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Impact of halophytic compost along with farmyard manure and *Rhizobium* on biochemical and soil physico-chemical properties of organically cultivated urd bean.

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Abstract

The intensive use of chemical fertilizers may have negative impact on plant growth and soil environment, but the application of organic manures could alleviate these problems. So, this experiment was proposed to study the effect of organics and bio-organics on biochemical studies and soil physico-chemical properties of black gram. In a two-year field experiment, there were six treatments: (T_o) Control (no manure), (T_1) *Sesuvium portacultum* compost @ 6.25 t h^{-1}, (T_2) *Suaeda maritima compost* @ 6.25 t ha^{-1}, (T_3) *Sesuvium portacultum* compost @ 3.13 t h^{-1} + FYM @ 3.13 t h^{-1}, (T_4)*Suaeda maritima* compost @ 3.13 t ha^{-1} + FYM @ 3.13 t h^{-1}, (T_5) *Sesuvium portacultum* compost @ 3.13 t h^{-1} + FYM + *Rhizobium* @ 2kg ha $^{-1}$, (T_6) *Suaeda maritima compost* @ 3.13 t ha^{-1} + FYM @ 3.13 t h^{-1} + *Rhizobium* @ 2kg ha $^{-1}$. Consortium of T_6 (*Suaeda maritima* compost @ 3.13 t ha^{-1} + FYM @ 3.13 t h^{-1} + *Rhizobium* @ 2kg ha $^{-1}$)enhanced seed protein (61.66 %), chlorophyll (34.88 %) and soluble protein (34.45 %)in black gram over other treatments and control. The physico-chemical properties of soil such as soil pH(13.45 %), Ec(24.0 %)and bulk density 17.60 % were drastically reduced while organic carbon 33.0 % was significantly higher in T_6 treatment over other treatments and control. Besides, (T_6) *Suaeda maritima* compost @ 3.13 t ha^{-1} + FYM @ 3.13 t h^{-1} + *Rhizobium* @ 2kg ha^{-1} applied plots registered higher agronomics (nitrogen 52.46%, potassium 47.61%, phosphorous 46.20 % and iron 32.81%, copper 38.94%, zinc 36.0 % and manganese 33.84 %) in soil of black gram when compared to other treatments and control. Results revealed that long term application of halophytic compost combined with farm yard manure and *Rhizobium* has superior promoting effect on biochemical studies and soil physico-chemical properties of black gram.

Key words: -Black gram, Farmyard manure, Halophytic compost, *Rhizobium*

Introduction

Inorganic fertilizers have become increasingly expensive, making them unaffordable especially for small scale farmers (Malav *et al.*, 2015). Nevertheless, overuse of inorganic fertilizers by commercial farmers has now been considered a threat to human health and the environment (Sharma and Singhvi, 2017). The continued decline of soil fertility caused by the loss of nutrients leaves the addition of organic fertilizers as the only alternative to improve soil fertility and sustain crop productivity (Nasir *et al.*, 2015). Large amounts of organic waste are being produced daily from urban and rural areas from different sources (Abubaker, 2012). This creates disposal problems, nevertheless recycling and utilization of organic wastes for renewable energy and source of fertilizer provides a solution. While the need to address soil fertility challenges are immense, smallholder farmers also face challenges with energy sources.

In order to avoid waste or loss to the environment, all organic resources that have a positive influence on soil fertility and crop productivity may need to be utilized (Smith *et al.*, 2014). The organic fertilizers for improving quality of agricultural soils include livestock manures, industrial sewage, agricultural material and domestic waste, compost (Islam *et al.*, 2014). The utilization of organic compost is also a sustainable technique to enhance the physical, chemical and biological properties of soil along with crop yield as compared to other fertilizers (Abbas *et al.*, 2020). Application of compost resulted in an increase in soil organic matter (Qayyum *et al.*, 2017) as well as the microbial activity along with plant growth (Chirakkara and Reddy, 2015). Organic Compost supplies nutrients to the soil and also results in efficient water holding capacity, improvement in structure of soil along with microbial activity and carbon sequestration (Guerrini *et al.*, 2017). Besides, compost organic farming is mostly dependent on the natural microflora of the soil which constitutes all kinds of useful bacteria and fungi including the arbuscular mycorrhiza fungi (AMF) called plant growth promoting rhizobacteria (PGPR). Biofertilizers keep the soil environment rich in all kinds of micro- and macro-nutrients via nitrogen fixation, phosphate and potassium solubilisation or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil and PGPR adopt various possible ways to accelerate the rate of crop production (Ansari *et al.*, 2015).

Black gram (*Vigna mungo* L.) is one of the most important pulse crops, which can be grown in tropical and subtropical regions of the world. Black gram is also known as urd and mash in India (Kumar and Simaiya, 2019). Black gram is native of India and originated from the *Phaseolus sublobatus,* a wild plant. Black gram is very nutritious as it contains a high level of carbohydrate (60 g /100 g), protein (20-25 g /100 g), phosphorus (385 mg / 100 g),calcium (145 mg / 100 g) and iron (7.8 mg / 100g) (Raju, 2019). Black gram crop is a mini-fertilizer factory because it has unique characteristics of maintaining and restoring soil fertility through fixing atmospheric nitrogen in symbiotic association with *Rhizobium* bacteria present in root nodules (Swaminathan *et al.*, 2021).

Halophytes are plants that exhibit high salt tolerance, allowing them to survive and thrive under extremely saline conditions (Meng *et al.*, 2018). Halophytes constitute less than two per cent of the global flora (Hasanuzzaman*et al.*, 2014). In the world, 2000 to 3000 halophytic plant species are identified mainly belonging to angiosperms (Sabovljevic*et al.*, 2007). In India, there distribution is mainly confined to arid, semiarid inlands and highly saline wetlands along the tropical and sub-tropical coasts (Kumari *et al.*, 2015). The primary purpose of the present study is when halophytes are subjected to composting, it is possible that NaCl content present in the tissues will degrade during decomposition. Na^+ in NaCl may chelate with the organic acids produced during decomposition and release the Cl^-, resulting in the reduction of NaCl. Decomposition nullifies the presence of NaCl content in the plant tissues (Ravindran *et al.*, 2007). Watson (2003) also stated that leaching the compost with water reduce the concentration of soluble salts.

Material and Methods

The field experiment was conducted at Experimental farm, Department of Agronomy, Faculty of Agriculture, Annamalai Nagar, Tamil Nadu, India during June-October (Kharif) 2019. The experimental farm is geographically located at 11° 24' N Latitude and 79° 44' E Longitude at an altitude of +5.79 M above mean sea level. The maximum temperature was 29.0 °C to 39.5 °C with mean of 34.25 °C. The relative humidity ranged from 61 to 80 per cent with a mean of 70.5 per cent and crop received rainfall of 1400.9 mm.

Selection of Species

Two fast growing and dominant halophytes such as *Suaeda maritima* (L.) Dumort and *Sesuvium portulacastrum* L. were identified for making compost after detailed survey.

Compost preparation

Three months old healthy halophytes were harvested from nursery and used for the preparation of halophytic compost. The halophytes as well as rice straw were chopped well and the substrates were piled loosely in a compost pit to provide better aeration within the heap. The material was too compact and no heavy weights were put on top. Aeration was provided by placing perforated bamboo trunks horizontally and vertically at regular intervals, to carry air through the compost heap. The compost activator, consisting of a cellulolytic fungus (*Trichoderma harzianum)* was broadcast onto the substrates during pilling. The amount of activator used was usually 1.0 per cent of the total weight of the substrate (i.e., about 1 kg compost activator is mixed thoroughly with the substrates (Cuevas, 1997). The heap was covered over completely with white plastic sheets. Heat was maintained at 50 °C or higher and the heap was turned over every 5-7 days for the first two weeks and thereafter once every two weeks. Turning over the pile provided adequate aeration and evened up the rate of decomposition throughout pile. By the end of the third month, the compost was ready for use. It was dark brown, crumbly and hard with earthy aroma.

Preparation of Land

The field was ploughed with tractor drawn disc plough fallowed by a thorough harrowing to break the clods. The field was properly levelled and plot of 4m × 3m size were emarked with raised bunds all around to minimize the movement of nutrient. Channels were laid to facilitate irrigation to plots individually.

Crop Variety

The black gram variety ADT-5 released by Tamil Nadu Agriculture University, Coimbatore was selected for the present study.

Experimental Soil

The Physico-chemical properties of the soil are presented in Table 1. The experimental soil was slightly alkaline with pH 8.1.

Soil characteristics of the experimental field		
Properties	**-**	**Value**
Mechanical Composition	-	
Coarse sand (%)	-	49.83
Silt (%)	-	18.20
Clay (%)	-	16.68
Textural class	-	Sandy loam
B. **Physical properties**	-	
Bulk density (g. cm-2)	-	1.42
C. Chemical Properties	-	
Electrical conductivity (dsm^{-1})	-	1.40
pH	-	8.1
Organic carbon (%)	-	0.40
Available Nitrogen (Kg ha^{-1})	-	173.0
Available Phosphorus (Kg ha^{-1})	-	21.9
Available Potassium (Kg ha^{-1})	-	363.75

Table 2. Compost treatments and their concentrations

Treatments	Compost application
T_0	Control (Without compost)
T_1	*Sesuvium portulacastrum* compost @ 6.25 t ha^{-1}
T_2	*Suaeda maritima* compost @ 6.25 t ha^{-1}
T_3	*Sesuvium portulacastrum* compost @ 3.13 t ha^{-1} + Farmyard manure @ 3.13 t ha^{-1}
T_4	*Suaeda maritima* compost @ 3.13 t ha^{-1} + Farmyard manure @ 3.13 t ha^{-1}
T_5	*Sesuvium portulacastrum* compost @ 3.13 t ha^{-1} + Farmyard manure @ 3.13 t ha^{-1} + *Rhizobium* @ 2 kg ha^{-1}
T_6	*Suaeda maritima* compost @ 3.13 t ha^{-1} + Farmyard manure @ 3.13 t ha^{-1} + *Rhizobium* @ 2 kg ha^{-1}

Biochemical Estimation

Seed protein was estimated following the standard procedure of (Humphries 1956), Chlorophyll was estimated by the methods described by (Moran and Porath, 1980) and Soluble protein was determined by the standard procedures of (Bradford, 1976).

Soil Analysis

The soil of the experimental site was tested before the experimentation in order to know the soil nature (Table 1). Furthermore, soil samples were collected periodically from the root zone of black gram. The soil samples were air dried and sieved through 2 mm sieve to analyse soil physico-chemical properties such as bulk density (Blake and Hartge, 1986), soil pH (Jackson, 1973), soil EC (Jackson, 1973), OC (Walkley and Black, 1934), available nitrogen (Page et al., 1982), available phosphorus (Olsen et al., 1954), available potassium (Knudsen et al., 1982) and soil micronutrients by (Lindsay and Norvell, 1978).

Results and Discussion

Properties of the halophytic compost

Initially an experiment was carried to find out whether the process of decomposition of halophytes reduces the NaCl concentration in the compost. From the results (Table 3) it was observed that after 90 days NaCl concentration in the halophytic compost was drastically reduced to 40.47 per cent Na^+ and 48.0 per cent Cl^- in *Suaeda maritima* compost and 32.63 per cent Na^+ and 43.35 percent Cl^- in *Sesuviumportulacastrum*compost. It was also observed from the studies at the end of decomposition *Suaeda maritima* compost in combination with farmyard manure and *Rhizobium* showed higher nutrient content value when compared to other halophytic composts. Nutrients such as N, P, K, Ca, Mg and micronutrients were found higher in *Suaeda maritima* compost in combination with farmyard manure and *Rhizobium*. The reduction in soil pH was also noticed in *Suaeda maritima* compost along with Farmyard manure and *Rhizobium* over control and other treatments.

Influence of halophytic compost on biochemical properties of *Vigna mungo* L.

Data presented in figures (1,2 and 3) showed that incorporation of halophytic compost alone or along with farm yard manure and *Rhizobium* showed significant increase in biochemical properties of *Vigna mungo.* Among six halophytic treatments, T_6 (*Suaedamaritima* compost combined with farm yard manure and *Rhizobium*) increased seed protein 61.66 per cent, chlorophyll 34.88 per cent and soluble protein 34.45 per cent in black gram when compared to other treatments and control. Higher seed protein content in black gram might be due the greater amount of nitrogen supplied by halophytic compost along with farmyard manure and *rhizobium* and since nitrogen is the constituent of amino acids which is known to be building blocks of protein. Similar findings were found by Bommesha et al., (2012). The use of halophytic compost along with farm yard manure and *Rhizobium* enhanced the plant physiological parameters like chlorophyll which might be due the enhanced nutrients absorption and assimilation. Ondiek et al., (2011) found higher chlorophyll a and b in organically amended plots than unmanured control in African nightshade species. Similar observations were found by (Rizwan and Ansari, 2017). Similar to chlorophyll, soluble protein was also increased in plots which received consortia of halophytic compost along with farmyard manure and *Rhizobium*. It might be due to higher absorption of nitrogen and phosphorus from soil by crop plants due to their availability under the influence of application of organics and bio-organics. Similar findings were observed by (Uyanoz, 2007).

Soil physico-chemical properties

Physico-chemical properties of soil were markedly influenced in the organically sound plots, especially T_6 (*Suaeda maritima* compost combined with farm yard manure and *Rhizobium*) as compared to other treatments and unmanured control. Spaccini et al. (2004) and Tejada et al. (2006) propounded that incorporation of organic manures acted as cementing materials which helps in flocculation of soil assisting in soil aggregations. However, improvement depends on the composition and nutrient status of organic inputs applied into soil. Another report with respect to this study suggested that soil aggregation is markedly correlated with the humic acids but not fulvic acids due to its direct role in clay-organic formation (Whalen et al., 2003). Mucilage and mucilage like compounds produced by microbes registered marked improvement in soil aggregation (Six et al., 2004).

In the present study Soil pH (13.45 percent) was found to be reduced in T_6 (*Suaeda maritima* compost combined with farm yard manure and *Rhizobium*) when compared to other treatments and control (Table 4). Reduction in soil pH might be due the release of H^+ via nitrification or the production of organic acids during decomposition. Similar findings were observed by (Rashad et al., 2011). Similarly, like soil pH, soil EC (24.0 per cent) was also reduced in T_6 (*Suaeda maritima* compost combined with farm yard manure and *Rhizobium*) over other treatments and unmanured control (Table 4). It might be due to production of organic acids during decomposition in soil (Das and Singh, 2014).

Soil bulk density (17.60 per cent) significantly decreased in the organic amended soil than unmanured control. Among six halophytic treatments higher reduction in Soil bulk density was found in T_6 (*Suaeda maritima* compost combined with farm yard manure and *Rhizobium*) when compared to other treatments and unmanured control (Table 4). This might be due to increased soil porosity which happened due to joint action of organics and bio-organics. Tejada et al. (2009) reported that soil BD were decreased due to compost addition to the soil leading to enhanced humic acid concentration, soil aeration, dilution of the denser soil mineral fractions, later on porosity and structural soil stability. Present study corroborated the earlier findings of Shukla and Tyagi (2009) and Nagar et al. (2016).

In the current study, increased soil organic carbon (33.0 per cent) was recorded in consortium T_6 (*Suaeda maritima* compost combined with farm yard manure and *Rhizobium*) over other treatments and control (Table 4). Oxidation rate of organics by soil microbes are the main cause behind increased soil organic carbon (Ramesh et al., 2009).

Nutrient status in soil

In the present study, application of halophytic compost combined with farmyard manure and *Rhizobium* enhanced the soil nutrient status macronutrients (N, P, K) and micronutrients (Fe, Mn, Cu and Zn) over unmanured control. Higher soil nutrient status such as nitrogen (52.46 per cent), phosphorus (47.61 per cent), potassium (46.20 per cent) and iron (32.81 per cent), manganese (33.84 per cent), copper (36.0 per cent), zinc (38.94 per cent) were found in T_6 (*Suaeda maritima* compost combined with farm yard manure and *Rhizobium*) when compared to other treatments and unmanured control (Table 5 and 6). This might be associated with the availability of higher quantum of N, P and K in the organic amended plots. Gopinath et al., (2008) revealed that addition of farmyard manure and *Lantana* sp. resulted increased nutrient status such as available N, P and K into the soil, might be due to the presence of plethora of nutrients into the organics applied to the field.

Conclusion

The inference could be drawn that conjoint application of halophytic compost combined with farmyard manure and *Rhizobium* showed higher impacts on biochemical and soil phyisco -chemical properties than unmanured control. Seed protein, Photosynthetic pigments (chlorophyll and soluble protein) and Soil nutrient status such as nitrogen, phosphorus, potassium and iron, manganese, copper and zinc registered manifold improvement in T_6 (*Suaeda maritima* compost combined with farm yard manure and *Rhizobium*) when compared to other treatments and unmanured control.

Therefore, based on these findings it is concluded that not only chemical fertilizers could fetch a good remuneration but also consortia of halophytic compost combined with farmyard manure and *Rhizobium* could also achieve the good returns under better management practices. Possibly, use of this fertilization regime would offer an opportunity for mitigation of soil pollution.

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