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Enhancement of Growth and Yield of *Arachis hypogeae* L. Using Different Biofertilizers

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Keywords: Arachis hypogeae, Basillus megaterium, Biofertilizer, FYM, Soil health.

Abstract. The field experiment was conducted in split design with three replicates in Arunagirimangalam village, Thiruvanamalai District to study the effect of groundnut haulm compost of single and combined inoculation of FYM, different biofertilizers (*Azotobacter, Azospirillum, Phosphobacteria, Rhizobium*) on growth, photosynthetic pigments, biochemical properties and yield of *Arachis hypogeae* L. The results of this experiment revealed that groundnut haulm with combined inoculation of biofertilizers significantly increased growth, photosynthetic pigments, biochemical and yield parameters of the test crop. Among various combinations, single inoculums of groundnut haulm performed better than control while groundnut haulm with combined inoculation of *Rhizobium* found better over single inoculation treatments. In general, it could be concluded that groundnut haulm compost and mixed with *Rhizobium* may be a good tool to improve the crop yield productivity and quantity and soil health.

Introduction

India is the third largest producer of oil seeds in the world. It accounts for 19% of area and 9% of the global production [1]. It is grown mostly under rainfed conditions and energy starved marginal lands which are prone to the vagaries of monsoons. In addition, groundnut crop is affected by several pests and diseases leading to low down productivity of less than 9 q ha^{-1}. Therefore the use of chemical fertilizers has concerned the delicate ecological balance of the soil, contaminated groundwater, developed resistant races of pathogens and increased human health risks [2]. Chemical pollutants are extremely dispersed in the environment and cause severe problems to human health, soil as well as the environment. In agroecosystems, the use of synthetic toxic chemical pesticides affects the soil fertility and growth of cultivated crops [3].

Similar studies showed that organic farming production system aims at promoting and enhancing agro-ecosystem health, biodiversity, biological cycles and soil biological activities. Crop plants remove varying amounts of different nutrients from soil and to compensate the loss from the soil, organic amendments rich in nutrients must be added [4]. In organic farming micro- & macro-organisms deliver a smorgasbord of minerals, vitamins and other nutrients to the crop at a metered place. Proper recycling of crop residues in the form of compost, vermicompost, green manure etc. [5]. In addition, the organic matter serves as nutrients and energy sources for soil microorganisms [6]. There is ongoing rigorous research worldwide with greater impetus to explore a wide range of rhizobacteria possessing novel traits like heavy metal detoxifying potentials [7], pesticide degradation/ tolerance [8, 9],

Vermicompost is stable in agriculture not only increases the population of useful microorganisms but also added the nutritious elements such as Nitrogen, phosphorus magnesium and potassium in the soil which improve the growth and activity of the crops [10]. Biofertilizers are known to play an important role in increasing availability of nitrogen and phosphorus also improving biological fixation of atmospheric nitrogen and enhance phosphorus availability to legume plants [11]. Therefore, the introduction of Rhizobium in soil with low nitrogen may help augment nitrogen fixation and thereby boost production of crops. Phosphorus is known to play an

important role in the growth and development of the leguminous plant and have a direct relation with root proliferations, straw strength, grain formation, crop maturation.

The growth-stimulating bacteria are *Azospirillum*, *Azotobacter*, and *Pseudomonas* which, additionally to biological fixation of nitrogen and solubilization of soil phosphate, considerably affect plant growth regulators especially auxin, gibberellin and cytokinin, hence develop the plant performance. *Azotobacter* is able to produce antifungal compounds that fight plant diseases and improve viability and germination of the plantlets and, as a result, improve the overall plant growth [12].

So, it was of interest to investigate whether a synergistic effect would occur if both groundnut haulm compost single and combined application of different biofertilizers (FYM, *Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) were used as an inoculation of on growth, biochemical and yield of *Arachis hypogeae* L. at various stages.

Materials and Methods

The field experiment was conducted in split design with three replicates in Arunagirimangalam Village, Arunagirimangalam village, Thiruvanamalai District, Soil was ploughed with tractor drawn disc plough followed by a thorough harrowing to break the clods. It was properly levelled and each plot (2.5 × 2.5 m size) was earmarked with raised bunds all around to minimize the movement of nutrient. Channels were laid to facilitate irrigation to plots individually. The treatments, which are as follows:

T1	:	Control
T2	:	1 tonne ha-1 haulm compost
T3	:	1 tonne ha-1 haulm compost + FYM
T4	:	2 tonnes ha-1 haulm compost
T5	:	2 tonnes ha-1 haulm compost + Azotobacter,
T6	:	3 tonnes ha-1 haulm compost
T7	:	3 tonnes ha-1 haulm compost + Azospirillum
T8	:	4 tonnes ha-1 haulm compost
T9	:	4 tonnes ha-1 haulm compost + Phosphobacteria
T10	:	5 tonnes ha-1 haulm compost
T11	:	5 tonnes ha-1 haulm compost + Rhizobium

In each plot, healthy seeds of *Arachis hypogeae* (groundnut) were sown on the moistened soil. Five plant samples were randomly collected at regular intervals (15, 30 and 60 DAS) and they were used for observations of shoot length (cm), root length (cm) and no. of lateral root were measured, fresh weight (g/plant) and dry weights (g/plant) were recorded after oven drying at 70˚C until reaching a constant weight. The number of pods per plant, seeds per pod and weight of 100 seeds was calculated at physiological maturity of the plant.

Chlorophyll content (mg g^{-1} fresh weight of leaves) was determined through organic solvent (80% acetone) extraction method as described by [13]. Proteins were estimated according to the method described by [14]. Total free amino acids were determined by the method described by Hamilton and Van Slyke (1943) [15]. Sugar determined by the method [16] following standard procedures. The significance of treatments was analysed using one way ANOVA. Significant differences between treatments were determined using Turkey's multiple range tests ($P<0.05$).

Results and Discussion

The comparison of groundnut haulm compost and mixed with different bio-fertilizer on the growth of groundnut is shown in Fig. 1 and 2. Shoot length and root length of groundnut *Arachis hypogeae* was increased significantly due to the single application of groundnut haulm compost, mixed with FYM and different bio-fertilizer treatments (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) compared with control. The highest shoot length and root length was obtained with the combined application of groundnut haulm compost mixed with *Rhizobium* in

various stages. In the reason about Phosphate soluble bacteria secrete some organic acids which can solubilize phosphate from insoluble and fixed forms to plant available forms. In this respect, the combined inoculation of *Thiobacillus* with *Rhizobium* increased the shoot, root length and plant biomass on *Arachis hypogeae* [17].

Also, [18] found that the increase in the growth of the biofertilized plants might be due to the ability of *B. megaterium* to produce some growth promoting substances such as IAA, gibberellins and abscisic acid. It is also well-known that B. *megaterium* produces organic, inorganic acids and CO_2 which lead to an increase in soil acidity and consequently convert the insoluble forms of phosphorus into soluble ones [19].

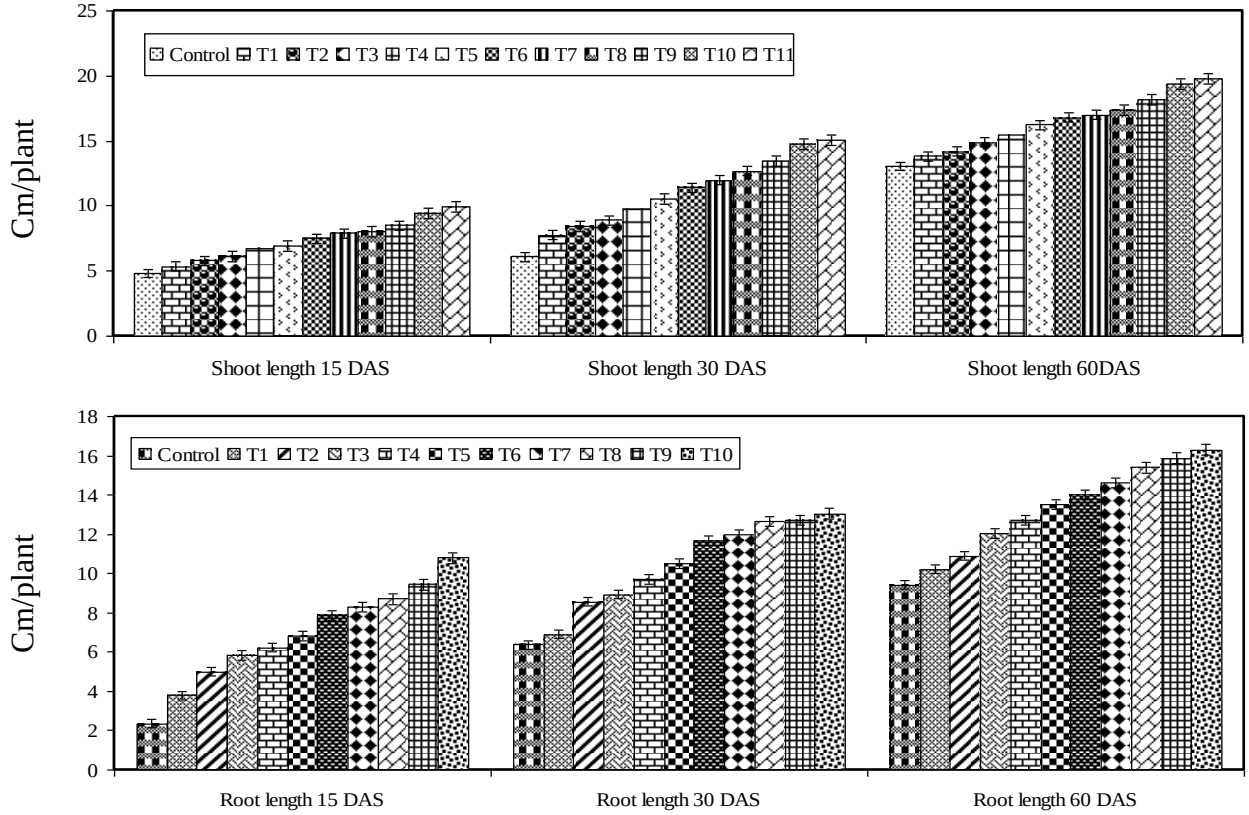

Figure 1, 2. Effect of different biofertilizers on morphological parameters (Shoot and Root length) of groundnut (*Arachis hypogaea* L.) at various stages.

As said by [20] the highest value of stem diameter was obtained by using the combined treatment between Brady+ Azoto + PDB+ AM as it recorded 15.2 cm on *Prosopis chilensis*. Seedlings inoculated with (*Azotobacter chroococcum*, *Azospirillum brazilense* and *B. circulans*) as soil inoculants gave significant increases in shoot length, root length and shoot dry weight when compared with control with the results obtained by [21] on *Moringa oleifera*.

Application of groundnut haulm compost, mixed with FYM and different bio-fertilizer (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) shows the significant difference the fresh weight and dry weight of groundnut *Arachis hypogeae* in various stages in Fig. 3, 4. The groundnut haulm compost and different bio-fertilizers significantly enhanced the plant biomass when compared to control. Combined application groundnut haulm compost and *Rhizobium* gave the highest biomass in leguminous plant groundnut at the same time other inoculations caused the least increases of these parameters. The increased shoot and root dry weight of plant could increase the chance for nutrients uptake through maximum exploitation of soil. Accordingly, similar profile clearly illustrated that the application of biological fertilizers in *Calendula officinallis* L. and *Matricaria recutita* increase in plant height and dry and wet weights of the shoots in the medicinal plants [22, 23]. Clearly illustrated that the dry matter of tomato plant was boosted by the combined use of biofertilizer and N:P:K [24].

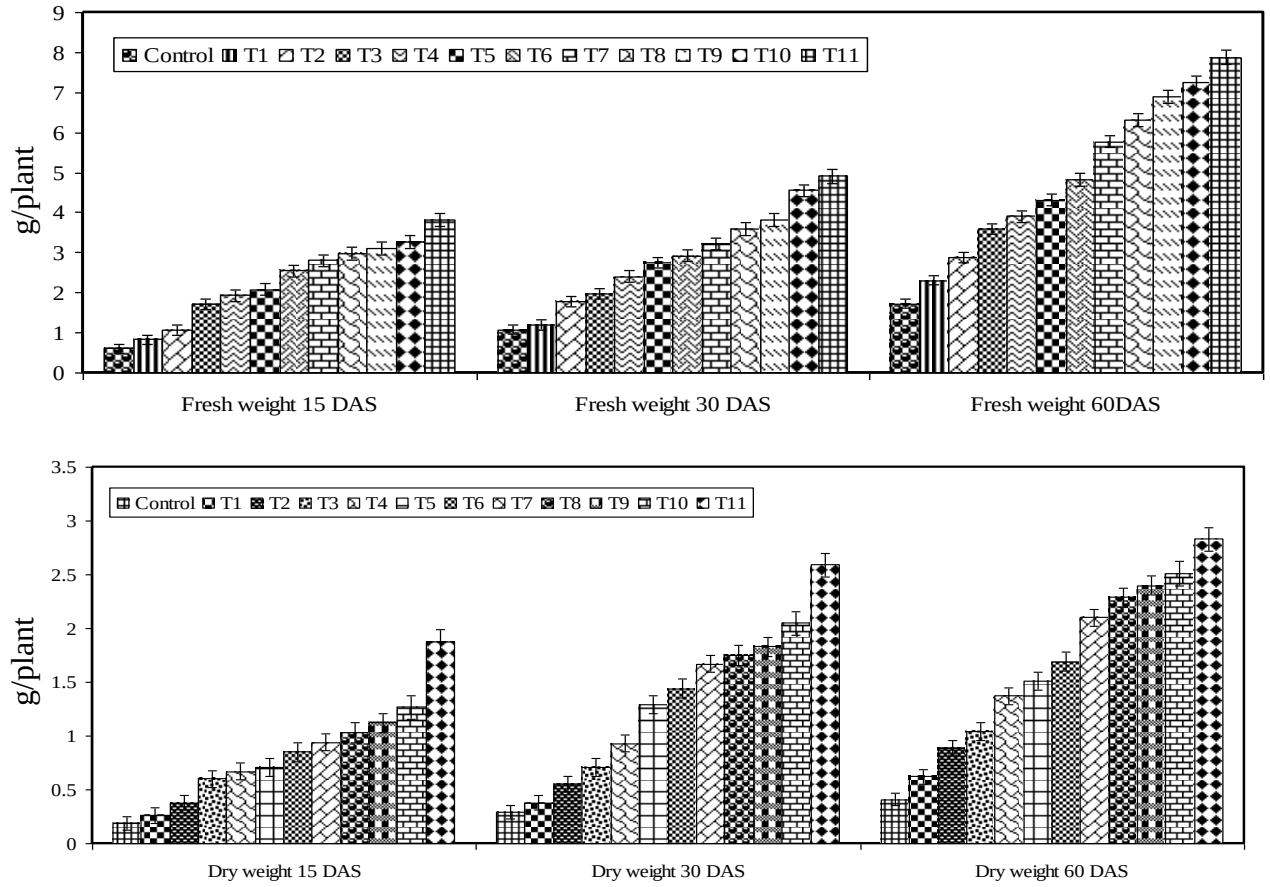

Figure 3, 4. Effect of different biofertilizers on morphological parameters (Fresh and Dry weight) of groundnut (*Arachis hypogaea* L.) at various stages.

Data in Fig. 5 and 6 show that the groundnut haulm compost mixed with FYM and different bio-fertilizers (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) shows the significant increase in the photosynthetic pigments of groundnut *Arachis hypogeae* compared to control. Combined inoculation groundnut haulm compost mixed with *Rhizobium* recorded in highest amount of photosynthetic pigments such as Chl "a", Chl "b" at different stages at the same time groundnut haulm compost mixed with bio-fertilizer (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) inoculation caused the least increase of Chl a, Chl "b". The reason, Increased chlorophyll might be attributed to the increased biological nitro-fixation, better organic nitrogen utilization, better development of root system and the possible synthesis of plant growth regulators like IAA, GA3 and cytokinins [25]. Chlorophyll is the molecule that absorbs sunlight and uses its energy to produce carbohydrates from CO_2 and water. The catabolic products viz., proteins, glycosides, tannins, carotenoids are the secondary metabolites. It has been proved that chlorophyll plays an important role in the ATP generation and prevention of important plant constituents [26].

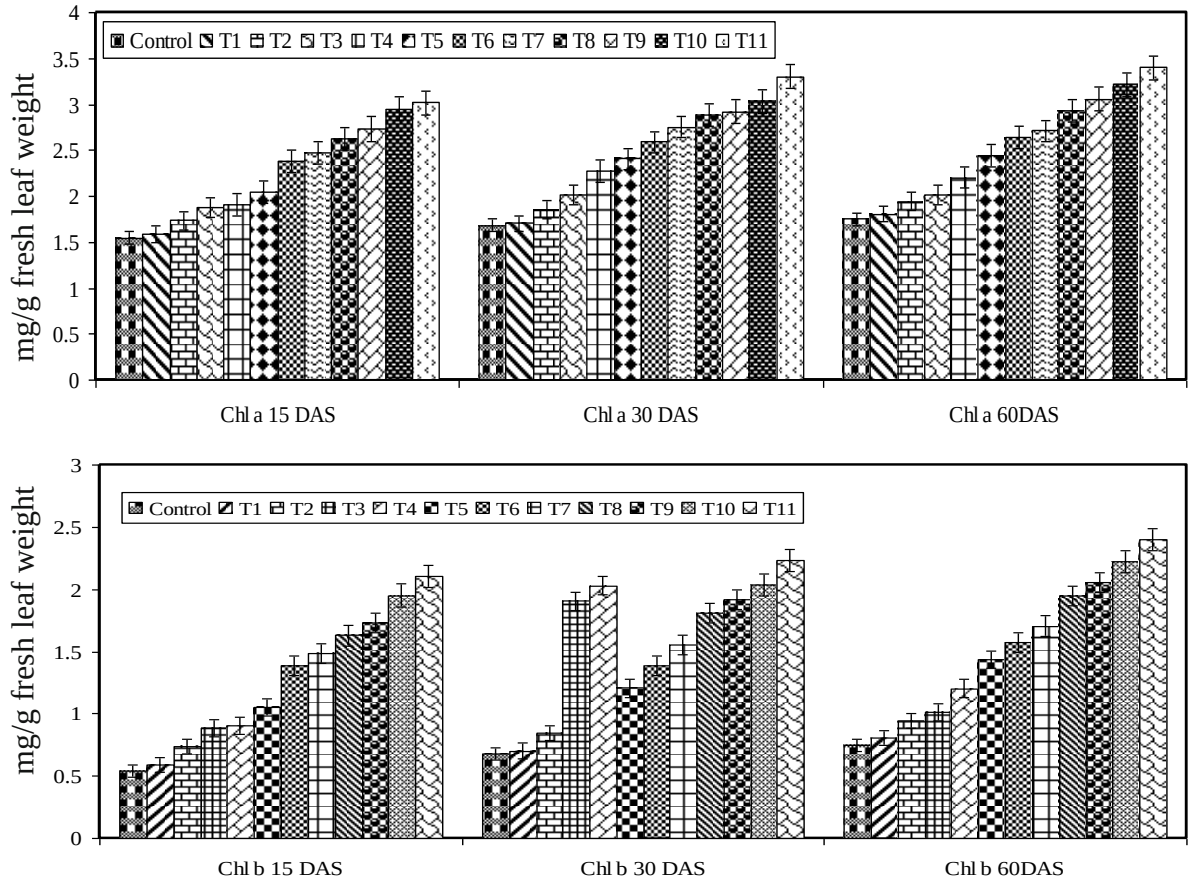

Figure 5, 6. Effect of different biofertilizers on photosynthetic pigments (Chlorophyll "a", "b") of groundnut (*Arachis hypogaea* L.) at various stages.

The obtained results revealed that the Biochemical such as total sugar was significantly increased by application of groundnut haulm compost mixed with FYM and different bio-fertilizer (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) on *Arachis hypogeae* shown in (Fig. 7). The highest Biochemical content total sugar was obtained by using combined inoculation groundnut haulm compost mixed with *Rhizobium* treatment between as it recorded at various stages. However, the inoculation groundnut haulm compost mixed with different bio-fertilizer showed its superiority in this control. In this respect, [27] the combination treatments between PGPR and Mycorrhizae have the highest values in the presence of Putrescence at 2.5 mM compared with the individual application and control.

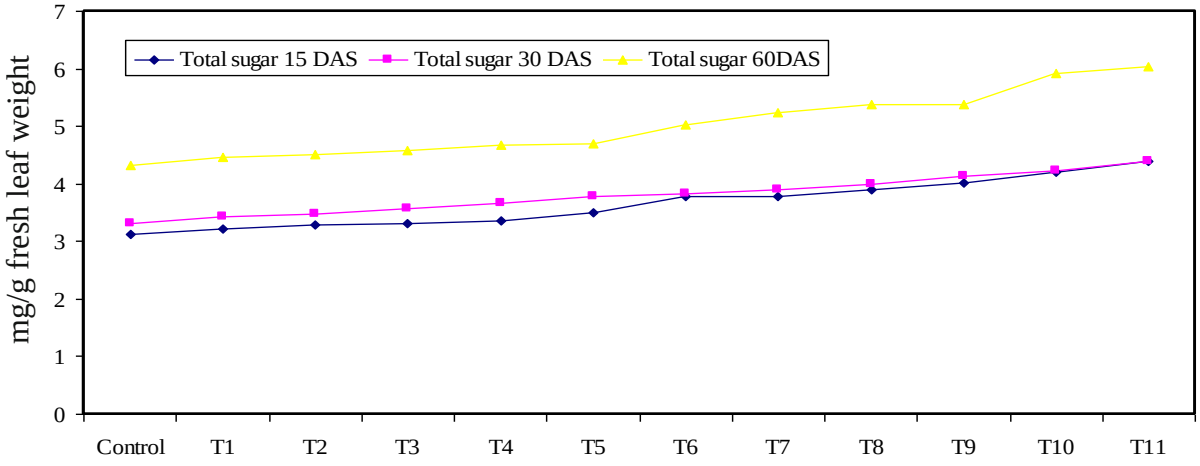

Figure 7. Effect of groundnut haulm compost mixed with FYM and different bio-fertilizer on biochemical (total sugar) content of groundnut (*Arachis hypogaea* L.) at various stages.

From this Fig. 8, 9 it could be concluded that the groundnut haulm compost mixed with FYM and different bio-fertilizer (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) gave an increase in protein and aminoacid content when compared to control at various stages. The treatments which gave the utmost increase in protein and amino acid were groundnut haulm compost mixed with FYM used as combined inoculants while groundnut haulm compost mixed with different Biofertilizers inoculation caused the least increase of protein and amino acid content of *Arachis hypogeae*. It might be ascribed to increased nitrogen uptake of leaves due to the combined inoculation of biofertilizers. Because biofertilizer supports phytohormones production, which stimulates nutrients absorption as well as photosynthesis process, as a result of this protein content increases [28]. In addition, in a study, 1 % biofertilizer (*Ulva lactuca*) along with 50 % recommended rate of chemical fertilizers improved the content of protein and carbohydrate in *Tagetus erecta* [29].

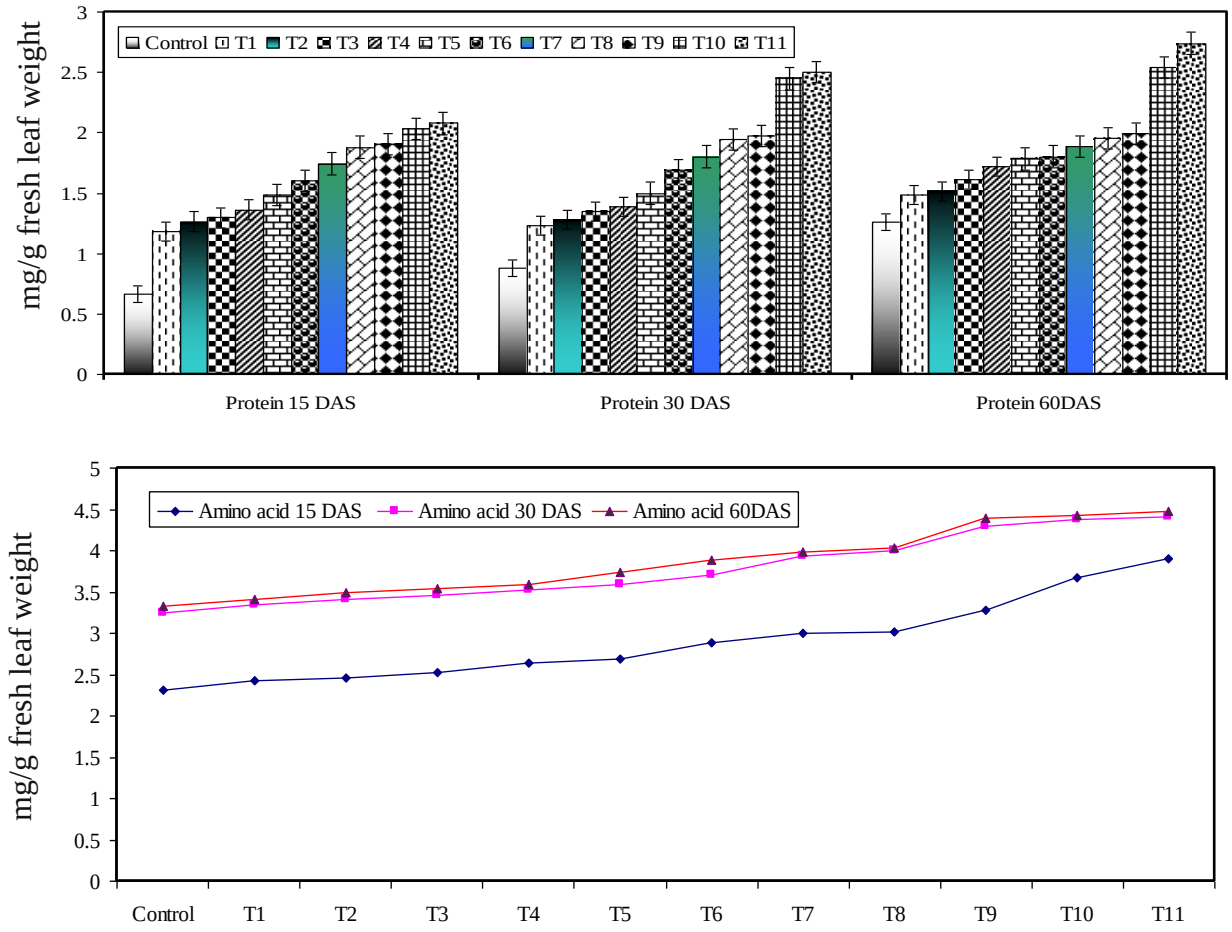

Figure 8, 9. Effect of groundnut haulm compost mixed with FYM and different bio-fertilizer on biochemical (Protein and Aminoacid) of groundnut (*Arachis hypogaea* L.) at various stages.

Fig. 10 indicated that the groundnut haulm compost mixed with FYM and different bio-fertilizer (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) application had a considerable effect on yield (Number of pods per plant and Weight of seeds per 100 seeds) compared with untreated control. It could be noticed that groundnut haulm compost mixed with different bio-fertilizer *Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium* increased *Arachis hypogeae* yield. Concerning to inoculation of Groundnut haulm compost mixed with *Rhizobium* gave the highest yield (Number of pods per plant and Weight of seeds per 100 seeds) various stages. [30, 31] also reported FYM 6.0 t/ha and vermicompost significantly increased number of pods per plant, weight of pods per plant at harvest stages. According to [32] the inoculation of effective microorganisms (EM) at the rate of 90 ml/palm/year combined with potassium sulfate at

1.5 kg/palm/year as a soil inoculation has enhanced fruit set percentage, retained fruit percentage, yield and fruit quality of ‘‘Hayany’’ date palm cv. [33].

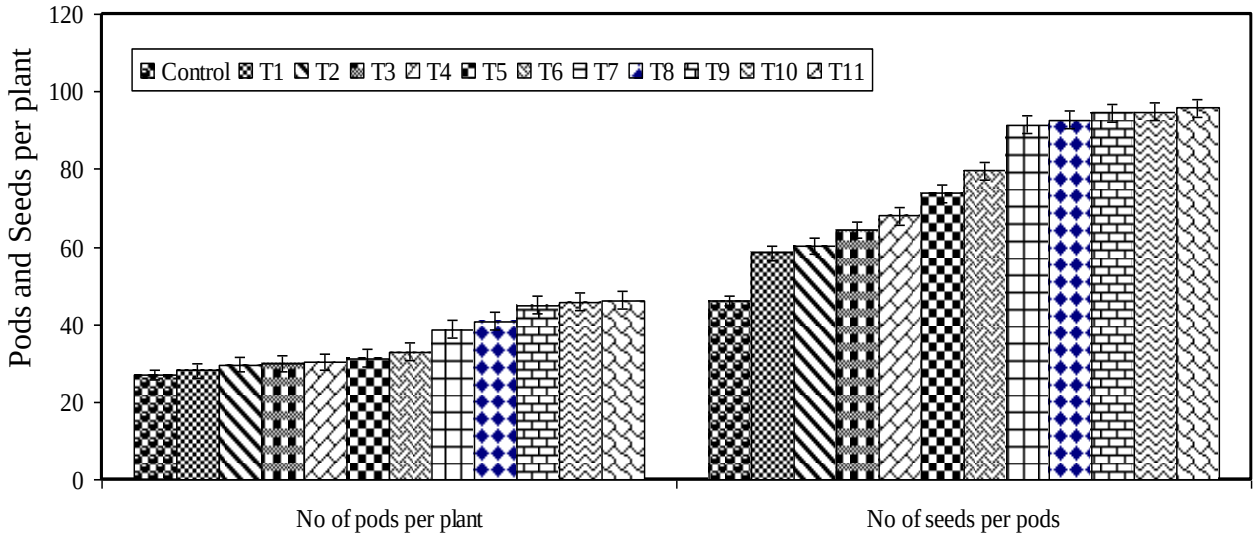

Figure 10. Effect of groundnut haulm compost mixed with FYM and different bio-fertilizer on yield parameters of groundnut (*Arachis hypogaea* L.) at harvesting stage.

Conclusion

From the result of the study presented here, it could be concluded that groundnut *Arachis hypogeae* growth, biochemical and yield could be promoted by the groundnut haulm compost mixed with FYM and different bio-fertilizer (*Azotobacter*, *Azospirillum*, *Phosphobacteria*, *Rhizobium*) application. The combined application of groundnut haulm compost mixed with *Rhizobium* had much more favourable results than another application on the growth, biochemicals and yield. Based on these findings, it may be recommended that the combined application of groundnut haulm compost mixed with *Rhizobium* is found to be economical and suitable for the growth of groundnut.

Conflict of Interest

The authors declare that there is no conflict of interest.

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