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RESEARCH ARTICLE

Enhancing black gram "[*Vigna mungo* (l.) Hepper]" nutrient uptake and yield through integrated use of organic manure and inorganic fertilizer application

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Abstract

Black gram is an important legume crop cultivated throughout the world for its protein content and economic importance. The integrated nutrient management practice is the key strategy to increase the production and productivity of black gram to meet the protein needs of the growing population. There is an immediate need for organic manure application along with inorganic fertilizer for increasing the nutrient uptake efficiency of crops. The goal of the field experiment was to maximise the delivery of nutrients by recycling residue from the cropping system's related components. Different organic manures and the appropriate dosages of NPK fertilisers were used in the studies from 2019 to 2021 and the field was laid out in split plot statistical design with 5 main plots *viz*., M_1, M_2, M_3, M_4, M_5 and 3 Sub plots were fixed with different fertilizer levels *viz*., S_1, S_2 and S_3. The significant influences on growth and yield attributes of black gram were observed. Nitrogen, phosphorus and potassium content and uptake in grain and haulm yield significantly increased with the application of M_2S_1 compared to other combinations tried in both years. This experiment highlights the effectiveness of integrated nutrient management (INM) using organic manure and inorganic fertilizers. This approach can improve crop yield while promoting sustainability by reducing reliance solely on chemical fertilizers.

Keywords

black gram; leaf area; nutrient management; nutrient uptake; organic manures; yield

Introduction

Pulses are an essential component of the sustainable agricultural system since they consume less water and carbon footprints in addition to their nutritional benefits. It has twice as much protein as wheat and thrice as much protein as rice, according to estimates it contains 20-25 % protein. Black gram (*Vigna mungo* L.) is one of the important pulse crops cultivated throughout the world. It has been stated that the crop fixes about 22.10 kg of N/ha, which is expected to supplement 47.9 kg of urea per ha. It is vital in Indian cuisine

since it includes vegetable protein and serves as a complement to a cereal-based diet (1). The yield of black gram is estimated at 15.05 lakh tonnes (2024) as compared to 17.68 lakh tonnes in 2022-23. Among the states, Madhya Pradesh is leading in black gram production with 6.59 lakh tonnes followed by Uttar Pradesh (2.74 lakh tonnes), Rajasthan (1.26 lakh tonnes), Jharkhand (0.87 lakh tonnes) Maharashtra (0.87 lakh tonnes) and Gujarat (0.53 lakh tonnes) (2). Black gram performs well under a variety of soils with clayey loam to loam in texture with good drainage. The soil nutrient status of the field was low in available nitrogen (259.4 kg/ha), high in available phosphorus (22.3 kg/ha) and high in available potassium (487.8 kg/ha).

Lesser use of fertilizer and poor agricultural soil are significant obstacles to raising productivity. In order to fully utilise the genetic potential of pulse crops, mineral nutrition is essential. Long-term soil quality improvement and increased crop yield are possible when inorganic fertilisers are used in conjunction with a variety of organic sources (2). More photosynthates will translocate from source to sink as a result of the gradual and constant release of nutrients from organic and inorganic sources, which will ultimately improve the yield-attributing characteristics. Regardless of the crop or season, the use of organic manure (Farm yard manure, vermicompost, press mud and poultry manure) along with chemical fertilisers had a stimulating effect on yield. The nitrogen and phosphorus substitution through different organics increased the productivity of black gram significantly and increased with the increasing levels of nutrients as proven earlier in the case of rice (3). Before the monsoon arrived, farm yards and tank silt were applied to agricultural lands. This improved the texture and moisture retention of the soil, which in turn led to increased crop yield. It also replenished the nutrients in the soil. The goal of this research was to determine how black gram growth and yield were impacted by both organic and inorganic nutrient sources.

Materials and Methods

From November 2019 to October 2021, field research was done at KVK, Needamangalam, Tamil Nadu Agricultural University, to determine the impact of various organic manures and inorganic fertilizer applications on black gram (Table 3). The experiments were fixed with 5 main plots and 3 sub-plots using a split-plot statistical design (Table 1). The nutrient status of fish pond silt from different poultry droppings-fed ponds and crop details followed in the experiment are given in (Table 2) and (Table 4) respectively.

The plant morphological and yield-related parameters were taken at the flowering and harvesting stages of the black gram crop in both years. Plant height was measured in centimetres, starting from the base of the plant and ending at the tip of the longest leaf that was extended. LAI was worked out as reported (4) for black gram. K factor value 0.75 was used for calculating the leaf area index.

$$LAI = \frac{\text{Leaf area of individual plant or hill (cm}^2\text{)}}{\text{Leaf area occupied by plant or hill (cm}^2\text{)}}$$

Table 1. Treatment details of the experiment

Main plot	Treatment details
M_1	Silt from pond where fish were fed with desi poultry droppings at 5 t/ha and vermi-compost at 5 t/ha
M_2	Silt from pond where fish were fed with duck droppings at 5 t/ha and vermi-compost at 5 t/ha
M_3	Silt from pond where fish were fed with turkey droppings at 5 t/ha and vermi-compost at 5 t/ha
M_4	Farmyard manure 12.5 t/ha
M_5	No organic manure application
Sub plot	
S_1	100 % recommended dose of fertilizer (25:50:25 Nitrogen: Phosphorus: Potassium kg/ha)
S_2	75 % recommended dose of fertilizer (18.7:37.5:18.7 Nitrogen: Phosphorus: Potassium kg/ha)
S_3	No fertilizer application

Table 2. Nutrient status of fish pond silt from different ponds

Sl. No.	Chemical constituents	Composition		
		Silt from Fish - Desi poultry pond	Silt from Fish - Turkey pond	Silt from Fish - Duck pond
1	Soil reaction (pH)	8.4	8.3	8.1
2	Electrical conductivity (dS m^{-1})	0.59	0.57	0.49
3	Organic Carbon (%)	0.81	0.76	0.86
4	Available N (kg/ha)	289	277	296
5	Available P (kg/ha)	21.8	21.2	22.9
6	Available K (kg/ha)	494.1	489.3	497.5

Table 3. Recommended organic manure and fertilizer schedule for various crops in the cropping system

Crop	Organic manure application (t/ha)			Fertilizer schedule (kg/ha)		
	Farmyard manure	Pond silt	Vermicompost	Nitrogen	Phosphorus	Potassium
Rice	12.5	5.0	5.0	150	50	50
Black gram	-	-	-	25	50	25
Maize	12.5	-	5.0	250	75	75

Table 4. Details of the crop in the experiment

Crop	Variety	Duratio (Days)	Season	Spacing (cm)	2019-20		2020-21	
					Date of sowing / Date of transplanting*	Date of harvest	Date of sowing / Date of transplanting*	Date of harvest
Rice	CO (R) 50	130-135	*Rabi*	20 x 10	02.11.19 27.11.19*	16.03.20	01.11.20 25.11.20*	16.03.21
Black gram	TNAU Black gram CO 6	60-65	Summer	30 x 10	25.03.20	30.05.20	10.04.21	14.06.21
Maize	TNAU maize hybrid CO H(M) 6	110	*Kharif*	60 x 25	23.06.20	10.10.20	03.07.21	20.10.21

The total dry matter was calculated from five uprooted plants without loss to rootlets from the sampling rows of each crop. These samples were first air-dried in shade and then oven-dried at 70 °C till they reached a constant weight and dry matter was expressed as kg/ha. The yield of pods (numbers/plant), seeds (numbers/pod) and test weight (g/100 grains) were recorded. After the grain from the net plot was dried to the appropriate moisture level, the yield was measured and expressed in kg/ha. After sun drying, the haulm yield from the net plot was measured and presented in kg/ha. To estimate the NPK concentrations, plant samples that were taken from the various treatments for dry matter assessment were oven-dried, ground finely in a Willey mill and then used. To calculate the NPK absorption for plants, the corresponding dry matter content was multiplied by the % concentration of the nutrients.

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{\% of nutrient x Total dry matter production (kg/ha)}}{100}$$

The research's data on the different traits were statistically evaluated (5). Critical Differences (CD) were calculated for comparison at the 0.05 levels of probability for any treatment differences that were determined to be significant.

Results and Discussion

Growth and Biomass characters

Supplementation of both organic and inorganic nutrient sources can enhance crop yield in black gram. Nutrients are essential for plant growth and development and their availability in the soil directly affects crop productivity. Organic and inorganic nutrient sources provide different forms of essential elements that plants need to thrive. The different sources of organic manures applied to black gram plants had a significant influence on plant height (Table 5). The higher plant height was recorded on the flowering stage with the residual effect of treatment (M_2) during both years. Application of the full recommended dose of NPK (25:50:25 NPK kg/ha) (S_1) resulted in significantly increased plant height, it was followed by the application of the 75 % suggested dose of NPK (18.7:37.5:18.7 NPK kg/ha) (S_2) during both the years. The application of organic nutrient sources likely resulted in increased plant height during the flowering stage. Both fish pond silt and vermicompost are rich in nutrients, including nitrogen, phosphorus and potassium, which are essential for plant growth and flowering. These nutrients promote robust vegetative growth, leading to taller plants. Duck droppings also consist of different micro and macro elements and plant growth-promoting hormones may induce the plant height (6).

The application of organic manure to black gram influenced the LAI of black gram during both the years of experimentation at the flowering and harvesting stages (Table 6). In 2020, the application of silt from the pond where fish were fed with duck droppings and vermicompost at 5 t/ha to rice produced higher LAI in the succeeding crop black gram followed by M_1. Similar results were recorded during 2020 at all stages. During both years of the experiment, higher LAI was seen with the application of the (S_1) followed by S_2. Application of Silt from the pond where fish were fed with duck droppings at 5 t/ha and vermicompost at 5 t/ha to preceding rice produced higher dry matter production in black gram and it was followed by the application of M_1 during both years and both the stages. Higher DMP was observed when S_1 treatment was applied and in both years, this was followed by S_2 during the flowering and harvesting stages (Table 7). The output of dry matter was significantly impacted by the quantities of

Table 5. Effect of different organic manure and inorganic fertilizer treatments on plant height of black gram

Treatments	2020								2021							
	Flowering (cm)				Harvesting (cm)				Flowering (cm)				Harvesting (cm)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	41.9	35.1	31.2	36.1	52.8	48.6	41.4	47.6	43.6	40.0	32.4	38.7	56.3	51.6	41.7	49.9
M_2	42.7	36.2	31.9	36.9	53.9	49.6	42.0	48.5	45.7	40.9	33.7	40.1	59.5	52.3	42.4	51.4
M_3	39.7	32.6	27.2	33.2	50.1	44.2	37.9	44.1	41.1	38.0	30.5	36.5	52.7	48.6	38.7	46.6
M_4	40.8	34.3	28.7	34.6	51.5	47.4	40.2	46.4	42.3	39.0	31.5	37.6	54.2	49.4	39.5	47.7
M_5	32.4	26.7	21.3	26.8	43.8	36.8	32.7	37.8	34.6	31.9	24.8	30.4	46.8	39.7	34.3	40.3
SEd	1.8	1.5	3.3	3.3	2.1	2.2	4.5	5.0	1.1	1.1	2.4	2.5	1.4	1.2	2.7	2.8
CD (P=0.05)	4.2	3.1	7.6	7.6	4.8	4.6	9.8	10.5	2.7	2.4	5.1	5.2	3.4	2.7	5.6	6.0

Table 6. Effect of different organic manure and inorganic fertilizer treatments on leaf area index of black gram

Treatments	2020								2021							
	Flowering				Harvesting				Flowering				Harvesting			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	4.83	4.22	3.59	4.21	4.24	3.88	3.35	3.82	4.87	4.32	3.68	4.29	4.37	3.92	3.37	3.89
M_2	4.94	4.36	3.71	4.34	4.40	3.99	3.43	3.94	4.91	4.48	3.79	4.39	4.48	4.04	3.45	3.99
M_3	4.58	4.09	3.34	4.00	4.05	3.71	3.14	3.63	4.59	4.06	3.39	4.01	4.12	3.65	3.21	3.66
M_4	4.64	4.15	3.43	4.07	4.19	3.77	3.25	3.74	4.79	4.18	3.47	4.15	4.25	3.85	3.28	3.79
M_5	3.81	3.24	2.79	3.28	3.54	3.04	2.47	3.02	4.27	3.82	2.87	3.65	3.57	3.18	2.78	3.18
SEd	0.12	0.13	0.28	0.30	0.19	0.17	0.36	0.38	0.13	0.11	0.24	0.25	0.15	0.10	0.25	0.24
CD (P=0.05)	0.27	0.28	0.61	0.72	0.44	0.35	0.81	0.82	0.31	0.23	0.58	0.56	0.35	0.22	0.57	0.54

Table 7. Effect of different organic manure and inorganic fertilizer treatments on dry matter production of black gram

Treatments	2020								2021							
	Flowering (kg/ha)				Harvesting (kg/ha)				Flowering (kg/ha)				Harvesting (kg/ha)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	1830	1569	1218	1539	3284	2769	2139	2731	1944	1655	1291	1630	3618	2947	2288	2951
M_2	1972	1607	1254	1611	3611	2859	2196	2889	2019	1696	1345	1687	3885	3066	2395	3115
M_3	1653	1370	1154	1392	2963	2478	1926	2456	1758	1460	1189	1469	3079	2577	2098	2584
M_4	1760	1489	1170	1473	3156	2662	2051	2623	1877	1551	1240	1556	3282	2776	2137	2731
M_5	1352	1098	798	1083	2313	2016	1508	1946	1384	1162	922	1156	2589	2073	1616	2092
SEd	59	55	117	123	51	46	99	104	56	35	86	80	95	46	128	104
CD (P=0.05)	136	115	243	251	119	97	214	218	131	73	183	163	220	97	283	218

inorganic fertilisers and the various sources of organic manures. The combined application of Silt from the pond where fish were fed with duck droppings at 5 t/ha and vermicompost at 5 t/ha + 100 % RDF (M_2S_1) produced high dry matter production in both the years of experiment 2020 and 2021. The combined application of organic and inorganic manure (50 % recommended dose of fertilizer + 50 % vermicompost) to the black gram improved accessibility of major and minor nutrients to plants and might have enhanced early root growth and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting in increased plant growth attributes (Plant height, LAI and Dry matter production) and finally increase plant growth rate (7). Combined application of organic and inorganic fertilizers enhanced the release of nutrients early in the crop period. Such beneficial effects of combined application along with a better edaphic environment available to the crop might have improved all the growth attributes of green gram (Plant height, LAI and dry matter production) (8). The highest values of growth parameters such as plant height, number of branches/plant, % flowering and number of root nodules were recorded with the application of 100 % RDF (inorganic) + FYM at 2 t/ha followed by the application of 100 % RDF (inorganic) + Vermicompost at1.0 t/ha (9). The application of 50 % RDF aligns with 25 % FYM and 25 % Vermicompost recorded significantly higher plant height and dry matter accumulation/plant as compared to no FYM application in green gram (10). The number of pods per plant is another important yield attributing factor which differed significantly with vermicompost at 1 t/ha + RDF and broadcast method application of FYM at 5 t/ha + RDF as compared to only RDF. This might be attributed to better availability of nutrients (11). Fish pond silt is the accumulation of sediment, organic matter and nutrients that settle at the bottom of fish ponds. When the pond is fed with duck droppings, it adds additional organic matter and nutrients to the silt. This nutrient-rich silt can serve as a valuable source of nutrients for plants when applied to the soil and it increases the availability of nutrients present in the soil in greater duration (12).

Yield and yield attributes

Application of organic manure to black gram increased the number of pods/plant of black gram during both the years of experiment. Application of Silt from the pond where fish were fed with duck droppings at 5 t/ha and vermicompost at 5 t/ha applied to preceding rice produced a higher number of pods/plant in black gram followed by M_1 during 2020 and 2021. Applying the S_1 - 100 % recommended dose of fertilizer (25:50:25 NPK kg/ha) resulted in a greater number of pods/plant in black gram for both years among all the fertiliser levels tested. The interaction effect between organic manures and inorganic fertilizers levels was not significant in both years. This may be due to the nutrients in the silt becoming available to the black gram plants, promoting healthy vegetative growth and better flowering, which ultimately leads to increased pod formation (13).

A higher number of seeds/pod were recorded with the application of M_2 which significantly differs from the application of M_3 (Tables 8, 9). The least number of seeds/pod was recorded under M_5 during both years. A higher number of seeds/pod in black gram was recorded with the application of S_1 during both years. Application of different sources of organic and levels of fertilizer NPK failed to produce an interaction effect on the number of seeds/pod in

Table 8. Effect of different organic manure and inorganic fertilizer treatments on yield attributes of black gram during 2020

Treatments	Number of pods/plant				Number of seeds/pod				100 seed weight (g)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	49.7	39.7	27.8	39.1	6.6	6.2	5.7	6.2	6.09	6.01	5.86	5.99
M_2	52.8	44.8	33.6	43.7	6.8	6.3	5.9	6.3	6.14	6.08	5.88	6.03
M_3	46.7	35.8	26.1	36.2	6.2	6.1	5.3	5.9	5.95	5.91	5.76	5.87
M_4	50.9	41.6	29.5	40.7	6.4	6.1	5.4	6.0	6.01	5.96	5.81	5.93
M_5	38.9	31.4	22.9	31.1	6.2	5.7	5.2	5.7	6.06	5.88	5.76	5.90
SEd	1.1	1.0	2.2	2.3	0.2	0.2	0.4	0.4	0.22	0.14	0.35	0.33
CD (P=0.05)	2.7	2.2	5.3	5.1	0.4	0.4	1.1	NS	0.52	0.31	0.92	0.76

Table 9. Effect of different organic manure and inorganic fertilizer treatments on yield attributes of black gram during 2021

Treatments	Number of pods/plant				Number of seeds/pod				100 seed weight (g)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	54.4	46.2	36.0	45.5	6.7	6.3	5.6	6.2	6.15	5.88	5.77	5.93
M_2	56.7	47.1	37.8	47.2	6.9	6.4	5.7	6.3	6.19	5.98	5.81	5.99
M_3	49.0	39.2	32.5	40.3	6.3	5.9	5.1	5.8	5.97	5.53	5.57	5.69
M_4	52.2	43.6	33.6	43.1	6.4	6.1	5.4	6.0	6.09	5.76	5.62	5.82
M_5	39.8	31.3	26.4	32.5	6.3	5.6	4.9	5.6	5.86	5.37	5.44	5.56
SEd	1.8	1.1	2.7	2.6	0.2	0.2	0.3	0.4	0.20	0.14	0.33	0.32
CD (P=0.05)	4.1	2.4	5.6	5.8	0.4	0.4	0.9	1.0	0.5	0.30	0.62	0.81

black gram. The application of (M_2) recorded higher test weight which was on par with other organic manure applied treatments. Among the different levels of inorganic fertilizer tried, S_1 recorded a higher test weight which was on par with S_2 and no manure recorded the lowest value on test weight in black gram. The application of vermicompost to the soil can enhance nutrient availability, water retention, and microbial activity, creating a favorable condition for the black gram plants to thrive and produce more pods (14).

The application of inorganic fertiliser and organic manures to black gram had a substantial impact on grain yield. During both years, the application of (M_2) resulted in greater grain yields. The application of S_1 treatment during both experimental years resulted in a better grain yield. In both trial years, there was no significant interaction between the levels of inorganic fertilisers and organic manures. Higher haulm yields were recorded with the application of M_2. The application of S_1 produced a higher haulm yield when compared to the other fertiliser levels tested (Table 10). The combined application of organic and inorganic fertilizers has a favourable influence on yield because organic fertilizers help to reduce the danger of nutrient leaching even after inorganic fertilizers are applied to the soil. Furthermore, vermicompost is one of the finest cures for maintaining soil health as well as crop plant productivity, especially when used in conjunction with chemical fertilizers (15).

The significant improvement in yield attributing characters such as pods/plant, 1000 grain weight, number of grains, grain yield and haulm yield due to application of 100 % RDF (inorganic) + Vermicompost at 1.0 t/ha + Rhizobium for black gram (9). Applying vermicompost at 5 t/ ha and poultry manure at 5 t/ha, coupled with 50 % RDF, produced the maximum number of seeds/pod, yield/plant, grain yield/m^2 and total dry weight/plant in black gram (12). The application of 6.25 t/ha of vermicompost combined with 100 % RDF and seed treatment with phosphorus and potash solubilizing bacteria significantly improved the physio-chemical characteristics, growth and yield attributes of green gram (8). With a steady supply of nutrients from the fish pond silt, the crops can exhibit increased vegetative growth. Higher biomass often translates to higher grain yield as the plants have more resources to allocate towards grain production (10).

Table 10. Effect of different organic manure and inorganic fertilizer treatments on grain and haulm yield of black gram

Treatments	2020								2021							
	Grain yield (kg/ha)				Haulm yield (kg/ha)				Grain yield (kg/ha)				Haulm yield (kg/ha)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	948	798	618	788	1975	1671	1278	1641	1016	852	663	844	2070	1734	1345	1716
M_2	991	818	647	819	2064	1719	1339	1707	1148	894	681	908	2218	1806	1438	1821
M_3	867	724	587	726	1783	1494	1159	1479	917	776	628	774	1872	1545	1263	1560
M_4	919	765	606	763	1887	1591	1216	1565	968	823	637	809	1945	1627	1309	1627
M_5	711	545	434	563	1462	1225	926	1204	759	608	477	615	1511	1218	982	1237
SEd	22	23	47	51	60	25	76	56	25	15	38	35	60	20	71	46
CD (P=0.05)	51	48	96	106	140	52	170	118	58	33	84	74	139	43	159	96

Nutrient uptake efficiency of black gram

The application of organic manures and inorganic fertilisation to black gram had a substantial impact on nutrient uptake (Fig. 1, 2). The higher nitrogen uptake was recorded with the (M_2) at both flowering and harvesting stages during both years of the experiment. During both years of the experiment at both phases, the application of S_1 was found to have a higher nitrogen uptake than the application of (S_2). Among the different sources of organic manures and inorganic fertilizers used, the application of M_2S_1 registered higher nitrogen uptake in both the years of experiment.

The higher phosphorus uptake was recorded with the silt from the pond where fish were fed with duck droppings at 5 t/ha and vermicompost at 5 t/ha (M_2) which significantly differs from all other treatments. The different levels of fertilizer application had a significant influence on phosphorus uptake in black gram. The higher phosphorus uptake was recorded with the application of S_1 during both the years of the experiment at both stages. Among the different sources of organic manures and inorganic fertilizer used, the application of treatment M_2S_1 registered higher phosphorus in both the years of the experiment at both stages.

Application of (M_2) to preceding rice crop enhanced higher potassium uptake in succeeding black gram. The interaction effect was significant at the harvesting stage during 2019-20 and 2020-21. The potassium uptake was significantly influenced by the combined application of (M_2S_1) registered higher potassium uptake in both the years of the experiment. The interaction effect was not significant in the flowering stage during both years. The uptake of N, P and K in grain and haulm was higher with the application of soil test-based NPK + 10 t FYM/ha + 30 kg S/ha + 1 kg Mo/ha along with Rhizobium (16). The addition of a higher quantity of organic matter through black gram litter fall, roots and root nodules produced organic acids which in turn stabilized native nutrients and led to the availability of major nutrients for longer periods (17). Vermicompost is also a source of nitrogen, phosphorus and potassium as it is derived from organic matter that contains this essential nutrient. The nitrogen in vermicompost is present in organic forms and gradually becomes available to plants as it undergoes decomposition and mineralization by soil microbes. The slow release of nitrogen from vermicompost can support sustained growth and development of black gram, potentially

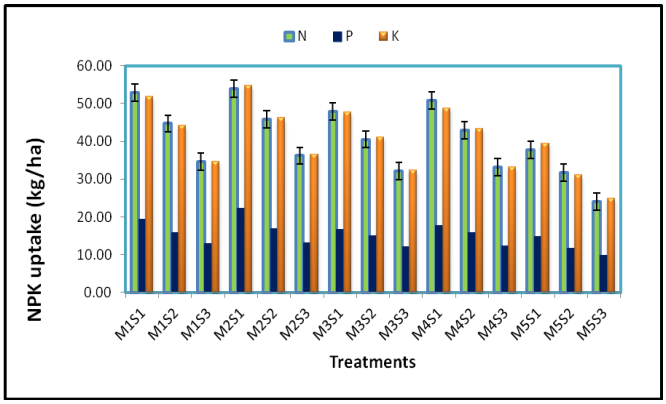

Fig. 1. Effect of different organic manure and inorganic fertilizer treatments on nutrient uptake of black gram during 2020.

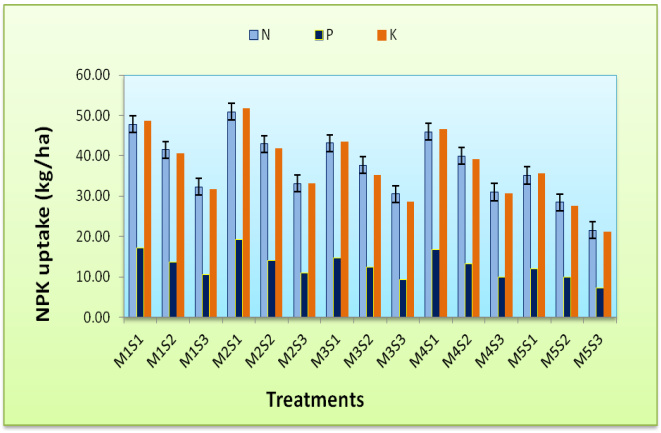

Fig. 2. Effect of different organic manure and inorganic fertilizer treatments on nutrient uptake of black gram during 2021.

leading to a higher nutrient uptake efficiency compared to rapidly available nutrient sources (18).

Conclusion

The findings from these field experiments highlight the potential benefits of using recycled organic materials (M_2) along with 100 % NPK fertilizer (25:50:25 NPK kg/ha) for black gram cultivation. The practice of residue recycling and organic nutrient supplementation can be sustainable and environmentally friendly, promoting better soil health, nutrient cycling and overall agricultural productivity. It's important to note that the success of such practices can be influenced by various factors, including soil type, crop variety, climate and proper application techniques. Farmers and agronomists can use these research results as a basis for implementing optimized nutrient management practices in black gram cultivation to achieve higher yields and sustainable production.

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Authors' contributions

AR and SR designed the experiment and carried out the experiment and PC and MSK performed growth and physiological analysis of plants. NA and SA performed statistical analysis. AR, ST and NK wrote and reviewed the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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