

# Impact of Various Nutrient Sources on Black Gram (*Vigna mungo* L. Hepper) Productivity and Soil Properties of Under Organic Farming

## ABSTRACT

A field experiment was conducted in the Organic farm, Department of Natural Resource Management, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat in the year 2021 in summer season. The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) comprising of two factors each having three levels *i. e.* soil application *viz.*, S<sub>1</sub> (100 % RDN through NADEP compost), S<sub>2</sub> (Ghan-jivamrut @ 500 kg/ha) and S<sub>3</sub> (Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha) and foliar application *viz.*, F<sub>0</sub> (Control), F<sub>1</sub> (Novel organic liquid nutrient @ 1 %) and F<sub>2</sub> (*Moringa* leaf extract @ 3 %) was given thrice at 15, 30 and 45 DAS. The result revealed that S<sub>1</sub> treatment significantly recorded the seed yield. While for foliar application, the treatment F<sub>2</sub> significantly recorded the highest seed yield and stover yield but remained at par with F<sub>1</sub> treatment. It can be determined that the soil application of 100 per cent RDN through NADEP compost and foliar application of either 3 per cent *Moringa* leaf extract or 1 per cent Novel organic liquid nutrient at 15, 30 and 45 DAS resulted in higher yield and also improved the soil properties as compared to the initial status of soil after harvest of black gram under organic farm.

**Keywords** :: Biofertilizer, Black gram, Ghan-jivamrut, Jivamrut, NADEP compost, Novel organic liquid nutrient, *Moringa* leaf extract, Organic Farming, Soil properties, Yield.

## 1. INTRODUCTION

“Organic farming in recent years is gaining impetus due to realization of inherent advantages it confers in sustaining crop production and also in maintaining dynamic soil nutrient status and safe environment” (Lokanath and Parameshwarappa, 2006). Black gram [*Vigna mungo* (L) Hepper] is one of the most important pulse crops in India, being an excellent source of high nutritious with protein, carbohydrates, minerals and vitamins. It is hardy crop and thrives well in adverse climatic conditions so it can be grown in all the seasons. (Anon., 2014). To overcome the problem of food security this would help a lot as it contains 26 % protein which is two to three times of cereal crops. It has unique importance in Ayurveda (Selvakumar *et al.*, 2012). It can be used for various purpose like seed, green manure purpose as well as act as good fodder. It is mainly consumed in form of dal (Ajila and Rao, 2009). Dal in combination with polished white rice are fermented for preparing South Indian cuisine like dosa, idli, *etc.* and used as non-fermented for preparing papad, baris and cooked dal (Senthil *et al.*, 2006). The use of green revolution technology in need of increased demand of food grain has led to overuse of chemical fertilizers leading to deterioration of soil properties. The solution to the problem is organic farming which mainly deals with the use of more on-farm inputs and excludes the use of chemical fertilizers, insecticides, pesticides, *etc* (Reddy, 2019). Black gram being a legume crop does not require much nitrogen as it has ability to fix atmospheric nitrogen in the soil by the process of biological nitrogen fixation carried out by rhizobia present in root nodules of the plant (Zahran, 1999). Composting is the one of the most effective and beneficial component of organic farming, biological recycling by which waste is converted into organic manure. NADEP compost method. It is a good quality black or brown compost rich in plant nutrients and can easily hold soil moisture (Kumawat *et al.*, 2017). The cow based organic manure like jivamrut, bijamrut, panchgavya are being used as good alternative of chemical fertilizer (Kaur, 2020). Biofertilizers are

microbial preparations containing efficient strains of beneficial microorganisms which are used for accelerating certain microbial processes to augment the availability of nutrients in a form that plants can assimilate readily (Anon., 2016). The use of *Moringa* leaf extract as bio-stimulant for foliar spray which has not gained much of popularity is now being focused by the researchers to make its most possible use as is easily available to farmers and can be prepared easily. *Moringa oleifera* is commonly known as the horseradish or drumstick tree (Bhatti *et al.*, 2007). Its leaves have high nutritional and medicinal values, as they are rich in fiber, protein, carbohydrate, essential amino acids, essential minerals, and vitamins (El Sohaimy *et al.*, 2015). Fresh *Moringa oleifera* leaves have been shown to have zeatin, a cytokinin related hormone (Fuglie, 2000). The zeatin is one form of the most common forms of naturally occurring cytokinin in plants which helps to enhance crop growth and yield (Proseus, 2006). Enriched banana pseudo stem sap is the liquid obtained from banana pseudo-stem while separating fiber the extractant remained. The banana pseudo-stem contained macro elements in the range of 1 - 1.12 per cent N, 0.50 - 0.71 per cent P, 2.39 to 20.2 per cent K and micro-nutrients in the range of 259 to 323.2 mg/kg Fe, 47.3 to 241.3 mg/kg Mn, 10.1 to 107.4 mg/kg Zn and 13.4 to 83.6 mg/kg Cu (Salunke, 2010). The foliar spray of this sap helps to promote crop growth, protect crop from harmful pest and enhances crop yield. A patent product "NOVEL- Liquid Organic Nutrient" has been developed by the Banana Pseudo-stem Processing Unit, Navsari Agricultural University, Navsari, Gujarat. So, use and proper management of organic nutrient for pulse crop is important for creating ecofriendly environment for future generation.

## 2. MATERIALS AND METHODS

The present research work was carried out at Organic Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat during summer season of 2021, which is geographically situated at the coastal region of South Gujarat at 20° 57' N latitude and 72° 54' E longitude with an altitude of 10 m above the mean sea level. The weather conditions during the growing season were normal and favorable for the crop Black gram *cv.* GU 3. The statistical design selected for the experiment was Randomized Block Design with Factorial concept which included two factors *i. e.* soil application and foliar application, each having three levels and replicated three times. The three factors included in soil application were *viz.*, S<sub>1</sub> : 100 % RDN through NADEP compost, S<sub>2</sub> : Ghan-jivamrut @ 500 kg/ha and S<sub>3</sub> : Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha. While the other three factors included in foliar application (F) were *viz.*, F<sub>0</sub> : Control, F<sub>1</sub> : Novel organic liquid nutrient @ 1 % and F<sub>2</sub> : *Moringa* leaf extract @ 3 %. The soil application of organic sources namely NADEP compost and Ghan-jivamrut was given prior to sowing and single application of jivamrut was done at the time of first irrigation as per the treatments. The foliar applications of liquid organic nutrients was applied at 15, 30 and 45 DAS as per the treatment. Before sowing the seed were inoculated with *Rhizobium* and PS Beach @ 10 ml/kg seed.

The representative soil samples of experimental field were drawn from 0-15 cm prior to the application of various treatments as well as after the harvest of the crop for the determination of initial physico-chemical properties of the soil of experimental site. The information regarding the initial physico-chemical properties of the experimental site and the method used for the analysis has been furnished in the Table 1.

**Table 1: Method of analysis of the soil properties**

Sr. No.	Particulars	Soil depth (0-15 cm)	Method of analysis	Reference
<b>A) Physical Properties of soil</b>				
1.	Sand (%)	18.50	International Pipette Method	Piper, 1966
2.	Slit (%)	25.00		
3.	Clay (%)	56.50		
4.	Textured Class	Clayey		
<b>B) Chemical Properties of soil</b>				
1.	pH <sub>(1:2.5)</sub>	7.40	Potentiometric	Jackson, 1973
2.	EC <sub>(1:2.5)</sub> (dS/m)	0.32	EC meter	Jackson, 1973
3.	Organic Carbon (%)	0.81	Walkley and Black Method	Jackson, 1973
4.	Available N (kg/ha)	258.7	Alkaline KMnO <sub>4</sub> Method	Subbiah and Asija, 1956
5.	Available P <sub>2</sub> O <sub>5</sub> (kg/ha)	56.80	Olsen's Method Extraction with 0.5 M NaHCO <sub>3</sub> (pH 8.5) and Spectrophotometric determination	Olsen <i>et al.</i> , 1954
6.	Available K <sub>2</sub> O (kg/ha)	497.52	Flame Photometric Method Extraction with Neutral Normal Ammonium acetate and Flame photometric determination	Jackson, 1973

### 3. RESULTS AND DISCUSSION

#### 3.1 Productivity

##### 3.1.1 Seed yield

The results showed that the application of 100 per cent RDN through NADEP compost significantly recorded the highest seed yield *i. e.* 1041 kg/ha. While the S<sub>2</sub> treatment where 500 kg/ha Ghan-jivamrut was applied recorded the lowest yield of 836 kg/ha. The foliar spray of 3 per cent *Moringa* leaf extract (F<sub>2</sub> treatment) resulted in significantly higher seed yield (1051 kg/ha) and was statistically similar with foliar spray of 1 per cent Novel organic liquid nutrient (F<sub>1</sub> treatment) which recorded 937 kg/ha seed yield. While the F<sub>0</sub> treatment as control where no foliar application was given recorded the lowest seed yield *i. e.* 805 kg/ha (Table 2). An examination of seed yield data revealed that soil application of organic nutrient sources and foliar spray of liquid organic sources greatly influenced seed production, as much variation was detected and had a favorable impact on it. 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 *Moringa* leaf extract 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 to interaction effect. The previous experiment results noted by Chaudhari (2013) in green gram and Rathva

(2013) in pigeon pea, Abohassan and Abusuwar (2017) in green gram, Gunasekar *et al.* (2018), Nivethadeviet *al.* (2021) in black gram and Irshad *et al.* (2022) in chickpea were found to be closely related with the findings of present research work.

### 3.1.2 Stover yield

Based on the results, it was concluded that the stover yield was significantly influenced by the soil application and foliar application of the organic nutrient sources (Table 2). The S<sub>1</sub> (100 % RDN through NADEP compost) treatment recorded significantly higher stover yield of 2696 kg/ha and it remained at par with S<sub>3</sub> (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 per cent *viz.*, F<sub>2</sub> treatment recorded significantly higher stover yield of 2725 kg/ha but was statistically similar with F<sub>1</sub> treatment where, Novel organic liquid nutrient @ 1 per cent was sprayed and it recorded 2446 kg/ha stover yield. The F<sub>0</sub> treatment, control where no spray was given recorded the lowest 2228 kg/ha stover yield. 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) in green gram and Rathva (2013) in pigeon pea, Gunasekar *et al.* (2018) in black gram, Nivethadeviet *al.* (2021) in black gram and Irshad *et al.* (2022) in chickpea.

### 3.1.3 Harvest index

The results showed that the harvest index did not significantly differ due to the influence of soil application and foliar application of the various organic nutrient sources. Numerically, the S<sub>1</sub> treatment recorded the highest harvest index followed by S<sub>2</sub> and S<sub>3</sub> treatment *i. e.* 28.24 %, 27.82 % and 26.49 %, respectively. While in foliar application, the F<sub>1</sub> treatment (Novel organic liquid nutrient @ 1 %) recorded numerically the highest harvest index of 27.98 per cent in comparison to F<sub>2</sub> treatment and F<sub>0</sub> treatment which recorded 27.83 per cent and 26.75 per cent harvest index, respectively (Table 2). The harvest index was not substantially inferred due to the interaction between soil and foliar application of the various organic nutrient sources, and the result was statistically insignificant.

### 3.2 Soil Properties

The soil samples were collected from the experimental field before sowing of the black gram and then the soil properties were analyzed in the laboratory which have been depicted in Table 1. It was observed that the organic carbon content in soil was 0.81 per cent at initial period which indicates medium range of OC content. The available nitrogen was 258.6 kg/ha, available phosphorus was 56.80 kg/ha and the available potassium was 497.52 kg/ha in the soil before the experiment. It can be said that the soil was in medium nitrogen and phosphorus in medium range while the available potassium was high

The organic carbon content was numerically higher in S<sub>1</sub> (100 % RDN through NADEP compost) treatment 0.82 per cent followed by S<sub>3</sub> *i. e.* Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha treatment with 0.80 per cent and then S<sub>2</sub> *i. e.* Ghan-jivamrut @ 500 kg/ha treatment with 0.79 per cent (Fig.1). The foliar application of the organic sources failed to influence the organic carbon content in the soil and the obtained result was statistically non-significant. Numerically the highest organic carbon content was recorded for the F<sub>1</sub> *i. e.* Novel organic liquid nutrient @ 1 % treatment *i. e.* 0.81 per cent. However, both the F<sub>0</sub> and F<sub>2</sub> treatment recorded similar 0.80 per cent organic carbon content. The interaction effect of soil and foliar application of various organic nutrient sources showed non-significant result for the organic carbon content in soil after harvest.

The statistically non-significant result was obtained for the available nitrogen assessed after the harvest of black gram. It was noted that S<sub>1</sub> treatment recorded numerically the highest available nitrogen of 267.26 kg/ha while the S<sub>2</sub> treatment recorded the lowest available nitrogen 259.97 kg/ha. Looking at the analyzed data, the available nitrogen in soil did not show any variation due to foliar application of the liquid nutrient sources. Numerically the highest available nitrogen 266.29 kg/ha was noted for the F<sub>2</sub>(*Moringa* leaf extract @ 3%) treatment followed by 264.21 kg/ha for the F<sub>1</sub>(Novel organic liquid nutrient @ 1 %) treatment (Fig. 1). The available nitrogen in the soil after harvest did not significantly differ due to the influence of interaction effect between the soil and foliar application of various nutrient sources.

The perusal data of available phosphorus indicated that available P<sub>2</sub>O<sub>5</sub> was not significantly influenced by the soil application of organic nutrient sources. But numerically the highest available phosphorus was observed in S<sub>1</sub> treatment *i. e.* 60.20 kg/ha however, the S<sub>2</sub> treatment noted the least available phosphorus of 57.25 kg/ha. The explicit data of the regarding the influence of the foliar spray of liquid organic sources gave non-significant result for the available phosphorus. The F<sub>1</sub>(Novel organic liquid nutrient @ 1 %) treatment numerically recorded the highest 60.16 kg/ha available phosphorus while the F<sub>2</sub>(*Moringa* leaf extract @ 3%) treatment recorded the lowest 57.50 kg/ha available phosphorus (Fig. 1). The interaction between soil and foliar application of various sources showed non-significant result for the available phosphorus in soil after harvest of black gram.

On examination of the available potassium, it was noticed that no variation was observed in it as the soil application of various organic sources failed to influence the available potassium in soil. The numerically available potassium in soil after harvest of black gram was noted the highest 504.48 kg/ha for the S<sub>1</sub>(100 % RDN through NADEP compost) treatment. In comparison to application of Ghan-jivamrut @ 500 kg/ha (491.62 kg/ha) the combined application of Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha (498.65 kg/ha) recorded higher available potassium after harvest of black gram. The mean data obtained for the available potassium in soil concluded that the foliar application of the liquid organic sources failed to influence it and result obtained was statistically non-significant. Numerically the available potassium obtained was higher for F<sub>2</sub> treatment (514.93 kg/ha) followed by F<sub>1</sub> treatment (490.41 kg/ha) and the F<sub>0</sub> treatment (489.41 kg/ha) (Fig. 1). The perusal data of the available potassium in soil after harvest of black gram indicated non-significant result due to interaction between the soil and foliar application of the organic nutrient sources.

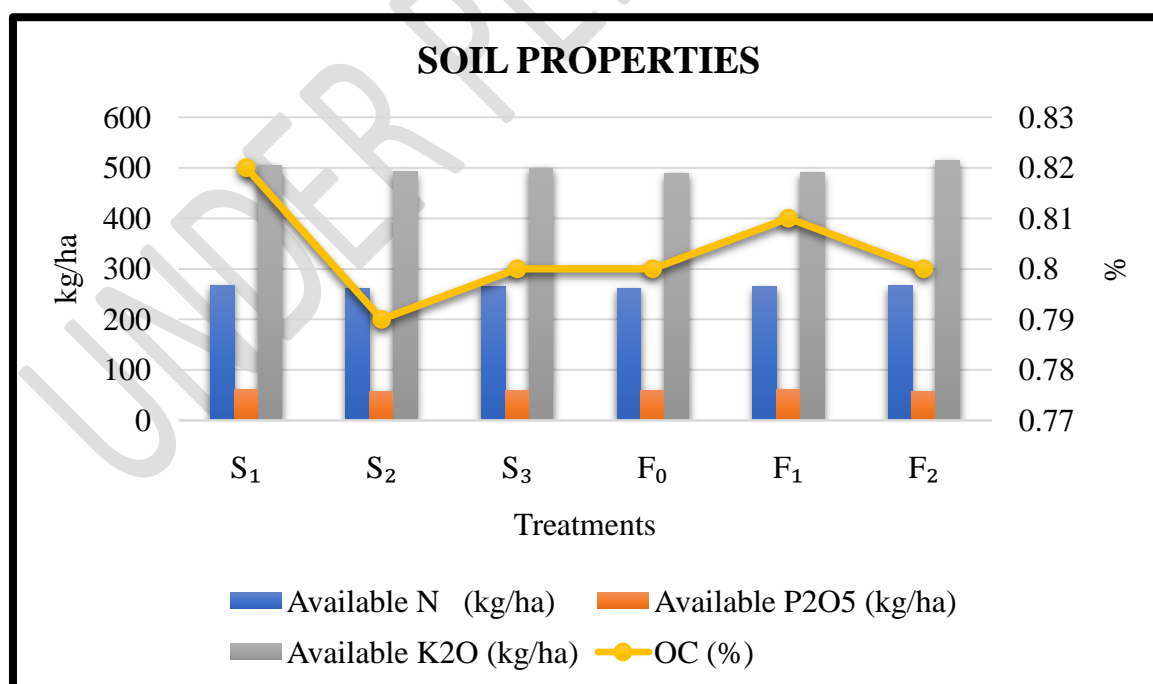
As the experiment was carried out certified organic farm the soil is already rich in organic carbon content and the black gram being pulse crop its duration is only of three months so it can not have drastic change in the soil properties. The results of present study are in conformity with the previously reported findings of Chaudhari (2013) in green gram, Gundrashiya (2013) in cowpea, Bag *et al.* (2015) in cowpea and Akhila *et al.* (2017) in green gram.

#### 4. CONCLUSION

From the results of the above study, it can be arrived at a conclusion that the soil application of 100 per cent RDN through NADEP compost and foliar application of either 3 per cent *Moringa* leaf extract or 1 per cent Novel organic liquid nutrient at 15, 30 and 45 days after sowing should be adopted to achieve higher yield and acquire improvements in soil properties for black gram under organic farming.

**Table 2 : Effect of different organic nutrient source on yield of Black gram cv. GU 3**

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
<b>Factor I : Soil application (S)</b>			
S <sub>1</sub> - 100 % RDN through NADEP compost	1041	2696	28.24
S <sub>2</sub> - Ghan-jivamrut @ 500 kg/ha	836	2166	27.82
S <sub>3</sub> - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	917	2536	26.49
SEm ±	40	123	1.17
CD at 5 %	120	379	NS
<b>Factor II : Foliar application (F)</b>			
F <sub>0</sub> - Control	805	2228	26.75
F <sub>1</sub> - Novel organic liquid nutrient @ 1 %	937	2446	27.98
F <sub>2</sub> - Moringaleaf extract @ 3%	1051	2725	27.83
SEm ±	40	126	1.17
CD at 5 %	120	379	NS
<b>Interaction</b>			
S×F	NS	NS	NS
CV %	12.89	15.36	12.74



**Figure 1: Effect of different treatments on soil properties after harvest of Black gram**

## REFERENCE

- Abohassan, R. A. and Abusuwar, A. O. (2018). Effects of *Moringa oleifera* leaf extracts on growth and productivity of three leguminous crops. *Legum. Res.Int. J.*, **41** (1): 114-119.
- Ajila, C. M. and Rao, U. P. (2009). Purification and characterization of black gram (*Vigna mungo*) husk peroxidase. *J. Mol. Catal. B: Enzymatic*, **60** (1-2): 36-44.
- Ajila, C. M. and Rao, U. P. (2009). Purification and characterization of black gram (*Vigna mungo*) husk peroxidase. *J. Mol. Catal. B: Enzymatic*, **60** (1-2): 36-44.
- Akhila, K.; Kaswala, A. R.; Priyanka and Dubey P. K. (2017). Effect of liquid fertilizers on nutrient uptake and soil properties of the green gram (*Vigna radiata*) crop under organic farming. *J. Pharm. Innov.*, **6** (11): 224-228.
- Anonymous (2014). Organic Black gram farming – Production in India. Retrieved from <https://www.agrifarming.in/organic-black-gram-farming-production-in-india>.
- Anonymous(2016). TNAU AGRITECH PORTAL. Retrieved from [agritech.tnau.ac.in](http://agritech.tnau.ac.in)
- Bag, P. A.; Kaswala, A. R. and Patel, A. I. (2015). Effect of liquid organic manures on yield and soil properties in chickpea (*Cicer arietinum* L.). *Trends Biosci.*, **8** (3): 695-698.
- Bhatti, H. N.; Mumtaz, B.; Hanif, M. A. and Nadeem, R. (2007). Removal of Zn (II) ions from aqueous solution using *Moringa oleifera* Lam. (Horseradish tree) biomass. *Process Biochem.*, **42** (4): 547-553.
- Chaudhari, N. N. (2013). 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. pp 57-75.
- El Sohaimy, S. A.; Hamad, G. M.; Mohamed, S. E.; Amar, M. H. and Al-Hindi, R. R. (2015). Biochemical and functional properties of *Moringa oleifera* leaves and their potential as a functional food. *Glob. Adv. Res. J. Agric. Sci.*, **4** (4): 188-199.
- Fuglie, L. J. (2000). New uses of *Moringa* studied in Nicaragua. *ECHO Development Notes*, **68**: 1-25.
- Gunasekar, J.; Reddy, K. S.; Sindhu, G. P.; Anand, S.; Kalaiyarasi, G.; Anbarasu, M. and Dharmaraj, K. (2018). 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.*, **7** (2): 3205-3214.
- Gundrashiya, R. R. (2013). Effect of spraying of banana pseudo-stem based enriched sap at different concentration on growth and yield of different crops. *Thesis M.Sc. (Agri.)*, N. M. College of Agriculture, N.A.U., Navsari, India. pp. 48-92.
- Irshad, S.; Matloob, A.; Iqbal, S.; Ibrar, D.; Hasnain, Z.; Khan, S.; Rashid, N.; Nawaz, M.; Rao, M. I.; Wahid, M. A.; Al-Hashimi, A.; Elshikh, M. and Diao, Z. H. (2022). Foliar application of potassium and *Moringa* leaf extract improves growth, physiology and productivity of kabuli chickpea grown under varying sowing regimes. *Plos one*, **17** (2): 1-19.
- Jackson, M. L. (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi. pp. 183-192.

- Kaur, A. (2020). JIVAMRUTHAM: An effective activator of soil microorganisms. *Just Agriculture multidisciplinary e-Newsletter*, **1** (1): 1-5.
- Khatkar, R.; Abraham, T. and Joseph, S. A. (2007). Effect of biofertilizers and sulphur levels on growth and yield of black gram (*Vigna mungo* L.). *Legum. Res. Int. J.*, **30** (3): 233-234.
- Kumawat, N.; Tomar, I. S.; Kumar, R. and Sahu, Y. K. (2017). Preparation of NADEP compost for sustaining farming community. *Popular Kheti*, **5** (4): 56-60.
- Lokanath, H.M. and Parameshwarappa, K.G. (2006). Effect of organics on the productivity of Spanish bunch groundnut under rainfed farming situations. In: *Proceedings of 18th World Congress of Soil Science*. Philadelphia, Pennsylvania, USA, pp. 62-63.
- Nivethadevi, P.; Swaminathan, C.; Kannan, P. and Tamilselvi, E. (2021). 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.*, 1-5.
- Olsen, S. R.; Cole, C. W.; Wathade, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soil by extraction with NaHCO<sub>3</sub>. USDA Cir. No.959, Washington, 13 p.
- Piper, C. S. (1966). Soil and plant analysis, *Academic Press*, New York.
- Proseus, P. (2006). Biosynthesis-plant hormones and growth regulators: Chemistry and biology. Biosynth Ag. Co., Switzerland. Retrieved from [http://www.biosynth.com/index.asp?topic\\_id](http://www.biosynth.com/index.asp?topic_id).
- Rathva, K. S. (2013). 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.
- Reddy, S. R. (2019). "*Principles of Agronomy*", ANGR Agricultural University, S. V. Agricultural College, Tirupati, Andhra Pradesh, India. pp. 692-693.
- Reddy, S. R. (2019). "*Principles of Agronomy*", ANGR Agricultural University, S. V. Agricultural College, Tirupati, Andhra Pradesh, India. pp. 692-693.
- Salunke, J. R. (2010). 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.
- Selvakumar, G.; Reetha, S. and Thamizhiniyan, P. (2012). Response of biofertilizers on growth, yield attributes and associated protein profiling changes of black gram (*Vigna mungo* L. Hepper). *World appl. Sci. J.*, **16** (10): 1368-1374.
- Senthil, A.; Ravi, R. and Vasanth, A. K. (2006). Quality characteristics of black gram papad. *Int. J. Food Sci. Nutri.*, **57**: 29-37.
- Senthil, A.; Ravi, R. and Vasanth, A. K. (2006). Quality characteristics of black gram papad. *Int. J. Food Sci. Nutri.*, **57**: 29-37.
- Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soil. *Curr. Sci.*, **25**: 259-260.
- Zahran, H. H. (1999). *Rhizobium*-Legume symbiosis and nitrogen fixation under severe conditions and in an arid climate. *American Soc. Microbiol.*, **63** (4): 968-989.

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