E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(6): 535-539
Received: 02-03-2024
Accepted: 06-04-2024

Dr. Ch. Ramulu
Department of Soil Science and Agricultural Chemistry, Regional Agricultural Research Station, PJTSAU, Telangana, India

Dr. R Shravankumar
Department of Soil Science and Agricultural Chemistry, Regional Agricultural Research Station, PJTSAU, Telangana, India

Dr. G Padmaja
Department of Soil Science and Agricultural Chemistry, Regional Agricultural Research Station, PJTSAU, Telangana, India

Dr. R Uma Reddy
Department of Soil Science and Agricultural Chemistry, Regional Agricultural Research Station, PJTSAU, Telangana, India

Corresponding Author:
Dr. Ch. Ramulu
Department of Soil Science and Agricultural Chemistry, Regional Agricultural Research Station, PJTSAU, Telangana, India

Effect of different nutrient management practices on growth, yield and economics of kharif rice in Telangana

Dr. Ch. Ramulu, Dr. R Shravankumar, Dr. G Padmaja and Dr. R Uma Reddy

DOI: https://doi.org/10.33545/2618060X.2024.v7.i6Sh.936

Abstract
The field experiment was conducted during kharif-2019, 2020 and 2021 at Regional Agricultural Research Station (RARS) Warangal, located at 18^0 01.077 N latitude 79^0 36.197 E longitude and an altitude of 259 m above mean sea level to study the effect of different nutrient management practices on growth, yield and economics of kharif rice. The experiment was laid out in completely randomized block design with 5 treatments of different nutrient management practices (organi, chemical, INM, control and natural farming) replicated in four times. The results revealed that, the experimental soil was sandy loam in texture, slightly alkaline in reaction (pH: 8.12) and non saline in nature (EC: 0.46 dSm^{-1}). Organic carbon (0.59%) and available nitrogen (141 kg ha^{-1}) were low, medium in available phosphorus (34 kg ha^{-1}) and potassium (278 kg ha^{-1}), sufficient in available Zn (0.70 mg kg^{-1}) and Fe (4.56 mg kg^{-1}). Significantly higher number of tillers and panicles m^{-2} i.e. 365 and 301, respectively were found in INM over natural farming i.e 309 and 272, respectively and control i.e.279 and 224, respectively but at par with organic farming i.e. 337 and 280, respectively and chemical farming i.e. 346 and 285, respectively. Significantly higher panicle weight (3.13 g) was recorded in INM over control (2.57 g), natural farming (2.71 g) and organic farming (2.76 g) but at par with chemical farming (3.04 g). Significantly higher panicle length (22.21 cm) was recorded in INM over control (20.75 cm), natural farming (21.09 cm) and organic farming (21.35 cm) but at par with chemical farming (21.88 cm). Significantly higher number of filled grains $panicle^{-1}$(195) was recorded in INM over control (160), natural farming (174) and organic farming (168) but at par with chemical farming (186). Significantly higher grain yield (5357 kg ha^{-1}) was recorded in INM over control (3632 kg ha^{-1}), natural farming (3986 kg ha^{-1}) and organic farming (4843 kg ha^{-1}) but at par with chemical farming (5164 kg ha^{-1}). Significantly higher straw yield (6428 kg ha^{-1}) was recorded in INM over all other nutrients management practices. The B:C ratio was negative in all three years under study in organic farming and higher B:C ratio was found in chemical farming followed by INM and lower B:C ratio was found in control.

Keywords: Organic farming, chemical farming and natural farming

Introduction
Rice (*Oryza sativa* L.) is the staple food crop of 63 to 65 percent people of India. The crop at present is grown in 43 million hectares of land with production of 96.7 million tonnes. Its production has to be raised to 160 million tonnes by 2030 with a minimum annual growth rate of 2.35% (Venkatramani 2005) [8]. Use of chemical fertilizers though has increased the crop yield, it has several ill effects on soil, environment as well as human and animal health hazards besides making the crop productivity unsustainable in the long run. Indiscriminate use of high levels of N, P and K fertilizers, often leads to nutritional imbalance particularly for micronutrients which ultimately cause deterioration in physicochemical properties of soil and steadily decrease crop yield (Gupta *et al*. 2000) [9]. Use of organic manures improves the soil, physico-chemical and microbiological as it has all essential plant nutrients enriching soil fertility (Choudhary and Suri 2009, 2014; Paul *et al*. 2014, 2016, Choudhary and Rahi 2018) [3, 4, 5, 6, 7]. As more number of farmers are cultivating paddy under organic farming in Telangana state. Keeping in view above facts, a field experiment was conducted to assess the relative performance of different nutrient management practices in terms of growth, yield and economics of kharif rice in Telangana.

Materials and Methods

The field experiment was conducted during kharif-2019, 2020 and 2021in RARS Warangal, located at 18^0 01.077 N latitude 79^0 36.197 E longitude and an altitude of 259 m above mean sea level to study the effect of different nutrient management practices on growth, yield and economics of kharif rice in Telangana. A composite soil sample was collected from 0-20 cm depth during the study, processed and tested in soil science laboratory for soil texture, pH, EC, Organic Carbon (OC%), available nitrogen, phosphorus and available potassium, available Zinc and Iron following standard procedures. The experiment was laid out in completely randomized block design with 5 treatments replicated in four times. The treatments were; T_1 = Organic Farming, T_2 = Chemical Farming, T_3 = Integrated Nutrient Management (INM), T_4 = Control T_5 = Natural Farming. Rice (WGL-32100) was sown during third week of July, transplanted in third week of August. Farm yard manure was applied in organic farming on the nitrogen equivalent basis before transplanting (T_1). The Recommended Dose of Fertilizers (RDF) were applied in chemical farming as per the schedule (T_2). Half of the nitrogen through farm yard manure and remaining half in the form of urea, recommended dose of phosphorus and potassium was applied in the form of DAP and MOP, respectively as per the schedule in INM (T_3). Neither FYM nor chemical fertilizers were applied in control (T_4). The bio enhancers were used as per the standard procedure in the natural farming (T_5). The other cultural practices were carried out according to the standard practices in the rice fields and harvested at 135 days after sowing. The grain and straw samples were collected at harvest, oven dried at 70 °C processed and estimated for total content of N, P and K following standard procedures.

Results and Discussion

The experimental soil was sandy loam in texture, slightly alkaline in reaction (pH: 8.12) and non saline in nature (EC: 0.46 dSm^{-1}). Organic carbon (0.59%) and available nitrogen (141 kg ha^{-1}) were low, medium in available phosphorus (34 kg ha^{-1}) and potassium (278 kg ha^{-1}), sufficient in available Zn (0.70 mg kg^{-1}) and Fe (4.56 mg kg^{-1}).

Plant height

Significantly higher plant height was recorded in INM (112 cm) over control (103 cm) and natural farming (103 cm) but at par with chemical farming (111 cm) and organic farming (109 cm) in 2019. Significantly higher plant height was found in INM (124 cm) over control (109 cm) and natural farming (113 cm) but at par with chemical farming (120 cm) and organic farming (120 cm) in 2020. Non significantly higher plant height (118 cm) was recorded in INM and lower plant height (103 cm) was found in control in 2021 and significantly higher plant height (122 cm) was recorded in INM over all other nutrient management practices in pooled data. Such increase in plant height, might be due to supply of higher nutrients through inorganic fertilizers easily available to plants adequately providing congenial growth which improve the metabolic activity and photosynthesis efficiently and finally improve the dry matter production in sink. These results were in confirmity with Lal Singh *et al*.(2012) [12] they reported that the maximum plant height was noticed with application of 15 t FYM + 120:60:30 kg N: P_2O_5: K_2O ha^{-1} which was significantly superior to rest of the treatments except plant height which was at par with 15 t FYM + 60:60:30 kg N: P_2O_5: K_2O ha^{-1} in 2008 and plant height with 15 t FYM + 60:60:30 kg N: P_2O_5: K_2O ha^{-1} and 15 t FYM ha^{-1} in 2009 and also Mohanty *et al* (2013) [13] stated that plant height of rice at harvest exhibited significant differences due to integrated nutrient management. At harvest 1/3rd N each through chemical fertilizer, FYM and Azolla registered the highest plant height (100.12 cm) as compared to other treatment combinations and was closely followed by application of 50% RDN as chemical fertilizer + 25% RDN as FYM + Azospirillum (98.80 cm), 50% N each through chemical fertilizer and dhaincha (97.95 cm). All these treatments were at par and were superior to sole application of 100% chemical fertilizer alone.

Tillers

Significantly higher number of tillers m^{-2} (347) was recorded in INM over control (255) and natural farming (285) but at par with chemical (327) and organic farming (297) in 2019. Significantly higher number of tillers m^{-2} (403) was found in INM over control (289), natural farming (293) and chemical farming (332) but on par with organic farming (382) in 2020. Significantly higher number of tillers m^{-2} (337) was recorded in INM over natural farming (296) and control (242) but at par with organic farming (317) and chemical farming (321) in 2021 and in pooled data significantly higher number of tillers m^{-2}(365) was found in INM over natural farming (309) and control (279) but at par with organic farming (337) and chemical farming (346). Such increase in tillers might be due to supply of higher nutrients through inorganic fertilizers easily available to plants adequately providing congenial growth which improve the metabolic activity and photosynthesis efficiently and finally improve the dry matter production in sink. These results were supported by Lal singh *et al*. (2012) [12] they stated that the maximum tillers $hill^{-1}$ was noticed with application of 15 t FYM + 120:60:30 kg N: P_2O_5: K_2O ha^{-1}, which was significantly superior to rest of the treatments and mohanty *et al* (2013) [13] stated that application of 1/3rd N each from chemical fertilizer, FYM and Azolla with higher leaf area index and more number of tillers $hill^{-1}$ registered significantly highest dry matter accumulation (985 g/m^2) at 75 DAT.

Table 2: Plant height and tillers of kharif rice as influenced by different nutrient management practices

Treatments	Plant height(cm)				Tillers (m^{-2})			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
Organic farming	109	120	112	117	297	382	317	337
Chemical farming	111	120	115	119	327	332	321	346
INM	112	124	118	122	347	403	337	365
Control	103	109	103	112	255	289	242	279
Natural farming	103	113	110	110	285	293	296	309
SE m±	1.15	1.89	3.28	0.66	10.12	18.50	10.68	12.64
CD (P=0.05)	3.46	5.72	NS	2.00	30	56	32.29	38.21
CV (%)	2.39	3.62	6.58	1.28	7.27	12.17	7.89	8.64

Number of panicles

Significantly higher number of panicles m^{-2} (335) was recorded in INM over control (240), organic farming (283) and natural farming (280) but at par with chemical farming (310) in 2019. In 2020 significantly higher number of panicles m^{-2} (344) was recorded in INM over organic farming (258), control (236) and natural farming (256) but at par with chemical farming (291). Significantly higher number of panicles m^{-2} (276) was found in INM over control (175) but on par with organic (262), chemical (270) and natural farming (250) in 2021 and significantly higher number of panicles m^{-2} (301) was recorded in INM over control (224) and natural farming (272) but at par with chemical

farming (285) and organic farming (280) in pooled data. Increase in growth attributes might be owing to improvement in physico-chemical properties of soil and availability of essential nutrients in optimum quantity, which might have supported the vegetative growth of plant. This clearly indicated that combination of organic and inorganic sources of plant nutrients had advantageous effect over chemical fertilizer alone. These results were supported by Panwar (2014) [14], he stated that maximum panicles m^{-2}, panicle length and number of grains $panicle^{-1}$ were recorded with FYM 5 tonnes ha^{-1} + Azolla coupled with 75% of recommended dose of fertilizer which were closely followed by FYM 5 tonnes ha^{-1} + Azolla dual cropping in the presence of 50 and 100% of recommended dose of fertilizer and also Lal singh *et al*. (2012) [12] stated that the effective tillers $hill^{-1}$, were noticed with application of 15 t FYM + 120-60-30 kg N-P_2O_5- K_2O ha^{-1}, which was significantly superior to rest of the treatments.

Panicle weight (g)

Significantly higher panicle weight (3.76 g) was recorded in INM over control (2.78 g), natural farming (2.93 g) and organic farming (3.01 g) but at par with chemical farming (3.36 g) in 2019. Significantly higher panicle weight (3.43 g) was found in INM over organic farming (2.90 g), natural farming (2.72 g) and control (2.53 g) but on par with chemical farming (3.01 g) in 2020. Non significantly higher panicle weight (2.90 g) was found in INM and lower found in control (2.18 g) in 2021 and significantly higher panicle weight (3.13 g) was recorded in INM over control (2.57 g), natural farming (2.71 g) and organic farming (2.76 g) but at par with chemical farming (3.04 g) in pooled data. The higher growth attributes in integrated nutrient management plots may be ascribed to higher availability of NPK and other nutrients, elevated population of beneficial micro-organisms, production of growth promoting hormones, antibiotics, enzymes etc which helps in improvement of soil health as compared to recommended dose of N fertilizer and control.

Table 3: Number of panicles and panicle weight of kharif rice as influenced by different nutrient management practices

Treatments	Panicles (m^{-2})				Panicle weight (g)			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
Organic farming	283	258	262	280	3.01	2.90	2.35	2.76
Chemical farming	310	291	270	285	3.36	3.01	2.44	3.04
INM	335	344	276	301	3.76	3.43	2.90	3.13
Control	240	236	175	224	2.78	2.53	2.18	2.57
Natural farming	280	256	250	272	2.93	2.72	2.34	2.71
SEm+	8.80	22.80	11.21	9.14	0.14	0.17	0.17	0.09
CD(P=0.05)	26.60	68.94	33.90	27.62	0.43	0.51	NS	0.29
CV (%)	6.79	18.40	10.17	7.50	10.03	12.82	15.21	7.42

Panicle length (cm)

Significantly higher panicle length (22.68 cm) was recorded in INM over control (21.10 cm) and natural farming (21.44 cm) but at par with chemical farming (22.56 cm) and organic farming (21.82 cm) in 2019. Significantly higher panicle length (23.34 cm) was found in INM over organic farming (21.22 cm), natural farming (21.20 cm), control (20.24 cm) and chemical farming (21.82 cm) in 2020. Non significantly higher panicle length (21.76 cm) was found in INM and lower found in control (20.42 cm) in 2021 and significantly higher panicle length (22.21 cm) was recorded in INM over control (20.75 cm), natural farming (21.09 cm) and organic farming (21.35 cm) but at par with chemical farming (21.88 cm) in pooled data. The higher growth attributes in integrated nutrient management plots may be ascribed to higher availability of NPK and other nutrients, elevated population of beneficial micro-organisms, production of growth promoting hormones, antibiotics, enzymes etc which helps in improvement of soil health as compared to recommended dose of N fertilizer and control. These results were in conformity with Gulab Singh Yadav *et al* (2013) [15] with regards to panicle length and test weight, different N sources dose not had significant effect on panicle length during both the seasons and test weight only during kharif season. Although, maximum values of panicle length (31 and 28.9 cm) and test weight (27.3 and 26.4 g) were recorded with the application of FYM@ 11.2 tonnes ha^{-1} along with 50% recommended doses of N fertilizers during both the seasons, respectively followed by 50% recommended N fertilizer dose and Glyricidia leaves @ 11.6 tonnes ha^{-1}.

Filled grains $panicle^{-1}$

Significantly higher number of filled grains $panicle^{-1}$ (231) was recorded in INM over control (157) and natural farming (197) but at par with organic farming (210) and chemical farming (215) in 2019. Significantly higher number of filled grains $panicle^{-1}$ (189) were found in INM over natural farming (164) and control (147) but at par with chemical farming (169) and organic farming (168) in 2020. In 2021 non significantly higher number of filled grains $panicle^{-1}$(190) were recorded in INM and lower number (137) was found in control and significantly higher number of filled grains $panicle^{-1}$(195) was recorded in INM over control (160), natural farming (174) and organic farming (168) but at par with chemical farming (186) in pooled data. The higher growth attributes in integrated nutrient management plots may be ascribed to higher availability of NPK and other nutrients, elevated population of beneficial micro-organisms, production of growth promoting hormones, antibiotics, enzymes etc which helps in improvement of soil health as compared to recommended dose of N fertilizer and control. These results were in conformity with Gulab Singh Yadav *et al* (2013) [15] They reported that among the N sources, application of FYM @11.2 tonnes/ha along with 50% recommended doses of N fertilizers recorded maximum number of productive tillers/hill (12.7 and 12.5), filled grains/panicle (147.5 and 141.5) and grain yield (5.05 and 4.63 tonnes/ha) during both the seasons, respectively followed by the combination of 50% recommended N fertilizer dose and Glyricidia leaves @11.6 tonnes/ha. However, both the treatments remained statistically at par to each other but significantly superior over the other N sources.

Table 4: Panicle length and filled grains $panicle^{-1}$ of kharif rice as influenced by different nutrients management practices

Treatments	Panicle length (cm)				Filled grains $panicle^{-1}$			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
Organic farming	21.82	21.22	20.72	21.35	210	168	147	168
Chemical farming	22.56	21.82	20.96	21.88	215	169	153	186
INM	22.68	23.34	21.76	22.21	231	189	190	195
Control	21.10	20.24	20.42	20.75	157	147	137	160
Natural farming	21.44	21.20	20.56	21.09	197	164	143	174
SEm+	0.29	0.28	0.45	0.19	8.63	7.71	12.80	5.44
CD(P=0.05)	0.89	0.84	NS	0.58	26.10	23.31	NS	16.45
CV (%)	3.00	2.86	4.86	2.01	9.27	10.29	18.60	6.89

Grain yield

Grain yield was significantly influenced due to different nutrient management practices in all three years and pooled study.

However, significantly higher grain yield (5830 kg ha^{-1}) was recorded in INM over control (4612 kg ha^{-1}) and natural farming (4784 kg ha^{-1}) but at par with chemical (5600 kg ha^{-1}) and organic farming (5312 kg ha^{-1}) in 2019. Significantly higher grain yield (5937 kg ha^{-1}) was recorded in INM over natural farming (4075 kg ha^{-1}), chemical (4727 kg ha^{-1}), control (3530 kg ha^{-1}) and organic farming (4077 kg ha^{-1}) in 2020 and significantly higher grain yield (4935 kg ha^{-1}) was found in INM over control (2755 kg ha^{-1}) and natural farming (3099kg ha^{-1}) but at par with organic farming (4821kg ha^{-1}) and chemical farming (4855 kg ha^{-1}) in 2021 and significantly higher grain yield (5357 kg ha^{-1}) was recorded in INM over control (3632 kg ha^{-1}), natural farming (3986 kg ha^{-1}) and organic farming (4843 kg ha^{-1}) but at par with chemical farming (5164 kg ha^{-1}) in pooled data. Such increase in plant height, yield attributes and yield might be due to supply of higher nutrients through inorganic fertilizers easily available to plants adequately providing congenial growth which improve the metabolic activity and photosynthesis efficiently and finally improve the dry matter production in sink. Similar results were also reported by H. Banerjee* and S. Pal (2009) [11] they reported that, under both the rice-rice crop sequences (HYV-HYV and hybrid-hybrid) maximum production per annum was recorded where the crop was fertilized with 100% recommended dose of nutrient through chemical fertilizer in both the seasons (9.20 and 10.25 t ha^{-1} yr^{-1} in HYV-HYV and hybrid-hybrid rice sequence, respectively) and also these results were supported with results reported by Harish MN (2019) revealed that rice grain yield was significantly higher in INM practice (4.18 t/ha) followed by inorganic (4.02 t/ha) and organic practice (3.74 t/ha) and least in control treatment (2.26 t/ha).

Straw yield

Straw yield was significantly influenced by different nutrient management practice in kharif rice in all three years under study. However, significantly higher straw yield (7732 kg ha^{-1}) was recorded in INM over control (5666 kg ha^{-1}) and natural (5976 kg ha^{-1}) but on par with organic farming (7008 kg ha^{-1}) and chemical farming (7052 kg ha^{-1}) in 2019. Significantly higher straw yield (6531 kg ha^{-1}) was recorded in INM over organic farming (4483 kg ha^{-1}), chemical farming (5200 kg ha^{-1}), control (3883 kg ha^{-1}) and natural farming (4484 kg ha^{-1}) in 2020. Significantly higher straw yield (5829 kg ha^{-1}) was found in INM over control (3430 kg ha^{-1}) and natural farming (3809 kg ha^{-1}) but at par with organic farming (5703 kg ha^{-1}) and chemical farming (5741 kg ha^{-1}) in 2021 and significantly higher straw yield (6428 kg ha^{-1}) was recorded in INM over control (4326 kg ha^{-1}), natural farming (5100 kg ha^{-1}), organic farming (5668 kg ha^{-1}) and chemical farming (5856 kg ha^{-1}) in pooled data. Generally, neither sole use of organic manures nor sole use of chemical fertilizers can achieve the crop yield sustainability, thus, their integrated use might have maintained the higher yield levels by supplying primary and secondary micronutrients, and might have enhanced the efficiency of applied nutrients by maintaining favourable soil physico-chemical and microbiological parameters (Choudhary and Suri 2009, 2014; Paul *et al*. 2014, Choudhary and Rahi 2018) [3, 4, 5, 7]. The INM practice exhibited higher grain and straw yield over their respective counter parts. These results were supported by Harish MN 2019 revealed that rice straw yield was significantly higher in INM practice (6.36 t ha^{-1}) followed by inorganic (6.29 t ha^{-1}) and organic practice (6.05 t ha^{-1}) and least in control treatment (3.90 t ha^{-1}).

Table 5: Grain and straw yield of kharif rice as influenced by different nutrient management practices

Treatments	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
Organic farming	5312	4077	4821	4843	7008	4483	5703	5668
Chemical farming	5600	4727	4855	5164	7052	5200	5741	5856
INM	5830	5937	4935	5357	7732	6531	5829	6428
Control	4612	3530	2755	3632	5666	3883	3430	4326
Natural farming	4784	4075	3099	3986	5976	4484	3809	5100
SEm±	279	347	207	122.28	346	382	131	174.96
CD(P=0.05)	842	1050	626	369.76	1045	1155	395	529.04
CV(%)	11.92	17.38	11.31	5.95	11.91	18.21	5.96	7.15

Economics: The B:C ratio was negative in all three years under study in organic farming and higher B:C ratio was found in chemical farming followed by INM and lower B:C ratio was found in control due to low yields were obtained.

Table 6: Cost economics of vanakalam rice as influenced by different nutrient management practices

Treatments	B:C Ratio			
	2019	2020	2021	Pooled
Organic farming	0.79	0.85	0.83	0.82
Chemical farming	1.10	1.17	1.02	1.10
INM	1.00	1.00	1.00	1.00
Control	0.70	0.62	0.60	0.64
Natural farming	0.72	0.69	0.71	0.71

Conclusion

The study demonstrated that Integrated Nutrient Management (INM) significantly enhanced various growth parameters and yield attributes of kharif rice compared to other nutrient management practices. The superior performance of INM, evidenced by higher plant height, increased number of tillers, panicles, panicle weight, panicle length, filled grains per panicle, grain yield, and straw yield, underscores its efficacy in optimizing nutrient availability and fostering plant growth. These results highlight the potential of INM in improving crop productivity and sustainability, suggesting its adoption as a promising agricultural practice for enhancing rice production under similar agro-climatic conditions. Such findings contribute to the body of knowledge supporting balanced nutrient management strategies for sustainable agriculture.

References

1. Harish MN, Choudhary AK, Singh YV, Pooniya V, Das A, Varatharajan T, Babu S. Influence of varieties and nutrient management practices on productivity, nutrient acquisition and resource-use efficiency of rice (*Oryza sativa*) in North-eastern hill region of India. Indian J Agric Sci. 2019 Feb;89(2):367-370.
2. Singh L, Singh P, Kotru R, Hasan B, Chand L, Lone BA. Cow urine spray and integrated nutrient management of rice on productivity and energy use under temperate valley conditions. Indian J Agric Sci. 2012 Jul;82(7):593-598.
3. Choudhary AK, Suri VK. Effect of organic manures and inorganic fertilizers on productivity, nutrient uptake and soil fertility in wheat (Triticum aestivum) - paddy (*Oryza sativa*) crop sequence in western Himalayas. Curr Adv Agric Sci. 2009;1(2):65-69.
4. Choudhary AK, Suri VK. Integrated nutrient management technology for direct-seeded upland rice (*Oryza sativa*) in north-western Himalayas. Commun Soil Sci Plant Anal. 2014;45(6):777-784.

5. Paul J, Choudhary AK, Suri VK, Sharma AK, Kumar V, Shobhna. Bioresource nutrient recycling and its relationship with biofertility indicators of soil health and nutrient dynamics in rice-wheat cropping system. Commun Soil Sci Plant Anal. 2014;45(7):912-924.
6. Paul J, Choudhary AK, Sharma S, Savita, Bohra M, Dixit AK, Kumar P. Potato production through bio-resources: Long-term effects on tuber productivity, quality, carbon sequestration and soil health in temperate Himalayas. Sci Hortic. 2016;213:152-163.
7. Choudhary AK, Rahi S. Organic cultivation of high yielding turmeric (Curcuma longa L.) cultivars: A viable alternative to enhance rhizome productivity, profitability, quality and resource-use efficiency in monkey-menace areas of north-western Himalayas. Ind Crops Prod. 2018;124:495-504.
8. Venkatramani G. Making a smart recovery. In: The Hindu Survey of Indian Agriculture. Chennai: The Hindu Group of Publications; c2005. p. 5-6.
9. Gupta LP, Bisht PS, Pandey PC. Integrated organic and inorganic N management in low land rice. Oryza. 2000;75(2):120-123.
10. Harish MN, Choudhary AK, Singh YV, Pooniya V, Das A, Varatharajan T, Babu S. Influence of varieties and nutrient management practices on productivity, nutrient acquisition and resource-use efficiency of rice (*Oryza sativa*) in North-eastern hill region of India. Indian J Agric Sci. 2019 Feb;89(2):367-370.
11. Banerjee H, Pal S. Integrated nutrient management for rice-rice cropping system. Oryza. 2009;46(1):32-36.
12. Singh L, Singh P, Kotru R, Hasan B, Chand L, Lone BA. Cow urine spray and integrated nutrient management of rice on productivity and energy use under temperate valley conditions. Indian J Agric Sci. 2012 Jul;82(7):593-598.
13. Mohanty M, Nanda SS, Barik AK. Effect of integrated nutrient management on growth, yield, nutrient uptake and economics of wet season rice (*Oryza sativa*) in Odisha. Indian J Agric Sci. 2013 Jun;83(6):599-604.
14. Panwar AS. Integrated nutrient management for sustaining wetland rice (*Oryza sativa*) production in mid hills altitude of Meghalaya. Indian J Agric Sci. 2014 Jul;84(7):828-831.
15. Yadav GS, Datta M, Babu S, Debnath C, Sarkar PK. Growth and productivity of lowland rice (*Oryza sativa*) as influenced by substitution of nitrogen fertilizer by organic sources. Indian J Agric Sci. 2013 Oct;83(10):1038-1042.