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Impact on soil fertility status and concentration of nutrient (N, P and K) in grain by adopting nutrient management practices in rice crop (*Oryza sativa* L.) Under different establishment methods

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Abstract
The present investigation was carried out to find the Impact on soil fertility status by adopting nutrient management practices in Rice Crop (*Oryza Sativa* L.) under different establishment methods. The experiment was conducted in A_2 block at N. E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand. The treatments consisting three establishment methods in main plots and five nutrient management practices in sub plots (fifteen combination) was laid out in split plot design (SPD) with three replications. The result revealed that, the concentration of nutrient (viz. N, P and K) in grain as well as in straw was affected significantly and was higher with transplanting method. Application of RDF(recommended dose of fertilizer)+5tFYM/ha exhibited statistically higher concentration and uptake, while RDF RDF(recommended dose of fertilizer) alone recorded significantly less concentration and uptake value of all nutrients. The status of available N, P and K in soil remained unaffected due to different establishment methods, however higher values were obtained in transplanting method with application of RDF+5tFYM/ha.

Keywords: Rice crop (*Oryza sativa* L.), nutrient management, establishment methods

Introduction

Rice (*Oryza sativa* L.) is familiar as a superlative commodity to mankind, because it is actually a life, an ethos, a tradition and a means of livelihood to millions of people. It is also an important staple foodstuff providing 66-70 per cent body calorie intake of the consumers which are about 50 per cent of the world's population residing in Asia, where 90 per cent of the world's rice is full-grown and consumed. In India, it is appraised that the demand, of rice will be of 140 million tonnes in 2025. At present, India has 42.41 million hectare of cultivated land under rice cultivation with a production of 106.04 million tonnes (Economic survey of India, 2014) [12].

Modification in rice establishment methods can be used to shrink cost of cultivation even the productivity remains the same or increased. Transplanting method is the common practice of rice establishment in most of the irrigated areas in the world. Due to resource constraints, especially water and labourers, dry seeding under dry condition is now emerging new trend in rice cultivation. Aerobic method of rice cultivation, where fields remain unsaturated throughout the season like an upland crop offers an opportunity to produce rice with less water and tillage operations and rapid reduction in total water usage from 27-51% with increased productivity of 32-88% (Bouman *et al.*, 2002) [8]. This practice is an alternative to the conventional rice cultivation system in regions where rainfall and fresh water resources are limited and becoming popular as it reduces the cost of production, by reduced irrigation and realizing good yields and water productivity. Input water savings of 35-57% can be achieved for dry seeded rice sown into non-puddled fields (Singh *et al.*, 2003) [51]. Another method of direct seeding is wet-direct seeding, as it involves puddled condition for sowing pre-germinated rice seeds, in well puddle, well levelled and recently drained seed beds. (Tuong and Bouman, 2003) [57].

Nutrient management is also a major constituent of soil and crop management system in rice. Knowing the required nutrients for all stages of growth and understanding the soil's ability to supply them is critical to profitable crop production. Among major nutrients like NPK, nitrogen is a key nutrient of rice production and requires proper application management (Nedunchezhiyan and Laxminarayan, 2011) [36]. In estimation it was found that 24 per cent of the increase in Asian rice was attributed to use of fertilizers, mainly nitrogen (Baker *et al.*, 1985) [5], (Alam *et al.*, 2005) [1].

Also injudicious use of high analysed fertilizers often leads to imbalance in nutrients especially micronutrients, which ultimately cause deterioration of soil physio-chemical properties and steadily decreases crop yield (Gupta *et al*., 2002) [19]. Continuous use of inorganic fertilizers has brought loss of vital soil fauna and flora. This calls for the development of integrated nutrient management systems (INMS) where reduced amount of chemical fertilizer is supplemented through organic sources for improvement and maintenance of soil fertility leading to sustained crop production, as organic manures modify the soil physical behaviour and increases the efficiency of applied nutrients (Pandey *et al.*, 2007) [39].

The use of farmyard manure and compost to improve rice yield is recognized by farmers for many centuries. By recycling of all the organic wastes, China has been able to grow in a sustainable manner for decades with no micronutrient problems and has provided healthy environment to their people (FAO, 1977) [15]. In India too, there is tremendous potential of recycling organic waste (Gaur *et al.*, 1990) [16].

Materials and Methods

The experiment was conducted in A_2 block at N. E. Borlaug Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, District Udham Singh Nagar, Uttarakhand during the *kharif* season of 2015. This experiment was laid out in spilt-plot design keeping establishment method in main plots and nutrient management practices in sub-plots with three replications. The details of treatments in this study are given below:

Treatments:- (split plot design)
Establishment methods (Main Plot)
T1: Aerobic (Direct seeded rice)
T2: Wet-direct seeding
T3: Transplanting

Nutrient management practices (Sub Plot)
F1: RDF (Recommended dose of fertilizer) (120:60:40) N: P_2O_5: K_2O kg/ha
F2: 75%RDF (90:45:30) +FYM/ha (Equivalent to 25% N dose)
F3: 150% RDF (180:90:60)
F4: RDF (90:60:40) (LCC based N application)
F5: RDF (120:60:40) + 5 tonnes FYM/ha (Location specific)

Note: In direct seeding and Wet direct seeding N was applied as ¼ basal + ½ tillering + ¼ PI and in Transplanted rice N was applied as ½ basal + ¼ tillering + ¼ PI.
Variety: HKR-47, Replication: 3, Treatments: 15, Total No. of plots: 45

Fertilizer application

Before seeding, full dose of phosphorus and potassium and 25% N was applied as basal in aerobic, wet-direct seeded plots and 50% N with full dose of phosphorus and potassium was applied as basal in transplanted rice plots through urea (46% N), NPK fertilizer (12:32:16) and Murate of potash (60% K_2O), respectively and incorporated into soil, as per dose required in a particular treatment. The remaining quantity of nitrogen was top dressed in two splits: at tillering (50% in aerobic and wet-direct seeded plots and 25% in transplanted rice plots) and at panicle initiation stage 25%N was applied in all plots as per the treatment. Also prior to sowing or transplanting FYM was applied as per treatment on required sub-plots and thoroughly incorporated into the top 15 cm soil with the help of spade manually. In treatment involving application of nitrogen on the basis of leaf colour char (LCC), full recommended dose of phosphorus, potassium and one-fourth of the recommended dose of nitrogen (30 kg/ha) was applied as basal and remaining nitrogen was top dressed at the rate of 30 kg N/ha two times, when the average of the reading of the leaves of selected rice plants was found less than 4 in leaf colour chart (LCC).

Leaf colour chart measurements and fertilizer N application

The LCC developed by International Rice Research institute in 1996 with strips of six shades of green colour showing increasing intensity of colour with increasing number from 1 to 6 was used in the study. Ten disease-free rice plants were randomly selected from each plot. The topmost fully expanded leaf was placed on the top of leaf colour chart and colour of the middle part of the leaf was graded according to the corresponding colour strip on the LCC. During measurement, the leaf being measured was kept under the shade of the body to avoid the colour variance caused by sun light. In rice, a basal dose of 30 kg N/ha was applied 0 to 7 DAS/DAT and LCC readings were taken at weekly intervals starting from 15 DAS/DAT of rice until initiation of flowering stage. When colour of 6 out of 10 leaves fell below a threshold of shade 4 on the LCC, 30 kg N/ha was top dressed on the same day.

Chemical analysis of soil samples

Soil samples were taken from each plot at a depth of 20 cm and were dried at room temperature in shade and were sieved in 1mm sieve. These soil samples were analyzed for available N, P and K by using following procedure:

Available nitrogen

Available nitrogen was estimated by alkaline $KMnO_4$ method where the organic matter in soil is oxidized with hot alkaline $KMnO_4$ solution. The ammonia evolved during oxidation is distilled and trapped in boric acid mixed indicator solution. The amount of NH_3 trapped was estimated by titrating with standard acid (Subbaiah and Asija, 1956) [54].

Available phosphorus

Available phosphorus was extracted with sodium bicarbonate (0.5 M) at pH 8.5 (Olsen's reagent) and the amount of P in the extract was estimated by chlorostannous reduced phosphor-molybdate blue colour method using spectrophotometer at wave length of 660 nm (Jackson, 1973) [21].

Available potassium

Available potassium was extracted with neutral normal ammonium acetate and determined using flame photometer (Jackson, 1973) [21].

Chemical analysis of plant samples

Plant samples used for the study component were used for chemical study. Samples were dried in a drier for 48-72 hours at 65±5ºC and dried plant samples were then grounded and sieved in 1mm sieve. These grain and straw samples were analyzed for N, P and K by using following procedure.

Methods and instruments used for estimation of major contents in plant materials

Element	Method/ instrument used and unit of content
Nitrogen%	The modified micro-Kjeldahl method (Jackson, 1973) [21] was used for the N% in straw and grain by digesting samples in sulphuric in a micro-Kjeldhal flask (digestion tube) on a hot plate. The distillation process was carried out using Nitrogen Analyser (Gerhart) and titration was carried out using digital burette.
Phosphorus%	Vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973) [21] was used and the intensity of yellow colour was read with Spectro-photometer at 420 nm and the contents were expressed in terms of percentage phosphorus
Potassium%	Flame emission photometery method (Jackson, 1973) [21] was used to estimate potassium content in di-acid digested samples and reported as percent potassium.

Nutrient uptake

The nutrient uptake by rice at harvest was worked out by multiplying the values of their concentration with the yields using the following equation:

$$\text{Nutrient uptake by grain} = \frac{\text{Nutrient content} \times \text{grain yield (kg/ha)}}{100}$$

$$\text{Nutrient uptake by straw} = \frac{\text{Nutrient content} \times \text{dry matter production (kg/ha)}}{100}$$

Observation and sampling procedures

Results and Discussion

Nitrogen content and uptake

Data pertaining to nitrogen content and uptake are presented in Table 1. Nitrogen uptake by grain, straw and total uptake by plants was significantly higher under transplanting method compared to other establishment methods. Under aerobic method nitrogen content in grain and total uptake were significantly less than other methods. While in case of straw, wet-direct seeded and aerobic methods caused similar nitrogen uptake.

Table 1: Nitrogen content (%) and uptake (kg/ha) in grain and straw as influenced by the treatments.

Treatments	N content (%)		N uptake (kg/ha)		Total uptake (kg/ha)
	Grain	Straw	Grain	Straw	
Establishment methods					
Wet direct seeded	1.23	0.568	69.5	34.4	104
Aerobic	1.21	0.545	66.6	33.6	100
Transplanted	1.25	0.574	74.9	36.1	111
S.E.m ±	0.004	0.004	0.4	0.3	0.4
C.D. (5%)	0.01	0.017	1.7	1.2	2
Nutrient management					
RDF	1.19	0.528	62.6	29.8	93
75% RDF+FYM(equiv. to 25%N)	1.23	0.578	68.4	34.9	103
150%RDF	1.21	0.546	70.7	34.4	105
RDF(LCC based N)	1.24	0.563	73.5	35.7	109
RDF+5tFYM/ha	1.26	0.597	76.8	38.6	116
S.E.m ±	0.004	0.005	1.04	.83	1.6
C.D. (5%)	0.01	0.015	3.0	2.4	5

Among nutrient management treatments, RDF+5tFYM/ha caused significantly higher and RDF alone registered significantly lower N uptake by grain, straw and also the total uptake. N uptake by grain and total uptake was similar due to 75%RDF+FYM (equivalent to 25%N) and 150%RDF but significantly less than RDF (LCC based N) and RDF+5tFYM/ha. The straw N content was similar due to 75%RDF+FYM (equivalent to 25%N), 150%RDF and RDF (LCC based N).

Phosphorus content and uptake

Data pertaining to phosphorus content and uptake are presented in Table 2.

Table 2: Phosphorus content (%) and uptake (kg/ha) in straw and grain as influenced by the treatments

Treatments	P content (%)		P uptake (kg/ha)		Total uptake (kg/ha)
	Grain	Straw	Grain	Straw	
Establishment methods					
Wet direct seeded	0.368	0.111	20.7	6.7	28
Aerobic	0.349	0.106	19.2	6.5	26
Transplanted	0.383	0.117	23.0	7.4	30
S.E.m ±	0.002	0.006	0.3	0.07	0.4
C.D. (5%)	0.010	0.002	1.2	0.3	1
Nutrient management					
RDF	0.350	0.101	18.3	5.7	24
75% RDF+FYM(equiv. to 25% N)	0.366	0.115	20.2	6.9	27
150%RDF	0.355	0.108	20.6	6.8	28

RDF (LCC based N)	0.362	0.114	21.4	7.2	29
RDF+5tFYM/ha	0.400	0.120	24.3	7.8	32
S.E.m ±	0.004	0.0014	0.46	0.17	0.6
C.D. (5%)	0.011	0.004	1.4	0.5	2

Phosphorus content and uptake by crop was significantly higher due to transplanting method compared to other methods. Aerobic method registered significantly less phosphorus content and uptake in grain, straw as well as total phosphorus uptake except for phosphorus uptake by straw, where wet-direct seeded and aerobic methods resulted in comparable phosphorus uptake.
Among nutrient management treatments, RDF+5tFYM/ha caused significantly higher and RDF alone caused significantly lower phosphorus content and uptake by rice crop compared to remaining nutrient management treatments. The use of 75%RDF+FYM (equivalent to 25%N), 150%RDF and RDF (LCC based N) treatments caused similar phosphorus content and uptake by rice crop. However, 75%RDF+FYM (equivalent to 25%N) and RDF (LCC based N) treatments registered similar phosphorus content in straw but significantly higher than 150%RDF.

Potassium content and uptake

Data pertaining to potassium content and uptake are presented in Table 3**.** Potassium content and uptake in grain and total uptake by plant was significantly higher due to transplanting method compared to other establishment methods. However, aerobic method registered significantly less potassium content in straw compared to wet-direct seeded and transplanted rice which had comparable straw potassium content. The wet-direct seeded and aerobic methods resulted in similar potassium content by grain and potassium uptake by grain, straw and plant uptake.
Among nutrient management treatments potassium content and uptake by grain, straw and plant was significantly higher due to RDF+5t FYM/ha and significantly lower due to RDF compared to remaining treatments. Potassium content in grain due to 75%RDF+FYM (equivalent to 25%N) and RDF (LCC based N) was similar but significantly higher than RDF alone. The straw potassium content due to 150%RDF, being at par with RDF (LCC based N), was significantly less compared to 75%RDF+FYM (equivalent to 25%N) treatment.
Significantly higher uptake of total nitrogen, phosphorus and potassium by the rice crop was noticed in transplanting method of cultivation compared to the aerobic and wet-direct seeded methods. Continuous flooding under transplanting method coupled with the application of FYM might have improved the soil physio-chemical properties and thus root activity to improve the uptake of nutrients (Awan *et al.*, 1989 and Song *et al.*, 2009) [3, 52]. Also, the higher uptake of nutrients by rice crop under transplanting method might have occurred due to minimum inter and intra-plant competition for resources which must have facilitated the increased uptake of nutrients by grain and straw (Saikia *et al*., 1992) [47]. However, apart from lesser competition for resources, the higher uptake of nutrients under transplanting method might also be due to higher grain and straw yield under transplanting method as the uptake is a function of yield and nutrient content. This finding is in accordance to those of Jaiswal and Singh (2001) [23].
Increased uptake of nutrients was also observed with the application of RDF+5tFYM/ha. The supply of timely required nutrients through RDF+5tFYM/ha might have supplied balanced nutrition which resulted in enhanced nutrient uptake. Like-wise increased concentration of nutrients in grain and straw were also observed with the application of RDF+5tFYM/ha compared to other nutrient management treatments (Jacqueline *et al*., 2008) [22]. The higher uptake of nutrient by plant due to RDF+5tFYM/ha was also reported by Ghosh *et al*. (2014). Application of FYM in combination with inorganic fertilizers significantly increases N uptake by rice crop and also this combination proved helpful in increased uptake of phosphorus by rice crop over RDF alone (Zhang *et al*., 1998) [58].
The increased uptake of N might have helped to extract more K from soil has been reported by Pal *et al*. (2005) [38]. Also, Bhadoria and Prokash (2003) [7] observed significantly greater K uptake by the rice plants using organic manures in combination with chemical fertilizers over the application of 100% RDF or organic matter alone. These results are in the agreement with the findings of Sreelatha *et al*. (2006) [53], who reported that, the application of organic manure and chemical fertilizers significantly increases K uptake by rice. The application of FYM in combination with fertilizers significantly increased the availability of nutrients. It might be due to the fact that FYM with inorganic fertilizers enhances the nutrient uptake by making linkages with a part of nutrient elements and prevented them from leaching and other losses (Greenland, 1971) [18].

Table 3: Potassium content (%) and uptake (kg/ha) in straw and grain as influenced by the treatments

Treatments	Potassium content (%)		Potassium uptake (kg/ha)		Total uptake (kg/ha)
	Grain	Straw	Grain	Straw	
Establishment methods					
Wet direct seeded	0.461	1.51	26.04	91.8	118
Aerobic	0.454	1.48	25.02	91.5	117
Transplanted	0.479	1.53	28.69	96.5	125
S.E.m ±	0.001	0.001	0.27	0.94	1.1
C.D. (5%)	0.007	0.02	1.07	3.7	5
Nutrient management					
RDF	0.441	1.44	23.07	81.7	105
75% RDF+FYM(equiv. to 25% N)	0.470	1.53	25.99	92.9	119
150%RDF	0.456	1.49	26.52	94.2	121
RDF(LCC based N)	0.466	1.51	27.55	96.3	124
RDF+5tFYM/ha	0.491	1.56	29.79	101.2	131
S.E.m ±	0.004	0.008	0.39	1.8	2.1
C.D. (5%)	0.008	0.02	1.10	5.5	6

Increase in nitrogen, phosphorus and potassium uptake by rice crop was associated with corresponding increase in grain and straw yields (Table 8) in RDF+5tFYM/ha treatment.

Available N, P and K in soil

Data pertaining to available N, P and K in soil are presented in Table 4**.** Available N, P and K in soil remained unaffected due to different methods of establishment, however higher values were obtained in transplanting method. Different nutrient management treatments significantly affected available N, P and K in soil. The values of available N, P and K in soil were significantly higher with application of RDF+5tFYM/ha and significantly lower due to RDF alone compared to remaining treatments except in case of available P where RDF, being *at par* with 150%RDF, caused significant reduction in available P compared to remaining treatments. Available N in soil due to 75%RDF+FYM (equivalent to 25%N) and RDF (LCC based N) was similar but significantly higher than 150%RDF. Soil available K in soil due to RDF+5tFYM/ha remained *at par* with 75%RDF+FYM (equivalent to 25%N) but caused significantly more soil available K compared to other nutrient management treatments. Use of RDF and RDF (LCC based N) caused similar soil available K but significantly less than 75%RDF+FYM (equivalent to 25%N) and significantly higher than RDF.

In present study due to different establishment methods no significant result was observed on the availability of nitrogen, phosphorus and potassium in soil after the harvest of rice crop. It might be due to short term study conducted on rice under different establishment methods, which could not led to any influence on the availability of N, P and K. However, RDF+5tFYM/ha treatment recorded significantly higher status of available N, P and K in soil compared to RDF alone. This might be due to better integration of inorganic and organic fertilizer sources which has led to increased availability of nutrients in soil. As the rate of decomposition of farmyard manure is comparatively slow in contrast to the inorganic fertilizers alone and due to slow decomposition and gradual release of the nutrients into the labile pool and become available for longer duration (Das *et al*., 2014) [10]. Prasad (1994) [40] also observed an increase in availability of nutrients in soil for longer duration with the application of FYM along with 100 per cent recommended dose of fertilizers. Application of FYM to rice increased soil fertility status due to an increase in soil available N, P and K contents (Meelu and Morris, 1984 and Kumar *et al*., 1992) [28]. Therefore, an integrated approach with the use of organic and inorganic inputs is essential as it nourishes the soil in many ways and supplies all the essential nutrients to crops in sufficient amounts and makes nutrients readily available in soil for longer duration (Kalyanasundaram and Kumar, 2003) [26].

Table 4: Available N, P and K in soil as influenced by various treatments.

Treatments	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Establishment methods			
Wet direct seeded	235	21	232
Aerobic	234	21	230
Transplanted	235	22	234
S.E.m ±	0.7	0.5	0.8
C.D. (5%)	Ns	Ns	Ns
Nutrient management			
RDF	222	19	224
75% RDF+FYM(equiv. to 25% N)	237	22	237
150%RDF	231	20	229
RDF(LCC based N)	235	21	232
RDF+5tFYM/ha	242	24	239
S.E.m ±	0.9	0.4	1.2
C.D. (5%)	3	1	3

Conclusion

Based on above studies, it is concluded that under normal condition, transplanting method along with application of RDF+5tFYM/ha and RDF (LCC based N) can be recommended for better soil characteristics.

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