The Pharma Innovation Journal 2022; 11(10): 312-316

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(10): 312-313

www.thepharmajournal.com
Received: 02-07-2022
Accepted: 13-09-2022

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Influence of spacing and nutrient management practices on quality, soil fertility after harvest, nutrient content and their uptake in summer blackgram (*Vigna mungo* L. Heeper) under organic conditions

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Abstract
A field experiment was carried out during summer season of year 2021 at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand with view to study the "Influence of spacing and nutrient management practices on quality, soil fertility after harvest, nutrient content and their uptake in summer blackgram (*Vigna mungo* L. Heeper) under organic conditions". The experiment consisted of twelve treatment combinations comprised of two different spacing *viz.*, S_1: 30 × 10 cm and S_2: 45 × 10 cm related to main factor and nutrient management practices *viz.*, N_1: 100% N through FYM + ST (5 ml/kg seed) of *Rhizobium*, N_2: 100% N through vermicompost + ST (5 ml/kg seed) of *Rhizobium*, N_3: 100% N through castor cake + ST (5 ml/kg seed) of *Rhizobium*, N_4: 75% N through FYM + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation, N_5: 75% N through vermicompost + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation and N_6: 75% N through castor cake + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation allotted to sub factor and were tested under randomized block design with factorial concept and replicated thrice. Crop sown at spacing 45 × 10 cm (S_2) recorded numerically higher protein content, protein yield, N, P, K, S and Zn content in both seed and haulm of blackgram. While significantly higher N, P, K, S and Zn uptake by seed and haulm were recorded with crop sown at spacing 30 × 10 cm (S_1). Application of 100% N through castor cake + ST (5 ml/kg seed) of *Rhizobium* treatment recorded significantly higher protein yield, K content in seed and haulm, N, P, K, S and Zn uptake by seed, N, K and S uptake by haulm and S in soil after harvest of blackgram. While in case of N and P content in seed and haulm, P and Zn uptake by haulm were recorded significantly higher under application of 75% N through castor cake + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation.

Keywords: Blackgram, FYM, vermicompost, castor cake, content, uptake

Introduction
Black gram (*Vigna mungo* L. Hepper) is one of the most important pulse crops among the various grain legumes. According to vavilov (1951)[14] it is native to India, belong to the family Leguminaceae. It is a rich protein food, contains about 26% protein, 1.2% fat and 56.6% carbohydrates on dry weight basis and it is rich source of calcium and iron. Blackgram is grown on 4.67 mha with a production of 2.34 MT and productivity of 501 kg/ha in the country (Anonymous, 2021) [1]. This crop is extensively grown in the states of Maharashtra, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Tamil Nadu, Rajasthan and Gujarat. In Gujarat, it is grown in about 3.74 lakh hectare with a production of 2.00 lakh tons and productivity of 845 kg/ha (Anonymous, 2021) [1].

Management of nutrient involving organic manures and biological sources has the potential to enhance the yield increment and also sustain the production level since it can supply all the essential nutrients require by the plants besides, improving nutrient use efficiency and improving soil physico-chemical properties. Further, due to soil building capacity of the organic manures through addition of additional soil humus and encouraging the microbial activity of diverse beneficial organism, the yield potential promote with remarkable level. *Rhizobium* inoculation has been known to benefit in capturing atmospheric nitrogen for soil fertility that was scientifically proved in the 19th century (Shrivastav and Gupta, 2011) [11]. Organic manures like FYM, vermicompost, castor cake *etc*. enhance the soil microbial activity, which supplies nitrogen, phosphorus, sulphur and other nutrients in available form to the plants through biological decomposition (Mukherjee, 2015) [5].

Materials and Methods

A field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during the year 2021 to find out yield and economics of summer blackgram (*Vigna mungo* L. Heeper) as influenced by different spacing and nutrient management practices under organic conditions. The experimental site was organic certified and loamy sand in texture, alkaline in nature (7.92 pH) with low soluble salts (0.30 dS/m) and available nitrogen (217 kg/ha), medium in organic carbon (0.53%) and available phosphorus (29.25 kg/ha) and high in available potassium (261 kg/ha). Total twelve treatment combinations comprised of two different spacing *viz.*, S_1: 30 × 10 cm and S_2: 45 × 10 cm related to main factor and nutrient management practices *viz.*, N_1: 100%N through FYM + ST (5 ml/kg seed) of Rhizobium, N_2: 100% N through vermicompost + ST (5 ml/kg seed) of *Rhizobium*, N_3: 100% N through castor cake + ST (5 ml/kg seed) of *Rhizobium*, N_4: 75% N through FYM + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation, N_5: 75% N through vermicompost + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation and N_6: 75% N through castor cake + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation allotted to sub factor and were tested under randomized block design with factorial concept and replicated thrice. In the experiment, blackgram variety T 9 was used as a test crop.

The observations on protein content, protein yield, N, P, K, S and Zn content and uptake in seed and haulm, available N, P_2O_5, K_2O, S, Zn and microbial count in soil after harvest of blackgram was recorded. The protein content in seed was calculated by multiplying nitrogen content of seed with the conversion factor 6.25 and protein yield was computed by multiplying the data of protein content in seed and seed yield of blackgram by using following formula:

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content (\%)} \times \text{Seed yield (kg/ha)}}{100}$$

Plant samples of seed and haulm of blackgram collected at harvest form each net plot and were ground in Willey mill to pass through 40 mesh sieve. The ground material was collected in butter paper bags and later used for chemical analysis. Nitrogen, phosphorus and potassium content from seed and haulm were estimated using standard procedures given by Jackson (1973) [4].The nutrient uptake of the seed and haulm of blackgram crop was calculated by following formula:

$$\text{Uptake by seed/haulm (kg/ha)} = \frac{\text{Nutrient content in seed/haulm (\%)} \times \text{Seed/haulm yield (kg/ha)}}{100}$$

The composite soil samples were drawn from 0-22.5 cm depth before starting of experimentation while, after harvest soil samples were taken separately from each net plots. The soil samples were dried under shade, ground and then sieved through 2 mm size sieve. The soil samples collected after harvest of blackgram were used to determine available nitrogen, phosphorus, potassium, sulphur, zinc and total microbial count. Available nitrogen was determined by Alkaline Potassium Permagnate method described by Subbiah and Asija (1956)[12], available phosphorus is determined by Olsen's method using 0.5 M $NaHCO_3$ (Olsen *et al*., 1954) [7] and available potassium is determined by using Neutral Normal Ammonium Acetate (pH 7.0) method described by Jackson (1973) [4] by using Flame Photometer. For microbial count soil samples were analyzed for counting microbial colony forming units by serial dilution techniques (Dhingra & Sinclair, 1993) [3].

Results and Discussion

The data pertaining to quality, soil fertility after harvest, nutrient content and their uptake in summer blackgram as influenced by different spacing and nutrient management practices with their statistical inference are presented and discussed as under:

A. Effect of Spacing

The data pertaining to protein content and protein yield as influenced by different spacing and nutrient management treatments are presented in Table 1. Significantly higher protein content and protein yield were recorded under the spacing S_2 (45 × 10 cm) which were comparable with S_1 (30 × 10 cm). It might be due to better utilization of sunlight which facilitate better translocation of assimilates leading to higher seed reserves so increased protein content of seeds. Besides this, beneficial effect of organic manures on protein content was may be due to increased nitrogen content in seeds and nitrogen is an integral part of protein and the phosphorus is a structural element of certain co-enzyme involved in protein synthesis. These results are in close vicinity with the findings of Veeraputhiran (2009) [15].

The data pertaining to content and uptake by seed and haulm of blackgram are presented in Tables 2 and 3. The results revealed that the S content in seed of blackgram was found to be significant while, N, P, K and Zn content in seed and haulm was found to be non-significant but the numerically higher values of N, P, K, S and Zn content in seed and haulm was observed with crop sown at spacing S_2 (45 × 10 cm). It might be due to increase in root growth that increases the root activity under higher plant density which enables the increased absorption of nutrients from soil. Similarly, Sathyamoorthi *et al*. (2007) [9] also observed that higher plant density per unit area compete more for available nutrients resulting in higher nitrogen content in seed and haulm of greengram. Similarly, uptake of N, P, K, S and Zn by seed and haulm were significantly influenced by various spacing treatments and significantly higher values of all nutrients were found with crop sown at spacing S_1 (30 × 10 cm).

The data on available soil nutrient status after the harvest of blackgram as influenced by different spacing are presented in Table 4 and results revealed that different spacing have non-significant influence on available N, P, K, S and DTPA Zn after the harvest of blackgram.

The data on EC, pH and OC% status after the harvest of blackgram as influenced by different spacing treatments were presented in Table 5. The results revealed that different spacing have not any significant influence on EC, pH and OC% status while, significantly higher total microbial count was recorded under the spacing S_2 (30 × 10 cm).

Table 1: Influence of different treatments on protein content and protein yield of summer blackgram

Treatments	Protein content (%)	Protein yield (kg/ha)
S: Spacing		
S_1: 30 × 10 cm	24.12	178.84
S_2: 45 × 10 cm	24.49	148.62
SEm+	0.205	4.15
CD (P=0.05)	NS	12.18
N: Nutrient management		
N_1: 100% N through FYM + ST (5 ml/kg seed) of *Rhizobium*	23.53	162.51
N_2: 100% N through vermicompost + ST (5 ml/kg seed) of *Rhizobium*	23.77	166.06
N_3: 100% N through castor cake + ST (5 ml/kg seed) of *Rhizobium*	24.75	198.06
N_4: 75% N through FYM + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation	24.14	122.51
N_5: 75% N through vermicompost + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation	24.68	144.62
N_6: 75% N through castor cake + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation	24.97	188.60
SEm+	0.356	7.19
CD (P=0.05)	1.044	21.10
Interaction (S × N)		
CD (P=0.05)	NS	NS
CV %	3.59	10.76

B. Effect of Nutrient Management

The data pertaining to protein content and protein yield as influenced by different nutrient management treatments are presented in Table 1. Significantly higher protein content was recorded under the application of treatment N_6 while, significantly higher protein yield was recorded under the treatment N_3. It might be due to increased availability and higher content of nitrogen because of better nitrogen fixation and increased availability of phosphorus due to phosphate solubilization which ultimately increased nitrogen availability and thereby protein synthesis. These results are in close vicinity with the findings of Murugan and Chitraputhirapillai (2011) [6] and Tagore *et al.* (2014) [6].

The data pertaining to N, P, K, S and Zn content in seed and haulm of blackgram as influenced by different nutrient management treatments are presented in Table 2. Significantly higher N and P content in seed and N content haulm were recorded under the application of treatment N_6. It might be due to application of castor cake and vermicompost contains all macro and trace nutrients which made available to the crop gradually and steadily contributing towards the balance nutrition of crop. While, significantly higher K content in seed of blackgram was recorded under treatment N_3. These results are in close vicinity with the findings of Murugan and Chitraputhirapillai (2011) [6]. Significantly higher S and Zn content in seed was recorded under treatment N_2 while, in case of haulm significantly higher S and Zn content was recorded under treatment N_1.

Table 2: N, P, K, S and Zn content in seed and haulm of summer blackgram as influenced by different spacing and nutrient management treatments

Treatments	Content in seed (%)					Content in haulm (%)				
	N	P	K	S	Zn	N	P	K	S	Zn
S: Spacing						**S: Spacing**				
S_1	3.86	0.57	0.57	0.32	24.42	0.52	0.37	1.06	0.50	12.79
S_2	3.92	0.58	0.58	0.34	25.39	0.53	0.38	1.09	0.48	13.45
SEm+	0.033	0.006	0.005	0.005	0.332	0.005	0.005	0.010	0.006	0.270
CD (P=0.05)	NS	NS	NS	0.013	NS	NS	NS	NS	NS	NS
N: Nutrient management						**N: Nutrient management**				
N_1	3.76	0.52	0.53	0.31	23.24	0.50	0.36	1.05	0.50	14.51
N_2	3.80	0.55	0.57	0.35	27.63	0.52	0.38	1.07	0.49	11.29
N_3	3.96	0.62	0.64	0.31	24.53	0.55	0.37	1.09	0.50	14.03
N_4	3.86	0.53	0.53	0.34	22.69	0.53	0.37	1.05	0.49	12.37
N_5	3.95	0.58	0.54	0.33	25.55	0.52	0.38	1.09	0.49	12.09
N_6	3.99	0.65	0.63	0.32	25.80	0.56	0.40	1.10	0.48	14.46
SEm+	0.057	0.011	0.008	0.008	0.575	0.009	0.009	0.017	0.011	0.467
CD (P=0.05)	0.167	0.031	0.024	0.023	1.687	0.025	NS	NS	NS	1.371
Interaction (S × N)						**Interaction (S × N)**				
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	3.58	4.52	3.48	5.86	5.66	3.96	5.62	3.77	5.29	8.72

Table 3: N, P, K, S and Zn uptake by seed and haulm of summer blackgram as influenced by different spacing and nutrient management treatments

Treatments	Uptake by seed (kg/ha)					Uptake by haulm (kg/ha)				
	N	P	K	S	Zn	N	P	K	S	Zn
S: Spacing						**S: Spacing**				
S_1	28.61	4.24	4.27	2.34	182.27	9.25	6.60	18.87	8.82	226.29
S_2	23.78	3.54	3.52	2.03	153.98	6.61	4.71	13.40	5.95	167.92
SEm±	0.66	0.10	0.09	0.06	3.63	0.25	0.19	0.51	0.26	6.37
CD (P=0.05)	1.95	0.29	0.29	0.18	10.66	0.74	0.56	1.50	0.76	18.69
N: Nutrient management						**N: Nutrient management**				
N_1	26.00	3.57	3.66	2.15	160.26	6.64	4.82	14.09	6.77	196.06
N_2	26.57	3.86	3.98	2.43	192.80	7.85	5.81	16.12	7.44	168.88
N_3	31.69	4.94	5.12	2.45	196.06	9.79	6.63	19.58	8.96	247.65
N_4	19.60	2.69	2.70	1.74	114.51	6.04	4.19	12.01	5.59	140.93
N_5	23.14	3.37	3.18	1.94	149.99	7.73	5.69	16.19	7.32	178.27
N_6	30.17	4.93	4.71	2.42	195.12	9.51	6.80	18.81	8.22	250.85
SEm±	1.15	0.17	0.17	0.11	6.29	0.44	0.33	0.89	0.45	11.03
CD (P=0.05)	3.38	0.51	0.50	0.31	18.46	1.28	0.98	2.60	1.31	32.38
Interaction (S × N)						**Interaction (S × N)**				
CD (P=0.05)	4.77	0.72	NS	NS	NS	1.82	NS	NS	NS	NS
CV %	10.76	10.95	10.64	11.82	9.17	13.54	14.41	13.46	14.84	13.71

The data pertaining to N, P, K, S and Zn uptake in seed and haulm of blackgram as influenced by different nutrient management treatments are presented in Table 3. Significantly higher N, P, K, S and Zn uptake by seed as well as N, K and S uptake by haulm were recorded under treatment N_3. While, significantly higher P and Zn uptake were recorded under application of treatment N_6.

The data pertaining to available N, P, K, S and Zn content of soil after harvest of blackgram as influenced by different nutrient management treatments are presented in Table 4. Significantly higher available N and Zn of soil were recorded under application of treatment N_1. While, in case of available P significantly higher values was recorded with treatment N_2.

Table 4: Available nitrogen, phosphorous and potash of soil after harvest of blackgram as influenced by different spacing and nutrient management treatments

Treatments	Available nutrients (kg/ha)			Available S (mg/kg)	DTPA Zn (mg/kg)
	N	P_2O_5	K_2O		
Initial	217	29.25	260.52	11.51	1.02
S: Spacing					
S_1	234	30.10	264	11.90	1.25
S_2	232	30.72	264	11.97	1.26
SEm±	3	0.272	3	0.109	0.008
CD (P=0.05)	NS	NS	NS	NS	NS
N: Nutrient management					
N_1	241	30.11	263	12.22	1.32
N_2	224	31.55	268	11.72	1.28
N_3	234	30.94	263	12.24	1.31
N_4	240	29.29	262	11.65	1.22
N_5	223	30.05	267	11.99	1.21
N_6	237	30.52	263	11.79	1.19
SEm±	5	0.47	6	0.188	0.013
CD (P=0.05)	14	1.38	NS	NS	0.039
Interaction (S × N)					
CD (P=0.05)	NS	NS	NS	NS	NS
CV %	5.08	3.80	5.29	3.86	2.58

Table 5: EC, pH and organic carbon content of soil after harvest of blackgram as influenced by different spacing and nutrient management treatments

Treatments	EC(dS/m)	pH	OC%	Total microbial count (cfu/g)
Initial	0.300	7.92	0.53	$4.47(3.0 \times 10^4)$
S: Spacing				
S_1	0.338	7.78	0.55	$6.23(4.6 \times 10^6)$
S_2	0.338	7.78	0.54	$6.28(4.4 \times 10^6)$
SEm±	0.004	0.088	0.007	0.009
CD (P=0.05)	NS	NS	NS	0.027
N: Nutrient management				
N_1	0.340	7.77	0.57	$5.59(3.9 \times 10^5)$
N_2	0.331	7.82	0.55	$5.56(3.7 \times 10^5)$
N_3	0.348	7.78	0.55	$5.57(3.8 \times 10^5)$
N_4	0.342	7.73	0.54	$6.93(8.5 \times 10^6)$
N_5	0.330	7.85	0.53	$6.94(8.6 \times 10^6)$
N_6	0.337	7.76	0.55	$6.94(8.7 \times 10^6)$
SEm±	0.006	0.152	0.012	0.016
CD (P=0.05)	NS	NS	NS	0.047
Interaction (S × N)				
CD (P=0.05)	NS	NS	NS	0.067
CV %	4.52	4.77	5.19	6.3

The data pertaining to EC, pH, OC% and microbial count of soil after harvest of blackgram as influenced by different nutrient management treatments are presented in Table 5. Significantly higher total microbial count of soil was recorded under treatment N_6. While EC, pH and OC% content was recorded non-significant. The increase in organic carbon content in the FYM consisting treatment could be attributed to direct incorporation of the organic matter in the soil. Further, addition of FYM released nutrients slowly and contributed to the residual pool of organic nitrogen, phosphorus and potassium in the soil and reduces nutrient loss from the soil by improving soil organic matter hence, increased organic carbon content in the soil. Similar results were also noticed by Sharma and Dayal (2005) [10], Chaudhary (2015) [2] and Patil (2017) [8].

Table 6: Interaction effect of spacing and nutrient management practices on uptake of N by seed and haulm, P uptake by seed and total microbial count

Treatments	Uptake of N by seed		Uptake of P by seed		Uptake of N by haulm		Total microbial count (cfu/g)	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
N_1	28.06	23.94	3.86	3.28	6.87	6.42	5.57	5.61
N_2	28.75	24.39	4.26	3.46	9.16	6.54	5.52	5.60
N_3	38.30	25.07	5.87	3.99	11.46	8.11	5.55	5.61
N_4	20.59	18.61	2.77	2.61	6.63	5.45	6.95	6.92
N_5	22.56	23.72	3.28	3.46	9.64	5.82	6.95	6.92
N_6	33.41	26.94	5.42	4.43	11.72	4.29	6.96	6.92
SEm±	1.63		0.25		0.62		0.014	
CD (P=0.05)	4.77		0.72		1.82		0.067	
CV %	10.76		10.95		13.54		6.30	

Interaction effect

Interaction effect of different spacing and nutrient management practices with respect to uptake of N and P by seed, uptake of N by haulm and total microbial count were found significant (Table 6). Results given in Table 6 revealed that treatment combination S_1N_3 recorded significantly higher N and P uptake by seed. While in case of N uptake by haulm and total microbial count found significantly higher under treatment combination S_1N_6.

Conclusion

From the results of one-year experimentation, it can be concluded that summer blackgram should be sown at spacing 45 × 10 cm and fertilized with application of 100% N through castor cake + ST (5 ml/kg seed) of *Rhizobium* or 75% N through castor cake + ST of *Rhizobium* + SA of Bio NP 1 L/ha at first irrigation for getting higher nutrient uptake, quality of crop and to maintain the chemical and microbial properties of soil.

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