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Yield and yield attributes of upland rice (*Oryza sativa* L.) as influenced by P dose and partial N substitution

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Abstract
A field experiment was conducted in the Instructional farm, College of Agriculture, Vellayani, Thiruvananthapuram during *Kharif,* 2018 to study the influence of P dose, to assess the feasibility of partial substitution of inorganic N with FYM, VC and *in situ* green manure cowpea on yield of upland rice. The variety used was Aiswarya (PTB 52). The yield attributes and yield *viz.*, number of productive tillers m^{-2}, weight of panicle, number of spikelets $panicle^{-1}$, number of filled grains $panicle^{-1}$, grain yield, straw yield and harvest index were favorably influenced by treatments. Application of 30 kg $P_2 0_5$ ha^{-1} and 120 kg N ha^{-1} through 50% N as CF, 25% N as FYM and *in situ* green manure cowpea (T_5) recorded the maximum yield attributes and yield except number of spikelets $panicle^{-1}$. The treatment T_5 recorded maximum grain and straw yields of 3357 and 4133 kg ha^{-1} respectively and was on par with T_6 and superior to other treatments. The maximum HI of 0.45 was recorded by the treatments T_5 and T_6.

Keywords: Upland rice, Farm yard manure (FYM), vermicompost (VC), green manure (GM) cowpea, organic and inorganic fertilizer, integrating nutrient managing (INM)

Introduction
Rice (*Oryza sativa* L.) is the most important and extensively grown crop in tropical and subtropical regions of the world and a staple food for more than 70 per cent of the world population. In India, rice is grown over an area of 43 m ha with total production of 95 m t amounting to 40 per cent of the total food production (Kumar *et al.*, 2017) [1]. The scope for expansion of area under sole crop of rice is limited and the best alternative is to bring more area under upland rice cultivation. A number of abiotic and biotic stresses can depress the upland rice yiels. Upland rice is generally grown on low fertile, strongly weathered soils to which little lime and fertilizers are applied.

One of the key constraints for production is P deficiency, often associated with high P fixation and severe soil acidity (Gupta and O'Toole, 1986) [2]. External nutrient inputs are essential to improve and sustain crop production on these soils. Combined application of organic and inorganic sources of nutrients is a must for sustaining higher productivity in upland rice. The use of inorganic fertilizers to sustain crop was found to increase yield only for some few years but on long-term, it has not been effective and leads to soil degradation (Satyanarayana *et al.*, 2002) [3]. Green manures add organic matter to the soil and recycle nutrients into the soil. Legumes will improve soil fertility through biological N fixation. The present productivity of upland rice in Kerala is less than 1 t ha^{-1}. Suitable nutrient management practices must be adopted to overcome the constraints involved in low productivity of upland rice. The validity of integration of FYM, green manuring and chemical fertilizers is lacking for optimizing the productivity of rainfed upland rice in farmer's fields. There is a possibility of increasing upland rice production by increasing P dose with substitution of N using different organic sources.

Materials and Methods
A field experiment on 'Yield and yield attributes of upland rice (*Oryza sativa* L.) as influenced by P dose and partial N substitution' was conducted in block 4 of Instructional farm, College of Agriculture, Vellayani, Thiruvananthapuram during *Kharif,* 2018. The soil of the experimental field was red sandy clay loam belonging to the order oxisols, Vellayani series. Aiswarya (PTB 52), released from Regional Agricultural Research Station (RARS), Pattambi was used for conducting the experiment.

The spacing was 20cm x 10cm. Well decomposed and dried farmyard manure (FYM) containing 0.5 per cent N, 0.3% P_20_5 and 0.4% K_20 and Vermicompost (VC) with 1.23% N, 0.5% P_20_5 and 1.54% were used for the experiment. Green manure (GM) cowpea variety Anaswara was sown in between two rows of rice and incorporated after 45 days. Nutrient content of N in cowpea is 2.7%. The fertilizers used for the experiment were urea (46% N), Rajphos (20% P_20_5) and muriate of potash (60% K_20).

The experiment was laid out in randomized block design with 11 treatments and 3 replications. The treatments were T_1: 30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (100% N as CF, Chemical Fertilizer), T_2: 45 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (100% N as CF), T_3: 30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF + 50% N as FYM), T_4: 45 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF + 50% N as FYM), T_5: 30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF, 25% N as FYM and *in situ* green manure cowpea), T_6: 45 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF, 25% N as FYM and *in situ* green manure cowpea), T_7: 30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF + 50% N as VC), T_8: 45 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF + 50% N as VC), T_9 :30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF, 25% N as VC and *in situ* green manure cowpea), T_{10} : 45 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} (50% N as CF, 25% N as VC and *in situ* green manure cowpea) and T_{11}: 30 kg P_20_5 ha^{-1} and 60 kg N ha^{-1} 100% N as CF (control). Uniform dose of 60 kg K_2O ha^{-1} was applied to all treatments except control where it was 30 kg K_2O ha^{-1}. Farmyard manure @ 5 t ha^{-1} was added to all the plots uniformly and additionally calculated amount of FYM and VC as per the treatments were applied and mixed well with the top soil. Green manure cowpea was sown along with rice and incorporated into the soil after 45 days as per the treatments. Nitrogen was applied equally at 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 as basal at the time of leveling. Potassium was applied in two equal splits, first at basal and remaining at panicle initiation stage.

The yield attributes *viz.*, number of productive tillers m^{-2}, panicle weight, number of spikelets panicle^{-1} and filled grains panicle^{-1} were recorded at harvest stage. Grain and straw yields were recorded at the time of harvest. The harvest index was worked out.

Results and Discussion

The results of the study revealed that yield attributes and yield (Tables 1 and 2) *viz*., number of productive tillers m^{-2}, weight of panicle (g), number of spikelets panicle^{-1}, number of filled grains panicle^{-1}, grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (HI) were favorably influenced by treatments.

Table 1: Effect of P dose and N sources on number of productive tillers m^{-2}, weight of panicle, number of spikelets panicle^{-1} and number of filled grains panicle^{-1}

Treatments	Productive tillers m^{-2}	Panicle weight (g)	Number of spikelets panicle^{-1}	Number of filled grains panicle^{-1}
T_1	297.33	3.22	127.07	111.63
T_2	302.67	3.23	128.63	113.30
T_3	308.00	3.25	129.53	115.97
T_4	312.00	3.35	132.63	114.63
T_5	334.67	3.47	134.20	128.53
T_6	318.67	3.32	134.87	125.73
T_7	295.33	3.08	122.63	113.87
T_8	296.67	3.27	129.87	120.57
T_9	310.00	3.28	131.07	122.97
T_{10}	306.00	3.25	128.83	116.73
T_{11}	252.00	2.95	117.50	103.30
SEm (±)	5.22	0.06	2.50	4.10
CD(0.05)	15.520	0.184	7.421	12.168

Yield attributes

All the characters except number of spikelets panicle^{-1} were improved by the treatment T_5 (30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} with 50% N as CF, 25% N as FYM and in situ green manure cowpea), while T_6 (45 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} with 50% N as CF, 25% N as FYM and in situ green manure cowpea) registered the maximum number of spikelets panicle^{-1}. Integrated use of organic and inorganic fertilizers produced significantly higher number of productive tillers m^{-2}, number of spikelets panicle^{-1} and number of filled spikelets panicle^{-1}. Supplying adequate nutrients in readily available form through integrated nutrient management (INM) increased the number of productive tillers m^{-2}. The highest number of spikelets panicle^{-1} for a combination of FYM and inorganic fertilizers was due to high available N at the panicle initiation stage and more productive tillers m^{-2} (Nachimuthu *et al*., 2007) [4]. Effective translocation of photosynthates from source to sink might have resulted in higher grain filling and higher number of filled grains panicle^{-1}. Increased availability and uptake of nutrients in treatment T_5 resulted in higher weight of panicle, productive tillers, number of spikelet and filled grains. This was in conformity with the findings of Ranjini (2002) [5] and Kumar (2016) [6] in upland rice.

Table 2: Effect of P levels and N sources on grain yield, straw yield and harvest index.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest Index
T_1	2577	3615	0.42
T_2	2677	3700	0.42
T_3	2951	3980	0.43
T_4	3057	4002	0.43
T_5	3357	4133	0.45
T_6	3240	4033	0.45
T_7	2965	3974	0.43
T_8	3064	3984	0.43
T_9	3106	4000	0.44
T_{10}	3057	3996	0.43
T_{11}	1745	2477	0.41
SEm (±)	38	42	0.002
CD(0.05)	111.5	125.0	0.007

Yield

The results revealed the significant influence of treatments on grain, straw yields and HI (Table 2 and Fig. 1.). The treatment T_5 (30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} with 50% N as CF, 25% N as FYM and in situ green manure cowpea) produced the

maximum grain and straw yields of 3357 and 4133 kg ha^{-1} respectively. Yield is the ultimate manifestation of yield attributes. The favourable influence of INM on yield attributes such as number of productive tillers m^{-2}, weight of panicle, number of spikelets $panicle^{-1}$ and number of filled grains $panicle^{-1}$ might have contributed to higher grain, straw yields and HI. Significant increase in grain and straw yields could be attributed to higher photosynthetic activities and efficient translocation of photosynthates from source to sink might have contributed to higher yield attributes and yield. Application of FYM and GM cowpea in combination with CF significantly increased the grain and straw yields. Higher grain yield due to application of FYM, GM cowpea and CF might be due to combined effect of nutrient supply, synergism and overall improvement in soil physical, chemical and biological properties. An additional rice grain yield of 1796 kg ha^{-1} and straw yield of 1709 kg ha^{-1} were obtained with the application of 30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} with 50% N as CF, 25% N as FYM and in situ green manure cowpea (T_5) over T_{11} (60 kg N applied as 100% CF and 30 kg P_20_5 ha^{-1}) which is complete application of N through CF. It is clearly evident that combined application of CF and FYM and GM cowpea produced maximum grain, straw yields and HI compared to sole application of N as CF. Application of FYM promoted the bacterial, actinomycetes and fungal population in soil and more biomass which served as a source of carbon and nutrients (Selvi *et al*., 2004) [7]. The increased activity of micro organism in FYM might have attributed to faster decomposition of organic matter of FYM and succulent GM cowpea, which favoured faster mineralization for greater release of nutrients and their continuous availability in soil for sustaining higher grain and straw yields of upland rice. Similar findings were reported by Ranjini (2002) [5] and Kumar (2016) [6] in upland rice.

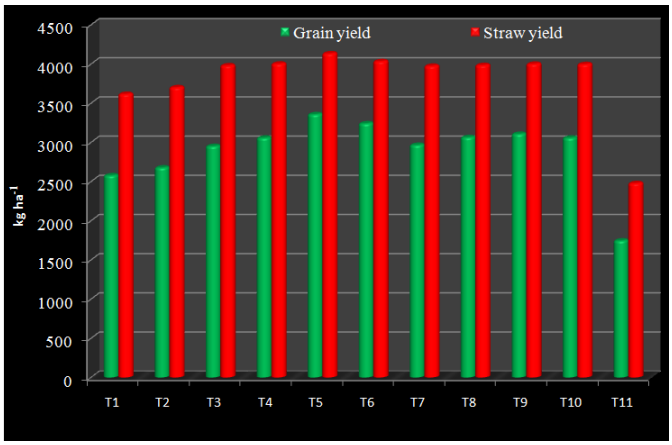

Fig 1: Effect of P levels and N sources on grain and straw yields

Conclusion

The result revealed higher yield attributes and yield of upland rice due to treatment T_5 (30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} with 50% N as CF, 25% N as FYM and *in situ* green manure cowpea). Therefore the combined application of 30 kg P_20_5 ha^{-1} and 120 kg N ha^{-1} applied as 50% N as CF, 25% N as FYM and *in situ* green manure cowpea can be recommended for upland rice farmers.

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