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Suman G Sahu
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Ashish Kumar Dash
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Narayan Panda
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Kshitipati Padhan
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Sweta Nanda
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Bishnupriya Patra
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Ambika Prasad Mishra
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Meenakhi Prusty
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Sushanta Kumar Pattanayak
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Corresponding Author:
Suman G Sahu
Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, India

Effect of long term INM practices on photosynthetic activity, nutrient content, nodulation and yield of blackgram in acid Inceptisols of Odisha

Suman G Sahu, Ashish Kumar Dash, Narayan Panda, Kshitipati Padhan, Sweta Nanda, Bishnupriya Patra, Ambika Prasad Mishra, Meenakhi Prusty and Sushanta Kumar Pattanayak

Abstract
A long-term field experiment was started in the College of Agriculture, OUAT, Bhubaneswar, Odisha since *kharif* 2010 in a randomized block design with 08 treatments and three replications under a cereal-vegetable-pulse cropping system. Different observations on plant were taken during crop growth period to evaluate the performance of the test crop towards different package and practices followed. The test crop was blackgram, *cv* PU31 the 26th crop in the sequence. The treatments were T_1: Control, T_2: Soil Test Dose (STD), T_3: STD + Farm Yard Manure (F), T_4: STD + Vermicompost (VC), T_5: STD + F + Biofertilizers (BFs), T_6: STD + VC + BFs, T_7: STD + F + L + BFs, and T_8: STD + VC + L + BFs which consisted of different combinations of inorganic fertilizers, organic manures (FYM and vermicompost), ameliorant (lime) and biofertilizers. Blackgram crop was grown in the experimental plot with different organic and inorganic fertilizers as per the treatment plans. The economic yield of crop blackgram recorded highest (0.82 t ha^{-1}) in the treatment supplied with inorganic and organic source of nutrient with lime and significantly higher than rest other treatments and lowest was obtained in STD (0.18 t ha^{-1}). Leaf samples from different treatments were collected at different growth stages for study of photosynthetic activity. The highest values 1.45, 1.91 and 1.95 mg g^{-1} of fresh leaves were recorded for chlorophyll content with treatment where vermicompost was added with all the ingredients. Whereas lowest values were recorded for chlorophyll content with control. However, the nodulation, nodular nitrogen content and nutrient content of grain and plant (stover) after harvest of the crop were found to be better with the treatment where vermicompost was integrated with inorganic fertilizer, biofertilizer and lime.

Keywords: Blackgram, chlorophyll content, economic yield, INM, nodular nitrogen

Introduction
Blackgram [*Vigna mungo* (L.)] is the third important pulse crop of India which is cultivated over a wide range of agro-climatic zones of the country. It fits for both abnormal and normal weather situation. It occupies about 3.25 million ha area in the country producing 1.5 million tons of seed with the average productivity of 462 kg ha^{-1} (AICRP, 2013). Blackgram is generally grown in soil with low fertility status or with application of low quantity of organic and inorganic sources and use of existing genotypes.

Imbalance use of chemical fertilizers not only lower productivity but also adversely affects soil health by decreasing soil organic carbon, microbial flora and hardening of soil. The integrated nutrient management (INM) ensures higher productivity, minimizes expenditure on costly fertilizer inputs, improves physical properties of soil, efficiency of added nutrients and at the same time ensures good soil health and is also an environment-friendly approach (Kumpawat, 2010) [13].

The INM, entails the maintenance/adjustment of soil fertility to an optimum level for crop productivity to obtain the maximum benefit from all possible sources of plant nutrients organics as well as inorganics in an integrated manner, is an essential step to address the twin concerns of nutrient excess and nutrient depletion. INM is also important for marginal farmers who cannot afford to supply crop nutrients through costly chemical fertilizers (Aulakh, 2009) [21]. The biofertilizers have shown encouraging results in sustaining the crop productivity and improving the soil fertility (Govindan and Thirumurugan, 2005) [22]. The application of *Rhizobium*-biofertilizer enhances the productivity and nodular characteristics in pulse crops (Athul *et al*. 2022) [2], Inoculation of *Rhizobium* with VAM increases the nodulation, nutrient

uptake and biomass of *Acacia mangium* saplings (Sethi *et al*., 2021) [17].

Material Methods

The present investigation was conducted with the long-term experiment plot laid out in 2010 at College of Agriculture, Bhubaneswar, India. The experimental site is located at 20° 15′ 86″ north latitude and 85° 28′ 68″ east longitude and at an elevation of 25.9 m above mean sea level (MSL) and 60 kms. west of the Bay of Bengal. The climate was hot and humid sub-tropical with dry season prevailing from October to June and wet season from July to September. The soil of the experimental site belongs to order Inceptisols having loamy sand texture and comes under sub-group *vertic ustochrept*. The field experiment was conducted during kharif 2018 in a randomized block designs with 3 replications and 08 treatments such as T_1: Control, T_2: Soil Test Dose (STD), T_3: STD + Farm Yard Manure (F), t_4: STD + Vermi Compost (VC), T_5: STD + F + Biofertilisers (BFs), T_6: STD + VC + BFs, T_7: STD + F + L + BFs, T_8: STD + VC + L + BFs. The treatments were consisted of different combinations of inorganic fertilizers, organic manures (FYM and vermicompost), ameliorant (lime) and biofertilizers as per the following details:

The treatments were consisted of different combinations of inorganic fertilizers, organic manures (FYM and vermicompost), ameliorant (lime) and biofertilizers

T_1	No nutrients	Control
T_2	Soil test-based dose of inorganic fertilizers (STD)	STD
T_3	STD+FYM @ 5 t ha^{-1}	STD+F
T_4	STD+Vermicompost @ 2.5 t ha^{-1}	STD+VC
T_5	STD+FYM+*Rhizobium* (BFs)	STD+F+BFs
T_6	STD+VC+BFs	STD+VC+BFs
T_7	STD+FYM+Lime @0.2LR +BFs	STD +F +BFs +L
T_8	STD+VC+Lime@0.2LR+BFs	STD+ VC +BFs +L

As per the treatment plans blackgram crop was grown in the experimental plot. Leaf samples were collected from different treatments for analysis of nitrogen and chlorophyll content at different of growth stage of blackgram.

Soil samples were collected from each plot at 0-15 cm before initiation of the sowing of crop and after harvest of crop. Processed soil samples were preserved in polythene bottles for analysis of different chemical parameters by using standard procedures. The observed values of different parameters were analyzed statistically as per the procedure outlined by Gomez and Gomez (1984) [23].

Results and Discussion

Effect of long term INM on chlorophyll content of leaves

The chlorophyll content of blackgram leaves is presented in table 1. At 15 DAS the chlorophyll content of leaves varied from 1.14 mg g-^{1} of fresh leaves to 1.45 mg g-^{1} of fresh leaves. Highest chlorophyll content was found with the treatment where all the inputs like inorganic fertilisers, organic manures, lime as soil amendment, bio fertilizers were added i.e.,1.45 mg g-^{1} of fresh leaves. The lowest chlorophyll content was recorded with control i.e., 1.14 mg g-^{1} of fresh leaves. With addition of lime and FYM the chlorophyll content was recorded to be 1.33 mg g-^{1} of fresh leaves and it was followed by the packages with STD+ organics+ bio-fertilisers (1.29-1.31 mg kg^{-1} of fresh leaves), STD+ organics (1.20-1.24 mg kg^{-1} of fresh leaves). The lime integrated treatments were significantly higher chlorophyll content than the other treatments.

The chlorophyll content of black gram leaves at 30 DAS ranged from 1.34 to 1.91 mg kg^{-1} of fresh leaves. The highest chlorophyll content was recorded with the treatment with VC addition with lime and bio fertilisers which was followed by the treatment FYM application with lime and bio fertilisers with a value of 1.85 mg kg^{-1} of fresh leaves. It was followed by the package with the organics+ bio fertilisers, then by only organics. The lowest chlorophyll content was found with the package where no inputs were applied.

The chlorophyll content of black gram leaves at 45 DAS varied between 1.43 mg kg^{-1} of fresh leaves to 1.95 mg kg^{-1} of fresh leaves. The lowest chlorophyll content was found with control whereas the highest chlorophyll content was found with the lime integrated treatment with vermin compost. The lime integrated had significantly higher chlorophyll content than the STD and control.

Table 1: Effect of long term INM practices on chlorophyll content (mg kg^{-1} of fresh leaves) of leaves of blackgram at different growth stages

Sl. No.	INM practices	15 DAS	30 DAS	45 DAS
1	Control	1.14	1.34	1.43
2	STD	1.15	1.48	1.57
3	STD+F	1.20	1.61	1.62
4	STD+VC	1.24	1.68	1.68
5	STD+F+BFs	1.29	1.76	1.77
6	STD+VC+BFs	1.31	1.79	1.81
7	STD+F+L+BFs	1.33	1.85	1.86
8	STD+VC+L+BFs	1.45	1.91	1.95
LSD	(P=0.05)	0.192	0.156	0.075

Effect of long term INM on nutrient acquisition of blackgram

The nutrient content of different plant parts is given in the table 2. Influence of long term INM practices on nitrogen content in blackgram seeds varied from 2.57 to 3.79%. The lowest nitrogen content in blackgram was recorded with control i.e., 2.57% whereas highest was with the treatment where all the inputs like inorganic fertilisers, organic fertilisers, lime and bio-fertilisers were applied i.e., 3.79%. With addition of inorganic fertilisers and organic manures there was significant increase in nitrogen content decrease in nitrogen content of in blackgram than the control. The lime integrated treatments were significantly different from the control and STD. The nitrogen content of blackgram stover were varied from 1.37% to 2.25%. Highest was found with the treatment where all the inputs like inorganic fertilisers, organic manures, lime as soil amendment, bio fertilizers were added i.e., 2.25%. The lowest nitrogen content was recorded with control i.e., 1.37%. With addition of lime and FYM the chlorophyll content was recorded to be 1.79% and it was followed by the packages with STD+ organics+ bio-fertilisers (1.66-1.7%), STD+ organics (1.6-1.66%). The lime integrated treatments were significantly higher chlorophyll content than the other treatments. This could be attributed to the ability of the *Rhizobium* to fix atmospheric nitrogen in symbiotic association with legumes and ability of PSB culture species *Bacillus megatherium* to bring sparingly soluble/insoluble inorganic and/or organic phosphates into soluble forms by secreting organic acids and it's synergistic with *Rhizobium* (Jat and Ahalawat 2004, Kumpawat 2010) [5, 13]. Similar

findings were also reported by Singh and Chauhan (2005) [18] and Rathi *et al.* (2009) [16].

The phosphorus content of blackgram seeds was varied from 0.27 to 0.42%. The lowest nitrogen content of in blackgram was recorded with control i.e., 0.27% whereas highest was with the treatment where all the inputs like inorganic fertilisers, organic fertilisers, lime and bio-fertilisers were applied i.e., 0.42%. With addition of inorganic fertilisers and organic manures there was significant increase in phosphorus content than the control. The phosphorus content of blackgram stover were varied from 0.11% to 0.23%. Highest was found with the treatment where all the inputs like inorganic fertilisers, organic manures, lime as soil amendment, bio fertilizers were added i.e., 0.23%. The lowest nitrogen content was recorded with control i.e 0.11%. With addition of lime and FYM the chlorophyll content was recorded to be 0.21% and it was followed by the packages with STD+ organics+ bio-fertilisers (0.15-0.17%), STD+ organics (0.13-0.14%). The lime integrated treatments were significantly higher chlorophyll content than the other treatments. Increase in phosphorus content of grain and stover were due to the increased nutrient availability with conjunctive use of FYM and inorganic sources along with *Rhizobium* inoculation were responsible for better uptake of nutrients and ultimately accumulation in plant tissue. These results are in conformity with the findings of Karpagam and Rajesh (2014) [8] and Kumawat *et al.* (2015) [12].

The potassium content of in blackgram seeds was varied from 0.63 to 0.95%. The lowest potassium content of in blackgram was recorded with control i.e., 0.63% whereas highest was with the treatment where all the inputs like inorganic fertilisers, organic fertilisers, lime and bio-fertilisers were applied i.e., 0.95%. With addition of inorganic fertilisers and organic manures there was significant increase in nitrogen content decrease in nitrogen content of in blackgram than the control. The lime integrated treatments were significantly different from the control and STD. The potassium content of blackgram stover were varied from 0.7% to 1.43%. Highest was found with the treatment where all the inputs like inorganic fertilisers, organic manures, lime as soil amendment, bio fertilizers were added i.e.,1.43%. The lowest nitrogen content was recorded with control i.e., 0.7%. The lime integrated treatments were significantly higher chlorophyll content than the other treatments.

Table 2: Effect of long term INM practices on nutrient content of blackgram

Sl. No	INM practices	Seed			Plant		
		N	P	K	N	P	K
		(%)					
1	Control	2.57	0.27	0.63	1.37	0.11	0.7
2	STD	3.24	0.28	0.69	1.40	0.12	1.13
3	STD+F	3.27	0.32	0.75	1.51	0.13	1.16
4	STD+VC	3.28	0.34	0.82	1.6	0.14	1.22
5	STD+F+BFs	3.3	0.38	0.83	1.66	0.15	1.27
6	STD+VC+BFs	3.39	0.39	0.87	1.7	0.17	1.34
7	STD+F+L+BFs	3.68	0.4	0.91	1.79	0.21	1.41
8	STD+VC+L+BFs	3.79	0.42	0.95	2.25	0.23	1.43
LSD	(P=0.05)	0.759	0.066	0.07	2.35	0.027	0.179

Effect of long term INM on nodulation and productivity of blackgram

The number of nodules per plant are presented in table 3 which varied from 66.3 to 120.3. Highest nodules were found with the treatment where all the inputs like inorganic fertilisers, organic manures, lime as soil amendment, bio fertilizers were added i.e., 66.3. The lowest chlorophyll content was recorded with control i.e., 66.3. With addition of lime and vermicompost the nodule N content was recorded to be highest i.e., 0.42% and it was followed by the packages with STD+ organics+ bio-fertilisers (0.34-0.37%), STD+ organics (0.28-0.3%). The lime integrated treatments were significantly higher chlorophyll content than the other treatments. Rautela *et al.* (2001) [24] reported that Rhizobium inoculation increased the nodulation and crop growth. It might have resulted due to more competitive ability of microbes near roots which is the site for microbial infection. Well-developed root system provides more evidence for infection resulting in greater number of nodules. These finding are found relevant to Hussain *et al*., (2015) [4], Dhakal *et al*., (2016) [3], Meena and Ram (2016) [14], Kant *et al*., (2016) [7] and Mohammad *et al*., (2017) [15].

The no of pods per plant was varied from 6.7 to 27. The lowest no of pods per plant of in blackgram was recorded with control i.e., 6.7% whereas highest was with the treatment where all the inputs like inorganic fertilisers, organic fertilisers, lime and bio-fertilisers were applied i.e., 27. With addition of inorganic fertilisers and organic manures there was significant increase in nitrogen content increase in nitrogen content of in blackgram than the control. The no of seeds per pod was varied from 4.33 to 7. The lowest no of pods per plant of in blackgram was recorded with control i.e., 4.33 whereas highest was with the treatment where all the inputs like inorganic fertilisers, organic fertilisers, lime and bio-fertilisers were applied i.e., 7. With organic addition all the treatments had significantly higher no of seeds per plant. Kadam *et al*. (2014) [6], Kumar *et al*. (2020) [11] and Zannat *et al*. (2020) [20] had similar kind of result where integrated use of nutrient results into better pods plant^{-1} and seeds pod^{-1}

The yield of blackgram varied between 0.18 t/ha to 0.82 t/ha. the lowest yield was found with STD whereas the highest yield was found with the lime integrated treatment with FYM. The lime integrated had significantly higher yield than the STD and control. The treatments where all the inputs applied were statistically at par with the only bio-fertiliser added treatments. Yield is cumulative effect of vegetative growth and yield attributes. Since, the vegetative growth and yield attributes were increased by the better supply of nutrients through soil test based NPK, S, Mo, FYM and *Rhizobium* application hence, grain and stover yield also increased. These results are corroborated by the findings of Khosro and Yousef (2012) [9] Amruta *et al.* (2015) [1] and Zahida *et al.* (2016) [19].

Table 3: Effect of long term INM practices on nodulation and productivity of blackgram

Sl. No.	INM practices	No of Nodule plant^{-1}	Nodule N content (%)	No of pods plant^{-1}	No of seeds pod^{-1}	Economic yield (t ha^{-1})
1	Control	66.3	0.20	6.7	4.33	0.25
2	STD	81.3	0.23	13.3	4.67	0.18
3	STD+F	93.0	0.28	15.3	5.00	0.57
4	STD+VC	100.0	0.30	18.7	5.33	0.56
5	STD+F+BFs	102.3	0.34	20.3	5.67	0.41
6	STD+VC+BFs	108.7	0.37	21.0	6.33	0.4
7	STD+F+L+BFs	116.3	0.40	25.8	6.67	0.82
8	STD+VC+L+BFs	120.3	0.42	27.0	7.00	0.8
LSD	(P=0.05)	5.446	0.021	6.153	0.965	0.042

Conclusion

The integrated application of organic and inorganic manures increased yield of blackgram over only organic and inorganic packages. The photosynthetic activity and nodular characteristics also higher in integrated nutrient management package than other packages. No of seed pod^{-1} and no of pod plant^{-1} were higher in integrated package in comparisons to inorganic and organic packages. Application of lime in acid soil increased the productivity as well as nutrient uptake by the plant. Among organics, the nodulation, nodular nitrogen content and nutrient content of grain and plant were found to be superior in the treatment where vermicompost was integrated with inorganic fertilizer, biofertilizer and lime.

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