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Effect of INM on nutrient content and quality parameters of maize in typic haplustepts

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Abstract
A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *Kharif* season of 2020-21 to find out the effect of INM on nutrient content and quality parameters of maize in typic haplustepts. The field experiment was laid out in a factorial randomized block design with twenty four treatments in three replications. The treatments comprised of three levels of vermicompost i.e. Control (VC_0), Vermicompost @ 2.5 t ha^{-1} (VC_1), Vermicompost @ 5 t ha^{-1} (VC_2), four levels of chemical fertilizers i.e. Control (F_0), 50% RDF (F_1), 75% RDF (F_2), 100% RDF (F_3) and two levels of biofertilizer i.e. Control (B_0), *Azotobacter* + PSB (B_1). The results revealed that highest nutrient content and protein content in maize was recorded with the integrated use of Vermicompost @ 5 t ha^{-1} (VC_2)+ 75% RDF (F_2)+ *Azotobacter* + PSB (B_1) compare to all other treatment.

Keywords: Maize, vermicompost, RDF, *Azotobacter* +PSB, nutrient content and quality parameters

Introduction
Integrated Nutrient Management (INM) involves efficient and judicious use of all the major components of plant nutrient sources *viz.* chemical fertilizer in conjunction with animal manures, compost, green manures, legumes in cropping system, bio fertilizers, crop residues, or recyclable waste and other locally available nutrient sources for sustaining soil fertility, health and productivity. Vermicompost is a nutrient rich organic fertilizer and soil conditioner by addition of vermicompost in soil it improve the soil physical, chemical as well as biological properties (Ashokan, 2008) [2]. Biofertilizers are economical as their cost is very low and are also the renewable sources through which the plant gets nutrients which supplemented with chemical fertilizers. Biofertilizers provides nutrient supply like nitrogen and phosphorous through their activities in the soil or rhizosphere and makes them available to the plants on the soil. Fertilizer plays an important role to increase the productivity of rainfed maize. It is reported that 50% increase in yield of rainfed crops attributed to fertilizer application. Response to application of fertilizer nutrient in dry land was reported across the location in the country. Continuous use of only chemical fertilizers in intensive cropping system is leading to imbalance of nutrients in soil, which has an adverse effect on soil health and also on crop yields.

Maize (*Zea mays* L.) is a multi-faceted crop grown for food, fodder, feed and industrial purpose globally. Maize belongs to family *Gramineae* and popularly known as corn, ranking third among the food crops, next to rice and wheat in the world and ranking fourth after rice, wheat and sorghum in India. It is the most widely cultivated crop with global production volume just near 1.07 billion tonnes. In India, this coarse grain is currently being cultivated an area of 9.72 million ha with production and productivity of 28.64 million tonnes and 2945 kg ha^{-1}, respectively (DAC&FW, 2019-20) [1]. In India, Andhra Pradesh was reported to be the largest producer of maize among the producing state contributing 21% of total production, followed by Karnataka 16%, Rajasthan 10%, Bihar and Maharashtra 9% each as well as Uttar Pradesh and Madhya Pradesh each contribute 6%. In the state of Rajasthan, it covers an area of 0.89 million ha with production and productivity of 1.21 million tonnes and 1355 kg ha^{-1}, respectively (DAC&FW, 2019-20) [1].

Material and Methods
The field experiment was carried out at Instructional Farm, Rajasthan College of Agriculture, Udaipur (24º35' N latitude, 74º42' E longitude and at an altitude of 579.5 m above mean sea

level). The region falls under agro-climatic zone IV a (Sub-Humid Southern Plain and Arawali Hills) of Rajasthan. The climate of the study area is sub-humid with an average maximum temperature of 33.60 °C. The mean annual rainfall of the region varies in between 650 to 750 mm. The soil of the experimental field was clay loam in texture and slightly alkaline in reaction. From the fertility point of view soil was medium in N, P, and K and has sufficient level of DTPA extractable Fe, Mn, Zn and Cu. The experiment was laid out in factorial randomized block design and replicated thrice in the plot area of 18 m^2. Treatments consisted of three levels of organic manure, four levels of chemical fertilizer and two levels of biofertilizer. Vermicompost was prepared by utilizing raw materials i.e. cow dung, earthworm, weed biomass and maize stover. For preparation of compost, either a plastic or a concrete tank can be used. The size of the tank depends upon the availability of raw materials. Collect the biomass and place it under the sun for about 8-12 days. Now chop it to the required size using the cutter. Prepare a cow dung slurry and sprinkle it on the heap for quick decomposition. After that add a layer (2-3 inch) of soil or sand at the bottom of the tank. Now prepare fine bedding by adding partially decomposed cow dung, dried leaves and other biodegradable wastes collected from fields and kitchen. Distribute them evenly on the sand layer, continue adding both the chopped bio-waste and partially decomposed cow dung layer-wise into the tank up to a depth of 0.5-1.0 ft. After adding all the bio-wastes, release the earthworm species over the mixture and cover the compost mixture with dry straw or gunny bags. Sprinkle water on a regular basis to maintain the moisture content of the compost. Cover the tank with a thatch roof to prevent the entry of ants, lizards, mouse, snakes, etc. and protect the compost from rainwater and direct sunshine. Have a frequent check to avoid the compost from overheating. Maintain proper moisture and temperature. In order to test the significance of variation in experimental data obtained for various treatment effects, data will be statistically analyzed as per the method outlined by Panse and Sukhatme (1985) [8], the value of test at 5 and 1 per cent level of significant was determined and the values of SEm, CV per cent were calculated.

Results and Discussion

Effect of INM on nutrient content of maize

The application of chemical fertilizers, organic manure and biofertilizer enhanced the nutrient content in maize. The data presented in table 1 revealed that nitrogen content in seed (1.655, 1.663 and 1.659%) and stover (0.687, 0.699 and 0.693%) of maize were found to improve with the application of vermicompost @ 5 t ha^{-1} as compared to rest of the treatments during both the years and in pooled analysis respectively. Data depicted in Table 1 indicated that significantly higher nitrogen content in seed (1.656, 1.665 and 1.660%) and stover (0.689, 0.700 and 0.695%) were observed due to application of 100% RDF compared to rest of the treatments during both the years and on pooled basis. It was at par with application of 75% RDF and significantly higher over application of 50% RDF and control. Significantly higher nitrogen content in seed (1.649, 1.659 and 1.654%) and stover (0.684, 0.696 and 0.690%) of maize were obtained with seed inoculation with biofertilizers (*Azotobacter* + PSB) over control during both the years and in pooled analysis respectively. The positive influence of organic manures, chemical fertilizers and biofertilizer on nitrogen, phosphorus and potassium content appears to be due to improved nutritional environment both in root zone and plant system. Increased availability of these nutrients in root zone coupled with increased metabolic activities at the cellular level probably increased the nutrient uptake and accumulation in the vegetative parts. Increased accumulation of these nutrients in vegetative parts possibly with improved metabolism led to higher translocation of nutrients to reproductive organs of the crop. Similar findings were observed by Singh and Singh (2017) [11].

Phosphorus content in seed (0.442, 0.444 and 0.443%) and stover (0.274, 0.279 and 0.277%) of maize were significantly enhanced with the application of vermicompost @ 5 t ha^{-1} during both the years and in pooled analysis respectively (Table 1). A reference of data in Table 1 indicated that significantly higher phosphorus content in seed (0.445, 0.446 and 0.446%) and stover (0.274, 0.279 and 0.276%) of maize were observed with the application of 100% RDF as compared to 50% RDF and control during both the years and on pooled basis, respectively. It was at par with application of 75% RDF and found significantly superior over application of 50% RDF and control. Significantly higher phosphorus content in seed (0.441, 0.444 and 0.443%) and stover (0.684, 0.696 and 0.690%) of maize were obtained with seed inoculation with biofertilizers (*Azotobacter* + PSB) over control during both the years and in pooled analysis respectively (Table 1). The considerable increase in nutrient content by seed and stover could also be attributed to the fact that the application of vermicompost, chemical fertilizers (RDF) and biofertilizers might have been stimulated plant growth and activity of soil micro-organisms resulted in higher fungal, bacterial and actinomycetes population and activity of soil enzymes (Reddy *et al.*, 2016b) [10].

A perusal of data in Table 2 showed that application of organic manures, recommended dose of fertilizers and biofertilizers significantly increased the potassium content in seed and stover of maize during experimentation. Significantly higher potassium content in seed (0.485, 0.488 and 0.486%) and stover (1.376, 1.383 and 1.379%) of maize were recorded with application of vermicompost @ 5 t ha^{-1} over vermicompost @ 2.5 t ha^{-1} and control during both the years and in pooled analysis respectively. Among chemical fertilizer levels, significantly highest potassium content in seed (0.486, 0.490 and 0.488%) and stover (1.376, 1.384 and 1.380%) of maize were recorded under application of 100% RDF over rest of the treatments during both the years and on pooled basis, respectively and it was found at par with application of 75% RDF (Table 2). The data presented in Table 2 showed that potassium content in seed (0.484, 0.486 and 0.485%) and stover (1.374, 1.381 and 1.377%) of maize were significantly affected due to seed inoculation with biofertilizers (*Azotobacter* + PSB) during 2020, 2021 and in pooled analysis respectively. The significant increase in nutrient content is due to greater availability of nutrients in the soil applied through organic manures, chemical fertilizers and biofertilizer addition. This might be due to the improved nutritional environment in rhizosphere and in plant system, leading to the enhanced translocation of nutrients in plant parts. Similar results were also reported by Mani *et al.* (2011) [6], Priyanka *et al*. (2019) [9] and Jayanthi *et al*. (2020) [4].

Table 1: Effect of Integrated Nutrient Management on nitrogen and phosphorus content in maize

Treatments	Nitrogen content (%)						Phosphorus content (%)					
	Seed			Stover			Seed			Stover		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
A. Organic manures												
Control	1.477	1.485	1.481	0.629	0.642	0.636	0.396	0.400	0.398	0.254	0.259	0.256
Vermicompost @ 2.5 t ha^{-1}	1.584	1.588	1.586	0.654	0.673	0.663	0.420	0.428	0.424	0.265	0.268	0.267
Vermicompost @ 5 t ha^{-1}	1.655	1.663	1.659	0.687	0.699	0.693	0.442	0.444	0.443	0.274	0.279	0.277
SEm±	0.008	0.009	0.006	0.002	0.004	0.002	0.004	0.003	0.002	0.002	0.001	0.001
CD (P=0.05)	0.022	0.024	0.016	0.007	0.010	0.006	0.010	0.008	0.006	0.005	0.004	0.003
B. Chemical fertilizers (% RDF)												
Control	1.481	1.484	1.483	0.621	0.640	0.630	0.393	0.397	0.395	0.252	0.256	0.254
50 % RDF	1.512	1.520	1.516	0.631	0.655	0.643	0.405	0.412	0.409	0.261	0.263	0.262
75 % RDF	1.639	1.648	1.643	0.685	0.691	0.688	0.434	0.441	0.438	0.270	0.277	0.274
100 % RDF	1.656	1.665	1.660	0.689	0.700	0.695	0.445	0.446	0.446	0.274	0.279	0.276
SEm±	0.009	0.010	0.007	0.003	0.004	0.003	0.004	0.003	0.003	0.002	0.002	0.001
CD (P=0.05)	0.026	0.028	0.019	0.008	0.012	0.008	0.012	0.009	0.008	0.006	0.005	0.004
C. Bio fertilizer												
Control	1.495	1.499	1.497	0.629	0.647	0.638	0.398	0.404	0.401	0.255	0.259	0.257
Azotobacter + PSB	1.649	1.659	1.654	0.684	0.696	0.690	0.441	0.444	0.443	0.273	0.278	0.276
SEm±	0.006	0.008	0.005	0.002	0.003	0.002	0.003	0.003	0.002	0.002	0.001	0.001
CD (P=0.05)	0.018	0.023	0.013	0.006	0.010	0.005	0.008	0.007	0.005	0.004	0.004	0.003

Table 2: Effect of Integrated Nutrient Management on potassium content in maize

Treatments	Potassium (%)					
	Seed			Stover		
	2020	2021	Pooled	2020	2021	Pooled
A. Organic manures						
Control	0.458	0.463	0.460	1.301	1.322	1.312
Vermicompost @ 2.5 t ha^{-1}	0.470	0.476	0.473	1.343	1.353	1.348
Vermicompost @ 5 t ha^{-1}	0.485	0.488	0.486	1.376	1.383	1.379
SEm±	0.002	0.003	0.002	0.009	0.006	0.005
CD (P=0.05)	0.005	0.007	0.004	0.025	0.018	0.015
B. Chemical fertilizers (% RDF)						
Control	0.454	0.456	0.455	1.300	1.315	1.307
50 % RDF	0.463	0.470	0.466	1.330	1.342	1.336
75 % RDF	0.482	0.487	0.485	1.353	1.370	1.362
100 % RDF	0.486	0.490	0.488	1.376	1.384	1.380
SEm±	0.002	0.003	0.002	0.010	0.007	0.006
CD (P=0.05)	0.006	0.009	0.005	0.029	0.021	0.019
C. Bio fertilizer						
Control	0.459	0.465	0.462	1.307	1.324	1.315
Azotobacter + PSB	0.484	0.486	0.485	1.374	1.381	1.377
SEm±	0.001	0.002	0.001	0.007	0.006	0.004
CD (P=0.05)	0.004	0.007	0.004	0.021	0.017	0.013

Table 3: Effect of Integrated Nutrient Management on protein content in seed of maize

Treatments	Protein content in seed (%)		
	2020	2021	Pooled
A. Organic manures			
Control	9.23	9.28	9.26
Vermicompost @ 2.5 t ha^{-1}	9.90	9.93	9.91
Vermicompost @ 5 t ha^{-1}	10.35	10.40	10.37
SEm±	0.05	0.05	0.04
CD (P=0.05)	0.14	0.15	0.10
B. Chemical fertilizers (% RDF)			
Control	9.26	9.28	9.27
50 % RDF	9.45	9.50	9.47
75 % RDF	10.24	10.30	10.27
100 % RDF	10.35	10.41	10.38
SEm±	0.06	0.06	0.04
CD (P=0.05)	0.16	0.18	0.12
C. Bio fertilizer			
Control	9.34	9.37	9.35
Azotobacter + PSB	10.31	10.37	10.34
SEm±	0.04	0.05	0.03
CD (P=0.05)	0.11	0.14	0.08

Effect of INM on protein content of maize

Protein content in seed of maize was increased with application of organic manure, chemical fertilizers and biofertilizer (Table 3). Maximum protein content (10.37, 10.38 and 10.34%) was recorded with the application of vermicompost @ 5 t ha^{-1}, 100% RDF and seed inoculation with biofertilizers (*Azotobacter* + PSB) respectively over rest of the treatments based on pooled analysis. Since nitrogen is an important component of protein, higher N concentration in seed resulted in higher synthesis of protein in plant. The enhanced seed protein content with the application of vermicompost, recommended dose of fertilizers (RDF) and biofertilizers may be caused by increased N availability due to the breakdown of organic matter and a balanced supply of the majority of nutrients that are also important for the synthesis of amino acids and proteins. These results are in closed agreement with findings of Mali *et al*. (2017) [5], Bhuva and Detroja (2018) [3] and Meena (2019) [7].

Conclusion

Based on the results of two year experimentation, it may be inferred that application of Vermicompost @ 5 t ha^{-1} (VC_2), 75% RDF (F_2) and *Azotobacter* + PSB (B_1) significantly increased the nutrient content and protein content in seed of maize in typic haplustepts.

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