB71 was 10.95% more over the hybrid 25P25. Xie et al. (2007) reported that biomass production varied with variety which rendering different straw yield. Significant difference on straw yield of hybrid rice was observed when different sources of phosphatic fertilizers applied (Table 3). The highest straw yield hill^{-1} (64.01 g) was obtained from DAP application. The lowest straw yield hill^{-1} (56.57 g) was obtained from SSP application. The increase in straw yield hill^{-1} with DAP application was 13.15% higher over the crop receiving the SSP treatment. The highest straw yield hill^{-1} (62.29 g) was recorded with twice spraying of HBR at PI+flowering stage. However, the lowest straw yield hill^{-1} (58.29 g) was observed in crop receiving only one spraying at panicle initiation stage. The grain yield increase with twice spraying of HBR was 6.86% over the one spraying of HBR at PI stage.

3.8. Harvest index

The difference in harvest index due to variety was also significant (Table 3). The maximum harvest index was obtained from PHB71 (46%) and the lowest harvest index was obtained from 25P25 (42.45%). There was also significant effect of different sources of phosphorus was found on the harvest index of hybrid rice. The maximum harvest index was obtained from the treatment of DAP and the lowest from SSP treated plot. The highest harvest index (45.29%) was observed with twice spraying of HBR at PI+flowering stage. However, the lowest harvest index (43.16%) was observed in crop receiving one spraying of HBR at PI stage. In general, the harvest index was higher in hybrid rice indicating efficient translocation of assimilates for grain production of economic yield. The results are conformity with those of Bhowmick and Nayak (2000), Datta and Mistry (1958), and Nakashita et al. (2003)

4. Conclusion

Based on the above result and discussion following conclusion can be drawn that cultivation of PHB71 with application of DAP as well as two spraying of homo-brassinolide at panicle initiation+flowering stages improved chlorophyll content, yield attributing parameters, fertility (%), harvest index, straw and grain yield of hybrid rice.

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