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Nutrient (Nitrogen, Phosphorous and Potassium) Uptake Capacity and Efficiency of different Elite Rice (*Oryza sativa* L.) Varieties under Delayed Planting Conditions

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ABSTRACT

Background: The present investigation was concentrated to determine the nutrient uptake capacity of different varieties of rice (*Oryza sativa* L.) under delayed planting condition. The purpose of the study is to evaluate the nutrient content in straw and grain in different varieties of rice to understand the nutrient acquisition capacity.

Methods: The experiment was conducted during *kharif*-2018 in a split plot design with three replications at Agricultural Research Farm, BHU, Varanasi with a combination of four rice varieties (HUR-3022, DRR-44, HUR-4-3 and HUR-105) as subplot factor and three dates of planting (06/09/2018, 13/08/2018 and 20/08/2018) as main-plot factor.

Result: Among the varieties, DRR-44 was observed efficient for N, P and K absorption under timely planting conditions and recorded higher N content (1.01%) than HUR-3022 (0.91%) and HUR-105 (0.86%). The P (0.45%) and K (0.29%) content were observed highest for the variety DRR-44 on the first date of planting (06/08/2018). Maximum N, P and K uptake by grain and straw were recorded in DRR-44 followed by HUR-3022 and HUR-105. DRR-44 was also the highest grain and straw yielder. Thus, improved varieties of rice with higher nutrient use efficiency should be the priority for quality and higher yield of straw and grain of the crop.

Key words: Delayed planting, Nitrogen, Nutrient uptake, Phosphorous, Potassium, Rice.

INTRODUCTION

Rice (*Oryza sativa* L.) is the second most important cereal crop after wheat in the World and the foremost staple food crop in Asia (Ya-jie *et al.,* 2020). The high yielding varieties (HYVs) of rice are very popular among the farmers due to superior in yield along with resistant/tolerant to many biotic and abiotic stresses (Singh and Singh, 2017). Continuous growing of HYV and injudicious application of chemical fertilizers exhausted many farm lands. This results imbalance of soil Nitrogen (N), Phosphorous (P) and Potassium (K) and the deficiency is observed in crops (Saleque *et al.,* 1998). N, P and K are the very essential nutrients and are highly demanded during growth and development of rice through different metabolic and physiological processes (Mantovani *et al.,* 2017). Nutrients affect the flowering and grain filling of the crop to obtain optimum yield (Moe *et al.,* 2019). Nitrogen increases plant height, number of panicle, number of filled spikelets and mostly needed during early and mid-tillering, panicle initiation, grain development (Murthy *et al.,* 2015; Tinghong *et al.,* 2019) and increases yield (Ramulu *et al.,* 2020). Phosphorous has participates to increase the panicle size, number of filled grains and number of seeds per panicle (Plaxton and Tran, 2011). Appropriate potassium promotes tillering, root elongation, culm thickness, tolerance to diseases and pests, resistance to lodging (Kong *et al.,* 2014). Proper potassium (K) nutrition is critical for maximizing rice grain yields with proper grain filling (Nieves-Cordones *et al.,* 2019). Therefore, nutrient use efficient varieties of rice are always desirable (Islam *et al.,* 2008). If the nutrients are limited in the soil or the variety is unable to uptake the nutrient in an efficient manner under late planting, then the nutrient content will be low in the straw and grains. Low nutrient status in the rice straw reduces the fodder value of the crop whereas, low nutrient status in the grain ultimately leads to nutrient deficiency in our diet (Islam *et al.,* 2008). Therefore, suitable dates of planting are very crucial for management of rice to increase the yield. Considering the above facts, the present investigation was concentrated to determine the nutrient uptake capacity and efficiency of different varieties of rice under delayed planting for sustainable rice production. The purpose of the study is to

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evaluate the nutrient content in straw and grain in different varieties of rice to understand the nutrient acquisition capacity of the varieties under delayed planting condition.

MATERIALS AND METHODS

Experimental materials and design

The present investigation was conducted during *kharif*-2018 and laid out in a split plot design with three replications at Agricultural Research Farm, BHU, Varanasi, U.P., India, with a combination of four varieties (V1-HUR-3022, V2-DRR-44, V3-HUR-4-3 and V4-HUR-105) as sub-plot factor and three dates of planting (D1-05/09/2018, D2-13/08/2018 and D3-20/08/2018) as main-plot factor. Due to the late harvest of wheat in some regions of Uttar Pradesh, the sowing of rice is delayed. So based on this criterion the following dates of planting of rice are selected to select a suitable date of sowing. The detailed descriptions of experimental of materials are given in Table 1.

Methodology for determination of N, P and K uptake

The straw ad grains of different varieties were harvested separately from each replication. Then they were taken to dry under hot air oven for at least 48 hours at 70°C temperature. The samples were then ground and screened through 40 mesh sieve for analysis of nitrogen, phosphorous and potash. The nitrogen content of both grain and straw was estimated by modified Kjeldal apparatus method (Jakson, 1973). Phosphorus content of both grain and straw were determined through Vanado-molybdate phosphoric acid yellow color method (Jakson, 1973), whereas potassium content was determined through the Flame photometer method (Jakson, 1973). The total N, P and K uptake by the plant (kg/ha) was estimated by multiplying their respective dry weights of the plant samples.

The statistical analysis was conducted by using data analysis software WASP version 1.0 (https://ccari.res.in/waspnew.html) and Microsoft Excel-2010. Analysis of variance was accomplished to get the concluding remarks. The standard error of mean and level of significance (at 5%) was estimated by using F-test.

RESULTS AND DISCUSSION

Analysis of straw nutrient content in different varieties of rice and their interaction effects with date of planting

The observations showed planting on 06/08/2018 recorded higher nitrogen content (1.87%) in straw, over planting on 13/08/2018 (1.86%) and 20/08/2018 (1.86%) (Table 2 and Fig 1). As the date of planting delayed onwards from 06/08/2018, the nitrogen content decreased marginally in straw. DRR-44 had showed its superiority over other varieties and recorded significantly higher nitrogen content (2.1%), followed by HUR-3022 (2.003%) and HUR-105 (1.74%), while HUR-4-3 recorded lowest nitrogen content (1.62%) in the straw (Table 2 and Fig 1). Rice planted on 06/08/2018

Table 1: Desirable features of elite rice varieties used for the experimental studies.

Rice variety	Desirable features
1. HUR-3022	Developed by B.H.U and released by SVRC, U.P. for Uttar Pradesh in 2004. Maturity in 105-110 days, high yielding (50-55 q/ha), resistant to lodging and blast disease.
2. DRR-44	Developed IIRR, Hyderabad and released in 2014 for Uttarakhand, Bihar and Haryana. Duration 120 day, high yielding (80 q/ha), resistant to drought and blast disease.
3. HUR-4-3	Developed by B.H.U. and released by SVRC, U.P. for Eastern and Western Uttar Pradesh. Maturity in 135-140 days, yield 55-58 q/ha and resistant to BPH.
4. HUR-105	Developed by B.H.U. Maturity in130-135 days, yield 60-70 q/ha, resistant to drought and BLB.

Table 2: Mean comparison results of straw and grain yield and their N, P, K content (%) in elite varieties of rice.

Treatments	Straw yield	Grain yield	Straw			Grain		
	(t/ha)	(t/ha)	N(%)	P(%)	K(%)	N(%)	P(%)	K(%)
Planting dates								
D1(06/08/2018)	4.04	3.35	1.87	0.65	5.09	2.69	1.2	0.75
D2(13/8/2018)	3.12	2.04	1.86	0.64	5.09	2.68	1.16	0.74
D3(20/8/2018)	2.13	1.34	1.86	0.63	5.08	2.63	1.16	0.71
SEm ±	0.259	0.112	0.007	0.003	0.004	0.012	0.005	0.001
CD (p=0.05)	0.984	0.439	0.028	0.014	0.017	0.049	0.018	0.006
Variety								
HUR-3022	3.2	2.4	2.003	0.693	5.16	2.67	1.16	0.75
DRR-44	4.76	3.8	2.1	0.746	5.45	2.97	1.3	0.79
HUR-4-3	2.1	1.07	1.62	0.53	4.78	2.47	1.1	0.68
HUR-105	2.67	1.64	1.74	0.60	4.97	2.56	1.14	0.70
SEm ±	46.882	0.407	0.005	0.006	0.009	0.010	0.005	0.004
CD (p=0.05)	139.295	1.208	0.014	0.017	0.026	0.031	0.014	0.012

showed higher straw P content (0.65%) and planting on 13/08/2018 and 20/08/2018 had shown equal P content. As the date of planting delayed from first to second, the P content in straw also decreases. Among different varieties, DRR-44 showed significantly higher P content (0.746%) in straw followed by HUR-3022 (0.693%) and HUR-105 (0.6%). The variety HUR-4-3 is not very efficient in phosphorous uptake as observed under study. The varieties influenced significantly to the potassium content in the straw under different planting dates. Planting on 06/08/2018 and 13/08/2018 recorded similar and significantly higher potassium content (5.09%) than the third date of planting. As the date of planting delayed towards 20/08/2018, the potassium content in straw decreased but not up to the level of significance. When the different rice varieties of rice were compared for K content, variety DRR-44 (5.45%) showed its preeminence over other three varieties. The variety HUR-4-3 recorded the lowest K content (4.78%) in straw (Table 2 and Fig 1).

The interaction effects were studied among the three dates of planting and four varieties. Irrespective of the dates of planting, all the varieties showed highest straw N, P and K content on first date of planting 06/08/2018. The date of planting on 06/08/2018 had shown N-uptake of 0.71% by the variety DRR-44. Among all the varieties, DRR-44 was observed efficient for N, P and K absorption under timely planting condition. The first date of planting is appropriate for all the four varieties (Table 3).

Analysis of grain nutrient content of different varieties and their interaction effects with date of planting

The nitrogen content of the grain of different varieties showed that planting on 06/08/2018 recorded higher nitrogen in grain over 13/08/2018 and 20/08/2018 date of planting. As the date of planting delayed, the nitrogen content decreased marginally in grain. Among the different rice varieties DRR-44 showed its superiority in grain nitrogen content with 0.97% over other varieties such as HUR-3022 (2.67%) and HUR-105 (2.57%). The data revealed that the delaying the date of planting has not shown significant variation on grain P-content. Rice planted on the date 06/08/2018 showed higher grain P-content (1.2%) over on 13/08/2018. As the date of planting delayed, the grain P(%) content decreases proportionately. Among different varieties, DRR-44 (1.3%) had showed significantly higher grain phosphorous content, followed by HUR-3022 (1.16%) and HUR-105 (1.14%). Planting on 06/08/2018 had recorded significantly higher potassium content (0.75%) in grain which was at par with 13/08/2018 (0.74) and 20/08/2018 (0.71%). Date of planting affects rice straw total K(%) marginally among each other. As the date of planting delayed, the straw potassium decreased but not very significantly. Among the different rice varieties DRR-44 (0.79%) showed its superiority over other three varieties and recorded significantly higher potassium content in grain followed by HUR-3022 (0.75%) and HUR-105 (0.70%). HUR-4-3 (0.68%) recorded the lowest K-content in grain (Table 2).

The interaction effects were studied to evaluate the grain N, P and K content in different rice varieties. The date of planting on 06/08/2018 was shown higher content of N content for all the varieties. The variety DRR-44 had recorded higher N content (1.01%) than HUR-3022 (0.91%) and HUR-105 (0.86%). The variety HUR-3022 has recorded equal N content (0.88%) both in 2nd and 3rd date of planting *i.e*. 13/08/2018 and 20/08/2018, respectively. The P (0.45%) and K (0.29%) content were observed highest for the variety DRR-44 on first date of planting (06/08/2018). But subsequently the P and K contents were reduced as the date of planting delayed for the same varieties. The varieties HUR-4-3 and HUR-105 are equally potent for potassium uptake (0.25%) (Table 3).

Due to the late harvest of wheat in wheat-rice rotation, unavailability of labors in time and poor weather condition delayed the rice sowing (Liu *et al.,* 2015). Therefore, it is necessary to search a suitable variety and date of sowing to result a good yield with better nutrient uptake capacity. The change in planting time significantly affects the crop establishment in rice. Under timely planting condition, the

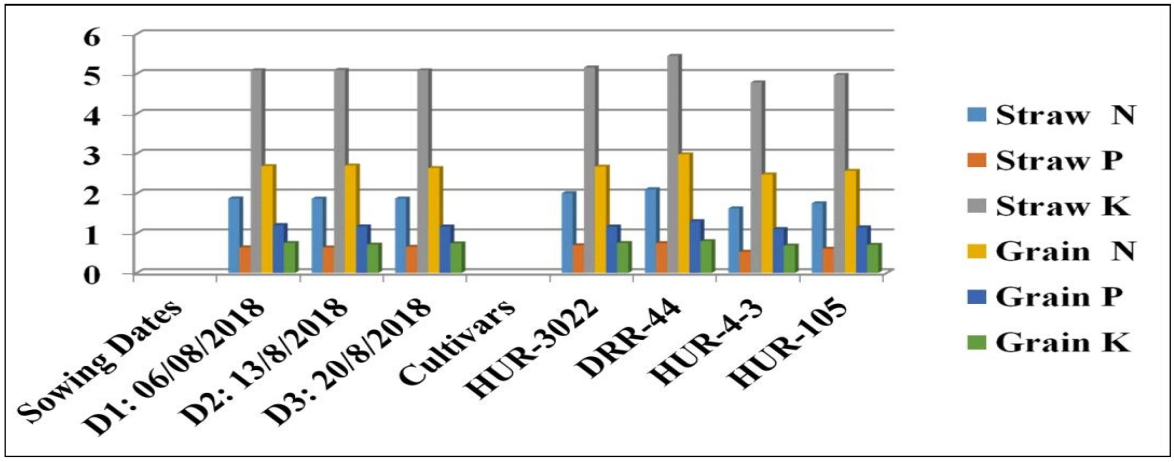


Fig 1: N, P and K content in straw and grain of different varieties of rice as affected by different dates of planting.

Table 3: Interaction study of straw and grain-N, P and K content (%) in different varieties of rice with dates of planting.

Variety	Straw N (%)				Straw P (%)				Straw K (%)			
	D1	D2	D3	Subplot mean	D1	D2	D3	Subplot mean	D1	D2	D3	Subplot mean
HUR-3022	0.68	0.66	0.66	0.66	0.24	0.23	0.23	0.23	1.73	1.72	1.70	1.72
DRR-44	0.71	0.70	0.69	0.70	0.26	0.25	0.24	0.25	1.83	1.82	1.80	1.81
HUR-4-3	0.55	0.54	0.53	0.54	0.18	0.18	0.17	0.17	1.61	1.60	1.58	1.59
HUR-105	0.59	0.58	0.58	0.58	0.22	0.20	0.19	0.20	1.66	1.66	1.65	1.65
Main plot mean	0.63	0.62	0.61		0.22	0.21	0.20		1.70	1.70	1.68	
SEm ±	0.008				0.010				0.015			
CD (p=0.05)	0.024				0.029				0.045			
Variety	**Grain N (%)**				**Grain P (%)**				**Grain K (%)**			
	D1	D2	D3	Subplot mean	D1	D2	D3	Subplot mean	D1	D2	D3	Subplot mean
HUR-3022	0.91	0.88	0.88	0.89	0.41	0.39	0.36	0.38	0.27	0.25	0.23	0.25
DRR-44	1.01	0.99	0.98	0.99	0.45	0.42	0.43	0.43	0.29	0.26	0.25	0.26
HUR-4-3	0.84	0.82	0.81	0.82	0.38	0.37	0.35	0.36	0.25	0.23	0.22	0.23
HUR-105	0.86	0.86	0.84	0.85	0.39	0.39	0.37	0.38	0.25	0.24	0.22	0.23
Main plot mean	0.90	0.88	0.87		0.40	0.39	0.37		0.26	0.24	0.23	
SEm ±	0.018				0.008				0.007			
CD(p=0.05)	0.054				0.024				0.021			

Where, D1-06/08/2018, D2-13/8/2018, D3-20/8/2018.

crops get all the available resources from the environment to give a better yield. But, when the planting time was delayed, the varieties were unable to get sufficient moisture and temperature to give their full potential. The delayed planting hamper the efficient development of root system of the crop varieties. The protein and chlorophyll content of the leaves were reduced, so that the leaves reduce their efficiency. When the rate photosynthesis is reduced, the dry matter production in the form of grain and straw is reduced. The results were in accordance with the findings of Plaxton and Tran, 2011; Brar and Bhullar, 2013; Wang and Wu, 2013 for the importance of N, P and K-uptake for growth and development in rice to increase the productivity. The parallel results were also found in other cereal and pulse crops like wheat (Jat *et al.,* 2013) and chickpea (Neenu *et al.,* 2017).

Analysis of straw and grain yield under delayed planting condition

Decreasing trend of straw yield was viewed with delaying date of planting from 06/08/2018 (4.04 t ha^{-1}) towards 20/08/2018 (2.13 t ha^{-1}). DRR-44 (4.76 t ha^{-1}) recorded higher straw yield followed by HUR-3022 (3.2 t ha^{-1}). Among the varieties, DRR-44 is highest yielder (3.8 t ha^{-1}) as compared to other varieties HUR-3022 (2.4 t ha^{-1}), HUR-105 (2.67 t ha^{-1}) and HUR-4-3 (2.1 t ha^{-1}). When the planting date was delayed, the varieties are never got same kind of environment (water, temperature and light) to explore the complete physiological and metabolic processes. Therefore, ultimately the dry matter accumulations in the straw as well as in the grains were reduced remarkably. The present investigations were in accordance with the finding of (Stellacci *et al.,* 2013; Mantovani *et al.,* 2017).

CONCLUSION

Deficiency in soil native nutrient status may affect the nutrient uptake and efficiency of the succeeding rice crop in rice-wheat cropping system. Henceforth, the present experiment was attempted to study the nutrient uptake and use efficiency of rice varieties. The maximum N, P and K concentration and uptake by both grain and straw were recorded by variety DRR-44 followed by HUR-3022, HUR-105 and HUR-4-3. The variety DRR-44 was also highest grain and straw yielder on ideal date of planting as compared to the other three varieties. Thus, this can be suggested to the farmers to go for planting DRR-44 on first week of August to get good yield. The study confirmed that, rice varieties sown on 06/08/2018 were found to be more competitive and able to uptake more nutrients form the soil environment as compared to those planted on 13/08/2018 and 20/08/2018. Delayed time of planting reduces the capacity of nutrient intake in the rice. Thus, improved varieties of rice with higher nutrient use efficiency should be the priority for quality and higher yield of straw and grain. Although we have only focused on the straw and grain nutrient content, but it is very imperative to analyze the nutrient content in specific plant parts (*e.g*. leaf, sheath, panicle and seeds) at all critical growth stages (active tillering, flowering, grain filling and harvesting) throughout the crop growth period to understand the nutrient acquisition capacity of different rice varieties to grow under delayed planting condition. At the same time proper planning of N, P and K- fertilizer application should be followed to meet the crop needs which ultimately facilitate the better growth and development of the crop at all stages to boost the rice yield.

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Conflict of interest

The authors declare that they have no conflict of interest.

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