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M Saravana Kumar
College of Horticulture, Vellanikkara, Kerala Agricultural University, Kerala, India

GA Manjunatha
College of Horticulture, Vellanikkara, Kerala Agricultural University, Kerala, India

R Rajakumar
College of Horticulture, Vellanikkara, Kerala Agricultural University, Kerala, India

S Dhilsha
College of Agriculture, Vellayani, Kerala Agricultural University, Kerala, India

Correspondence
M Saravana Kumar
College of Horticulture, Vellanikkara, Kerala Agricultural University, Kerala, India

Soil fertility and crop productivity in upland rice (*Oryza sativa* L.) under different NK levels and FYM substitution

M Saravana Kumar, GA Manjunatha, R Rajakumar and S Dhilsha

Abstract
A field experiment was conducted in College of Agriculture, Padannakkad, to study the response of soil fertility and crop productivity in upland rice to different levels of NK and substitution of inorganic N through FYM. Results revealed that application of 120 kg N ha^{-1} (50% through FYM) and 60 kg K_2O ha^{-1} recorded the lowest bulk density, highest porosity, whereas highest water holding capacity was recorded by application of 100 kg N ha^{-1} (50% through FYM) and 50 kg K_2O ha^{-1}. Regarding nutrient status, available N and P_2O_5 were found to be enhanced due to the application of 120 kg N ha^{-1} with 25 per cent substituted by FYM and 60 kg K_2O ha^{-1} and the highest available K_2O and organic carbon per cent was recorded with the application of 120 kg N ha^{-1} with 50 per cent substituted as FYM and 60 kg K_2O ha^{-1}. The highest yield attributes (highest number of productive tillers m^{-2}, filled grains $panicle^{-1}$ and 1000 grain weight), grain (2822 kg ha^{-1}) and straw (3560 kg ha^{-1}) yields were obtained with the application of 120 kg N ha^{-1} with 50 per cent substituted by FYM and 60 kg K_2O ha^{-1} and was on par with 120 kg N ha^{-1} with 25 per cent substituted as FYM and 60 kg K_2O ha^{-1}.

Keywords: soil fertility, productivity, FYM, upland rice

Introduction
Upland rice is grown in about 13 per cent of the area under rice in India, but contributes to only 4 per cent of the rice production. The present level of productivity of upland rice in Kerala is less than 1 t ha^{-1}. The major constraints in upland rice are moisture stress, nutrient imbalance, high weed infestation and poor soil fertility. Lack of nutrients is the ultimate cause of poor growth of upland rice, even correcting the nutrient deficiencies not produced the yield comparable to lowland situation. High productivity can be achieved through proper nutrient management practices.
Among the essential plant nutrients nitrogen is an essential component of amino acids and related proteins of the plant structure. Potassium is considered next to nitrogen as regards its role in rice production and it usually takes up more K than N. Potassium promotes growth, yield attributes, yield, increases resistance to pests, regulates water utilization by plant and strengthens plant tissues.
The intensive use of chemical inputs has not only polluted the soil, water and environment causing their degradation but also affected the life of human beings. So, it is time to look for measures to stimulate sustainability in production of rice on long-term basis. Integrated use of inorganic and organic sources of plant nutrients has a tremendous potential in not only sustaining agricultural productivity and soil health but also in substituting a part of fertilizer requirement by organics for different crops and cropping system.

Material and Methods
A field experiment was conducted in the farmer's field near to the College of Agriculture, Padannakkad. The soil was sandy loam having pH 4.8, organic carbon 0.39 per cent, available nitrogen 197 kg ha^{-1}, available P_2O_5 4.03 kg ha^{-1} and K_2O 153 kg ha^{-1}. The experiment was laid out in randomised block design with 10 treatments with three replications. Treatment details are as follows: T_1 - 80 kg N applied as 100 % CF (Chemical Fertilizer) and 40 kg K_2O, T_2 - 80 kg N applied as 60 kg CF, 20 kg FYM and 40 Kg K_2O, T_3 - 80 kg N applied as 40 kg CF, 40 kg FYM and 40 kg K_2O, T_4 - 100 kg N applied as 100 % CF and 50 kg K_2O, T_5 - 100 kg N applied as 75 kg CF, 25 kg FYM and 50 kg K_2O, T_6 - 100 kg N applied as 50 kg CF, 50 kg FYM and 50 kg K_2O, T_7 - 20 kg N applied as 100 % CF and 60 kg K_2O, T_8 - 120 kg N applied

as 90 kg CF, 30 kg FYM and 60 kg K_2O, T_9 - 120 kg N applied as 60 kg CF, 60 kg FYM and 60 kg K_2O and T_{10} - 60 kg N applied as 100 % CF and 30 kg K_2O. A dose of 30 kg P_2O_5 ha^{-1} was uniformly applied to all treatments. Seeds of Aiswarya variety were dibbled at 2-3 per hill at 20 cm x 15 cm spacing. Farmyard manure (0.5:0.2:0.3 per cent NPK) was applied @ 5 t ha^{-1} uniformly to all plots. The additional quantity of FYM required was calculated and applied as per the treatments and mixed well with the top soil. Nitrogen was applied in the form of urea equally in three split doses, first at basal, second at active tillering and third at panicle initiation stage as per the treatments. Full dose of phosphorus was applied in the form of rock phosphate at the time of levelling. Potassium was applied in the form of muriate of potash in two equal splits, first at basal and remaining at panicle initiation stage as per the treatments. Soil samples were collected from the experimental area (0-15 cm depth) at initial and after harvest. The samples thus collected were air dried, passed through 2 mm sieve and analysed for its physical and chemical properties using standard procedures (Table 1 and 2). The parameters thus obtained were subjected to statistical scrutiny as outlined by Panse and Sukhatme (1985) [5].

Table 1: Physical properties of soil (pre- sowing)

Particulars	Results	Method
Sand (%)	75	International pipette method (Robinson, 1922) [7]
Silt (%)	5.5	
Clay (%)	17.5	
Texture	Sandy loam	
Bulk density	1.25	Measuring cylinder method (Dakshanamoorthy and Guptha, 1968) [3]
Porosity (%)	44.68	
Water holding capacity (%)	19.43	

Table 2: Chemical properties of soil (pre- sowing)

Particulars	Results	Method
pH	4.8	pH meter (Jackson, 1973) [4]
Organic carbon	0.39	Chromic acid wet digestion method (Walkley and Black, 1934) [11]
Available N (kg ha^{-1}	197	Alkaline Permanganate method (Subbiah and Asija, 1956) [10]
Available P(kg ha^{-1})	4.03	Bray extraction and photoelectric colorimetry (Jackson, 1973) [4]
Available K(kg ha^{-1})	153	Flame photometry (Stanford and English, 1949) [9]

Results and Discussion

Soil Physical Properties

The soil physical properties were favourably influenced by treatments (Table 3 and Fig. 1). The lowest bulk density and highest porosity values were recorded by the application of 120 kg N ha^{-1} with 50 per cent substituted as FYM and 60 kg K_2O ha^{-1}. Lowering of bulk density due to continuous application of chemical fertilizers along with organics might be due to addition of higher organic carbon that resulted in more pore space and good soil aggregation (Sepehya *et al.*, 2012) [8]. The highest water holding capacity was recorded by the application of 100 kg N ha^{-1} with 50 per cent substituted as FYM and 50 kg K_2O ha^{-1}. This could be ascribed to the improvement in structural condition of soil due to the application of FYM with inorganics (Bhatnagar *et al.* 1992) [2]. Also the higher water holding capacity of the added organic matter in turn might have increased the water holding capacity of the soil.

Table 3: Effect of treatments on soil physical properties after the experiment

Treatments	Bulk Density (g cc^{-1})	Porosity (%)	Water Holding Capacity (%)
T_1	1.18	45.73	20.11
T_2	1.14	47.94	20.23
T_3	1.15	47.48	20.67
T_4	1.15	47.32	19.92
T_5	1.18	45.70	20.67
T_6	1.13	48.20	22.66
T_7	1.14	47.86	20.79
T_8	1.11	49.25	22.30
T_9	1.07	50.76	22.14
T_{10}	1.20	44.95	17.44
SEm(±)	0.03	1.07	1.09
CD (0.05)	0.07	3.19	1.86

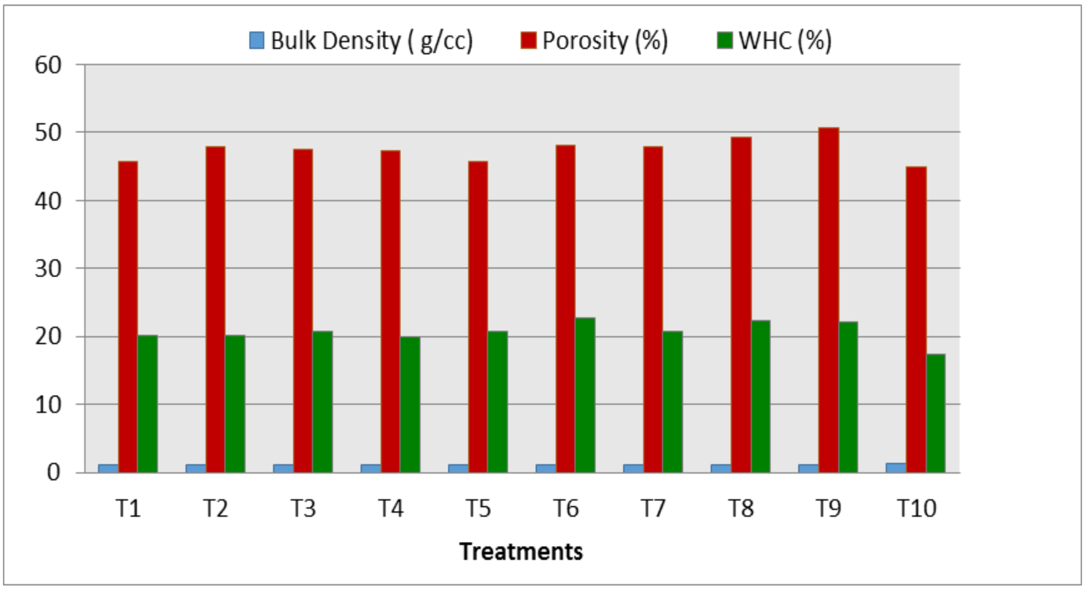

Fig 1: Effect of treatment on physical properties of soil

Soil Chemical Properties

The available nutrient status of the soil was significantly improved by the application of treatments (Table 4). At post harvest stage, soil available N and P_2O_5 were found to be enhanced due to the application of 120 kg N ha^{-1} with 25 per cent substituted by FYM and 60 kg K_2O ha^{-1}. Higher N availability in the soil due to FYM addition might be due to continuous and slow release of nutrients from FYM, increased biomass and accumulated soil organic matter as reported by Ajaykumar (2015)[1]. Combined application of N, K and FYM registered a build up of available P in the soil. This might be due to the fact that during the mineralization of enriched organics, a number of organic acids, especially the hydroxyl ions (product of microbial metabolism) are produced, which released P through chelation or by removal of metal ions from the insoluble metal phosphates. The Highest value for soil available K_2O was recorded by the application of 120 kg N ha^{-1} with 50 per cent substituted as FYM and 60 kg K_2O ha^{-1}. The increase in available K might be due to the combined effects of addition of K through fertilizers and organic sources, and weathering of K minerals and loss of K from the soil including crop removal. The application of 120 kg N ha^{-1} with 50 per cent substituted as FYM and 60 kg K_2O ha^{-1} recorded the highest organic carbon status of the soil. Increase in organic carbon status of the soil due to FYM application was mainly due to addition of organic matter (Patnaik *et al.*, 1989) [6].

Crop productivity

Application of 120 kg N ha^{-1} with 50 per cent substituted by FYM and 60 kg K_2O ha^{-1} (T_9) registered highest number of productive tillers m^{-2}, filled grains $panicle^{-1}$ and 1000 grain weight. The highest grain (2822 kg ha^{-1}) and straw (3560 kg ha^{-1}) yields were obtained with the application of 120 kg N ha^{-1} with 50 per cent substituted by FYM and 60 kg K_2O ha^{-1} (T_9) and was on par with 120 kg N ha^{-1} with 25 per cent substituted as FYM and 60 kg K_2O ha^{-1} (T_8) (Table 5).

Table 4: Effect of treatments on chemical properties of soil after the experiment

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Organic carbon (%)
T_1	220.70	10.27	203.13	0.41
T_2	241.53	8.84	199.67	0.45
T_3	228.80	12.16	211.87	0.56
T_4	244.83	8.55	204.50	0.53
T_5	246.67	9.52	261.00	0.61
T_6	254.07	14.95	226.07	0.64
T_7	248.73	9.87	240.13	0.59
T_8	265.63	15.29	267.77	0.66
T_9	261.73	13.05	277.17	0.69
T_{10}	207.17	6.59	185.63	0.40
SEm(±)	5.69	0.84	6.30	0.02
CD (0.05)	16.89	2.51	18.71	0.03

Table 5: Effect of treatments on yield attributes and yield of upland rice

Treatments	Number of productive tillers $hill^{-1}$	Number of filled grains $panicle^{-1}$	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	10.60	126.80	25.51	1797	2716
T_2	10.87	106.33	25.53	2044	2949
T_3	10.60	127.87	26.34	1780	2482
T_4	12.00	133.60	25.00	2120	2919
T_5	12.87	140.20	26.07	2281	3129
T_6	10.67	136.03	26.95	2485	3383
T_7	12.80	114.67	26.65	2600	3406
T_8	11.60	116.47	27.61	2785	3457
T_9	12.87	147.33	28.28	2822	3560
T_{10}	7.67	97.27	25.15	1668	2571
SEm(±)	0.81	8.08	1.44	96.29	68.83
C.D (0.05)	2.41	24.05	NS	202.30	204.52

Conclusion

In upland rice cultivation, nutrient management plays an important role in limiting the yield. Continuous application of fertilizer will have a deleterious effect on soil health as well as environment and results in lower rice production. From the present study it could be concluded that integrated application of 120 kg N ha^{-1} with 50 per cent substituted as FYM and 60 kg K_2O ha^{-1} improves the crop growth parameters and yield attributes, and fetch more income for farmers, with an additional advantage of improving the soil health.

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