UTILIZATION OF LAC FACTORY WASTE FOR INTEGRATED NUTRIENT MANAGEMENT IN BRINJAL AND ITS EFFECT ON SOIL FERTILITY

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Abstract

A field experiment was conducted at ICAR-Indian Institute of Natural Resins and Gums, Jharkhand for three consecutive years during 2013-15 to evaluate the effectiveness of lac mud on productivity of brinjal and its effect on soil fertility status. Lac mud obtained from factory was grinded in fine particles and treated with lime (@ 25 g per kg of lac mud, followed by enriching with each of N, P and K (@ 0.5per cent on weight basis, and Azotobacter and PSB each @ 25 g/kg of lac mud. This enriched lac mud or vermicompost was applied, considering the nitrogen, phosphorus and potassium recommendation in the crop and percent N, P and K substitution by lac mud or vermicompost as per treatment at the time of planting in the root zone. Experimental result revealed that application of 1/4th of recommended nitrogen through decomposed enriched lac mud, 1/4th through vermicompost and ½ through fertilizer resulted in significantly higher fruit yield, average fruit weight and number of fruits per plant of brinjal. Fruit yield, fruit weight and number of fruits per plant in this treatment was 22.05, 11.23 and 25.0 percent higher over 100% N through inorganic source (farmers' practice), respectively. Integration of decomposed enriched lac mud in soil nutrient management schedule helps in correcting the soil pH (acidity) which is key of soil fertility and crop production. It improves and maintains organic carbon in the soil as well as it also maintains the available soil nitrogen, phosphorus, potassium and zinc at higher levels. Water holding capacity of soil also improves with its application. Beneficial effect of lac mud on yield and its attributes of brinjal was probably due to favourable soil physical conditions, enhanced microbial activity besides supplying nutrients with increased recovery percentage under lac mud applied plots.

Key words: *Lac mud, Factory waste, Brinjal, Integrated nutrient management, Vermicompost*

Introduction

For sustainability, neither chemical fertilizer nor organic manures alone but their integrated use has been observed to be highly beneficial (Singh *et al.* 2001; Singh *et al.* 2013). Current development in sustainability involves a rational exploitation of different alternative sources of plant nutrients including industrial waste product. Lac mud is the waste product of lac processing industries which is obtained to a tune of about 2.5 to 4.5% on dry and wet weight basis, respectively, of the raw material (sticklac) processed. Lac is natural, nontoxic, biodegradable and renewable natural resin. It has gain momentum in cultivation in recent times due to its use in diversified high value field, accounting for about 50–60% of the total world lac production. Total production and export figures of lac in 2012-13 were 19,577 and 4,361 tons, respectively (Yogi *et al.,* 2014). Lac resin is secreted by the tiny lac insects (mainly *Kerria lacca* Kerr). The insects are cultured on tender shoots of lac hosts and derives its nutrition by sucking the saps from the hosts and it secretes natural resins which is deposited all-around the twigs. Harvesting of lac crop is done by cutting of host twigs deposited with natural resins. The basic raw material for lac industry, sticklac, is obtained by scraping lac incrustation deposited on twigs of hosts. Removing the sticks, stones, other impurities *etc.* as far as possible from sticklac by crushing, sieving, winnowing and washing out the dye with water (primary processing) yields the semi refined product known as seedlac (used for manufacture of value-added lac product shellac, Bleached lac *etc.*) and washed out liquid is passed to the big pits as waste material. After evaporation from this waste material, solid material left is called as lac mud which is removed from pits after drying so that further washed out liquid from primary processing of lac may be store in empty pits. It is mostly dumped due to lack of proper method of disposal which may create pollution hazards. In long run, it is not suitable for sustainability of lac industry and in turn lac production system. Beneficial effect of lac mud has been reported in rice, rose and spinach (Singh 2001, Singh *et al.* 2015, Singh *et al.* 2016). However, no other information is available for utilization of lac mud as a part of nutrient management.

The brinjal or egg plant (*Solanum melongena* L.) is cultivated as one of the leading and the second major vegetable crops next to tomato in India. It is a long duration crop with high production ability which puts tremendous pressure on soil for removal of large quantities of nutrients from the soil. A brinjal crop yielding 60 t ha^{-1} of fruit removes 190 kg N, 10.9 kg P and 128 kg K from soil (Hedge, 1997). As such liberal application of nutrients is needed to meet the nutritional requirements of the crops, however, wake of energy crisis, harmful effect on soil health and ever increasing prices of chemical fertilizers becomes problem before the producers. Integrated nutrient management is one of the important parts of continuous improvement of soil productivity and it can only be possible by the judicious use of fertilizers along with rational exploitation of different alternative sources of plant nutrients including industrial waste. Therefore, the present investigation was undertaken to evaluate the effectiveness of lac mud (lac factory waste) on productivity of brinjal and its effect on soil fertility status.

Materials And Methods

A field experiment was conducted at the research farm of ICAR-Indian Institute of Natural Resins and Gums, Ranchi, India (23^{0}23" N latitude, 85^{0}23" E longitude and 650 m above mean sea level) for three consecutive years during 2013-15 to evaluate the effectiveness of lac mud on productivity of brinjal and its effect on soil fertility status. The climate of the region is characterized mild, salubrious climate, with a rather heavy rainfall pattern of about 1400 mm average, of which about 1250 mm is during the monsoon. Soil of the experimental field was lateritic type, pH 4.52 and was having the contents of available organic carbon - 0.55%, nitrogen – 265.46 kg/ha, phosphorus -37.50 kg/ha and potassium -224.76 kg/ha with EC -0.195 dSm^{-1}. Decomposed lac mud was obtained from lac processing factory, Bundu (Ranchi, Jharkhand) and its analysis revealed higher content of organic carbon (23.3%) and organic matter (40.2%). Besides it also contains 0.65% N, 0.31% P_2O_5 and 0.12% K_2O. Sulphur (3442 ppm), copper (20.8 ppm), zinc (182.3 ppm), iron (5853 ppm), boron (15 ppm) and molybdenum content (13.4 ppm) in lac mud was found quite higher. It was grinded in fine particles and was mixed with lime for correcting the pH @ 25 g lime per kg of lac mud and kept for one day. It was enriched with each of N, P and K @ 0.5 percent. This mixture was kept for two days. After that, Azotobacter and PSB each @ 25 g/kg lac mud was incorporated under sufficient moisture and kept for one day. Six different enriched lac mud (ELM) based treatments *viz*., 100% N through ELM, 75% N through ELM + 25% N through inorganic source, 50% N through ELM + 50% N through inorganic source, 25% N through ELM + 75% N through inorganic source, 25% N through ELM + 25% N through vermicompost + 50% N through inorganic source and 12.5% N through ELM + 12.5% N through vermicompost + 75% N through inorganic source was compared with 100% N through inorganic source (farmers' practice) and control (where no manure and fertilizers was applied). The experiment, thus, consisting of eight treatments was laid out in randomized block design with three replications in crop sequence of brinjal – spinach - tomato. Brinjal variety Swarn Pratibha was planted in first fortnight of July during 2013, 2014 and 2015; and final harvesting of brinjal fruits was done during October-November of respective years. Row to row and plant to plant spacing was kept at 60 cm x 50 cm, respectively. Recommended doses of N, P_2O_5 and K_2O (120:80:60 kg/ha, respectively) were used as per treatments. ELM or vermicompost was applied, considering the nitrogen, phosphorus and potassium recommendation in the crop and percent N, P and K substitution by ELM or vermicompost as per treatment at the time of planting in the root zone. Full ELM/vermicompost, one-third of remaining nitrogen and remaining full doses of phosphorus and potash were applied at the time of planting through fertilizers. Remaining quantity of nitrogen through fertilizers was side dressed in two equal splits at 25 and 50 days after planting. Crop was raised following standard package of practices. Growth observations (plant height, stem girth and number of primary branches per plant) were recorded at 75 days after planting. Fruit yield and other yield contributing characters (number of fruits/plant and average fruit weight) were recorded at harvest. Soil samples were collected after completion of three crop sequences and analyzed for organic carbon by CHSNS analyzer, available phosphorus by Olsen method (Olsen *et al*. 1954) and available potassium by flame-photometer. Other soil parameters were analyzed as per standard procedure. The data of brinjal of all the years were statistically analyzed separately. As the error variance was homogeneous, pooled analysis was done according to Cochran and Cox (1957). Various treatments were compared under randomized block design. The critical difference (CD) was computed to determine statistically significant treatment differences.

$CD = (\sqrt{VEr\&1})\ t_{5\%}$

where, VE is the error variance, r is the number of replications, $t_{5\%}$ is the table value of t at 5 % level of significance at error degree of freedom.

Results And Discussion

A close review of the data presented in Table 1 revealed that integrated application of different sources of nutrients i.e. enriched lac mud (ELM), vermicompost (VC) and inorganic fertilizer had a great influence at all growth, yield and its attributes. Significant differences were observed at all the parameters. Substitution of 25% N through ELM, 25% N through VC and 50% N through inorganic source recorded the highest fruit yield (3.95 t/ha), number of fruits per plant (8) and average fruit weight (189.67 g) of brinjal as well highest plant height (73.15 cm), stem girth (3.28 cm) and number of primary branches/plant (8). Fruit yield under this treatment was at par with application of 12.5% N through ELM + 12.5% N through VC + 75% N through inorganic source, 50% N through ELM + 50% N through inorganic source and 25% N through ELM + 75% N through inorganic source. These four treatments proved superiority over 100% N through inorganic source with respect to fruit yield and number of fruits/plant, however differences in average fruit weight recorded under application of 25% N through ELM + 25% N through VC + 50% N through inorganic source and 100% N through inorganic source were not significant. Treatments, 75% N through ELM + 25% N through inorganic source and 100% N through ELM failed to record significantly higher fruit yield over 100% N through inorganic source. Although, all the treatments of integrated application of different sources of nutrients i.e. ELM, VC and inorganic fertilizer were effective to enhance the plant growth, yield and its attributes of brinjal, but application of 25% N through ELM + 25% N through VC + 50% N through inorganic source was observed most beneficial for the growth and yield of brinjal. Fruit yield, average fruit weight and number of fruits per plant obtained under application of 25% N through ELM + 25% N through VC + 50% N through inorganic source was 22.05, 11.23 and 25.0 percent higher over 100% N through inorganic source (farmers' practice), respectively.

Values of soil characteristics after 3 years of cropping indicated significantly higher content of organic carbon, available nitrogen, phosphorus, potash and zinc in ELM applied plots as compared to plots where only recommended source of inorganic fertilizers were applied and control (Table 2). Organic carbon, available nitrogen and phosphorus content was highest under application of 100% N through ELM, but it was at par with 25% N through ELM + 25% N through VC + 50% N through inorganic source. But in case of available potash and zinc content, 25% N through ELM + 25% N through VC + 50% N through inorganic source recorded significantly lower content compared to 100% N through ELM. Soil pH, EC, water holding capacity and bulk density were maintained at better level of crop growth under ELM applied plots.

Increase in fruit yield under integrated application of different sources of nutrients i.e. ELM, VC and inorganic fertilizer may be attributed to increased vegetative growth and yield attributes viz., number of fruits per plant and average fruit weight. Better soil physical and chemical status of soil after three year of cropping under integrated application of different sources of nutrients i.e. ELM, VC and inorganic fertilizer reflects that lac mud could have resulted in enhanced availability of applied as well as native soil nutrients, synchronized nutrient demand of the crop with nutrient supply from native and applied sources, favourable soil physical conditions, enhanced microbial activity besides minimizing the deterioration of soil, water and ecosystem by promoting carbon sequestration, reducing nutrient losses to ground and surface water bodies and to atmosphere. Increase in uptake of nutrients results in faster synthesis and translocation of photosynthates from source(leaves) to sink (fruits) and influencing the fruit dry matter increasing the yield attributes and yield (Susan, 1995). Chumei and Singh (2013) reported that organic manures are good source of nutrient for brinjal crop, by saving of 50% of chemical fertilizers without any compromise on yield and quality parameters of brinjal. There is a significant build up of organic carbon in the soil after harvest of the crop. It upon decomposition and mineralization, supplied available nutrients directly to the plants (Singh *et al*. 2013). A large numbers of workers (Shrivastava *et al*. 2009, Kashyap *et al.* 2014, Kumar 2016) reported synergistic interaction among organic manures and inorganic fertilizer nutrients which modified the quantum of nutrient uptake by plants as their effect is not merely added up but is actually enhanced. Beneficial effect of lac mud on grain yield of rice, flower yield of rose and leaf yield of spinach have also been reported earlier (Singh 2001, Singh *et al*. 2015, Singh *et al*. 2016).

From present investigation, it may be concluded that enriched lac mud may be used as a substitute of other organic manure for higher fruit yield of brinjal and it may reduce the application dose of nitrogen through inorganic source by 25-50%. Enriched lac mud may be applied as 25% N through ELM + 25% N through vermicompost + 50% N through inorganic source or 50% N through ELM + 50% N through inorganic source or 25% N through ELM + 75% N through inorganic source or 12.5% N through ELM + 12.5% N through vermicompost + 75% N through inorganic source, depending on availability of lac mud. It helps in correcting the soil pH (acidity), improves and maintains organic carbon, available soil nitrogen, phosphorus, potassium and zinc at higher levels. Water holding capacity of soil also improves with its application.

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Table 1: Effect of lac mud based INM treatments on performance of brinjal (pooled data of 3 years)

Treatment	Plant height (cm)	Stem girth (cm)	No. of primary branches/plant	No. of fruits/ plant	Average fruit weight (g)	Fruit yield (t/ha)
100% N through enriched lac mud (ELM)	57.54^{c}	2.87^{a}	4.2^{d}	5.6^{c}	160.62^{b}	2.84^{b}
75% N through ELM + 25% N through inorganic source	59.72^{bc}	2.98^{a}	4.8^{cd}	6.0^{c}	167.86^{ab}	3.10^{b}
50% N through ELM + 50% N through inorganic source	64.79^{abc}	3.19^{a}	6.6^{b}	7.6^{a}	178.79^{ab}	3.69^{a}
25% N through ELM + 75% N through inorganic source	65.07^{abc}	3.17^{a}	6.7^{b}	7.4^{ab}	177.96^{ab}	3.69^{a}
25% N through ELM + 25% N through vermi-compost + 50% N through inorganic source	73.15^{a}	3.28^{a}	8.2^{a}	8.0^{a}	189.67^{a}	3.95^{a}
12.5% N through ELM + 12.5% N through vermi-compost + 75% N through inorganic source	68.66^{ab}	3.22^{a}	7.1^{b}	7.4^{ab}	181.40^{ab}	3.79^{a}
100% N through inorganic source (farmers' practice)	61.13^{bc}	3.05^{a}	5.5^{c}	6.4^{bc}	170.42^{ab}	3.23^{b}
Control (No manure and fertilizers)	37.34^{d}	2.01^{b}	2.6^{e}	3.6^{d}	103.41^{c}	1.14^{c}
S Ed	4.568	0.24	0.34	0.48	11.03	0.20
CD (P= 0.05)	9.80	0.51	0.73	1.03	23.65	0.43

Table 2: Effect of lac mud based INM treatments on soil fertility levels

Treatment	OC (%)	Available Nitrogen (kg ha-1)	Available Phosphorus (kg ha-1)	Available Potash (kg ha-1)	Zinc (mgkg-1)	pH	EC (dSm-1)	Water Holding Capacity (%)	Bulk density (g/cm3)
Pre-sowing values	0.55	265.46	37.50	224.76	1.517	4.52	0.195	31.50	1.45
Post-harvest values (after3 years of cropping)									
100% N through enriched lac mud (ELM)	0.81^{a}	395.96^{a}	64.75^{a}	353.39^{a}	3.138^{a}	6.32^{a}	0.092^{a}	39.24^{a}	1.34^{c}
75% N through ELM + 25% N through inorganic source	0.79^{ab}	392.48^{a}	63.27^{a}	345.76^{b}	3.083^{a}	6.17^{ab}	0.090^{ab}	38.54^{b}	1.34^{c}
50% N through ELM + 50% N through inorganic source	0.75^{bc}	375.16^{b}	60.43^{ab}	324.84^{d}	2.690^{c}	6.04^{abc}	0.084^{bcd}	36.33^{d}	1.36^{bc}
25% N through ELM + 75% N through inorganic source	0.68^{d}	339.11^{c}	56.84^{b}	315.22^{f}	2.437^{e}	5.75^{c}	0.080^{cd}	34.81^{f}	1.40^{b}
25% N through ELM + 25% N through vermi-compost + 50% N through inorganic source	0.78^{ab}	388.96^{ab}	61.74^{ab}	336.78^{c}	2.937^{b}	6.17^{ab}	0.086^{abc}	37.43^{c}	1.35^{bc}
12.5% N through ELM + 12.5% N through vermi-compost + 75% N through inorganic source	0.71^{cd}	345.09^{c}	57.38^{b}	320.49^{e}	2.563^{d}	5.94^{bc}	0.078^{d}	35.77^{e}	1.38^{bc}
100% N through inorganic source (farmers' practice)	0.59^{e}	291.21^{d}	49.26^{c}	295.26^{g}	1.517^{f}	4.52^{d}	0.065^{e}	29.18^{g}	1.47^{a}
Control (No manure and fertilizers)	0.57^{e}	284.24^{d}	46.47^{c}	224.74^{h}	1.227^{g}	4.51^{d}	0.064^{e}	28.27^{h}	1.45^{a}
S Ed	0.0241	7.9852	2.3716	1.9907	0.0359	0.1387	0.0032	0.0938	0.0240
CD (P= 0.05)	0.0517	17.1284	5.0871	4.2702	0.0771	0.2974	0.0068	0.2012	0.0515