INNOVARE JOURNAL OF AGRICULTURAL SCIENCE

Vol 12, Issue 6, 2024

ISSN - 2321-6832

Research Article

OPPORTUNITIES OF INTEGRATED NUTRIENT MANAGEMENT IN KANCHANPUR, NEPAL

JANAK PANT*, PRAVA DAWADI

Department of Soil Science and Agricultural Engineering, Agriculture and Forestry University, Rampur, Chitwan, Nepal. Email: janakpant500@gmail.com

Received: 21 August 2024, Revised and Accepted: 13 October 2024

ABSTRACT

Objectives: The study of opportunities for integrated nutrient management lacking in the Kanchanpur district. Hence, an experiment was carried out to study different combinations of fertilizers to determine suitable integration of fertilizers during November 2023–September 2024.

Methods: The experiment was conducted in a randomized complete block design. Paddy and vegetable (cauliflower) crops were selected for the 14 research. The sources of fertilizers applied in the research were FYM (Farmyard Manure), poultry manure, vermicompost, green manures, and chemical fertilizer. Six combinations of treatments were prepared, namely (i) T1: 100% N from the recommended dose of chemical fertilizer (RDF) (RDF:200:120:80 NPK kg/ha), (ii) T2: 50% N from RDF+50% N from farmyard manure (FYM), (iii) T3: 50% N from RDF+50% N from poultry manure (PM), (iv) T4: 50% N from RDF+50% N from vermicompost (VC), (v) T5: 50% N from RDF+50% N from green manure (GM), and (vi) T6: 20% N from 17 RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM.

Results: Combinations of 50% N from RDF+50% N from FYM, 50% N from RDF+50% N from PM, 50% N from RDF+50% N from VC, and 50% N from RDF+50% N from GM provided almost similar results in plant parameters, root, and soil property. Sole application of 100% N from the RDF resulted with the lowest effect in plant and soil attributes.

Conclusion: The integration of 20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM was found to be the most effective nutrient management opportunity in the district.

Keywords: Integrated, Management, Soil, Treatment.

 DOI: http://dx.doi.org/10.22159/ijags.2024v12i6.52912. Journal homepage: https://innovareacademics.in/journals/index.php/ijags

INTRODUCTION

Integrated nutrient management (INM) refers to the maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic, and biological components in an integrated manner. Fertilizers have played a prominent role in improving production and productivity in Asia and have transformed food scarcity into sufficiency. INM consists of the application of local products such as natural and mineral fertilizer, crop residues, farmyard manure (FYM), integration of agriculture and forestry, soil amendments, farm waste recycling, waste products from kitchen, green manures (GM), and compost (Rautaray *et al*., 2003; Shah *et al*., 2003; Shah and Ahmad, 2006; Khoshgoftarmanesh *et al*., 2010; Selim and Al-Owied, 2017; Selim, 2018). According to the researchers, the implications of organic manures may have negative consequences, and some organic materials limit the growth and development of plants when applied solely, maybe due to proliferating levels of phytotoxins and high C/N ratio, particularly in organic materials which are not mature (Haug, 1993; De Bertoldi *et al*., 2010).

It is imperative to improve and manage natural resources including soil, air, and water, for improving food production while protecting the environment. In the contemporary situation, the major constraints observed in planning and executing agriculture-related matters may compound hunger and food deficit, and planners are the projection of a world without hunger and poverty intensified by rising standards of living in rural regions, where the majority of poor people live and their total dependence on agriculture for living to fulfill their food demands (Wheller and Braun, 2018). Due to the alarming state of world population and scarcity of land, crop production and productivity should be increased to meet the objective of zero hunger. To compensate for food hunger and improve food production management of soil and fertility is of utmost value. It has been found that most producers face costs of production due to the pressure of quick and high production by the application of chemical fertilizers. This has created a situation of financial loss and stress for farmers. Through numerous studies, it has been observed that the sole application of NPK as per the test of soil results in low production as per recommendation and realized using other micronutrients or combinations of fertilizers. Long-term and continuous use of N fertilizers results in soil acidity which results in soil infertility where crops resist additional application of N fertilizers (Sainju *et al*., 2019). The productivity of soil declines gradually.

Increased chemical fertilizer costs and awareness of environmental pollution have necessitated using organic fertilizers for the development of more efficient fertility management programs. To achieve sustainable and appropriate production and healthy soil it is felt necessary to apply a systematic mixture of organic, inorganic, and bio-organic microorganisms in a balanced way, which is also known to be INM approach (Janssen *et al*., 1993). This helps to enhance soil networks, layers, micronutrients, and crop absorption of fertilizer in a balanced way. In addition, it can match the crop nutrient requirements and decrease the problems of nutrient deficiency creating a healthy environment without affecting its living and non-living components. If the mixture is properly not carried out, it may result in soil degradation, nutrient deficiency, and soil runoff (Craft and Nelson, 1996). The soil with rich organic matter and nutrients is then indirectly degraded.

Organic manures in a proper blend with chemical fertilizers will predictably support crop growth. If organic matter is scientifically added with chemical fertilizers growth, development and productivity of crops could be noticed (Kumar *et al*., 2009). Kumar and Sharma (2004) reported that the application of organic manures with recommended

NPK was found crucial to gain the expected yield and release of soil micronutrients (NPK) in both tomatoes and carrots. Hence, the farmers may profit through the recycling of organic waste, found locally, which helps to influence planners that lead producers to minimize and replace the problems of traditional methods of organic waste disposal, with minimum or zero hampering of plants, ecological systems, or beneath ground layers including the health of human to grasp the potential application of existing natural resources (Gaur *et al*., 1995; Kumar and Sharma, 2004; Abdel-Aziz and Al-Barakah, 2005; Khoshgoftarmanesh *et al*., 2010). Such a mixture has unexpected benefits to soil and crop, and ultimately to the producers.

Biofertilizers are mostly bacteria or fungi that help in nitrogen fixation, phosphate solubilization, sulfur oxidation, plant hormone production, and decomposition of organic compounds (Verma *et al*., 2018). GM may release nutrients slowly which are much beneficial for plant roots to consume gradually leading to improved efficiency of nutrient uptake, crop growth, and production (Desaeger and Rao, 2001). These manures are easily available and effective when mixed with other forms of fertilizers.

Locally available organic sources of nutrients such as FYM, poultry manure (PM), and vermicompost (VC) should not be applied solely. Application of organic manures and biological fertilizers cannot alone enhance the production of crops despite sustaining soil health. The study of opportunities for combined and systematic application of fertilizers still lacking in the district. In this study, various sources of fertilizers were assessed discretely and in a combined manner to determine suitable and effective combinations of fertilizers.

METHODS

Various sources and methods of fertilizer application include FYM, PM, VC, GMs, and chemical fertilizer was five aspects of research conducted in the Kanchanpur district during November 2023–September 2024.

The experiment was carried out in a randomized complete block design (RCBD). Paddy and vegetables (cauliflower) were selected for the research. Cultivation methods were conducted as per the land preparation, field design, sowing, transplantation, and harvesting. The effect of fertilizer and methods were assessed from randomly selected 10 sample plants of each crop from the field. Plants were tagged and numbered for recording the data. Plant parameters consist of the number of leaves, plant height, weight of cauliflower curd, and yield. Root parameters were assessed after the application of each treatment. Soil samples from depths up to 10 cm were collected to test in the laboratory. Combinations of six treatments were prepared as per Table 1.

The recorded data were all tabulated and systematically arranged using MS Excel which was subjected to analysis of variance and Duncan's multiple range test (DMRT-0.05 level) for mean separations using Gen stat software.

RESULTS

Effect on plant parameters

It was observed that except integrated and standalone treatment of nitrogen, the effect of treatment in a number of leaves, height, weight of curd, and yield was almost similar. The average numbers of leaves in paddy and cauliflower were found to be 15 and 18 with the application of (T6) 20% N from recommended dose of fertilizer (RDF)+20% N from FYM+20% N from PM+20% from VC+20% N from GM followed by 11 and 12 (paddy and cauliflower) from the application of (T5) 50% N from RDF+50% N from GM, 12 and 13 (paddy and cauliflower) through the application of (T4) 50% N from RDF+50% N from VC, both 11 (paddy and cauliflower) from the application of (T3) 50% N from RDF+50% N from PM, 12 and 14 (paddy and cauliflower) from the application of (T2) 50% N from RDF+50% N from FYM and 9 and 10 (paddy and cauliflower) by the application of (T1) 100% N from recommended dose of chemical fertilizer (RDF) (RDF: 200:120:80 NPK kg/ha). The least number of leaves, weight of curd, and yield were observed in standalone treatment, that is, T1-100% N from RDF (RDF: 200:120:80 NPK kg/ha). The most excellent yield in rice and cauliflower (in t/ha) was favored in all mixed fertilizers of (T6) 20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM, that is, 2.3 and 14 respectively (Fig. 1).

Effects in root length and diameter

It was recorded that variation in root length and diameter in each crop was almost non-significant in T2, T3, T4, and T5 except T1 and T6 applied fields. The root length and diameter were found highest of 23 cm and 0.05 cm in paddy, and 18 cm and 0.93 cm in cauliflower with T6-20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM treated field. Whereas root length and diameter were noticed to be lowest of 15 cm and 0.01 cm in rice and 13 cm and 0.61 in cauliflower through T1-100% N from RDF (RDF: 200:120:80 NPK kg/ha) treated field (Fig. 2).

Effects in soil pH, organic matter, total nitrogen, and phosphorus

It was observed that soil pH and total nitrogen values with 6.87 and 0.12 were found more toward neutrality in T6-20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM, whereas total nitrogen was uniform with 0.12 (%) in T5-50%N from RDF+50% N from GM and T2-50% N from RDF+50% N from FYM treated plots. Organic matter was observed highest with the values 2.68 in T2-50% N from RDF+50% N from FYM followed by T6-20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM and T1-100% N from RDF (RDF: 200:120:80 NPK kg/ha), whereas intermediate values for T3, T4, and T5 were almost significantly similar with each other. Highest phosphorus values were analyzed in T1-100% N from RDF (RDF: 200:120:80 NPK kg/ha) with 147 kg/ha followed by T6-20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM with 145 kg/ha and least in T4-50% N from RDF+50% N from VC with 106 kg/ha, whereas other values were intermediate and uniform with each other in case of T2, T3, and T5 treated plots (Table 2).

DISCUSSION

Effects on plant parameters

The number of leaves, height, weight of curd, and yield of rice and cauliflower were found highest in the field treated with RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM (T6). The results of the present investigation in terms of plant height correlate with the findings of Rakesh *et al.* (2006), Mitiku *et al.* (2014), and Shree

Table 1: Treatment details of experimental field

Treatment symbol	Treatment detail
T1	100% N from the recommended dose of chemical fertilizer (RDF) (RDF: 200:120:80 NPK kg/ha)
T2	50% N from RDF+50% N from FYM
T3	50% N from RDF+50% N from poultry manure
T4	50% N from RDF+50% N from vermicompost
T5	50% N from RDF+50% N from green manure
T6	20% N from RDF+20% N from FYM+20% N from poultry manure+20% from vermicompost+20% N from green manure

RDF: Recommended dose of fertilizer, FYM: Farmyard manure

Table 2: Effects of various treatments on soil attributes

Treatments	Soil pH	Organic matter (%)	Total nitrogen (%)	Total phosphorus (kg/ha)
T6	6.87	2.34	0.12	145
T5	6.53	2.08	0.12	120
T4	6.64	2.22	0.13	106
T3	6.48	2.27	0.11	136
T2	6.52	2.68	0.12	115
T1	6.21	1.69	0.08	147

pH: Potential of hydrogen, %: Percentage, kg/ha: Kilogram per hectare

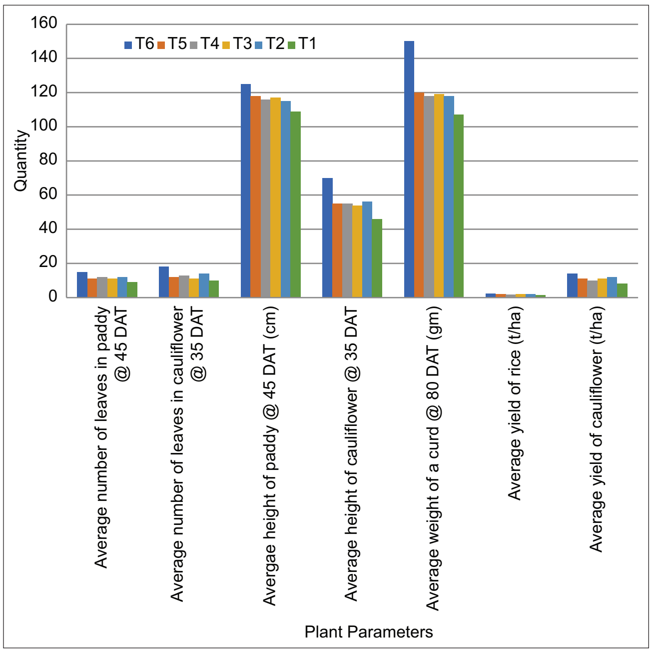

Fig. 1: Comparison of various treatments in plant parameters. DAT: Days after transplantation, t/ha: Ton per Hectare, cm: Centimeter

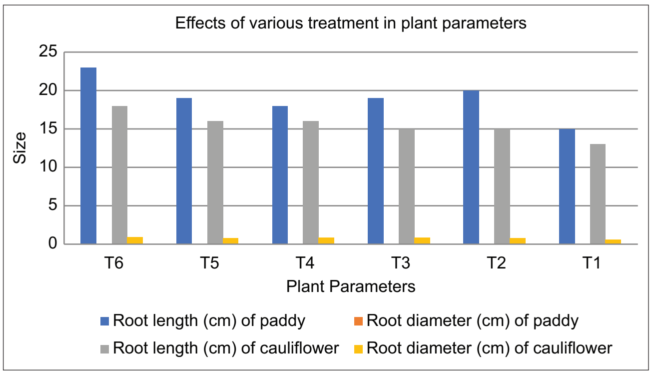

Fig. 2: Effects of different treatments on root length and diameter. cm: Centimeter

et al. (2014) who reported increased plant height due to the combined application of organic and inorganic fertilizers. The result may reflect adding organic manures with inorganic fertilizers which uplifts the availability of nutrients considerably resulting in a positive effect on growth parameters. Kumar *et al.* (2013) analyzed the maximum number of leaves in broccoli under integrated application of inorganic fertilizers and VC. The characteristics of organic manure of solubilizing effect on soil nutrients including chelating effects on metal ions and hence increased availability of nutrients to the plants. Mehdi *et al.* (2011) study furthers those combinations of chemical fertilizer and GM (sesbania) provides good results in the yield of crops, which coincides with the present study. The results found were in following the findings of Bhanushalini *et al.* (2002), Ghosh *et al.* (2009), and Dalal *et al.* (2010), according to whom the integration of chemical fertilizer with VC provides the best curd weight in cauliflower. The increased curd size in integrated treatment with VC could be due to the added supply of nutrients and a prolific root system improving the absorption of water and nutrients along with the physical environment.

In comparison with the other sources of organic manure or treatment combination the appropriate and regular availability of nutrient from vermicomposting (VC) is observed better in the yield of paddy. The finding coincides with the research study of Singh and Kumar (2010). The significant yield with increasing levels of fertilizers might be due to a better quantity of nutrients applied in the soil, Yadav and Meena (2014) reported similar results. This result was supported by the experiment of Kumar *et al.* (2008) and Ahmed *et al.* (2014).

Effects in root length and diameter

The root length and diameter were found highest in paddy and cauliflower with 20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM treated field. Similar findings were also observed in research performed by Gadi *et al.* (2017) in green gram. This may be attributed to improved soil properties such as bulk density and water-holding capacity encouraged by organic manures and better availability of nutrients which promote root length and proliferation. Our finding represents quality root development under integrated treatment combinations as supported by results found by Khatri *et al.* (2019) in radish. This may be due to the mixing of organic manure reducing mechanical resistance, better aeration, and lower bulk density of the surface soil that facilitated better root proliferation creating proper growth and development of roots.

It was noticed that integrated application of organic and inorganic fertilizers could markedly improve crop root length density, root volume, and root dry weight, as well as the depths of root penetration (Mandal *et al*., 2003). It was reported that the incorporation of organic manure into paddy soil helps to increase the size of the root, its quality, and diameter due to increased absorption area, and root surface phosphatase activity (Yang *et al*., 2004).

Effects in soil pH, organic matter, total nitrogen, and phosphorus

It was observed that soil pH and total nitrogen were found more toward neutrality in T6-20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM applied field. This reflects that the application of inorganic fertilizer creates the soil acidic while integrating organic and inorganic fertilizers helps to balance the soil pH. A similar result was observed in a study done by Kafle *et al.* (2019) under the integrated application of organic and inorganic fertilizers. This may be attributed to the buffering capacity of the organic manures, which resists transformation in pH values; however, mixing of organic manures tends to enhance the pH values and leads to neutrality.

The increased total nitrogen may be attributed to the slow release of the mineral nutrients while the low total nitrogen might be attributed to the loss of the mineral nutrients or due to the efficient utilization of mineralized nitrogen in a short growing period. Similar results were noticed in the past study of Choudhary *et al.* (2012) and Devi *et al.* (2018).

Organic matter was observed highest in 50% N from RDF+50% N from FYM applied field in comparison with other treatment combinations. Higher amounts of organic matter in the soil receiving an integrated supply of chemical fertilizer and FYM might be observed with intensive amounts of FYM applied in the field. Citak and Sonmez (2001) reported that FYM and PM application had positive effects on soil organic matter more than the other organic manures. Kafle *et al.* (2019) and Ojha *et al.* (2019) also studied the organic residue of plant and animal wastes, which are the basis of organic matter and humus, which supply nutrients for the critical role of microorganisms and plant root development.

The highest phosphorus values were analyzed in 100% N from RDF (RDF: 200:120:80 NPK kg/ha) followed by T6-20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM with 145 kg/ha applied field. Treatment having inorganic fertilizer increases the soil's available phosphorus. The result was in light with Devi *et al.* (2018) who observed the addition of organic manure such as FYM, VC, GM, and PM with inorganic fertilizer had a beneficial effect in improving the phosphate availability thus reducing phosphorus accumulation in soil. Low phosphorus content in INM treatments may be because of the efficient utilization of phosphorus by the plants.

CONCLUSION

It was challenging to analyze soil properties in the laboratory. Study of opportunities of INM lacks in the research area. Hence, an experiment was conducted to study various combinations of fertilizers to determine suitable integration of fertilizers with their method of fertigation during November 2023–September 2024. The experiment was carried out in RCBD. Paddy and vegetable (cauliflower) crops were selected for the research. Combinations of 50% N from RDF+50% N from FYM, 50% N from RDF+50% N from PM, 50% N from RDF+50% N from VC, and 50% N from RDF+50% N from GM provided almost similar results in plant parameters, root, and soil property. Sole application of 100% N from the RDF (RDF: 200:120:80 NPK kg/ha) resulted in the lowest effect. The integration of 20% N from RDF+20% N from FYM+20% N from PM+20% from VC+20% N from GM was found most effective and sustainable for better soil property and crop development.

ACKNOWLEDGMENT

I would like to express my sincere gratitude to my supervisor, Asst. Prof. Suraj Karki for his insightful support, invaluable guidance, and supervision. I always remember the kind support I got from the staff of municipalities and farmers of Kanchanpur district. I think this entire work was impossible without the support of my family. I am indebted to my parents for all kinds of desired support. I am highly thankful to my teammates and colleagues who have consistently supported me during the research and article preparation process. Finally, I must thank all known and unknown helping hands from my organization, and all other respected persons.

CONFLICT OF INTEREST

The submitted research and article are the original work of the authors (Mr. Janak Pant and Mrs. Prava Dawadi) and both authors have contributed significantly to the pursuance of the research.

It is declared that the submitted article is free of fore-publication or from the current review process except this. Copyrights of all the authors embedded in this paper are truly respected and non-replicable. We are ready to commit any punishment relying on if found guilty or punishable.

AUTHORS FUNDING

The research was carried out without any funding from external sources.

REFERENCES

Abdel-Aziz, R. A., & Al-Barakah, F. N. (2005). Composting technology and the impact of compost on soil biochemical properties. *Arab Gulf Journal of Scientific Research*, *23*(2), 80-91.

Ahmed, S., Basumatary, A., Das, K. N., Medhi, B. K., & Srivastava, A. K. (2014). Effect of integrated nutrient management on yield, nutrient uptake, and soil fertility in Autumn rice on Inceptisol of Assam. *Annals of Plant and Soil Research*, *16*(3), 192-197.

Bhanushalini, S., Channal, H. T., Hebsur, N. S., Dharmatti, P. R., & Sarangamath, P. A. (2002). Effect of nitrogen management on yield of knol-khol and population of *Azospirillum* in vertisol. *Karnataka Journal of Agricultural Sciences*, *15*(1), 151-153.

Choudhary, S., Soni, A. K., & Jat, N. K. (2012). Effect of organic and inorganic sources of nutrients on growth, yield and quality of sprouting broccoli cv. CBH-1. *Indian Journal of Horticulture, 69*(1), 550-554.

Citak, S., & Sonmez, S. (2001). Effects of different organic manure applications on the macro nutrient contents of soil in different growing seasons. *Journal of Agricultural Science and Technology*, *5*(1), 157-163.

Craft, C. M., & Nelson, E. B. (1996). Microbial properties of composts that suppress damping-off and root rot of creeping bentgrass caused by *Pythium graminicola*. *Applied and Environmental Microbiology, 62*(5), 1550-1557.

Dalal, V. V., Bharadiya, P. S., & Aghav, V. D. (2010). Effect of organic and inorganic sources of nitrogen on quality of cabbage (*Brassica oleracea* var. *Capitata* L.). *International Journal of Agricultural Sciences*, *6*(2), 599-601.

De Bertoldi, M. H., Insam, I. H., & Franke-Whittle, M. (2010). Production and utilization of suppressive compost: Environmental, food and health benefits. In *Microbes at Work from Wastes to Resources* (Vol. 1) (pp. 153-170). Berlin: Springer.

Desaeger, J., & Rao, M. R. (2001). The potential of mixed covers of *Sesbania*, *Tephrosia* and *Crotalaria* to minimize nematode problems on subsequent crops. *Field Crops Research, 70*(2), 111-125.

Devi, M., Spehia, R. S., Menon, S., Mogta, A., & Verma, A. (2018). Influence of integrated nutrient management on growth and yield of cauliflower (*Brassica oleracea* var. Botrytis) and soil nutrient status. *International Journal of Chemical Studies*, *6*(2), 2988-2991.

Gadi, P., Dawson, J., & Shankar, M. (2017). Effect of different organic manures, inorganic fertilizers and growth regulators on growth and yield of greengram (*Vigna Radiata* L.). *Bulletin of Environment, Pharmacology and Life Sciences*, *6*(1), 67-75.

Gaur, A. C., Singh, G., & Tandon, H. L. S. (1995). Recycling of rural and urban wastes through conventional and vermicomposting. In *Recycling of crop, animal, human and industrial wastes in agriculture* (pp. 31-35). New Delhi: FDCO-India.

Ghosh, C., Mandal, J., & Chattopadhyay, G. N. (2009). Effect of Vermicompost on Growth and Yield of Cabbage. In *International conference on horticulture* (pp. 1758-1759).

Haug, R. T. (1993). *The practical handbook of compost engineering*. Boca Raton, FL, USA: Lewis Publishers.

Janssen, B. H., van Reuler, H., & Prins, W. H. (1993). Integrated nutrient management: Using organic and mineral fertilizers. In *The role of plant nutrients for sustainable crop production in sub-Saharan Africa* (pp. 89-105). Wageningen, Netherlands: Ponsen and Looijen.

Kafle, K., Shriwastav, C. P., & Marasini, M. (2019). Influence of integrated nutrient management practices on soil properties and potato yield (*Solanum tuberosum*. L) in an Inceptisol of Khajura, Banke. *International Journal of Applied Science and Biotechnology, 7*(3), 365-369.

Khatri, K. B., Ojha, R. S., Pandey, K. R., & Khanal, B. R. (2019). Effects of different sources of organic manures in growth and yield of radish (*Raphanus sativus* L.) *International Journal of Applied Sciences and Biotechnology, 7*(1), 39-42.

Khoshgoftarmanesh, A. H., Schulin, R., Chaney, R. L., Daneshbakhsh, B., & Afyuni, M. (2010). Micronutrient-efficient genotypes for crop yield and nutritional quality in sustainable agriculture. *A review, Agronomy for Sustainable Development*, *30*(1), 83-107.

Kumar, A., Sharma, S., & Mishra, S. (2009). Application of farmyard manure and vermin-compost on vegetative and generative characteristics of *Jatropha curcas*. *Journal of Phytopathology*, *1*(4), 206-222.

Kumar, B., Gupta, R. K., & Bhandari, A. L. (2008). Soil fertility changes after long-term application of organic manures and crop residues under rice-wheat system. *Journal of Indian Society of the Soil Science*, *56*(1), 80-85.

Kumar, M., Das, B., Prasad, K. K., & Kumar, P. (2013). Effect of integrated nutrient management on growth and yield of broccoli (*Brassica oleracea* var. italica) under Jharkhand conditions. *Journal of Vegetable*

Science, *40*(1), 117-120.

Kumar, P., & Sharma, S. K. (2004). Integrated nutrient management for sustainable cabbage- tomato cropping sequence under mid hill conditions of Himachal Pradesh. *Indian Journal of Horticulture*, *61*(4), 331-334.

Mandal, U. K., Singh, G., Victor, U. S., & Sharma, K. L. (2003). Green manuring: Its effect on soil properties and crop growth under rice-wheat cropping system. *European Journal of Agronomy*, *19*(2), 225-237.

Mehdi, S. M., Sarfraz, M., Abbas, S. T., & Shabbir, G. (2011). Integrated nutrient management for rice-wheat cropping system in a recently reclaimed soil. *Soil & Environment Journal*, *30*(1), 36-44.

Mitiku, W., Temedo, T., Singh, T. N., & Teferi, M. (2014). Effect of integrated nutrient management on yield and yield components of barley (*Hordium vulgare* L.) in Keffa Zone, Southwestern Ethiopia. *Science Technology Arts Research Journal*, *3*(2), 34-42.

Ojha, R. B., Pandeand, K., & Khatri, K. (2019). Nutrient Risk management using organic manures in radish production at Rampur, Chitwan, Nepal. In *Advances in ecological and environmental research* (pp. 21-31). Italy: FAO, Rome.

Rakesh, S., Chaurasia, S. N., & Singh, S. N. (2006). Response of nitrogen sources and spacing on growth and yield of broccoli (*Brassica oleracea* var. Italica plenck). *Vegetables Science, 33*(2), 198-200.

Rautaray, S. K., Ghosh, B. C., & Mittra, B. N (2003). Effect of fly ash, organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in a rice-mustard cropping sequence under acid lateritic soils. *Bioresource Technology, 90*(3), 275-283.

Sainju, U., Ghimire, R., & Pradhan, G. (2019). Nitrogen fertilization I: Impact on crop, soil, and environment. In E. C. Rigobelo and A. P. Serra (Eds.), *Nitrogen Fixation.* London: Intech Open.

Selim, M. (2018). Potential role of cropping system and integrated nutrient management on nutrients uptake and utilization by maize grown in calcareous soil. *Egyptian Journal of Agronomy*, *40*(3), 297-312.

Selim, M. M., & Al-Owied, A. J. A. (2017). Genotypic responses of pearl millet to integrated nutrient management. *Bioscience Research*, *14*(2), 156-169.

Shah, Z., & Ahmad, M. I. (2006). Effect of integrated use of farmyard manure and urea on yield and nitrogen uptake of wheat. *Journal of Agricultural and Biological Science*, *1*(1), 60-65.

Shah, Z., Shah, S. H., Peoples, M. B., Schwenke, G. D., & Herridge, D. F. (2003). Crop residue and fertilizer N effects on nitrogen fixation and yields of legume-cereal rotations and soil organic fertility. *Field Crops Research*, *83*(1), 1-11.

Shree, S., Singh, V. K., & Kumar, R. (2014). Effect of integrated nutrient management on yield and quality of cauliflower (*Brassica Oleracea* var *Botrytis* L.). *An International Quarterly Journal of Life Sciences*, *9*(3), 1053-1058.

Singh, D., & Kumar, A. (2010). Effect of sources of nitrogen on growth, yield, and uptake of nutrient in rice. *Annals of Plant and Soil Research*, *16*(4), 359-361.

Verma, M., Mishra, J., & Arora, N. K. (2018). Plant growth-promoting Rhizobacteria: Diversity and applications. In *Environmental Biotechnology of Sustainable Future* (pp. 129-173). Cham: Springer.

Wheller, T., & Braun, J. (2018). Climate change impacts on global food security. *Science,* 341(6145), 508-513.

Yadav, L., & Meena, N. (2014). Performance of aromatic rice (*Oryza sativa*) genotype as influenced by integrated nitrogen management. *Indian Journal of Agronomy*, *59*(2), 51-255.

Yang, C. M., Yang, L. Z., Yang, Y. X., & Ou, Y. Z. (2004). Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. *Agricultural Water Management, 70*(1), 67-81.