



Effect of continuous application of organics to supply nitrogen and phosphorus on maize (*Zea mays*) and chickpea (*Cicer arietinum*) under irrigated condition*

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Maize (*Zea mays* L.) in *kharif* and chickpea (*Cicer arietinum* L.) in *rabi* is one of the important crop sequences of India in both irrigated and rainfed areas (Ahlawat *et al.* 2005). This sequence occupies 0.54 million ha area and contributes 0.65% of total food grains of the country (Yadav 1996). In the Malaprabha Command of Northern Karnataka, maize in *kharif* and chickpea in *rabi* is the most profitable cropping system occupying more than 80 thousand ha (Rajkumara *et al.* 2009). Of these two crops, maize removes 148 kg N, 62 kg P₂O₅ and 133 kg K₂O/ha and addition of nutrients is often less than the removal (AICRP 2006). The residue generation has been estimated at 9.2 million tonnes in chickpea and 10.9 million tonnes in maize with respective nutrient supply potential of 1.70 and 2.01 lakh tonnes (Beri *et al.* 2002). Sustaining the crop productivity for a long time is a challenging problem in some of the crop sequences involving major crops like rice, wheat and maize. Since maize fodder has less utility as feed for animals and farmers resort to burning of crop residues as a means of easy disposal and clearing fields for the succeeding chickpea crop. Since these crop residues have the potential of nutrient supply, this study was initiated to know the long term effect of nutrient substitution through different sources of organics like maize crop residues, green leaf manuring, farmyard manure and vermicompost in maize–chickpea sequence under irrigated conditions.

A field experiment was conducted at Water Management Research Centre, Belvatagi during 2004–05 to 2009–10. The experiment was laid out in completely randomized block design with six replications. Treatments consist of 75% recommended nutrients (N/P) through organics, 100% (N/P)

through organics, 50% (N/P) through organics + 50% (N/P) through inorganics and 100% (N/P) through inorganics. In the second year, one more treatment, i.e. 100% through inorganics + FYM @ 10 tonnes/ha was added. Nitrogen was applied through organics for maize, whereas phosphorus was applied through organics for chickpea. Application of organics was done based on the average nitrogen and phosphorus content based on the dry weight of the raw materials. In maize to supply 75% nitrogen (112.5 kg N) through organics the following materials, i.e. maize crop residues (5 tonnes/ha), farmyard manure (5 tonnes/ha), *Glyricidia* leaf manure (1 tonne/ha) and vermicompost (5.7 tonnes/ha) were used. Supply of 100% nitrogen (150 kg N/ha) was done through maize crop residues (5 tonnes/ha), farm yard manure (5 tonnes/ha), *Glyricidia* leaf manure (1 tonne/ha) and vermicompost (10 tonnes/ha) and for integrated treatment maize crop residues (2.5 tonnes/ha), farmyard manure (2.5 tonnes/ha), *Glyricidia* leaf manure (1 tonne/ha) and vermicompost (3.6 tonnes/ha) were used. The supply of recommended phosphorous (50 kg P₂O₅/ha) to chickpea was done through organics by using vermicompost (T1 7.5 tonnes/ha, T2 10 tonnes/ha and T3 5 tonnes/ha). Recommended dose of 150 kg N, 75 kg P₂O₅ and 37.5 kg K₂O/ha was used for maize and for chickpea 25 kg N and 50 kg P₂O₅/ha was applied. The soil was clay with pH 8.2, organic carbon 0.58%, and available P₂O₅ 39 kg/ha and available K₂O 857 kg/ha at the beginning of the experiment. Field capacity of the soil was 40% and wilting point 21.60%. Soil organic carbon, pH and electrical conductivity were analyzed by following standard procedures. Soil physical properties like bulk density, water holding capacity and porosity were also analyzed. Annual rainfall received during 2004, 2005, 2006, 2007, 2008 and 2009 was 481, 541, 443, 729, 818 and 939 mm, respectively.

The application of nitrogen through organics and inorganics significantly affected the grain yield and straw yield of maize in five out of six years (Table 1). Application of nitrogen through organics either at 50, 75 or 100% of the

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Table 1 Grain yield of maize and chickpea as influenced by organic and inorganic nutrient treatments (2004–09)

Treatment	Maize grain yield (tonnes/ha)							Chickpea grain yield (tonnes/ha)					
	2004	2005	2006	2007	2008	2009	Pooled	2004	2005	2006	2007	2009	Pooled
T1–Fully organic (75% NP)	1.50 c	2.68 d	2.95 b	1.90 c	3.49	3.49 c	2.67 e	1.93	0.86	1.28	0.632	0.704	1.086
T2–Fully organic (100% NP)	1.84 c	3.96 c	2.76 b	2.53 c	3.99	3.66 c	3.12 d	1.95	1.02	1.43	0.728	0.736	1.184
T3–Integrated (50% org + 50% inorg)	4.20 b	4.16 c	6.21 a	4.78 b	4.15	3.93 c	4.57 c	1.98	1.35	1.44	0.685	0.791	1.277
T4 – Fully inorganic (100%)	5.31 a	6.00 b	6.08 a	5.48 ab	4.23	5.09 b	5.37 b	2.03	1.38	1.65	0.730	0.928	1.349
T5–100% inorganic + 10 tonnes FYM/ha		6.56 a	6.14 a	6.12 a	4.49	6.44 a	5.95 a		1.64	0.562	0.958	1.034	
SEm ±	0.093	0.14	0.27	0.26	0.36	0.24	0.12	0.075	0.06	0.01	0.051	0.067	0.038
CD (P=0.05)	0.28	0.42	0.80	0.75	NS	0.73	0.36	NS	0.19	NS	NS	NS	0.111

recommended dose did influence the maize yields even after three years (pooled). During 2006 there was a significant increase in the maize yield by applying recommended nitrogen through 50% organic and 50% as inorganic form (6.21 tonnes/ha) and this yield was equivalent to the yield obtained in 100% inorganic form (6.08 tonnes/ha) and 100% inorganics + FYM @ 10 t/ha (6.14 tonnes/ha). However, in 2008 no significant difference was observed. In the sixth year application of nitrogen through 75% organics (3.49 tonnes/ha) or 100% organics (3.66 tonnes/ha) were on par with 50% organics + 50% inorganics (3.93 tonnes/ha). However, they were significantly lower than fully inorganics (100%) or fully inorganics + FYM @ 10 tonnes/ha. The grain yield in maize was increased from 1.5 tonnes/ha in 2004 to 3.49 tonnes/ha in 2009. Similar increase was also noticed with 100% nitrogen from 1.84 tonnes/ha to 3.66 tonnes/ha. This indicated the cumulative effect of organics over the years on maize grain yield. On the contrary, application of inorganics produced uniform yields without much variation from 2004 to 2009. Similar increase in the basmati yield was obtained with recommended dose of fertilizer over organics alone or in different combinations for two years by Niru Kumari *et al.* (2010) at Ranchi. Application of organics alone either greenmanure/FYM/vermicompost/karanj cake was not sufficient in meeting the nutrient requirement of basmati rice. Application of entire nitrogen through organics (either 75% or 100%) was not sufficient as this reduced the maize grain yield by half to one third. This may be because of higher nutrient removal by the maize crop with lesser additions in return through organics (Ahlawat *et al.* 2005). Harvest index of maize was significantly higher in 100% inorganics + FYM @ 10 tonnes/ha and it was on par with 50% organics + 50% inorganics and 100% inorganics.

The effect of phosphorus substitution through organics and inorganics was significant on grain yield of chickpea

only in second year out of five years (Table 1). Fully inorganic treatment recorded higher chickpea yield over organics. In 2005, significantly higher chickpea grain yield was obtained with 100% inorganic (1.38 tonnes/ha) followed by 50% organic + 50% inorganic (1.35 tonnes/ha). Pooled data indicated significantly higher yield in fully inorganic (100%) and this was on par with 50% organic + 50% inorganic (1.277 tonnes/ha). Addition of FYM @ 10 tonnes/ha along with 100% inorganic was on par with 75% organics only and this may be because of the lesser time available for the buildup of soil fertility, i.e. three years as against five years in other organic treatments. Substitution of phosphorus entirely by organics (100%) was effective in sustaining the yields probably due to lower requirement of nutrients by the chickpea crop. However only 75% phosphorus through organics was not sufficient to meet requirements of chickpea and decreased yield during all the three years of investigation. Ahlawat *et al.* 2005 reported similar low nutrient requirement of chickpea in sequence with maize crop receiving 100% recommended fertilizer. Harvest index of chickpea was unaffected by the organics and inorganics and their combination of treatments.

Pooled data (Table 2) indicated maize equivalent yield was significantly higher (10.18 tonnes/ha) with 100% inorganics alone over other organic treatments but was on par with 100% inorganics + FYM 10 tonnes/ha. Maize equivalent yield in integrated nutrient management was on par with 100% inorganics + FYM @ 10 tonnes/ha. This resulted in significantly higher gross returns (Rs 88 824/ha), net returns (Rs 68 430/ha) and B:C ratio (4.357) in 100% inorganics over all other treatments. Application of 50% organics + 50% inorganics recorded a B:C ratio of 3.157 and was higher than 100% inorganics + FYM @ 10 tonnes/ha but significantly lower than 100% inorganics. Over the years organic treatments are expected to match with inorganics treatments due to their cumulative effects of fertility on soil.

Table 2 Soil physical and chemical properties as influenced by organic and inorganic nutrient treatments (2004–09)

Treatment	Maize equivalent yield (tonnes/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio	Bulk density (Mg/m ³)		Water holding capacity (%)		Porosity (%)	pH		Electrical conductivity (dS/m)		Organic carbon (%)	
					After 1 year	After 6 year	After 1 year	After 6 year		After 1 year	After 6 year	After 1 year	After 6 year	After 1 year	After 6 year
T1 – Fully organic (75% N/P)	6.54 d	56 789	32 739	2.362	1.36	1.28	73.6	51.69	8.30	8.31	0.34	0.35	0.62	0.61	
T2 – Fully organic (100% N/P)	7.35 c	63 837	37 787	2.450	1.36	1.25	74.0	52.83	8.20	8.39	0.32	0.33	0.67	0.68	
T3 – Integrated (50% org + 50% inorg)	9.13 b	79 421	54 249	3.157	1.36	1.35	73.2	49.05	8.30	8.39	0.34	0.39	0.62	0.61	
T4 – Fully inorganic (100%)	10.18 a	88 824	68 430	4.357	1.36	1.38	71.6	47.17	8.20	8.31	0.37	0.34	0.54	0.52	
T5 – 100% inorganic + 10 tonnes FYM/ha	9.65 ab	84 535	54 141	2.780	1.36	1.32	72.8	50.18	8.20	8.37	0.37	0.43	0.58	0.62	
SEm ±	0.199	1 686	1 686	0.066											
CD (P=0.05)	0.588	4 975	4 975	0.195											

Maize – ₹ 8 500/tonnes, Chickpea – ₹ 30 000/tonnes

Similar higher B:C ratio was obtained in recommended dose of fertilizer treatment in scented rice at Ranchi due to higher cost of the organics and lower yields in the organic treatments (Niru Kumari *et al.* 2010). Supplementing nutrients only through organics was not sufficient to increase the chickpea equivalent yields (Ahlawat *et al.* 2005).

The data on organic carbon content of the soil after six cycles of maize–chickpea sequence revealed that 75% organics (0.61%), 100% organics (0.68%), 50% organics + 50% inorganics (0.61%) were higher than 100% inorganics alone (0.52%) (Table 2). There was a decline in the organic carbon status in the inorganic treatment while it was increase in the organic treatments. Further, improvement in the bulk density, maximum water holding capacity, porosity and nutrient status of the soil was noticed in organic treatments. It appears effect of organics is more of improvement in physical properties than fertility of the soil (Sharma *et al.* 2000). Similar results were confirmed by Ahlawat *et al.* (2005) and Niru Kumari *et al.* (2010).

In maize, recommended dose of nitrogen needs to be applied in the form of inorganics in combination with FYM @ 10 tonnes/ha for sustained high yields. However in chickpea 50% of the phosphorus may be replaced by organics to attain higher yield. Similar observations were also made by Ahlawat *et al.* (2005) where, chickpea did not require any fertilizer when maize received 100% recommended dose of fertilizer. Maize–chickpea crop sequence needs at least six years to shift from 100% inorganics to integrated nutrient management under irrigated conditions of North Karnataka in vertisols.

SUMMARY

A field experiment was conducted at Water Management Research Centre, Belavatagi during 2004–09 for six years to study the effect of nutrients applied through organics and inorganics. Application of nitrogen either 75% or 100% through organics in maize was not sufficient in sustaining the maize grain yield. Application of 100% inorganics fertilizer + 10 tonnes FYM/ha (5.95 tonnes/ha) gave significantly higher grain yield over all other organics and organics + inorganics treatment. In chickpea, application of 100% P through inorganics gave higher chickpea yields (1.349 tonnes/ha) and was on par with 50% organics + 50% inorganics (1.277 tonnes/ha) and this indicated organics may reduce inorganics in the long run. Economic parameters were significantly higher in 100% inorganic treatment. Addition of organics either 75% or 100% improved the organic carbon and other physical properties of the soil over inorganics treatment.

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