The Bioscan 15(4): 453-457, 2020
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

EFFECT OF BALANCED NUTRIENT MANAGEMENT ON BLACKGRAM (*Vigna mungo* L.) IN RED AND LATERITIC SOILS OF WEST BENGAL

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KEYWORDS
Black gram
Balanced Nutrient Management
Yield
Uptake

Received on :
01.08.2020

Accepted on :
10.09.2020

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ABSTRACT
A field experiment was conducted at Agricultural Farm of Palli Siksha Bhavana, Visva-Bharati, Sriniketan during pre-kharif 2015 to assess the response of balance fertilization on available nutrient status, yield, nutrient uptake and protein content of black gram in red and lateritic soils of West Bengal. The experiment was laid out in randomized block design with seventeen treatments. Results revealed that the highest seed, stover and biological yield were 12.76, 24.68 and 37.44 q ha^{-1} respectively recorded with combined application of macro and micronutrients along with FYM @ 5t ha^{-1}. The highest uptake of nitrogen (40.72 kg ha^{-1} in seed and 42.71 kg ha^{1} in stover) and phosphorus (6.61 kg ha^{-1} in seed and 5.63 kg ha^{-1} in stover) was found in T_{16} followed by T_{15}. Similarly, highest uptake of potassium (10.61 kg ha^{-1} in seed and 9.54 kg ha^{-1} in stover) was found in T8 followed by T_{16} and highest uptake of sulphur (4.25 kg ha^{-1} in seed and 7.65 kg ha^{-1} in stover) was found in T_4 followed by T_{16}. Data regarding protein content in black gram was ranged between 16.45 to 22.42%. The balanced fertilization may be suggested for higher yield and nutrient uptake along with overall betterment.

INTRODUCTION

Pulses occupy a unique position in Indian agriculture by virtue of the fact that they constitute a major and the only high protein component to the average Indian diet (Phogat *et al.*, 2020). Black gram (*Vigna mungo* L. Hepper) is one of the most important pulse crops among the various grain legumes. According to Vavilov (1951) it is native to India, belong to the family Leguminosae. 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 (Amruta *et al.*, 2015). As the world population grows day by day, deterioration of natural sources occurs to meet their food demand. Thus, one of the most important challenges facing food demand today is to sustain natural resources including soil and water and protect the environment (Tungoe *et al.*, 2018). Application of balanced fertilizer increases vegetative growth and improves yield and quality of produce (Singh *et al.*, 2015). The nutrients available to plant particularly nitrogen and phosphorus are important constituents of protein and phospholipids. Like other pulse crops, it has unique characteristics of maintaining and restoring soil fertility through biological nitrogen fixation. Sulphur is essential for synthesis of proteins, vitamins and sulphur containing essential amino acids and is also associated with nitrogen metabolism (Najar *et al.*, 2011) Red and lateritic soils are major soils in the state of West Bengal where the levels of crop productivity are usually low, owing to various soil related constraints such as low pH, organic matter, and nutrient availability (Bhattacharya *et al.*, 2004). Therefore, the aforesaid consequences have paved way to adopt balanced fertilization for better yield of black gram in red and lateritic soils.

Integration of recommended dose of fertilizer along with essential micro nutrients *viz*; boron, molybdenum, zinc and organic manures are major components in balanced fertilizer management which would result, slow and steady release of these inorganic fertilizers to increase the availability of nutrients and finally improve the yield attributing character (Rathiya e*t al.*, 2018). Improvement in seed yield of black gram through use of boron is very important in cell division and in pod and seed formation. Boron influence the absorption of N, P, K and its deficiency changed the equilibrium of optimum of those three macronutrients. The N and B concentrations of grain for black gram were markedly influenced by B treatment indicating that the B had a positive role on protein synthesis (Saren *et al.*, 2017). Molybdenum, being a constituent of nitrate reductase and nitrogenase enzymes, is associated with ammonia reduction and nitrogen fixation and its deficiency adversely affects growth and yield of black gram. Zinc is needed by crops especially pulses in sufficiently large quantity. Balance fertilization containing Zn is found to be effective way of getting higher yield, monetary return and improving nutritional quality of pulses. Therefore, applications of micronutrients in addition to essential major elements have gained practical significance. Application of organic manure, on the other side provide a good substrate for the growth of micro-organisms and maintain a favorable nutrient supply environment and improve soil physical properties (Tyagi *et al.*, 2014). Hence, keeping above facts in view, the present investigation was carried out to study the effect of balanced nutrient management on available nutrient status, yield, nutrient uptake and protein content on black gram in red and lateritic soils of West Bengal.

MATERIALS AND METHODS

A field experiment was conducted on black gram during pre-kharif season of 2015 in red and lateritic soils of West Bengal at the Agricultural Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan. The experimental farm was situated at 23°39´ N latitude and 87°42´ E longitude with an average altitude of 58.9 m above the mean sea level under sub humid semi-arid region of West Bengal. After harvesting the crop, representative soil samples were collected from experimental site of 0-15 cm soil depth, processed and physico-chemical properties of soils were measured with the prescribed standard procedure (Jackson, 1973). The soil of the experimental site was sandy loam in texture with pH 5.67 and EC 0.11 dSm^{-1}, organic carbon 0.32% and available N, P, K and S was 160, 15.92, 72 and 11.23 kg ha^{-1} respectively. The status of soil micronutrients *viz*. B (0.20 mg kg^{-1}) and Zn (1.08 mg kg^{-1}) was also low.

The experiment was laid out in randomized block design (RBD) with three replication and seventeen treatments. The seed of black gram cv. WBU 108 was sown @ 20 kg ha^{-1} in a plot size of 2.5x2 m^2, maintaining line spacing 30 cm. The macro and micronutrient inputs were applied through various sources. The cultural practices were done as per recommended package of practices. FYM was incorporated before 20 days sowing in all treatments. The final plant samples were collected at harvest from each plot, cleaned, oven dried at 60oC and ground in a steel grinder. The nutrients like N, P and K content in seed and stover were determined by modified Kjeldahl method, vanadomolbedophosphoric yellow colour method and flame photometer, respectively (Jackson 1973). Available sulphur and boron were determined turbidimetrically (Chesnin and Yien, 1950) and in hot water (Jackson, 1973), respectively. Micronutrients were determined by methods of Lindsay and Norvell (1978). The representative dry samples of seed and stover were analyzed for ascertaining the nutrient (N, P, K and S) content. Seed and stover samples were digested in H_2SO_4 for determination of nitrogen (AOAC, 1995) and in di-acid mixture (HNO_3: $HClO_4$, 9:4 v/v) for phosphorus and potassium estimation (Bhargava and Raghupathi, 1984). The nutrients uptake by seed and stover were calculated by multiplying nutrient content with seed and stover yield (kg ha^{-1}). Crude protein content was determined by multiplying percentage of nitrogen content in grain of rice with a factor of 6.25 and expressed in percentage. Statistical analyses were done as per standard method prescribed by Gomez and Gomez (1984)

RESULTS AND DISCUSSION

Response of balanced fertilization on soil nutrient status after harvest of black gram

Postharvest soil available nutrient status (N, P, K, S) along with organic carbon, yield and uptake of nutrients, protein content after the harvest of black gram was significantly influenced by graded nutrient levels. The data regarding integration of recommended dose of fertilizer along with essential micro nutrients *viz*; boron, zinc and FYM on organic carbon, available NPKS content in black gram were given at table 1. The application of different treatment combinations had no significant effect on organic carbon content of soil after harvest of crop due to application of various nutrients during the year

Table 1: Response of Balanced Fertilization on Soil Nutrient Status after harvest of Black gram

Treatments	Organic C (%)	Available N ($kgha^{-1}$)	Available P ($kgha^{-1}$)	Available K ($kgha^{-1}$)	Available S ($kgha^{-1}$)
T_1- $N_{25}P_{50}K_{25}$FYM@5tha^{-1}	0.32	135.44	17.95	97.22	13.98
T_2- $N_{25}P_{50}K_{25}S_{20}$FYM@5tha^{-1}	0.32	133.8	17.01	111.78	14.11
T_3- $N_{25}P_{50}K_{25}S_{30}$FYM@5tha^{-1}	0.21	145.62	18.87	102.53	16.53
T_4- $N_{25}P_{50}K_{25}S_{40}$FYM@5tha^{-1}	0.32	136.53	18.43	104.76	18.7
T_5- N_{25}FYM@5tha^{-1}	0.28	140.53	15.03	92.06	13.5
T_6- $N_{25}P_{50}K_{50}$FYM@5tha^{-1}	0.26	135.22	17.15	122.04	12.14
T_7- $N_{25}P_{50}K_{70}$FYM@5tha^{-1}	0.38	142.62	18.37	130.19	13.18
T_8- $N_{25}P_{50}K_{90}$FYM@5tha^{-1}	0.23	133.8	16.6	145.44	13.64
T_9- $N_{25}P_{50}K_{25}Zn_2$FYM@5tha^{-1}	0.26	157.25	18.91	109.16	12.34
T_{10}- $N_{25}P_{50}K_{25}Zn_4$FYM@5tha^{-1}	0.24	153.98	17.23	107.45	14.14
T_{11}- $N_{25}P_{50}K_{25}Zn_6$FYM@5tha^{-1}	0.26	150.53	19.09	101.01	12.94
T_{12}- $N_{25}P_{50}K_{25}B_{0.5}$FYM@5t$ha^{-1}$	0.28	155.89	18.09	104.83	13.69
T_{13}- $N_{25}P_{50}K_{25}B_{1.0}$FYM@5t$ha^{-1}$	0.3	158.62	19.14	111.48	12.02
T_{14}- $N_{25}P_{50}K_{25}B_{1.5}$FYM@5t$ha^{-1}$	0.29	162.34	19.79	103.06	12.26
T_{15}-$N_{25}P_{50}K_{25}S_{20}Zn_2B_{0.5}$FYM@5t$ha^{-1}$	0.27	175.62	22.07	129.95	14.4
T_{16}-$N_{25}P_{50}K_{25}S_{30}Zn_4B_1$FYM@5t$ha^{-1}$	0.26	192.34	24.64	138.17	16.83
T_{17}- Control	0.13	121.25	15.53	89.9	11.51
SE(m)	0.03	16.034	0.888	8.62	1.481
CD(P = 0.05)	0.01	49.404	2.737	26.57	4.564
CV	19.78	17.53	8.78	13.31	12.75

Table 2: Response of Balanced Fertilization on yield attributes and protein content of Black gram

Treatments	Seed yield (qha^{-1})	Stover yield (qha^{-1})	Biological yield (qha^{-1})	Protein content (%)
T_1- $N_{25}P_{50}K_{25}$FYM@5tha^{-1}	9.87	20.6	30.47	18.12
T_2- $N_{25}P_{50}K_{25}S_{20}$FYM@5tha^{-1}	10.85	20.99	31.84	19.95
T_3- $N_{25}P_{50}K_{25}S_{30}$FYM@5tha^{-1}	11.31	21.89	33.2	20.53
T_4- $N_{25}P_{50}K_{25}S_{40}$FYM@5tha^{-1}	11.45	22.49	33.94	20.85
T_5- N_{25}FYM@5tha^{-1}	11.87	20.48	32.35	17.73
T_6- $N_{25}P_{50}K_{50}$FYM@5tha^{-1}	11.83	20.47	32.3	18.67
T_7- $N_{25}P_{50}K_{70}$FYM@5tha^{-1}	11.73	21.25	32.98	19.6
T8- $N_{25}P_{50}K_{90}$FYM@5tha^{-1}	10.19	21.97	32.16	19.37
T_9- $N_{25}P_{50}K_{25}Zn_2$FYM@5tha^{-1}	11.85	22.07	33.92	17.62
T_{10}- $N_{25}P_{50}K_{25}Zn_4$FYM@5tha^{-1}	12.17	19.59	31.76	20.3
T_{11}- $N_{25}P_{50}K_{25}Zn_6$FYM@5tha^{-1}	11.63	20.83	32.46	20.18
T_{12}- $N_{25}P_{50}K_{25}B_{0.5}$FYM@5tha^{-1}	11.07	20.77	31.84	20.07
T_{13}- $N_{25}P_{50}K_{25}B_{1.0}$FYM@5tha^{-1}	11.03	20.33	31.36	19.25
T_{14}- $N_{25}P_{50}K_{25}B_{1.5}$FYM@5tha^{-1}	11.01	20.21	31.22	21.82
T_{15}-$N_{25}P_{50}K_{25}S_{20}Zn_2B_{0.5}$FYM@5tha^{-1}	12.33	22.76	35.09	21.95
T_{16}-$N_{25}P_{50}K_{25}S_{30}Zn_4B_1$FYM@5tha^{-1}	12.76	24.68	37.44	22.42
T_{17}- Control	8.56	16.12	24.68	16.45
SE(m)	0.439	1.737	1.868	0.285
CD(P = 0.05)	1.353	5.352	5.755	0.879
CV	6.77	14.22	9.99	2.541

Table 3: Response of Balanced Fertilization nutrient uptake (kgha^{-1}) of Black gram

Treatments	Nitrogen uptake (kgha^{-1})		Phosphorus uptake (kgha^{-1})		Potassium uptake (kgha^{-1})		Sulphur uptake (kgha^{-1})	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
T_1- $N_{25}P_{50}K_{25}$FYM@5tha^{-1}	31.27	33.47	6.13	5.63	7.71	7.13	2.32	5.42
T_2- $N_{25}P_{50}K_{25}S_{20}$FYM@5tha^{-1}	32.65	34.06	7.43	6.04	.7.95	7.35	3.47	6.93
T_3- $N_{25}P_{50}K_{25}S_{30}$FYM@5tha^{-1}	34.15	34.11	7.85	6.67	8.28	7.38	3.83	7.02
T_4- $N_{25}P_{50}K_{25}S_{40}$FYM@5tha^{-1}	37.74	34.32	8.15	6.72	8.51	7.6	4.25	7.65
T_5- N_{25}FYM@5tha^{-1}	34.68	32.25	5.27	6.13	7.13	6.35	2.4	6.25
T_6- $N_{25}P_{50}K_{50}$FYM@5tha^{-1}	35.28	31.4	6.75	7.05	9.91	8.3	2.92	6.52
T_7- $N_{25}P_{50}K_{70}$FYM@5tha^{-1}	36.77	32.05	6.94	7.35	10.11	8.55	3.1	6.27
T_8- $N_{25}P_{50}K_{90}$FYM@5tha^{-1}	34.55	33.71	7.11	7.66	10.61	9.54	3.25	6.49
T_9- $N_{25}P_{50}K_{25}Zn_2$FYM@5tha^{-1}	34.42	33.11	7.37	7.42	8.47	8.09	3.36	6.68
T_{10}- $N_{25}P_{50}K_{25}Zn_4$FYM@5tha^{-1}	35.53	34.7	7.56	7.86	8.3	7.56	3.42	6.77
T_{11}- $N_{25}P_{50}K_{25}Zn_6$FYM@5tha^{-1}	35.6	34.76	8.09	8.23	8.55	7.49	3.51	6.8
T_{12}- $N_{25}P_{50}K_{25}B_{0.5}$FYM@5tha^{-1}	36.55	36.91	7.78	8.26	8.74	7.86	3.62	6.64
T_{13}- $N_{25}P_{50}K_{25}B_{1.0}$FYM@5tha^{-1}	36.97	36.64	8.11	8.41	9.25	8.04	3.75	6.71
T_{14}- $N_{25}P_{50}K_{25}B_{1.5}$FYM@5tha^{-1}	37.47	37.8	8.35	8.6	9.51	8.22	3.68	6.92
T_{15}-$N_{25}P_{50}K_{25}S_{20}Zn_2B_{0.5}$FYM@5tha^{-1}	38.33	39.63	8.87	9.05	9.8	8.26	3.81	7.01
T_{16}-$N_{25}P_{50}K_{25}S_3$0Zn_4B_1FYM@5tha^{-1}	40.72	42.71	9.97	9.63	10.23	9.15	4.03	7.25
T_{17}- Control	22.55	24.21	4.31	3.82	6.39	3.5	1.33	3.82
SE(m)	1.507	3.362	0.36	0.763	0.515	0.642	0.143	1.385
CD(P = 0.05)	4.645	10.36	1.109	2.352	1.588	1.981	0.442	4.267
CV	7.45	18.01	7.71	17.07	7.82	13.59	9.08	26.59

of investigation. The organic carbon content varied between 0.13% to 0.38%. The data also showed that among the different treatment combinations, maximum available nitrogen and phosphorus content in black gram (192.34 kg ha^{-1} and 24.64 kg ha^{-1} respectively) were observed in the treatment T_{16} receiving boron @1.0 kg ha^{-1}, zinc @4.0 kg ha^{-1} along with nitrogen @25 kg ha^{-1}, phosphorus@ 50 kg ha^{-1}, potassium@ 25 kg ha^{-1} and sulphur @ 30 kg ha^{-1}. Available potassium content in soils was ranged from 89.90 to 145.44 kg ha^{-1}. The maximum value of available potassium was recorded in T_8 with application of potassium @ 90 kg ha^{-1} followed by T_{16}. Data on available sulphur content varied between 11.51 and 18.70 kg ha^{-1}. The maximum value of available sulphur was recorded in T_4 with application of sulphur @ 40 kg ha^{-1} followed by T_{16}. The minimum value of nutrients in all cases was recorded in plots receiving no fertilizers (control). We observed that increasing rate of sulphur and potassium application increases the availability of the nutrient followed by T_{16}. Treatment effect in all the cases was found to be significant. The results obtained are in conformity with Rathiya *et al.*, 2018 and Bhattacharya *et al.*, 2004.

Response of balanced fertilization on yield and protein content of black gram

The data pertaining to seed, stover and biological yield along with protein content of black gram during 2015 are presented in table 2. Balanced nutrient management irrespective of different sources of nutrients and FYM @ 5tha^{-1} significantly increased protein content in seed as well as seed, stover and total biological yield (Tungoe *et al.*, 2018, Singh *et al.*, 2015)

The seed yield of black gram ranged from 8.56 q ha^{-1} to 12.76 q ha^{-1}. Minimum seed yield was obtained in plots receiving no fertilizers (control). Seed yield of black gram was found to increase with increasing levels of sulphur application along with micronutrients. The maximum seed yield was observed in plots receiving the dose of sulphur application @30 kg ha^{1} along with zinc and boron @ 4 and 1 kg ha^{-1}. The response of sulphur was more pronounced in seed yield in plots treated with nitrogen @ 25 kg ha^{-1} along with FYM @ 5tha^{-1}. Increase in number of pods and dry matter yield could be as a result of nitrogen being involved in carbohydrate and protein metabolism that promotes cell division and enlargement resulting in more productive pods and dry matter yields (Ramesh *et al.*, 2016).

More or less similar trend was observed in case of stover yield. Stover yield ranged from 16.12 q ha^{-1} to 24.68 q ha^{-1}. The maximum seed yield was observed in T_{16}. Minimum stover yield was obtained in plots receiving no fertilizers (control). The increase in yield due to application of sulphur may be due to better metabolism and increased efficiency of other nutrients (Kumawat *et al.*, 2013)

Similarly, the maximum biological yield was recorded in T_{16} (37.44 q ha^{-1}) followed by T_{15} (35.09 q ha^{-1}) and minimum value was obtained in plots receiving no fertilizers (control). The higher yield of black gram might be due to balanced fertilization along with FYM @ 5 t ha^{-1} which help to increase the soil fertility through improvement in soil physical, chemical and biological characteristics (Tungoe *et al.*, 2018). Vairavan (2011) reported that application of recommended dose of fertilizer in combination with FYM @ 5 t ha^{-1} recorded higher growth, yield attributes and yield of black gram. Application of nitrogenous fertilizer improve the vegetative growth of plant, provide dark green colour and increase protein synthesis. Application of phosphatic fertilizer increase seed germination, root growth, early flowering and fruit setting. Potassic fertilizers govern all physiological activities in plants. B fertilizers in such soils to check further deterioration of agricultural production (Jana *et al.*, 2006) and helps in improvement in seed yield of black gram as it is very important in cell division and in pod and seed formation (Vitosh *et al.*, 1997, Singh *et al.*, 2015).

Results revealed that levels of sulphur and micro nutrients have significant effect on the protein content in black gram. The protein content of black gram seed increased over control with increasing levels of sulphur irrespective of other nutrients (Table 2). The protein content of black gram ranged from 16.45 to 22.42 %. The highest protein content was found in T_{16} (22.42%) followed by T_{15} (21.95%) and lowest yield was found in control. The significant increase in protein content of black gram was due to increased nitrogen content in seed and nitrogen which is an integral part of protein. It may also be attributed due to increased availability of phosphorus, as it is structural element of certain co-enzymes involved in protein synthesis (Patil *et al.*, 2010). Sulphur has been reported to increase per cent protein and per cent amino acids in pulses (Singh 1993).

Response of balanced fertilization on nutrient uptake (kgha^{1}) in seed and stover of black gram

The highest nutrient content in seed and stover may be due to greater availability of nutrients and their efficient absorption by the roots of black gram (Balu *et al.*, 1995; Akbari *et al.*, 2005). The use of micronutrients likes B and Zn either alone or in combination also enhanced N, P and S uptake by seed and stover significantly over control. The maximum N, P and S uptake by seed and stover were recorded with integrated use of micronutrients (Singh *et al.*, 2015). Effect of balanced fertilization on nutrient concentration in seed and stover of black gram is given in table 3.

Nitrogen content in seed was ranged between 22.55 and 40.72 kg ha^{-1}. Application of micro nutrients and FYM had significant effect on increasing nitrogen content in seeds. The maximum result was recorded T_{16} followed by T_{15}. Nitrogen content in stover varied from 24.21 to 42.71 kg ha^{-1}. The minimum value in both the cases were found in plots receiving no fertilizer (control). Treatment effect was found to be significant in altering total nitrogen content in seed and stover. It was observed that the nitrogen content in seeds of black gram were higher than stover content.

Phosphorus content in black gram seed varied from 2.31 to 6.61 kg ha^{-1}. Minimum result was obtained in plots receiving no fertilizers (control) and the maximum value was obtained in T_{16} followed by T_{15}. In case of phosphorus content in stover the value varied from 2.82 to 5.63 kg ha^{-1}. The maximum result was recorded with application of zinc and boron @ 4 and 1 kg ha^{-1} respectively along with sulphur application @ 30 kg ha^{-1}. The minimum result was recorded with no application of fertilizers (control). Treatment effect was found to be significant in altering total phosphorus content in seed and stover.

The values regarding potassium content in seed ranged from 6.39 to 10.61 kg ha^{-1} and in stover ranged from 3.50 and 9.54 kg ha^{-1}. The maximum potassium content was recorded in T_8 with application of potassium @ 90 kg ha^{-1} followed by T_{16} in both the cases. The minimum result was recorded with no application of fertilizers (control). Here it was noticed that application of micronutrients along with potassic fertilizer increased potassium content in seed and stover.

Sulphur content in seeds ranged between 1.33 and 4.25 kg ha^{-1} and in stover ranged from 3.82 and 7.65 kg ha^{-1}. Application of zinc and boron @ 4 and 1.0 kg ha^{-1} respectively along with sulphur application @ 30 kg ha^{-1} give significant result in sulphur content in grains. The maximum value was recorded in T_4 receiving maximum sulphur @ 40 kg ha^{-1} followed by T_{16} and the minimum value in both the cases observed in control plots. Treatment effect was found to be significant in altering total sulphur content in seed and stover. Here also it was observed that application of micronutrients along with sulphated fertilizer increased sulphur content in seed and stover.

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