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Integrated nutrient management in sorghum (*Sorghum bicolor*)–chickpea (*Cicer arietinum*) cropping sequence under irrigated conditions

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ABSTRACT

A field experiment was conducted during 2001–02 and 2002–03 at Rahuri, Maharashtra, to study the effect of integrated nutrient management in sorghum [*Sorghum bicolor* (L.) Moench]–chickpea *(Cicer arietinum* L.) cropping sequence under irrigation. Application of 75% recommended dose of fertilizer (RDF) + farmyard manure (FYM) + biofertilizer [*Azospirillum* and phosphate-solubilizing bacteria (PSB)] gave significantly higher plant height, dry mater, yield attributes and grain and fodder yields of sorghum, and was on a par with application of 100% RDF through inorganics alone showing 25% saving of nutrients. The residual effect of application of 5 tonnes FYM/ha to preceding sorghum resulted in significantly higher growth, yield attributes and yield of chickpea owing to 100% RDF to chickpea and at par with that of 50% RDF showing 50% saving of nutrients. The net monetary returns and benefit : cost (B : C) ratio of a sequence were significantly higher owing to 100% RDF which were at par with that of 75% RDF + FYM + biofertilizer. The fertilizer levels to chickpea showed the highest net monetary owing to 100% RDF and highest B : C ratio owing to 50% RDF. Significantly higher nutrient balance was recorded because of 75 % RDF + FYM + biofertilizers applied to sorghum and 100% RDF applied to chickpea.

Key words : INM, Sorghum–chickpea sequence, Growth, Yield, Economics, Nutrient balance

Nutrient supply is a key factor in crop production but the global crises of energy and due to escalation in the price of chemical fertilizers, a greater emphasis has to be laid on supplementing the chemical fertilizers with low-priced sources of nutrients such as organics and biofertilizers. Application of organic materials along with inorganic fertilizers into soil leads increase in productivity of the system and also sustained the soil health for longer period. Organic sources of nutrients applied to the preceding crop benefits the succeeding crop to a great extent (Hegde and Dwivedi, 1992). It is well known that the organic sources cannot meet the total nutrients need of modern agriculture, integrated use of nutrients seems to be more appropriate. Incorporation of organic sources and later on its decomposition determines the availability of the nutrients. Therefore, the present study was undertaken with a view to find out the efficient combination of organic and inorganic fertilizers under sorghum–chickpea cropping sequence under irrigated conditions.

MATERIALS AND METHODS

A field experiment was conducted at Rahuri, Maharashtra, during the rainy (*kharif*) and winter (*rabi*) seasons of 2001–02 and 2002–03 on clayey soil, having pH 8.0 and electrical conductivity 0.29 dS/m. It was medium in organic carbon (0.52 %), low in available nitrogen (175.62 kg/ha), medium in available phosphorus (15.05 kg/ha) and very high in available potassium (553.62 kg/ha). The experiment was laid out in randomized block design during the *kharif* with 8 main plot treatments of integrated nutrient management to *kharif* sorghum replicated thrice (Table 1) and during the winter (*rabi*) season each main plot treatment was subdivided into 3 sub-plot treatments with 3 levels of RDF to chickpea, resulting in 24 treatment combinations in *rabi* replicated thrice in split-plot design (Table 2). Recommended doses of inorganic fertilizers consisting of 120 kg N and 60 kg each of P_2O_5 and K_2O/ha to sorghum and 25 kg N and 50 kg P_2O_5/ha were applied to chickpea. For sorghum N was applied in 2 splits, half at sowing along with entire quantity of P_2O_5 and K_2O and remaining 30 days after sowing, and that for chickpea as entire quantity of N and P_2O_5 at sowing. Nitrogen, phosphorus and potassium were applied through urea, single superphosphate and muriate of potash re-

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spectively. The FYM was added @ 5 tonnes/ha and biofertilizers used in the form of seed inoculation were *Azospirillum* and phosphate-solubilizing bacteria (PSB) according to the treatments. Sorghum (cv. 'CSH 17') and chickpea (cv. 'Vijay') were sown using seed rate of 7.5 kg/ha and 60 kg/ha with a spacing of 45 cm × 15 cm and 30 cm × 10 cm, respectively at optimum time. The experiment was laid out at the same site each year. The crop sequence received total rainfall of 557.7 mm in 2001–02 and 418.4 mm in 2002–03 during the crop-growth periods. Both the crops were irrigated as per the critical growth stages and also considering the distribution of rainfall. Net returns and B : C ratio for each treatment was worked out on the basis of market value of the inputs and products. The soil and plant samples were analysed for N, P and K using standard analytical procedures. The nutrient uptake and nutrient balance were worked out.

RESULTS AND DISCUSSION

Sorghum

Growth parameters: Performance of sorghum was better with the combined application of organic, inorganic and biofertilizers than that of the control. Plant height and dry matter during both the years (Table 1) were maximum with 75% RDF + FYM + biofertilizer and significantly superior to those recorded in rest of the treatments. The lowest plant height and dry matter were recorded in the control. The higher dry-matter accumulation may be attributed to the more plant height of the corresponding tretments. Parasuraman *et al.* (2000) reported similar results in sorghum–horsegram cropping sequence.

Yield attributes and yield: The crop performance in respect of yield and yield attributes was significantly improved by combined application of organic, inorganic and biofertilizer than the inorganics alone. The pooled mean analysis of grain yield showed almost all the integrated nutrient management (INM) treatments at par with each other except the control and the treatment 75% RDF + FYM + biofertilizer recorded higher values owing to higher values of ear length, ear weight and 1,000-grain weight (Table 1). Application of 75% RDF + FYM + biofertilizer produced higher 1,000-grain weight and higher ear dimensions. Bigger ear size not only provided sufficient space for accommodating maximum grains/ear but also provided sufficient space to increase their dry matter which was rightly revealed by higher 1,000-grain weight. The present findings support the results of Patil and Sheelavantar (2000). The pooled analysis of fodder yield showed significantly higher value with 75% RDF + FYM followed by 75% RDF + FYM + biofertilizer which were at par with almost all the treatments except the control and 50% RDF + biofertilizer. The higher fodder yield in these treatments may be attributed to taller plant height of the corresponding treatments. Gangwar and Singh (1992) also reported that application of organic manure in conjunction with lower doses of N, P and K resulted in higher growth and yield in fodder sorghum-gram cropping sequence.

Chickpea

Residual effect of INM in sorghum: The INM treatments applied to preceding crop sorghum showed significant effect on plant height, dry matter, yield attributes and yield of chickpea (Table 2). The highest plant height was recorded with 75% RDF + FYM + biofertilizer during the first year and 75% RDF + FYM during the second year. The dry matter was maximum and significantly superior

Table 1. Effect of integrated nutrient management on growth, yield attributes and yield of (pooled) sorghum

Treatment	Growth parameters				Yield attributes (pooled mean)				Yield		
	Plant height at harvest (cm)		Dry matter at harvest (g)		Length of ear (cm)	Girth of ear (cm)	Weight of ear (cm) (g)	Grain weight/ear (g)	1,000-grain weight (g)	Grain yield (q/ha)	Fodder yield (q/ha)
	2001–02	2002–03	2001–02	2002–03							
Control	155.9	169.8	91.9	149.6	23.4	13.6	70.5	46.1	24.3	20.97	81.13
100% RDF	172.6	204.7	118.1	214.0	27.1	18.8	111.9	89.7	26.1	62.02	131.18
75% RDF + FYM	170.4	203.8	102.8	215.1	28.6	18.7	123.9	93.3	25.1	59.79	134.63
75% RDF + biofertilizer	170.2	201.5	103.0	202.2	30.1	19.8	114.4	88.3	25.7	53.86	117.64
75% RDF + FYM + biofertilizer	173.9	206.0	149.4	251.6	30.3	20.4	130.2	97.9	26.4	64.66	133.68
50% RDF + FYM	166.8	202.2	137.0	226.7	28.9	19.4	117.6	82.6	24.8	55.96	125.02
50% RDF + biofertilizer	165.5	200.1	108.2	210.0	29.0	19.7	118.8	81.5	24.6	53.40	110.78
50% RDF + FYM + biofertilizer	168.6	202.4	137.9	226.7	29.6	19.4	118.2	85.7	26.3	59.04	128.03
CD (P=0.05)	N.S.	4.7	13.9	21.3	1.3	0.7	20.3	12.7	0.7	12.36	20.46

RDF, Recommended dose of fertilizer; FYM, farmyard manure; NS, not significant

owing to 75% RDF + FYM + biofertilizer during both the years. The yield attributes of chickpea, viz. pods/plant, showed significantly higher values with 50% RDF + FYM resulting in higher grain yield. The 100-grain weight was maximum owing to 75% RDF + FYM + biofertilizer. The straw (*bhusa*) yield was also maximum with 50% RDF + FYM applied to sorghum.

Response to fertilizer levels : The fertilizer applied to chickpea showed significant influence on the performance of chickpea. Application of 100% RDF recorded significantly higher values of plant height, dry matter, yield attributes and grain and straw (*bhusa*) yield and the maximum value was recorded with 100% RDF which was at par with that of 50% RDF, indicating saving of the nutrients to the extent of 50% during *rabi.* This might be owing to the availability of nitrogen during entire growing season because of slow mineralization of organic nitrogen from FYM applied to sorghum in sorghum–chickpea crop sequence. Singh *et al.* (1999) also reported similar results in rice–chickpea cropping sequence.

Economics

The residual effect of INM treatments applied to preceding crop sorghum was also reflected in economics of the sequence (Table 3). The net monetary returns were significantly higher with 100% RDF, followed by 75% RDF + FYM + biofertilizer and were at par with each other and also with all the treatments except the control. The statistical parity of the treatments clearly indicated that the reduced levels of chemical fertilizers in conjunction with organic manures is a good proposition from economical point of view. The fertilizer levels applied to chickpea resulted in highest net monetary returns owing to 100% RDF which was at par with that of 50% RDF. Highest benefit : cost (B : C) ratio was observed with 100% RDF, followed by 50% RDF + biofertilizer. This can be attributed to lower input and application cost of biofertilizer and comparatively higher contribution in the yield. Studies conducted at different locations also reported higher B : C ratio with combination of FYM with RDF under sorghum-based cropping systems (AICSIP, 1999). The fertilizer applied to chickpea recorded the highest B : C ratio with 50% RDF. This can be attributed to the lower input cost due to reduced level of 50% RDF, but at par yield with 100% RDF resulting in higher B : C ratio than that of 100% RDF.

Nutrient balance

The nutrient balance pertaining to nitrogen, phosphorus and potassium at the end of second sequence of sorghum–chickpea showed beneficial effect due to INM to sorghum (Table 3). Maximum net balance of nitrogen was recorded under treatment 75% RDF + FYM + biofertilizer. Maximum net balance of phosphorus and potassium was re-

Table 2. Residual effect of integrated nutrient management (INM) in sorghum and fertilizer levels to chickpea on growth, yield attributes and yield

Treatment	Growth parameters				Yield attribues (pooled mean)			Yield (pooled mean)	
	Plant height at harvest (cm)		Dry matter at harvest (g)		Pods/ plant	Grain weight/ plant (g)	100-grain weight	Grain yield (q/ha)	*Bhusa* yield (q/ha)
	2001–02	2002–03	2001–02	2002–03					
INM to sorghum (kharif)									
Control	37.38	37.18	29.78	28.16	55.9	8.9	15.2	20.03	24.65
100% RDF	39.89	37.98	45.33	37.95	60.7	9.7	17.4	21.20	22.53
75% RDF + FYM	39.20	39.47	38.00	32.12	67.6	10.6	17.5	19.95	23.38
75% RDF + biofertilizer	40.18	38.56	43.89	26.72	68.5	10.1	16.9	19.81	23.67
75% RDF + FYM + biofertilizer	41.29	39.00	52.11	49.45	63.3	9.7	17.6	21.44	24.48
50% RDF + FYM	40.29	38.71	49.78	35.93	73.7	12.0	17.4	21.52	26.33
50% RDF + biofertilizer	40.60	39.36	41.56	29.21	68.5	10.4	17.2	20.84	24.55
50% RDF + FYM + biofertilizer	39.93	39.38	42.67	40.33	65.8	9.7	17.5	19.50	23.08
CD (P=0.05)	0.95	1.02	11.62	1.90	8.4	1.8	0.1	N.S.	N.S.
Fertilizer levels to chickpea (rabi)									
Control	38.68	36.72	36.29	26.56	56.8	8.6	16.4	18.00	20.63
50% RDF	40.02	38.98	40.29	33.35	67.6	10.5	17.1	21.04	24.81
100% RDF	40.83	40.40	52.08	41.29	72.1	11.3	17.7	22.57	26.81
CD (P=0.05)	0.52	0.55	3.57	1.40	6.2	1.2	0.1	5.62	9.49

RDF, Recommended dose of fertilizer; FYM, farmyard manure; N.S., not significant

Table 3. Economics and nutrient balance under sorghum–chickpea cropping sequence under integrated nutrient managment (INM)

Treatment	Nutrients applied during 4 seasons (kg/ha)			Nutrient uptake by crop during 4 seasons (kg/ha)			Soil-available nutrients after 4 seasons (kg/ha)			Net returns (Rs/ha)	Benefit : cost ratio
	N	P	K	N	P	K	N	P	K		
INM to sorghum (kharif)											
Control	25.0	22.0	0.0	372.4	65.5	176.0	133.8	8.2	305.8	22,415	2.05
100% RDF	265.0	74.8	99.6	679.7	124.9	293.0	192.3	11.3	357.5	39,984	2.74
75% RDF + FYM	268.5	117.1	149.7	674.5	115.5	284.2	175.6	11.1	385.7	35,740	2.35
75% RDF + FYM + biofertilizer	205.0	61.6	74.7	568.8	103.5	246.2	175.6	12.3	390.4	34,765	2.51
75% RDF + FYM + biofertilizer	268.5	117.1	149.1	734.4	128.5	310.1	184.0	12.7	428.1	39,288	2.51
50% RDF + FYM	208.5	103.9	124.8	629.9	105.9	262.0	200.7	11.7	423.4	35,936	2.43
50% RDF+biofertilizer	145.0	48.4	49.8	530.4	97.0	232.5	175.6	12.6	413.9	36,481	2.63
50% RDF + FYM + biofertilizer	208.5	103.9	124.8	640.2	114.7	270.9	167.3	13.0	418.7	34,722	2.36
CD (P=0.05)										8,218	
Fertilizer levels to chickpea (rabi)											
Control	0.0	0.0	0.0	544.8	99.2	245.7	144.3	9.6	388.1	31,698	2.36
50% RDF	25.0	22.0	0.0	625.8	107.6	261.2	181.9	11.7	389.8	35,657	2.42
100% RDF	50.0	44.0	0.0	660.6	114.0	280.0	200.7	13.4	393.4	37,393	2.37
CD (P=0.05)										2,097	

Initial status of nutrients (kg/ha) : N=175.6; P=15.0; K=553.6; RDF, Recommended dose of fertilizer; FYM, farmyard manure

corded with 50% RDF + biofertilizers applied to sorghum. Similar results were also reported by Shelke *et al.*(1997) in sorghum–wheat cropping systems. The treatment effects were also noticed due to the fertilizer levels applied to chickpea (*rabi*). The maximum residual status of available nitrogen and potassium was observed with the application of 100% RDF followed 50% RDF and lowest nutrient balance of nitrogen and potassium was due to the control treatment. In respect of phosphorus balance, control treatment was superior to all the treatments followed by 50% RDF and least by the 100% RDF.

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