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Effect of integrated nutrient management on productivity, quality and economics of maize (*Zea mays* L.) on typic Haplustepts of Rajasthan

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ABSTRACT

A two year field experiment was conducted at the Rajasthan College of Agriculture, Udaipur during kharif season of 2018 and 2019 to study the effect of integrated nutrient management on yield attributes, yield, protein content of maize and monetary returns. The ten treatments were evaluated in randomized block design with three replications. The application of 75% RDF through chemical fertilizer + 25% RDF through vermicompost + Azotobacter + VAM produced the highest grain 4.26 t ha^{-1} and stover 6.47 t ha^{-1} yield of maize and enhanced the overall productivity of maize by increasing number of cob per plant, cob length, weight per cob, number of grain per cob, test weight. Protein content of grains increased by 33.2% and 2.85% with application of 75% RDF through chemical fertilizer + 25% RDF through vermicompost + Azotobacter + VAM as compared to control and 100% chemical fertilizer, respectively. The highest net returns of 65377.4 Rs ha^{-1} with benefit cost ratio 2.27 was recorded in the plot fortified with 75% RDF through chemical fertilizer + 25% RDF through vermicompost + Azotobacter + VAM. The total uptake of nutrients (N, P and K) by maize was significantly higher under the treatment receiving 75% RDF through chemical fertilizer + 25% RDF through vermicompost + Azotobacter + VAM. The minimum values of all the parameters were recorded under control.

Key words: Integrated nutrient management, maize, productivity, quality

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop of India and plays a pivotal role in agricultural economy as staple food for larger section of population, raw material for industries and feed for animals. Maize occupies a pride place among cereal crops in India. It has emerged as third most important food crop after rice and wheat as it represents 9.48 percent of total cereal production. In India, it covers an area of 9.18 m ha with production of 27.23 million tonnes and productivity status of 2965 kg ha^{-1} contributing nearly 10.46 per cent in the national food basket (Agricultural Statistics, 2019). In the State of Rajasthan, maize covers an area of 0.86 million ha with production and productivity of 1.96 million tonnes and 2285 kg ha^{-1}, respectively (Agricultural Statistics, 2019). The INM refers systems which aim to improve and maintain soil fertility for sustaining crop productivity and involves the use of chemical fertilizers in conjunction with organic manures which are rich input through biological process. Incorporation of organic sources along with chemical fertilizers are effective in increasing the nutrient availability in soil, improving physico-chemical properties of soil and ultimately enhance the productivity of crop (Sharma *et al.* 2020). The use of organic manure as a renewable source of plant nutrients is assuming importance. In this endeavor proper balance of organic and inorganic fertilizer is important not only for increasing yield but also for sustaining soil health. Hence, a study was undertaken to evaluate the effect of integrated nutrient management on yield, quality and nutrient uptake by maize.

MATERIALS AND METHODS

The experiment was conducted at Instructional Farm of Rajasthan College of Agriculture, Udaipur. The site is situated in south-eastern part of Rajasthan at an altitude of 579.5 m above mean sea level, at 24^{o}35' N latitude and 74^{o}42' E longitude. The region falls under agro-climatic zone IV a (Sub- Humid Southern Plain and Arawali Hills) of Rajasthan. The soil of the experimental field was sandy clay loam in texture, non-saline and slightly alkaline in reaction. The soil was medium in N (265 kg ha^{-1}), P (15.27 kg ha^{-1}), K (482 kg ha^{-1}) and have sufficient level of DTPA extractable Fe (2.63 mg

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kg^{-1}), Mn (9.09 mg kg^{-1}), Zn (1.92 mg kg^{-1}) and Cu (1.55 mg kg^{-1}). The experiment consisted of 10 treatments comprising inorganic fertilizers and their combinations with different organic manures and biofertilizers *viz.,* T_1- Control, T_2- 100% Chemical fertilizer, T_3- 50% Chemical fertilizer + 50% FYM (N 0.49, P 0.25 and K 0.48%) + *Azotobacter* + VAM, T_4- 75% Chemical fertilizer + 25% FYM + *Azotobacter* + VAM, T_5- 50% Chemical fertilizer + 50% Vermicompost (N 1.6%, P 1.3% and K 1.2%) + *Azotobacter* + VAM, T_6- 75% Chemical fertilizer + 25% Vermicompost + *Azotobacter* + VAM, T_7- 50% Chemical fertilizer + 50% Enriched compost (N 1.2, P 2.1 and K 0.9%) + *Azotobacter* + VAM, T_8- 75% Chemical fertilizer + 25% Enriched compost + *Azotobacter* + VAM, T_9- 50% Chemical fertilizer + 50% Poultry manure (N 1.4, P 1.0 and K 1.1%) + *Azotobacter* + VAM and T_{10}- 75% Chemical fertilizer + 25% Poultry manure + *Azotobacter* + VAM, respectively. . Incorporation of organic manures were done before one month of sowing as per the treatment requirements. These treatments were evaluated under randomized block design with 3 replications. Sowing of maize was done on 5th July 2018 & 2nd July 2019. Number of cob per plant, cob length, weight per cob, number of grains per cob, test weight, grain yield, stover yield, biological yield, net returns, benefit cost ratio were recorded. The grain and stover samples were analysed for N, P and K content by adopting standard procedures. The uptake of nutrients was computed from the data on nutrient concentration multiplied by yield. The data generated were statistically analysed (Gomez and Gomez 1984)

RESULTS AND DISCUSSION

Yield attributes

Significant enhancement in yield attributes was recorded by applying various treatments to supply nutrients (Table 1). The maximum cob length (21.1 cm) was found with application of 75% Chemical fertilizer + 25% Vermicompost + *Azotobacter* + VAM. Weight cob^{-1} was found maximum (367 g) with the application of 75% Chemical fertilizer + 25% Vermicompost + *Azotobacter* + VAM. The highest yield attributes realized with application of balanced and integrated combination of chemical fertilizers with vermicompost and biofertilizers could be ascribed due to their profound influence on vegetative and reproductive growth of the maize. The maximum number of grains cob^{-1} (315.5) was found under 75% RDF through chemical fertilizer + 25% RDF through vermicompost + *Azotobacter* + VAM. Application of 75% Chemical fertilizer + 25% Vermicompost + *Azotobacter* + VAM application produced the maximum test weight (229.5 g). This may be attributed to the favourable effect of vermicompost and biofertilizer on microbial and root proliferation in soil which caused solubilizing effect of native nutrients. Baradhan and Kumar (2018) and Snehaa *et al.* (2019) reported similar results.

Table 1: Effect of INM on yield attributes and quality of maize (mean of 2 years)

Treatment	Cob $plant^{-1}$	Cob length (cm)	Weight cob^{-1} (g)	Grain cob^{-1}	Test weight (g)	Protein content (%)
T_1	1.14	17.2	296.5	255.0	144.5	7.5
T_2	1.18	20.4	352.0	295.0	217.0	9.8
T_3	1.16	17.7	315.5	270.5	180.5	8.1
T_4	1.15	19.3	340.5	290.0	210.5	9.3
T_5	1.17	18.7	335.0	285.5	203.5	9.0
T_6	1.18	21.1	367.0	315.5	229.5	10.1
T_7	1.15	18.0	320.0	273.0	185.0	8.3
T_8	1.17	19.8	348.0	292.5	215.5	9.7
T_9	1.17	18.1	326.0	276.5	195.5	8.7
T_{10}	1.16	20.8	354.5	298.5	220.0	9.9
SEm±	0.02	0.49	7.07	6.27	7.25	0.11
CD (P=0.05)	NS	1.41	20.28	17.99	20.79	0.30

Quality

Protein content in grains was found maximu+m (10.1%) with 75% chemical fertilizer + 25% Vermicompost + *Azotobacter* + VAM application, which was at par with T_{10} (9.9%). Protein content in grain increased by 2.8% and 33.3% in T_6 as compared to sole application of

chemical fertilizers (9.8%) and control (7.6%). The protein content of grain is related to its nitrogen content, the nitrogen consumption of plant increased due to the nitrogen mineralization of vermicompost and biological nitrogen fixation by biofertilizer (*Azotobacter*) there by increased in nitrogen content in grain. Ali *et al.* (2019) and Kour and Singh (2020) reported similar results.

Yield and economics

It is clearly seen from the data (Table 2) that highest grain yield (4.26 t ha^{-1}) was found in the plot which was fortified with 75% Chemical fertilizer + 25% Vermicompost + *Azotobacter* + VAM. Stover yield was also found maximum (6.47 t ha^{-1}) with the application of 75% RDF through chemical fertilizer + 25% RDF through vermicompost + *Azotobacter* + VAM. The increases in grain and stover yield of maize due to the application of T_6 were 11.23% and 7.12% over only chemical fertilizers (T_2) and 155.10% and 75.81% over control (T_1), respectively. Significant increase in the yield due to integrative combination of chemical fertilizer, vermicompost and biofertilizer could be ascribed to their direct influence on dry matter production in leaf and stem by virtue of increased photosynthetic efficiency. Results of present investigation are alike to the findings of,Shah and Wani (2017) and Shekhawat *et al.* (2021).

Maximum net returns and benefit cost ratio were recorded with the application of 75% RDF through chemical fertilizer + 25% RDF through vermicompost + *Azotobacter* + VAM). It is obvious that net returns increases with the increase in grain and stover yield. The integrated nutrient management increases the expenditure on chemical fertilizers, organic manures and biofertilizers as compared to control, but generated extra produce excluding the extra cost of treatment, resulting in better net returns. Naveen *et al.* (2019) and (Mahato *et al.* 2020) also reported similar results.

Table 2: Effect of INM on yield, total nutrient uptake and economics of maize (mean of 2 years)

Treatment	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Netreturns (Rs. ha^{-1})	Benefit : Cost
T_1	1.67	3.68	41.02	10.5	49.1	19870.8	0.95
T_2	3.83	6.04	104.3	25.7	105.0	59155.8	2.25
T_3	3.23	5.29	73.0	18.5	76.3	37088.6	1.04
T_4	3.66	5.92	96.0	24.1	97.2	51078.8	1.64
T_5	3.59	5.77	90.3	22.0	91.9	49292.1	1.58
T_6	4.26	6.47	118.4	28.8	116.9	65377.4	2.27
T_7	3.34	5.44	77.7	21.4	81.3	41502.1	1.23
T_8	3.82	5.99	102.6	27.4	103.3	55106.9	1.83
T_9	3.45	5.67	84.7	20.6	87.4	45508.4	1.41
T_{10}	3.99	6.30	110.0	26.5	111.2	59719.9	2.03
SEm±	0.12	0.16	3.61	0.83	4.23	2112.6	
CD(P=0.05)	0.34	0.46	10.74	2.46	12.56	6059.3	

Total Nutrient Uptake

It is apparent form the data (Table 2) that total uptake of nitrogen by maize was observed maximum (118.4 kg ha^{-1}) in T_6 (75% RDF through chemical fertilizer + 25% RDF through vermicompost + *Azotobactor* + VAM). Nitrogen uptake by grain was increased by 13.5% and 188.6% in T_6 as compared to only chemical fertilizers (104.3 kg ha^{-1}) and control (41.0 kg ha^{-1}), respectively. The maximum (28.8 kg ha^{-1}) total phosphorus uptake by maize was found with 75% RDF through chemical fertilizer + 25% RDF through vermicompost + *Azotobactor* + VAM. The increases in phosphorus uptake by maize were 12.0% and 173.4% in T_6 as compared to sole application of chemical fertilizers (25.7 kg ha^{-1}) and control (10.5 kg ha^{-1}), respectively. The highest uptake of potassium (116.8 kg ha^{-1}) was found with 75% RDF through chemical fertilizer + 25% RDF through vermicompost + *Azotobactor* + VAM, which was at par with T_{10} (111.2 kg ha^{-1}). Potassium uptake by maize was increased by 11.2% and 137.9% as compared to only chemical fertilizers (105.0 kg ha^{-1}) and control (49.1 kg ha^{-1}), respectively The minimum values of nutrients (N, P & K) uptake were recorded under unfertilized control

plot. Vermicompost proved superior to FYM in respect of total nutrients uptake by maize. The increase in uptake of primary nutrients in vermicompost amended plots could be attributed to the fact that organic manures after decomposition releases the cations, which after becoming available for plant use increase their uptake by the plants. The nutrient uptake directly depends on the yield of the crop and the nutrient concentration of the crop. The favourable effects of combination of chemical fertilizer with vermicompost and biofertilizer may be due to increased microbial activities which in turn releases organic acids to bring down the soil pH to a range where the availability of plant nutrients are maximum.Similar results were found by Paramesh *et al.* (2015), Shah and Wani (2017) and Arthy *et al.* (2020).

On the basis of results, it can be concluded that the productivity, quality and economics of maize were significantly increased by the application of 75% RDF through chemical fertilizer + 25% RDF through vermicompost + *Azotobacter* + VAM as compared to sole application of chemical fertilizers and unfertilized control plot which was followed by 75% RDF through chemical fertilizer + 25% RDF through poultry manure + *Azotobacter* + VAM (T_{10})

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