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Study on effect of nutrient management practices on yield and quality of maize (*Zea mays* L.)

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ABSTRACT

A field experiment on “Study on effect of nutrient management practices on yield and quality of maize (*Zea mays* L.)” was conducted during kharif 2024-25 at the Research farm of Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). The experiment consisted of twelve treatments with different sources of nutrient management in various manners. Among them, a set of twelve treatments viz., T_1 - Control, T_2 - 25 % RDF + FYM @ 8 t/ha, T_3 - 50 % RDF + FYM @ 6 t/ha, T_4 - 100 % RDF (NPK @ 120:60:40 kg/ha), T_5 - 25% RDF + Vermicompost @ 8 t/ha, T_6 - 50% RDF + Vermicompost @ 6 t/ha, T_7 - 25% RDF + Azotobactor, T_8 - 50% RDF + PSB, T_9 - 25% RDF + FYM @ 8 t/ha + Azotobactor, T_{10} - 50% RDF + FYM @ 5 t/ha + PSB, T_{11} - FYM @ 10 t/ha + PSB, T_{12} - FYM @ 5 t/ha + Vermicompost @ 5 t/ha + PSB were tested in randomized block design with 3 replications. The experiment was laid out in a randomised block design (RBD) with three replications.

The application of 100% Recommended Dose of Fertilizers (RDF) at 120:60:40 NPK kg/ha significantly enhanced the growth, yield attributes, and productivity of maize across all observed parameters. This nutrient management practice led to the highest plant height, number of leaves per plant, fresh and dry biomass, number and size of cobs, grain weight, and grain yield at both plant and hectare levels. Moreover, it resulted in a significantly higher harvest index and protein content, indicating better partitioning of dry matter and improved nutritional quality of the grain. These outcomes demonstrate the effectiveness of balanced fertilization in maximising the physiological performance and output of maize. In terms of economic returns, manual hand weeding treatment, although associated with a higher cost of cultivation, achieved the highest gross and net monetary returns as well as the most favorable benefit-cost (B:C) ratio of 3.13:1. This suggests that investing in labour-intensive weed control methods can substantially improve profitability when paired with optimal nutrient management. Thus, integrating 100% RDF application with effective weed management strategies like manual hand weeding can serve as a sustainable approach to enhance maize productivity and farm income.

Keywords: Organic, Branches, Bio-fertilisers, Grains, Silk, Tassel, Seed index, Stover yield

Introduction

Maize (*Zea mays* L.), commonly referred to as corn, is one of the most vital cereal crops globally, serving as a staple food, a source of animal feed, and an industrial raw material. As the third most cultivated crop after wheat and rice, maize plays a pivotal role in ensuring global food security and sustaining rural livelihoods. Its adaptability to diverse agro-climatic conditions and its multifaceted uses make it indispensable in both developed and developing countries. However, achieving high productivity and grain quality in maize is heavily influenced by a range of agronomic practices, among which nutrient management stands out as a critical factor.

Maize (*Zea mays* L.) is one of the most widely cultivated cereal crops globally and holds significant importance for food, feed, and industrial applications. It is cultivated in over 160 countries across diverse agro-climatic zones, covering more than 197 million hectares worldwide, with an annual production exceeding 1.2 billion tonnes (FAO, 2023) [1]. In India, maize occupies around 9.5 million hectares with a total production of approximately 31.5 million tonnes and an average productivity of 3.3 tonnes per hectare (Directorate of Economics and Statistics, 2022) [2]. The crop's versatility and adaptability to various soil and climate conditions make it a key component in agricultural systems. Despite its vast cultivation, maize productivity varies significantly due to differences in agro-techniques, soil fertility, and nutrient management practices, indicating substantial potential for improvement through scientific interventions.

Nutritionally, maize plays a critical role in the diets of millions, especially in developing countries, where it is a staple food. Maize grains are a rich source of carbohydrates, providing about 365 kcal per 100 grams, and contain moderate amounts of protein (7–10%), dietary fiber, and essential micronutrients such as magnesium, zinc, and B-complex vitamins (Nuss *et al.*, 2010) [3]. However, maize is relatively low in essential amino acids like lysine and tryptophan, which can limit its protein quality. To address this, biofortified vari-

eties such as Quality Protein Maize (QPM) have been developed. Given its nutritional significance and growing global demand, optimizing maize production through improved agronomic practices, especially nutrient management, is crucial to enhance both food security and nutritional outcomes.

Nutrient management in maize cultivation involves the judicious application of essential plant nutrients, including macronutrients (such as nitrogen, phosphorus, and potassium) and micronutrients (like zinc, boron, and iron), to optimize plant growth and development. Modern agricultural systems face the dual challenge of maintaining soil fertility while enhancing crop productivity in a sustainable manner. Imbalanced or excessive use of chemical fertilizers, a common practice in intensive maize farming, often leads to soil degradation, nutrient leaching, and environmental pollution. Conversely, insufficient nutrient supply can severely limit the crop's genetic yield potential. Therefore, integrated and site-specific nutrient management strategies have become increasingly important to address these challenges effectively.

The adoption of Nutrient Management (NM) practices—combining organic manures, crop residues, green manures, biofertilizers, and inorganic fertilizers—offers a balanced approach that not only sustains soil health but also improves the yield and quality attributes of maize. Organic sources enhance microbial activity and soil structure, while inorganic fertilizers provide immediate nutrient availability. Furthermore, advancements in precision agriculture now allow for the targeted application of nutrients based on real-time soil and crop needs, minimizing waste and maximizing efficiency. The synergy between different nutrient sources and application techniques can significantly influence the physiological and biochemical processes in maize, thereby improving both quantitative and qualitative crop parameters.

Yield attributes of maize, including cob length, kernel number per cob, grain weight, and overall biomass, are directly linked to the crop's nutrient status throughout its growth stages. Likewise, quality parameters such as protein content, starch concentration, oil percentage, and mineral composition are influenced by nutrient availability and uptake. Research has shown that specific nutrient combinations and timings of application can enhance the nutritive value of maize grains, which is especially important in addressing malnutrition in maize-consuming populations. Understanding these dynamics requires well-designed field experiments that analyze the interaction between soil fertility management and crop performance under varying agro-ecological conditions.

Therefore, this study aims to systematically assess the impact of diverse nutrient management practices on the yield and quality of maize. It seeks to evaluate the efficacy of organic, inorganic, and integrated nutrient management strategies under field conditions. The goal is to generate data that can inform best practices for sustainable maize production, ensuring higher yields without compromising soil health or grain quality. By exploring the interplay between nutrient inputs and crop outputs, this research contributes to the broader objective of sustainable agriculture and food security.

Maize is an exhaustive cereal crop. Ensuring balanced quantity of nutrients in a given soil for good plant growth is the greatest challenge of the day as yield potentials vary, among soils. For maintaining sustained crop production, balanced manuring is essential to build up soil health. The adequate quantities of manure need to be addressed for the soils in a proper way as to facilitate the nutrient needs of the crop and as well for maintenance of soil health. The organic sources will improve the nutrient use efficiency of added chemical fertilizers by reducing nutrient losses and enhancing nutrient availability to plant. However, the organic fraction of soil is subjected to depletion as a result of continuous farming and also due to environmental factors. Proper agronomic practices need to be followed to conserve organic fraction that aims at sustained on-farm generation and use of organic manures. Organic manuring has been recognized as most efficient agronomic practice for stimulation for various biological transformations in the soil fertility and health.

Chemical fertilizers deteriorate the quality of produce and are expensive too, leading to reduction in net profit and returns to the farmers. The integrated nutrient management system approach utilizes a judicious combination of inorganic fertilizer and organic manure in building soil fertility and to increase the production potential of crop (Kumar *et al.*, 2013) [4]. A suitable combination of organic and inorganic source of nutrients is necessary for sustainable agriculture that can ensure food production with high quality. Integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. It is generally believed that combining organics with inorganic fertilizer will increase synchrony and reduce losses by converting inorganic N into organic forms. Studies have shown that it is not always true. The application of organic manures influences the physical and chemical properties of soil and enhances the biological activities. It is also positively correlated with soil porosity and enzymatic activity (Srinivas *et al.*, 2015) [5]. Applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties as well as supply of essential plant nutrients for higher production (Kharche *et al.*, 2013) [6].

Thus, judicious combination of organic manure, inorganic fertilizers and its combination supply/management aims at maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner. In plant nutrition, organic matter level of a soil is the key property that decides the availability status of essential nutrients. The fertility status of soils in semi-arid region of M.P. is also poor and low organic carbon status due to high temperature.

In recent years use of organic manures like FYM and vermicompost for improving the productivity of crop and maintaining soil fertility and productivity of soil is gaining prominence (Mahokar *et al.*, 2007) [7]. Organic agriculture is derived as a production system which largely excludes or completely avoids the use of synthetically compounded pesticides, fertilizers, growth regulators, preservatives and livestock feed additives, organic agriculture practices thus rely upon recycling of crop residues, animal manure, off-farm organic residues and wastes. Organic agriculture is gaining movement in India due to the individual as well as group efforts to conserve environments and avoid contamination of the farm produce from the use of chemical fertilizers and pesticides. The important tenet of organic food movement is that promotes ecological soundness and sustainable use of natural resources, also a maintenance of crop diversity. The problem of high cost of chemical fertilizers fully meet out nutrient requirement of crop by single source therefore integrated nutrient management such as organic matters like farmyard manure, vermicompost, poultry manure and biofertilizer uses has become necessary.

Materials and methods

The experiment was carried out at the Research farm of the Department of Agronomy, School of Agriculture Science, Technology & Research, Sardar Patel University, Balaghat (M.P.). The experiment was conducted in a randomised complete block design with three replications. Different nutrient management practices on yield and quality of maize will be allocated to the plots as per treatments. The seed rate used as 15 kg/ha for sowing with 60.0 x 30.0 cm row-to-row and plant-to-plant distance. The experiment comprised twelve treatments with different combinations of organic and inorganic nutrient sources. The control (T_1) received no fertilizers or organics. Treatments T_2 and T_3 integrated 25% and 50% of the Recommended Dose of Fertilizers (RDF) with Farmyard Manure (FYM) at 8 t/ha and 6 t/ha, respectively. T_4 represented the full RDF of NPK at 120:60:40 kg/ha. Treatments T_5 and T_6 combined 25% and 50% RDF with Vermicompost at 8 t/ha and 6 t/ha, respectively. Biofertilizer-based treatments included T_7 (25% RDF + Azotobacter) and T_8 (50% RDF + PSB). More integrated treatments were T_9 (25% RDF + FYM @ 8 t/ha + Azotobacter) and T_{10} (50% RDF + FYM @ 5 t/ha + PSB). T_{11} received FYM @ 10 t/ha + PSB, while T_{12} included FYM @ 5

t/ha, Vermicompost @ 5 t/ha, and PSB. These treatments aim to explore the effect of integrated nutrient management on crop performance. The fertiliser grades were applied as per the treatments. All the other agronomic practices were applied uniformly to all the treatments. The experiment will consist of the following factors, along with their respective levels.

Results and discussion

Application of different nutrient management brought significant increase in growth attributes like plant height, number of leaves per plant, fresh weight of plant and dry weight of plant of the maize during the experimental year. The increase in growth attributes with the application of 100 % RDF (NPK @ 120:60:40 kg/ha), recommended dose of fertilizer application might be due to improved photosynthetically active leaf area for longer period during vegetative and reproductive phases, led to more absorption and utilization of radiant energy which ultimately resulted in higher dry matter accumulation and significant increase in plant growth. It has been observed from the data that the different treatments viz., organic, inorganic and bio-fertilizers and their combinations had significant influence on vegetative growth characters like plant height, number of leaves per plant, leaf length, fresh weight of leaves.

In the present investigation, it is evident from the data that the height of maize plant was significantly increased under all treatments at the time of harvest. Application of 100 % RDF (NPK @ 120:60:40 kg/ha) played a unique role in the supply of essential plant nutrients in optimum quantity during growth period, thereby increasing photosynthates and their translocation towards the vegetative organs. The similar beneficial effect of combined use of fertilizers, organic manure and biofertilizers on plant height was recorded by Shabnam *et al.* (2011) [8] in maize. The highest plant height was due to readily availability of required quantities of nitrogen, which is being a constituent of amino acids, nucleotides, nucleic acids, many coenzymes, auxins, cytokinins and alkaloids, resulted in increased cell elongation, cell enlargement and cell division.

Yield attributing characters of maize viz., number of cobs per plant, number of rows per cob, number of grains per row, number of grains per cob, length of cob and test weight, were significantly improved due to application of higher level of nutrients. Application of 100 % RDF (NPK @ 120:60:40 kg/ha) probably enhanced the highest cob length, cob diameter and cob weight. Further application of 100 % RDF (NPK @ 120:60:40 kg/ha) though, attained the highest values of all the yield-determining characters. It may be attributed to the beneficial effects of higher growth parameters in this treatment. Large available of stored photosynthetic and translocated in to various yield attributes. Continuous mineralisation and availability of nutrients as per the requirements during later stages of the plant growth might be the reason for higher values of yield attributes.

The combined application of NPK rates to the maize increased the availability of major nutrients to plant due to enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth attributes and finally increased crop growth rate. This is further supported that soil of the experimental field was low in available nitrogen (176.6 kg /ha), medium in available phosphorus (12.5 kg /ha) and potassium (200.0 kg /ha) and this might be the cause in more response of the crop to the application of 100 % RDF (NPK @ 120:60:40 kg/ha). The optimum dose of nutrient application in basal dose provide good soil condition and early season healthy crop growth. The crop-weed competition reduces in season of crop growth because the timely sowing of crop, its controlled weeds in early stage. Thereafter crop-weed competition is reduced. The results are in close agreement with the findings of Mahesh *et al.* (2010) [9] and Saurabh *et al.* (2016) [10].

It would be resulted that different nutrient management treatments significant influence on protein content of maize. The significantly higher values of protein % were recorded with application of 100 % RDF in maize. This might be due to higher N content in grain and

subsequently higher N uptake was found with the above-mentioned treatments that support to enhance protein content. This could also be explained on the basis of better availability of desired and required nutrients in crop root zone and also the increase uptake by maize roots and enhanced photosynthetic and metabolic activity resulting in better partitioning of photosynthates to sinks, which reflected in quality enhancement in terms of protein content. In addition to its role in the formation of protein, nitrogen is an integral part of chlorophyll which is primary absorber of light energy needed for photosynthesis. Further, an adequate supply of phosphorous early in the life cycle of plant through chemical fertilizer is important in laying down the primordia of its reproductive parts. This finding closely associated with those of Singh *et al.*, (2013) [11] in pearl millet and Iqbal *et al.* (2014) [12] in maize

The ultimate aim of the grower is to secure maximum income out of the present resource. The organic sources of nutrients not only produce highest and sustainable crop yields and quality produce but also maintain the soil fertility with maximum net income/ha. Among the fertilizer treatments, 100 % RDF (NPK @ 120:60:40 kg/ha) resulted in the highest net profit with the highest B: C ratio. The economic assessment (viz., cost of cultivation, GMR, NMR and benefit per rupee investment) is essential to evaluate the effect of a particular treatment for its practical utility by the farmers. The farmers are mainly interested in earning more profit from a unit area, time and investment. Thus, the economic analysis of the treatment gives valuable information to farmers.

The economic evaluation of maize production in terms of gross monetary returns, net monetary returns and B:C ratio varied due to the application of nutrient levels during the experimental year. Fertilization at 100 % RDF (NPK @ 120:60:40 kg/ha) was found the most remunerative fertility level in maize. It fetched the net returns of ₹ 66,055.6/ha thereby indicating a significant increase of rest of the treatments. As net return is calculated by grain yields by their sale prices and subtracting the total cost of cultivation including treatment-wise cost. These variations in the NMR were owing to differences in produce (grain yields) of crop. The highest B: C ratio at 100 % RDF (NPK @ 120:60:40 kg/ha) (3.13: 1) was due to comparatively lower additional cost in comparison to others. Highest B: C ratio was owing to reduction in cost of treatment as compared to the highest concentration of other nutrient levels. Similar results were also reported by Saurabh *et al.* (2016) [10], Satybhan *et al.* (2018) [13] and Satybhan *et al.* (2018) [13]. The present results corroborate with those of Vivek *et al.* (2018) [14], Bhatt *et al.* (2020) [15] and Mahato *et al.* (2020) [16].

Conclusion

The application of 100% Recommended Dose of Fertilizers (RDF) at 120:60:40 kg NPK/ha markedly improved the growth, yield attributes, and overall productivity of maize, resulting in the highest values for plant height, number of leaves per plant, fresh and dry biomass, cob number and size, grain weight, and grain yield both per plant and per hectare. This balanced fertilization not only enhanced physiological performance but also led to a significantly higher harvest index and protein content, reflecting superior dry matter partitioning and improved nutritional quality of the grain. Economically, while manual hand weeding involved a higher cultivation cost, it delivered the highest gross and net returns along with the most favorable benefit-cost (B:C) ratio of 3.13:1, indicating that labor-intensive but effective weed control, when combined with optimal fertilization, can significantly boost farm profitability. These findings highlight the potential of integrating 100% RDF with efficient weed management strategies such as manual weeding to sustainably enhance maize yield and income. For future agricultural practices and research, it is essential to investigate integrated nutrient and weed management approaches that pair full RDF application with more sustainable, cost-effective weed control options like mulching, cover cropping, or bio-herbicides. Furthermore, long-term field trials assessing the impact of continuous RDF use on soil health, nutrient-use efficiency, and environmental sustainability are necessary. The incorporation of precision

agriculture tools to tailor fertilizer and weed control practices based on site-specific needs could further optimize resource use, enhance maize productivity, and reduce ecological footprints, paving the way

for sustainable intensification of maize farming systems.

Table 1. Study on effect of nutrient management practices on yield and quality of maize (*Zea mays* L.)

Treatment	Plant height at harvest (cm)	Number of leaves/plant at harvest	Fresh weight of plant (g)	Dry weight of plant (g)	Number of cobs per plant	Number of grains per row	Test weight	Grain yield per hectare (q/ha)	Harvest index (%)	Stalk yield per hectare (q/ha)	Protein content (%)	B: C ratio
Control	116.30	8.23	173.83	29.02	1.43	27.16	200.76	25.33	41.96	34.99	10.66	1.91
25 % RDF + FYM @ 8 t/ha	181.25	9.43	270	37.74	1.49	33.89	214.81	38.22	45.78	45.22	12.26	2.47
50 % RDF + FYM @ 6 t/ha	184.90	9.76	323.3	39.09	1.69	37.76	215.35	39.19	45.04	47.73	12.44	2.26
100 % RDF (NPK @ 120:60:40 kg/ha)	218.99	12.03	395.46	52.48	2.23	41.89	224.51	48.42	48.02	52.36	14.49	3.13
25% RDF + Vermicompost @ 8 t/ha	191.96	10.09	336.96	40.36	1.89	38.96	218.6	43.39	45.64	51.57	12.92	2.16
50% RDF + Vermicompost @ 6 t/ha	193.45	10.36	352.34	41.73	1.96	40.23	219.8	45	46.18	52.28	13.27	1.88
25% RDF + Azotobactor	172.73	8.96	201.26	34.07	1.63	30.16	207.7	36.94	47.75	40.37	11.73	2.79
50% RDF + PSB	176.45	8.89	233.62	35.96	1.49	32.36	210.89	37.05	46.13	43.15	12.13	2.6
25% RDF + FYM @ 8 t/ha + Azotobactor	179.10	9.49	247.76	36.82	1.49	33.56	213.23	37.3	45.68	44.18	12.26	2.45
50% RDF + FYM @ 5 t/ha + PSB	187.12	9.89	305.25	39.27	1.83	38.43	215.68	40.36	43.95	51.36	12.5	2.35
FYM @ 10 t/ha + PSB	187.03	9.29	285.75	38.08	1.56	36.36	215.13	38.28	45.52	45.64	12.34	2.38
FYM @ 5 t/ha + Vermicompost @ 5 t/ha + PSB	207.08	11.43	370.73	50.11	2.03	41.03	221.19	48.05	47.86	52.31	13.54	1.83
S. Em±	2.61	0.25	5.42	1.21	0.09	0.53	1.61	1.46	1.25	1.29	0.38	
C.D. (P = 0.05)	7.69	0.78	14.86	3.52	0.30	1.52	4.68	4.45	3.46	3.55	1.11	

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