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Response of dry seeding of *Kharif* paddy (*Oryza sativa* L.) Varieties to different fertilizer levels on nutrient (NPK) content, nutrient (NPK) uptake and available nutrient (NPK) at harvest

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Abstract

The agronomic investigation entitled, "Response of dry seeding of *Kharif* paddy (*Oryza sativa* L.) varieties to different fertilizer Levels" was undertaken at Post Graduate Research Farm, Agronomy Section of Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur (M.S.), India during *Kharif,* 2019. The experiment was laid out in a split plot design with four replications and nine treatment combinations comprising of three varieties V_1- Indrayani, V_2- Phule Radha and V_3- Bhogawati as main plot treatments and three fertilizer levels F_1- 75% RDF, F_2- 100% RDF and F_3- 125% RDF as sub plot treatments on sandy clay loam soil. The content of N, P and K (%) in grain and straw, total uptake of nutrients (NPK kg ha^{-1}) by paddy crop and available N, P and K kg ha^{-1} in soil after harvest were influenced significantly due to different treatments. The content of N, P and K in grain were (1.24%, 0.31% & 0.14%) and straw (0.78%, 0.19% & 1.49%) respectively, total uptake of nutrients were (142.66, 35.85 & 138.56 NPK kg ha^{-1}) respectively by paddy crop were found significantly maximum with the variety Indrayani followed by Bhogawati and which was superior over Phule Radha. Available N, P and K were (268.09, 36.42 & 277.17 NPK kg ha^{-1}) respectively in soil after harvest were found significantly maximum with the variety Phule Radha followed by Bhogawati which was superior over Indrayani. The content of N, P and K in grain were (1.29%, 0.31% & 0.14%) and straw (0.79%, 0.20% & 1.49%) respectively, total uptake of nutrients were (146.35, 36.85 & 140.19 NPK kg ha^{-1}) respectively by paddy crop and available N, P and K were (267.24, 37.22 & 289.91 NPK kg ha^{-1}) respectively in soil after harvest were found significantly maximum with the application of 125% RDF ha^{-1} which was at par with application of 100% RDF ha^{-1} and significantly superior over 75% RDF ha^{-1}.

Keywords: Variety, fertilizer levels, NPK content, NPK uptake, available NPK

Introduction

Among cereals, rice has been staple food for more than 60 per cent of the world population, providing energy for about 40% of the world population where every third person on earth consumes rice every day in one form or other (Virdia and Mehta, 2009) [50]. Therefore, crop paddy (*Oryza sativa* L.) is an important crop which is extensively grown in tropical and subtropical regions of the world. The worldwide paddy production in 2019-20, China was the leading country with a production of 146.73 million metric tonnes followed by India with 115.00 million metric tonnes (Anonymous, 2020) [2]. In India major growing states are West Bengal, Tamilnadu, AP, Kerla, Goa, KN Orissa, Punjab. In MH states Kokan region (Ratnagri, Raigad, Sindudurga, Thane) major and Satara, Sangli, Kollapur minor growing districts along the west coast and Bhandara, Gondiya, Chandrapur and Gadchiroli in the Eastern Parts of the state. Paddy is cultivated in India in a very wide range of ecosystems from irrigated to shallow lowlands, mid-deep lowlands, and deep lowlands to uplands. Transplanting is the major method of paddy cultivation in India. However, transplanting is becoming increasingly difficult due to shortage and high cost of labour, scarcity of water, and reduced profit. Thus, direct seeding is gaining popularity among farmers of India as in other Asian countries. Direct-seeding constitutes both wet and dry seeding and it does away with the need for seedlings, nursery preparation, uprooting of seedlings and transplanting. In Sub Montane Zone of Maharashtra and especially in Kolhapur district, it is mostly grown by transplanted method; however, there are some of the pockets, where direct seeding and dibbling is practiced.

Nutrient dynamics altogether varies in both DSR and PTR systems mainly because of the difference in land preparation and water management techniques. In case of DSR, soil remains aerobic beacause of dry land preparation as compared to PTR where soil is kept flooded and is puddled. Puddling has positive impact on weed control (Sahid and Hossain, 1995) [33] and nutrient availability102 (Wassmann *et al.*, 2004) [51]. In submerged conditions, less oxygen in the rhizosphere prevents oxidation of $NH4^{+}$ and thus reduce leaching (Krick *et al.*, 1994) [4], increase availability of P (Singh *et al.*, 2002) [41] as well as of Fe (Pande *et al.*, 1985 and Surendra, 2002) [27]. Deficiencies of micronutrients are of major concern in DSR. A shift from PTR to DSR affect Zn availability to rice (Gao *et al.*, 2002) and it reduces because of reduced release of Zn from highly insoluble fractions in aerobic rice fields. Zn deficiency is caused by high pH, high carbonate content58 and more bicarbonates in calcareous soils which immobolize Zn because of inhibition effect (Dogar, *et al*., 1980) [6]. Availability of P and Zn increases when pH is below neutral in the rhizosphere, because of their increased solubility (Saleque and Kirk, 1995) [35]. Zn uptake by DSR is also affected by source as well as time of Zn application. Availability of Fe is often particularly high in anaerobic soils because of low redox potential. In aerobic soils, however, Fe may become limiting, especially when the soil pH is high. Moreover, nutrient uptake and supply to plants may be reduced because of lower delivery rates to roots through mass flow and diffusion as both of these processes are influenced by the reduced soil water content. Thus, unsaturated soil conditions in DSR fields can lead to iron deficiency and plants show chlorosis. Prolonged iron deficiency may result in severe yield losses in DSR, hence care should be taken to manage iron deficiency. In the dry-seeded aerobic treatments, the iron content was about half of that in the submerged PTR and WSR treatments. The values of 2.1-2.6 ppm in the aerobic treatment were below the critical limit of 4.5 ppm 91. Therefore, appropriate nutrient management strategies based on nutrient dynamic studies in DSR need to be developed. The recommended doses of P, K and Zinc for DSR and PTR are same and apply these at the time of sowing. Apply K on soil test basis. Apply N @ 150 kg /ha in 4 splits 2, 4, 7 and 10 weeks after seeding. In case of basmati rice, apply 25% higher N dose in direct seeding as compared to transplanted crop (Kaur and Singh, 2017) [17].

Much work on fertilizer management in rice has been carried out for CT-TPR but limited work has been conducted in Dry-DSR, including ZT-dry-DSR. In Dry-drill-DSR, because of more aerobic conditions and alternate wetting/drying cycles, the availability of several nutrients including N and micronutrients such as Zn and Fe, is likely to be a constraint (Ponnamperuma, 1972). In addition, loss of N due to nitrification/denitrification, volatilization, and leaching is likely to be higher in Dry-DSR than in CT-TPR (Singh and Singh, 1988) [42]. General recommendations for NPK fertilizers are similar to those in puddled transplanted rice, except that a slightly higher dose of N (22.5– 30 kg ha^{-1}) is suggested in DSR (Dingkuhn *et al.*, 1991; Gathala *et al.*, 2011) [5, 9]. This is to compensate for the higher losses and lower availability of N from soil mineralization at the early stage as well as the longer duration of the crop in the main field in Dry-DSR. Early studies conducted in Korea indicated that 40–50% more N fertilizer should be applied in Dry-DSR than in CT-TPR (Park *et al.*, 1990) [29], although higher N application also leads to disease susceptibility and crop lodging. The general recommendation is to apply a full dose of P and K and one-third N as basal at the time of sowing using a seed-cum-fertilizer drill/planter. This allows placement of the fertilizer just below the seeds and hence improves fertilizer efficiency. Split applications of N are necessary to maximize grain yield and to reduce N losses and increase N uptake. Split applications ensure a supply of N to match crop demand at the critical growth stages. The remaining two-third dose of N should be applied as topdressing in equal parts at active tillering and panicle initiation stage. In addition, N can be managed using a leaf color chart (LCC) (Alam *et al.*, 2005) [1]. Two options are recommended for applying fertilizer N using an LCC. In the fixed-time option, N is applied at a preset timing of active tillering and panicle initiation, and the dose can be adjusted upward or downward based on leaf color. In the real-time option, farmers monitor the color of rice leaves at regular intervals of 7–10 days from early tillering (20 DAS) and N is applied whenever the color is below a critical threshold value (Gupta *et al*., 2006; Kumar and Ladha, 2011) [13, 20].

For high-yielding inbreds and hybrids, N application should be based on a critical LCC value of 4, whereas, for basmati types, N should be applied at a critical value of 3 (Gopal *et al.*, 2010) [12]. Since more N is applied in Dry-DSR and losses are higher than in CT-TPR, more efficient N management for Dry-DSR is needed. Slow-release (SRF) or controlled-release N fertilizers (CRFs) offer the advantage of a "one-shot dose" of N and the option to reduce N losses because of their delayed release pattern, which may better match crop demand (Shoji *et al.*, 2001) [39]. One-shot application will also reduce labor cost. CRF improves N use efficiency and yield compared with untreated urea. Because of these benefits, CRF with polymer-coated urea is used by Japanese farmers in ZT-dry-DSR (Fashola *et al.*, 2002) [7]. Despite these benefits, farmers' use of CRF is limited mainly because of the high costs associated with it. The cost of CRF may be four to eight times higher than that of conventional fertilizers (Shaviv and Mikkelsen, 1993) [38]. In addition, published results on the performance of SRFs/CRFs compared with conventional fertilizers are not consistent. Stutterheim *et al.*, (1994) [44] and Fashola *et al.*, (2002) [7] have demonstrated higher N use efficiency through the use of CRFs. Saigusa (2005) [34] reported higher N recovery of co-situs (placement of both fertilizer and seeds or roots at the same site) application of CRF with polyolefin-coated ureas of 100-day type (POCU-100) than conventional ammonium sulfate fertilizer applied as basal and topdressed in zero-till direct-seeded rice in Japan. In contrast, Wilson *et al.*, (1990) [53], Wells and Norman (1992) [52], and Golden *et al.*, (2009) [11] reported inferior performance of SRF or CRF compared with conventional urea top dressed immediately before permanent flood establishment. Split application of K has also been suggested for direct seeding in medium-textured soil (PhilRice, 2002) [30]. In these soils, K can be split, with 50% as basal and 50% at early panicle initiation stage. Deficiency of Zn and Fe is more common in aerobic/non-flooded rice systems than in flooded rice systems (Sharma *et al.*, 2002; Choudhury *et al.*, 2007; Pal *et al.*, 2008) [37, 3, 28]. Therefore, micronutrient management is critical in Dry-DSR. To avoid zinc deficiency, 25–50 kg ha^{-1} zinc sulfate is recommended. Basal application of zinc to the soil is found to be the best. However, if a basal application is missed, the deficiency can be corrected by topdressing up to 45 days. Zinc can be supplied by foliar application (0.5% zinc sulfate) two to three times at intervals of 7–15 days just after the appearance of deficiency symptoms. For iron, it has been observed that foliar application is superior to soil application (Datta *et al*., 2003) [4]. Foliar-applied Fe is easily translocated acropetally and even retranslocated basipetally. A total of 9 kg Fe ha^{-1} in three splits (40, 60, and 75 DAS) as foliar application (3% of FeSO47H2O solution) has been found to be effective (Pal *et al*., 2008) [28].

Comparative yields of DSR (2.2-8.7 t /ha) can be obtained by adopting proper management practices. DSR sowing is more cost effective technology as B: C varies from 2.29-3.12 as compared to transplanting (1.93-2.66). Water productivity is high in DSR and exceeds corresponding values in transplanting by >25%. Labour saving in DSR ranges from 13-37%. DSR is technically and economically feasible, eco-friendly alternative to conventional puddled transplanted rice (Kaur and Singh, 2017) [17]. Dry direct-seeded rice is a sustainable and very feasible alternative to TPR in Central China, based on comparable yield performance and higher resource use efficiencies. Without sprout cultivation and transplanting, it consumed less irrigation water and demands less labor, thus reducing the total inputs. Comparable rice yield in the dry direct-seeded rice system and low input demand justifies the higher output to input ratio. In addition, compared with transplanted-flooded rice, the higher NUE and lower total N uptake in dry direct seeded rice illustrated that improved N uptake of rice plants through cultivation and breeding can make a further increase in grain yield of dry direct-seeded rice. The Yangliangyou-6 breed appeared superior to the rest of the varieties regarding its performance on yield, WP, and NUE, and can be successfully used in dry direct-seeded rice culture. However, the evaluation of yield and resource use efficiency was limited by time and space, thus overall evaluation needs multi-location–multi-year experiments. Furthermore, evaluations regarding integrated economic efficiency and ecological benefits of dry direct-seeded flooded rice are required. In addition, there is need to study soil ecology in dry direct seeded rice culture and develop site-specific production technologies for dry direct-seeded rice (Liu *et al*., 2015) [21].

In the sub-montane zone of Maharashtra and specially in Kolhapur district, there are several paddy cultivars developed by the Agriculture University and Private Seed Companies which are used by the local farmers for puddle transplanted paddy cultivation. But, there are no any cultivar developed for dry seeded condition and for other direct seeding methods under rainfed condition. The promising and popular varieties famous among the farmers developed by Agriculture University are therefore selected to study the yield potential for different fertilizer doses in dry direct seeded paddy cultivation. The research study will be helpful for choosing the suitable varieties and fertilizer doses for getting higher optimum yield in dry seeding condition. Major paddy growing areas in the region are highly sandy clay loams. Poor fertility and low moisture holding capacity are the characteristics of these soils. Fertilizer input is one of the major determinants of the profitability of the paddy grown on these soils. Fertilizer use efficiency is low in the region due to heavy rainfall and it is revealed from the studies that use of different fertilizers improves fertilizer use efficiency (Tondon, 1992) [46]. The information on nutrient requirements of the crop to be supplied through straight fertilizers is available. However, the information on requirement of nutrients in paddy established by comparing different fertilizer sources is lacking. Thus, farmers' adoption for a variety becomes different as the performance of the variety under suboptimal nutrient conditions is least as important as their performance under optimal nutrient supplies.

Materials and methods

The experiment was laid out in a split plot design with four replications and nine treatment combinations comprising of three varieties V_1- Indrayani, V_2- Phule Radha and V_3-Bhogawati as main plot treatments and three fertilizer levels F_1- 75% RDF, F_2- 100% RDF and F_3- 125% RDF as sub plot treatments. The gross and net plot size were 6.00 m x 4.5 m and 5.00 m x 3.6 m, respectively. A spacing of 22.5 cm was adopted in seed sowing between two rows.

The soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction (pH 7.70) (Jackson, 1973) [14], having electrical conductivity 0.28 dS m^{-1} (Jackson, 1973) [14] and organic carbon content was very low (0.18%) (Jackson, 1973) [14], low in available nitrogen (254.90 kg ha^{-1}) estimated by alkaline permanganate oxidation method as outlined by Subbaiah and Asija (1956) [40], medium in available phosphorus (28.70 kg ha^{-1}) determined by Spectro photometer method as outlined by Olsen (1954) [25] and high in available potassium (276.20 kg ha^{-1}) by flame photometer method (Jackson, 1973) [14].

The crop was sown on 3rd of June, 2019 by line sowing method with different varieties and fertilizer levels. The paddy crop was fertilized treatment wise as per different fertilizer levels. The fertilizers were applied at the time of sowing of paddy seed, 40 per cent nitrogen, and full dose of P_2O_5 and of K_2O was applied as basal dose. The remaining 60 per cent nitrogen was applied in two splits; 40 per cent at maximum tillering stage i.e. 30 DAS and 20 per cent at 60 DAS. Nitrogen was applied through urea (46% N), P_2O_5 through Diammonium phosphate (18:46:00), K_2O through Muriate of Potash (60% K_2O).

Plant analysis: The sample from different plant parts of observational plants were used for chemical estimation of total nitrogen, phosphorus and potassium. The concentration of nitrogen in plant and grain was estimated by Micro Kjeldhal method. The phosphorus was determined by Calorimetric method (Jackson, 1973) [14] and potassium was estimated by flame photometer method.

Collection, preparation and digestion of Plant Samples: The plant samples collected after harvest were cleaned shade dried and then dried in hot air oven at 65 ^{0}C. Further, these samples were milled to considerable fineness in a mill and stored in plastic bags for further analysis. The powdered plant sample 0.5 g passed through 100 mm sieve was pre-digested with concentrated nitric acid over night. Further, pre-digested samples were treated with tri-acid (nitric acid : sulphuric acid : perchloric acid in ratio 9:1:4) mixture and kept on sand bath for digestion. After complete digestion the precipitate was dissolved in 6 N HCl and Transferred to the 100 ml volumetric flask through Whatman No. 42 filter paper by thoroughly washing with double distilled water and finally the volume was made to 100 ml and preserved for further analysis.

Nitrogen (N) content estimation: The powdered 0.5 g plant sample was digested with concentrated sulphuric acid and digestion mixture ($CuSO_4$ + K_2SO_4 + selenium powder). The digest was transferred to the micro kjeldhal distillation flask and the ammonia liberated was distilled in presence of alkali collected in 2 per cent boric acid and the distillate was titrated against standard acid (Jackson, 1973) [14].

Phosphorous (P) content estimation: The phosphorus in plant sample was determined by Vanado molybdateoposphoric yellow colour method (Jackson, 1973) [14].

Potssium (K) content estimation: The potassium content in the digested samples was determined by flame photometer after making appropriate dilution (Jackson, 1973) [14].

Uptake studies: The uptake of nitrogen, phosphorus and potassium (kg ha^{-1}) was worked out by multiplying the percentage of these nutrients in grain, straw with the corresponding yields of the respective constituent**:**

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient conc. (\%) x Wt. of dry matter (kg ha}^{-1})}{100}$$

Statistical analysis: The statistical analysis of split plot design with with 4 replications, 3 main plot treatments and 3 sub-plot treatments was done by standard procedures suggested by Panse and Sukhatme (1967) [26].

Result and discussion

I) Effect on nutrient (NPK) content (%) in grain and straw of paddy

A. Effect of varieties

The nutrient (NPK) content in grain and straw of paddy was significantly influenced by paddy varieties. The significantly higher nutrient (NPK) content in grain and straw of paddy was observed with the paddy variety Indrayani which was at par with the variety Bhogawati. The lowest nutrient (NPK) content in grain and straw of paddy was recorded the variety Phule Radha. Similar results were reported by Jagtap (2007) [15], Singh *et al*., (2013) [43] and Shahane *et al*., (2018) [36]

B. Effect of fertilizer levels

The nutrient (NPK) content in grain and straw of paddy was significantly influenced by fertilizer levels. The application of 125% RDF through straight fertilizers recorded significantly higher nutrient (NPK) content in grain and straw of paddy over the rest of fertilizer levels and which was at par with application of 100% RDF. The lowest nutrient (NPK) content in grain and straw of paddy was recorded with application of 75% RDF. Shahane *et al*., (2018) [36], Ghorpade (2015) [10], Yesuf and Balcha (2014) [54], Singh *et al*., (2013) [43] and Vijayan and Sreedharan (1972) [49] found similar research finding.

C. Interaction effect

The interaction effect between different varieties and fertilizer levels was found non-significant in respect of nutrient (NPK) content in grain and straw of paddy.

II) Effect on total uptake of nutrients (N, P_2O_2, K_2O) by paddy crop (kg ha^{-1})

A. Effect of varieties

Among the different varieties of paddy the Indryani variety recorded the higher mean total uptake of nutrients (N, P_2O_2, K_2O) and which was at par with Bhogawati and significantly superior over the variety Phule Radha. Similar findings were reported by Talashilkar *et al*., (2000) [47] and Savant *et al*., (2000) [47].

B. Effect of fertilizer levels

The application of 125% RDF recorded the higher mean total uptake of nutrients (N, P_2O_2, K_2O) which was remained at with the application of 100% RDF and significantly superior over the application of 75% RDF (114.69 ha^{-1}). Ghorpade (2015) [10], Murthy *et al*., (2015) [24], Venureddy (2014) [48] and Marskole *et al*., (2017) [23] found research findings similar with present findings.

Table 1: Mean nitrogen, phosphorus and potassium content (%) of paddy as influenced by different treatments

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
Main plot : Paddy varieties						
V_1- Indrayani	1.24	0.78	0.31	0.19	0.14	1.49
V_2- Phule Radha	1.14	0.68	0.27	0.14	0.11	1.42
V_3- Bhogawati	1.22	0.74	0.28	0.17	0.13	1.45
S. Em±	0.02	0.02	0.01	0.01	0.01	0.01
C. D. at 5%	0.05	0.06	0.03	0.03	0.02	0.04
Sub plot : Fertilizer levels						
F_1 - 75% RDF	1.09	0.67	0.26	0.13	0.10	1.42
F_2 -100% RDF	1.23	0.74	0.29	0.17	0.13	1.47
F_3 - 125% RDF	1.29	0.79	0.31	0.20	0.14	1.49
S. Em±	0.03	0.02	0.01	0.02	0.01	0.02
C. D. at 5%	0.08	0.07	0.04	0.05	0.03	0.05
Interactions : V × F						
S. Em±	0.03	0.02	0.01	0.02	0.01	0.02
C. D. at 5%	NS	NS	NS	NS	NS	NS
General mean	1.20	0.73	0.29	0.17	0.12	1.46

C. Interaction effect

The interaction effect between different varieties and fertilizer levels was found non-significant in respect of total uptake of nutrients (N, P_2O_2, K_2O) by paddy crop.

III) Effect on available nutrients (NPK) (kg ha^{-1})

A. Effect of varieties

The variety Phule Radha recorded significantly maximum mean available soil nutrients (NPK) after harvest and which was remained at par with the variety Bhogawati (257.35 kg ha^{-1}). The variety Indrayani recorded significantly minimum mean available soil nutrients (NPK) after harvest. Similar results were reported by Kumar *et al*., (2017) [19] and Riste *et al*., (2017) [31].

Table 2: Mean total uptake of nutrients (Nitrogen, Phosphorus and Potassium) (kg ha^{-1}) of paddy as influenced by different treatments

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Main plot : Paddy varieties									
V_1- Indrayani	74.64	68.01	142.66	19.13	16.72	35.85	8.47	130.08	138.56
V_2- Phule Radha	55.5	55.30	110.86	13.34	11.86	25.21	5.75	114.86	120.62
V_3- Bhogawati	70.24	63.37	133.61	16.19	14.88	31.07	7.40	122.94	130.35
S. Em±	2.48	1.61	6.28	1.18	0.88	1.34	0.36	2.23	2.12
C. D. at 5%	8.94	5.78	18.58	3.48	3.04	5.34	1.17	8.51	8.47
Sub plot : Fertilizer levels									

F_1 - 75% RDF	53.56	52.77	106.34	12.98	10.32	20.31	5.01	109.12	114.69
F_2 -100% RDF	70.73	63.70	134.44	16.85	15.12	31.97	6.93	127.08	134.65
F_3 - 125% RDF	76.14	70.21	146.35	18.83	18.02	36.85	7.80	131.68	140.19
S. Em±	1.88	1.95	6.00	0.76	1.02	1.47	0.29	1.47	1.92
C. D. at 5%	6.25	7.12	17.82	2.93	3.18	5.89	0.97	6.01	7.47
Interactions : V × F									
S. Em±	1.67	1.61	10.39	0.69	1.77	2.22	0.35	3.48	3.63
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	66.81	62.23	129.05	16.22	14.5	30.71	7.21	122.63	129.84

Table 3: Mean available Nitrogen, Phosphorus and Potassium in soil (kg ha^{-1}) as influenced by various treatments

Treatments	Available nitrogen (kg ha^{-1})	Available phosphorous (kg ha^{-1})	Available potassium (kg ha^{-1})
Main plot : Paddy varieties			
V_1- Indrayani	246.62	32.76	270.41
V_2- Phule Radha	268.09	36.42	287.18
V_3- Bhogawati	257.35	35.36	277.17
S. Em±	4.27	0.83	4.56
C. D. at 5%	14.77	2.86	14.89
Sub plot : Fertilizer levels			
F_1 - 75% RDF	248.37	31.40	265.03
F_2 -100% RDF	256.44	35.92	279.82
F_3 - 125% RDF	267.24	37.22	289.91
S. Em±	4.98	0.61	6.12
C. D. at 5%	14.81	1.81	21.07
Interactions : V × F			
S. Em±	8.63	1.05	9.88
C. D. at 5%	NS	NS	NS
General mean	257.35	34.85	278.25
Initial status of soil	254.90	28.70	276.20

B. Effect of fertilizer levels
Application of 125% RDF recorded significantly the higher mean available soil nutrients (NPK) as compared to rest of the fertilizer levels after harvest and which was at par with the application 100% RDF. The significantly lowest mean available soil nutrients (NPK) recorded with the application of 75% RDF. Nitrogen availability increases with higher doses of applied nitrogenous fertilizers. These findings were in conformity with earlier reported by Ghorpade, (2015) [10], Murthy *et al*., (2015) [24], Kumar *et al*., (2017) [19], Riste *et al*., (2017) [31], Jain *et al*., (2018) [16] and Mahto *et al*., (2018) [22].

C. Interaction effect
The interaction effect between the varieties and the fertilizer levels was found non-significant in respect of available soil nutrients (NPK) of paddy after harvest.

Conclusion
Based on the investigation, it is concluded that among the varieties, Indrayani as well as Bhogawati recorded higher content of N, P and K (%) in grain and straw, total uptake of nutrients (NPK kg ha^{-1}) by paddy crop and available N, P and K kg ha^{-1} in soil after harvest and therefore both varieties are suitable for better fertilizer consumption in Sub Montane Zone of Maharashtra and in Kolhapur district under dry seeded condition. Among the fertilizer levels tried, the application of 100% RDF ha^{-1} and 125% RDF ha^{-1} is both can give higher of N, P and K (%) in grain and straw, total uptake of nutrients (NPK kg ha^{-1}) by paddy crop and available N, P and K kg ha^{-1} in soil after harvest. The content of N, P and K (%) in grain and straw, total uptake of nutrients (NPK kg ha^{-1}) by paddy crop and available N, P and K kg ha^{-1} in soil after harvest were not influenced by different interaction treatment combinations formed due different varieties and different fertilizer levels.

References

1. Alam MM, Ladha JK, Khan RS, Foyjunnessa, Rashid H, Khan AH, *et al*. Leaf color chart for managing nitrogen fertilizer in lowland rice in Bangladesh. Agron. J. 2005;97:949-959.
2. Anonymous. USDA- World Agricultural Production, (2020). Foreign Agricultural Service Circular Series WAP, 2020a, 1-20.
3. Choudhury BU, Bouman BAM, Singh AK. Yield and water productivity of rice-wheat on raised beds at New Delhi. India Field Crops Res 2007;100:229-239.
4. Datta SP, Saharan N, Rattan RK. Micronutrient fertilizers, sources and methods of application. In Integrated Micronutrient Management for Sustainable Agriculture (D. K. Das and D. Saha, Eds.), BCKV, West Bengal, India, 2003, 71-89.
5. Dingkuhn M, Penning de Vries FWT, De Datta SK, Van Laar HH. Concepts for a new plant type for direct seeded flooded tropical rice. In Direct Seeded Flooded Rice in the Tropics, 17–38. International Rice Research Institute (IRRI), Los Ban˜ os, Philippines, 1991.
6. Dogar MA, Hai T. Effect of N, P and HCO_3- levels in the nutrient solution on rate of Zn absorption by rice roots and Zn content. Z. *Pflanzen physiologie* 1980;98:203-212.
7. Fashola OO, Hayashi K, Wakatsuki T. Effect of water management and polyolefin-coated urea on growth and nitrogen uptake of indica rice. J Plant Nutr. 2002;25:2173-2190.
8. Gao XP, Zou CQ, Fan XY, Zhang FS, Hoffland E. From flooded to aerobic conditions in rice cultivation: consequences for zinc uptake. Plant Soil, 2006;280:41-47.
9. Gathala MK, Ladha JK, Kumar V, Saharawat YS, Kumar V, Sharma PK, *et al*. Tillage and crop establishment

affects sustainability of South Asian rice-wheat system. Agron. J 2011;103(4):961-971.
10. Ghorpade GS. Integrated nitrogen management in upland paddy (*Oryza sativa* L.). *Thesis.* Submitted to MPKV, Rahuri, 2015.
11. Golden BR, Slaton NA, Norman RJ, Wilson CEJr, DeLong RE. Evaluation of polymer-coated urea for direct-seeded, delayed-flood rice production. Soil Sci. Soc. Am. J 2009;73:375-383.
12. Gopal R, Jat RK, Malik RK, Kumar V, Alam MM, Jat ML *et al*. Direct Dry Seeded Rice Production Technology and Weed Management in Rice Based Systems. Technical Bulletin. International Maize and Wheat Improvement Center, New Delhi, India, 2010, 28.
13. Gupta RK, Ladha JK, Singh S, Singh R, Jat ML, Saharawat Y *et al*. Production Technology for Direct Seeded Rice. Technical Bulletin Series 8. In "Rice–Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India, 2006, 14.
14. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 1973, 256-260.
15. Jagtap PP. Effect of integrated use of manures, fertilizers and deep placement of UB-DAP on growth, yield, nutrient uptake and quality of *Ratnagiri*-1 rice (*Oryza sativa* L.) in lateritic soils. M. Sc. (Agri.) *Thesis.* Dr. B.S.K.K.V. Dapoli (Unpublished). India (M.S.), 2007.
16. Jain G, Singh CS, Sing AK, Singh SK, Puran AN. Effects of nitrogen levels and weed management practices on growth, yield and uptake of rice under aerobic conditions. J Pharmacognosy and Phytochemistry, SP 2018;(1):381-385.
17. Kaur J, Singh A. Direct seeded rice: prospects, problems/ Constraints and researchable issues in India. Curr. Agri. Res 2017;5(1):13-32.
18. Kirk GJD, Solivas JL, Begg CBM. The rice root–soil interface. In: Kirk, G.J.D. (Ed.), Rice roots: Nutrient and Water Use. International Rice Research Institute, Philippines, Los Banos, 1994, 1-10.
19. Kumar S, Kour S, Gupta M, Kachroo D, Singh H. Influence of rice varieties and fertility levels on performance of rice and soil nutrient status under aerobic conditions. J Appl. & Nat. Sci 2017;9(2):1164-11.
20. Kumar V, Ladha JK. Direct seeding of rice: recent developments and future research needs. Adv. Agron 2011;111:297-413.
21. Liu H, Hussain S, Zheng M, Peng S, Huang J, Cui K, *et al*. Dry direct-seeded rice as an alternative to transplanted-flooded rice in Central China. Agron. Sustain. Dev. 2015;35:285-294.
22. Mahto DK, Chaudhary SK, Yadav SK, Kumar V, Sharma RP, Pal M. Response of Nitrogen, Phosphorus, Potassium and Zinc Nutrition on Rice (*Oryza sativa* L.) – Maize (*Zea mays* L.) Cropping System. Int. J Curr. Microbiol. App. Sci., Special 2018;7:5182-5188.
23. Marskole VP, Shukla VK, Sahu RP, Dwivedi BS, Singh RB. Effect of Nutrient Management on Productivity and Economics of Rice. M.Sc. (Agri.) *Thesis*, JNKVV, Jabalpur 2017.
24. Murthy KMD, Rao AU, Vijay D, Sridhar TV. Effect of levels of nitrogen phosphorus and potassium on performance of rice. Indian J Agric. Res 2015;49(1):2015: 83-87.
25. Olsen SR, Cole CW, Wathode FS, Peun LA. Estimation of available phosphorus in soil by extraction with Co3. U.S.D.A. Cir, 1954, 939.
26. Panse VG, Sukhamate PV. Statistical methods for agricultural workers, ICAR, New Delhi, 1967, 361.
27. Pandey NC, Samantaray RN, Mohanty SK. Nutrient changes in direct- seeded submerged rice soils with varying nutrio-environments. Plant Soil 1985;88:299-306.
28. Pal S, Datta SP, Rattan RK, Singh AK. Diagnosis and amelioration of iron deficiency under aerobic rice. J Plant Nutr 2008;31:919-940.
29. Park ST, Son Y, Lee SK, Chung KS. Studies on major cultivation methods for dry direct seeding. Res. Rep. RDA (Rice) 1990;32:18-28.
30. Phil Rice (The Philippine Rice Research Institute). Integrated nutrient management for rice production. In "Rice Technology Bulletin No. 45" The Philippine Rice Research Institute (PhilRice), Maligaya, Nueva Ecija, Philippines, 2002, 24.
31. Ponnamperuma FN. The chemistry of submerged soils. Adv. Agron, 1972, 29-96.
32. Riste K, Gohain T, Kikon K. Response of local rice (*Oryza sativa* L.) cultivars to recommended NPK fertilizer dose under upland rainfed conditions. Agric. Sci. Digest 2017;37(1):10-15.
33. Savant NK, Dalvi AS, Dhane SS. Integrated nutrient management system for rainfed transplanted rice. *Oryza*. 2000;37(1):80-81.
34. Sahid IB, Hossain MS. The effects of flooding and sowing depth on the survival and growth of five rice-weed species. Plant Protection Quarterly 1995;10:139-142.
35. Saigusa M. New fertilizer management to maximize yield and minimize environmental effects in rice culture. "Rice Is Life: Scientific Perspectives for the 21st Century. Proceedings of the World Rice Research Conference, 4–7 November 2004, Tsukuba, Japan, 2005, 372-373.
36. Saleque MA, Kirk GJD. Root induced solubilization of phosphate in the rhizosphere of low land rice. New Phytology 1995;129:325-336.
37. Shahane AA, Singh YS, Kumar D, Prasanna R. Interaction effect of nitrogen, phosphorus, and zinc fertilization on growth, yield, and nutrient contents of aromatic rice varieties, J Plant Nutri 2018;41(18):2344-2355.
38. Sharma PK, Bhushan L, Ladha JK, Naresh RK, Gupta RK, Balasubramanian BV *et al*. Crop-water relations in rice-wheat cropping under different tillage systems and water-management practices in a marginally sodic mediumtextured soil. In Water-Wise Rice Production (B. A. M. Bouman, H. Hengsdijk, B. Hardy, P. S. Bindraban, T. P. Tuong, and J. K. Ladha, Eds.), International Rice Research Institute, Los Ban˜os, Philippines, 2002, 223-235.
39. Shaviv A, Mikkelsen RL. Controlled-release fertilizers to increase efficiency of nutrient use and minimize environmental degradation: A review. Fert. Res 1993;35:1-12.
40. Shoji S, Delgado J, Mosier A, Miura Y. Use of controlled release fertilizers and nitrification inhibitors to increase nitrogen use efficiency and to conserve air and water quality. Commun. Soil Sci. Plant Anal 2001;32:1051-1070.
41. Subbiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soil. Current Sci 1956;25:256-260.

42. Singh AK, Choudhury BU, Bouman BAM. Effects of rice establishment methods on crop performance, water use, and mineral nitrogen. In: Water –wise rice production (B.A.M, Bouman, H. Hengsdijk, B. Hardy, P.S. Bindraban, T.P. Tuong, J. K. Ladha, Eds.),: International Rice Research Institute, Los Ban˜ os, Philippines, 2002, 237-246.
43. Singh GR, Singh TA. Leaching losses and use efficiency of nitrogen in rice fertilized with urea supergranules. J Ind. Soc. Soil Sci 1988;36:274-279.
44. Singh YV, Singh KK, Sharma SK. Influence of crop nutrition on grain yield, seed quality and water productivity under two rice cultivation systems. Rice Sci 2013;20(2):129-138.
45. Stutterheim NC, Barbier JM, Nougaredes B. The efficiency of fertilizer nitrogen in irrigated, direct seeded rice (*O. sativa* L.) in Europe. Fert. Res 1994;37:235-244.
46. Surendra S, Sharma SN, Rajendra P, Singh S, Prasad R. The effect of seeding and tillage methods on productivity of rice–wheat cropping system. Soil Tillage Research. 2001;61:125-131.
47. Tondon HLS. Non-traditional sectors for fertilizers use. FDCO, New Delhi, India, 1992, 132.
48. Talashilkar SC, Savant DS, Dhamapurkar VB, Savant NK. Yield and nutrient uptake by rice as influenced by integrated use of calcium silicate slag and UB-DAP in acid lateritic soil. J Ind. Soc. Soil Sci 2000;48(4):847-849.
49. Venureddy C. Effect of continuous application of Fertilizers and Manures on Soil Physical Properties, Nutrient Uptake, Growth and Yield of rice. M.Sc. (Agri.) *Thesis*, Indira Gandhi Krishi Vishwavidyalaya, Raipur, 2014.
50. Vijayan G, Sreedharan C. Effect of levels and times of application of potash on IR 8. Gujarat Agric. Univ. Research J 1972;9(1):57-64.
51. Virdia HM, Mehta HD. Integrated Nutrient Management in Transplanted Rice (*Oryza sativa* L.). J Rice Res 2009;2(2):99-104.
52. Wassmann R, Neue HU, Ladha JK, Aulakh MS. Mitigating greenhouse gas emissions from rice–wheat cropping system in Asia. Environmental Development Sustainability 2004;6:65-90.
53. Wells BR, Norman RJ. Response of rice to amended ureas as nitrogen sources. In Arkansas Soil Fertility Studies 1991 (W. E. Sabbe, Ed.), Res. Ser 1992;421:65-69.
54. Wilson CE Jr, Norman RJ, Wells BR. Dicyandiamide influence on uptake of preplant-applied fertilizer nitrogen by rice. Soil Sci. Soc. Am. J 1990;54:1157-1161.
55. Yesuf E, Balcha A. Effect of nitrogen application on grain yield and nitrogen efficiency of rice (*Oryza sativa* L). Asian J Crop. Sci 2014;6(3):273-280.