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RESEARCH ARTICLE

Effect of FYM, biofertilizers and zinc on yield and macro nutrients uptake of maize (*Zea mays* L.)

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SUMMARY

Maize (*Zea mays* L.)-wheat (*Triticum aestivum* L.) is a common cropping sequence in large part of India, including Rajasthan. However, productivity of this sequence under rainfed condition is quite low; an important constraint being the supply of mineral nutrients especially zinc. A majority of the farmers in Rajasthan do not apply zinc in this sequence, mainly because of their ignorance about its role as well as high cost. The cereal based cropping system and application of continuous profit motivated imbalanced nutrient application is the matter of great concern for sustainability. In spite of heavy inputs, the net result in such a system is the decline in crop yields because of limitation of one or more micronutrients. Use of chemical fertilizer or organic alone cannot achieve and sustain the desired levels of use of organic manure with chemical fertilizers very essential as this not only sustains higher levels of productivity but also improve soil health and enhance the nutrient use efficiency. Keeping the above facts under consideration, an experiment was carried out to study the response of continuous maize-wheat cropping and fertilizer application on crop yields and nutrient status of the soil.

Key Words : FYM, Biofertilizers, Zinc, Yield, Maize, Macro nutrients

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Maize (*zea mays* L.) is an important cereal crop of India and plays a pivotal role in agricultural economy both as staple food for larger section of population, raw material for industries and feed for animals. Though, it is consumed all over country but it is staple food of people in the hilly and sub mountain tracts of northern India (Jain and Sharma, 1993).There is no cereal on earth which has so immense yield potential as maize and that is why it is called as "queen of cereals". Being a C_4 plants, maize is capable of utilizing solar radiation more efficiently compared to other cereals. Despite high potential and photosynthesis explorative crop, its average productivity achieved in India is only 2357 kg ha^{-1} with the production of 19.28 Mt (Economic Survey, 2008-09). In Rajasthan maize is grown on 1.05 m ha with the production and productivity of 1.95 Mt and 1860 kg ha^{-1}, respectively (Anonymous, 2010a). In the state, it is predominantly grown in South Eastern parts as it is highly adoptive under the prevailing agro-ecological conditions of this region. The productivity of maize in Southern parts particularly in Udaipur district is 1841 kg ha^{-1} (Anonymous, 2010a) which is deplorably low compared to the world average of 50 q ha^{-1} (Anonymous, 2010b) as well as national average. Thus, there is a wide gap between potential productivity and actual yield realized at the farmer's field that can be bridged by development and dissemination of appropriate location specific production technologies.

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MATERIAL AND METHODS

A field experiment was conducted at instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University

Table A: Physicochemical properties of soil (0-15 cm)			
Characteristics	content	content	References
	2006	2007	
Mechanical			
Sand (%)	34.6	34.2	International pipette method
Silt (%)	39.2	38.6	
Clay (%)	24.1	24.5	
Texture clay	Sandy clay loam	Sandy clay loam	
Physical			
Bulk density (Mg m^{-3})	1.45	1.46	Piper (1950)
Hydraulic conductivity (cm hr^{-1})	0.192	0.197	Black (1965)
Water stable aggregates< .25mm (%)	17.54	18.54	Black (1965)
Chemical			
pH (1:2)	8.22	8.17	Richard (1950)
Electrical conductivity(1:2) dS m^{-1}	0.73	0.75	Richard (1950)
$CaCo_3$ (%0	3.15	3.21	Piper (1950)
CEC [cmo1(p^+) kg^{-1}]	19.74	20.21	Black (1965)
Organic ^{Carbon} (%)	0.71	0.73	Walkley and Black (1934)
Available nitrogen (kg ha^{-1})	233.4	234.6	Subbiah and Asija (1956)
Available phosphorus(kg ha^{-1})	13.64	13.92	Olsen *et al.* (1954)
Available potassium (kg ha^{-1})	336.2	339.8	Jackson (1973)
Total nitrogen (mg kg^{-1})	604.8	612.5	Bremmer (1965)
Total phosphorus (mg kg^{-1})	362.9	258.4	Syres *et al.* (1968)
DTPA extractable			
Zn (mg kg^{-1})	0.52	0.55	Lindsay and Novei (1978)
Fe (mg kg^{-1})	5.71	5.86	Lindsay and Novei (1978)
Cu (mg kg^{-1})	1.72	1.84	Lindsay and Novei (1978)
Mn (mg kg^{-1})	5.89	5.77	Lindsay and Novei (1978)

of Agriculture and Technology, Udaipur (Rajasthan) on Typic Haplustepts during two years of 2006-07 and 2007-08. The soil of the experimental field was sandy clay loam in texture with medium fertility, slightly alkaline in reaction (pH 8.22 and 8.17), medium in organic carbon (0.71 and 0.73%), available nitrogen (233.4 and 234.6 kg N ha^{-1}), available phosphorus (13.6 and 13.9 kg P_2O_5 ha^{-1}), high in potassium (336.2 and 339.8 kg K_2O ha^{-1}) low in available zinc (0.52 and 0.55 mg Zn kg^{-1}) in 2006 and 2007, respectively. The experiment consisted of 32 treatment combinations comprising of two levels of farmyard manure (0 and 10 tones FYM ha^{-1}), four levels of biofertilizers [no inoculation, *Azotobacter,* vesicular arbuscular mycorrhizae (VAM) and *Azotobacter*+ VAM co-inoculation]. *Azotobacter* and VAM were used as biofertilizers for fixing atmospheric nitrogen and increasing phosphorus availability and four levels of zinc (0, 2.5, 5.0 and 7.5 kg Zn ha^{-1}). These treatments were evaluated in split plot design with three replications and maize as test crop in *Kharif* season. The physico-chemical properties of soil (0-15 cm) are given in Table A.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Grain and stover yield of maize:

Effect of FYM:

Table 1 shows the effect of FYM, biofertilizers and Zn levels on grain yield of maize during both the years of investigation. All the applied treatments significantly affected grain yield of maize during both the years of experimentation. An examination of data (Table 1) reveal that application of FYM @ 10 t ha^{-1} resulted in significant increase in grain yield of maize (32.78 q ha^{-1}) which was 19.81 per cent higher over no FYM application on pooled basis (27.36 q ha^{-1}).

The application of FYM @ 10 t ha^{-1} resulted in significant increase in stover yield of maize over control during both the years of experimentation and on pooled basis. The corresponding increase in stover yield with application of FYM @ 10 t ha^{-1} (59.71 q ha^{-1}) was 19.68 per cent higher than without FYM application (49.89 q ha^{-1}) on pooled basis.

Addition of FYM is known to favorably improve soil physical and biological properties. FYM as a source of organic matter improves soil structure, reduces soil compaction and increases water holding capacity (Biswas and Mukherjee, 1997). FYM also provides energy for N-fixation by free living heterotrophic micro-organisms. The amount of N fixation by micro-organisms if influenced by energy available in the form of organic residues. All these factors contributed to enhance

Table 1: Effect of FYM, biofertilizers and zinc on yield and macro nutrients uptake of maize

Treatments	Grain yield qha^{-1}			Stover yield qha^{-1}			N uptake kgha^{-1}						P uptake kgha^{-1}						K uptake kgha^{-1}					
							Grain			Stover			Grain			Stover			Grain			Stover		
	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled
FYM (t ha^{-1})																								
0	26.97	27.74	27.36	49.11	50.67	49.89	52.41	53.71	53.06	38.24	39.81	39.03	10.20	10.42	10.31	7.91	7.99	7.95	11.90	12.47	12.18	47.12	48.25	47.68
10	32.17	33.38	32.78	58.71	60.71	59.71	69.24	71.42	70.33	49.82	52.28	51.05	13.52	13.77	13.65	10.18	10.46	10.32	14.99	15.88	15.44	59.23	60.93	60.08
S.E.±	0.37	0.38	0.26	0.68	0.69	0.49	0.84	0.99	0.65	0.70	0.66	0.48	0.16	0.18	0.12	0.14	0.12	0.09	0.19	0.23	0.15	0.78	0.80	0.56
C.D. (P=0.05)	1.11	1.15	0.76	2.07	2.10	1.41	2.54	3.00	1.88	2.12	1.99	1.39	0.49	0.56	0.35	0.41	0.37	0.26	0.57	0.70	0.43	2.35	2.43	1.62
Biofertilizers																								
No inoculation	26.55	27.42	26.98	48.65	50.46	49.56	52.31	53.72	53.01	37.79	39.14	38.47	10.17	10.29	10.23	7.90	8.09	7.99	11.70	12.26	11.98	46.52	47.98	47.25
Azotobacter	30.14	30.81	30.47	54.04	55.99	55.01	63.01	63.98	63.50	44.74	46.89	45.81	11.72	11.83	11.78	8.94	9.06	9.00	13.34	13.95	13.65	52.26	53.71	52.99
VAM	30.10	31.05	30.58	55.01	56.52	55.76	61.25	63.14	62.19	43.58	46.33	45.10	12.33	12.62	12.48	9.37	9.47	9.42	13.89	14.71	14.30	55.17	56.04	55.61
Azoto+VAM	31.49	32.97	32.23	57.94	59.80	58.87	66.71	69.42	68.07	49.71	51.83	50.77	13.22	13.65	13.43	9.97	10.29	10.13	14.85	15.77	15.31	58.74	60.63	59.68
S.E.±	0.59	0.54	0.37	0.96	0.98	0.69	1.18	1.40	0.92	0.99	0.93	0.68	0.23	0.26	0.17	0.19	0.17	0.13	0.26	0.33	0.21	1.10	1.13	0.79
C.D. (P=0.05)	1.57	1.63	1.08	2.93	2.96	1.99	3.59	4.25	2.66	3.00	2.81	1.96	0.69	0.79	0.50	0.58	0.52	0.37	0.80	0.99	0.61	3.33	3.44	2.29
Zinc levels (kg ha^{-1})																								
0	26.65	27.70	27.17	49.12	50.85	49.99	51.87	54.28	53.07	38.22	40.10	39.16	11.22	11.35	11.28	8.62	8.78	8.70	12.01	12.70	12.35	48.11	49.40	48.76
2.5	29.51	30.04	29.77	53.34	54.94	54.14	59.92	60.60	60.26	43.46	45.42	44.44	11.99	11.95	11.97	9.05	9.18	9.12	13.40	13.91	13.66	52.53	53.81	53.17
5.0	30.93	32.02	31.48	56.11	57.93	57.02	64.74	66.66	65.70	46.51	48.62	47.56	12.14	12.53	12.34	9.24	9.43	9.33	14.10	14.90	14.50	55.50	56.99	56.25
7.5	31.21	32.49	31.85	57.06	59.04	58.05	66.75	68.72	67.74	47.93	50.05	48.99	12.10	12.57	12.33	9.27	9.52	9.40	14.27	15.20	14.73	56.55	58.15	57.35
S.E.±	0.49	0.52	0.36	0.92	0.87	0.63	0.97	1.09	0.73	0.81	0.84	0.58	0.21	0.22	0.15	0.16	0.14	0.11	0.25	0.23	0.17	0.95	0.96	0.68
C.D. (P=0.05)	1.40	1.47	1.00	2.61	2.47	1.77	2.76	3.10	2.05	2.29	2.38	1.63	0.58	0.62	0.42	0.46	0.40	0.30	0.70	0.65	0.47	2.69	2.74	1.90

crop yields. Results of present investigation also corroborate the findings of Verma *et al*. (2006).

Effect of biofertilizers:

The grain yield of maize increased significantly with inoculation by *Azotobacter*, VAM and *Azotobacter* +VAM over no inoculation, during both the years of experiment. On pooled basis dual inoculation of *Azotobacter* + VAM was resulted 19.46 per cent higher grain yield over no inoculation (26.98 q ha^{-1}).

A perusal of data in Table 1 indicates that a significantly increase in stover yield was recorded with biofertilizers inoculation during both the years of experiment. On pooled basis inoculation of *Azotobacter*, VAM and *Azotobacter*+ VAM resulted in 10.10, 12.51 and 18.79 per cent increase in stover yield over no inoculation (49.56 q ha^{-1}). The improvement in yield of crops were limited when these biofertilizers were used singly, however, a significant additive effect was observed when they were used together. The observed additive influence of biofertilizer is attributable to mutually beneficial and synergistic role played by each group of biofertilizer used. Such mutually beneficial synergistic effect has also been reported by Radwan (1998).

Effect of zinc:

The application of zinc at increasing levels significantly improved the grain yield of maize up to 5 kg Zn ha^{-1} during both the years and up to 7.5 kg Zn ha^{-1} and on pooled basis. Further increase in level up to 7.5 kg Zn ha^{-1} though had positive influence but failed to bring about significant enhancement during both the years. On pooled basis, application of 2.5, 5 and 7.5 kg Zn ha^{-1} resulted in 9.57, 15.86 and 17.22 per cent increased the grain yield of maize over control, respectively.

The application of zinc at increasing levels significantly improved the stover yield of maize up to 5 kg Zn ha^{-1} during both the years and on pooled basis. Further increase in level up to 7.5 kg Zn ha^{-1} though had positive influence but failed to bring about significantly enhancement during both the years. On pooled basis, application of 2.5, 5 and 7.5 kg Zn ha^{-1} resulted in 8.30, 14.06 and 16.12 per cent increased the stover yield of maize over control, respectively. Such improvement in yield with increased zinc levels has also been observed by several workers (Dwivedi *et al*., 2002 and Khan *et al*., 2007).

Nutrients uptake of maize grain and stover:

Nitrogen uptake kg ha^{-1}:

The application of FYM significantly increased nitrogen uptake by maize in grain and in stover over no FYM during both the years. On pooled basis application of 10 t FYM ha^{-1} increased the nitrogen uptake by maize grain and stover over no FYM by a margin of 32.55 and 30.80 per cent, respectively. The favourable and significant influence of organic manure (FYM) might be due to enhanced growth characters, increasing rate of N, P and K avaibality for longer period from FYM which synchronized the crop demand.

Table 1 revealed that nitrogen uptake by grain and stover of maize increased significantly with inoculation of *Azotobactor*, VAM and Co inoculation of *Azotobactor* and VAM over uninoclated control during both the years of examinations as well as on pooled basis. Inoculation of *Azotobactor*, VAM and dual inoculation + VAM increased uptake of nitrogen by 19.79, 17.32 and 28.41 per cent in grain and 19.08, 17.23 and 31.97 per cent nitrogen uptake by stover of maize, over no inoculation, respectively on pooled basis. Such improvement in nutrient uptake with increased N levels have been observed by several workers (Verma *et al*., 2006).

The application of zinc at increasing levels significantly influenced the nitrogen uptake by grain and stover of maize up to 5.0 kg Zn ha^{-1} during both the years and on pooled basis. Further increased in level to 7.5 kg Zn ha^{-1} though had positive influence but failed to bring above significant enhancement during both the years as well as on pooled basis. On pooled basis application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} resulted in 13.55, 23.80 and 27.64 per cent increase in grain and 13.48, 21.45 and 25.10 per cent increase in stover, respectively, over control.

Phosphorus uptake kg ha^{-1}:

The application of FYM 10 t ha^{-1} significantly increase phosphorus uptake by grain and stover of maize over no FYM in both the years. On pooled basis, application of 10 t FYM ha^{-1} increased the phosphorus uptake by grain and stover over no FYM by a margin of 32.40 per cent and 29.81 per cent, respectively.

Phosphorus uptake by grain and stover of maize increased significantly with the inoculation of *Azotobactor*, VAM and co inoculation of *Azotobactor* and VAM and over uninoclated during both the years on pooled basis, inoculation of *Azotobactor*, VAM and *Azotobactor* + VAM increased 15.15, 21.99 and 31.38 per cent phosphorus uptake by grain and 12.64, 17.90 and 26.78 per cent phosphorus uptake by stover of maize over control, respectively. These results are in conformity with finding of Verma *et al*. (2006).

The application of zinc levels significantly improved the phosphorus uptake by grain and stover of maize during both the year of investigation, on pooled basis, application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} resulted in 6.12, 9.40 and 9.31 per cent in grain and 4.83, 7.24 and 8.05 per cent in increase phosphorus uptake by stover of maize, respectively, over control.

Potassium uptake kg ha^{-1}:

The application of FYM 10 t ha^{-1} significantly improve potassium uptake by grain and stover of maize over no FYM in during both the years. On pooled basis, application of 10 t FYM ha^{-1} increased potassium uptake by grain and stover of maize over no FYM by a margin of 26.77 and 26.01 per cent, respectively. The results are in conformity with finding of

Pathak *et al.* (2005).

The potassium uptake by grain and stover of maize increased significantly with the inoculation of *Azotobacter*, VAM and dual inoculation of *Azotobacter* and VAM over uninoclated control during both the years on pooled basis, inoculation of *Azotobacter*, VAM and *Azotobacter* + VAM increased 13.94, 19.37 and 27.80 per cent in grain and 12.15, 17.69 and 26.31 per cent increased potassium uptake in stover, respectively over no inoculation.

The applications of zinc at increasing levels significantly influence the potassium uptake by grain and stover of maize upto 5.0 kg Zn ha^{-1} during both the years and pooled basis. Further increased in level to 7.5 kg Zn ha^{-1} though had positive influence but failed to bring about significant enhancement during both the years as well as on pooled basis. On pooled basis, application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} resulted in 10.61, 17.41 and 19.27 per cent in grain and 9.04, 15.36 and 17.62 per cent increased potassium uptake by stover over control, respectively. Similar finding have also been reported by Khurana *et al.* (2002).

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