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Influence of integrated nutrient management on quality protein maize (*Zea mays)* productivity and soils of southern Rajasthan*

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Maize (*Zea mays* L.) is a staple food of the vast tribal population of southern Rajasthan. It fulfills their food demand but due to non-availability of quality protein source, they suffer from malnutrition. Therefore, quality protein maize assumes a great significance in the nutritional security of the tribal population. The average productivity of maize is (1.2 tonnes/ha) in general and quality protein in particular is low due to low inherent fertility of the soil of this region. Poor crop management practices may deplete the nutrient further. The recommended dose of fertilizer for maize is 90 kg N + 40 kg P_2O_4/ha in the region. However, there is no separate recommendation for this newly introduced maize type quality protein having high requirement of fertilizers (DMR 2006). Recommending the use of sole chemical fertilizers in poor and degraded soil of the risk-prone tribal region will be deliberate mistake, whereas conjunctive use of organic manure and chemical fertilizers will augment the efficiency of both the substances to enhance productivity (Kler and Walia 2006). Farmyard manure as a source of plant nutrients has been used since ancient times. Now-a-day's vermicompost has been advocated as good organic manure for use in integrated nutrient management practices (Jat and Ahlawat 2004). Vermicompost is dropping of earthworms after the intestinal digestion of organic matter and has high in nutritive value. Limited studies on vermicompost indicate that it increases macrospore space, resulting in improved air water relation. The application of vermicompost also favourably affects soil *p*H, microbial population and soil physical and chemical properties (Anchal *et al.*2008). Among the phosphorus sources, die-ammonium phosphate is rated one of the best but higher cost of die-ammonium phosphate has restricted its wider application. Another indigenous water soluble source single super phosphate has proved effective and economically viable for various crops. Also realizing the fact that in addition to phosphorus, single superphosphate contains Ca and S which may be useful in synthesis of certain amino acid and involved in various metabolic enzymatic processes in plants, which may improve productivity of quality protein maize. This necessitated evaluation of these two phosphorus sources for their relative efficiency and economic viability in reference to quality protein maize. Thus, the present investigation was carried out to find out the most appropriate integrated nutrient management option for quality protein maize on the soils of southern Rajasthan.

A field experiment was conducted during rainy (*kharif*) seasons of 2004 and 2005 at the Instructional farm Rajasthan College of Agriculture, Udaipur which represents a typical sub-tropical climate. It is situated at an altitude of 582.17 m above mean sea level. The soil was clay loam, alkaline (*p*H 8.5) in reaction, medium in available nitrogen (258.4 kg/ha), available phosphorus (10.5 kg/ha) and available potassium (285.3 kg/ha). The bulk density and organic carbon content were 1.37 and 0.73%, respectively. The experiment consisted of three fertilizers levels (75%, 100% and 125% recommended does of fertilizer (RDF), three organic sources (No organic manure, farmyard manure 10 tonnes/ha and vermicompost 5 tonnes/ha) and two phosphorus sources (die-ammonium phosphate and single superphosphate). The 100% RDF was 90 kg N + 40 kg P_2O_5/ha. The organic sources were used as additional dose over and above the treatments of fertilizer levels. Well rotten farmyard manure was incorporated in respective plots 20 days before sowing, whereas vermicompost was incorporated at sowing. On dry weight basis the farmyard manure and vermicompost contained 0.50, 0.25, 0.53 and 2.00, 1.0, 1.42% N, P and K respectively. Full dose of P and 1/3rd dose of N were applied at sowing through urea, di-ammonium phosphate and single super phosphate as per treatment. The remaining N was applied in two equal splits at knee high and tassel initiation stages. The quality protein maize hybrid 'HQPM 1' was used as test crop. To control weeds, pre-emergence application of atrazine 0.5 kg ai/ha, followed by 1 hoeing and weeding 25 days after sowing was carried out. The crop was sown in

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first fortnight of July at 60 cm × 25 cm spacing and harvested in October in both the years. For determining soil properties, soil samples from each experimental plot were drawn up to 30 cm depth after harvest of second year crop and subjected to chemical analysis. The standard methods were employed for analysis of soil samples for nitrogen, phosphorus, bulk density and organic carbon content as well as for computation of crop growth rate and leaf area index.

Application of 100% recommended dose of fertilizer significantly improved plant height, leaf area index, cobs/plant, cob length, test weight over 75% recommended dose of fertilizer (Table 1). Further increase in fertilizer level failed to record statistical significance over 100% recommended dose of fertilizer in this respect. However, dry matter at harvest, crop growth rate between 45 and 75 days after sowing and grains/cob responded significantly up to 125% recommended dose of fertilizer. The grain and stover yield improved significantly by enriching the soil with 125% recommended dose of fertilizer by 7.60, 40.71 and 8.62, 43.23% over 100 and 75% recommended dose of fertilizer, respectively. Net returns declined when fertilizer level was reduced to 75%. Contrarily significant increase was obtained by increasing the rate of fertilizer application from 100% recommended dose of fertilizer to 125% recommended dose of fertilizer. The highest B : C ratio was recorded with 125% recommended dose of fertilizer which was at par with 100% recommended dose of fertilizer but significantly higher over 75% recommended dose of fertilizer. After two years of experimentation, application of 125% recommended dose of fertilizer favourably improved organic carbon, N and P status of soil over 100 and 75% recommended dose of fertilizer (Table 2). However, reduced bulk density significantly compared to lower doses of fertilizer application. The better nutritional environment under the influence of increased fertilizer dose seems to have promoted height of plants and growth of individual leaf by way of active cell division and elongation, which might have increased interception, absorption and utilization of radiant energy, consequently resulting in increased in leaf area index, crop growth rate thereby, overall growth and finally grain yield. These results corroborate the findings of Jat and Ahlawat (2004).

Application of farmyard manure and vermicompost significantly increased growth, yield attributes and yield of quality protein maize over no organic matter application. Among the sources, vermicompost application significantly improved dry matter, crop growth rate and grains/cob over farmyard manure, however, both the sources proved equally efficient in terms of plant height, leaf area index, cobs/plant, cob length, grain and stover yields. The highest net returns were recorded under farmyard manure, which was at par with vermicompost and both the sources proved significantly superior over control. B : C ratio recorded under farmyard manure was significantly higher over no organic manure and vermicompost. The better performance of vermicompost might be on account of readily available plant nutrients, growth-enhancing substances and number of beneficial organism, like N_2-fixing and P-solublizing and cellulose decomposing organisms (Barik and Gulati 2009). Low net returns and B : C ratio under vermicompost application were due to its higher cost. It was also observed that in the treatment receiving farmyard manure and vermicompost, the bulk density was relatively lower compared to no organic manure application. However, they improved organic carbon

Table 1 Effect of integrated nutrient management on growth and yield attributes of quality protein maize (pooled data two years)

Treatment	Plant height at harvest(cm)	Dry matter (g/plant) at harvest	LAI	CGR 47–75 DAS (g/m^2/day)	Cobs/plant	Grains/cob	Cob length (cm)	Test weight (g)
Fertilizer level								
75%RDF	177.6	150.9	2.64	11.55	1.04	249	14.6	201
100%RDF	200.0	184.6	2.79	14.20	1.14	288	15.8	210
125%RDF	210.8	201.6	2.90	17.78	1.17	305	16.4	216
CD(*P*=0.05)	11.12	12.27	0.13	2.06	0.06	15.3	0.81	6.18
Sources of manure								
Control(no manure)	180.5	153.3	2.64	12.22	1.04	254	14.7	198
FYM (10 tonnes/ha)	200.1	185.4	2.81	14.70	1.15	283	15.9	212
Vermicompost (5 tonnes/ha)	207.7	198.4	2.88	17.30	1.16	305	16.1	218
CD(*P*=0.05	11.12	12.27	0.13	2.06	0.06	15.3	0.81	6.18
Phosphorus source								
DAP	189.6	175.4	2.73	14.46	1.10	279	15.2	206
SSP	202.6	182.5	2.83	15.02	1.14	283	15.9	212
CD(*P*=0.05)	9.08	NS	NS	NS	NS	NS	NS	5.05

RDF, Recommended dose of fertilizer; FYM, farmyard manure; CGR, crop growth rate; LAI, leaf area index

Table 2 Effect of integrated nutrient management on soil properties, yield and economics of quality protein maize

Treatment	BD (%)	OC (%)	Available N(kg/ha)	Available P(kg/ha)	Grain yield (tonnes/ha)	Stover yield (tonnes/ha)	Net returns (Rs/ha)	B: C ratio
Fertilizer level								
75%RDF	1.36	0.79	272.6	19.17	3.06	5.51	23615	1.87
100%RDF	1.30	0.84	291.5	19.39	4.00	7.27	34352	2.66
125%RDF	1.25	0.86	297.1	20.17	4.30	7.90	37600	2.83
CD(*P*=0.05)	0.009	0.007	0.783	0.114	0.24	0.55	2882	0.22
Sources of manure								
Control (no manure)	1.35	0.74	287.4	18.57	2.94	5.48	24636	2.38
FYM (10 tonnes/ha)	1.20	0.89	289.7	19.87	4.13	7.46	35531	2.67
Vermicompost (5 tonnes/ha)	1.30	0.86	290.8	20.29	4.29	7.75	35400	2.31
CD (*P*=0.05)	0.009	0.007	0.783	0.114	0.24	0.55	2882	0.22
Phosphorus source								
DAP	1.30	0.85	286.3	19.54	3.69	6.72	30773	2.37
SSP	1.31	0.81	287.7	19.61	3.88	7.07	32938	2.54
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

DAP, Di-ammonium phosphate, SSP, single superphosphate; BD, bulk density; OC, organic carbon

content, N and P status of soil. The low bulk density under farmyard manure and vermicompost application could be ascribed to better soil aggregation and aeration brought about by organic amendments by adding various humic fractions (Kadalli *et al*. 2000), whereas improvement in organic carbon, N and P status of soil might be on account of direct addition of organic matter through farmyard manure and vermicompost and recycling of organic material in form of crop residue, like roots, leaf fall and stumps (Jat and Ahlawat 2004).

Except plant height and test weight, most of growth, yield attributes and yield were at par under both the sources of phosphorus application. This seems to be due to complete water solubility of both the sources (Havlin *et al*. 2003).

SUMMARY

The experiment was conducted at Rajasthan college of Agriculture, Udaipur during rainy seasons of 2003 and 2004 in order to evaluate and develop integrated nutrient management package for quality protein maize in southern Rajasthan. The treatments comprising three fertilizer levels (75% recommended dose of fertilizer, 100% recommended dose of fertilizer, viz 90 kg N + 40 kg P_2O_5/ha and 125% recommended dose of fertilizer), three sources of organic manure (control, farmyard manure and vermicompost) and two phosphorus sources (die-ammonium phosphate and single super phosphate) were replicated thrice in randomized block design. The farmyard manure and vermicompost were used as additional dose over and above the treatments of fertilizer levels. Application of 125% recommended dose of fertilizer significantly enhanced growth, yield components, yield and maintained higher nutrient status in soil and proved profitable compared to 100% and 75% recommended dose of fertilizer. Addition of 125% recommended dose of fertilizer also favoured soil health functions compared to other treatments. Integration of either of farmyard manure or vermicompost with chemical fertilizers was found equally effective with respect to all parameters. However, sources of P did not bring significant variation in any of the parameters. It is concluded that application of 125% recommended dose of fertilizer through urea, single super phosphate or die-ammonium phosphate along with 10 tons of farmyard manure or 5 tons of vermicompost/ha forms an ideal module of integrated nutrient management for higher productivity of quality protein maize in southern Rajasthan.

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