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Effect of nutrient practices on performance and quality of rabi green gram (*Vigna radiata* L.) - pearl millet (*Pennisetum glaucum* L.) cropping sequence

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Abstract
The investigation was conducted during rabi and summer seasons of 2017-18 and 2018-19at College Farm, Navsari Agricultural University, Navsari to study the production potential of green gram - pearl millet cropping sequence under integrated nutrient management system. The treatment consisted of five treatment of integrated nutrient management to green gram in rabi season as main plot treatments replicated four times in randomized block design. During summer season each main plot treatment was split into four sub plot treatments with four levels of nitrogen to pearl millet resulting in twenty treatment combinations replicated four times in split plot design. 75% RDN through vermicompost + Bio-fertilizer (Rhizobium) (RDF: 20-40-00 N-P_2O_5-K_2O kg/ha) to rabi green gram and 100% RDF (120-60-00 N-P_2O_5-K_2O kg/ha) summer pearl millet in green gram – pearl millet sequence gave maximum production with better quality under south Gujarat condition.

Keywords: Green gram- pearl millet, integrated nutrient management, cropping sequence

Introduction
Green gram is an important pulse crop of India as it is grown on an area of 3.44 million hectares with total production of 1.4 million tonnes and productivity of 407 kg/ha. In Gujarat, it is cultivated on about 1.52 lakh hectares with an annual production of 0.847 lakh tonnes and average productivity of 557 kg/ha (Anon., 2018_a) [1]. Pearl millet is commonly known as Bajri or Bajra in India. It is the most drought tolerant crop among cereals and millets and water requirement is low. Pearl millet can be grown on a wide variety of soils, but being sensitive to water logging condition, it does best on well drained sandy loam soil. In India, it is annually grown on 74.58 lakh hectares area producing nearly 97.31 lakh tonnes of grains with productivity of 1305 kg/ha. Gujarat occupies an area of 4.31 lakh hectares and production of 9.31 lakh tonnes with productivity of 2160 kg/ha (Anon., 2018_b) [1]. In the recent past, cropping system approach has gained importance in agriculture and relative enterprises. A system consist of several components which are closely related to an interacting among themselves. In agriculture, management practices are usually formulated for individual crops. However, farmers are cultivating different crops in different season based on their adaptability to a particular season, domestic needs and profitability, therefore production technology should be developed keeping in view all the crops grown in a year or more than one year if any sequence or rotation extends beyond one year. Such a package of management practices for all the crops leads to efficient use of costly inputs, besides reduction in production cost. For instants, residual effect of manures and fertilizers applied and nitrogen fix by legumes can considerably bring down the production cost if all the crops are consider instead of individual crops. In this context, cropping system approaches gaining importance. Although a good deal of information is available on fertilizer application for higher production of green gram as well as pearl millet and so far FYM is the organic source which has been used predominantly but meager work has been done on vermicompost, bio-compost and bio-fertilizer as an organic source as far as green gram- pearl millet sequence is concerned.

Materials and Methods
The present investigation was carried out by laying out a field experiment on *rabi* green gram with different levels of recommended dose of fertilizer in combination with biocompost, vermicompost, farm yard manure (FYM) and bio-fertilizer (*Rhizobium*) in *rabi* season and levels of fertilizer to pearl millet in summer for two consecutive years on same site. The field experiment was conducted at the College Farm, Navsari Agricultural University, Navsari

during *rabi* and summer seasons of 2017-18 and 2018-19. The topography of the experimental site was fairly uniform and levelled. Data on soil analysis revealed that soil of experimental plot was clay in texture. Low in organic carbon (0.42%) and available nitrogen (196.80 kg/ha), medium in available phosphorus (38.30 kg/ha) and high in available potassium (315.43 kg/ha). The soil was found slightly alkaline (pH 8.23) with normal electric conductivity (0.30 dS/m).The treatment consisted of integrated nutrient management viz., M_1-RDF (20-40-00 N-P_2O_5 –K_2O kg/ha), M_2 - 75% RDN through biocompost + Biofertilizer (*Rhizobium*), M_3 -75% RDN through vermicompost + Biofertilizer (*Rhizobium*), M4-75% RDN through FYM + Biofertilizer (*Rhizobium*) and M_5 - control to green gram in *rabi* season as main plot treatments replicated four times in randomized block design. During summer season each main plot treatment was split into four sub plot treatments with four levels of nitrogen *viz.*, S_1 - control, S_2 -50% RDN, S_3 -75% RDN and S_4-100% RDN (RDF: 20-40-00 N-P_2O_5–K_2O kg/ha) to pearl millet resulting in twenty treatment combinations replicated four times in split plot design.

Result and Discussion

Rabi green gram

Among treatments of INM, treatment M_3 (75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*)) gave significantly higher seed as compared to rest of the treatments. The remarkable increase in seed yield under treatment M_3 was due to readily available nutrient and have growth hormones in vermicompost, will increase effect of this treatment over FYM and biocompost treatment, which resulted higher values of various growth attributes and yield attributes. It is well known fact that these parameters positively correlate with seed and stover yield. These findings are in close agreement with those reported by Tyagi *et al*. (2014) [16], Kachariya (2015) [7] and Sushil *et al.* (2015) [15].

N, P_2O_5 and K_2O content in seed and total uptake of green gram were significantly influenced due to different INM treatments applied to the crop (Table 2). Treatment with 75 % RDN through vermicompost + Bio-fertilizer (*Rhizobium*) recorded maximum N, P_2O_5 and K_2O content in grain. The higher concentration of nutrients (Table 1) in green gram seed might be due to addition of nitrogen, phosphorus and potassium in soil through application of organic sources of nutrients especially with readily availability with vermicompost and additionally fixed by *rhizobium* which in turn increased efficiency of applied nutrients. On pooled data basis, significantly higher total uptake of N, P_2O_5 and K_2O by green gram crop was observed with treatment M_3. The nutrient uptake is a function of yield and nutrient concentration in plant. This might be due to higher crop biomass production due to better nourishment resulted into higher uptake. These findings are in accordance with Tyagi *et al*. (2014) [16] and Patel *et al.* (2016) [11] reported higher nutrient uptake with application of organic with bio-fertilizer, in green gram.

Protein content in green gram seed and protein yield was found significant due to influence of INM treatments (Table 1 and 2). On the basis of pooled results, maximum protein content was recorded under application of 75 % RDN through vermicompost + Bio-fertilizer (*Rhizobium*)- M_3. The increase in protein content of green gram seed due to more quantity of nitrogen content in seed (Table 1) which resulted into improvement in metabolic activities in the plant, while increasing in protein yield due to higher protein content and higher seed yield in this treatment (Table 1).

Summer Pearl millet

Effect of main plot treatments

The differences in grain yield were reached up to the level of significance. Preceding crop green gram fertilized with treatment M_3 (75 % RDN through vermicompost + Bio-fertilizer (*Rhizobium*)) recorded significantly higher grain of succeeding pearl millet during both the years and in pooled analysis over rest of the treatments. The increased grain yield of pearl millet crop due to INM to preceding *rabi* green gram might be due to good crop growth (growth attributes) resulted in to maximum values of yield attributes, ultimately it influenced positively on yield, as growth and yield parameters might have positive correlation with grain and straw yield of pearl millet. Similar results also were reported earlier by Malik (2003) [8] in gram - rice, Jat and Ahlawat (2006) [6] in chickpea - maize, Prajapat *et al.* (2014) [12] in soyabean - sorghum, Umale (2016) [17] in green gram - maize cropping sequence.

N content in grain and total N, P_2O_5 and K_2O uptake by pearl millet were influenced significantly due to residual effect of INM applied to preceding *rabi* green gram crop. The maximum N content in grain was recorded under treatment with 75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*)-M_3. On the basis of pooled data, total uptake of N, P_2O_5 and K_2O by pearl millet crop was maximum in treatment $M_{3.}$

The increase in nutrient content and total uptake by pearl millet might be due to the residual effect of applied of organic manure to previous crop *i.e*. vermicompost and biofertilizer due to which there was more availability of nutrients to the crops, improvement in soil physical, chemical and biological properties through application of vermicompost as well as fixation of atmospheric N and conversion of other nutrients in available form and ultimately better nourishment of crop and higher crop biomass production. These findings are in agreement with those of Shivakumar and Ahlawat (2008) [14] soyabean - maize, Ramawtar *et al*. (2013) [13] in cluster bean - wheat, Desai (2016) [4] in soyabean - maize, Umale (2016) [17] in green gram - maize, Bijarnia *et al.* (2017) [3] in mustard - pearl millet cropping sequence.

The data on protein yield (Table 4) were significantly influenced by residual effect of INM applied to preceding *rabi* green gram. Maximum protein yield was recorded under the treatment of M_3 75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*). The improvement in protein yield in grain was due to increase in nitrogen content in grain. These results are in consonance with those of Pankhaniya (2007) [9] in soyabean - sorghum, Desai (2016) [4] in soyabean - maize cropping sequence.

Effect of sub plot treatments

On pooled data basis, statistically higher values of grain yield and straw yield were recorded with the application of 100% RDN over the rest of the other treatment. The magnitude of increase in grain yield under treatments 100 % RDN (S_4) was 11.63, 20.50 and 34.65 per cent over 75% RDN (S_3), 50% RDN (S_2), control (S_1) treatment, respectively. The highest grain yield could be due to the cumulative effect of improvement in yield attributes viz., number of effective tillers/plant, ear head length and girth and test weight, These results are also in agreement with findings of Jadhav *et al.* (2011) [5] and Patel (2014) [10].

The present study reveals that N content in grain as well as total N, P_2O_5 and K_2O uptake by pearl millet were significantly influenced due to nitrogen levels. Treatments 100% RDN gave statistically higher results in terms of N content in grain as well as total uptake of N, P_2O_5 and K_2O. The higher content and more removal of nutrient might be due to more availability of nutrient and higher biomass production. Similar results in respect of nutrient content and uptake by pearl millet with application of various levels of RDN were also reported by Jadhav *et al.* (2011) [5] and (Patel 2014) [10].

Protein yield of pearl millet (Table 4) were significantly influenced by nitrogen level treatments. Treatments 100% RDN recorded statistically maximum values in terms of protein yield and found significantly superior to control. Similar trends of protein content and protein yield of pearl millet with application of RDF levels were reported by Jadhav *et al.* (2011) [5] and (Patel 2014) [10].

Table 1: Yield and nutrient content of *rabi* green gram as influenced by different treatments of integrated nutrient management

Treatments	Seed yield (kg/ha)			Protein content (%)			N content in seed (%)			P_2O_5 content in seed (%)			K_2Ocontent in seed (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
M_1	1240	1336	1288	20.26	20.06	20.16	3.24	3.21	3.23	0.84	0.87	0.86	2.08	2.06	2.07
M_2	1375	1585	1480	22.35	23.05	22.70	3.58	3.69	3.63	0.98	0.94	0.96	2.14	2.13	2.13
M_3	1486	1615	1551	23.23	23.69	23.46	3.72	3.79	3.75	1.02	0.97	0.99	2.32	2.17	2.25
M_4	1282	1418	1350	20.45	21.11	20.78	3.27	3.38	3.33	0.92	0.90	0.91	2.12	2.06	2.09
M_5	945	1020	982	16.28	17.82	17.05	2.60	2.85	2.73	0.72	0.75	0.73	1.94	1.89	1.91
SEm±	63.67	79.16	48.02	0.48	0.50	0.34	0.08	0.08	0.06	0.02	0.02	0.01	0.04	0.05	0.03
CD (P=0.05)	196	244	139	1.50	1.56	1.00	0.24	0.25	0.16	0.05	0.05	0.04	0.14	0.14	0.09
CV%	10.06	11.35	10.80	4.77	4.80	4.79	4.77	4.81	4.79	3.54	3.77	3.66	4.16	4.52	4.34
Interaction (Y x T)															
SEm±	71.83			0.50			0.08			0.02			0.04		
CD (P=0.05)	NS			NS			NS			NS			NS		

M_1: RDF (RDF: 20-40-00 NPK kg/ha), M_2: 75% RDN through biocompost + Bio-fertilizer (*Rhizobium*), M_3: 75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*), M_4: 75% RDN through FYM + Bio-fertilizer (*Rhizobium*) and M_5: Control.

Table 2: Total nutrient uptake and protein yield of *rabi* green gram as influenced by different treatments of integrated nutrient management

Treatments	Total N uptake (kg/ha)			Total P_2O_5 uptake (kg/ha)			Total K_2O uptake (kg/ha)			Protein yield (kg/ha)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
M_1	60.59	62.96	61.77	20.01	21.47	20.74	71.66	73.06	72.36	251.52	268.42	259.97
M_2	75.45	84.86	80.16	25.75	27.64	26.70	84.67	92.34	88.50	307.58	366.15	336.87
M_3	84.17	90.55	87.36	30.26	30.43	30.34	97.40	98.40	97.90	344.26	383.17	363.72
M_4	63.99	70.08	67.04	22.37	23.72	23.04	77.24	79.18	78.21	262.48	299.50	280.99
M_5	35.78	40.98	38.38	12.72	14.12	13.42	51.26	54.34	52.80	152.74	180.51	166.62
SEm±	2.75	3.44	2.09	1.06	0.92	0.66	4.07	3.92	2.66	11.83	18.95	10.75
CD (P=0.05)	8.46	10.59	6.06	3.27	2.82	1.91	12.54	12.06	7.72	36.55	54.40	31.15
CV%	8.58	9.83	9.29	9.54	7.80	8.67	10.65	9.85	10.25	8.99	12.65	11.22
Interaction (Y x T)												
SEm±	3.11			0.99			3.99			15.81		
CD (P=0.05)	NS			NS			NS			NS		

Table 4: Nutrient content of summer pearl millet as influenced by different treatments

Treatments	Grain yield (kg/ha)			N content in grain (%)			P_2O_5 content in grain (%)			K_2O content in grain (%)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Main plot treatment												
M_1	3644	3795	3720	1.59	1.60	1.60	0.756	0.767	0.761	0.828	0.831	0.829
M_2	3811	3879	3845	1.62	1.65	1.63	0.761	0.770	0.765	0.831	0.832	0.831
M_3	3995	4180	4088	1.71	1.67	1.69	0.769	0.779	0.774	0.844	0.845	0.845
M_4	3689	3808	3749	1.64	1.63	1.64	0.758	0.768	0.763	0.826	0.827	0.827
M_5	3379	3520	3449	1.55	1.53	1.54	0.761	0.771	0.766	0.829	0.829	0.829
SEm±	105.78	111.11	71.49	0.02	0.02	0.01	0.009	0.009	0.006	0.012	0.010	0.008
CD (P=0.05)	326	342	207	0.07	0.05	0.04	NS	NS	NS	NS	NS	NS
CV%	11.43	11.58	11.51	5.37	3.92	4.70	5.35	5.21	5.28	6.07	5.72	5.89
Sub Plot treatment												
S_1	3122	3337	3229	1.58	1.56	1.57	0.755	0.765	0.760	0.819	0.820	0.820
S_2	3575	3641	3608	1.62	1.61	1.61	0.758	0.768	0.763	0.833	0.834	0.833
S_3	3857	3933	3895	1.62	1.62	1.62	0.765	0.776	0.770	0.834	0.836	0.835
S_4	4260	4435	4348	1.67	1.68	1.67	0.765	0.775	0.770	0.840	0.841	0.840
SEm±	76.76	84.46	56.52	0.01	0.01	0.01	0.006	0.006	0.009	0.007	0.007	0.004
CD (P=0.05)	219	241	159	0.04	0.04	0.02	NS	NS	NS	NS	NS	NS
CV%	9.27	9.85	9.57	3.47	3.53	3.50	3.64	3.48	3.56	4.18	4.40	4.29
Interaction (M x S) SEm±	171.63	188.85	119.97	0.02	0.02	0.02	0.006	0.006	0.009	0.015	0.016	0.011
Interaction (M x S) CD (P=0.05)	489	538	337	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (Pooled)	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±		CD (P=0.05)	SEm±		CD (P=0.05)
Interaction (Pooled) M x Y	108.48	NS		0.02	NS		0.009		NS	0.011		NS
Interaction (Pooled) S x Y	80.70	NS		0.01	NS		0.004		NS	0.007		NS

	M x S x Y	180.45	NS	0.03	NS	0.011	NS	0.015	NS

M_1: RDF (RDF: 20-40-00 NPK kg/ha), M_2: 75% RDN through biocompost + Bio-fertilizer (*Rhizobium*), M_3: 75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*), M_4: 75% RDN through FYM + Bio-fertilizer (*Rhizobium*) and M_5: Control
S_1: Control, S_2: 50% RDN, S_3: 75% RDN and S_4: 100% RDN (RDF: 120:60:00 NPK kg/ha)

Table 3: quality and nutrient uptake of summer pearl millet as influenced by different INM treatments

Treatments	Total N uptake (kg/ha)			Total P_2O_5 uptake (kg/ha)			Total K_2O uptake (kg/ha)			Protein yield (kg/ha)		
	2018	**2019**	**Pooled**	**2018**	**2019**	**Pooled**	**2018**	**2019**	**Pooled**	**2018**	**2019**	**Pooled**
Main plot treatment												
M_1	103.61	107.02	105.31	40.57	41.89	41.23	99.38	99.28	99.33	362.90	379.99	371.44
M_2	110.18	114.02	112.10	42.43	43.45	42.94	103.42	104.54	103.98	386.36	400.35	393.35
M_3	122.58	125.74	124.16	45.43	47.47	46.45	111.92	114.32	113.12	429.29	439.76	434.52
M_4	108.38	109.84	109.11	41.21	42.09	41.65	101.02	99.64	100.33	378.87	389.80	384.33
M_5	95.83	99.41	97.62	38.09	39.64	38.87	93.05	97.05	95.05	328.22	337.47	332.84
SEm±	2.64	2.66	1.87	1.10	1.14	0.79	2.48	2.58	1.79	11.45	10.71	7.28
CD (P=0.05)	8.12	8.21	5.61	3.39	3.51	2.37	7.64	7.96	5.37	35.30	33.02	21.10
CV%	9.75	9.58	9.67	10.60	10.64	10.62	9.74	10.04	9.89	12.15	11.01	11.58
Sub Plot treatment												
S_1	91.15	95.12	93.14	35.44	37.38	36.41	89.23	91.37	90.30	308.99	325.41	317.20
S_2	102.89	104.98	103.94	39.60	40.36	39.98	96.86	97.54	97.20	362.48	367.45	364.96
S_3	111.30	113.63	112.47	43.26	44.12	43.69	103.97	104.58	104.27	391.32	398.65	394.98
S_4	127.12	131.09	129.10	47.88	49.77	48.83	116.97	118.37	117.67	445.72	466.39	456.05
SEm±	2.14	2.22	1.54	0.96	0.99	0.68	2.39	2.30	1.65	8.34	8.78	5.99
CD (P=0.05)	6.11	6.31	4.60	2.72	2.80	2.04	6.80	6.56	4.95	23.77	25.04	16.87
CV%	8.87	8.91	8.89	10.30	10.27	10.28	10.50	10.00	10.25	9.89	10.09	9.99
Interaction SEm± (M x S)	4.80	4.95	3.44	2.14	0.73	1.53	5.34	5.15	3.71	18.65	19.64	12.73
CD (P=0.05)	14.77	15.26	10.20	NS	NS	4.59	NS	NS	11.13	53.16	55.99	35.77
Interaction (Pooled)	SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±	CD (P=0.05)		SEm±		CD (P=0.05)
M x Y	2.64	NS		1.12	NS		2.53	NS		11.09		NS
S x Y	2.18	NS		0.97	NS		2.34	NS		8.56		NS
M x S x Y	4.87	NS		2.17	NS		5.24	NS		19.15		NS

M_1: RDF (RDF: 20-40-00 NPK kg/ha), M_2: 75% RDN through biocompost + Bio-fertilizer (*Rhizobium*), M_3: 75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*), M_4: 75% RDN through FYM + Bio-fertilizer (*Rhizobium*) and M_5: Control
S_1: Control, S_2: 50% RDN, S_3: 75% RDN and S_4: 100% RDN (RDF: 120:60:00 NPK kg/ha)

Conclusion

On the basis of experimental results, it can be concluded that for getting higher yield along with better quality *rabi* green gram crop should be nourished with 75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*) (RDF: 20-40-00 N-P_2O_5-K_2O kg/ha) and summer pearl millet crop should be fertilized with 100% RDF (120-60-00 N-P_2O_5-K_2O kg/ha) in green gram – pearl millet sequence under south Gujarat condition.

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