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Influence of varied rates of macronutrients fertilization on nutrient uptake and pest incidence of paddy

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Abstract
A preliminary survey involving one hundred farmers of Mandya district growing paddy was carried out to know the amount of fertilizer used for growing the crop. Based on the survey result, the fertilizer rates were categorized as sub-optimal (50-100%), optimal (101-175%) and super-optimal (176% and >176%) keeping UAS, Bangalore recommendation, as base. Further, these varied rates were tested under field condition to know its effect on growth, yield, pest and disease incidence of paddy at College of Agriculture, V. C. Farm, Mandya during *Kharif* 2020.

The nitrogen content of paddy was higher (0.98 and 1.31% in straw and grain, respectively) due to application of super-optimal dose of NPK (T_9- 169:23:60 kg per acre). On the other hand, P and K content were higher (0.47 and 0.39%: 0.97 and 0.49%, respectively) with balanced (2:1:1) application of 90:45:46 kg per acre NPK. Significantly outstanding uptake of N (121.58 Kg ha^{-1}) was observed in grain as well as straw of paddy with 169:23:60 kg per acre NPK application. Whereas, higher uptake of P (43.76 Kg ha^{-1}), K (73.83 Kg ha^{-1}) were recorded in treatment T_7 with 90:46:45 Kg per acre NPK, respectively. With super-optimal dose of (169:23:60 kg per acre) NPK registered higher (88.64, 29.65, 24.33, 13.97, 12.22, 11.16 and 7.27% of leaf folder, caseworm, stem borer, gundhi bug, sheath rot, leaf spot and narrow leaf spot, respectively) insect pest and disease infestation. Inferior per cent invasion was documented with super optimal dose (27:12.5:15 kg per acre) of NPK (58.37, 14.75, 12.08, 7.35, 4.06, 6.27% of leaf folder, caseworm, stem borer, gundhi bug, sheath rot and leaf spot, respectively) except narrow leaf spot (3.30%) recorded least in optimal dose of NPK (T_6- 65:23:40 kg per acre).

Keywords: Sub optimal, super optimal, NPK, leaf folder, stem borer, sheath rot, and narrow leaf spot

Introduction
Paddy (*Oryza sativa* L) is the most important cereal (*Poaceae*) and staple food crop of 113 counties. Globally its production was more than 759.6 m t during 2017 of which approximately 90 per cent is produced and consumed in Asia. India ranks second in the production after China with cultivated area of 43.39 m ha, production and productivity of 104.32 m t and 24.04 q ha^{-1}, respectively. In Karnataka rice is being grown in 27 districts with an area of 1.06 m ha having annual production of 2.70 m t and productivity of 25.47 q ha^{-1}. The total area in Mandya district for paddy cultivation was 79.89 lakh ha with the production of 30.52 q ha^{-1}. (Anon., 2016) [1].

The average state and national productivity of paddy is almost 50 per cent lower than world average productivity (Anon., 2016) [1]. The lower productivity of rice in the farmer's field suggests that there is an opportunity to increase the productivity with scientific crop management practices. Among several practices scientific nutrient management plays a vital role in harnessing sustainable yield.

Nitrogen (N) is most important nutrient for photosynthesis and biomass production, whereas phosphorus (P) is essential for root growth, flowering, ripening and also resistance towards disease and drought. Potassium (K) affects crop metabolism, growth, grain filling, and viability of pollen grains (Datta *et al*., 1985) [6]. Although all seventeen essential plant nutrients are important in achieving genetic potential yield of any crop or variety. The imbalanced macronutrients supply is known to ominously affect productivity of paddy (Jiban *et al*., 2020) [9].

Considering the above facts, a preliminary surveying of hundred paddy growing farmers of Mandya district with predeveloped questionnaire was conducted to obtain the details of quantity and type of fertilizer application, incidence and management of pest and disease cost of cultivation etc., based on the generated information sub-optimal (50 - 100%), optimal (101 - 175%) and super-optimal (176% and >176%) fertilizer application rate over recommended N dose was identified. Keeping this as reference a field experiment entitled "Studies on sub-optimal, optimal and super optimal dose of NPK on growth, yield, pest and disease incidence of paddy" was conducted with the objective is to study the effect of sub-optimal, optimal and super optimal doses of NPK on its uptake and pest incidence of paddy.

Materials and Methods

A field experiment was conducted at Agriculture College Farm, V.C. Farm, Mandya to evaluate various NPK doses followed by farmers on growth, yield and incidences of disease and pest in paddy.

To fix the treatments, a preliminary survey of different paddy growing farmers of Mandya district was done by developing the questionnaire to obtain the information on type and amount of fertilizer, pest incidence and their management in paddy during cropping period (Appendices IV). The data collected from 100 farmers and survey was grouped as sub-optimal (50 - 100%), optimal (101 - 175%) and super-optimal (176% and >176%) based on recommended nitrogen dose of paddy as a reference point. Based on this treatment were grouped and details were finalized as follows.

Treatment details

Treatments	N: P2O5: K2O levels in kg acre^{-1}	Classified
T_1	Control	
T_2	RPP (40: 20: 20)	Recommended PoP
T_3	FP-1 (23:10:10)	Sub-optimal dose
T_4	FP-2 (27:12.5:15)	
T_5	FP -3 (45:23:10)	Optimal dose
T_6	FP -4 (65:23:40)	
T_7	FP -5 (90:46:45)	Super-optimal dose
T_8	FP -6 (121:23:60)	
T_9	FP -7 (169:23:60)	

Note: FP-farmers practice,
RPP- Recommended Package of Practices, the dose is N: P2O5: K2O kg per acre

The soil sample and plant samples were analysed using standard protocols as mentioned in "A text book of soil analysis" by Baruah and Barthakur, (1997) [13].

The pest (case worm and leaf folder) incidence and infestation were recorded at 30 days after transplanting at five days interval and stem borer and gundhi bug incident were also recorded at 85 days after transplanting at five days interval and scoring were done as per the standard (Standard Evaluation System (SES) for Rice, IRRI).

Observation on brown spot, narrow brown leaf spot and sheath rot were recorded at 70 days after transplanting at 5 days interval and scoring were done as per the standard (Standard Evaluation System (SES) for Rice, IRRI). The data collected from the experimental field were analyzed statistically following the procedure as described by Gomez and Gomez (1984) [14].

Results and Discussion

Different NPK fertilizer grades suggestively influenced the nitrogen content in the straw and grain of paddy (Table 1). Nitrogen content and uptake were highest in super-optimal dose treatments T_9 (0.98 and 1.31%, respectively and 66.09 and 55.49 kg ha^{-1}, respectively) followed by T_8 (0.95 and 1.28%, respectively and59.15 and 50.32 kg ha^{-1}, respectively) and T_7 (0.94 and 1.25%, respectively and 57.42 and 48.16 kg ha^{-1}) at harvest with the nitrogen application of 169, 121 and 90 kg per acre, respectively.

The lowermost N content was found in the absolute control which was followed by sub-optimal dose treatments T_3 (0.65 and 0.95%, respectively and 33.46 and 23.51 kg ha^{-1}, respectively) and T_4 (0.68 and 0.99%, respectively and 36.66 and 26.20 kg ha^{-1}, respectively)

and also, these treatments (T_3 & T_4) were on par with each other. The intensification of N content and uptake in straw and grain might be due to higher dose of NPK application, their synergistic interaction might have led to amplified availability of nitrogen in the soil which facilitate higher uptake of nitrogen (Belete *et al*. 2018) [4]. The higher nitrogen content in the grain could be due to the fact that higher nitrogen uptake facilitated more storage of nitrogen at booting stage which was used for resupply at the grain filling stage. The analogous results were reported by Montemurro *et al.* (2007) [10].

Correspondingly, NPK fertilizer grades had significantly influenced the phosphorous content and uptake in paddy straw and grain. The maximum level of P content and uptake were found in super-optimal dose treatment T_7 (0.47 and 0.39%, respectively and 24.08 and 43.76 kg ha^{-1}, respectively) followed by T_8 (0.43 and 0.35%, respectively and 16.17 and 22.78 kg ha^{-1}, respectively) at harvest, respectively with the application of fertilizers at the rate of 90:46:45 (ratio of 2:1:1) and 121:23:60 (ratio of 6:1:3) kg per acre NPK, respectively.

The Diminutive value of P content and uptake were found in absolute control (0.21 and 0.20%, respectively, and 5.39 and 5.96 kg ha^{-1}, respectively) followed by sub-optimal dose treatment T_3 (0.27 and 0.24%, respectively and 8.45 and 9.77 kg ha^{-1}, respectively) at harvest, respectively. Rest of treatments were on par with each other. The increased phosphorous content at all the growth period of crop and in grain at T_7 might be due to balanced nutrition (2:1:1 NPK ratio) with synergetic interaction among macronutrients and optimal supply of P, activates physiological process which resulted in better root growth, thus leading to the higher absorption of nutrients. The results are toeing the line with findings of Dong *et al*. (2012) [7] and Baishya *et al*. (2015) [2].

The potassium content and uptake in the straw and grain of paddy were outrageously influenced by the different NPK fertilizer levels. Potassium content and uptake has found to be premier in super-optimal dose treatment T_7 (0.97 and 0.49% respectively and 24.72 and 49.11 kg ha^{-1}, respectively) followed by high super-optimal dose of NPK in T_9 with the content of 0.92 and 0.45%, respectively but highest uptake was noticed with 20.67 and 52.09 kg ha^{-1}, respectively) and also T_8 (0.90 and 0.47%, respectively and 21.72 and 47.67 kg ha^{-1}, respectively) at harvest, with the potassium application at the rate of 45, 60 and 60 kg per acre respectively. The lowermost potassium content was found in the absolute control which was followed by sub-optimal dose treatment T_3 (0.69 and 0.33%, respectively and 11.62 and 24.96 kg ha^{-1}, respectively) and also in T_4(0.71 and 0.35%, respectively and 12.96 and 27.35 kg ha^{-1}, respectively). Further, remaining treatments were on par with each other in both grain and straw. The reason for the higher content of potassium in T_7 at all the growth stage and in grain might be due to the fact that balanced nutrition (2:1:1 NPK ratio) and synergetic effect of macronutrients allowed higher uptake of the

potassium. These results were corroborated with the findings of Wilson 1993 [12] and Bijay Singh. (2018) [5].

Incidence of pest and diseases in paddy

The data on insect pest and disease *viz*., leaf folder, case worm, stem borer, gundhi bug, brown leaf spot, narrow leaf spot and sheath rot of paddy as influenced by fertilizer levels recorded at different growth stages (Table 20, 21 and 22)

The incidence of leaf folder in paddy was started at 30 DAT which was influenced portentously by the NPK fertilizer levels. The premier leaf folder incidence was found in super-optimal dose treatment T_9 (9.44%) followed by T_8 (8.65%) and T_7 (8.11%) with the application of NPK at the rate of 169:23:60, 121:23:60 and 90:46:45 kg per acre NPK, respectively. Expressively nethermost incidence of leaf folder was found in sub-optimal dose treatment T_4 (5.85%) followed by RPP treatment T_2 (6.10%) with the application of NPK at the rate of 27:12.5:15 and 40:20:20 kg per acre, respectively which could be attributed to high nitrogen application led to synthesis high protein intern prolonged vegetative growth attracted leaf folder with dense leaf

Correspondingly, caseworm population found to infest the paddy at 30 DAT and expressively influenced with different dose of NPK fertilizer application. The lowermost incidence of leaf folder was noted in sub-optimal dose T_4 (14.75%) followed by recommended dose T_2 (15.8%) with the application of NPK at the rate of 27:12.5:15 and 40:20:20 kg per acre NPK, respectively. The highest incidence was found in super- optimal dose treatments T_9 (29.65%), T_8 (26.93%) and T_7 (23.83%) with the application of NPK at the rate of 169:23:60, 121:23:60 and 90:46:45 kg per acre, respectively. On the other hand, rest of the treatments were found to be on par with each other (T_1, T_3, T_5 and T_6). Due to greenish robust with congenial condition might have attracted the caseworm at the early stage to lay their eggs. Super optimal dose treatments T_9 (24.33%), T_8 (21.70%) and T_7 (21.66%) documented significantly high infestation of stem borer due to prolonged vegetation with high plant height attracted the stem borer even at 85 to 100 days of transplanting and less phosphorous and potassium content (dilution) with NPK application at the rate of 169:23:60, 121:23:60, and 90:46:45 kg per acre respectively and its invasion was taken place after 85 DAT. Auxiliary, the lowermost incidence of stem borer was found in sub-optimal dose treatment T_4 (12.08%) and in RPP treatment T_2 (12.51%). Conversely, other treatments were on par with each other.

Correspondingly, gundhi bug incursion was also started invading after 85 DAT which was significantly varied with different dose of NPK fertilizer. The highest incidence was found in all super optimal dose treatments *viz*., T_9 (13.97%) , T_8 (12.38%) and T_7 (12.21%) with the application of NPK at the rate of 169:23:60, 121:23:60, and 90:46:45 kg per acre NPK, respectively. The bottommost incidence of gundhi bug was found in sub-optimal dose treatment T_4 (7.35) followed by RPP dose treatment T_2 (8.54) with the application of NPK at the rate of 27:12.5:15 and 40:20:20 kg per acre, respectively. The infestation of gundhi bug was imbalanced nutrition of phosphorous and potassium which actually act as a barrier in attracting to its grains (Table 1)

The infestation of brown leaf spot disease of paddy was logged after 85 DAT and inclined significantly by the sub-, super-, and optimal dose treatments. The lowermost incidence of brown leaf spot was found in sub-optimal dose treatment T_4 (4.61%) followed by T_2 (4.65%) with the application of NPK at the rate of 27:12.5: 15 and 40:20:20kg per acre, respectively. The highest incidence was found in all super optimal dose treatments T_9 (11.16%) followed by T_8 (9.41%) and T_7 (8.36%) with the application NPK at the rate of 169:23:60, 121:23:60, and 90:46:45 kg per acre, respectively. Leaf spot invading dominated in later stages of the paddy might be less micronutrient supply and also decreased pest and diseases resistance offered by the crop.

The paddy crop disease incidence of narrow leaf spot was noticed at 85 DAT and was influenced significantly by the different NPK fertilizer levels. The highest incidence was found in all super optimal dose treatments T_9 (7.27%), T_8 (6.13%) and T_7 (5.62%) with the application NPK at the rate of 169:23:60, 121:23:60, and 90:46:45 kg per acre, respectively. The nethermost incidence of narrow leaf spot was found in optimal dose T_6 (3.30%) followed by recommended package of practice treatment T_2 (3.46%) with the application of NPK at the rate of 65:23:40 and 40:20:20 kg per acre, respectively. Other treatments found to be on par with each other. The incidence of sheath rot of paddy was influenced significantly by the NPK fertilizer levels. The lowest incidence of sheath rot of paddy was found in optimal dose treatments T_4 (4.06%) followed by RPP treatment T_2 (4.07%) with the application of NPK at the rate of 40:20:20 and 27:12.5:15 kg per acre, respectively. The uppermost incidence was found in all super optimal dose treatments T_9 (12.22%) T_8 (9.53%) and T_7 (7.91%) with the application of NPK at the rate of 169:23:60, 121:23:60 and 90:46:45 kg per acre, respectively.

The N content in the paddy plant significantly influenced the insect pest and disease infestation. Significantly higher insect pest and diseases were recorded in the treatment which received high nitrogen levels *viz*., T_9 (169 N kg per acre), T_8 (121 N kg per acre) and T_7 (90 N kg per acre) which are super optimal doses. The higher application of nitrogen leads to profuse plant growth thereby mutual shades which reduces the photosynthesis of plant. This creates imbalance nitrogen to carbohydrate ratio which leads to accumulation of soluble nitrogen which may be responsible for ammonium toxicity in plant. Auxiliary, this might have led to augmented vulnerability of crop to pest and disease incidence (Supriya *et al*., 2009) [11].

With the intensification concentration of potassium and phosphorous in plant has a positive correlation on insect pest and disease invasion but found to be non-significant (Table 5). It was pragmatic that with the improved nitrogen content had a significant effect on vegetative growth of the crop. The active vegetative growth might have created favourable environment for insect pest and disease incursion. The higher disease and insect pest influx might be due to high amount of nitrogen application with imbalanced P and K which lacks definite recommended ratio of NPK (2:1:1). This might have prolonged vegetative phase that gave enough time for insect pest and disease attack. According to Supriya *et al.* (2009) [11], higher dose of NPK prolonged the vegetative period but potassium and phosphorous had no significant effect on duration of crop.

Leaf folder and case worm infestation correlated with NPK content of paddy on 30 DAT, brown leaf spot and narrow leaf spot of paddy was correlated with NPK content on 60 DAT, whereas, stem borer, gundhi bug and sheath rot infestation were correlated with NPK content of paddy at 90 DAT. Correlation with 30, 60 and 90 DAT NPK content was obtainable in Table.5. The insect pest and disease infestation with plant NPK content were found that nitrogen significantly influenced pest attack but phosphorous and potassium were found to be positive interaction but non-significant except for narrow leaf spot incidence. With the increase dose of nitrogen levels induced the

susceptibility of rice to pathogen. The increase in infestation of narrow leaf spot of paddy with the increased phosphorous might be due to congenial environment condition for narrow leaf spot infestation. Plant susceptibility to pathogen infection controlled by environmental condition (Hua, 2013) [8].

Conclusion

The farmers practicing imbalanced nutrition in paddy cultivation are inviting more devasting pest and disease. They may also loose the quality of the produce with either under or high application of NPK fertilizer.

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