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JB Patil
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agriculture University,
Navsari (Gujarat), India

MK Arvadia
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agriculture University,
Navsari (Gujarat), India

DS Thorave
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agriculture University,
Navsari (Gujarat), India

Correspondence
JB Patil
Department of Agronomy,
N. M. College of Agriculture,
Navsari Agriculture University,
Navsari (Gujarat), India

Effect of integrated nitrogen management on yield, economics and soil properties in sorghum-green gram cropping sequence under South Gujarat

JB Patil, MK Arvadia and DS Thorave

Abstract
A field experiment was conducted at the College Farm, Navsari Agricultural University, Navsari (Gujarat) on clayey soil to study the residual effect of INM and direct effect of RDF on growth, yield and economics of green gram in sorghum-green gram copping system during the year 2015-16 and 2016-17. The seven treatments consisted of integrated nitrogen management to sorghum in *rabi* season as main plot treatments in RBD. During summer season each main plot treatments was splited into three sub plot treatments with three levels of recommended dose of fertilizers to green gram in split plot design. Result revealed that 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha was found significantly superior grain (34.55 q/ha) and stover yield (87.17 q/ha) compared to rest of treatments in sorghum. Residual effect of preceding crop sorghum fertilized with T_1-100% RDF through inorganic fertilizer + biocompost @ 10 t/ha recorded higher grain yield (9.84 q/ha) and stover yield (23.64 q/ha) of succeeding green gram. Similarly, statistically same values of grain yield, stover yield of green gram were recorded with the application of 100% RDF and 75% RDF but are significantly superior to control. Maximum net return in sorghum (Rs. 59146/ha), residual effect on summer green gram (Rs 35548/ha) and crop sequence (Rs 94694/ha) with higher B:C ratio (2.42) were recorded in the treatment receiving 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha. However, in case of direct application of RDF levels, highest net returns was recorded with the application of 100% RDF and followed by 75% RDF. Significantly higher sorghum equivalent yield (64.08 q/ha) was recorded with application of 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha to *rabi* sorghum and under 100% RDF and 75% RDF to green gram. As regards to the economics of treatments combination of cropping sequence, T_1S_1 and T_1S_2 recorded maximum net monitory return of ₹99659/ha and ₹ 99601/ha with B:C ratio of 2.48 and 2.49, respectively. In respect of soil properties, 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha to sorghum while treatment 100% RDF and 75% RDF to green gram showed considerable increase in net available balance of nitrogen, phosphorus and potassium and organic carbon content after two years over its initial status. Bulk density of soil was reduced over its initial status in these treatments.

Key wards: Sorghum-Green gram sequence, Growth attributes, Yield attributes Economics and Residual effect of INM

1. Introduction
Presently emphasis has been given to cultivate more than one crop on same piece of land as mixed/intercrop or sequence, as it has been prove by research that preceding crop affect the growth and yield of succeeding crop. But generally in crop sequence cereal crops is taken after legumes crops as the legumes crops requires less amount of fertilization and it restore the soil fertility. Now it is time to judge the cereal-legume crop sequence instead of legume-cereal crop sequence.

Sorghum (*Sorghum bicolor* L.) is a unique drought resistant crop among the major cereals and the fifth most important cereal in the world after wheat, rice, maize and barley. Due to heavy rains and winds during *kharif* season losses are observed in agricultural crops. So, *rabi* sorghum may be an option for the *kharif* sorghum in such areas. *Rabi* sorghum may help to reduce the production gap caused due to replaced *kharif* sorghum in sorghum producing states viz., Maharashtra, Gujarat, Karnataka and Andhra Pradesh. Green gram is an important pulse crop of India as it is grown an area of 2.98 million hectares with total production of 1.61 million tonnes and productivity of 407 kg/ha (Singh *et al.* 2015) [17]. In India, major green gram producing states are Odisha, Madhya Pradesh, Rajasthan, Maharashtra, Gujarat and

Bihar. In Gujarat, it is cultivated in about 2.3 lakh hectares with an annual production of 1.21 lakh tonnes and average productivity of 526 kg /ha (Anonymous, 2015). Nutrient management has been key input in intensive cropping. Organic manuring is becoming an important component of environmentally sound sustainable agriculture. It is important for maintaining soil organic matter, necessary for favourable soil structure, soil and water conservation and soil microbial and faunal activity. Inadequate and imbalanced use of plant nutrients is one of the major constraints for low productivity of pulse crops. The beneficial effect of organics in improving the soil fertility and productivity is well documented by various researchers. Hence, an experiment was conducted to assess the effect of different INM treatments in sorghum-green gram cropping sequence under south Gujarat condition.

2. Materials and methods

A field experiment was conducted at the College Farm, Navsari Agricultural University, Navsari (Gujarat) during the year 2015-16 and 2016-17. The soil of the experimental field was clayey in texture, low in organic carbon (0.39%) and available nitrogen (204.50 kg/ha), medium in available phosphorus (39.20 kg/ha) and high in available potassium (302.50 kg/ha). The soil was slightly alkaline in reaction (pH 7.7). The treatment consisted of integrated nitrogen management viz.,100% RDF through inorganic fertilizer + biocompost @ 10 t/ha (T1), 100% RDN through inorganic fertilizer (T2), 75% RDN through inorganic fertilizer + 25% RDN through biocompost (T3), 75% RDN through inorganic fertilizer + 25% RDN through biocompost + biofertilizer (T4), 50% RDN through inorganic fertilizer + 50% RDN through biocompost (T5), 50% RDN through inorganic fertilizer + 50% RDN through biocompost + biofertilizer (T6) and fallow (T7) to sorghum in *rabi* season as main plot treatments replicated four times in randomized block design. During summer season each main plot treatments was splited into three sub plot treatments with three levels of recommended dose of fertilizers viz., S1 - 100% RDF, S2 - 75% RDF and S3 – control to green gram resulting in twenty one treatment combinations replicated four times in split plot design. The experiment was conducted on same site without changing the randomization of the treatment for the successive year to assess the residual effects.

Sorghum cv. GJ-38 was sown with spacing of 45 cm x 10 cm in the third week of October and harvested in second week of February during both the years. Biocompost was applied as per treatment before sowing and mixed well in soil. Biofertilizers (Azospirillum and PSB) are also applied as per treatment in liquid form @ 2.5 lit/ha each in soil before sowing. The green gram cv Meha was sown with spacing of 30 cm x 10 cm. The total inorganic fertilizer application to green gram was done at the time of sowing. All the growth and yield attributes observations are recorded from five plant selected from net plot, while net plot yield was converted into hectare basis. In case of chemical analysis, soil samples are collected and analyzed for various nutrients by standard procedure. The net realization was calculated by deducting the total cost of cultivation from the gross realization for each treatment. Statistical analysis was worked out as per the method described by Panse and Sukhatme (1967) [10].

3. Result and Discussion

3.1 Effect on Yield

3.1.1 Yield of Sorghum: - The differences in grain yield and stover yield were up to the level of significance. Among INM, 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha gave significantly superior grain and stover yield compared to rest of treatments. The magnitude of increase in grain yield with application of 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha (T_1) was 13.99, 14.40, 21.61, 31.62 and 38.97 per cent over T_2, T_4, T_3, T_6 and T_5 treatments, respectively, while in case of stover yield it was 9.27, 16.03, 18.09, 20.82 and 22.66 per cent over T_2, T_4, T_3, T_6 and T_5 treatments, respectively. This was might be due to higher values of various growth attributes and yield attributes. These findings are in close agreement with those reported by Ponnuswamy *et al.* (2002) [14], Sonune *et al.* (2003) [18], Patidar and Mali (2004) [13] and Patel (2015).

3.1.2 Yield of green gram: Preceding crop sorghum fertilized with 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha recorded significantly higher grain yield of succeeding green gram. Stover yield of green gram was maximum in 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha and was statistically at par with T_6 and T_5. The increased seed and stover yields of green gram due to INM to preceding *rabi* sorghum might be due to good crop growth (growth attributes) resulted in to maximum values of yield attributes, ultimately it influence positively on yield, as growth and yield parameters shows positive and significant correlation with grain and stover yield of green gram. Similar results reported earlier by Gawai and Pawar (2006) [4] in sorghum-chickpea, Gudadhe (2008) [5] in cotton-chickpea, Shanwad *et al*. (2010) [15] in maize-bengal gram and Sindhi (2016) [16] in maize-green gram cropping sequence.

Similarly, statistically same values of grain yield, stover yield of green gram were recorded with the application of 100% RDF and 75% RDF but are significantly superior to control. Thus, the overall better growth performance and higher values of the yield attributes reflected into higher grain and stover yields under this treatment. Same result was reported by Patel *et al*. (2016) as well as Sindhi (2016) [16].

3.2 Economics

3.2.1 Sorghum: Maximum net returns of 59146 ₹/ha was recorded with the treatment receiving 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha fallowed by application of 100% RDF through inorganic fertilizer with net returns of 53449 ₹/ha over rest of treatments. This might be due to higher yield of crop with this treatment. Similar results reported earlier by Mahakulkar *et al* (1998) [9], Jat *et al*. (2003) [8] and Patel (2015) in sorghum crop.

3.2.2 Green gram: Among the various treatments applied to the preceding *rabi* sorghum crop, application of 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha recorded maximum net monetary returns (₹ 35548/ha) with B:C ratio of summer green gram compared to rest of treatments. This was due to higher gross yield of green gram. Similar benefits of residual effect of integrated nutrient management were reported earlier by Gudadhe (2008) [5] under cotton-chickpea, Shanwad *et al*. (2010) [15] in maize-bengal gram, Imade (2014) [6] in rice green gram and Sindhi (2016) [16] in maize green gram cropping sequence.

The maximum net returns of Rs. ₹30490/ha was recorded with the application of 100% RDF and followed by 75% RDF with net returns of ₹29947/ha. This might be due to higher yield of crop with these treatments. Similar findings in green gram crop with application of different levels of RDF were

reported by Ambhore (2004) [1], Patel (2012) as well as Sindhi (2016) [16].

3.2.3 Sequence: The net monetary return of ₹94694/ha) with B: C ratio value 2.42 was highest due to application of 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha to *rabi* sorghum, while net monetary returns of ₹ 83298/ha and ₹82775/ha with B:C of 2.39 and 2.40 was recorded in treatment 100% RDF and 75% RDF, respectively. As regards to the economics of treatments combination of cropping sequence (Table 2), T_1S_1 and T_1S_2 recorded maximum net monitory return of ₹99659/ha and ₹ 99601/ha with B:C ratio of 2.48 and 2.49, respectively. The results were in close conformity with those reported Gudadhe *et al*. (2008) [5] under cotton-chickpea cropping sequence and Sindhi (2016) [16] in maize-green gram cropping sequence.

3.2.4 Sorghum equivalent yield: The effect of the INM to preceding *rabi* sorghum crop and RDF to summer green gram expressed in terms of total productivity as sorghum equivalent yield indicated that the sorghum equivalent yield from the cropping sequence as a whole differed significantly due to INM to sorghum and levels of RDF to green gram. The sorghum equivalent yield due to application 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha and green gram under 100% RDF and 75% RDF was recorded significantly higher than rest of treatments. The similar findings had been reported by Gudadhe *et al*. (2008) [5] under cotton-chickpea cropping sequence and Sindhi (2016) [16] in maize-green gram cropping sequence.

3.4 Effect on Soil Properties

3.4.1 Bulk density: Residual effect of INM applied to sorghum were influence significantly with regard to bulk density of soil after completion of sequence. Treatment 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha recorded lower bulk density than all other treatments. Decrease in bulk density over its initial value under INM system might be the result of higher organic matter content, more pore space and better aggregation of soil particles. This result was in close conformity with those reported by Imade (2014) [6] in rice-green gram and Sindhi (2016) [16] in maize-green gram cropping system.

Bulk density was also significantly affected by different RDF treatments to green gram. Treatments 100% RDF and 75% RDF recorded statistically equal bulk density but found significantly lower bulk density over control. It might be due to the higher root and shoot biomass production in treatments of RDF application, ultimately resulted in to higher organic matter content and more pore space which binds the soil particles. Similar result as regards to bulk density in green gram was reported by Imade (2014) [6] and Sindhi (2016) [16].

3.4.2 Organic carbon: Significantly highest organic carbon was recorded under application of 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha compared with rest of treatments. Its might be due to direct application of large quantity of organic matter in the soil through biocompost. The increase in organic carbon content of the soil with the application of fertilizers and FYM had also been reported by Imade (2014) [6] in rice-green gram.

Treatments 100% RDF and 75% RDF registered statistically equal organic carbon content in soil, but recorded significantly higher organic carbon over control. This might be due to the production of higher root and shoot biomass which add more amount of organic matter in the soil resulted in rise of organic carbon content in soil. Result was conformity with Imade (2014) [6] in green gram.

3.4.3 Available nutrient in soil after completion of two years

The available nitrogen and phosphorus in soil after two years influenced significantly, while available potassium did not differ significantly due to the residual effect of INM treatments applied to *rabi* sorghum crop (Table 3). The application of 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha recorded significantly higher available nitrogen and phosphorus in soil compared to rest of treatments. Treatments without application of biocompost shows depletion in available nitrogen over initial status. Significantly higher available N due to INM may be ascribed to mineralization of nitrogen due to addition of organic manures (biocompost). The higher available phosphorus content due to INM may be attributed to minimization of phosphorus fixation and organic recycling. Higher available K due to INM may be ascribed to acidulation as a result of decomposition of organic matter and release of mineral K_2O in soil solution. These results are in partial fulfillment with Bandopadhyay and Puste (2002) [3] in rice-pulse, Imade (2014) [6] in rice-green gram and Sindhi (2016) [16] in maize-green gram cropping sequence.

Available nitrogen content of soil with the application of different levels of RDF influenced significantly. However, available phosphorus and potassium content was found non significant. Treatment 100% RDF and 75% RDF recorded statistically same values of available nitrogen content in soil, but significantly superior to control treatment. All three treatments showed increase in available nutrient status in soil over its initial status. It might be due to the direct application of inorganic fertilizers and addition of organic matter *viz.*, roots, root nodules and shedding of leaves *etc.* These results are on the line with the findings of Jat *et al*. (2012) [7] and Patel *et al.* (2012) and Sindhi (2016) [16] on same green gram crop.

3.4.4 Net available nutrient balance in soil after two years:

Result on net available nutrients (Table 3) after completion of sequence in treatments of INM to sorghum and RDF to green gram showed considerable difference among different treatments. The 100% RDF through inorganic fertilizer + biocompost @ 10 t/ha to sorghum while treatment 100% RDF or 75% RDF to green gram showed considerable increase in net available nutrient after two years over its initial status. This might be due to addition of organic manures and shedding effect of leaves in case of legumes also helped to maintain the organic carbon status of the soil and also the improvement in the physical conditions of the soil which ultimately resulted in availability of nutrients in soil. Similar findings were reported earlier by Bandopadhyay and Puste (2002) [3] under rice–pulse cropping sequence, Gawai and power (2006) under sorghum check pea and Sindhi (2016) [16] in maize-green gram cropping sequence.

Table 1: Effect of INM on yield and economics in sorghum-green gram cropping sequence (Average of two years)

q	Sorghum (q/ha)		Green gram (q/ha)		Net monetary return (Rs)			B:C ratio sequence	Sorghum Equivalent yield (q/ha)
	Grain	Stover	Grain	Stover	Sorghum	Green gram	Sequence		
I). Main plot treatment									
T_1	34.55	87.14	9.84	23.64	59146	35548	94694	2.42	64.08
T_2	30.31	79.75	8.01	20.65	53449	23643	77092	2.25	54.33
T_3	28.41	73.79	8.28	20.84	47914	25337	73227	2.19	53.25
T_4	30.20	75.10	8.37	21.29	51387	25985	77348	2.24	55.30
T_5	24.86	71.04	8.78	22.21	40043	28724	68767	2.12	51.19
T_6	26.25	72.12	8.88	23.26	42647	29629	72276	2.16	52.38
T_7	-	-	6.79	17.94	-	15530	9513	1.26	20.37
S. Em±	0.82	1.88	0.21	0.58	-	-	-	-	0.88
C.D. at 5 %	2.48	5.68	0.63	1.73	-	-	-	-	2.62
C.V. %	5.65	4.93	8.77	9.40	-	-	-	-	6.09
II). Sub plot treatment									
S_1 : 100 % RDF	-	-	9.17	23.10	-	30490	83298	2.39	52.44
S_2 : 75 % RDF	-	-	9.03	22.35	-	29947	82755	2.40	52.03
S_3 : Control	-	-	7.06	18.76	-	18590	71398	2.24	46.13
S. Em±	-	-	0.06	0.29	-	-	-	-	0.19
C.D. at 5 %	-	-	0.18	0.83	-	-	-	-	0.54
C.V. %	-	-	3.96	7.20	-	-	-	-	1.99
Interaction (M x S)									
S. Em±	-	-	0.17	0.77	-	-	-	-	0.50
C.D. at 5 %	-	-	NS	NS	-	-	-	-	NS
C.V. %	-	-	3.96	7.20	-	-	-	-	1.99

T_1: 100% RDF through inorganic fertilizer + biocompost @ 10 tonnes/ ha, T_2: 100 % RDN through inorganic fertilizer, T_3: 75% RDN through inorganic fertilizer + 25% RDN through biocompost, T_4: 75% RDN through inorganic fertilizer + 25% RDN through biocompost + biofertilizers, T_5: 50% RDN through inorganic fertilizer + 50% RDN through biocompost, T_6: 50 % RDN through inorganic fertilizer + 50 % RDN through biocompost + biofertilizers, T_7: Fallow

Table 2: Economics of sorghum - green gram cropping sequence as influenced by different treatment combinations (Average of two years)

Treatment combinations	Gross monetary returns (₹/ha)			Cost of cultivation (₹/ha)			Net monetary returns (₹/ha)	B : C ratio
	Sorghum	Green gram	Sequence	Sorghum	Green gram	Sequence		
T_1S_1	95242	71958	167200	36096	31445	67541	99659	2.48
T_1S_2	95242	71394	166636	36096	30939	67035	99601	2.49
T_1S_3	95242	55044	150286	36096	29419	65515	84771	2.29
T_2S_1	84545	59325	143870	31096	31445	62541	81329	2.30
T_2S_2	84545	58701	143246	31096	30939	62035	81211	2.31
T_2S_3	84545	44682	129227	31096	29419	60515	68712	2.14
T_3S_1	78957	61008	139965	31067	31445	62512	77453	2.24
T_3S_2	78957	60186	139143	31067	30939	62006	77137	2.24
T_3S_3	78957	46599	125556	31067	29419	60486	65070	2.08
T_4S_1	82930	61563	144493	31567	31445	63012	81481	2.29
T_4S_2	82930	60390	143320	31567	30939	62506	80814	2.29
T_4S_3	82930	47808	130738	31567	29419	60986	69752	2.14
T_5S_1	71032	63798	134830	30989	31445	62434	72396	2.16
T_5S_2	71032	63201	134233	30989	30939	61928	72305	2.17
T_5S_3	71032	50970	122002	30989	29419	60408	61594	2.02
T_6S_1	74136	65376	139512	31489	31445	62934	76578	2.22
T_6S_2	74136	64479	138615	31489	30939	62428	76187	2.22
T_6S_3	74136	50856	124992	31489	29419	60908	64084	2.05
T_7S_1	0	50505	50505	6017	31445	37462	13043	1.35
T_7S_2	0	47796	47796	6017	30939	36956	10840	1.29
T_7S_3	0	40128	40128	6017	29419	35436	4692	1.13

Table 3. Effect of INM on soil properties after two years in sorghum-green gram cropping sequence (Average of two years)

Treatments	Bulk density (g/cc)	Organic carbon (%)	Available nutrients in soil (kg/ha)			Net available balance of nutrient (kg/ha)		
			N	P	K			
I). Main plot treatment								
T_1	1.34	0.53	239.42	47.88	333.73	36.47	9.19	32.44
T_2	1.40	0.41	200.31	42.29	303.71	-3.15	3.45	2.66
T_3	1.39	0.45	218.61	43.78	325.23	15.32	5.28	24.19
T_4	1.37	0.46	219.38	43.90	326.88	16.25	5.41	25.82
T_5	1.35	0.48	225.99	44.42	329.02	22.87	5.74	27.82
T_6	1.35	0.49	227.63	44.65	331.07	24.67	5.94	29.85
T_7	1.40	0.39	198.75	40.99	301.03	-5.14	2.35	-0.88

S. Em±	0.01	0.00	3.06	0.90	8.59	-	-	-
C.D. at 5 %	0.03	0.01	9.10	2.66	NS	-	-	-
C.V. %	2.12	3.29	4.85	7.06	9.26	-	-	-
II). Sub plot treatment								
S_1 : 100 % RDF	1.36	0.48	224.99	44.67	326.58	22.03	6.14	24.91
S_2 : 75 % RDF	1.36	0.47	222.76	44.22	323.34	19.33	5.66	21.93
S_3 : Control	1.38	0.43	208.00	43.07	314.66	4.61	4.21	13.97
S. Em±	0.00	0.00	1.38	0.49	3.62	-	-	-
C.D. at 5 %	0.01	0.01	3.94	NS	NS	-	-	-
C.V. %	1.88	3.71	3.34	5.88	5.95	-	-	-
Initial status of soil	**1.40**	**0.39**	**204.5**	**39.20**	**302.50**			

T_1: 100% RDF through inorganic fertilizer + biocompost @ 10 tonnes/ ha, T_2: 100 % RDN through inorganic fertilizer, T_3: 75% RDN through inorganic fertilizer + 25% RDN through biocompost, T_4: 75% RDN through inorganic fertilizer + 25% RDN through biocompost + biofertilizers, T_5: 50% RDN through inorganic fertilizer + 50% RDN through biocompost, T_6: 50 % RDN through inorganic fertilizer + 50 % RDN through biocompost + biofertilizers, T_7: Fallow

4. Conclusion

On the basis of experimental results, it can be concluded that for getting maximum yield, returns and maintenance of soil status, *rabi* sorghum crop should be nourished 100% RDF (80:40:00 NPK kg/ha) through inorganic fertilizer + biocompost @ 10 t/ha and summer green gram crop should be fertilized with 75% RDF (15-30-00 kg N-P-K/ha) through inorganic fertilizer in sorghum- green gram sequence under south Gujarat condition.

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