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A sustainable agro-biotechnology for quality seedling production of *Jatropha curcas L.* in tropical nursery conditions

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KEYWORDS

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A B S T R A C T

Nursery experiments were conducted to select the suitable bioinoculants with locally available organic source to improve quality seedling production of *Jatropha curcas L.* Two months old Clones was procured from the Mission Biofuel India Pvt. of Madurai district, Tamilnadu, India. Clones were transplanted in a mixture of UnSterilised sand, Soil, and Farm Yard Manure (FYM) in the ratio of 2:1:1 in a 13x 26 cm polyethylene bag. In order to find out the suitable organic and bio-inoculants and their combinations to achieve maximum overall growth and minimise the cost of clones production, The Compost, Seaweed fertilizer and Biofertilizers were applied individually and in combinations. Clones were kept under identical nursery conditions. Clones were harvested to estimate root length, shoot length, basal diameter, root weight, shoot weight were recorded 180 days after transplantation. Results show that the total clone growth and biomass were significantly increased in all the treatments compared to control plants. Biofertilizers co-inoculated with compost and seaweeds produced the maximum growth, biomass and quality seedling. Among all the treatments, inoculation with seaweed fertilizers + biofertilizers + compost recorded maximum shoot length followed by compost. These treatments recorded 12.96% and 6.53% increased over control. The total biomass is highest in seedling treated with seaweed fertilizers + biofertilizers + compost and it was recorded 44.87% increased over control. This clearly indicates that biofertilizers act synergistically when inoculated with organic and seaweed fertilizers. It is recommended that Seaweed fertilizers, biofertilizers and compost can be simultaneously used for quality seedling production.

Introduction

Plants play an important role in the solar energy transport to bio-energy. As a potential biofuel plant species, physic nut (*Jatropha curcas L.*) has attracted great attention worldwide, with an increasing number of plantations in many tropical countries. It is a multipurpose crop of significant economic importance as a biofuel. Moreover, parts of the shrub are used in traditional medicine and as raw material for pharmaceutical and cosmetic industries (Paramathma *et al.*, 2006).

Jatropha curcas L. is a shrub belonging to the Euphorbiaceae family and is considered to be an important energy crop due to the production of biodiesel that can be utilized as a suitable alternative fuel resource. It is cultivated in many parts of the tropics and subtropics as a hedge crop and for traditional use (Heller, 1996; Kumar and Sharma, 2008). *Jatropha* occurs mainly at lower altitudes (0–500 m) in areas with average annual temperatures well above 20°C but can grow at higher altitudes and tolerates slight frost. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. The current distribution shows that introduction has been most successful in the drier regions of the tropics and can grow under a wide range of rainfall regimes from 250mm to over 1200mm per annum (Katwal and Soni 2003).

In Southern District of Tamilnadu, farmers worried every year as their crops get destroyed due to draught and lack of proper irrigation. Moreover, these farmers are heavily burdened under debt that they take to purchase seeds, fertilizers, pesticides etc. for cultivation and their inability to payback these loans and incapability to sustain their families, forces them to take such drastic steps. Since *Jatropha* grows on lands that are not well irrigated, it is a boon for these farmers.

Organic manure has a tremendous potentiality in improving the soil quality and there by the yield. Similarly, Seaweed Extracts (SE) and seaweed have been used as fertilizers and soil conditioners for centuries (Aitken and Senn, 1965). The seaweeds are used as animal feed and as raw material for many industries and they are also used as manure (Chapman and Chapman, 1980). The seaweeds have a large number of organic compounds which when applied to the plants exert some effect on their growth. In recent years, it has been demonstrated that seaweed products contain phytohormones, and the stimulating effects of seaweed extracts may be attributed to these components, especially cytokinins. Seaweed extracts exhibit various beneficial effects on plant growth and development (Crouch *et al.*, 1990). They may enhance nutrient uptake, regulate plant growth substances, increase chlorophyll content, protein synthesis and cell division, promote root and shoot growth and improve seed germination (Button and Noyes, 1964; Van Staden *et al.*, 1994).

Due to mechanization of agricultural industry, the availability of Farm yard Manure (FYM) is very low. However, there is no single medium that can be used for all purposes but general horticulture properties have been underlined (James, 1987; Swanson, 1989). This includes slightly acetic pH (5.5–6.5), high cat ion exchange capacity, low inherent fertility, adequate porosity. Mixing with other organic waste such as compost and seaweed fertilizers can also used for producing good quality seedlings in the nursery. A study (Michelsen, 1992) indicates that nursery conditions in the tropics are not always optimal for quality seedling production. These can be overcome by addition of good quality organic manure.

Though the substrate is applied with nutrient solution the quality of seedling is very poor due to insufficiency of desired microorganisms (many of the microorganisms are host specific) and the low level of the rate of mineralization and nitrogen fixation. As a result the quality of the seedling is very poor, compost, seaweed fertilizers and biofertilizers seems to be work best when mixed with other plant growth media or soil. Hence there is a need

for degree of standardization of the potting media with suitable organic, seaweed and biofertilizers to ensure an adequate plant nutrient status. Hence the present research work was aimed to select the suitable organic manure, biofertilizer and their combination to produce quality seedlings of *Jatropha curcas* using locally available organic waste to reduce the cost of seedling production.

Materials and Methods

Clones

Two months old Clones was procured from the Mission Biofuel India Pvt. of Madurai district, Tamilnadu, India. Clones were transplanted in a mixture of unsterilised sand, Soil, FYM in the ratio of 2:1:1 in a 13x 26 cm polyethylene bag. In order to find out the suitable organic and bio-inoculants and their combinations to achieve maximum overall growth and minimise the cost of clonal production, the following treatments were given.

Microbial diversity and analysis

The sample quantity of soil (10 g) was suspended in 99 ml of sterile normal saline in 250 ml flask and shaken at 150 rpm for about 20 min at 37 °C. The supernatant was serially diluted and inoculated in respective media for the isolation of desired rhizobacteria. Using spread plate technique, these soil suspensions (0.1 ml) were spread on differential media. Nitrogen free Bromothymol blue (NfB) Agar for the isolation of *Azospirillum*, and Pikovskaya's Agar for the isolation of phosphate solubilizers were used in this study. The plates were incubated at room temperature for 24 h for bacteria (Warcup, 1950; Wicklow and Carroll, 1981). Number of colonies obtained on all these agar plates was counted and their colony characteristics were recorded. Fast growing prominent colonies were selected for further studies. The isolates were studied for their morphological characteristics after performing Gram staining. They were purified by subculturing and preserved on their respective basal medium contains 40% glycerol at -4 °C (Kennedy and Smith, 1995).

AM fungi

AM fungus, *Glomus fasciculatum*, was isolated and recorded as dominant species in the rhizosphere soil of Casuarina (Rajendran *et al.*, 2003). It was multiplied in pot culture in the sterilised mixture of sand and soil (1: 1 v/v) and maintained in the roots of *Sorghum vulgare* as the host plant. The inoculum contained extrametrical hyphae, chlamydospores and infected root segments. Inoculum potentials were determined by the most probable number (Porter, 1979) and 2,500 infective propagules 10 gram of inoculum.

Seaweeds

The seaweeds *Ulva*, *Padina* and *Sargassam* were collected from Mandapam, Rameswaram coast in Ramanathapuram District in the southeast coast of Tamil Nadu. Seaweeds were washed thoroughly and dried in the sun followed by oven drying for 48 hours at 40^{o}C and powdered. Five hundred gram of dry powder soaked in 100 ml of ethyl alcohol for 12 hours with intermittent stirring. The alcohol extract was decanted and residue was boiled with 300ml distilled water for 30 minutes and filtered alcohol extract and water soluble constituents were mixed and the volume was made up to 500ml with water to constitute 100% solution. From this, 0.75% concentration for used nursery experiment.

Treatments

T_0- Control (Vermiculite alone)
T_1-Seaweed fertilizers
T_2-Biofertilizers (*Arbuscular Mycorrhiza* (AM)+ *Azospirillum* + Phosphobacterium)
T_3-Compost (Agricultural waste compost)
T_4- Seaweed fertilizers+ Biofertilizers
T_5- Seaweed fertilizers + Compost
T_6- Biofertilizers + Compost
T_7- Seaweed fertilizers+ Biofertilizers + Compost

Experimental Design

Nursery experiment was conducted at the east coast district of Ramnathapuram, in Tamil Nadu, India. The experiment was set-up in a completely randomised design with 8 treatments and 25 replicates,10 gram of compost and 10 gram of peat based biofertilizers and 10 ml of seaweed liquid fertilizers were amended in the seedlings seven days after transplantation. All the plants were kept under identical nursery condition up to 180 days.

Harvesting and measurement

180 days after transplantation, from each treatment, a total of 12 clones were randomly selected, height and basal diameter were recorded. clones were carefully uprooted without disturbing the root system and washed in the running tap water. Excess of water was wiped out by placing them between the folds of blotting paper. The clones were cut at collar region, dried separately at 70^{o} C in paper bags in hot air oven and biomass estimation (root and shoot dry weight) was carried out using top pan electronic balance. Seedlings Quality Index was calculated using the formula of Dickson *et al.* (1960).

$$\text{Seedlings Quality Index (SQI)} = \frac{\text{Total weight (g / plant}^{-1})}{\frac{\text{Height (cm)}}{\text{Root collar diameter (mm)}} + \frac{\text{Shoot weight (g / plant}^{-1})}{\text{Root weight (g / plant}^{-1})}}$$

Quantitative estimation of the Micro Organisms

The dilution plate counting method was employed for the enumeration of microbial population in the soil samples. Appropriate dilutions were done with Pikovskaya's medium for Phosphobacteria (Sundara Rao and Sinha 1963). N-free semi solid malate medium for *Azospirillum* (Dobereiner *et al.*, 1976). An aliquot of 1 ml of the respective dilution was spread in sterile petriplates of 90-mm diameter and dispensed with respective media. Plates were rotated gently thrice in clockwise and anticlockwise direction to ensure uniform distribution of the soil suspension. The plates were incubated at 28^{0}C. The colonies were counted on third day for phosphobacteria and *Azospirillum* using colony counter and expressed the population colony-forming unit (cfu) per gram of soil.

Assessment of mycorrhizal infection

Mycorrhizal root infection was assessed by following the procedure of Phillips and Hayman (1970). The root segments were placed in a 2.5% aqueous solution of KOH (w/v) and boiled in a water bath at 90 ^{o} C for 15 minutes. The roots were rinsed with several changes of water and lightened in H_2O_2 (3 ml of 20% NH_4OH in 30 ml H_2O_2) for 10–45 minutes. They were again thoroughly rinsed with water several times and acidified by soaking in 40–50 ml of 1% HCl for 3 min. Acidified roots were stained in an acidic glycerol solution (500 ml glycerol, 450 ml H_2O, 50 ml 1% HCl) containing 0.05% trypan blue. The trypan

blue solution was poured off and the roots were washed in acidic glycerol at room temperature to remove excess stain. The stained roots were mounted in a glass slide and percentage of infection was calculated.

$$\text{Percentage of Root colonization} = \frac{\text{Number of root bits showing VAM infection}}{\text{Total number of root bits examined}} \times 100$$

Microbial inoculation effect was calculated based on the mycorrhizal inoculation effect proposed by Bagyaraj (1992).

$$\text{Microbial inoculation effect} = \frac{\text{Dry weight of inoculated plant*- Mean dry weight of uninoculated plant}}{\text{Dry weight of inoculated plant*}} \times 100$$

Where, the asterisks indicate all microbial inoculations including AM fungi.

Nutrient Analysis

Plant samples were taken for the nutrient analysis. The oven-dried plant samples were ground to pass through a 0.5 millimetre plastic sieve before digestion.

Nitrogen and Phosphorus

The dried plant material was ground in a mortar and pestle and the total nitrogen content was estimated by the conventional micro-1`Kjeldahl method (Umbreit *et al.*, 1972). Total phosphorus was estimated by the method of Fiski-Subba-Rao as modified by Bartlett (1959).

Estimation of total Potassium, Calcium and Magnesium

1 gram of plant sample was digested with tri- acid mixture with HNO_3, H_2SO_4 and $HCLO_4$ in the ratio of 9:2:1 until it become colourless. After digestion it was filtered and the volume was made up to 100 ml. Potassium in the extract was determined using a flame photometer (Jackson, 1973). Calcium and Magnesium were determined by the Versenate method as described by Jackson (1973).

Statistical analysis

The data were statistically analysed by analysis of variance (ANOVA) and treatment means were separated using Duncan's Multiple Range Test ($P<0.05$) (Duncan, 1955).

Results and Discussion

This study presents result of the measurements of collar diameter, total height, above and below ground biomass, suitable combination of Seaweed fertilizers and Compost for bioinoculants to improve the planting stock of *Jatropha curcas* in nursery condition at arid zone of Tamilnadu, India.

Growth

Inoculated with combined inoculation of Seaweed fertilizers + Biofertilizers + Compost (T_7). It was recorded as 83% increased over control.

Number of leaves

Among all the treatments, inoculation with Seaweed fertilizers + Biofertilizers + Compost (T_7) recorded maximum number of leaves followed by Biofertilizers (T_2). These treatments recorded 50% and 33% increase over control.

Among the individual inoculation, Seaweed fertilizers (T_1) amended clones also showed maximum number of leaves and was statistically on par with other dual inoculation of Biofertilizers + Compost (T_5) inoculated seedlings.

Collar diameter

Statistically, the result revealed that the treatments and their interaction were found to be significant (Table 1). However, highest collar diameter was recorded in clones inoculated with combined inoculation of Seaweed fertilizers+ Biofertilizers + Compost (T_7). It was recorded as 83% increased over control.

Shoot length

Significant increase in shoot length was recorded in *Jatropha* clones inoculated with different biofertilizers compared with control at 180 days (Table 1). Analysis of data on growth revealed that the combined inoculation of Seaweed fertilizers+ Biofertilizers + Compost (T_7) was found to be most effective in increasing the growth of clones followed by Compost (T_3).

Among all the treatments, inoculation with Seaweed fertilizers+ Biofertilizers + Compost (T_7) treated clones recorded maximum shoot length followed by compost (T_3). These treatments recorded 37% and 24% increase over control respectively.

Root length

Statistically, there is no difference in the root length. Among all the treatments, inoculation with (T_7) Seaweed fertilizers + Biofertilizers + Compost recorded maximum root length followed by Seaweed fertilizers + Compost (T_5). These treatments recorded 3.40% and 2.60% increase over control respectively.

Total length

Among all the treatments, inoculation with Seaweed fertilizers + Biofertilizers + Compost (T7) recorded maximum length followed by Biofertilizers + Compost (T6). These treatments recorded 26.2% and 6.80% increase over control.

Leaf biomass

The data pertaining to shoot and root dry matter accumulation and total biomass is presented in Table 2.The result indicated that the significant response among treatments evaluated after 180 days of biofertilizers inoculation. The highest biomass in the shoot was recorded in clones inoculated with compost (T_3) alone and it was recorded as 35% increase over control. It was statistically on a par with Seaweed fertilizers+ Biofertilizers + Compost (T_7). They were followed by 55% increased with Compost +Seaweed fertilizers (T_7).

Shoot biomass

In shoot biomass, among all the treatments, inoculation with (T_7) Biofertilizers + Compost recorded maximum shoot biomass followed by Compost +Seaweed fertilizers (T_6). These treatments recorded 82% and 61% increase over control respectively.

Root biomass

Higher root biomass was obtained in treated seedlings when compared to control. Seaweed fertilizers+ biofertilizers + compost (T_7) treated seedlings recorded higher root biomass. It was recorded as 72% increased over control. It was followed by biofertilizers (T_2) and it was statistically on a par with biofertilizers + compost (T_6). They were recorded as 51% (T_2) and 50% (T_6) respectively increased over control.

Total Biomass of Seedling

The total biomass is highest in *Jatropha* treated with seaweed fertilizers+ biofertilizers + compost (T7). It was

recorded as 87% increase over control. It was followed by 56% in clones treated with dual inoculation of compost+seaweed fertilizers (T_6). In dual inoculation, biofertilizers + compost (T_5) was recorded as 49% and it was statistically on a par with biofertilizers (T_2) (Table 2).

Seedling Quality Index

Maximum quality seedling index was obtained in seedlings treated with Seaweed fertilizers + biofertilizers + compost (T_7) followed by seedlings treated with compost + seaweed fertilizers (T_6). Among the single inoculations biofertilizers (T_2), showed the highest seedling Quality Index (Fig. 2)

Microbial inoculation effect

Microbial inoculation effect was highest in the seedlings inoculated with biofertilizers + compost (T_7) and followed by Seaweed fertilizers + biofertilizers + compost (T_6) (Fig. 3).

Potting media play a key role in such containers, as limited space is available to the plant for its development, A medium based on mineral soils, air spaces and it compacts down very quickly uses of compost is recommended to overcome these difficulties. Compost has lot of air spaces in it which allows the root to grow quickly and abundantly (Mohit, 1999).

There is no single growing medium that can be used for all purpose but general horticulture properties have been underlined (James, 1987; Swanson, 1989). These include slightly acidic pH (5.5–6.5), high cation exchange capacity, low inherent fertility, adequate porosity and freedom from pest. Growing media for forestry seedlings generally are composite of 2–3 components. Similarly, in the present investigation also corroborate with above statement, when the potting mixture is prepared with seaweed fertilizers + biofertilizers + compost (T_7) produced best quality seedlings in container. The highest growth, biomass and quality seedlings were obtained in seedlings grown in potting mixture comprised of Seaweed fertilizers + biofertilizers + compost which might be due to favourable physicochemical properties of the respective potting medium.

There is no single growing medium that can be used for all purpose but general horticulture properties have been underlined (James, 1987; Swanson, 1989). These include slightly acidic pH (5.5–6.5), high cation exchange capacity, low inherent fertility, adequate porosity and freedom from pest. Growing media for forestry seedlings generally are composite of 2–3 components. Similarly, in the present investigation also corroborate with above statement, when the potting mixture is prepared with seaweed fertilizers + biofertilizers + compost produced best quality clones in container.

Azospirillum inoculated clones had shown better growth and root biomass when compared to control. Similarly, Mohan and Rajendran (2014) observed in growth promotion in *Feronia elephantum*, Rajendran *et al.,* (2003), Rajendran and Devaraj (2004) observed that the *Casuarina equisetifolia* seedlings inoculated with *Azospirillum brasilense* increased the growth of plants by 90 percent over uninoculated control. This may be due to increased root biomass and accumulation of nitrogen (Wong and Stenberg, 1979).

Further *Azospirillum* also produced gibberellin and cytokinin like substances (Tien *et al.,* 1979) which promote the growth of the seedlings. In the present study Azospirillum co-inoculated with other biofertilizers had better growth and root

biomass. The increase growth may be attributed to increasing root surface area and nitrogen fixation ability of *Azospirillum brasilense.*

Table.1 Effect of sea weeds, organic and biofertilizers on the growth of *Jatropha curcas* clone (180 days after inoculation)

Treatment	Number of Leaves	Collar diameter (mm)	Shoot height (cm)	Root length (cm)	Total length (cm)
T_0	9.2a	1.5^{a}± 0.414	42.9^{b} ± 0.243	15.58^{a} ±0.512	58.48^{b} ±0.512
T_1	9.5a	1.6^{a}±0.541	39.2^{a}± 0.532	15.68^{a}± 0.541	54.88^{a}± 0.541
T_2	11.6c	1.8^{b}± 0.335	50.9^{c}± 0.132	15.70^{b}± 0.841	61.78^{b}± 0.320
T_3	8.5a	1.9^{c} ± 0.246	52.5^{c}± 0.553	15.83^{b}± 0.320	66.73^{d}± 0.320
T_4	9.0a	1.11^{d} ± 0.231	49.5^{c}± 0.410	16.00^{b} ±0.231	65.5^{d} ±0.231
T_5	9.1a	1.10^{c}± 0.442	48.4^{c} ±0.532	16.08^{b}± 0.320	64.40^{d}± 0.520
T_6	9.7b	1.9^{d}± 0.551	45.7^{b} ±0.541	16.00^{b}± 0.520	68.20^{e}± 0.841
T_7	12.8	2.4^{e} ± 0.552	55.1^{d}± 0.543	16.11^{b} ±0.478	71.21^{f} ±0.478

± Standard deviation.

Means followed by a common letter(s) in the same column are not significantly different at the 5% level by DMRT

Treatments**:** T_0- Control; T_1-Sea weed fertilizers; T_2- Biofertilizers; T_3- Compost; T_4- Seaweed fertilizers+ Biofertilizers; T_5- Seaweed fertilizers + Compost; T_6- Biofertilizers + Compost; T_7- Seaweed fertilizers + Biofertilizers + Compost

Table.2 Effect of sea weeds, organic and biofertilizers on the biomass of *Jatropha curcas* clone (180 days after inoculation)

Treatments	Leaf dry weight (g / plant)	Shoot dry weight (g / plant)	Root dry weight (g / plant)	Total dry weight (g / plant)
T_0	0.75a	5.63^{a} ± 1.410	1.12^{a}± 0.365	6.32^{b} ± 0.185
T_1	0.80b	4.23^{b} ± 1.250	1.16^{b}± 0.254	4.99^{a} ± 0.541
T_2	1.02d	7.46^{b} ±0.854	1.63^{c} ±0.521	8.94^{d} ± 0.250
T_3	1.11e	6.59^{bc}± 0.854	1.18^{c}± 0.652	7.55^{c}± 0.652
T_4	1.02d	5.67^{ab}± 0.852	1.22^{b}± 0.541	6.71^{b}± 0.652
T_5	1.00c	8.01+± 0.410	1.49^{d}± 0.365	9.45^{e}± 0.520
T_6	0.98c	8.48^{bc}± 0.410	1.63^{c}± 0.521	9.89^{e}± 0.632
T_7	1.63f	9.53^{d}± 0.410	1.65^{b}± 0.541	11.82^{f}± 0.251

± Standard deviation. Means followed by a common letter(s) in the same column are not significantly different at the 5% level by DMRT

Treatments: T_0- Control; T_1-Sea weed fertilizers; T_2- Biofertilizers; T_3- Compost; T_4- Seaweed fertilizers+ Biofertilizers; T_5- Seaweed fertilizers + Compost; T_6- Biofertilizers + Compost; T_7- Seaweed fertilizers + Biofertilizers+Compost

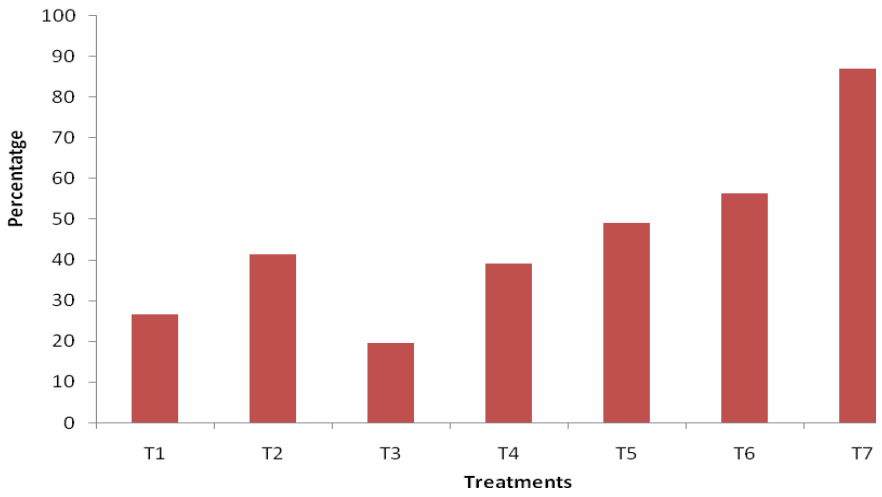
Table.3 Effect of sea weeds, organic manure and bio-fertilizers on the Nutrient concentration (%) and Nutrient content (g/clone) of *Jatropha curcas* clone (180 days after inoculation)

Treatments	N(%)	P(%)	K(%)	Ca(%)	Mg(%)
T_0	1.26 (0.079)	0.06 (0.003)	0.993(0.062)	0.795(0.050)	0.11(0.006)
T_1	1.84 (0.091)	0.07 (0.003)	1.110(0.055)	1.110(0.055)	0.16(0.007)
T_2	1.58 (0.141)	0.08(0.007)	1.172(0.104)	1.162(0.103)	0.14(0.012)
T_3	1.76 (.132)	0.10(0.007)	1.189(0.089)	1.182(0.089)	0.16(0.012)
T_4	1.89 (0.126)	0.10(0.006)	1.189(0.079)	1.110(0.074)	0.16(0.010)
T_5	1.80 (0.170)	0.10(0.009)	1.190(0.112)	1.112(0.105)	0.17(0.016)
T_6	1.90 (0.187)	0.11(0.010)	1.200(0.118)	1.352(0.133)	0.18(0.017)
T_7	1.96 (0.231)	0.12(0.014)	1.212(0.143)	1.400(0.165)	0.19(0.022)

Figures in parenthesis is nutrient uptake (g/plant)

Treatments: T_0- Control; T_1-Sea weed fertilizers; T_2- Biofertilizers; T_3- Compost; T_4- Seaweed fertilizers+ Biofertilizers; T_5- Seaweed fertilizers + Compost; T_6- Biofertilizers + Compost; T_7- Seaweed fertilizers + Biofertilizers+Compost

Fig.3 Microbial inoculation effect (Percentage) on the growth of *Jatropha curcas* treated with seaweeds, organic and biofertilizers



T_0- Control; T_1-Sea weed fertilizers; T_2- Biofertilizers; T_3- Compost; T_4- Seaweed fertilizers+Biofertilizers; T_5- Seaweed fertilizers+Compost; T_6- Biofertilizers + Compost; T_7- Seaweed fertilizers+Biofertilizers+Compost.

In the present study the biofertilizers including phosphate solubilizing bacteria inoculated with *Jatropha* clones showed improved growth, biomass and quality planting stock and the above results corroborated with earlier report made by Rajendran *et al.* (2003) in *Casuarina equisetifolia*, Mohammad and Ram Prasad (1988) in *Eucalyptus camaldulensis* and Young (1990) in *Leucaena leucocephala*, Rajendran and Meenakshi Sundaran (2007) in *Azadirachta indica*, Rajendran and Jayasree (2007) in *Acacia nilotica*, Kasthuri Kasthuri Rengamani *et al.*, (2006) in

Moringa oleifera. This may be due to conversion of insoluble phosphorus to soluble form and thus making available intake by plants. Phosphobacterium also produce auxins and gibberellin, which may have favourable effect on plant growth (Somani *et al.*, 1990).

Presence of growth regulators in marine algae and their effect at lower concentration alerts physiological properties leading to higher yield (Temple and Bomke, 1989). In the present study higher growth, biomass and nutrient uptake was estimated in *Jatropha* clone amended with seaweeds alone and combination with compost and biofertilizers. It may be due major plant nutrients present in the Seaweed (Yama moto *et al.*, 1979) and number of growth promoting substances including auxins, Gibberellins in *Sargassam* (Zhang *et al.*, 1991) and other marine algae.

This study is a holistic approach of sustainable utilization of bio-resources and management with locally available resources for planting stock production in nurseries. Use of biofertilizers with seaweeds and organic fertilizers in the growth of *Jatropha* clone in the present study evidently shows increase in growth and biomass. It is inferred that under appropriate management, the use of more efficient biofertilizers, co-inoculation with organic compost and seaweed fertilizers lead to an increased growth and biomass of *Jatropha* clone in tropical nursery conditions. The present study has clearly shown that the combined application of Seaweed fertilizers + Biofertilizers +Compost play a significant role in improving the growth response and nutrient uptake of *Jatropha* thereby producing good quality planting stock. These clones may perform better growth, survival and more biomass production in nutrient impoverished soil.

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This study is a holistic approach of sustainable utilization of bio-resources and management with locally available resources for planting stock production in nurseries. Use of biofertilizers with