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Effect of Organic Foliar Nutrition on Performance and Production Potential of Mungbean [*Vigna radiata* L.]

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ABSTRACT

Background: Foliar spray of nutrients offers a best way to accelerate crop growth and boost up productivity of mungbean under irrigated conditions to meet out the demand raised by ever increasing population of our country. The study was framed to investigate physiochemical and biological properties of fermented fish waste extract (FFWE) and its effects on productivity performance in mungbean.

Methods: The organic liquid FFWE was characterized for its physiochemical and biological properties in the laboratory. Field experiments were conducted during *Kharif* 2019 and 2020 in mungbean to study the effect of FFWE as foliar spray on growth, yield, quality and economics. Treatments consisted of foliar spray of different concentrations of FFWE (0.5, 1.0, 1.5 and 2.0 %) compared with 1% urea and control. The treatments were replicated four times in a randomized block design.

Result: Laboratory analysis showed that fermented fish waste extract contains considerable amount of essential nutrients namely nitrogen (1.87%), phosphorus (0.49%), potassium (0.93%), calcium (0.54%), magnesium (0.26%), sulphur (0.04%), copper (3.1 ppm), zinc (38.2 ppm), manganese (4.8 ppm) and iron (118 ppm). The microbial population *viz*., total bacteria, fungi and actinomycetes in FFWE were found to be 196±1.8, 11±0.06 and 203±0.87 (CFU/mL), respectively. Field experiments revealed that 2.0% FFWE foliar spray at flowering stage and 15 days after first spray in mungbean found to improve the plant height, (40.8 cm) dry matter production (1770 kg/ha), leaf chlorophyll (SPAD value 40.0), number of pods per plant (28.3), seeds per pod (9.9), grain yield (665 kg/ha) and grain protein (23.4%). Economics of foliar nutrition showed that foliar spray of 2.0% FFWE gave higher net return of Rs. 24057/- per ha and benefit cost ratio of 2.30. Thus, it could be concluded that foliar spray of 2.0% fermented fish waste extract could be considered as an excellent source of organic liquid manure for enhancing the productivity of mungbean.

Key words: Economics, Fermented fish waste extract, Foliar spray, Mungbean, Yield.

INTRODUCTION

Mungbean (*Vigna radiata* L.) is the third most important and significant short-term pulse crop in India. It enriches soil by fixing nitrogen from the atmosphere through root nodules. In India, total production of mungbean was 24.6 lakh tonnes from 47.6 lakh ha area at a productivity of 516 kg ha^{-1} during 2018-19 (Anonymous, 2018-19). Production of mungbean in India is insufficient to meet the ever increasing domestic demand. The potential yield of mungbean is low due to inadequate management practices (Dixit and Elamathi, 2008). Abscission of flowers, low partitioning efficiency and shedding of pods were the main reasons for low productivity of mungbean (Kunjammal and Sukumar, 2019). Foliar spray of nutrients offers a best way to accelerate crop growth and boost up productivity of mungbean under irrigated conditions to meet out the demand raised by ever increasing population of our country. It is being a short duration crop responds well to foliar application of nutrients. Foliar application is the method of applying fertilizer/ nutrients on foliage of the plants for better nutrient absorption. It is a supplemental form of nutrient that plays a vital role in elevating seed yield of pulses (Chandrasekhar and Bangarusamy, 2003). It is found to be beneficial when soil applied fertilizer cannot be completely available to the crop (Ganapathy *et al*., 2008). Improved pod formation and seed setting percentage were obtained in foliar application of nutrients by reducing flower drop. Foliar application of nutrients increases the fertiliser use efficiency, thus increasing yield and reducing cost of production in pulses (Mir *et al*., 2010).

Different nutrients are being applied as foliar supply to increase the yield of irrigated mungbean. Foliar spray of 2% DAP at flowering stage and 15 days after first spray increased the yield through improving physiological and biochemical attributes of mungbean. Organic farming is gaining popularity in year by year (Dangour *et al*., 2010) and it is essential to find out organic source of nutrients for mungbean production. In this context, fish waste available in the fish market has to be converted as source of nutrient

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by fermentation process. Fermented fish waste extract (FFWE) is prepared by mixing equal amount of fish waste and jaggery (1 kg of each fish waste and jaggery) and kept in an air tight plastic jar/bottle. After 10 days, the liquid portion was filtered and used for spraying (Maghirang, 2011). It is of great value to both plants and microorganisms in their growth, because it contains various nutrients and types of amino acids (Balraj and Geetha, 2019). Foliar application of fish emulsions promoted seedling growth of tomato ((Murray and Anderson, 2004) and increased the microbial action in the soil (El-Tarabily *et al*., 2003). Recently, organic farmers are using this fermented fish waste extract as a source of plant nutrients in many crops. However, scientific evidence on this organic manure particularly its constituents and its effect on crop growth and yields of crops are not available. Hence, the present investigation has been undertaken to evaluate the fermented fish waste extract scientifically on its chemical and biological properties and effect on the growth, yield, quality and economics of mungbean.

MATERIALS AND METHODS

Preparation of fermented fish waste extract and characterization

Fish waste was collected from the local fish market, Tiruchirappalli, Tamil Nadu, India. Equal amount of fish waste and jaggery were taken (1 kg of each fish waste and jaggery). The fermentation process was carried out in a broad mouthed glass jar. The materials were mixed well and stored in a cool dry place. This preparation was kept in the shade for a period of 15 days in order to facilitate the fermentation process. After 15 days, the liquid portion was filtered and used for spraying (Maghirang, 2011) (Fig 1). Then it was filtered and used in biochemical and spectrometry analysis. Sensory evaluation was done to assess the mold growth, presence of maggots in the extract. In addition, odour and colour were visually observed and noted. Quantitative analysis for total solids, pH, EC of fish waste extract was done in triplicates. All the macro and secondary nutrients were analysed by following the standard procedures (Singh *et al*., 1999). Triple acid extract method was adopted to analyze micronutrients (Zn, Fe, Cu, Mn) using ICP-OES Model: 6500 series (Inductively Coupled Plasma Optical Emission Spectrometry). Microbial population present in the fermented fish waste extract at 15 days after preparation (DAP) was determined by serial dilution plate count method. Samples from fish waste extract were taken at 1 ml of liquid sample mixed in 9 ml sterilized water blank to give 10^{-1} dilutions. Subsequent dilutions up to 10^{-5} were made by transferring serially 1 ml of each dilution to 9 ml sterilized water blanks. The population of bacteria, fungi and actinomycetes were estimated by serial dilution and plate count technique by plating on appropriate media *viz*., nutrient agar, rosebengal media and kenknights agar media, respectively. The inoculated plates were kept for incubation at 30°C ± 1°C and emerged colonies were counted. The incubation time was varied based on the microorganisms. Microbial population was expressed as colony forming units (CFU) ml^{-1} of liquid sample (Jensen, 1968). Microbial load (bacteria, fungi and actinomycetes) was assessed by following the standard serial dilution and plating technique (Subba Rao, 1993).

Field experimental details

Field experiments were conducted during *Kharif*, 2019 and 2020 at Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli 620 027, Tamil Nadu, India to study the effect of fermented fish waste extract on the production potential of mungbean. The experimental soil was alkaline in nature (pH-9.1), sandy clay loam in texture, moderately drained and classified as *Vetric Ustropept*. Soil was low in available nitrogen (113 kg/ha), medium in available phosphorus (14 kg/ha) and high in available potassium (288 kg/ha). Field experiments were laid out in randomized block design with four replications. Treatments consisted of different concentration of fermented fish waste extract (0.5, 1.0, 1.5 and 2.0%) compared with 1% urea and control. Fermented fish waste extract was sprayed twice at the time of flowering and 15 days after first spray in mungbean. Sodic soil tolerant mungbean variety VBN 2 was used. Observations on growth parameters like plant height, dry matter production were recorded at harvest stage. Leaf chlorophyll content was assessed using chlorophyll meter (SPAD meter) in the fully opened leaf. Yield attributes were recorded by selecting 10 plants in each plot and yield was estimated based on produce harvested from net plot for each treatment and expressed at 14% moisture, whereas the grain yield (kg/ha) was reported as grain weight from the net plot. Harvest index was calculated by following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Protein content in grain was analysed as per the procedure given by Lowry *et al*. (1951) and expressed in percentage. Economics of various treatments were worked out by using prevailing input cost and market price of grain.

Statistical analysis

Statistical analysis of recorded data was carried out using computer package 'IRRISTAT' applying the analysis of variance technique (Gomez and Gomez, 1984). The critical difference (5% level of probability) was computed for comparing treatment means in cases where effect came out to be significant by F-test.

RESULTS AND DISCUSSION

Physical characters/sensory evaluation of fermented fish waste extract

The sensory evaluation was done to assess the colour, odour, texture, mold growth and maggot pollution of fermented fish waste extract (FFWE) and is presented in Table 1. The freshly prepared FFWE was in orange colour with brown tinge and it started to change against time. It attained dark colour from the first week of preparation onwards. There was no mold growth in fresh preparation of fish amino acid, whereas it was first observed 10 DAP. White mat was observed on the surface of the formulation. Once the fermentation process was over (after 15 days) a light mold growth was observed might be due to the low availability of food to the fungi from decayed tissue (Schwarz *et al*., 2015). It was initially possessed foul characteristic smell. Gases like hydrogen sulfide, carbon dioxide, methane might have released that caused the foul smell during fermentation process (Carter *et al*., 2008). After the fermentation process was over, the odour became pleasant and smelled like honey. This might be due to the complete decomposition of the fish tissues. The sense of touch delivers the nature of texture which is decided by the inner makeup of the product. In this study, the texture of the fermented fish waste extract showed honey like thick syrup.

Table 1: Physiochemical properties of fermented fish waste extract.

Parameters	Value
Colour	Dark brown
Odour	Pleasant odour
Mold growth	White mat on surface
Maggot population	Maggot found
Texture	Honey like
pH	3.2±0.07
EC (dSm^{-1})	4.91±0.06
Organci carbon (%)	3.56±0.09
TDS (ppm)	7.23±0.06
Nitrogen (%)	1.87±0.004
Phosphours (%)	0.49±0.01
Potassium (%)	0.93±0.02
Calcium (%)	0.54±0.01
Magnesium (%)	0.26±0.01
Sulphur (%)	0.04±0.00
Copper (ppm)	3.1±0.06
Zinc (ppm)	38.2±0.26
Manganese (ppm)	4.8±0.06
Iron (ppm)	118±0.18
Bacteria (10^6 CFU ml^{-1})	226±0.82
Fungi (10^4 CFU ml^{-1})	10±0.21
Actinobacteria (10^2 CFU ml^{-1})	198±1.65

Data are expressed as mean±SEM (n=3).

Physiochemical and biological properties of fermented fish waste extract

The physiochemical properties of fermented fish waste extract is given in Table 1. The pH of fermented fish waste extract was 3.2±0.21. This is mainly due to microbial activity of fermentation that causes acidity after preparation (Chakraborty *et al*., 2019). The electrical conductivity of fermented fish waste extract was 4.91±0.19 dSm^{-1}. Dissolved concentration for the studied formulation was 7.23±0.13 ppm. The organic carbon content was 3.56±0.09 %. This might be due to the synthesis of several organic compounds during the decomposition process through physical breakdown and biochemical transformation of complex organic molecules resulted in increased organic carbon (Chakraborty *et al*., 2019).

Besides these, fermented fish waste extract contained a substantial amount of macro nutrients like N, P, K, Ca, Mg, S and micro nutrients (Zn, Fe, Mn, Cu) which can be effectively utilized by the crops (Table 2). Fermented fish waste extract contained 1.87% nitrogen, 0.49% phosphorus, 0.93% potassium, 0.54% calcium, 0.26% magnesium, 0.04% sulphur, 3.1 ppm copper, 38.2 ppm zinc, 4.8 ppm manganese and 118 ppm iron. The reason behind the effectiveness of fermented fish waste extract is that the ingredients of fermented fish waste extract have been fermented, which means that the proteins, fats, carbohydrates etc. are broken into simple low molecular weight products. Therefore, nutrients from fermented fish waste extract become available to the plants faster than from the traditionally applied organic matter (Neff *et al*., 2003).

The microbial populations of total bacteria, fungi and actinomycets in FFWE of 196±1.8, 11±0.06 and 203±0.87 (CFU/mL), respectively were found (Table 1). Jaggery acted as a food source for enhancing the microbial population for the degradation of fish tissue.

Performance of mungbean

Growth parameters

Foliar application of 2.0% FFWE twice at reproductive stage produced significantly taller plants (40.8 cm) and dry matter production (1770 kg/ha) in mungbean (Table 2). However, it was comparable with 1.5% FFWE and 1.0% urea spray.

Table 2: Effect of foliar spray of fermented fish waste extracts on growth parameters, leaf chlorophyll and yield attributes of mungbean (mean value of two seasons).

Treatments	Plant height (cm)	DMP (kg/ha)	Leaf chlorophyll (SPAD value)	Number of pods/plant	Number of seeds/pod	Test weight (g)
T_1- 0.5% Fermented fish waste extract	38.4	1533	36.8	21.2	8.3	4.33
T_2- 1.0% Fermented fish waste extract	39.7	1609	38.3	23.0	8.7	4.40
T_3- 1.5% Fermented fish waste extract	40.7	1719	39.5	27.4	9.7	4.56
T_4- 2.0% Fermented fish waste extract	40.8	1770	40.0	28.3	9.9	4.58
T_5- 1% Urea	39.5	1752	38.3	27.7	9.8	4.49
T_6- Control	35.6	1424	35.8	20.1	8.2	4.27
S.Em ±	1.1	63	0.8	0.8	0.2	0.12
CD (P=0.05)	2.3	133	1.8	1.7	0.5	0.24

This might be due to higher availability of nutrients from foliar spray of FFWE increased the cell division and metabolic activity resulting in higher plant height. Spraying of organic preparation like panchakavya increased the plant height in phyllanthus mainly due to the growth enzymes present in panchakavya which favoured rapid cell division and multiplication (Sanjutha *et al*., 2008). Increment in dry matter production under foliar spray of fermented fish waste extract was mainly because of foliar spray of fish amino acid during critical growth stages would have continuously supplied more nitrogen which increased the photosynthetic activity, higher LAI and better light interception and in turn more dry matter production. The control plot produced shorter plants than other treatments in both the years.

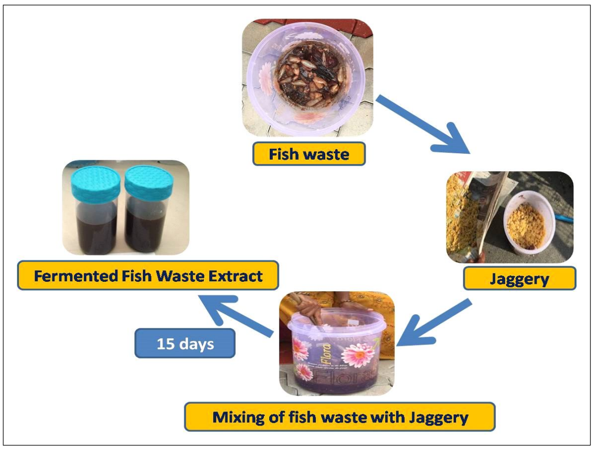

Fig 1: Preparation of fermented fish waste.

Leaf chlorophyll

Chlorophyll content of leaves was measured using SPAD meter and showed that foliar spray of 2.0% FFWE recorded higher values (40.0) at flowering stage of mungbean than other treatments. Lower values of chlorophyll content were noticed with 0.5% FFWE as well as in control. The relative increase in chlorophyll content was due to supply of higher nutrients especially nitrogen and micronutrients to the growing tissues by foliar spray of FFWE which led to the synthesis of leaf chlorophyll. Similarly, higher chlorophyll content in the leaves of tomato might be due to the presence of growth regulatory substances and essential plant nutrients in the egg lime mix with panchakavya spray (Perumal *et al*., 2006).

Yield parameters

Significantly more number of pods per plant (28.3) and seeds per pod (9.9) in mungbean were registered with foliar spray of 2.0% FFWE over 0.5% FFWE and control (Fig 2). It was on par 1.0% urea spray (Table 2). This is mainly because of increased nutrient supply by foliar spray of FFWE during critical physiological phases would have supported better assimilation of photosynthates and in turn higher number of pods per plant. More number of filled grains per pod was mainly due to nutrient supply through foliar spray led to better nutrient uptake, more photosynthetic activity improved source-sink relation thus resulted in production of more number of pods per plant. Similarly, foliar spray of fish amino acid and other fermented organic foliar fertilizer produced more florets compared to control in orchids (Maghirang, 2011).

Fig 2: Spraying of 2.0% FFWE and more number pods in mungbean.

Table 3: Effect of foliar spray of fermented fish waste extracts on grain yield, harvest index and economics of mungbean (mean value of two seasons).

Treatments	Grain yield (kg/ha)	Harvest index	Grain protein (%)	Gross return (Rs./ha)	Net return (Rs./ha)	Benefit cost ratio
T_1- 0.5% Fermented fish waste extract	527	0.34	22.5	33788	16454	1.95
T_2- 1.0% Fermented fish waste extract	571	0.35	22.7	36593	18887	2.06
T_3- 1.5% Fermented fish waste extract	633	0.37	23.1	40634	22556	2.24
T_4- 2.0% Fermented fish waste extract	665	0.38	23.4	42507	24057	2.30
T_5- 1% Urea	640	0.37	22.8	41020	23400	2.32
T_6- Control	489	0.34	21.3	31328	14828	1.89
S.Em ±	24	0.01	0.5		Data not statistically analysed	
CD (P=0.05)	51	0.02	1.2			

Grain yield

Foliar spray of 2.0% FFWE at flowering stage and 15 days after first spray recorded significantly higher grain yield (665 kg/ha) of mungbean than 0.5% FFWE and control (Table 3). However, it was comparable with 1.0% urea spray (640 kg/ha). Quick absorption and assimilation of more macro and micro nutrients present in the FFWE during foliar spray at critical stages of mungbean would have improved the metabolic activity, cell division and photosynthetic activity which resulted in higher plant height, more number of leaves, more chlorophyll content and finally higher yield attributes and grain yield. Similarly, foliar spray of fish emulsion increased the yield of tomato and peppers (Abbasi *et al*., 2003), rice (Priyanka *et al*., 2019) and amarathus (Ramesh *et al*., 2020). Foliar spray of 0.5% FFWE and control recorded lower grain yield of 527 and 489 kg/ha, respectively. Significantly higher harvest index of 0.38 was noticed with foliar spray of 2.0% FFWE than 0.5% FFWE and control. However, it was comparable with 1.5% FFWE and 1.0% urea spray.

Grain protein

Significantly higher grain protein content (23.4%) was obtained with foliar spray of 2.0% FFWE over control. However, it was on par with all other nutrients spray. The reason might be due to increased availability of nutrient at critical stages of crop growth through foliar application of nutrients using FFWE resulted in higher protein content in grains.

Economics

Economics of foliar nutrition revealed that foliar application of 2.0% FFWE gave higher gross return and net return and benefit cost ratio of Rs. 42507/- and 24057/- per ha and 2.30 in mungbean, respectively (Table 3). These might be due to the fact that minimum cost involved in preparation of fermented fish waste extract and foliar spray as well as higher grain yield obtained under this treatment. Similarly, foliar spray of organic input panchagavya gave higher net return and B: C ratio in rice (Yadav and Lourduraj, 2006). The least net return (Rs 14828.00 per ha) and BCR (1.89) were noticed under control condition followed by 0.5% FFWE spray (Rs 16454/- per ha and 1.95, respectively).

CONCLUSION

The present study confirms that fish waste could be effectively used as nutrient-rich organic liquid manure in mungbean production. The fermented fish waste extract was having pleasant odour and smelled like honey. It was found to contain considerable amount of important plant nutrients like nitrogen, potassium, phosphorus, calcium and magnesium. Field experiments on mungbean confirmed that foliar spray of 2.0% fermented fish waste extract increased the growth, yield parameters and grain yield of mungbean. Further, economic analysis also confirmed that higher net return and benefit cost ratio obtained when using fermented fish waste extract as foliar nutrient in mungbean. Thus, recycling and reusing of fish waste into a value-added product as source of liquid organic nutrient in mungbean as foliar spray at 2.0% concentration at critical stages of crop growth.

Conflict of interest: None.

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