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INTEGRATED APPROACH IN NUTRIENT MANAGEMENT FOR RICE-ONION- RESIDUAL GREENGRAM CROP SEQUENCE

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ABSTRACT
To achieve nutritional security keeping food security as a whole without hindering environmental balance, we must have to go for crop diversification in existing cropping pattern. Therefore, with the broader objectives of studying the effect of organic and inorganic sources of nutrients on the productivity, quality improvement of the crops and uptake of nutrients by the crops in sequence, an experiment was conducted in strip plot design with two (2) main plot treatments (B_0 *i.e.* without biofertilizer and B_1 *i.e.* with biofertilizer) and seven (7) sub plot treatments (F_1: 100% of the Recommended dose of fertilizers *i.e.* RDF, F_2: 75% of the RDF, F_3: 75% of the RDF +25% of N through FYM, F_4: 75% of the RDF +25% of N through vermicompost, F_5: 75% of the RDF +25% of N through neem cake, F_6: 75% of the RDF +25% of N through groundnut cake and F_7: 75% of the RDF +25% of N through mustard cake replicated thrice. The varieties were Satabdi (IET 4786), Sukhsagar (Local variety) and IPM 2-3 for rice, onion and greengram respectively, replicated thrice during 2011-13 in farmer's field. It can be concluded that, the combined use of organic, inorganic and biological sources of nutrients showed evidence of excellent results throughout the whole period of supervision (4.31 and 4.54 t ha^{-1} for rice and 20.73 and 23.81 t ha^{-1} for onion under main and subplot treatment respectively). In case of residual greengram, the treatment dominance was observed under the main plot treatment having biofertilzer (0.832 t ha^{-1}), sub plot treatment getting organic and inorganic sources of nutrients applied to the previous onion crop (0.861 t ha^{-1}). For maintaining the food security vis-à-vis environmental safety and economic profitability, it may be suggested to adopt the integrated nutrient management practices along with biofertilizer application for rice-onion- residual greengram crop sequence.

INTRODUCTION

After Green revolution, agro-technologies transformed our motherland from the image of "begging bowl" to not only self-sufficiency in food grains but also a leading exporter of some agricultural commodities in the global market. Despite this glorious progress during the last few decades we can-not ignore the grim side of the story like profuse population proliferation, slow agricultural growth rate, poverty of 26.1 % Indian, sufferings from acute malnutrition, poor resource or input use efficiency, over exploitation of natural resources and indiscriminate use of chemical fertilizer and pesticide causing imbalance in soil-water-crop-animal-human continuum vis-à-vis environmental degradation etc. In India augmenting crop production by increasing the area under cultivation is almost next to impossible. So for gaining food and nutritional security without hampering ecological balance an integrated approach in nutrient management of diversified cropping assumes great importance. Specifically to say that if we are to achieve nutritional security we must have to go for crop diversification in cropping pattern introducing crops like vegetables and pulses (Acharya and Mondal, 2007). Gangwar *et al.* (2004) stated that the cropping system needs to be inherently flexible to take advantage of economic opportunities and/or adapt to environmental realities. Inclusion of pulses, oilseeds and vegetables in the system is more beneficial than cereals after cereals, and such inclusion in a sequence changes the economics of the crop sequences. But it requires revised experimentation at regional and local level.

On the other hand to nourish the Protein Energy Malnourished (PEM) people and to maintain soil health properly pulse crop can be included in the cropping system. Moreover, time has already come to think about the survival of our country in the globalized market with quality/organic agricultural produces. Acharya (2006) revealed that inclusion of onion as a profit earning crop in the rice based crop sequence not only enhanced the system productivity and net production value as a whole but also maintained soil health all-together. Soil fertility status was increased due to the inclusion of legume, whereas cereal or oilseeds exhausted the soil as stated by Samui *et al.*, 2004). Likewise, the inclusion of legumes in rice based cropping system improves the soil health as a whole as reported by Brahmachari *et al.* (2009). Residual effect of nutrients through different sources applied to a crop in the system should be accounted for in the nutrient requirement or fertilizer recommendation for the succeeding crop (Thind *et al.*, 2007).

Furthermore, the basic concept underlying the integrated nutrient management system, nevertheless, remains in the maintenance and possible improvement of soil fertility for sustained crop productivity on long-term basis, it also reduces fertilizers input cost (Singh and Singh, 2002). Therefore, the broader objective of studying the effect of organic and inorganic sources of nutrients on the productivity and quality of the crops and nutrient uptake by the crops in rice–onion–greengram crop sequence was investigated under this experimentation.

MATERIALS AND METHODS

The field experiment was conducted at the farmer's field at Kalyani, Nadia, India under New Alluvial Zone of West Bengal during the years of June 2011 to June 2013, The experimental site was situated at 22º57′ N latitude and 88º20′ E longitude with the altitude of 9.8 meters above the mean sea level (MSL) and topographically the land was medium in situation having shallow tube well facility. The experiment was carried out in strip plot design with two (2) main plot treatments (B_0 *i.e.* without biofertilizer and B_1 i.e.withbiofertilizer) and seven (7) sub plot treatments (F_1: 100% of the Recommended dose of fertilizers i.e. RDF, F_2: 75% of the RDF, F_3: 75% of the RDF +25% of N through FYM, F_4: 75% of the RDF +25% of N through vermicompost, F_5: 75% of the RDF +25% of N through neem cake, F_6: 75% of the RDF +25% of N through groundnut cake and F_7: 75% of the RDF +25% of N through mustard cake replicated thrice.The soil of the experimental plot was sandy clay in texture, with moderate soil fertility status (pH 7.2, organic carbon 0.81%, total N 0.049%, available P_2O_5 21.9 kg ha^{-1}, available K_2O 174.48 kg ha^{-1}).The varieties were Satabdi (IET 4786), Sukhsagar (Local variety) and IPM 2-3 for rice, onion and greengram respectively. Rice seedlings were transplanted during 2nd/3rd week of July and onion seedlings were transplanted in the 3rd week of December while the greengram seeds were sown in the month of March of the respective two years. In case of rice and onion the roots of seedlings were dipped into *Azopirllum* slurry for 10 minutes before transplanting. In greengram the seeds were inoculated with *Rhizobium* culture before its sowing. Milling qualities like hulling, milling and head rice recovery were calculated by formulae as suggested by Khush *et al.* (1979).

Hulling % = (Weight of brown rice/weight of rough rice) × 100

Milling % = (Weight of milled rice/weight of rough rice) × 100

Head rice recovery (HRR) % = (Weight of head rice/weight of rough rice) × 100

The total soluble solids (TSS) were tested with the digital pocket refractometer PAL-1 (made by ATAGO) while the protein (approximate) content of greengram seeds were calculated by multiplying nitrogen content in seeds with a constant factor of 6.25 (AOAC, 2012).

RESULTS AND DISCUSSION

In case of rice, it was revealed from the experimental results that the main plot B_1 and sub plot F_6 recorded the highest grain yield of 4.31 and 4.54 t ha^{-1} respectively. The superior marketable bulb yield of onion was ascertained under the main plot treatment B_1 (biofertilzer) and sub plot treatment F_6 (75% RDF + 25% N through groundnut cake). The corresponding values being 20.73 and 23.81 t ha^{-1} under main and subplot treatments respectively. Both in rice and onion, the combined use of organic, inorganic and biological sources of nutrients showed evidence of excellent results throughout the whole period of supervision. In case of residual greengram, the treatment dominance was observed under the main plot treatment B_1 (biofertilzer), sub plot treatment F_6 (75% RDF + 25% N through groundnut cake) applied to the previous onion crop and the interaction effect between them *i.e.* B_1F_6 (Fig. 1). The corresponding values of yield of residual

Table 1: Variation in quality attributes of three crops in relation to potassium content as influenced by combined nutrient management practices (pooled of 2 years)

Treatment	Rice				Onion		Greengram	
	K content (%)	Hulling (%)	Milling (%)	Head rice recovery (%)	K content (%)	TSS (°Brix)	K content (%)	Protein (%)
Biofertilizer								
B_0	0.352	72.37	65.80	57.99	2.12	12.99	1.317	23.22
B_1	0.389	73.96	68.71	61.17	2.21	13.69	1.353	24.06
SEm ±	0.0002	0.073	0.67	0.087	0.119	0.002	0.050	0.0005
LSD (0.05)	0.005	0.258	2.37	0.307	0.419	0.043	0.176	0.002
Nutrient management								
F_1	0.355	72.4	66.68	57.58	2.037	12.215	2.607	22.45
F_2	0.313	69.96	63.91	54.66	1.796	11.983	2.500	21.79
F_3	0.362	72.73	66.36	57.75	2.172	13.110	2.655	23.37
F_4	0.373	74.58	67.90	61.97	2.240	14.158	2.730	24.00
F_5	0.392	75.69	69.20	63.36	2.317	14.623	2.730	24.49
F_6	0.420	73.65	69.13	61.66	2.352	13.679	2.773	25.04
F_7	0.382	73.15	67.61	60.07	2.274	13.624	2.695	24.31
S Em ±	0.002	0.315	0.68	0.064	0.130	0.005	0.071	0.0001
LSD(0.05)	0.007	0.560	1.20	2.229	0.231	0.037	0.126	0.004
Interaction B×F								
S Em ±	0.808	0.128	0.83	0.193	0.230	0.006	0.175	0.121
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Interaction F × B								
S Em ±	0.915	0.325	0.77	0.648	0.198	0.027	0.146	0.089
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

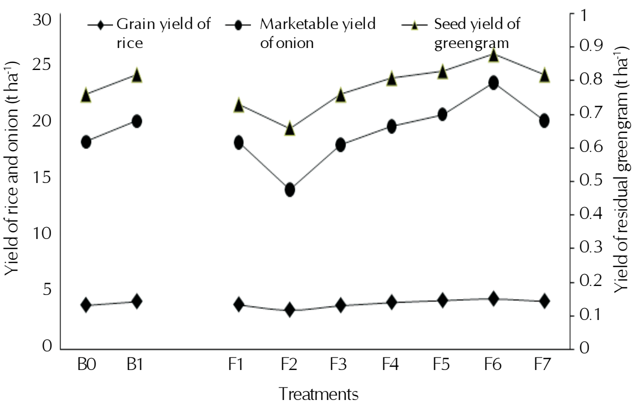

Figure1: Yield of crops in sequence

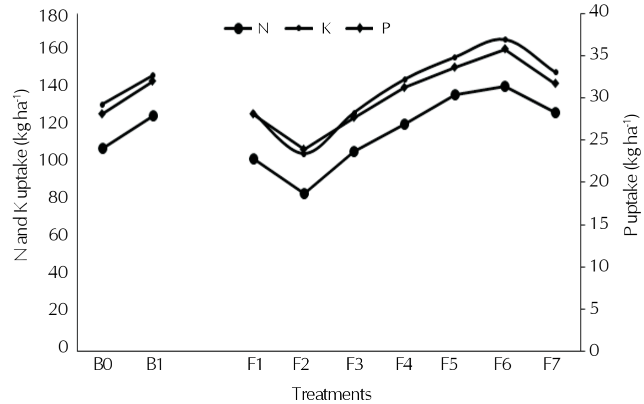

Figure 2: N, P and K uptake by rice

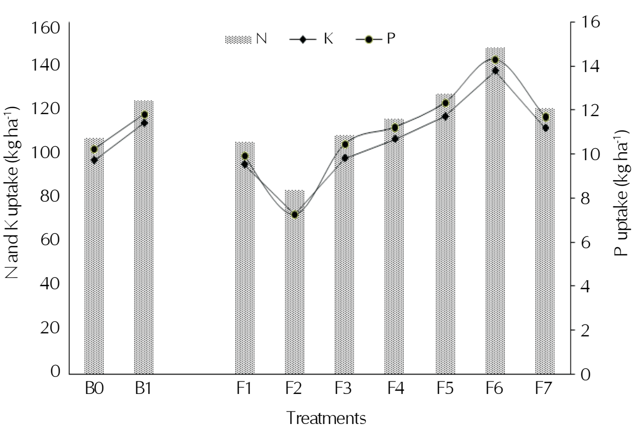

Figure 3: N, P and K uptake by onion

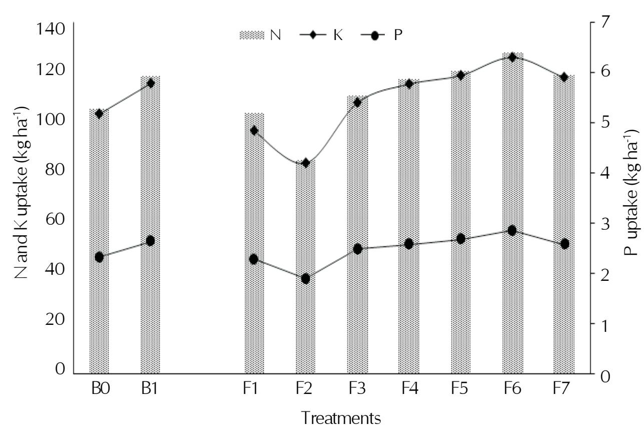

Figure 4: N, P and K uptake by greengram

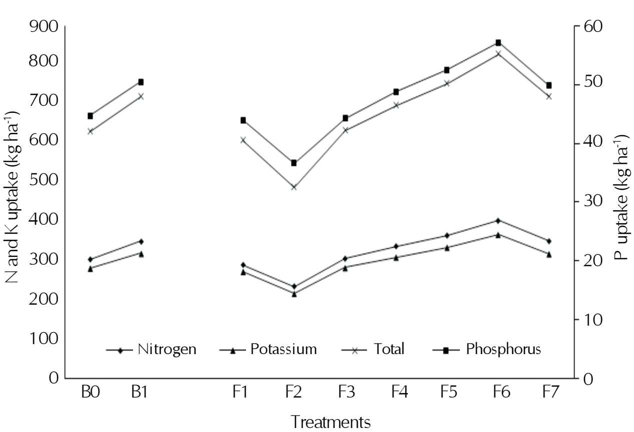

Figure 5: Nutrient uptake by three crops in sequence

greengram were 0.832 and 0.861 t ha^{-1} under main and subplot treatments respectively. The integration of organic (residual), inorganic (residual) and biological sources of nutrients exhibited outstanding results throughout the complete period of surveillance. The integration of different sources of plant nutrients (e.g. biofertilizer, different oilcakes, vermicompost, FYM, crop residues etc.) has a constructive role in maintaining balanced nutrient status, temperature, water retention capacity, microbial population etc. of the soil. All these superior properties of nutrient-source integration help in abundant root proliferation and simultaneous excellent water and nutrient mining by the crops. Better absorption of varied nutrients and water by the crops in sequence result in the production of ample photosynthates which ultimately makes their canopy growth rather biomass as a whole lustrous and large enough. The findings are in agreement with the observations of Kundu (2012), Nayek *et.al.* (2014) and Acharya and Mondal (2007).

Considering the quality attributes of rice it has been observed from the pooled data that the maximum value of K content (0.389%) was determined under the main plot treatment B_1 (with biofertilizer) reflecting the maximum values of hulling, milling and head rice recovery (73.96, 68.71 and 61.17% respectively). Likewise, the superior values of hulling, milling and head rice recovery (75.69, 69.20 and 63.36% respectively) were confirmed with the treatment F_5 (75% RDF + 25% N through neem cake) exhibiting the value of K content of 0.392%. The maximum value of K content of onion (2.21%) was determined under the main plot treatment B_1 (with biofertilizer) reflecting the maximum value of TSS (13.69 °Brix). Likewise, the superior value of TSS (14.62 °Brix) was established with the treatment F_5 (75% RDF + 25% N through neem cake) exhibiting the value of K content of 2.317%. In residual greengram the highest values of K content were recognized in the treatment B_1 and F_6 (residual) showing the values 1.35 and 2.77% respectively. Likewise, the maximum vales of protein % was calculated in the treatments B_1 and F_6

(residual) representing 24.06 and 25.04 % protein in greengram grown in the main plots and sub plots. The correlation matrix of K content in rice grain, onion plant and seed of greengram with their quality attributes documented that all quality attributes were highly significant and positively correlate with the K content of rice grain, onion plant and seeds of greengram respectively (Table 1). There may be multifarious reasons behind such happenings. A fractional substitution of chemical fertilizers by concentrated or bulky organic manures like neem cake, vermicompost , groundnut cake etc. results in the improvement in soil physical, chemical and biological properties leading to better root proliferation, improved nutrient uptake and better accumulation of photosynthates. They provide nutrients to all the crops in sequence bit by bit but in a steady manner along with the added advantage of rapid, bounty and easy nutrient supplying capacity of chemical fertilizer to the crops in integrated nutrient management based crop sequence. Again, neem seed cake performs the dual function of both fertilizer and pesticide, acts as soil enricher, reduces the growth of soil pest and bacteria, provides macro and micro nutrients essential for overall plant growth and helps to increase the yield of plants in the long run; it is biodegradable vis-à-vis ecofriendly and excellent soil conditioner. The compounds found in neem manure help to increase the nitrogen and phosphorous content in the soil. It is also rich in sulpher, potassium, calcium, nitrogen etc. Potassium and sulpher help in quality improvement of different crops. It does not have any aftermaths on plants, soil and other living organisms. It helps to eliminate bacteria responsible for denitrifying the soil and has anti-feedant properties that help to reduce the number and growth of insects and pests. Similar result was found by Nayek *et al.* (2014) and Kundu (2012).

Considering the nutrient uptake by different crops in sequence it may be concluded that the plots receiving biofertilizer resulted in more nitrogen uptake by rice crop showing the value of 125.75 kg ha^{-1} (Fig. 2). Across the years of study, the treatment F_6 emerged with the maximum value of nitrogen uptake (141.35 kg ha^{-1}) by whole rice plant. The maximum phosphorus uptake by rice plant (32.01 kg ha^{-1}) was noted in the treatment B_1 (with biofertilizer) and the treatment supremacy with reference to total phosphorus uptake (35.81 kg ha^{-1}) was noticed under the treatment F_6. Similar trend was observed in potassium uptake by rice plant, where the maximum amount of potassium *i.e.* 147.20 kg ha^{-1} was accrued under the treatment receiving biofertilizer in the main plots and 166.36 kg ha^{-1} under the sub plot treatment F_6(Fig. 3). Judging the pooled results of the effect of biofertilizer and nutrient management treatments it may be opined that the maximum quantities of nitrogen, phosphorus and potassium (114.18, 12.46 and 118.085 kg ha^{-1} respectively) were taken by the onion whole plant under the treatment B_1 (with biofertilizer) and the upmost uptake of nitrogen, phosphorus and potassium (137.9, 14.86 and 143.03 kg ha^{-1} by onion crop respectively) were observed under the treatment F_6 (Fig. 4). The maximum uptake of nitrogen, phosphorus and potassium (115.81, 5.94 and 52.96 kg ha^{-1}) were achieved in the treatment B_1. The statistical supremacy with respect to nitrogen, phosphorus and potassium uptake (126.19, 6.14 and 5.7.32 kg ha^{-1}) was recognized under the treatment F_6 (residual). The maximum values of nitrogen, phosphorus and potassium vis-à-vis total nutrient uptake (349.27, 50.40, 318.32 and 717.99 kg ha^{-1} respectively) were found under the treatment B_1 (with biofertilizer). The upmost uptake of nitrogen, phosphorus, potassiumand total nutrient (402.78, 57.08, 366.69 and 826.56 kg ha^{-1} respectively) were observed under the treatment F_6 (Fig. 5). Similar result was found by Nayek *et al.* (2014), Acharya and Mondal (2007), Chowdhury *et al.* (2014), Barik *et al.* (2006) and Saha *et al.* (2012). They opined that the integration of different sources of plant nutrients (e.g. biofertilizer , different oilcakes , vermicompost, FYM, crop residues etc) has a favourable role in maintaining proper nutrient status, temperature, water retention capacity, microbial population etc of the soil.

This may be due to the fact that the pre transplanting/ pre sowing inoculation through root dipping/seed treatment of crops in sequence with biofertilizers along with a little bit substitution of chemical fertilizers through organic manure especially oil cakes i.e. an integrated approach in nutrient management of crop sequence keeps the physical condition of soil better besides providing nutrients to the plant bit by bit but in a steady manner along with the added advantage of rapid, bounty and easy nutrient supplying capacity of chemical fertilizer to the crops. This type of nutrient management has also a sound role in better microbial proliferation resulting in good root growth and better accumulation of nutrients in the plant body ultimately profuse canopy of all the crops in sequence. Though the legume pulse was grown as a residual crop in the system after a cereal and a vegetable in succession, it was cultivated with biofertilizer. Thus, the third crop in residual condition not only faced no hindrance in nutrient grazing, but also adds nutrient to the soil through biological fixation which remained in the soil for the successive crops. In this way a proper nutrient balance of soil prevailed and judicious nutrient uptake by the crops occurred. The views may be supported by the findings of Nayek *et al.* (2014), Acharya and Mondal (2007), Hedge *et al.* (1998) and Yawalkar *et al.* (2008).

From the experimental findings, it can be concluded that combined use of organic, inorganic and biological sources of nutrients is the best choice in this aspect from the point of view of quantity and quality enhancement of the crops in sequence. Such type of practice helps in proper uptake of various mineral nutrients by plants. Moreover, a partial use of organics in some crops of the sequence will provide a scope for growing the third crop of that sequence in residual condition. So, this integrated approach in nutrient management under rice onion residual greengram crop sequence helps in escalating crop yield vis-a-vis maintaining the overall environment.

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