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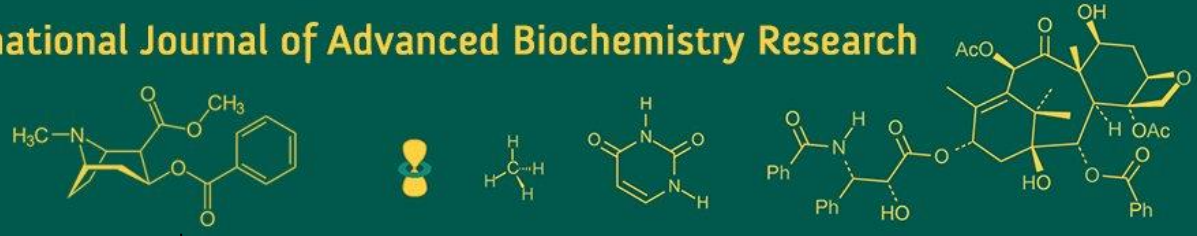

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Nutritional and cooking quality of organically grown black gram

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Abstract
The field trial was conducted out in summer season of the year 2021 on black gram *cv*. GU 3 at Organic Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat. The different organic nutrient sources used in the experiment were given through soil application and foliar application. The soil application of *viz*., S_1:100% RDN through NADEP compost, S_2: Ghan-jivamrut @ 500 kg/ha and S_3: Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha was given while for foliar application which was done thrice at 15, 30 and 45 days after sowing, the treatments were *viz*., F_0: Control, F_1: Novel organic liquid nutrient @ 1 percent and F_2: *Moringa* leaf extract @ 3 percent. From the result it was revealed that the protein content and the cooking quality of black gram did not significantly differ due to the various organic nutrient sources. However, the $S_3$and F_2treatment recorded the maximum protein content. The cooking quality *i.e.* hydration capacity, hydration index and swelling capacity was recorded numerically highest for the S_1 treatment as compared to other soil application treatments. From the foliar application of different treatments, the F_2 treatment recorded maximum hydration index, swelling capacity and the swelling index. So, from the above observations the soil application of 100 percent RDN through NADEP compost and foliar application of the *Moringa* leaf extract @ 3 percent would be benefitted to improve the quality of the black gram.

Keywords: Black gram, cooking quality, Ghan-jivamrut, Jivamrut, *Moringa* leaf extract, NADEP compost, novel organic liquid nutrient, nutrient content, organic farming, protein

Introduction
Day to day increase in population of the nation has led us to use the green revolution technology to overcome the problem of providing the nutritional security to people. But in the greed to get bumper crop production more and more use of chemical fertilizer was made which resulted in deterioration of food quality as well as the soil fertility also declined. So, for environmental safety and to initiate an economic and environmentally friendly cultivation process, organic farming is introduced into the Agricultural systems (Liu *et al*., 2021) [11]. Organic farming relies on using more on farm inputs and excludes use of off farm synthetic chemical resources (Reddy, 2019) [15]. Pulses being hardy crops perform well under organic farming. Black gram (*Vigna mungo* L. Hepper) which is commonly known as Mash Kalai, Urd and Urad bean. It belongs to family *Fabaceae* and is believed to be originated from South Asia, mainly India. It is one of the highly prized and most important annual short-duration pulse crops grown in India for seeds, green manure and forage. Black gram is all season crops grown in *kharif, rabi* and *zaid* season (Ajila and Rao, 2009) [2]. Black gram seeds are highly nutritious as it contains about 26 percent protein, which is almost three times that of cereals and other minerals and vitamins such as Vitamin A, B1 and B3. They are also rich in phosphorus, potassium, calcium and has a good amount of sodium (Selvakumar *et al.*, 2012) [17]. Black gram being a legume crop does not require much nitrogen as it has ability to fix atmospheric nitrogen in the soil (Zahran, 1999) [20]. The various organic sources can be used to improve the soil health as well quality of food. Organic sources like NADEP compost is rich in plant nutrients and can easily hold soil moisture helps to maintain soil fertility (Kumawat *et al*., 2017) [10]. The cow based organic manure like jivamrut, bijamrut, panchgavya are being used as good alternative of chemical fertilizer (Kaur, 2020). *Moringa oleifera* as a natural bio-stimulant Bio-stimulants are plant-based products or extracts of raw materials which contains auxins, gibberellins, abscisic acid,

ethylene and cytokinins (Wu *et al*., 2020) [19]. It also increases uptake of micronutrients and enhanced crop production (Murslain *et al*., 2014) [12]. The foliar feeding of *Moringa* leaf extract bio-stimulant is a complementary technique that can enhance growth, increase the yield of the crop and reduce the negative effects of abiotic stress during crop development (Karthiga *et al*., 2022) [8]. Fresh *Moringa oleifera* leaves have been shown to have zeatin, a cytokinin related hormone (Fuglie, 2000) [4]. In the contemporary time, Enriched banana pseudo stem sap is proving itself as a remedy for the harmful effect caused due to inorganic farming. A patent product "NOVEL- Liquid Organic Nutrient" has been developed by the Banana Pseudo-stem Processing Unit, Navsari Agricultural University, Navsari, Gujarat. It promotes crop growth, protect crop from harmful pest and enhances crop yield (Salunke, 2010) [16]. Owing to the ongoing situation of the world it has become necessary to find out appropriate organic nutrient management for pulse crop for an ecofriendly future.

Materials and Methods

The experiment was conducted at Organic Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat during summer season of the year 2021 on black gram *cv*. GU 3. The experiment was conducted in Navsari which falls under South Gujarat heavy rainfall zone having 'Deep Black soil' and locally it is called as 'black cotton soil'. It was reported that the soil was medium in available nitrogen and available phosphorus while it was high in available potassium. The organic carbon content was also in high range. The experiment was laid out in a Randomized Block Design with Factorial concept (FRBD), with two factors *viz*., soil application and foliar application each having three levels and was replicated thrice. The three level of soil application were namely, S_1:100% RDN through NADEP compost, S_2: Ghan-jivamrut @ 500 kg/ha and S_3: Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha and that of foliar application were *viz*., F_0: Control, F_1: Novel organic liquid nutrient @ 1% and F_2: Moringa leaf extract @ 3%. The application of foliar spray was done thrice at 15, 30 and 45 days after sowing. The weather conditions were favourable for the proper growth and development of the crop throughout the cropping period. The nutrient content in different organic source used during the experiment has been displayed below in the Table 1.

Table 1: The chemical composition of different organic source

Sr. No.	Parameters	Liquid/ Solid organic sources				
		NADEP compost (%)	Ghan-jivamrut (%)	Jivamrut (%)	Novel organic liquid nutrient (%)	*Moringa* leaf extract (%)
1.	N	1.35	0.95	0.091	0.062	0.97
2.	P	0.90	0.46	0.024	0.018	0.23
3.	K	1.23	1.12	0.118	0.180	0.92

Chemical Analysis of Plant Sample

The plant samples collected from the representative treatment plots were oven dried at 60±5 °C for 24 hours till the constant weight was recorded. Then the samples were grinded into powder form using the mixture grinder with stainless steel blade and were sieved using 2 mm sieve. Later, these samples were used for the analysis of N, P and K content using the standard methods of analysis shown in Table 2. While the nutrient uptake was calculated using the formula.

Nutrient Content (%)

The analysis of nutrient content from the seed and stover was found out using these samples by following the different standard methods of analysis as shown in the Table 2. The plant samples were digested using concentrated H_2SO_4 for nitrogen analysis and with diacid for analysis of phosphorus and potassium content.

Table 2: Different methods adopted for analysis of plant samples

Sr. No.	Parameters	Method of analysis	Reference
1.	Nitrogen (N)	Kjeldahl's Method	Jackson, 1973 [7]
2.	Phosphorus (P)	Spectrophotometry	Jackson, 1973 [7]
3.	Potassium (K)	Flame Photometric Method	Jackson, 1973 [7]

Quality Parameters

The different quality parameters were estimated using different methods and were based on formulas as furnished below.

Crude Protein Content (%)

The nitrogen content from the seed sample analyzed by the standard method of nitrogen analysis *i.e*. Kjeldahl's Method (Jackson, 1973) [7] was used to determine the crude protein content from the seeds. The crude protein content (%) was calculated by multiplying the nitrogen content (%) in seed by the conversion factor 6.25

The formula used for determination of the crude protein content (%) was:

Crude Protein content (%) = Nitrogen content in seed (%) x 6.25

Protein Yield (kg/ha)

The protein yield was obtained based on the crude protein content and dry matter yield of seed. The formula used for the determination of protein yield in kg/ha was:

$$\text{Protein yield (kg/ha)} = \frac{\text{Crude Protein content in grain (\%)} \times \text{Grain yield (kg/ha)}}{100}$$

Cooking Quality

The representative seed sample from the different treatment plots were collected separately at the time of harvest for the analysis of cooking quality *i. e.* hydration capacity, hydration index, swelling capacity and swelling index. These parameters were analyzed using the methods furnished below.

Hydration capacity (g/seed)

The100 g seeds were soaked in 100ml of distilled water in a measuring cylinder and then it was covered using an aluminum foil. The numbers of seeds in 100 g weighted seeds were counted. The seeds were left as it is to soak for 24 hours at room temperature (20±2 °C). After 24 hours of soaking, the excess water was removed and drained out using the tissue paper. The weight of the swollen seeds was measured using weighing balance (Wani *et al*., 2015) [18].

Hydration capacity was determined using the formula:

$$\text{Hydration capacity (g/seed)} = \frac{\text{Weight after soaking (g)} - \text{Weight before soaking (g)}}{\text{Number of seeds}}$$

Hydration index

Hydration index was determined based on Hydration capacity and weight of single seed (Wani *et al*., 2015) [18]. Hydration index of the seed was determined using the formula:

$$\text{Hydration index} = \frac{\text{Hydration capacity of seeds (g/seed)}}{\text{Weight of one seed (g)}}$$

Swelling capacity (ml/seed)

The 100 g seeds were taken and numbers of seeds present in it were counted. The volume of 100 g weighted seeds was predetermined using a graduated cylinder and they were subsequently soaked in the distilled water for overnight. Then the volume of seeds after soaking was measured using the graduated cylinder (Wani *et al*., 2015) [18].

Swelling capacity was determined using the formula:

$$\text{Swelling capacity (ml/seed)} = \frac{\text{Volume after soaking (ml)} - \text{Volume before soaking (ml)}}{\text{Number of seeds}}$$

Swelling index

The swelling index of the seed was determined using the formula:

$$\text{Swelling index} = \frac{\text{Swelling capacity of seeds (ml/seed)}}{\text{Volume of one seed (ml)}}$$

Result and Discussion

Nutrient Content in Seed

The nitrogen content in seed was numerically recorded the highest for the S_3 treatment **(**Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha) followed by S_1 (100% RDN through NADEP compost) treatment and S_2 **(**Ghan-jivamrut @ 500 kg/ha**)** containing 3.18, 3.16 and 3.14 percent nitrogen content in seed, respectively. The mean data obtained for the phosphorus content in seed indicated that there was no variation observed and numerically the highest 0.393 percent phosphorus content in seed was recorded for S_2 treatment while, the S_3 treatment recorded the lowest 0.385 percent phosphorus content. The potassium content in seed did not differ significantly due to the impact of soil application of organic sources. The result concluded that the potassium content in seed ranged from 1.20 – 1.22 percent in black gram seed.

For the foliar application the maximum value of nitrogen content *i. e.* 3.20 percent was recorded for the F_2 treatment. While the F_1 treatment recorded the lowest value 3.12 percent nitrogen content. It can be concluded that numerically the F_1 treatment where 1 percent Novel organic liquid nutrient was sprayed recorded the highest 0.393 percent phosphorus content followed by F_2 treatment with 0.389 percent P content where 3 percent *Moringa* leaf extract was sprayed. While the F_0 control treatment recorded lowest 0.383 percent P content. Numerically the maximum potassium content of 1.23 percent was recorded for the F_1 treatment while, the F_0 treatment recorded the least 1.20 percent potassium content in seeds of black gram (Fig. 1). Looking at the analyzed data it was revealed that the interaction effect between the soil and foliar application of the various organic nutrient sources showed non-significant result for the major nutrient *viz*., nitrogen, phosphorus and potassium content in black gram seeds.

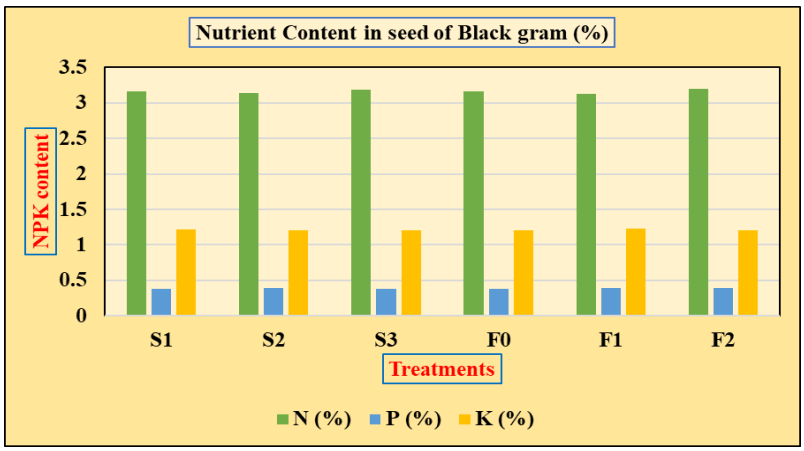

Fig 1: Effect of different treatment on N, P and K content in seed of black gram

Quality

Crude protein content

The crude protein content was recorded maximum 19.88 percent for S_3 (Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha) treatment followed by 19.77 percent for the S_1 (100% RDN was applied through NADEP compost) treatment and then 19.63 percent for the S_2 (Ghan-jivamrut @ 500 kg/ha) treatment. The data pertaining to the crude protein content in black gram seed did not statistically differ due to the foliar application of liquid organic nutrient sources applied thrice *i. e.* at 15, 30 and 45 DAS. The (F_2treatment) 3 percent *Moringa* leaf extract spray recorded numerically the highest 20.03 percent crude protein content. Whereas the (F_1 treatment) 1 percent Novel organic liquid nutrient spray numerically recorded the least 19.50 percent of crude protein content (Table 3). The results of the interaction effect between soil and foliar application of different organic nutrient sources on crude protein content of black gram seed was found to be statistically non-significant.

Protein yield

The significantly higher protein yield 198.98 kg/ha was obtained in S_1 treatment where 100 percent RDN was applied through NADEP compost and was found statistically similar with S_3(Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha) treatment recording 179.90 kg/ha protein yield. However, the lowest protein yield of 147.59 kg/ha was observed for the S_2 (Ghan-jivamrut @ 500 kg/ha) treatment. The impact of foliar spray of liquid organic nutrient sources given at 15, 30 and 45 DAS showed significant difference in results obtained for protein yield (kg/ha). The significantly the highest protein yield of 211.69 kg/ha was recorded for the F_2 treatment in which 3 percent *Moringa* leaf extract was sprayed. While the lowest 148.19 kg/ha protein yield was recorded for control treatment (Table 3). The protein yield did not statistically differ due to the interaction effect of soil and foliar application of the various organic nutrient sources. The results obtained for the present research work were in accordance with previous findings of Chaudhari (2013) [3] in green gram and Rathva (2013) [14] in pigeon pea.

Table 3: Effect of different treatments on crude protein content and protein yield of black gram

Treatments	Crude protein content (%)	Protein yield (kg/ha)
Factor I: Soil application (S)		
S_1 - 100% RDN through NADEP compost	19.77	198.98
S_2 - Ghan-jivamrut @ 500 kg/ha	19.63	147.59
S_3 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	19.88	179.90
SEm±	0.19	7.86
CD at 5%	NS	23.55
Factor II: Foliar application (F)		
F_0 – Control	19.74	148.19
F_1 - Novel organic liquid nutrient @ 1%	19.50	166.59
F_2–*Moringa*leaf extract @ 3%	20.03	211.69
SEm±	0.19	7.86
CD at 5%	NS	23.55
Interaction		
S×F	NS	NS
CV%	2.87	13.43

Effect of Different Treatments on Cooking Quality

The cooking quality *viz*., hydration capacity (g/seed), hydration index, swelling capacity (ml/seed) and swelling index of black gram *cv*. GU 3 was examined to assess the influence of soil and foliar application of the organic manure on it.

Hydration capacity and hydration Index

The hydration capacity of the black gram seed ranged between 0.0501 to 0.0504 g per seed when soil application of different sources of nutrients was given. The estimated hydration index of the black gram was recorded between 0.972 to 0.988. The S_1 treatment recorded numerically the highest 0.988 hydration index followed by the 0.979 and 0.972 for S_2 andS_3 treatment, respectively. The foliar spray of organic sources could not influence the hydration capacity and hydration index of the black gram *cv*. GU 3, so the results obtained were statistically non-significant. The hydration capacity calculated was found numerically the highest for the F_1 (Novel organic liquid nutrient @ 1%) treatment 0.0505 g/seed while the lowest hydration index was obtained for the F_0 (control) treatment 0.0501 g/seed. The hydration index 1.003 was recorded the highest for the F_2 treatment followed by F_1 treatment with 0.960 and then F_0 treatment with 0.957 (Fig. 2). An examination of the data obtained indicated that the interaction between soil and foliar supplication of organic nutrient sources did not differ significantly for the hydration capacity and hydration index of the black gram *cv*. GU 3.

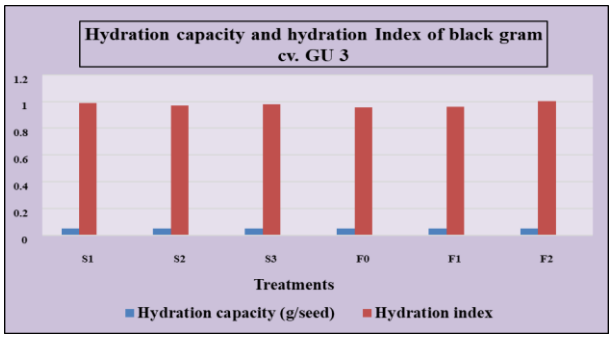

Fig 2: Hydration capacity and hydration Index of black gram cv. GU 3

Swelling capacity and swelling index

The prevailing data of swelling capacity revealed that the maximum swelling capacity 0.107 ml/seed was observed for the S_1 treatment (100% RDN applied through NADEP compost). However, the S_2 (Ghan-jivamrut @ 500 kg/ha) treatment recorded the lowest swelling capacity of 0.103

ml/seed. The results obtained for the swelling index was found statistically non-significant. The swelling index for the black gram *cv*. GU 3 ranged between 1.833 to 1.888 when soil application of different nutrient sources was given. Looking at the analyzed results of the swelling capacity and swelling index of the black gram *cv*. GU 3, it can be said that the foliar application of different treatment statistically failed to influence it. Numerically it can be said that the swelling capacity was recorded the highest 0.106 ml/seed for the F_2 (*Moringa* leaf extract @ 3%) treatment followed by the F_1 (Novel organic liquid nutrient @ 1%) treatment which recorded swelling capacity of 0.105 ml/seed. The swelling index of black gram was numerically the highest 1.869 for the F_2treatment while it was found lowest for the F_0 treatment with 1.860 swelling index (Fig. 3).The interaction effect was found to be statistically non-significant for the swelling capacity (ml/seed) and swelling index of the black gram.

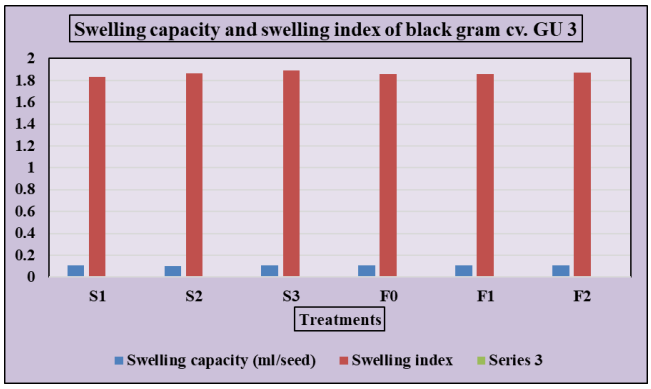

Fig 3: Swelling capacity and swelling index of black gram cv. GU 3

Yield

Seed yield

The significant result was obtained for the seed yield as the effect of soil application of organic nutrient sources showed positive impact on it. The result revealed that the application of 100 percent RDN through NADEP compost significantly recorded the highest seed yield *i. e.* 1041 kg/ha. While the S_2treatment where 500 kg/ha Ghan-jivamrut was applied recorded the lowest seed yield of 836 kg/ha. An appraisal of seed yield data indicated that foliar spray of liquid organic sources significantly influenced the seed yield as much variation was observed. The foliar spray of 3 percent *Moringa* leaf extract (F_2 treatment) resulted in significantly higher seed yield (1051 kg/ha) and was statistically similar with foliar spray of 1 percent Novel organic liquid nutrient (F_1 treatment) which recorded 937 kg/ha seed yield. While the F_0 treatment as control where no foliar application was given recorded the lowest seed yield *i. e.* 805 kg/ha (Table 4). The reason for the higher seed yield due to *Moringa* leaf extract may be that it increases the loading and unloading of assimilates across membrane boundaries of the vascular tissues leading to increase in yield. Cytokinins present in MLE also promote carbohydrate metabolism and create new source-sink relationships leading to increased yield of crop. The influence of interaction effect of soil and foliar application on the seed yield was found to be statistically non-significant. No variation in seed yield was observed due interaction effect. The previous experiment results noted by Chaudhari (2013) [3] in green gram and Rathva (2013) [14] in pigeon pea, Abohassan and Abusuwar (2017) [1] in green gram, Gunasekar *et al.* (2018) [5], Nivethadevi *et al.* (2021) [13] in black gram and Irshad *et al.* (2022) [6] in chickpea were found to be closely related with the findings of present research work.

Stover yield

From the result obtained it was concluded that the stover yield was significantly influenced by the soil application of the organic nutrient sources. The S_1 (100% RDN through NADEP compost) treatment recorded significantly higher stover yield of 2696 kg/ha and it remained at par with S_3 (Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha) treatment which recorded 2536 kg/ha stover yield. The result revealed that the foliar application of *Moringa* leaf extract @ 3 percent *viz*., F_2 treatment recorded significantly higher stover yield of 2725 kg/ha but was statistically similar with F_1 treatment where, Novel organic liquid nutrient @ 1 percent was sprayed and it recorded 2446 kg/ha stover yield. The F_0 treatment, control where no spray was given recorded the lowest 2228 kg/ha stover yield (Table 3). The statistically non-significant result was obtained for the stover yield due to the interaction effect between the soil and foliar application of various nutrient organic sources. The results of present study are in conformity with the previously reported findings of Chaudhari (2013) [3] in green gram and Rathva (2013) [14] in pigeon pea, Gunasekar *et al.* (2018) [5] in black gram, Nivethadevi *et al.* (2021) [13] in black gram and Irshad *et al.* (2022) [6] in chickpea.

Table 4: Effect of different treatments on yield and harvest index of black gram

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)
Factor I: Soil application (S)		
S_1 - 100% RDN through NADEP compost	1041	2696
S_2 - Ghan-jivamrut @ 500 kg/ha	836	2166
S_3 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	917	2536
SEm ±	40	123
CD at 5%	120	379
Factor II: Foliar application (F)		
F_0 - Control	805	2228
F_1 - Novel organic liquid nutrient @ 1%	937	2446
F_2–*Moringa*leaf extract @ 3%	1051	2725
SEm ±	40	126
CD at 5%	120	379
Interaction		
S×F	NS	NS
CV%	12.89	15.36

Conclusion

Based on the results obtained, it can be concluded that to obtain higher yield and to improve nutrient content as well as the cooking quality of the summer black gram *cv*. GU 3, the soil application of 100 percent RDN through NADEP compost and foliar application of either 3 percent *Moringa* leaf extract or 1 percent Novel organic liquid nutrient at 15, 30 and 45 days after sowing under organic farming.

References

1. Abohassan RA, Abusuwar AO. Effects of *Moringa oleifera* leaf extracts on growth and productivity of

three leguminous crops. Legum. Res. Int. J. 2018;41(1):114-119.
2. Ajila CM, Rao UP. Purification and characterization of black gram (*Vigna mungo*) husk peroxidase. J Mol Catal B Enzym. 2009;60(1-2):36-44.
3. Chaudhari NN. Performance of different organic manures on yield, quality, and uptake of nutrients by organically produced mung bean (*Vigna radiata* L.) cv. Meha. Thesis M.Sc. (Agri.), N. M. College of Agriculture, N.A.U., Navsari, India; c2013. p. 57-75.
4. Fuglie LJ. New uses of Moringa studied in Nicaragua. ECHO Development Notes. 2000;68:1-25.
5. Gunasekar J, Reddy KS, Sindhu GP, Anand S, Kalaiyarasi G, Anbarasu M, Dharmaraj K. Effect of leaf extracts and panchagavya foliar spray on plant characters, yield and resultant seed quality of black gram (*Vigna mungo* L.) cv. CO 6. Int. J. Curr. Microbiol. Appl. Sci. 2018;7(2):3205-3214.
6. Irshad S, Matloob A, Iqbal S, Ibrar D, Hasnain Z, Khan S, *et al*. Foliar application of potassium and Moringa leaf extract improves growth, physiology and productivity of kabuli chickpea grown under varying sowing regimes. PLoS One. 2022;17(2):e0263265.
7. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi; c1973. p. 183-192.
8. Karthiga D, Chozhavendhan S, Gandhiraj V, Aniskumar M. The effects of *Moringa oleifera* leaf extract as an organic bio-stimulant for the growth of various plants: Review. Biocatal Agric Biotechnol. 2022;43:102446.
9. Kaur A. JIVAMRUTHAM: An effective activator of soil microorganisms. Just Agriculture multidisciplinary e-Newsletter. 2020;1(1):1-5.
10. Kumawat N, Tomar IS, Kumar R, Sahu YK. Preparation of NADEP compost for sustaining farming community. Popular Kheti. 2017;5(4):56-60.
11. Liu J, Shu A, Song W, Shi W, Li M, Zhang W, *et al*. Long-term organic fertilizer substitution increases rice yield by improving soil properties and regulating soil bacteria. Geoderma. 2021;404:115287.
12. Murslain M, Javed N, Khan SA, Khan HU, Abbas H, Kamran M. Combined efficacy of *Moringa oleifera* leaves and a fungus, *Trichoderma harzianum* against Meloidogyne javanica on eggplant. Pakistan Journal of Zoology. 2014;46(3).
13. Nivethadevi P, Swaminathan C, Kannan P, Tamilselvi E. Seed fortification and foliar spraying with *Moringa oleifera* leaf extract enhances yield and yield attributes in black gram [*Vigna mungo* (L.) Hepper]. Legum. Res. Int. J. 2021;1-5.
14. Rathva KS. Response of pigeon pea (cv. Vaishali) to different planting geometries and organic sources. Thesis M.Sc. (Agri.), N. M. College of Agriculture, N.A.U., Navsari, India. 2013.
15. Reddy SR. Principles of Agronomy, ANGR Agricultural University, S. V. Agricultural College, Tirupati, Andhra Pradesh, India; c2019. p. 692-693.
16. Salunke JR. Feasibility of using banana pseudo-stem sap as liquid fertilizer in onion under drip irrigation. Thesis Ph.D., Soil and Water Management Department, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India; c2010.
17. Selvakumar G, Reetha S, Thamizhiniyan P. Response of biofertilizers on growth, yield attributes and associated protein profiling changes of black gram (*Vigna mungo* L. Hepper). World Appl. Sci. J. 2012;16(10):1368-1374.
18. Wani IA, Sogi DS, Wani AA, Gill BS. Physical and cooking characteristics of some kidney bean (*Phaseolus vulgaris* L.) cultivars. J. Saudi Soc. Agric. Sci. 2015;16(1):1-9.
19. Wu Q, Su N, Huang X, Ling X, Yu M, Cui J, Shabala S. Hydrogen-rich water promotes elongation of hypocotyls and roots in plants through mediating the level of endogenous gibberellin and auxin. Functional Plant Biology. 2020;47(9):771-778.
20. Zahran HH. Rhizobium-Legume symbiosis and nitrogen fixation under severe conditions and in an arid climate. American Soc. Microbiol. 1999;63(4):968-989.