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Optimization of fertilizer doses for desired yield targets of hybrid brinjal under IPNS by targeted yield model

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Abstract

Managing soil fertility is crucial in increasing crop productivity and improving nutritional security, while maintaining soil health and environmental quality. Fertilizer use play a key role to mitigate nutrient mining in soil and therefore, usage of Fertilizer inputs should be based on crop response to applied nutrients for various soil types. At this moment, Soil Test Crop Response based Integrated Plant Nutrition System (STCR-IPNS) has got a predominant role in managing demand driven nutrient supply to crops for enhanced yield, Fertilizer use efficiency and profitability to farmers. Nomograms for a range of soil test values under NPK alone and under IPNS for the desired yield target of hybrid brinjal are formulated using the above FPEs. When Fertilizer N, P_2O_5 and K_2O was applied along with FYM @ 25 t ha^{-1}, the extent of saving was 72, 40 and 58 kg of Fertilizer N, P_2O_5 and K_2O, respectively for hybrid brinjal resulting in economy of Fertilizer use under IPNS. Using nomograms, critical soil test values for available N, P and K were fixed for varying yield targets both under NPK alone and IPNS.

Keywords: STCR-IPNS; Hybrid Brinjal; Fertilizer Use Efficiency

1. Introduction

Soil test based application of plant nutrients helps to realise higher response ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrient imbalance in soil helps to harness the synergistic effects of balanced fertilization-Subba Rao and Srivastava, 2001. Location specific Fertilizer recommendations are possible for soils of varying fertility, resource conditions of farmers and levels of targeted yield for similar soil type and environment (Ahmed et al., 2002; Bera et al., 2006). Hence, it is necessary to have information on the optimum doses of Fertilizers and organic manures based on soil testing, nutrient uptake and efficiency of added nutrients by the crop to develop a guideline for judicious application of Fertilizers under Integrated Plant Nutrition System (IPNS).

2. Material and methods

Treatment structure and experimental design as followed in AICRP - STCR was adopted. Treatment structure was designed in such a way that yield- prediction and optimisation of Fertilizer doses could be made by targeted yield model. Treatment combinations and the levels of N, P2O5 and K2O and farm yard manure (FYM) are furnished in Fig 1. In test crop experiment, there were four levels of N, four levels of P2O5 and four levels of K2O. For N, there were four treatments at zero level, four at first level (80 kg N ha^{-1}), nine at second level (160 kg ha^{-1}), and seven at third level (240 kg N ha^{-1}). For P2O5, there were four treatments at zero level, five at first level (40 kg P2O5 ha^{-1}), ten at second level (80 kg P2O5 kg ha^{-1}) and five at third level (120 kg P2O5 ha^{-1}). For K2O, there were four treatments at zero level, seven

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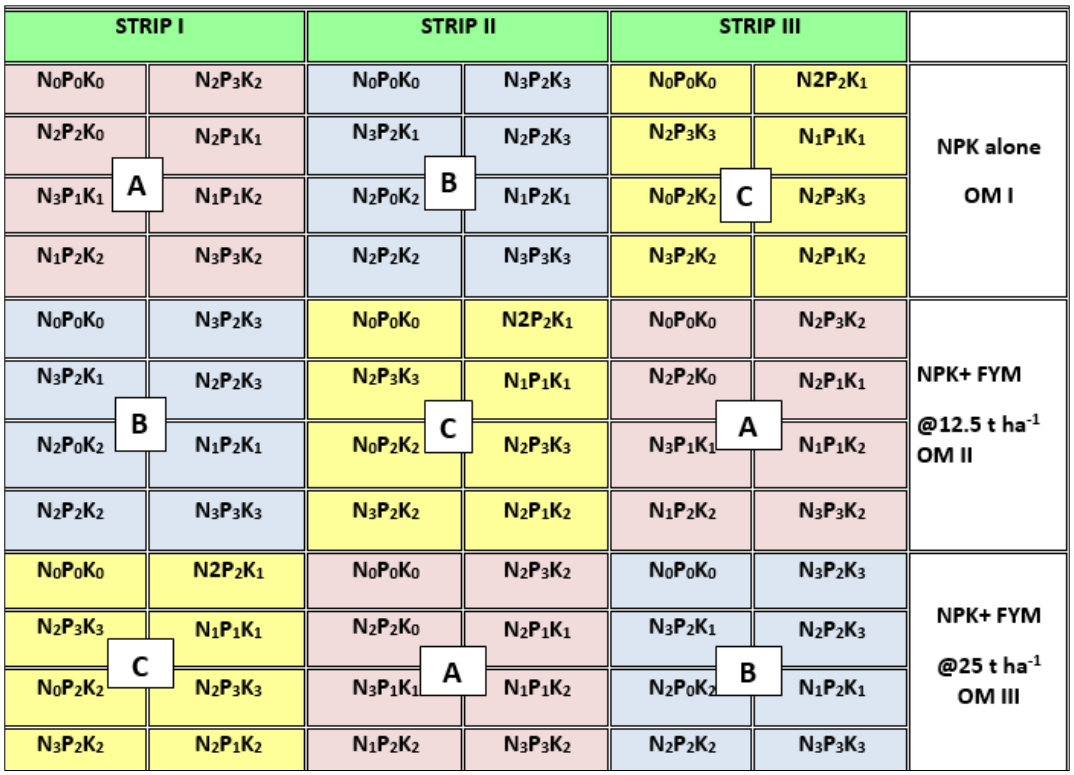
at first level (60 kg K2O ha^{-1}), nine treatments at second level (120 kg K2O ha^{-1}) and four treatments at third level (180 kg K2O ha^{-1}). Treatments were chosen so as to compute the response of each nutrient at different levels of application.



Plot size :9 x 3 m; Hybrid Brinjal Spacing: 75 x 55 cm

1. $N_0P_0K_0$	5. $N_1P_1K_1$	9. $N_2P_1K_1$	18. $N_3P_1K_1$
2. $N_0P_0K_0$	6. $N_1P_2K_1$	10. $N_2P_0K_2$	19. $N_3P_2K_1$
3. $N_0P_0K_0$	7. $N_1P_1K_2$	11. $N_2P_1K_2$	20. $N_3P_2K_2$
4. $N_0P_2K_2$	8. $N_1P_2K_2$	12. $N_2P_2K_2$	21. $N_3P_3K_1$
		13. $N2P_2K_1$	22. $N_3P_3K_2$
		14. $N_2P_2K_0$	23. $N_3P_2K_3$
		15. $N_2P_2K_3$	24. $N_3P_3K_3$
		16. $N_2P_3K_2$	
		17. $N_2P_3K_3$	

Figure 1 Layout plan of test crop experiment with hybrid brinjal

IPNS treatments *viz*., NPK alone, NPK plus FYM @ 12.5 and 25t ha^{-1} were superimposed across strips. There were 21 Fertilizer treatments along with three controls which were randomized in each strip in such a way that all treatments occurred in both directions and Fractional Factorial Randomized Block Design was adopted. With a view to provide balanced Fertilizer recommendations through inorganic and organic sources of nutrients, the soil testing research should be in the direction to accomplish the soil test values for desired yield targets of crops. Therefore, in the present investigation, Soil Test Crop Response based Fertilizer prescription equations were developed for hybrid brinjal under IPNS using the basic parameters (NR, Cs, Cf and Cfym) and discussed below:

Fertilizer prescription equations under

STCR-IPNS (NPK+FYM)

$$FN = 0.75\ T - 0.93\ SN - 0.53\ ON$$

$$FP_2O_5 = 0.34\ T - 2.97\ SP - 0.83\ OP$$

$$FK_2O = 0.55\ T - 0.68\ SK - 0.51\ OK$$

where, FN, FP_2O_5 and FK_2O are Fertilizer N, P_2O_5 and K_2O in kg ha^{-1} respectively; T is the fruit yield target in q ha-1; SN, SP, SK respectively are alkaline $KMnO_4$-N,Olsen-P and NH_4OAc-K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K in kg ha^{-1} supplied through FYM.

3. Results and discussion

3.1. Contribution of nutrients from FYM for hybrid brinjal (Fig.2)

FYM improves soil physical properties *viz*., soil structure, water holding capacity, aggregation and better environment for root development; chemical properties *viz.*, nutrient exchange,available nutrient status and organic carbon etc; biological properties *viz.*, microbial population, enzymatic activities *etc*. Further, FYM acts directly by increasing the fruit yield either by accelerating the respiratory process through cell permeability or by hormone growth action. Therefore, to assess the extent to which the Fertilizer requirements of hybrid brinjal can be reduced under IPNS, the contribution of nutrients from FYM is to be quantified. Accordingly, in the present investigation, the fourth basic parameter for the targeted yield model, the per cent contribution of N, from FYM (Cfym) was computed.

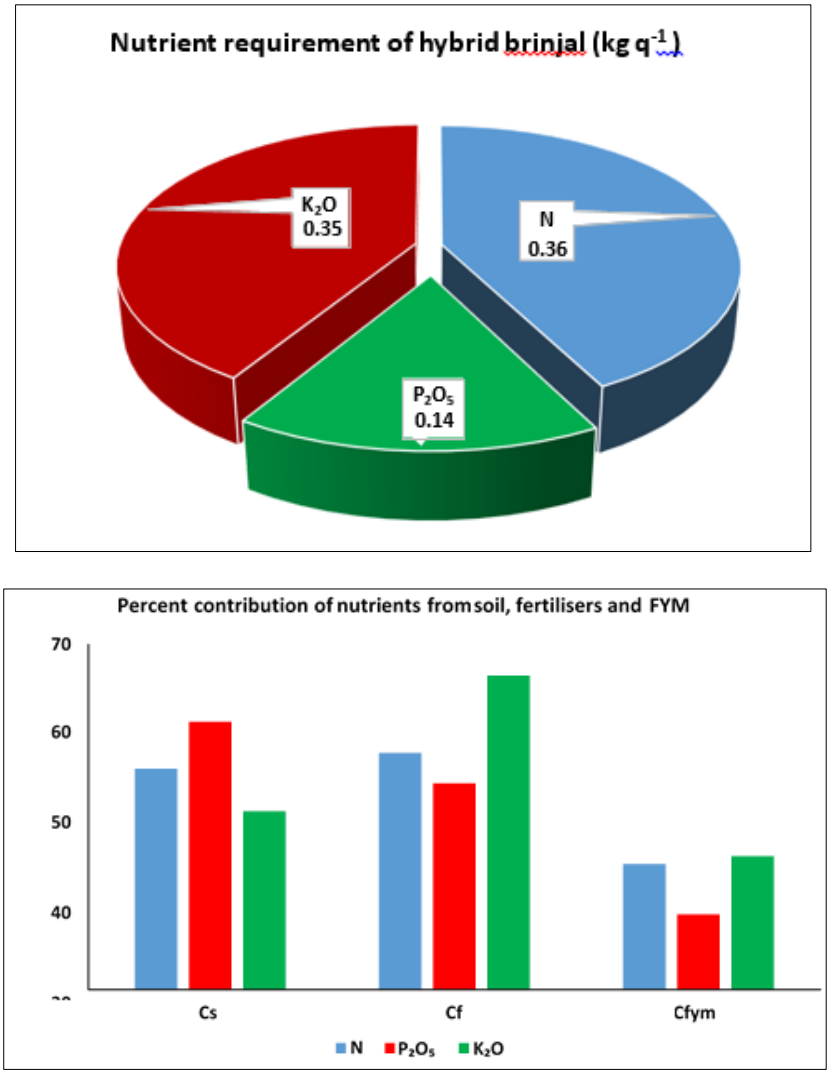


Figure 2 Optimisation of nutrient requirements for hybrid brinjal

The estimated per cent contribution of N, P_2O_5 and K_2O from FYM was 25.51, 15.25 and 27.03, respectively for hybrid brinjal which indicated that relatively higher contribution was recorded for K_2O followed by N and P_2O_5. Similar trend of result for contribution from FYM was also reported by Beena *et al.* (2018) for brinjal.

3.2. Soil test based Fertilizer prescriptions through IPNS (Fig.3)

With a view to provide balanced Fertilizer recommendations through inorganic and organic sources of nutrients, the soil testing research should be in the direction to accomplish the soil test values for desired yield targets of crops. Therefore, in the present investigation, Soil Test Crop Response based Fertilizer prescription equations were developed for hybrid brinjal under IPNS using the basic parameters (NR, Cs, Cf and Cfym) and discussed below:

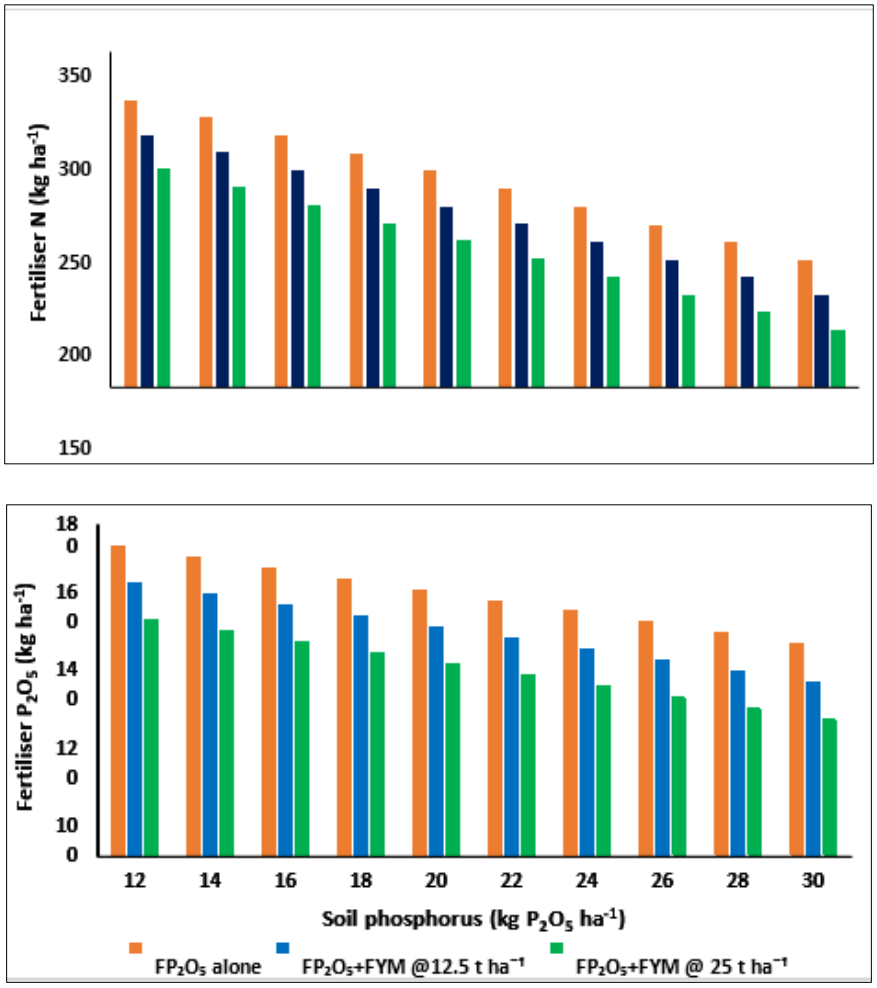
Fertilizer prescription equations under STCR-IPNS (NPK+FYM)

$$FN = 0.75\ T - 0.93\ SN - 0.53\ ON$$

$$FP2O5 = 0.34\ T - 2.97\ SP - 0.83\ OP$$

$$FK2O = 0.55\ T - 0.68\ SK - 0.51\ OK$$

where, FN, FP_2O_5 and FK_2O are Fertilizer N, P_2O_5 and K_2O in kg ha^{-1} respectively; T is the fruit yield target in q ha^{-1}; SN, SP, SK respectively are alkaline $KMnO_4$-N,Olsen-P and NH_4OAc-K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K in kg ha^{-1} supplied through FYM.



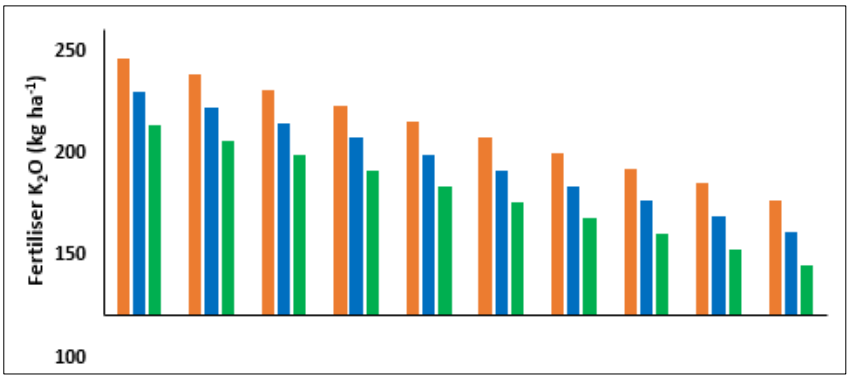


Figure 3 Soil test based Fertilizer doses for 60 t ha^{-1} yield target of hybridbrinjal under IPNS

These Fertilizer prescription equations would serve as a basis to prescribe the actual quantities of Fertilizer doses under IPNS when FYM was applied along with N, P and K Fertilizers. Fertilizer prescription equations for brinjal under Integrated Plant Nutrition System were reported by Basavaraja *et al.* (2012) for Karnataka, Kadu *et al.* (2012) for Maharashtra (Dey and Das.2014) for Rajasthan and Beena *et al.* (2018) for Ultisol of Kerala.

Ready reckoners (nomograms) were formulated for a range of soil test values and for desired yield target of hybrid brinjal under NPK alone and IPNS (NPK +FYM). An assessment of the estimates showed that when NPK alone was applied, for a soil test value of 220:26:240 kg ha^{-1} of available N, P and K respectively, the Fertilizer N, P_2O_5 and K_2O doses required to achieve a desired yield target of 50, 55 and 60 t ha^{-1} were 169, 93 and 113 kg ha^{-1}; 206, 110 and 141 kg ha^{-1} and 243, 127 and 169 kg ha^{-1} respectively. Whereas the Fertilizer N, P_2O_5 and K_2O doses required when FYM @ 12.5 t ha^{-1} was applied along with NPK were 132, 72 and 84 kg ha^{-1}; 170, 89 and 112 kg ha^{-1} and 207, 106 and 140 kg ha^{-1} respectively for 50, 55 and 60 t ha^{-1}. Similarly, when FYM @ 25 t ha^{-1} was applied along with NPK, the required Fertilizer doses were 100:52:75 kg ha^{-1}; 133, 70 and 83 kg ha^{-1} and 171, 87 and 111 kg ha^{-1}, respectively for 50, 55 and 60 t ha^{-1}.

The nomograms clearly revealed that with increase in yield target, there was a proportionate increase in Fertilizer doses for similar soil test values. Further, with increase insoil test values, there was a concomitant decrease in Fertilizer doses (Table 1,2 and 3). For example, in the present investigation, it has been found that for every increase in 20 kg available N, there was a reduction of 19 kg Fertilizer N; for every 2 kg increase in available P, the reduction was 6 kg Fertilizer P2O5 and for every increase in 20 kg available K, the decline was 14 kg Fertilizer K2O under both NPK alone and IPNS situations.

Table 1 Soil test based Fertilizer N for desired yield target of hybrid brinjal under NPK alone and IPNS

KMnO4-N (kg ha-1)	**Fertilizer doses (kg ha-1)**				
	NPK alone	**NPK+ FYM @ 12.5 tha-1**	**Per cent reduction**	**NPK+ FYM @ 25 t ha-1**	**Per cent reduction**
50 t ha-1					
160	225	188	16.4	151	32.9
180	206	170	17.5	132	35.9
200	187	151	19.3	114	39.0
220	169	132	21.9	100*	43.8
240	150	114	24.0	100*	49.3
260	131	100*	23.7	100*	55.7
280	113	100*	11.5	100*	55.8
300	100*	100*	0.0	100*	50.0

320	100*	100*	0.0	100*	50.0
340	100*	100*	0.0	100*	50.0
55 t ha-1					
160	262	226	13.7	189	27.9
180	243	207	14.8	171	29.6
200	225	188	16.4	152	32.4
220	206	170	17.5	133	35.4
240	187	151	19.3	115	38.5
260	169	132	21.9	100*	43.2
280	150	114	24.0	100*	48.7
300	131	100*	23.7	100*	55.0
320	113	100*	11.5	100*	55.8
340	100*	100*	0.0	100*	50.0
60 t ha-1					
160	299	263	12.0	227	24.1
180	281	244	13.2	208	26.0
200	262	226	13.7	189	27.9
220	243	207	14.8	171	29.6
240	225	188	16.4	152	32.4
260	206	170	17.5	133	35.4
280	187	151	19.3	115	38.5
300	169	132	21.9	100*	43.2
320	150	114	24.0	100*	48.7
340	131	100*	23.7	100*	55.0

NB: Blanket dose: 200 kg ha-1 of Fertilizer N; *Maintenance dose (50 per cent of the blanket dose)

**Maximum dose (150 per cent of the blanket dose)).

Table 2 Soil test based Fertilizer P_2O_5 for desired yield target of hybrid brinjal under NPK alone and IPNS

Olsen-P (kg ha^{-1})	**Fertilizer doses (kg ha^{-1})**				
	NPK alone	**NPK+ FYM @ 12.5 tha^{-1}**	**Per cent reduction**	**NPK+ FYM @ 25 t ha^{-1}**	**Per cent reduction**
50 t ha^{-1}					
12	134	114	14.9	94	29.9
14	128	108	15.6	88	31.3
16	122	102	16.4	82	32.8
18	116	96	17.2	76	34.5
20	110	90	18.2	70	36.4
22	105	84	20.0	64	39.0

24	99	78	21.2	58	41.4
26	93	72	22.6	52	44.1
28	87	66	24.1	50*	47.1
30	81	61	24.7	50*	50.6
55 t ha^{-1}					
12	150	131	13.2	111	26.5
14	145	125	13.8	105	27.6
16	139	119	14.4	99	28.8
18	133	113	15.0	93	30.1
20	127	107	15.7	87	31.5
22	122	101	17.2	82	33.6
24	116	95	18.1	76	35.3
26	110	89	19.1	70	37.3
28	104	83	20.2	64	39.4
30	98	77	21.4	58	41.8
60 t ha^{-1}					
12	150**	148	1.3	128	14.7
14	150**	142	5.3	122	18.7
16	150**	136	9.3	116	22.7
18	150	130	13.3	110	26.7
20	144	124	13.9	104	27.8
22	138	118	14.5	98	29.0
24	133	112	15.8	93	30.8
26	127	106	16.5	87	32.3
28	121	100	17.4	81	33.9
30	115	94	18.3	75	35.7

NB: Blanket dose: 100 kg ha-1 of Fertilizer P_2O_5; *Maintenance dose (50 per cent of the blanket dose);

**Maximum dose (150 per cent of the blanket dose)).

Table 3 Soil test based Fertilizer K_2O for desired yield target of hybrid brinjal under NPK alone and IPNS

NH4OAc-K (kg ha-1)			**Fertilizer doses (kg ha-1)**		
	NPK alone	**NPK+ FYM @ 12.5 tha-1**	**Per cent reduction**	**NPK+ FYM @ 25 t ha-1**	**Per cent reduction**
50 t ha-1					
160	168	139	17.3	110	34.5
180	154	125	18.8	97	37.0
200	140	111	20.0	83	40.7
220	127	98	22.8	75*	45.7

240	113	84	25.7	75*	50.4
260	99	75*	24.2	75*	57.6
280	86	75*	12.8	75*	56.4
300	75*	75*	0.0	75*	50.0
320	75*	75*	0.0	75*	50.0
340	75*	75*	0.0	75*	50.0
55 t ha-1					
160	196	167	14.8	138	29.6
180	182	153	15.9	125	31.3
200	168	139	16.7	111	33.9
220	155	126	18.7	97	37.4
240	141	112	20.6	83	41.1
260	127	98	22.8	75*	44.9
280	113	84	24.8	75*	50.4
300	100	75*	25.0	75*	58.0
320	86	75*	12.8	75*	56.4
340	75	75*	0.0	75*	50.0
60 t ha-1					
160	223	195	12.6	166	25.6
180	210	181	13.8	152	27.6
200	196	167	14.8	139	29.1
220	182	154	15.4	125	31.3
240	169	140	17.2	111	34.3
260	155	126	18.7	98	36.8
280	141	112	20.6	84	40.4
300	127	99	22.0	75*	44.9
320	114	85	25.4	75*	50.9
340	100	75*	25.0	75*	57.0

(NB: Blanket dose: 150 kg ha-1 of Fertilizer K_2O;*Maintenance dose (50 per cent of the blanket dose);

**Maximum dose (150 per cent of the blanket dose).

The application of inorganic Fertilizers along with FYM resulted in prominent reduction in Fertilizer requirement for hybrid brinjal. The saving of inorganic Fertilizers for the application of FYM @ 12.5 t ha^{-1} (with 25 per cent moisture and 0.73, 0.26 and 0.60 % of N, P and K respectively) was 36, 20 and 29 kg of Fertilizer N, P_2O_5 and K_2O respectively. If FYM @ 25 t ha^{-1} was applied, the savings were 72, 40 and 58 kg of Fertilizer N, P2O5 and K2O respectively.

The per cent reduction in N, P and K Fertilizers under IPNS also increased with increasing soil fertility levels with reference to N, P and K and decreased with increase in yield targets. Similar trend of results were reported by Santhi *et al.* (2011) for beetroot on Alfisol, Coumaravel (2012) for tomato, Muralidharudu *et al.* (2012), Dhinesh and Santhi (2016) for brinjal on Alfisol, Udaykumar and Santhi (2017) for pearl millet and Suresh and Santhi (2018) for maize.

4. Conclusion

With increasing soil available NPK status, the reduction in NPK Fertilizers under IPNS also increased and with an increase in yield targets decreased. Nomograms clearly revealed that with increase in yield target, there was a proportionate increase in Fertilizer doses for similar soil test values. Further, with increase in soil test values, there was a concomitant decrease in Fertilizer doses. Efficient use of applied nutrients was exhibited spectacularly under IPNS over NPK alone irrespective of yield targets of hybrid brinjal. Extent of saving of inorganic Fertilizers for brinjal with the application of FYM @ 12.5 t ha^{-1} (with 25 per cent moisture and 0.73, 0.26 and 0.60 % of N, P and K respectively) was 36, 20 and 29 kg of Fertilizer N, P_2O_5 and K_2O respectively. If FYM @ 25 t ha^{-1} was applied, the savings were 72, 40 and 58 kg of Fertilizer N, P_2O_5 and K_2O respectively.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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