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Effect of delayed planting of rice (*Oryza sativa* L.) varieties on crop nutrient status and grain quality of crop grown in Varanasi, India

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Abstract
A field experiment entitled "Performance of different rice (*Oryza sativa* L.) varieties under different dates of delayed planting" was carried out during kharif 2018 at Agricultural farm, Banaras Hindu University, Varanasi, Uttar Pradesh to find the effect of delayed planted rice varieties on crop nutrient status and grain quality. Four rice varieties and three dates of planting were allocated in main and subplot respectively in split plot which was replicated thrice. For determining the nutrient status plant sample and grains were collected at different crop growth stages i.e., at 30, 60 DAT and at harvest and analysed after processing. The results showed that the four rice varieties (V_1-Gargi, V_2- DRR-42, V_3-Sadabahar, and V_4-NDR-97) and three dates of planting (D_1- 5-08-2018, D_2- 13-08-2018 and D_3- 21-08-2018) under investigation differed significantly in various components of crop nutrient status *viz.* nutrient content and nutrient removal at different crop growth stages and in both grain and straw. It also varied significantly for crude protein content of grains similarly as crop nutrient status. The results revealed that highest amount nutrient content and removal were recorded by Gargi when planted on 5th August and the lowest amount by Sadabahar when planted on 21st August. The decreasing trend indicates the adverse effect of delayed planting on plant canopy and root development which consequently hampered the optimum nutrient absorption compared to timely planted crop. Hence, timely planting is an important non-monetary input responsible for enhanced production and productivity.

Keywords: timely planting, nutrient status, rice varieties, date of planting, delayed planting

Introduction
Rice (*Oryza sativa*. L) being the most important cereal crop after wheat is most widely consumed in the world. Asian countries are the largest producer (75% of the total global rice production) and consumer of rice (Lindner *et al.*, 2016) [7]. India's total acreage in rice production is approximately 43 million ha, producing about 118.43 million tons with an average productivity of 2.75 t ha^{-1} (NRRI, 2020) [8]. It is an indispensable food for more than half of the world's population within Asia and Africa. As it consists of a decent amount of protein, fibre, vitamin and minerals like iron and manganese. Hence, it secures the food and nutrient demands of the country simultaneously (Satapathy *et al.*, 2021) [10]. Therefore, increase in population will require 70 per cent more rice by 2025 (Kim, Krishnan, 2002) [5]. Due to this burgeoning population, India's rice production target for 2025 has increased to 140 million tons which can be accomplished only by increasing rice production by 2 million tons per year over the existing in the coming decade (Sridhar *et al.*, 2011) [11]. Rice is grown in vast areas of world but it has certain specific physical requirement for its successful cultivation which is achieved by its timely planting. Planting on time will provide high daily mean temperature, abundant water supply at critical stages and levelled field surfaces for uniform irrigation & drainage. Among the several agronomic practices, timely planting is the most important one as it indirectly determines the soil temperature, weather conditions and various biotic and abiotic stresses a young seedling of rice has to face during different Phenological stages. It is the most critically important non-monetary input for obtaining higher and quality rice yield. It varies with different farming situation, economic conditions, variety and agronomic constraints faced by farmers but it is the solution to rice production challenges faced by farmers. The maximum productivity of rice is recognized to be achieved by adopting the practice of optimum time of planting of the crop. It is mainly dependent on average agro-climatic conditions of the region. Variations in the date of planting influences the crop yield by

affecting it at two major phonological stages i.e., vegetative and reproductive phases (Dehghan, 2007) [2]. The optimum date of rice transplanting ensures proper vegetative growth, grain quantity and quality (Farrell *et al.*, 2003) [4]. Rice-wheat cropping sequence is the most important sequence of the Varanasi region of eastern U.P. Out of total cropped area, 63 and 68% area in kharif and rabi are occupied by rice and wheat respectively. The region of rice cultivation is characterized by several challenges like low availability of inputs, use of traditional practices like transplanting, less labour availability and many weather induced risks like late onset of monsoon etc. All this has led to delayed transplanting and other poor management due conditions which has reduced the rice yield drastically. Hence, there is an urgent need to develop appropriate rice cultivation practices which primarily focuses on the optimum time of planting suitable for different varieties cultivated in different region with other better specific cultivation practices. Right time of planting has much greater significance in crop production as it leads to benefits such as growth improvement as the crop is exposed to optimum weather conditions (like, temperature and sunshine hours etc.) and yield enhancement due to increased input use efficiency and photosynthetic efficiency leading to proper partitioning of assimilated photosynthates to different economical parts.

Materials and Methods

The present investigation was conducted under irrigated condition during the *kharif* season of 2018 at the Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The site was having alluvial soils of Indo-gangatic plains which was generally deep, flat and well drained with low available nitrogen (188.6 Kg ha^{-1}), medium available phosphorus (24.8 kg ha^{-1}) and potassium (206 Kg ha^{-1}). It was uniform in topography, homogenous in fertility with assured irrigation and other required input facilities. Under this field conditions a study was done to assess the effect of delayed planting of rice varieties on nutrient status and grain quality of crop. This was completed in a split plot design consisting of four rice varieties (V_1-Gargi, V_2- DRR-42, V_3-Sadabahar, and V_4-NDR-97) distributed in main plot and three planting dates (D_1- 5-08-2018, D_2- 13-08-2018 and D_3- 21-08-2018) which were randomly allocated in sub plots. Hence, twelve treatments were randomly allocated in three replications to minimise the errors. The field used for the experiment was under continuous cropping of rice and wheat with assured irrigation facility and homogenous fertility status. All the agronomical practices were carried out during the experiment from field preparation to harvesting in proper time to produce a good yield.

Result and Discussion

The plant nutrient analysis was completed via. Analysing the samples obtained at various crop growth stages i.e., 30, 60 DAT and at harvest. The samples at 30, 60 DAT were analysed only for its nutrient content. However, the harvest plant samples were analysed to obtain the nutrient content, removal and the protein content for assessing the quality of the product. It was revealed through processed data that all the components of crop nutrient status as well as grain quality as affected by protein percentage, followed the same progressively decreasing trend as the planting dates continues to get delayed i.e., 5th August followed by 13th August and 21st August.

Nutrient Content in Shoot

The nutrient content (N, P, K) was observed to be maximum in Gargi (V1) followed by DRR 42 (V2), NDR 97 (V4) and Sadabahar (V3) both at 30 & 60 DAT. The trends in nutrient content w.r.t. planting dates was found to be highest in crop planted on 5th August followed by 13th August and 21st August both at 30 and 60 DAT. Due to the significant interaction between the varieties and dates of planting, Gargi (V1) resulted in maximum nitrogen content when planted on 5th August (D1) whereas DRR 42 (V2) when planted on 21st August produced minimum nitrogen content at 30 DAT. Whereas, the interaction effect in phosphorus and potassium content showed that Gargi (V1) achieved maximum content when planted on 5th August (D1) and Sadabahar (V3) minimum when planted on 21st August (D3) both at 30 and 60 DAT.

Nitrogen content in grain and straw

The results revealed the varieties and dates of planting were significantly affected by the nitrogen content in grain as well as straw. The maximum nitrogen content in grain and straw were recorded in Gargi (V1) followed by DRR 42 (V2), NDR 97 (V4) and Sadabahar (V3). In case of nitrogen content in grain, DRR 42 (V2) was also found to be at par with NDR 97 (V4) but differed significantly with other two varieties. However, Gargi (V1) was found to be at par with DRR 42 (V2) but differed significantly with the other varieties in case of nitrogen content in straw.

Table 1: Effect of planting dates on nutrient content in shoot of rice varieties at different intervals

Parameters	Nitrogen content in shoot		Phosphorus content in shoot		Potassium content in shoot	
Treatments	**30 DAT**	**60 DAT**	**30 DAT**	**60 DAT**	**30 DAT**	**60 DAT**
Gargi (V_1)	0.75	0.77	0.08	0.11	1.52	1.79
DRR 42 (V_2)	0.71	0.75	0.07	0.10	1.39	1.65
Sadabahar (V_3)	0.69	0.69	0.05	0.08	1.28	1.24
NDR 97 (V_4)	0.71	0.72	0.06	0.09	1.33	1.55
Sem±	0.01	0.01	0.00	0.00	0.01	0.01
C.D.(p=0.05)	NS	0.05	0.00	0.01	0.03	0.04
5th August (D_1)	0.79	0.85	0.07	0.11	1.51	1.72
13th August (D_2)	0.72	0.72	0.05	0.09	1.38	1.56
21st August (D_3)	0.63	0.63	0.00	0.08	1.24	1.38
Sem±	0.01	0.01	0.00	0.00	0.02	0.01
C.D.(p=0.05)	0.03	0.04	0.00	0.01	0.05	0.02
Sem±	0.02	0.02	0.00	0.00	0.03	0.01
V X D C.D. (p=0.05)	0.06	NS	NS	0.01	0.10	0.04

Nitrogen removal by grain and straw

The varieties differed significantly for the removal of nitrogen in grains as well as straw. The maximum nitrogen removal was recorded by Gargi (V1) followed by DRR 42 (V2), NDR 97 (V4) and Sadabahar (V3). Gargi (V1) was observed to be at par with DRR 42 (V2) but differed significantly with remaining others. Nitrogen removal followed a significantly decreasing trend as the dates of planting were delayed.

Crude protein content in grains

The data pertaining to protein content in grain showed significant difference due to different varieties and the planting dates. Gargi (V1) obtained highest protein content with respect to the rest of the varieties i.e., DRR 42 (V2), NDR 97 (V4) and Sadabahar (V3). Delayed planting reduces the quality as well as quantity of the produce. Hence, with delay in planting the grain protein percentage significantly decreased.

Table 2: Effect of dates of planting on nitrogen content in grain and straw and nitrogen removal by grain and straw of different rice varieties

Treatments	NC in grain (%)	NR by grain (kg ha^{-1})	NC in straw (%)	NR by straw (kg ha^{-1})	CP (%)
Gargi (V_1)	1.16	25.64	0.56	23.19	7.22
DRR 42 (V_2)	1.07	21.27	0.53	22.63	6.67
Sadabahar (V_3)	0.91	14.84	0.40	13.92	5.68
NDR 97 (V_4)	1.04	18.55	0.49	17.21	6.53
Sem±	0.03	1.60	0.01	1.38	0.19
C.D.(p=0.05)	0.10	5.53	0.03	4.78	0.65
5th August (D_1)	1.24	30.13	0.58	26.23	7.74
13th August (D_2)	1.00	18.03	0.49	18.77	6.27
21st August (D_3)	0.89	12.06	0.42	12.72	5.56
Sem±	0.02	1.08	0.01	0.84	0.11
C.D.(p=0.05)	0.05	3.23	0.02	2.53	0.32
Sem±	0.03	2.16	0.01	1.69	0.21
V X D C.D.(p=0.05)	0.10	NS	NS	NS	0.64

*NC- nutrient content, NR- nutrient removal and CP- crude protein

Phosphorus content in grain and straw

Phosphorus content in grain and straw was significantly affected by delayed planting of different varieties. The maximum phosphorus content in grain and straw was observed in Gargi (V1) followed by DRR 42 (V2), NDR 97 (V4) and Sadabah ar (V3). Gargi (V1) was found to be at par with DRR 42 (V2) but differed significantly with other varieties in case of grain phosphorus content. Whereas, Gargi (V1) was found to be at par with DRR 42 (V2) and NDR 97 (V4) but significantly from Sadabahar (V3) in case of phosphorus content in straw. Phosphorus content in straw decreased significantly with delayed dates of planting. It was found to be significantly highest in crop planted on 5th August followed by 13th August and 21st August.

Phosphorus removal by grain and straw

The analysis of the recorded data proved that the phosphorus removal by grains as well as straw significantly differed with the different varieties under delayed planting. The data revealed that the maximum phosphorus removal was observed in Gargi (V1) followed by DRR 42 (V2), NDR 97 (V4) and Sadabahar (V3). The removal in grain in NDR 97 (V4) was found to be at par with Sadabahar (V3) but differed significantly with the other varieties. However, the removal in straw found variety Gargi (V1) to be at par with DRR 42 (V2) and NDR 97 (V4). Delayed planting significantly decreased the phosphorus removal. Hence, it was highest in crop planted on 5th August followed by 13th August and 21st August. The interaction effect revealed that the Gargi (V1) planted on 5th August (D1) obtained maximum phosphorus removal both by grain and straw whereas Sadabahar (V3) planted on 21st August (D3) obtained the minimum.

Table 3: Effect of date of planting on phosphorus content in grain and straw and phosphorus removal by grain and straw in different rice varieties

Treatments	PC in grain (%)	PR by grain (kg ha^{-1})	PC in straw (%)	PR by straw (kg ha^{-1})
Gargi (V_1)	0.20	4.46	0.10	4.27
DRR 42 (V_2)	0.18	3.54	0.09	3.77
Sadabahar (V_3)	0.16	2.69	0.06	2.26
NDR 97 (V_4)	0.17	2.99	0.08	2.70
Sem±	0.00	0.13	0.00	0.17
C.D.(p=0.05)	0.02	0.44	0.01	0.58
5th August (D_1)	0.21	4.95	0.10	4.68
13th August (D_2)	0.18	3.18	0.08	3.02
21st August (D_3)	0.16	2.14	0.07	2.05
Sem±	0.00	0.11	0.00	0.10
C.D.(p=0.05)	0.01	0.33	0.00	0.30
Sem±	0.01	0.22	0.00	0.20
V X D C.D.(p=0.05)	0.02	0.66	NS	0.59

Potassium content in grain and straw

The potassium content in grain and straw rice observed significant difference with different rice varieties and delayed planting dates. The maximum potassium content was observed in Gargi (V1) followed by DRR 42 (V2), NDR 97 (V4) and Sadabahar (V3). Gargi (V1) was found to be at par with DRR 42 (V2) and NDR 97 (V4) in grain potassium content. Whereas, in straw potassium aspect, NDR 97 (V4) was found to be at par with Sadabahar (V3) rest others are significantly different. The planting dates follow the same trend as above i.e., potassium content decreases significantly with delay in planting dates.

Potassium removal by grain and straw

The potassium removal by grains and straw was significantly influenced by delayed planting of different rice varieties. The maximum potassium removal was observed in Gargi (V1) followed by DRR 42 (V2), NDR 97 (V4) and Sadabahar (V3). All the varieties were significantly different from each other in removal by grain. Whereas, Gargi (V1) was found to be at par with DRR 42 (V2) and NDR 97 (V4) in removal by straw. Potassium removal by grain and straw was found to be significantly highest in crop planted on 5th August and goes on decreasing with the other delayed dates i.e., 13th August and 21st August. The interaction effect revealed that Gargi (V1) when planted on 5th August (D1) produced maximum potassium removal by grain and straw whereas Sadabahar (V3) planted on 21st August (D3) produced minimum potassium removal.

Table 4: Effect of date of planting on potassium content in grain and straw and potassium removal by grain and straw in different rice varieties

Treatments	PC in grain (%)	PR by grain (kg ha^{-1})	PC in straw (%)	PR by straw (kg ha^{-1})
Gargi (V_1)	0.29	6.22	2.08	85.10
DRR 42 (V_2)	0.27	5.26	1.85	77.22
Sadabahar (V_3)	0.23	3.62	1.33	46.06
NDR 97 (V_4)	0.25	4.32	1.46	51.46
Sem±	0.01	0.18	0.04	2.63
C.D.(p=0.05)	0.02	0.64	0.15	9.09
5th August (D_1)	0.28	6.81	1.87	84.45
13th August (D_2)	0.26	4.60	1.66	64.55
21st August (D_3)	0.23	3.15	1.50	45.88
Sem±	0.00	0.14	0.03	1.18
C.D.(p=0.05)	0.01	0.42	0.09	3.55
Sem±	0.01	0.28	0.06	2.37
V X D C.D.(p=0.05)	NS	0.83	NS	7.09

*PC- Potassium content, PR- Potassium removal

Discussion

The varieties and dates of planting under investigation differed significantly in their N, P and K content both in grain and straw. It also varied significantly for N, P, and K removal by both grain and straw. Highest amount of N, P and K were taken up by Gargi when planted on 5th August and the lowest amount by Sadabahar when planted on 21st August. The decreasing trend was due to adverse effect of delayed planting on plant canopy and root development which consequently hampered the optimum nutrient absorption compared to timely planted crop. Nutrient content in varieties is dependent on more accumulation of photosynthates before panicle initiation and ripening due to proper partitioning of assimilates in plant parts. Nutrient removal by varieties is directly related to dry matter production hence higher nutrient removal was due to increased biological yield of variety planted on first date (5th August). The results were in conformity with the findings of (Roy *et al.*, 2004 and Kumar and Prasad 2004) [9, 6].

Conclusion

From the above finding we can conclude that delayed planting does not have its adverse effect only on the vegetative phase of a crop production but also on the reproductive as well. As the proper accumulation of photosynthates and its partitioning leads to the development of quality produce in greater quantity. Hence, timely planting of rice which differs with varieties and agro-climatic regions needs to be effectively adopted to be able to secure the food and nutrition demands of the growing population.

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