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Productivity of rabi green gram (*Vigna radiata* L.) summer pearl millet (*Pennisetum glaucum* L.) cropping sequence as influenced by integrated nutrient management

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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 under south Gujarat condition.

Keywords: Cropping sequence, green gram- pearl millet, integrated nutrient management

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., 2018a) [2]. 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., 2018b) [3]. 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 sole crop 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

On the pooled basis growth and yield attributes (Table 1) *viz*. plant height, number of pods per plant and seed index were significantly influenced by the different integrated nutrient management treatment applied to the green gram crop in *rabi* season. Application of treatment M_3 (75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*)) resulted remarkable improved in the plant height, number of pods per plant and seed index. Here the treatment of organic sources provided enough amount of nutrients and organic matter which ultimately influenced the soil environment in positive ways for plant growth. The favourable soil condition finally resulted into higher values of almost all growth and yield parameters of green gram under this treatment. Nitrogen being a constituent of the plant cell influenced different physiological processes such as a cell division, cell elongation and chlorophyll production which ultimately resulted in better growth attributes. Similar results have been reported by various researchers in pulse crop. Tyagi *et al.* (2014) [14] reported in green gram integration of 100 per cent RDF + vermicompost 1.0 t/ha + *Rhizobium* resulted in significantly higher plant height, number of pods/plant, number of seeds/pod, and 1000 seed weight. Kachariya (2015) [6] recordedin green gram significantly higher plant height, number, number of seed/pod, number of pods/plant and test weight produced under 75% RDF applied along with vermicompost 1.25 t/ha. Sushil *et al.* (2015) [13] revealed that the application of 100% RDF + vermicompost 1.25 t/ha + Azatobactor 375 g/ ha significantly increased plant height and number of seeds per pod of green gram.

The results pertaining to the seed yield and stover yield have been described in Table 2. Treatment M_3 gave significantly higher seed and stover yield compared to rest of the treatments, while INM practices could not affected significantly on harvest index of green gram. On pooled data basis, magnitude of increase in seed yield with application of treatment M_3 was 4.79, 14.88, 20.41 and 57.94 percent over M_2, M_4, M_1 and M_5, respectively. where as the corresponding values for straw yield are 8.72, 18.79, 25.82 and 49.13 per cent. The remarkable increase in seed yield and stover 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 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) [14], Kachariya (2015) [6] and Sushil *et al.* (2015) [13].

Table 1: Growth and yield attributes of *rabi* green gram as influenced by different treatments of integrated nutrient management

Treatments	Plant height at harvest (cm)			Number of pods per plant			Seed index (g)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
M_1	64.26	65.12	64.69	14.41	13.22	13.81	4.07	4.09	4.08
M_2	77.16	78.07	77.62	17.70	17.54	17.62	4.27	4.36	4.31
M_3	80.32	81.24	80.78	18.19	18.13	18.16	4.37	4.42	4.39
M_4	73.86	74.80	74.33	16.08	15.66	15.87	4.18	4.27	4.22
M_5	57.98	58.82	58.40	9.89	10.07	9.98	3.78	3.67	3.72
SEm±	1.43	1.51	0.96	0.32	0.38	0.25	0.07	0.07	0.04
CD (P=0.05)	4.40	4.67	2.79	0.99	1.16	0.73	0.21	0.21	0.14
CV%	4.04	4.23	4.14	4.24	5.08	4.67	3.29	3.35	3.32
Interaction (Y x T)									
SEm±	1.47			0.35			0.07		
CD (P=0.05)	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: Yield of *rabi* green gram as influenced by different treatments of integrated nutrient management

Treatments	Seed yield (kg/ha)			Stover yield (kg/ha)			Harvest index (%)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
M_1	1240	1336	1288	2080	2039	2060	37.36	39.55	38.45
M_2	1375	1585	1480	2338	2430	2384	37.11	39.57	38.34
M_3	1486	1615	1551	2578	2606	2592	36.73	38.44	37.59
M_4	1282	1418	1350	2188	2175	2182	36.94	39.56	38.25
M_5	945	1020	982	1712	1763	1738	35.16	36.67	35.91
SEm±	63.67	79.16	48.02	122.33	119.62	79.81	1.08	1.51	0.86
CD (P=0.05)	196	244	139	377	369	231	NS	NS	NS
CV%	10.06	11.35	10.80	11.23	10.86	11.04	5.88	7.77	6.95
Interaction (Y x T)									

SEm±	71.83	120.98	1.31
CD (P=0.05)	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

Summer Pearl millet

Effect of main plot treatments

It is clear from table 3 that all growth and yield attributes in pooled *viz.* plant height, number of effective tillers per plant, earhead length and earhead girth of pearl millet was significantly influenced due to INM to preceding *rabi* green gram during both the years and in pooled. However, test weight of pearl millet could not influnced significantly due to INM treatments applied to preceding *rabi* green gram crop. On pooled basis maximum plant height, number of effective tillers per plant, test weight, earhead length and earhead girth of pearl millet observed under the residual effect of M_3 (75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*)), Here, the reason should be adequate supply of all the essential plant nutrients, better soil properties due to residual effect of combined application of organic manures (vermicompost and *rhizobium*) to preceding crop *rabi* green gram. Vermicompost have not been fully utilized by the green gram crop in first crop season by adding nitrogen fixation and addition of organic matter in form of crop residues left out and notably benefitted the succeeding pearl millet crop. Similarly, the beneficial residual effect of added organics fertilizers under cropping system on growth attributes reported by Malik (2003) [7] in gram - rice cropping sequence, Jat and Ahlawat (2006) [5] in chickpea - maize cropping sequence, Prajapat *et al.* (2014) in soyabean - sorghum cropping sequence, Umale (2016) [15] in green gram - maize cropping sequence.

The differences in grain yield and straw yield were reached up to the level of significance. The interaction effects M x S also have significant result on grain and straw yield of pearl millet crop during both years of experimentation and in pooled analysis. Preceding crop green gram fertilized with treatment M_3 recorded significantly higher grain and straw yield of succeeding pearl millet during both the years and in pooled analysis over rest of the treatments. The interaction effects on grain and straw yield presented in Tables 4 was significant during both the years and in pooled study. Treatment combination M_3S_4 *i.e* 75% RDN through vermicompost + Bio-fertilizer (*Rhizobium*) and 100% RDN to pearl millet recorded higher grain and straw yield of pearl millet. The increased grain and straw yields of pearl millet crop in INM treatments to preceding *rabi* green gram might be due to good crop growth 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) [7] in gram - rice, Jat and Ahlawat (2006) [5] in chickpea – maize, Umale (2016) [15] in green gram - maize cropping sequence. Harvest index of pearl millet did not reach to the level of significance in first year due to residual effect of INM treatments applied to *rabi* green gram.

Effect of sub plot treatments

On pooled basis, crop fertilized with 100% RDN plant height at harvest, number of effective tillers per plant, earhead length and earhead girth (Table 3) of pearl millet were significantly superior to control treatment at all growth stages expect test weight, but test weight increase with increasing levels of nitrogen. There is an increase in plant height, with nitrogen application throughout the crop growth span. The probable reason might be positive effect of nitrogen on growth character due to augment of cell division and cell expansion. Pearl millet cereal crop need/ respond more to applied nitrogen for photosynthetic production, which ultimately resulted in growth and development of crop. The study was in close conformity as observed by Ali (2010) [1], Meena *et al.* (2012), Patel (2014) [9] and Raval *et al.* (2014) [11]. The probable reason for increase in test weight due to highest level of nitrogen might be attributed to the better filling of grains resulting into bold sized seeds and consequently increasing test weight. Thus, all the yield attributes were remarkably improved and gave significant response of nitrogen application. The beneficial effect of nitrogen in growth and yield attributes were also reported by, Pathan *et al.* (2009) [10], Sakarvadia *et al.* (2012) [12] and Patel (2014) [9].

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, where as corresponding values for stover yield was 11.06, 19.35 and 24.00 per cent on pooled basis. 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, While improvement in straw yield was mainly on account of increase in the growth parameters due to nitrogen application. These results are also in agreement with findings of, Jadhav *et al.* (2011) [4], Sakarvadia (2012) [12] and Patel (2014) [9].

Table 3: Effect of interaction (M x S) on grain yield of pearl millet in pooled study.

Grain yield (kg/ha)					
M x S	**S_1**	**S_2**	**S_3**	**S_4**	**Mean (M)**
M_1	3184	3659	3830	4206	3720
M_2	3265	3727	3983	4405	3845
M_3	3352	3719	3973	5307	4088
M_4	3325	3662	3920	4087	3749
M_5	3020	3274	3771	3732	3449
Mean (S)	3229	3608	3895	4348	3770

Table 3: Growth and yield attibutes of summer pearl millet as influenced by different INM treatments

Treatments	Plant height			Number of effective tillers per plant			Test weight (g)			Earhead length (cm)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Main plot treatment (M)												
M_1	131.72	129.63	130.68	3.67	3.62	3.64	8.98	8.81	8.89	23.34	22.98	23.16
M_2	136.71	134.27	135.49	3.73	3.67	3.70	9.11	8.91	9.01	23.71	23.22	23.47
M_3	138.82	136.55	137.68	3.88	3.81	3.85	9.32	9.12	9.22	24.54	23.99	24.27
M_4	133.80	131.62	132.71	3.84	3.78	3.81	9.05	8.86	8.96	23.57	23.13	23.35
M_5	129.95	127.47	128.71	3.68	3.62	3.65	8.95	8.75	8.85	22.69	22.24	22.47
SEm±	1.85	1.84	1.21	0.05	0.05	0.03	0.13	0.15	0.09	0.37	0.34	0.23
CD (P=0.05)	5.71	5.68	3.51	0.16	NS	0.10	NS	NS	NS	1.14	1.05	0.68
CV%	5.53	5.60	5.56	5.71	5.65	5.68	5.74	6.65	6.20	6.29	5.92	6.11
Sub Plot treatment (S)												
S_1	125.82	123.53	124.68	3.64	3.58	3.61	8.62	8.44	8.53	22.06	21.59	21.83
S_2	128.96	126.52	127.74	3.62	3.56	3.59	8.90	8.71	8.81	22.94	22.46	22.70
S_3	134.30	131.93	133.12	3.78	3.72	3.75	9.14	8.95	9.05	23.74	23.30	23.52
S_4	147.71	145.65	146.68	4.01	3.94	3.97	9.66	9.46	9.56	25.55	25.10	25.32
SEm±	1.49	1.56	1.06	0.04	0.04	0.03	0.09	0.11	0.07	0.24	0.21	0.15
CD (P=0.05)	4.25	4.45	2.99	0.12	0.12	0.08	0.25	0.31	0.19	0.68	0.60	0.44
CV%	4.97	5.29	5.13	5.05	4.95	5.00	4.39	5.40	4.91	4.52	4.11	4.32
Interaction SEm±	0.33	3.49	2.27	0.09	0.09	0.06	0.20	0.24	0.15	0.53	0.47	0.33
(M x S) CD (P=0.05)	NS	NS	6.37	NS	NS	0.17	NS	NS	NS	NS	NS	0.94

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	1.85	NS	0.05	NS	0.14	NS	0.36	NS
S x Y	1.53	NS	0.04	NS	0.09	NS	0.23	NS
M x S x Y	3.41	NS	0.09	NS	0.22	NS	0.50	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 4: Yield attibutes and yield of summer pearl millet as influenced by different treatments

Treatments	Earhead girth (cm)			Grain yield (kg/ha)			Straw yield (kg/ha)			Harvest index (%)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Main plot treatment (M)												
M_1	9.49	9.35	9.42	3644	3795	3720	6705	6686	6695	35.27	36.05	35.66
M_2	9.80	9.66	9.73	3811	3879	3845	6916	7094	7005	35.44	35.33	35.38
M_3	10.01	9.90	9.96	3995	4180	4088	7436	7652	7544	34.83	35.24	35.04
M_4	9.71	9.58	9.65	3689	3808	3749	6874	6758	6816	34.86	36.02	35.44
M_5	9.55	9.37	9.46	3379	3520	3449	6453	6651	6552	34.30	34.65	34.48
SEm±	0.11	0.11	0.07	105.78	111.11	71.49	196.17	201.09	133.09	0.27	0.29	0.20
CD (P=0.05)	0.35	0.34	0.21	326	342	207	605	620	385	NS	0.89	0.59
CV%	4.74	4.64	4.69	11.43	11.58	11.51	11.41	11.54	11.48	3.13	3.25	3.19
Sub Plot treatment (S)												
S_1	9.41	9.28	9.35	3122	3337	3229	6250	6350	6300	33.31	34.50	33.90
S_2	9.52	9.37	9.45	3575	3641	3608	6506	6584	6545	35.41	35.59	35.50
S_3	9.78	9.65	9.71	3857	3933	3895	7011	7057	7034	35.46	35.79	35.62
S_4	10.14	9.99	10.06	4260	4435	4348	7741	7883	7812	35.59	35.95	35.77
SEm±	0.07	0.07	0.05	76.76	84.46	56.52	138.12	132.29	94.14	0.24	0.27	0.18
CD (P=0.05)	0.20	0.20	0.14	219	241	159	394	377	265	0.68	0.77	0.51
CV%	3.29	3.34	3.31	9.27	9.85	9.57	8.98	8.49	8.74	3.08	3.43	3.26
Interaction SEm±	0.16	0.16	0.11	171.63	188.85	119.97	308.85	295.82	200.92	0.54	0.61	0.38
(M x S) CD (P=0.05)	NS	NS	0.29	489	538	337	880	843	564	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)
M x Y	0.11	NS	108.48	NS	198.64	NS	0.28	NS
S x Y	0.07	NS	80.70	NS	135.24	NS	0.25	NS
M x S x Y	0.16	NS	180.45	NS	302.40	NS	0.57	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 5: Effect of interaction (M x S) on straw yield of pearl millet in pooled study.

Straw yield (kg/ha)					
M x S	**S_1**	**S_2**	**S_3**	**S_4**	**Mean (M)**
M_1	6107	6497	6779	7398	6695
M_2	6332	6717	7133	7837	7005
M_3	6589	6779	7220	9587	7544
M_4	6418	6580	6995	7273	6816
M_5	6052	6149	7043	6965	6552
Mean (S)	6300	6545	7034	7812	6923

Conclusion

On the basis of experimental results, it can be concluded that for getting higher yield in green gram – pearl millet sequance *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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