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INTEGRATED NUTRIENT MANAGEMENT AND METHOD OF APPLICATION ON NUTRIENT UPTAKE, MICROBIAL POPULATION AND DIFFERENT EFFICIENCIES IN RAINFED DIRECT SOWN FINGER MILLET *(ELEUSINE CORACANA L. GAERTN.)*

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ABSTRACT
A field experiment was conducted during North East Monsoon (NEM) at Tamil Nadu Agricultural University, Coimbatore to study the influence of integrated nutrient management and method of application on nutrient uptake, microbial population and different efficiencies in rainfed direct sown finger millet (*Eleusine coracana L. Gaertn.*). The experiment was laid out in randomized block design with thirteen treatments replicated thrice. The results revealed that the higher nutrient (NPK) uptake was observed under broad casting enriched FYM 4 t ha^{-1} + 100 % recommended N and K at all the stages of observation *viz.*, 30 DAS, 60 DAS and at harvest. This was on par with band placement of enriched FYM 2 t ha^{-1} + 100% recommended N and K and band placement of 2 t FYM ha^{-1} + 100% recommended dose of NPK. Regarding finger millet yield, the band placement of enriched farm yard manure (enriched FYM) 2.0 t ha^{-1} with 100% recommended N and K recorded higher grain yield. The different efficiencies *viz.*, agronomic efficiency (AE), physiological efficiency (PE) and nutrient use efficiency (NUE) of finger millet at different stages were influenced by the treatment practices. But the results showed an inconsistent pattern among the treatments. Whereas, the higher NUE was observed under band placement of enriched FYM 2 t ha^{-1} with 100 percent recommended N and K.

KEYWORDS: Agronomic efficiency, physiological efficiency, nutrient use efficiency, FYM enrichment.

INTRODUCTION

In rainfed condition, the growth and development of crops are risky one because of poor soil fertility, lack of soil moisture and improper nutrient management practices. Finger millet (*Eleusine coracana* L. Gaertn) is best suited crop especially for drought stricken areas. It contains the most important amino acid namely methionine, which is lacking in the diets of hundreds of millions of the poor who live on starchy staples and also a popular food among diabetic patients in the all over world due to its slow digestion indicates low blood sugar level. Finger millet is a good and healthy food during difficult times so, as to be called as "famine crop". Finger millet is one of the important millet crop grown in India and has the pride of place in having highest productivity among millets. In India, it is cultivated in Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Uttaranchal, Maharashtra, and Gujarat. Provision of food to the increasing population is an important task that can be achieved only by boosting the productivity of dryland crops because irrigated lands are fast approaching the limit of their productive potential. In the modern agriculture, use of inorganic fertilizers is important to achieve the food demand of increased population. The use of organic manures was declined due to availability and intensive use of inorganic fertilizers. But continuous inorganic fertilization reduced the built up in organic matter, available N, P and K as well as micronutrient status (Venkatesh Bharadwaj and Omanwar, 1994). On the other hand, use of organic manures can improve the quality of soil. The use of FYM along with chemical fertilizers increased the fertilizer use efficiency and sustained the soil health and productivity of the cropping system as reported by Kaore (2002). Fertilizer placement plays an important role in influencing fertilizer use efficiency especially N and P in such a way that fertilizers are made available to the entire root system. For dry land crops, deep placement of phosphorus will allow better establishment of the crops and consequently better nutrition of the plant and reduced the losses caused by denitrification, volatilization and leaching etc., (Balasubramaniyan and Palaniappan, 2001). Hence to achieve better yield through the sustainable nutrient management, the present study was carried out to investigate the performance of enriched FYM with inorganic fertilizers on nutrient uptake, microbial population and different efficiencies in rainfed direct sown finger millet.

MATERIALS & METHODS

A field experiment was carried out at Tamil Nadu Agricultural University, Coimbatore during NEM to study the effect of integrated nutrient management and method of application on nutrient uptake, microbial population and different efficiencies in rainfed direct sown finger millet (*Eleusine coracana* L. Gaertn.). The soil of experimental field was clay loam in texture, neutral in reaction (P^H 7.8), low in available nitrogen (217.0 kg ha^{-1}), medium in available phosphorus (12.6 kg ha^{-1}) and high in available

potash (330.0 kg ha^{-1}). The experiment was laid out in randomized block design (RBD) with thirteen treatments replicated thrice. The treatments included were: T_1 - Absolute control, T_2 - 50% recommended NPK (20:10:10) alone, T_3 - 100% recommended NPK (40:20:20) alone, T_4 - Broad casting 2.0 t FYM ha^{-1} + 50% recommended levels of NPK, T_5 - Broad casting 2.0 t FYM ha^{-1} + 100% recommended levels of NPK, T_6 - Broad casting enriched FYM 2.0 t ha^{-1} + 50% recommended N and K, T_7 - Broad casting enriched FYM at 2.0 t ha^{-1} + 100% recommended N and K, T_8 - Broad casting 4.0 t FYM ha^{-1} + 50% recommended levels of NPK, T_9 - Broad casting 4.0 t FYM ha^{-1} + 100% recommended levels of NPK, T_{10} - Broad casting enriched FYM at 4.0 t ha^{-1} + 50% recommended N and K, T_{11} - Broad casting enriched FYM at 4 t ha^{-1} + 100% recommended N and K, T_{12} - Band placement of 2.0 t FYM ha^{-1} + 100% recommended levels of NPK and T_{13} - Band placement of enriched FYM at 2.0 t ha^{-1} + 100% of recommended N and K. Enriched farm yard manure was prepared by mixing recommended quantity (as per the treatment) of well decomposed and well sieved FYM with recommended level 20 kg of P_2O_5 per hectare and applied as per the treatments. The FYM and enriched FYM contained 0.50 and 0.71 % N, 0.18 and 0.84 % P_2O_5 and 0.46 and 0.60 % K_2O respectively. The different types of micro- organisms were enumerated using differential media favouring the growth of bacteria, fungi and actinomycetes. The standard serial dilution plating technique was adopted for the estimation of microbial population.

Data on different efficiencies were worked out as follows,

Agronomic efficiency (AE)

The Agronomic efficiency i.e., the yield response per unit input as indicated by kg of grain per kg of nutrients was computed for N, P and K by using the following formula,

$$\text{AE for N or P or K} = \frac{\text{Grain yield in fertilized plot (kg ha}^{-1}\text{)} - \text{Grain yield in unfertilized plot (kg ha}^{-1}\text{)}}{\text{Quantity of nutrient (N or P or K) applied (kg ha}^{-1}\text{)}}$$

Physiological efficiency (PE)

The Physiological efficiency also known as efficiency of utilization as indicated by kg of grain per kg of absorbed nutrients (NPK) were computed using following formula,

$$\text{PE for N} = \frac{\text{Grain yield in fertilized plot (kg ha}^{-1}\text{)} - \text{Grain yield in un fertilized plot (kg ha}^{-1}\text{)}}{\text{N uptake in fertilized plot (kg ha}^{-1}\text{)} - \text{N uptake in un fertilized plot (kg ha}^{-1}\text{)}}$$

In a similar way, Physiological efficiency of P and K were also calculated for each treatment.

Nutrient use efficiency (NUE)

The utilization of applied nutrients (NPK) for each treatment was worked out using the following formula and expressed in percentage.

$$\text{NUE for N} = \frac{\text{N uptake in the treated plot (kg ha}^{-1}\text{)} - \text{N uptake in the control plot (kg ha}^{-1}\text{)}}{\text{Amount of nutrient N applied (kg ha}^{-1}\text{)}} \times 100$$

In a similar way, nutrient use efficiency for P and K were also calculated for each treatment.

RESULTS

Nutrients uptake

The plant nutrient uptake was carried out for three major nutrients (nitrogen, phosphorus and potassium) at the stages *viz.*, 30 DAS, 60 DAS and at harvest.

Nitrogen uptake

The mean data on nitrogen uptake of finger millet was significantly influenced by different treatments (Table 1). At 30 DAS, the nitrogen uptake of finger millet is appreciably influenced by different treatment practices. The highest nitrogen uptake was recorded in band placement of enriched FYM 2t ha^{-1} + 100 % recommended N and K (T_{13}) treatment with value of 35 kg ha^{-1} at 30 DAS. This was next followed by band placement of 2 t FYM ha^{-1} +100 % recommended levels of NPK (T_{12}) with a value of 32 kg ha^{-1} at 30 DAS. Broad casting of enriched FYM 4 t ha^{-1} + 100 percent recommended N and K (T_{11}) recorded higher nitrogen uptake with values of 47 and 64 kg ha^{-1} in 60 DAS and at harvest stage respectively as compared to all other treatments and broad casting 4 t FYM ha^{-1} + 100 percent recommended NPK (T_9) registered high nitrogen uptake with values of 45 and 58 kg ha^{-1} which was significantly on par with T_{12} and T_{13} treatments. In nitrogen uptake, Combination of FYM @ 2 and 4 t ha^{-1} with 50 percent NPK (T_4 and T_8) found superior over 50 percent NPK alone (T_2). The absolute control plot (T_1) registered lowest nitrogen uptake with values of 9, 17 and 31 kg ha^{-1} at 30 DAS, 60 DAS and at harvest stage respectively.

Phosphorus uptake

The data on phosphorus uptake indicated that it was significantly influenced by different treatments (Table 1). The band placement of enriched FYM 2 t ha^{-1} + 100 percent recommended N and K (T_{13}) showed highest phosphorus uptake among all the treatments irrespective of the stages with the values of 3.2 kg ha^{-1} (30 DAS), 15.2 kg ha^{-1} (60 DAS) respectively.

At harvest stage, broad casting of enriched FYM 4 t ha^{-1} + 100 % recommended N and K (T_{11}) registered higher phosphorus uptake with value of 20.9 kg ha^{-1} and which was on par with band placement of 2 t FYM ha^{-1} + 100 % recommended dose of NPK (T_{12}) with value of 20.8. As compared to 50 percent NPK alone (T_2), combined application of both 2 and 4 t FYM ha^{-1} + 50% NPK treatments performed better with regard to phosphorus uptake. The absolute control (T_1) recorded lowest phosphorus uptake with the values of 0.8, 7.1and 14.7 kg ha^{-1} at 30 DAS, 60 DAS and at harvest stage respectively.

Potassium uptake

Significantly highest potassium uptake was obtained with broad casting enriched FYM 4t ha^{-1} +100 % recommended N and K (T_{11}) with values of 13.2, 35.4 and 55.5 kg ha^{-1} at all the stages of observation and this was on par with band placement of enriched FYM 2t ha^{-1} + 100 % recommended N and K (T_{13}) and band placement of 2 t FYM ha^{-1} + 100 % recommended dose of NPK (T_{12}) at all the stages with values of 13.1 kg ha^{-1} (30 DAS), 35.3 kg ha^{-1} (60 DAS), 51.2 kg ha^{-1} (at harvest) and 13.0 kg ha^{-1} (30 DAS), 35.2 kg ha^{-1} (60 DAS) and 55.8 kg ha^{-1} (at harvest) respectively.

Combination of FYM @ 2 and 4 t ha^{-1} with 50 % NPK (T_4 and T_8) enhanced potassium uptake as compared to 50 percent NPK alone (T_2).The lowest Potassium uptake was obtained at all the stages in absolute control (T_1) with values of 8.1 kg ha^{-1}, 22.4 kg ha^{-1} and 37.9 kg ha^{-1} at respective stages (Table 1).

TABLE 1. Influence of INM and its method of application on nutrient uptake (kg ha^{-1}) of finger millet

Treatments	Nitrogen			Phosphorus			Potassium		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1 - Absolute control	9	17	31	0.8	7.1	14.7	8.1	22.4	37.9
T_2 - 50% recommended NPK (20:10:10) alone	14	24	36	1.5	8.2	16.3	8.4	27.7	40.3
T_3- 100% recommended NPK (40:20:20) alone	17	27	43	1.8	9.5	1.4	9.5	29.8	43.6
T_4 - Broad casting 2.0 t FYM ha^{-1} + 50% recommended levels of NPK	16	25	39	1.7	9.1	17.1	9.2	29.2	43.0
T_5 -Broad casting 2.0 t FYM ha^{-1} + 100% recommended levels of NPK	20	33	46	2.1	11.0	19.2	10.1	31.2	45.8
T_6 -Broad casting enriched FYM 2.0 t ha^{-1} + 50% recommended N and K	18	30	44	1.9	10.3	18.7	9.7	30.6	44.5
T_7 - Broad casting enriched FYM at 2.0 t ha^{-1} + 100% recommended N and K	21	36	49	2.2	11.6	19.3	10.3	31.9	48.9
T_8 -Broad casting 4.0 t FYM ha^{-1} + 50% recommended levels of NPK	22	39	50	2.3	12.2	19.4	10.6	33.3	49.1
T_9 -Broad casting 4.0 t FYM ha^{-1} + 100% recommended levels of NPK	27	45	58	2.7	13.1	20.5	11.8	35.2	53.2
T_{10} -Broad casting enriched FYM at 4.0 t ha^{-1} + 50% recommended N and K	24	43	54	2.5	12.5	20.4	11.2	34.1	49.9
T_{11} -Broad casting enriched FYM at 4 t ha^{-1} + 100% recommended N and K	30	47	64	3.0	14.8	20.9	13.2	35.4	55.5
T_{12} -Band placement of 2.0 t FYM ha^{-1} + 100% recommended levels of NPK	32	44	57	3.1	14.0	20.8	3.0	35.2	49.6
T_{13} -Band placement of enriched FYM at 2.0 t ha^{-1} + 100% of recommended N and K	35	45	60	3.2	15.2	20.5	13.1	35.3	51.2
SEd	1.15	1.69	1.39	0.28	0.45	0.44	0.41	0.94	0.47
CD(P=0.05)	2.37	3.49	2.88	0.59	0.93	0.92	0.85	1.95	0.96

MICROBIAL POPULATION

The microbial population *viz.*, bacteria, fungi and actinomycetes were estimated both in initial soil and in the soil after harvest stages.

Bacteria (10^6 g^{-1} dry soil)

The initial population of bacteria was ranged from 6.3 x 10^6 g^{-1} dry soil to 8.8 x 10^6 g^{-1} dry soil among the treatments (Table 2). The population was highest (40.1 x 10^6 g^{-1} dry soil) in the band placement of enriched FYM 2 t ha^{-1} + 100 percent recommended N and K (T_{13}) at the time of harvest. This was followed by broad casting of enriched FYM 4 t ha^{-1} + 100 percent recommended N and K (T_{11}) with value of 39.6 x 10^6 g^{-1} dry soil and band placement of 2 t FYM ha^{-1} + 100 percent recommended dose of NPK (T_{12}) with value of 37.7 x 10^6 g^{-1} dry soil. Broad casting of FYM 4 t ha^{-1} + 100 % recommended NPK (T_9) noticed more population of bacteria as compared to all other treatments except T_{13} and T_{12} and T_{11} treatments. The lowest population (7.2 x 10^6 g^{-1} dry soil) was recorded in the absolute control (T_1).

Fungi (10^3 g^{-1} dry soil)

The population of fungi at the initial stage was not varied much among the different treatments (Table 2). However it ranges from 5.0 to 6.6 x 10^3 g^{-1} dry soil among the different treatments. At harvest, the higher fungal population (17.9 x 10^3 g^{-1} dry soil) was recorded in the band placement of enriched FYM 2 t ha^{-1} + 100 % recommended N and K (T_{13}). This was followed by T_{11}

(16.8 x 10^3 g^{-1} dry soil). The least population of fungi (5.8 x 10^3 g^{-1} dry soil) was recorded in absolute control (T_1). Band placement of 2 t FYM ha^{-1} + 100 % recommended dose of NPK (T_{12}) showed higher fungal population (14.4 x 10^3 g^{-1} dry soil) as compared to all other broad casting treatments except T_{11}. As compared to 50 % alone (T_2), combined application of both 2 and 4 t FYM ha^{-1} + 50 percent NPK treatments pronounced better with regard to fungal population.

Actinomycetes (10^4 g^{-1} dry soil)

The actinomycetes population was also not varied among the different treatments at initial stage (Table 2). However it ranges from 2.8 to 4.3 x 10^4 g^{-1} dry soil. But the actinomycetes population of the post harvest soils differed significantly with reference to each treatment. The actinomycetes population ranged from 3.4 x 10^4 to 11.6 x 10^4 g^{-1} dry soil. The highest actinomycetes population (11.6 x 10^4 g^{-1} dry soil) was recorded in band placement of enriched FYM 2 t ha^{-1} + 100%recommended N and K (T_{13}) treatment at harvest stage. This was followed by broad casting of enriched FYM 4 t ha^{-1} + 100 percent recommended N and K (T_{11}) and band placement of 2 t FYM ha^{-1} + 100 % recommended dose of NPK (T_{12}) with values of 10.8 and 10.5 x $10^4 g^{-1}$ dry soil respectively. The lowest actinomycetes population (3.4 x 10^4 g^{-1} dry soil) was recorded in the absolute control (T_1).

TABLE 2. Influence of INM and its method of application on population of bacteria, fungi and actinomycetes of finger millet

Treatments	Initial population g^{-1} of dry soil			Post harvest population g^{-1} of dry soil		
	Bacteria CFU (X 10^6)	Fungi CFU (X 10^3)	Actino -mycetes CFU (X 10^4)	Bacteria CFU (X 10^6)	Fungi CFU (X 10^3)	Actino -mycetes CFU (X 10^4)
T_1 - Absolute control	6.3	5.0	2.8	7.2	5.8	3.4
T_2- 50% recommended NPK (20:10:10) alone	6.5	5.2	2.9	27.4	8.4	5.6
T_3- 100% recommended NPK (40:20:20) alone	6.9	5.5	3.1	29.2	9.6	6.5
T_4 -Broad casting 2.0 t FYM ha^{-1} + 50% recommended levels of NPK	6.8	5.4	3.1	29.7	9.2	6.2
T_5 -Broad casting 2.0 t FYM ha^{-1} + 100% recommended levels of NPK	7.3	5.7	3.4	30.3	10.7	7.7
T_6 - Broad casting enriched FYM 2.0 t ha^{-1} +50% recommended N and K	7.1	5.6	3.2	29.6	10.3	7.0
T_7 - Broad casting enriched FYM at 2.0 t ha^{-1} + 100% recommended N and K	7.5	5.9	3.5	31.5	11.2	8.2
T_8 - Broad casting 4.0 t FYM ha^{-1} + 50% recommended levels of NPK	7.6	6.0	3.6	32.9	11.9	8.6
T_9 - Broad casting 4.0 t FYM ha^{-1} + 100% recommended levels of NPK	8.0	6.3	3.9	34.8	13.5	9.7
T_{10} -Broad casting enriched FYM at 4.0 t ha^{-1} + 50% recommended N and K	7.8	6.1	3.8	33.3	12.7	9.3
T_{11} -Broad casting enriched FYM at 4 t ha^{-1} + 100% recommended N and K	8.6	6.5	4.2	39.6	16.8	10.8
T_{12} -Band placement of 2.0 t FYM ha^{-1} + 100% recommended levels of NPK	8.3	6.5	4.1	37.7	14.4	10.5
T_{13} -Band placement of enriched FYM at 2.0 t ha^{-1} + 100% of recommended N and K	8.8	6.6	4.3	40.1	17.9	11.6

Data not statistically analysed

DIFFERENT EFFICIENCIES

Agronomic efficiency (AE)

The data on agronomic efficiency (AE) revealed that agronomic efficiency was significantly influenced by the treatmental practices (Table 3). But the results of AE showed an inconsistent pattern among the treatments. The highest agronomic efficiency for nitrogen was observed with band placement of 2t FYM ha^{-1} +100 % recommended dose of NPK (T_{12}) with a value of 42.34 kg grain per kg of absorbed nutrient. This was followed by band placement of enriched FYM 2 t ha^{-1} + 100 % recommended N and K (T_{13}) with value of 42.08 kg grain per kg of absorbed nutrient. The lowest AE (20.9) was observed in 50 percent recommended NPK alone (T_2).

Regard to AE for phosphorus and potassium, band placem ent of enriched FYM 2 t ha^{-1} + 100 % of recommended N and K (T_{13}) registered higher AE for phosphorus with value of 129.60 kg grain per kg of absorbed nutrient and band placement of 2 t FYM ha^{-1} + 100 % recommended dose of NPK (T_{12}) recorded highest efficiency for potassium with value of 72.50 kg grain per kg of absorbed nutrient. Application of 50 percent recommended NPK alone (T_2) recorded lower AE for both phosphorus and potassium with value of 41.8 kg grain per kg of absorbed nutrient.

Physiological efficiency (PE)

The data on physiological efficiency (PE) was influenced by different treatments and not showed a significant pattern of increasing or decreasing (Table 3). The PE for nitrogen, phosphorus and potassium were differed based on the treat mental practices. Among all the treatments, the highest physiological efficiency for nitrogen was recorded with broad casting of 2 t FYM ha^{-1} + 50 % recommended NPK (T_4) with value of 109.50 kg grain per kg of absorbed nutrient and lowest PE for nitrogen was registered with broad casting of enriched FYM 4 t ha^{-1} +

100 % recommended N and K (T_{11}) with a value of 61.06 kg grain per kg of absorbed nutrient. Regards to PE for phosphorus, the highest and lowest efficiency were recorded in the band placement of enriched FYM 2 t ha^{-1} + 100 % recommended N and K (T_{13}) and application of 50 percent recommended dose of NPK alone (T_2) with values of 393.28 and 261.25 kg grain per kg of absorbed nutrient respectively. About PE for potassium, the highest efficiency was recorded in 100 percent recommended dose of NPK alone (T_3) with a value of 184.91 kg grain per kg of absorbed nutrient.

Nutrient use efficiency (NUE)

The nutrient use efficiency was recorded for nitrogen, phosphorus and potassium (Table 3). The data on nutrient use efficiency was influenced by different treatments. The nutrient use efficiency was found to be inconsistent pattern among the treatments. Band placement of enriched FYM 2 t ha^{-1} + 100 % recommended N and K (T_{13}) registered highest NUE for N, P and K with values of 53.5, 32.9 and 41.5 % respectively. This was closely followed by band placement of 2 t FYM ha^{-1} + 100 percent recommended NPK (T_{12}) which recorded higher NUE for N, P and K with values 52.0, 25.8 and 40.1 % respectively.

The lowest NUE use efficiency for N, P and K was registered with application of 50 % recommended dose of NPK alone (T_2) as compared to all other treatments with value of 25.0, 16.0 and 24.0 percent respectively. Among the broad casting treatments, broad casting of enriched FYM 4 t ha^{-1} + 100 % recommended N and K (T_{11}) recorded higher nutrient use efficiency with values of 48.2 percent (for N) and 40.0 percent (for K).

TABLE 3. Influence of INM and its method of application on different efficiencies of finger millet

Treatments	Agronomic efficiency			Physiological efficiency			Nutrient use efficiency		
	Kg of grain per kg of absorbed nutrient			Kg of grain per kg of absorbed nutrient			Percentage		
	N	P	K	N	P	K	N	P	K
T_1 - Absolute control	-	-	-	-	-	-	-	-	-
T_2 - 50% recommended NPK (20:10:10) alone	20.90	41.80	41.80	83.6	261.25	174.17	25.0	16	24.0
T_3 -100% recommended NPK (40:20:20) alone	26.35	52.70	52.70	87.83	284.86	184.91	27.5	18.5	28.5
T_4 - Broad casting 2.0 t FYM ha^{-1} + 50% recommended levels of NPK	29.20	64.41	45.60	109.50	365.00	171.76	26.6	17.6	26.5
T_5 - Broad casting 2.0 t FYM ha^{-1} + 100% recommended levels of NPK	27.18	57.58	46.54	90.60	302.00	172.02	30.0	19.1	33.5
T_6 - Broad casting enriched FYM 2.0 t ha^{-1} + 50% recommended N & K	33.71	65.51	52.41	88.69	288.25	174.70	38.0	22.7	30.0
T_7 - Broad casting enriched FYM at 2.0 t ha^{-1}+100% recommended N and K	27.55	84.83	46.66	82.94	324.57	135.73	33.2	26.1	34.4
T_8 - Broad casting 4.0 t FYM ha^{-1} + 50% recommended levels of NPK	42.25	98.26	59.51	88.95	359.57	150.89	47.5	27.3	39.4
T_9 - Broad casting 4.0 t FYM ha^{-1} + 100% recommended levels of NPK	31.27	68.97	48.85	69.48	323.45	122.61	45.0	21.3	39.8
T_{10} -Broad casting enriched FYM at 4.0 t ha^{-1} + 50% recommended N and K	37.21	51.16	52.97	78.30	315.96	150.08	47.5	16.2	35.3
T_{11} -Broad casting enriched FYM at 4 t ha^{-1} + 100% recommended N and K	29.46	57.24	45.80	61.06	325.00	114.49	48.2	17.6	40.0
T_{12} -Band placement of 2.0 t FYM ha^{-1} + 100% recommended levels of NPK	42.34	89.70	72.50	81.42	347.04	180.94	52.0	25.8	40.1
T_{13} -Band placement of enriched FYM at 2.0 t ha^{-1} + 100% of recommended N and K	42.08	129.60	71.28	78.66	393.28	171.50	53.5	32.9	41.5

Data not statistically analysed

DISCUSSION

Nutrients uptake

In general, the performance of a crop in terms of growth and yield mainly depends on the nutrient uptake (Fig. 10, 11 and 12). The increased organic acids with respect to microbial decomposition of organic matter of FYM might be one of the possible reason for increased uptake of nutrients in broad casting treatment of 4 t enriched FYM ha^{-1} + 100 % of recommended N and K (T_{11}). This result corroborates the findings of Gopal Reddy and Suryanarayan Reddy (1999). This was followed by band placement of enriched farm yard manure 2 t ha^{-1} + 100 % of recommended N and K (T_{13}) and band placement of FYM 2 t ha^{-1}+ 100 % recommended dose of NPK (T_{12}) recorded with better uptake of nutrients due to combined application of FYM with increased nitrogen level. Similar results were also reported previously by Syed Ismail *et al.* (2001). Broad casting of 2 t FYM ha^{-1} + 50% recommend ded NPK (T_4) and broad casting of 2 t enriched FYM ha^{-1} + 50 % recommended N and K (T_6) registered lower plant nutrients uptake. This might be due to more time taken for FYM decomposition with lesser chemical fertilizers.

In general, the NPK uptake was increased with application of FYM (Venkatesh Bharadwaj *et al.*, 1994b) and P

fertilization accounting for higher N uptake over control obviously. This might be due to the increased root proliferation with increased in levels of P which has resulted in the better utilization of N by the finger millet crop. This was in conformity with the earlier findings of Natarajan (1981). Poor root growth and insufficient available soil nutrients were the major reasons for lower uptake of nutrients in the absolute control (T_1).

Microbial population

The increased proportion of labile carbon and nitrogen directly simulate the activity of the microorganisms. The higher microbial population *viz.*, bacteria, fungi and actinomycetes (Table 2) were recorded in band placement of enriched FYM 2 t ha^{-1} + 100 percent of recommended N and K (T_{13}) after harvest of the finger millet crop as compared to initial soil microbial population. It might be due to increased organic matter content in the soil and higher availability of nutrients to the crop. Nanda *et al.* (1988) reported that FYM highly increased the bacterial population as compared to fungi and actinomycetes. As compared to inorganic fertilizers, addition of FYM increased the activity of microorganisms (Maheswarappa *et al.,* 1999). This result provides support to the present study that application of recommended dose of NPK alone (T_3) registered lesser microbial population as compared to Broad casting of 2 t FYM ha^{-1} + 100 percent recommended N and K (T_5).

Nutrient use efficiency and other efficiencies

The better nutrient use efficiency (NUE) for NPK was obtained in band placement of enriched FYM 2 t ha^{-1} with 100 percent of recommended N and K (T_{13}). This might be due to reduction of N losses through nitrification and denitrification by band placement and also easy availability of nutrients to the crop by weed free competition is one of the reasons for higher NUE (Table 3). The results are in agreement to those findings of (Channa Naik *et al*., 1999).

Higher phosphorus use efficiency also registered in band placement of enriched FYM 2 t ha^{-1} + 100 percent of recommended N and K (T_{13}) due to combined application of FYM with super phosphate which in turn reduced P fixation in the soil complex. The fertilizer P efficiency reduced with increased in levels of P application obviously due to fixing absorption reactions by kaolinitic clay (Duraisamy *et al.,* 1990). This result provides supports to t he present investigation that addition of higher P fertilizer reduced PUE in broad casting of enriched FYM 4 t ha^{-1} + 50 percent recommended N and K (T_{10}) and broad casting of enriched FYM 4 t ha^{-1} + 100 percent recommended N and K (T_{11}) treatments. In general, broad casting of fertilizers increased the N loss and P fixation in the soil. Sarma and Ramana (1993) stated that applied potassium improved the NUE and total productive efficiency of NPK. Physiological efficiency (PE) is a measure of the amount of grain produced per unit quantity of nutrient absorbed. In the present study, PE varied for different treatments with inconsistent pattern due to different environmental factors and differential uptake under applied fertilizer treatments.

Band placement of enriched FYM 2 t ha^{-1} + 100 percent of recommended N and K (T_{13}) and band placement of FYM 2 t ha^{-1} + 100 percent recommended dose of NPK (T_{12}) recorded higher agronomic efficiency (AE) due to better production of grains for the application of fertilizer with higher NUE as compared to other treatments.

CONCLUSION

Combined use of organic and inorganic fertilizers with band placement application will help to improve the nutrient uptake, soil microbial population and nutrient use efficiency of rainfed direct sown finger millet when compared to application of inorganic fertilizers alone.

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