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Research Paper

Influence of balanced nutrition on productivity, economics and nutrient uptake of hybrid maize (*Zea mays*)–chickpea (*Cicer arietinum*) cropping sequence under irrigated ecosystem

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2012–13, 2013–14 and 2014–15 at farmers' fields of Nargund taluk of Gadag district, Karnataka, to study the response of maize (*Zea mays* L.)–chickpea (*Cicer arietinum* L.) cropping sequence to balanced nutrition. The experiment, consisting of 7 treatments, viz. absolute control, recommended N alone, recommended N and P, recommended N and K, recommended NPK, recommended NPK with $ZnSO_4$ and farmers practice, was replicated in 12 farmers' field in randomized complete-block design. Application of 150 kg/ha N, 75 kg/ha P and 37.5 kg/ha K along with 25 kg/ha $ZnSO_4$ to maize recorded significantly higher grain (5.42 t/ha) and stover (7.61 t/ha) yields, gross returns (63.86 × 10^3 ₹/ha), net returns (36.50× 10^3₹/ha) and benefit: cost ratio (2.33). Similarly, significantly higher NPK uptake was with this treatment combination. In the succeeding chickpea, application of 25 kg/ha N, 50 kg/ha P and 15 kg/ha $ZnSO_4$ resulted in significantly higher seed (1.38 t/ha) and haulm (1.93 t/ha) yields. This treatment also recorded significantly higher gross returns (47.16 × 10^3₹/ha), net returns (31.49 × 10^3₹/ha) and benefit: cost ratio (3.40). System productivity of the cropping sequence indicated that significantly higher maize-equivalent yield (9.22 t/ha), system production efficiency (41.92 kg/ha/day) and system net returns (67.99 × 10^3₹/ha) were observed with the application of 150 kg/ha N, 75 kg/ha P and 37.5 kg/ha K along with 25 kg/ha $ZnSO_4$ to maize and 25 kg/ha N, 50 kg/ha P and 15 kg/ha $ZnSO_4$ to succeeding chickpea.

Key words : Balanced nutrition, Economics, Maize–chickpea cropping system, Nutrient uptake, Productivity

Maize–chickpea is a popular and most profitable cropping system in northern part of Karnataka under irrigated ecosystem in Vertisols, because the crop components of the cropping system is meeting out marketing as well as family needs of the growers. However, in recent days, productivity of the cropping sequence is declining drastically, reasons could be many, among them imbalanced crop nutrition taken the lion share in deciding the productivity of the maize and chickpea (Jat *et al*., 2012; Sharma *et al*., 2012; Paramasivan *et al*., 2014). Maize is an important food and feed crop which ranks third after wheat and rice in the India and world. Because of its expanded use in the agro-industries, it is recognized as a leading commercial crop of great agro-economic value (Huang *et al.,* 2006). India grows about 8.71 million ha of maize, with total annual production of 22.3 million tonnes of grain giving an average yield of 2.55 tonnes per hectare (*www.indiastat.com*, 2014) that is tremendously lower than other maize-growing countries of the world (5.16 t/ha). Yield gap in maize is due to inadequate and imbalanced fertilization and lack of distinct fertilizer recommendations for high-yielding single-cross hybrids (Mohan Kumar *et al.,* 2015 and Hasim *et al*., 2015). Similarly, chickpea is also an important crop which suites to the *rabi* season in cropping sequence. Because of its cultivation after harvesting of nutrient-exhaustive maize crop under residual soil moisture, chickpea often suffers due to imbalanced crop nutrition. Of late, deficiency of micronutrients particularly Zn is also a factor in decline in the productivity of crops under intensive cultivation with no or little application of Zn fertilizers (Saha *et al*., 2015).

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Therefore, the present investigation was carried out to unlock the productivity potential of maize – chickpea cropping system with set of nutrient-combination treatments for 3 consecutive years on farmers' field under irrigated ecosystem.

MATERIALS AND METHODS

A field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2012–13, 2013–14 and 2014–15 on farmers' fields in Dadapur, Surkod and Bhairanahatti villages of Naragund taluk of Gadag district, situated in Southern Plateau and Hills Region and Northern Dry Zone of Karnataka. The physical and chemical characteristics of soils of all the sites presented in the Table 1 indicated that, soil is clay loam with the soil reaction ranging from 8.70 to 9.00, low in available N (56.4–94.4 kg/ha), medium in available P (16.8–19.0 kg/ha), high in available K (407.6–468.7 kg/ha) and deficit in Zn (0.22–0.31 mg/kg).

The experiment comprised 7 treatments, viz. control, recommended N, NP, NK, NPK, NPK+ $ZnSO_4$ and farmers' practice, applied to maize and chickpea in sequence. The experiment was conducted in randomized block design. At each site/village, 4 farmers were selected thus making 12 replications. The net plot size was 300 m^2 for each treatment. Maize cultivar 'Supper M 900' and chickpea cultivar 'JG 11' were sown. The recommended dose of N : P_2O_5 : K_2O : $ZnSO_4$ considered for maize was 150 : 75 : 37.5 : 25 kg/ha respectively, while for chickpea, it was 25 : 50 : 0 : 15 kg/ha. In farmers' practice, 100 : 58 : 0 and 10 : 30 : 0 kg/ha of N : P_2O_5: K_2O, respectively, were applied. Half of the N and full doses of P and K were applied at the time of sowing maize and remaining N was applied after 30 days. For chickpea, entire fertilizer was applied at the time of sowing. The N, P and K were applied through urea, diammonium phosphate (DAP) and muriate of potash (MoP) respectively. Besides, both crops were raised with recommended package of practices under irrigated condition. Both the crops were evaluated in terms of grain and stover/haulm yields, net returns and benefit: cost ratio. On system basis, chickpea grain yield was converted into maize-equivalent yield (MEY), taking into account the prices of grains of the respective years. The data of 3 years were pooled and analyzed as per standard procedure. Variability in soil, fertility status and climatic conditions prevailed were taken into account before pooled analysis. Plant samples were analyzed for N, P and K concentration in grain and stover/haulm and total N, P and K uptake was calculated by multiplying the respective nutrient concentrations with the yield. Production efficiency (kg/ha/day) was calculated by dividing the maize-grain-equivalent yield with total duration of the maize–chickpea system.

RESULTS AND DISCUSSION

Productivity of maize and chickpea

Application of recommended doses of NPK along with $ZnSO_4$ to both the crops resulted in significantly higher grain and stover/haulm yields of maize and chickpea on pooled basis (Table 2). The increase in grain yield of maize owing to application of recommended doses of NPK along with $ZnSO_4$ was 246, 82, 40, 52, 10 and 65% higher over the control, N, NP, NK, NPK and farmers' practice respectively (Table 2). Further in succeeding chickpea, significantly higher seed and haulm yields of chickpea were observed with application of NPK+$ZnSO_4$. The increase in grain yield with this treatment were to the tune of 129, 73, 36, 50, 14 and 63% higher over the control, N, NP, NK, NPK and farmers' practice respectively. Again with respect to system productivity, NPK fertilization along with recommended $ZnSO_4$ to component crops recorded significantly higher maize-equivalent yield (9.22 t/ha) on account of higher grain/seed yield of component crops. Significant improvement in the grain /seed yield may be attributed to significantly higher uptake of nutrients (NPK) by both crops (Table 3) owing the optimum supply of plant nutrients. Further, soils of the experimental sites are deficient in Zn, the application of this deficit

Table 1. Initial physico-chemical properties of soil at different experimental sites (mean data of 3 years)

Particulars	Experimental sites		
	Dandapur village	Bhairnahatti village	Surkod village
Textural class	Clay loam	Clay loam	Clay loam
*p*H	08.9	09.0	08.7
Available nitrogen (kg/ha)	94.4	56.4	71.8
Available phosphorus (kg/ha)	17.4	19.0	16.8
Available potassium (kg/ha)	447.7	407.6	468.7
Available S (kg/ha)	24.2	23.0	29.3
Available Zn (mg/kg)	0.25	0.22	0.31

nutrient helped both the crops to record higher yields over NPK treatment alone. This corroborates the findings of Sharma *et al.* (2012), Paramasivan *et al.* (2014) and Saha *et al*. (2015). The data also showed that application of N over the control, NP over N, NK over N, NPK over NP, and NK and NPK+$ZnSO_4$ over NPK had advantage in grain and stover/haulm yields of maize and chickpea on pooled basis. Among the nutrient combinations, NPK+$ZnSO_4$ application was found significantly superior to NP, NK and NPK. The results are in agreement with the findings of Hile *et al*. (2007) and Jain *et al.* (2012).

Nutrient uptake by maize and chickpea

Nutrient uptake by any crop is the product of nutrient concentration in the tissue and the dry-matter production potential. In the present study on pooled basis, an application of NPK+$ZnSO_4$ at recommended rates to maize recorded significantly higher N, P and K uptake at harvesting, followed by recommended NPK (Table 3). Similarly in chickpea, an application of recommended NPK along with $ZnSO_4$ recorded significantly higher uptake of N, P and K over rest of the treatments. The total uptake of nutrients (NPK) by maize–chickpea cropping system was the maximum under NPK+$ZnSO_4$ fertilization at recommended doses (Table 3). This could be attributed to the fact that added nutrients increased the N, P and K concentrations in grain and stover/ haulm of both the crops by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency which favoured better growth and crop yield. Jain *et al.* (2012) also reported higher uptake of N and P by grain and stover of maize–wheat cropping system with the application of fertilizers.

Post-harvest nutrient status of soil

The data on soil-fertility status after harvesting of the crops are presented in Table 5. The higher available nitrogen, phosphorus and potassium were observed with the application of 150 kg N, 75 kg P_2O_5, 37.5 kg K_2O, 25 kg $ZnSO_4$ to maize and 25 kg N, 50 kg P_2O_5,15 kg $ZnSO_4$ to chickpea over the other treatments. Further the inclusion of chickpea in the cropping system was responsible for

Table 2. Grain/seed, stover/haulm yield and maize equivalent yield (MEY) as influenced by nutrient combinations (pooled data of 3 years)

Treatment	Maize		Chickpea		MEY (t/ha)
	Grain yield (t/ha)	Stover yield (t/ha)	Seed yield (t/ha)	Haulm yield (t/ha)	
Control	1.57	2.29	0.60	0.88	3.22
N	2.98	4.27	0.80	1.15	5.17
NP	3.86	5.54	1.01	1.44	6.66
NK	3.56	5.05	0.92	1.34	6.10
NPK	4.89	6.94	1.20	1.70	8.21
NPK+$ZnSO_4$	5.42	7.61	1.38	1.93	9.22
Farmers' practice	3.28	4.67	0.84	1.21	5.61
SEm±	0.033	0.049	0.013	0.017	0.069
CD (P=0.05)	0.099	0.147	0.039	0.053	0.207

Price (₹/kg) 2012–13, Maize ₹11.0 (grain), ₹0.50 (stover); chickpea ₹35.0 (grain), ₹1.0 (haulm); 2013–14, Maize ₹11.0 (grain), 0.50 (stover); chickpea ₹30.0 (grain), ₹1.0 (haulm); 2014–15, Maize ₹11.2 (grain), ₹0.75 (stover); chickpea ₹35.0 (grain), ₹2.0 (haulm)

Table 3. Nutrient uptake by maize and chickpea as influenced by nutrient treatments in maize–chickpea cropping sequence (pooled data of 3 years)

Treatment	Maize			Chickpea			System nutrient uptake		
	N (kg/ha)	P (kg/ha)	K (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Control	25.8	6.0	4.7	16.0	3.3	5.3	41.8	9.3	10.1
N	46.1	15.9	11.1	23.0	4.2	12.2	69.1	20.2	23.3
NP	63.9	20.8	15.7	30.3	5.3	16.6	94.3	26.1	32.3
NK	56.1	14.4	12.5	29.9	4.9	13.5	86.0	19.3	26.1
NPK	81.4	21.5	20.6	38.1	6.2	21.8	119.6	27.7	42.4
NPK+$ZnSO_4$	86.9	22.5	23.0	42.6	6.8	24.4	129.6	29.3	47.5
Farmers' practice	50.0	12.4	12.8	21.5	4.2	13.6	71.5	16.6	26.5
SEm±	0.65	0.7	0.24	0.35	0.05	0.24	2.15	1.21	0.83
CD (P=0.05)	1.95	2.09	1.54	1.05	0.15	0.72	6.54	4.33	2.50

nutrient build up of soil as chickpea being a legume add considerable amount of litter besides symbiotic N fixation. Mohan Kumar and Hiremath (2015) reported significant improvement in post-harvest soil fertility in elevated doses of fertilizer.

Economic analysis of cropping system

Application of 150 kg N, 75 kg P_2O_5, 37.5 kg K_2O and 25 kg $ZnSO_4$ to maize resulted in significantly higher gross returns, net returns and benefit: cost ratio over the remaining treatments (Table 4). Similarly, in succeeding chickpea, application of 25 kg N, 50 kg P_2O_5 and 15 kg $ZnSO_4$ resulted in the significantly higher gross returns, net returns and benefit: cost ratio and was significantly superior to the remaining treatments. Cropping system on the whole, maize fertilized with 150 kg N, 75 kg P_2O_5, 37.5 kg K_2O and 25 kg $ZnSO_4$ and chickpea with 25 kg N, 50 kg P_2O_5 and 15 kg $ZnSO_4$ recorded significantly higher system gross returns, net returns and benefit: cost ratio. These findings are in line with those of Sharma *et al*. (2012). Further in terms of system production efficiency, maize fertilized with 150 kg N, 75 kg P_2O_5, 37.5 kg K_2O and 25 kg $ZnSO_4$ and chickpea with 25 kg N, 50 kg P_2O_5 and 15 kg $ZnSO_4$ excelled over rest of the treatment combinations owing to significantly higher grain/seed yield of the component crops in the cropping sequence.

It may concluded that application of 150 kg N, 75 kg P_2O_5, 37.5 kg K_2O and 25 kg $ZnSO_4$ to maize and 25 kg N, 50 kg P_2O_5 and 15 kg $ZnSO_4$ to chickpea are required to harvest optimum crop yields, nutrient uptake and economic returns in maize–chickpea cropping sequence under irrigated ecosystem.

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Table 4. Economics of maize and chickpea as influenced by nutrients combinations in maize-chickpea cropping sequence (pooled data of 3 years)

Treatment	Maize			Chickpea			System economics			System
	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio	production efficiency (kg/ha/day)
Control	18.04	-2.32	0.88	20.66	10.98	2.17	38.70	8.65	1.28	14.66
N	35.00	12.31	1.54	27.26	15.31	2.26	62.27	27.62	1.80	23.52
NP	45.38	19.80	1.78	33.86	19.57	2.24	79.24	39.37	1.98	30.26
NK	41.99	18.87	1.82	31.41	19.65	2.66	73.40	38.52	2.10	27.72
NPK	55.99	31.21	2.34	41.21	25.89	2.69	97.20	57.10	2.42	37.33
NPK+$ZnSO_4$	63.86	36.50	2.33	47.16	31.49	3.4	111.02	67.99	2.58	41.92
Farmers' practice	32.82	14.91	1.65	28.97	16.08	2.22	95.13	30.99	1.48	25.48
SEm±	0.62	0.38	0.05	0.31	0.27	0.1	0.93	0.65	0.07	0.31
CD (P=0.05)	1.86	1.15	0.13	0.92	0.81	0.29	2.78	1.96	0.22	0.94

Table 5. Post-harvest soil-nutrient status as influenced by nutrients combinations in maize–chickpea cropping sequence

Treatment	Residual nitrogen (kg/ha)			Residual phosphorus (kg/ha)			Residual potassium (kg/ha)		
	2012–13	2013–14	2014–15	2012–13	2013–14	2014–15	2012–13	2013–14	2014–15
Control	75	117	86	18	19	10	381	613	557
N	90	124	81	19	18	14	393	553	550
NP	92	128	83	21	19	16	399	593	608
NK	99	129	91	21	18	10	408	581	608
NPK	114	130	81	22	19	16	421	602	608
NPK+$ZnSO_4$	125	136	91	24	20	17	427	597	608
Farmers' practice	87	125	83	19	19	15	381	592	730
SEm±	2.85	5.05	3.56	1.71	0.78	1.32	11.72	14.68	20.12
CD (P=0.05)	8.05	14.25	11.18	4.83	2.21	4.08	33.08	41.46	63.58

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