International Journal of Plant & Soil Science

34(4): 40-47, 2022; Article no.IJPSS.82277
ISSN: 2320-7035

Effect of Initial soil Fertility and Integrated Plant Nutrition System on Yield and NPK Uptake by Barnyard Millet

R. Selvam [a*], R. Santhi [b], S. Maragatham [a], C. N. Chandrasekhar [c] and Patil Santosh Ganapathi [d]

[a] Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore- 03, Tamil Nadu, India.
[b] Directorate of Natural Resource Management, Tamil Nadu Agricultural University, Coimbatore- 03, Tamil Nadu, India.
[c] Department of Crop Physiology & ICAR Nodal Officer, O/o Dean (Agri), Tamil Nadu Agricultural University, Coimbatore- 03, Tamil Nadu, India.
[d] Department of Physical Science & Information Technology, Tamil Nadu Agricultural University, Coimbatore- 03, Tamil Nadu, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i430856

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/82277

Original Research Article

Received 07 December 2021
Accepted 14 February 2022
Published 18 February 2022

ABSTRACT

This study examined the effect of soil fertility and Integrated Plant Nutrition System (IPNS) on the yield of barnyard millet (*var.* MDU 1) on the field of Eastern Block Farm in Tamil Nadu Agricultural University. Coimbatore. based on the inductive technique (fertility gradient concept). Among the three fertiliser strips, the first phase of the experiment involved adding graded fertilisers and growing fodder sorghum as a gradient crop to develop soil fertility variations. During the second phase, the barnyard millet test crop experiment included four levels each of N, P_2O_5, and K_2O fertilizers, plus three levels of farmyard manure (FYM). The results show that overall yield recorded in the highest initial fertility strip III. The highest yield of 2966 kg ha^{-1} was obtained with 60:30:40 kg ha^{-1} of N, P_2O_5, and K_2O along with 12.5 t ha^{-1} of FYM in strip II with initial soil available NPK status 198, 31, and 521 kg ha^{-1}, respectively. The lowest yield 1056 kg ha^{-1} was recorded in strip I under absolute

**Corresponding author: E-mail: selvaram426@gmail.com;*

control and the initial soil test values were 157, 13 and 470 kg ha^{-1} of $KMnO_4$-N, Olsen-P and NH_4OAc-K, respectively. Application of 12.5 t ha^{-1} of FYM alone increased yield of barnyard was 27.73 per cent over absolute control. Barnyard millet grain production and NPK uptake rose when initial soil fertility and fertiliser N, P_2O_5, K_2O, and FYM levels increased.

Keywords: Barnyard millet; initial soil fertility; IPNS; Nutrient uptake.

1. INTRODUCTION

India's biggest challenge in the twenty-first century is to generate enough food, fodder, fibre, and fuel to meet the diverse needs of the country's rapidly growing human and animal populations. Higher agricultural production of different crops, improved technologies, and increased cropping intensity may be able to meet this demand [1]. The Integrated Plant Nutrition System (IPNS) is a mechanism for managing plant nutrition and soil fertility in cropping and agricultural systems that is adapted to local site characteristics and resources. Plant nutrition is ecologically, socially, and economically viable, thanks to IPNS. At the same time, it encourages, informs, trains, and organises farmers to increase crop productivity while preserving soil fertility.

As a result of continuous cropping without effective nutrient management and the indiscriminate use of agrochemicals on soil and crops, India's agriculture faces various issues, including stagnating or even declining production and productivity growth rates of main crops, degraded soil fertility, declining factor productivity, low diversity of production systems, and growing production costs [2].

Fertilizer mining is currently a severe danger to agricultural soil due to a large gap between nutrient addition and nutrient removal. Farmers' uneven use of fertilisers without knowing soil fertility state and crop nutrient requirements, which creates severe impacts on soil and crop in terms of nutrient toxicity and insufficiency, is one of the reasons for reduced productivity. This technique not only harmed soil health but also cost farmers money [3]. As a result, the incorporation of fertilisers with organic resources becomes necessary. The combined use of organic and inorganic fertiliser sources, together with other complementing approaches, could be the overall strategy for boosting crop yields on a sustainable basis. Organics are known to improve soil structure, texture, and tilth, as well as to allow for faster and higher access of plant nutrients. Given the ever-increasing prices of fertilisers, it is becoming increasingly vital to assess the extent to which crop fertiliser requirements can be lowered through the concurrent use of organic manures [2].

Organic manures applied in conjunction with inorganic fertilisers may expedite the mineralization and immobilisation of plant nutrients, altering their availability in a variety of organic and inorganic soil forms. Organic manures are a valuable and renewable source of fertiliser, but applying them to the soil alone is insufficient to meet the nutrient requirements of modern crop varieties. Nonetheless, consistent treatment enhances soil resistance and resilience as well as biological activity and biomass, variety, and physical features [4]. As a result, combining inorganic fertilisers with organic manures may help to maintain sustainable output while also improving soil health due to their complementing benefits. Taking these facts into account, field studies were conducted to investigate the influence of IPNS and initial soil fertility levels on yield and NPK uptake by barnyard millet on an Inceptisol.

2. MATERIALS AND METHODS

During 2019-2020, a field experiment using barnyard millet (var. MDU 1) was done on Vertic Ustropept at the Tamil Nadu Agricultural University's Eastern Block farm in Coimbatore, Tamil Nadu. The experimental field's surface soil is a mixed black-calcareous, sandy clay loam with a pH of 8.3 and an electrical conductivity (EC) of 0.49 dS m^{-1}. The original available N ($KMnO_4$-N), P (Olsen-P), and K (NH_4OAc-K) status of the soil was 175, 21.0, and 505 kg ha^{-1}, respectively. The soil's P and K fixing capabilities were 100 and 80 kg ha^{-1}, respectively. The availability of DTPA extractable zinc (Zn), copper (Cu) and manganese (Mn) was sufficient, while iron (Fe) was insufficient.

Inductive approach was used to create the fertility gradient in the experimental field [5]. The experimental field was separated into three equal strips with $N_0P_0K_0$ (SI), $N_1P_1K_1$ (S II), and $N_2P_2K_2$ (S III) levels, and a gradient crop of fodder sorghum (var. CO 30) was planted in each. Twenty-four soil samples were obtained from each strip before and after the gradient crop was harvested, and the soil test values were compared for alkaline $KMnO_4$-N, Olsen-P, and NH_4OAc-K. Strip yields of fodder were recorded, and plant samples were taken and analysed for N, P, and K content, as well as absorption values for N, P, and K. The data on post-harvest soil N, P, and K availability, fodder yield, and N, P, and K uptake confirmed the creation of a soil fertility gradient among the three strips.

Following the development of soil fertility gradients, each strip was split into 24 plots, each of which included twenty-four treatments with four levels of N (0, 20, 40, and 60 kg ha^{-1}), P_2O_5 (0, 10, 20, and 30 kg ha^{-1}) and K_2O (0,10, 20, and 30 kg ha^{-1}) (0, 20, 40, and 60 kg ha^{-1}). The fractional factorial design was used for the test crop experiment, and the treatment structure is shown in Table 1. Each strip included twenty-four treatments, for a total of seventy-two plots, nine of which were NPK control plots and sixty-three of which were NPK treated plots. FYM @ 0, 6.25, and 12.5 t ha^{-1} IPNS treatments were placed across the strips. The treatments were randomised such that all 24 treatments might occur in any direction, and the test crop barnyard millet was cultivated (both side randomization). The initial surface soil samples from all plots were collected and analysed for alkaline $KMnO_4$-N, Olsen P, and NH_4OAc-K status. Grain and straw yields were recorded, and plot-specific grain and straw samples were analysed for total N [6], P, and K [7] contents, as well as barnyard millet N, P, and K uptake.

Table 1. Treatment structure for test crop experiment (barnyard millet)

Sl. No	Treatment combination			Levels of nutrients (kg ha^{-1})		
	N	P	K	N	P_2O_5	K_2O
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	2	2	0	20	40
5	1	1	1	20	10	20
6	1	2	1	20	20	20
7	1	1	2	20	10	40
8	1	2	2	20	20	40
9	2	1	1	40	10	20
10	2	0	2	40	0	40
11	2	1	2	40	10	40
12	2	2	2	40	20	40
13	2	2	1	40	20	20
14	2	2	0	40	20	0
15	2	2	3	40	20	60
16	2	3	2	40	30	40
17	2	3	3	40	30	60
18	3	1	1	60	10	20
19	3	2	1	60	20	20
20	3	2	2	60	20	40
21	3	3	1	60	30	20
22	3	3	2	60	30	40
23	3	2	3	60	20	60
24	3	3	3	60	30	60

3. RESULT AND DISCUSSION

Table 2 shows the range and mean of initial soil test readings, yield, and NPK uptake in various fertility strips. Table 3 shows the range and mean values of initial soil test values, yield, and nutrient uptake in NPK treated and NPK control plots.

3.1 Soil Fertility

The pre-sowing soil test data revealed that the $KMnO_4$-N values ranged from 157 to 165, 188 to 199, and 216 to 224 kg ha^{-1}, with a mean of 161,195, and 221 kg ha^{-1} in strips I, II, and III, respectively. In strip I, the pre-sowing soil test value of Olsen-P ranged from 13.0 to 17.0 kg ha^{-} with a mean of 15.4 kg ha^{-1}, from 25 to 31 kg ha^{-1} with a mean of 28.9 kg ha^{-1} in strip II, and from 36 to 41 kg ha^{-1} with a mean of 39.0 in strip III. For NH_4OAC-K, ranged from 470 to 478, 512 to 521 and 529 to 538 kg ha^{-1} with a mean value of 473, 516 533 kg ha^{-1}, Respectively for strips I, II, III.

The $KMnO_4$-N concentration ranged from 157 to 224 kg ha^{-1}, with a mean of 193 kg ha^{-1}. In NPK-treated plots, Olsen-P ranged from 13 to 41 kg ha^{-1}, with a mean of 28 kg ha^{-1}, and NH_4OAC-K ranged from 470 to 538 kg ha^{-1}, with a mean of 508 kg ha^{-1}. The range and mean value of $KMnO_4$-N, Olsen-P, and NH_4OAC-K in control plots were 157 to 221, 13 to 39, 470 to 530, and 189, 25 and 505 kg ha^{-1}, respectively.

The $KMnO_4$-N, Olsen-P, and NH_4OAC-K ranges in absolute control plots were 157 to 221, 13 to 36, and 476 to 529 kg ha^{-1}, with mean values of 189, 25, and 506 kg ha^{-1}, respectively. In 6.25 t FYM ha^{-1} alone, the range of $KMnO_4$-N, Olsen-P, and NH_4OAC-K was 157 to 221, 13 to 37, and 471 to 530 kg ha^{-1}, with a mean of 189, 25 and 505 kg ha^{-1}, respectively. The range and mean value of 12,5 t FYM ha^{-1} plots were 160 to 216, 14 to 39, and 470 to 529 kg ha^{-1}, respectively, and 188, 26 and 504 kg ha^{-1}, respectively.

Significant fertility changes were seen in several strips as a result of the application of graded quantities of fertilisers N, P_2O_5, and K_2O. SII had a 21.11 per cent increase in $KMnO_4$-N status over SI, SIII had a 37.3 per cent increase over SI, and SIII had a 13.3 per cent increase over SII. The increase in available N in soil due to improved adsorption of NH_4^+ ions by organic and inorganic colloids of the soil [8] could be attributed to better adsorption of NH_4^+ ions by organic and inorganic colloids of the soil.

The percent increase in Olsen-P of SII over SI was 87.7 per cent, SIII over SI was 153.9 per cent, and SIII over SII was 35.3 per cent (Table 2). The enhanced availability of P may be ascribed to the administration of phosphatic fertiliser at graded levels that are either equal to or greater than the experimental field's P fixing capability; otherwise, more P would have remained in the soil solution [9].

In case of NH_4OAc-K the per cent increase was 9.1 in SII over SI, 12.7 in SIII over SI and 3.3 in SIII over SII (Table 2). The possible causes include (i) the application of graded amounts of potassic fertilisers that are either on par with or above the soil's K fixing capacity, and (ii) the probable retention of the additional K by soil colloids in the exchangeable form [10]. The gradient experiment clearly demonstrated that an operational range of soil test values was recorded in the current investigation, with the amount of increase being greater for P, N, and K.

3.2 Grain Yield

The mean grain yield of barnyard millet was 1914, 2297 and 2428 kg ha^{-1}, respectively in strips I, II, and III. The mean yield increase in SII over SI was about 20.01 per cent and SIII over SI was 26.85 per cent and SIII over SII was 5.70 per cent (Table 2).

Table 4 shows the maximum and minimum yields in IPNS plots and NPK control plots. The maximum yield of 2966 kg ha^{-1} was observed in an IPNS plot that received 60:30:40 kg ha^{-1} of fertiliser N, P_2O_5, and K_2O, as well as 12.5 t ha^{-1} of FYM in strip II, with initial soil available NPK status of 198, 31 and 521 kg ha^{-1}, respectively. The yield increase was 69.96 per cent when compared to the control treatment, which received 0:20:40 kg ha^{-1} of N, P_2O_5, K_2O, and 12.5 t ha^{-1} FYM.

Table 2. Pre-sowing soil available N, P and K, yield and N, P and K uptake by barnyard millet in NPK treated and control plots of test crop experiment (stripwise)

Parameters	Strip I		Strip II		Strip III		Treated plot		Control plot	
	Range	Mean	Range	Mean	Range	Mean	Range	mean	Range	mean
	---(kg ha^{-1})---									
$KMnO_4$-N	157-165	161	188-199	195	216-224	221	157-224	193	157-221	189
Olsen-P	13-17	15.4	25-31	28.9	36-41	39.1	13-41	28	13-39	25
NH_4OAc-K	470-478	473	512-521	516	529-538	533	470-538	508	470-530	505
Grain Yield	1588-2380	1914	1218-2966	2297	1350-2940	2428	1588-2966	2330	1056-1716	1390
N uptake	36.1-52.4	45.5	44.4-76.9	57.5	46.7-79.2	70.0	42.9-79.2	59.0	36.1-63.4	48
P uptake	5.26-12.7	9.70	8.94-17.0	13.2	11.1-18.1	15.2	8.14-18.1	13.1	5.26-12.8	9.6
K uptake	28.9-57.5	45.4	35.8-72.1	53.2	37.4-76.8	59.0	40.7-76.9	54.3	28.9-48.9	40.3

Table3. Initial soil available NPK, yield and NPK uptake by barnyard millet in absolute control and FYM alone blocks

Parameter kg ha^{-1}	Absolute control		6.25 t Fym ha^{-1}		12.5 t Fym ha^{-1}	
	range	mean	Range	mean	Range	Mean
KMnO4-N	157-221	189	157-221	189	160-216	188
Olsen- P	13-36	25	13-37	25	14-39	26
NH4OAc-K	476-529	506	471-530	505	470-529	504
Grain yield	1056-1350	1208	1218-1598	1419	1344-1716	1543
N uptake	36.10-46.73	42.40	40.12-58.67	49.54	42.00-63.39	51.10
P uptake	5.26-11.10	8.43	6.94-12.16	9.91	7.65-12.84	10.45
K uptake	28.86-37.36	33.99	38.90-46.98	42.79	39.97-48.89	44.09

Table 4. Effect of pre-sowing soil available N, P and K status and IPNS (NPK+FYM) on grain yield and N, P and K uptake by barnyard millet

S.No	Particulars	Strip	Soil Test Values (kg ha^{-1})			Fertiliser doses (kg ha^{-1})			FYM (t ha^{-1})	Grain Yield (kg ha^{-1})	Total Uptake (kg ha^{-1})		
			SN	SP	SK	FN	FP_2O_5	FK_2O			UN	UP	UK
NPK Treated plots													
1.	Minimum yield	I	162	17	473	0	20	40	12.5	1588	42.9	8.1	41.2
2.	Maximum yield	II	198	31	521	60	30	40	12.5	2966	76.9	17.0	72.1
NPK Control plots													
1.	Minimum yield	I	157	13	476	0	0	0	0	1056	36.1	5.3	28.9
2.	Maximum yield	III	216	39	529	0	0	0	12.5	1716	63.39	12.8	48.9

Among the NPK control plots (Table 3), strip III produced the greatest grain yield of 1716 kg ha^{-1} with an application of FYM @ 12.5 t ha^{-1} and baseline soil test values of 216, 39, and 529 kg ha^{-1} of $KMnO_4$-N, Olsen-P, and NH_4OAc-K, respectively. Strip I had the lowest production of 1056 kg ha^{-1} under absolute control, while the initial soil test values of $KMnO_4$-N, Olsen-P, and NH_4OAc-K were 157, 13, and 473 kg ha^{-1}, respectively.

The application of 12.5 t ha^{-1} FYM alone resulted in a significant increase in production, with a yield increase of 27.73 per cent above the absolute control. The increase in grain yield in 6.25 t ha^{-1} alone plots over absolute control plots was 17.46 per cent, while the increase in grain yield in 12.5 t FYM ha^{-1} alone plots over 6.25 t FYM ha^{-1} alone plots was 8.73 per cent, respectively.

This could be attributed to an improvement in the soil's physicochemical properties and the supply of nutrients in balanced amounts, as well as the production of slow nutrients via the integrated use of FYM, which helped to produce more grains and ear length. The use of fertilisers and organic manures together may have enhanced soil organic matter, which would have boosted grain output and plant nutrient availability [1]. According to [11], FYM application increased the physical, chemical, and biological aspects of soil when compared to NPK alone treatments. Furthermore, the use of organic manure ensures a consistent supply of macro and micronutrients in the soil, resulting in increased yield. These findings support earlier studies (Sharma and Subenia. [12], Singh *et al*., [13], Gupta *et al*., [14]). The findings showed that combining the provision of nutrients from diverse sources might result in increased grain yields. Saraswathi *et al*. [15] discovered comparable findings.

3.3 Nutrient Uptake

The results on nutrient uptake revealed that N intake varied from 36.1 to 52.4 kg ha^{-1} in strip I, with a mean of 45.5 kg ha^{-1}, from 44.4 to 76.9 in strip II, with a mean of 57.5 kg ha^{-1}, and from 46.7 to 79.2 kg ha^{-1} in strip III, with a mean of 70.0 kg ha^{-1}. Strip I had a P uptake range of 5.26 to 12.73 kg ha^{-1} with a mean of 9.70 kg ha^{-1}, Strip II had a P uptake range of 8.94 to 17.0 with a mean of 13.2 kg ha^{-1}, and Strip III had a P uptake range of 11.1 to 18.1 kg ha^{-1} with a mean of 15.2 kg ha^{-1}. Strip I had a K uptake range of 28.9 to 57.5 kg ha^{-1} with a mean of 45.4 kg ha^{-1}, strip II had a range of 35.8 to 72.1 with a mean of 53.2 kg ha^{-1}, and strip III had a range of 37.4 to 76.8 kg ha^{-1} with a mean of 59.0 kg ha^{-1}. N, P, and K uptakes of treated plots ranged from 42.9 to 79.2, 8.14 to 18.1, and 40.7 to 76.9 kg ha^{-1}, with mean values of 59.0, 13.1, and 54.3 kg ha^{-1}, respectively. The range and mean values of N.P and K in all NPK control plots were 36.1 to 63.4, 5.26 to 12.8, and 28.9 to 48.9 kg ha^{-1}, with mean values of 48.0, 9.6, and 40.3 kg ha^{-1}, respectively.

The range and mean values of N, P, and K uptakes in absolute control plots were 36.10 to 46.73, 5.26 to 11.10, and 28.86 to 37.36 kg ha^{-1}, with a mean of 42.40, 8.43, and 33.99 kg ha^{-1}, respectively. In 6.25 t FYM ha^{-1} alone plots, N, P, and K uptakes vary from 40.12 to 58.67, 6.94 to 12.16, and 38.90 to 46.98 kg ha^{-1}, with a mean of 49.54, 9.91, and 42.79 kg ha^{-1}, respectively. The range and mean of N, P, and K uptakes from 12.5 t FYM ha^{-1} alone plots were 42.00 to 63.39, 7.66 to 12.84, and 39.97 to 48.89 kg ha^{-1}, respectively, and 52.10, 10.45, and 44.09 kg ha^{-1}.

The increases in N, P, and K uptake in 6.25 t FYM ha^{-1} alone plots were 16.85, 17.56, and 25.90 per cent higher than in absolute control plots, respectively. The increase in N, P and K uptake in 12.5 t FYM ha^{-1} alone plots over absolute control and 6.25 t FYM ha^{-1} alone plots were 22.89, 23.94 and 29.73 and 5.17, 5.43 and 3.04 per cent, respectively.

The results demonstrated unequivocally that combining FYM and inorganic sources increased barnyard millet yield. This might be due to FYM application having superior physical, chemical, and biological qualities over NPK alone treatments [11]. Furthermore, IPNS may have expedited carbohydrate synthesis and boosted glucose translocation from sink to source, thereby increasing production. These findings agreed with those of Harikrishna *et al*. [16], Prabu *et al*. [17], and Hiremath *et al*. [18] for tomato and okra, respectively.

The application of 0:20:40 kg ha^{-1} in strip I resulted in the lowest absorption (42.9, 8.1, and 41.2 kg ha^{-1} N, P, and K) with starting soil test values of 163, 12, and 454 kg ha^{-1} of $KMnO_4$-N, Olsen-P, and NH_4OAc-K, respectively. Similar findings were published by Coumaravel *et al* [19] and Udayakumar and Santhi [20] on the influence of nutrients from soil, inorganic, and organic sources on barnyard millet absorption.

The current study's data clearly reveal that initial soil fertility and IPNS had a substantial influence on barnyard millet grain production and nutrient absorption.

4. CONCLUSION

According to the findings of the current study, IPNS plus initial soil fertility had a stronger influence on grain yield and NPK uptake by barnyard millet than inorganic fertiliser alone. This might be because of integrated nutrient application, increased microbial population, and high organic carbon, which causes organic nutrients to be transformed to inorganic. Thus. Fertilizer usage in combination with FYM can play a key role in increasing barnyard millet yield potential because to its positive influence on nutrient availability and soil properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sharma VK, Pandey RN, Sarvendra K, Kapit AC and Suresh C. Soil test crop response based fertilizer recommendations under integrated nutrient management for higher productivity of pearl millet (Pennisetum glaucum) and (Triticum aestivum) wheat under long term experiment. Indian J. Agric. Sci. 2016;86(8):1076-81.
2. John DA and Babu GR. Lessons From the Aftermaths of Green Revolution on Food System and Health. Front. Sustain. Food Syst. 2021;5:644559.
   DOI: 10.3389/fsufs.2021.644559
3. Sharm N, Singhvi R. Effects of chemical fertilizers and pesticides on human health and environment: a review. Int. J. Agric. Environ. Biotechnol. 2017;10:675–680.
   DOI: 10.5958/2230-732X.2017.00083.3
4. Bargaz A, Lyamlouli K, Chtouki M, Zeroual Y. and Dhiba D. Soil Microbial Resources for Improving Fertilizers Efficiency in an Integrated Plant Nutrient Management System. Front. Microbiol. 2018;9:1606.
   DOI: 10.3389/fmicb.2018.01606
5. Ramamoorthy B, Narasimham RK, Dinesh, RS. Fertilizer application for specific yield targets on Sonora 64 (wheat). Indian Fmg. 1967;17:43-45
6. Humphries EC. Mineral components and ash analysis. Modern methods of plant analysis. Springer-Verlag, Berlin. 1956;1:468-562.
7. Piper CS. Soil and Plant analysis, Hans Publications, Bombay; 1966.
8. Havlin JL, Beaton JD, Tisdale SL and Nelson WL. Soil fertility and fertilizers - An introduction to nutrientmanagement, 7th Edn. Pearson Education Publishing Company, U.S.A; 2009.
9. Dibb DW, Fixen PE, Murphy LS. Balanced fertilization with particular reference to phosphates: Interaction of phosphorus with other inputs and management practices. Fert. Res. 1990;26:29-52.
10. Subba Rao A. Brar MS. Potassium. In: Fundamentals of Soil Science, ISSS, New Delhi. 2002:369 – 380
11. Geetha Kumari B. Mishra R. Kumar BK. Agarwal, Singh BP. Long term effect of manure, fertilizer and lime application on active and passive pools of soil organic carbon under maize-wheat cropping system in an Alfisol. J. Indian. Soc. Soil Sci. 2011;59:245-250.
12. Sharma U, Subehia SK. Effect of long-term integrated nutrient management on rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) productivity and soil properties in North-Western Himalaya J. Indian Soc. Soil Sci. 2014;62(3): 248-254
13. Singh YV, Singh SK, Sharma PK, Priyanka Singh. Soil Test Based Integrated Fertilizer Recommendation for Wheat (Triticum aestivum) in an Inceptisol of Eastern Plain Zone of Uttar Pradesh J. Indian Soc. Soil Sci., 2014;62(3):255-258
14. Gupta V, Sharma RS. and Vishavakarma SK. Long-term effect of integrated nutrient management on yield sustainability and soil fertility of rice (Oryza sati-va)-wheat (Triticum aestivum) cropping system. Indian J. Agron., 2006;51:160-164
15. Saraswathi Y, Vishawanath S, Ashwini NM, and Vandana S. (2015 Studies on feasibility and response of NPK application through different approaches in ragi under rainfed condition. The Ecoscan. 2015;7:349-353.
16. Harikrishna BL, Channal HT, Hebsur, NS, Dharmatti PR and Sarangamath PA. Integrated nutrient management on availability of nutrients, uptake and yield of tomato. Karnataka J. Agric. Sci.. 2002;15:275-278.

17. Prabu T, Narwadkar PR. and Sanindranath AK. Effect of integrated nutrient management on okra root and fruit yield. J. Soils and Crops. 2003;13:394-396.
18. Hiremath SM, Basavaraj N. and Basarkar PW. Influence of provinces and production practices on quality parameters of paprika. Karnataka J. Agric. Sci. 2006;19:357-361.
19. Dhinesh V, Santhi R. Effect of initial soil fertility and integrated plant nutrition system (IPNS) onyield and NPK uptake by brinjal on an Alfisol. Indian J. Agric. Res. 2016;50(2):131-134. DOI:10.18805/ijare.v0iOF.7101
20. Udayakumar S. and Santhi R. Effect of Integrated Plant Nutrition System (IPNS) and Initial Soil Fertility on Yield and NPK Uptake by Pearl Millet on Inceptisol. Inter. J. Agric. Sci. 2016;8(55): 3020-3024

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/82277