Improving Physiological and Yield Traits of Groundnut (*Arachis hypogaea* L.) by using Various Sources of Organic Wastes and Bio Fertilizers, *Rhizobia*

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**ABSTRACT**

**Background:** Investigations were carried out during *Rabi*, 2016 and *Summer*, 2017 at farmer’s field in Kodukkanpalayam village of Cuddalore District, Tamil Nadu to evaluate the direct effects of agro industrial wastes (bagasse ash, pressmud and distillery spentwash), crop residues, farmyard manure with 50% inorganic sources, with and without *Rhizobia* on various traits of groundnut. There were twelve treatments in randomized block design (RBD) with three replications. Results revealed that the growth and yield components of groundnut viz., plant height, DMP and LAI at flowering stage, number of pods per plant, hundred kernel weight, pod yield and kernel yield were greatly influenced by the treatments.

**Methods:** Combination of Pressmud @ 12.5 t ha⁻¹ + *Rhizobia* @ 2 kg ha⁻¹ + 50% RDF (T₁) recorded the highest and followed by the application of distillery spentwash @ 100 m³ ha⁻¹ + *Rhizobia* @ 2 kg ha⁻¹ + 50% RDF (T₂). Similar trend of results was recorded in *summer*, 2017 also. This might be due to the increase in the availability of nutrients, which increased the growth and yield attributes of groundnut in both the seasons. Also, use of agro industrial wastes and biofertilizers in any cropping sequence minimize the cost of inorganic fertilizers, thereby act as a boon to farmers by making the waste into wealth and maintain the soil health and fertility.

**Result:** The study revealed the scope of utilization of agro industrial wastes (bagasse ash, pressmud and distillery spentwash), organic sources (crop residues and FYM) and biofertilizer (*Rhizobia*) in Agriculture.

**Key words:** Biofertilizer, FYM, Growth and Yield, Organic wastes, Yield traits.

**INTRODUCTION**

Groundnut has been rightly acclaimed as *King of Oilseeds* by virtue of its special attention as the source of most important edible oil used in India. From the nutritional point of view, groundnut is popularly known as *Poor man’s Almond, Poor man’s Cashew* and also called as *Peanut, Monkey nut, Earthnut, Wonder nut and Goobers nut*. In India, groundnut is grown in an area of 4.60 million ha with the production of 7.46 MT and the productivity of 1645 kg ha⁻¹. In Tamilnadu, groundnut is grown in an area of 346.60 thousand ha and with the production of 892.30 thousand tonnes with a productivity of 1164 kg ha⁻¹ during 2016-2017 (India Agristat, 2018). It is the most important oil and cash crop of our country. The oil content of groundnut is 45-50 per cent and which is composed of mixed glycerides contains high proportions of essential unsaturated fatty acids (oleic - 50 to 65 per cent and linoleic - 8 to 30 per cent), carbohydrates, proteins (27 to 33 per cent), minerals and fat soluble vitamins like A, B and B₂ (Pandeeswarai and Kalaiarasu, 2017). About 80 per cent of India’s groundnut production is crushed for oil, 12 per cent is used as seed, 5 per cent for food and 2 per cent for export (Vala et al., 2017).

Indian agriculture has shifted from traditional to intensive farming with extensive use of chemical fertilizers and pesticides, which in turn has made our soils largely non-productive. Indian soils are also becoming poor in organic matter and there is a growing concern for regular application of organic manures and recycling crop residues to sustain productivity. Thus, there is a need to apply organic manures as essential part of crop production to balanced plant nutrition for sustainable agriculture.

Now-a-days, the availability of organic manures are scanty due to non interest and non availability of farmers to rear domestic animals. To replace the deficit of organic manure, the agro industrial wastes could be effectively utilized. Today, it is necessary to give importance to the wastes by indicating “wastes are resources” and therefore their management and utilization is must in an eco-friendly approach (Kumarimanimuthu Veeral and Kalaimathi, 2017). These wastes contain an array of valuable plant nutrients and these nutrients are dumped un-utilized by occupying valuable agricultural lands. Apart from sugar, these sugar industries discharge a large amount of by-products with tremendous pollution load (KambleShivaraj Kumar et al.,
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2017). The annual by-product production from these industries are approximately 7 mt of pressmud, 7.5 mt of molasses, 45 mt of bagasse and 15000 million litres of spentwash annually.

Bagasse ash is a multi-processed by-product produced from the milling of sugarcane contains essential amount of nutrients such as P, K, Ca, Mg, S, Zn, Cu, Fe and Mn (Seleman and Kheir, 2018). Pressmud is a soft, spongy, amorphous and dark brown to brownish material contains 50-70 per cent moisture, which is most favorable for soil microorganisms and earthworms. (Tejavath, 2017). The effluents originating from distilleries known as spentwash and strongest organic effluent. Crop residues are the parts or portion of a plant or crop left in the field after harvest, which are essential to maintain or enhance the soil physical, chemical and biological properties and prevent land degradation. (Sankaranarayanan, 2018). Farmyard manure (FYM) is a mixture of cattle dung, urine, litter or bedding material, portion of fodder not consumed by cattle and domestic wastes application of farmyard manure improves the soil fertility (Choudhary et al., 2017). Biofertilizers or microbial fertilizers or microbial inoculants are preparations containing live or latent cells of efficient strain of nitrogen fixing microorganisms used for seed or soil application with the objective of increasing the numbers of microorganisms in soil of groundnut farming.

Considering these facts in view, a field experiment was conducted to study the direct effects of agro industrial waste and biofertilizers on the growth yield and yield attributes of groundnut in Rabi, 2016 and Summer, 2017 under irrigated condition.

Crop management

The field experiment was carried out at Kodukkanpalayam village, Cuddalore District. The experimental farm is geographically situated at 11°46'29.2" N latitude and 79°40'1.38" E longitude with an altitude of about 20.65 m above the mean sea level (MSL). Weather at Kodukkanpalayam village is moderately warm with hot Summer months (Table 1 and 2). The mean annual rainfall is 1500 mm with a distribution of 1000 mm during North-East monsoon (October-December), 400 mm during South-West monsoon (June-September) and 100 mm during hot weather period (Apr-May). The mean maximum temperature fluctuates between 28°C and 37°C with a mean of 33°C, while the minimum temperature ranges from 15°C and 25°C with a mean of 21°C. The weather reports for the experimental field was collected from TNAU, Vegetable Research Station, Palur. The soil of the experimental field is sandy loam with a pH of 7.2. The soil is low in available nitrogen (272.01 kg ha⁻¹), medium in available phosphorus (19.65 kg ha⁻¹) and high in available potassium (286.63 kg ha⁻¹). The experimental field was irrigated with good quality irrigation water obtained from bore well. The experimental field was ploughed twice with the tractor drawn disc plough, followed by harrowing two times to break the clods. The field was properly leveled and plot size of 5 m x 4 m were earmarked with raised bunds all around to prevent seepage of water and nutrients from one plot to another plot. Channels were laid out to facilitate irrigation. There were twelve treatments involving T₁ – Control, T₂ – Bagasse ash @ 10 t ha⁻¹ + 50% RDF, T₃ – Pressmud @ 12.5 t ha⁻¹ + 50% RDF, T₄ – Diluted distillery spentwash @ 100 m³ ha⁻¹ + 50% RDF, T₅ – Crop residues @ 6.25 t ha⁻¹ + 50% RDF, T₆ – T₂ + Rhizobia @ 2 kg ha⁻¹, T₇ – T₃ + Rhizobia @ 2 kg ha⁻¹, T₈ – T₄ + Rhizobia @ 2 kg ha⁻¹, T₉ – T₅ + Rhizobia @ 2 kg ha⁻¹, T₁₀ – Rhizobia @ 2 kg ha⁻¹, T₁₁ – FYM @ 12.5 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹, T₁₂ – 100% RDF by adopting randomized block design (RBD) which was replicated thrice.

The agro industrial wastes and organic sources collected for this study was analyzed in ITALAB Pvt. Ltd., Chennai. Bagasse ash was applied @ 10 t ha⁻¹, Pressmud

Table 1: Direct effects of agro industrial wastes and biofertilizers on growth parameters of groundnut at 60 DAS.

| Treatments                          | Plant height (cm) | DMP (tha⁻¹) | LAI | Plant height (cm) | DMP (tha⁻¹) | LAI |
|------------------------------------|------------------|-------------|-----|------------------|-------------|-----|
| T₁ Control                         | 17.9             | 1.8         | 0.67| 18.0             | 1.9         | 0.66|
| T₂ Bagasse ash @ 10 t ha⁻¹ + 50% RDF | 24.0             | 2.5         | 1.10| 24.8             | 2.7         | 1.12|
| T₃ Pressmud @ 12.5 t ha⁻¹ + 50% RDF | 24.8             | 2.65        | 1.38| 24.9             | 2.7         | 1.44|
| T₄ Diluted distillery spentwash @ 100 m³ ha⁻¹ + 50% RDF | 24.3             | 2.5         | 1.24| 24.4             | 2.7         | 1.2 |
| T₅ Crop residues @ 6.25 t ha⁻¹ + 50% RDF | 23.8             | 2.4         | 0.97| 23.8             | 2.5         | 0.9 |
| T₆ T₂ + Rhizobia @ 2 kg ha⁻¹       | 25.0             | 2.7         | 1.66| 25.05            | 2.8         | 1.69|
| T₇ T₃ + Rhizobia @ 2 kg ha⁻¹       | 27.9             | 2.9         | 1.93| 27.8             | 2.9         | 1.95|
| T₈ T₄ + Rhizobia @ 2 kg ha⁻¹       | 26.5             | 2.8         | 1.80| 26.6             | 2.8         | 1.83|
| T₉ T₅ + Rhizobia @ 2 kg ha⁻¹       | 24.9             | 2.7         | 1.52| 25.1             | 2.7         | 1.55|
| T₁₀ Rhizobia @ 2 kg ha⁻¹           | 18.3             | 2.0         | 0.82| 18.62            | 2.1         | 0.84|
| T₁₁ FYM @ 12.5 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ | 24.5             | 2.5         | 1.51| 24.64            | 2.5         | 1.54|
| T₁₂ 100% RDF                       | 23.3             | 2.4         | 0.95| 23.56            | 2.4         | 0.97|
| SEₙ                                | 1.18             | 0.12        | 0.05| 1.51             | 0.14        | 1.06|
| CD (p = 0.05)                      | 2.45             | 0.25        | 0.30| 0.29             | 0.12        |     |
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Table 2: Direct effects of agro industrial wastes and biofertilizers on yield and yield parameters of groundnut.

| Treatment                | Rabi, 2016 | Summer, 2017 |
|--------------------------|------------|--------------|
|                          | Number of pods plant | Pod yield kg ha⁻¹ | Kernel yield kg ha⁻¹ | Number of pods plant | Pod yield kg ha⁻¹ | Kernel yield kg ha⁻¹ |
| T₁ Control               | 19.9       | 1020         | 539              | 20.1                  | 1148           | 843               |
| T₂ Bagasse ash @ 10 t ha⁻¹ + 50% RDF | 26.1       | 1351         | 822              | 26.2                  | 1554           | 1102              |
| T₃ Pressmud @ 12.5 t ha⁻¹ + 50% RDF | 23.2       | 1774         | 1110             | 23.9                  | 1621           | 928               |
| T₄ Diluted distillery spentwash @ 100 m³ ha⁻¹ + 50% RDF | 16.3       | 1496         | 913              | 15.8                  | 1374           | 762               |
| T₅ Crop residues @ 6.25 t ha⁻¹ + 50% RDF | 27.3       | 1253         | 733              | 28.0                  | 1402           | 1022              |
| T₆ + Rhizobia @ 2 kg ha⁻¹ | 29.4       | 1487         | 1027             | 30.0                  | 1664           | 1490              |
| T₇ + Rhizobia @ 2 kg ha⁻¹ | 27.4       | 1893         | 1498             | 27.4                  | 1696           | 1257              |
| T₈ + Rhizobia @ 2 kg ha⁻¹ | 20.1       | 1690         | 1252             | 20.0                  | 1518           | 830               |
| T₉ + Rhizobia @ 2 kg ha⁻¹ | 13.4       | 1308         | 837              | 13.4                  | 1235           | 689               |
| T₁₀ Rhizobia @ 2 kg ha⁻¹ | 19.9       | 1230         | 684              | 20.0                  | 1355           | 829               |
| T₁₁ FYM @ 12.5 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ | 24.1       | 1383         | 874              | 24.2                  | 1388           | 879               |
| T₁₂ 100% RDF             | 16.3       | 1415         | 823              | 16.0                  | 1410           | 820               |
|             SEd          | 1.07       | 61.56        | 51.89            | 51.89                  | 55.21          | 51.32             |
|             CD (p = 0.05) | 2.22       | 123.13       | 107.6            | 107.62                 | 110.42         | 102.65            |

was applied @ 12.5 t ha⁻¹, the distillery spentwash was applied after dilution @ 100 m³ with water at a ratio of 1:15 (Spentwash: water) in order to neutralize it (Distillery spentwash is acidic). Crop residue @ 6.25 t ha⁻¹ was applied and biofertilizer, Rhizobium was applied @ 2 kg ha⁻¹ of Rhizobium @ 2 kg ha⁻¹ was mixed with 10 kg of sand or well decomposed farmyard manure and broadcasted. The fertilizers were applied to the experimental field as per the recommended manural schedule of 17:34:54 kg of N, P, O₅ and K₂O ha⁻¹, respectively. Groundnut variety VRI 2 was chosen for this study and VRI 2 is popularly cultivated in this region for its suitability and yield potentiality. It is a bunch plant. Preventive plant protection measures were taken to protect the crop from damage of pest and diseases. Harvesting of groundnut was done by hand pulling of plants. The whole plants from the net plot leaving the border rows and pods were stripped manually. The pods were dried plot-wise separately under sun and the dry weight was recorded at 12 per cent of moisture. The data on varied growth and yield biometrics viz., plant height, LAI, DMP, number of pods plant⁻¹, pod yield, kernel yield, haulm yield, shelling percentage and test weight in groundnut were furnished. The observations recorded during the experiments were analyzed statistically using the procedure outlined by Gomez and Gomez (1984). Wherever the results were found significant, the critical differences were worked out at 0.05% probability level.

RESULTS AND DISCUSSION

From this, it was revealed that application of pressmud @ 12.5 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF (T₄) produced the tallest plants with the plant height of 27.9 and 27.8 cm at 60 DAS during rabi, 2016 and summer, 2017. This was followed by T₆ (diluted distillery spentwash @ 100 m³ ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF) and T₇ (bagasse ash @ 10 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF). The least plant height of 17.9 and 18.0 cm was recorded under control (T₁) during both seasons. The same trend was followed in DMP and LAI in both seasons. The data recorded on number of pods plant⁻¹, pod and kernel yield were observed at harvest stage were furnished in Table 2. Among the various agro industrial wastes applied, application of Pressmud @ 12.5 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF (T₄) registered the highest pod number plant⁻¹ followed by T₆ (diluted distillery spentwash @ 100 m³ ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF) and T₇ (bagasse ash @ 10 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF).

Among the various agro industrial wastes/FYM tested with and without Rhizobia, the treatment T₇ (pressmud @ 12.5 t ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF) and T₆ (diluted distillery spentwash @ 100 m³ ha⁻¹ + Rhizobia @ 2 kg ha⁻¹ + 50% RDF) greatly enhanced the growth attributes viz., plant height, LAI and DMP at different stages. As pressmud was a good source of nutrients, it might have corrected the nutrient deficiencies of the experimental soil and in turn might have produced favourable growth components. Further, its combination with biofertilizers such as Rhizobia fix 200-300 kg N ha⁻¹ which could be a potential tool in increasing the nutrient availability in soil (Mathivanan et al., 2017) and this could have contributed to the favourable growth and development of groundnut as evidenced from the present study.
Favourable effect of distillery spentwash observed in the present study was in line with the findings of Rathika and Ramesh (2013) who reported an increase in DMP and LAI with an addition of distillery spentwash. When pressmud was combined with *Rhizobia*, it exerted a remarkable effect on growth attributes of groundnut. This could be due to root elongation, more nutrient uptake by groundnut (Kausale et al., 2009), increased the plant height, dry weight of root and shoot, increased DMP. Role of *Rhizobia* on the transformation and nitrogen fixation was well established by Sharma et al. (2011) Application of pressmud @ 12.5 t ha\(^{-1}\) + *Rhizobia* @ 2 kg ha\(^{-1}\) +50% RDF (T\(_5\)) had significant influence on yield parameters and yield of groundnut. The trend on the effects of various industrial wastes with *Rhizobia* was observed to be consistent with that of growth parameters and nutrient uptake pattern. Compared with control, the above treatment gave an additional yield of 1820 kg ha\(^{-1}\). FYM/distillery spentwash when tried with *Rhizobia* gave better yield than pressmud/distillery spentwash alone.

The enhanced nutrient availability in the soil, generally characterized by coarse texture, poor organic carbon and favourable changes in physical and microbiological properties might be ascribed for the marked response in yield in groundnut. The increase in yield of groundnut may be owing to application of pressmud and its enrichment with *Rhizobia*, which supplied secondary and micronutrients along with major nutrients besides improving the soil condition, which enhanced the root proliferation and source to sink relationship. It stimulated the necessary growth and development in groundnut leading to better yield. The significant effect of pressmud was mainly attributed to its nutrient content and higher biological activity as stated by Banulekha (2007) and Pujar Amit (2017).

The results have evidently proved the advantage of combining industrial wastes such as bagasse ash, pressmud and distillery spentwash for crop production. Liberation of nutrients depend upon the absolute nutrient condense of the substances and of the carbonaceous compounds of the manures. Because of good supply of nutrients from pressmud, FYM, bagasse ash and distillery spentwash narrowed the C: N in the above combination of organic, inorganic and biofertilizers, there might have been higher mineralization of nutrients during high nutrient demand period. Adequate supply of macro and micro nutrients from the aforesaid combination might have favourable physiological process of the plants resulting in transport of adequate quantity of minerals. The present results on the effects of bagasse ash/pressmud/distillery spentwash on yield and yield attributes of groundnut are in agreement with the findings of Aulakh et al. (2007). The application of pressmud with biofertilizers (*Rhizobia*) increased the 100 grain weight and kernel yield in groundnut. The beneficial effect of combining pressmud/distillery spentwash along with *Rhizobia* on groundnut was well demonstrated by Akbari et al. (2011), Nana et al. (2015) and Bharath Tejavath (2017).

**CONCLUSION**

Based on the above results of the series of laboratory studies and field studies conducted, it could be concluded that the application of pressmud @ 12.5 t ha\(^{-1}\) + *Rhizobia* @ 2 kg ha\(^{-1}\) + 50% RDF (T\(_5\)) to groundnut and succeeding finger millet holds a promise as an effective agro technology for improved crop production and also for maintenance of soil fertility. The study clearly proved the beneficial effects of integrated agro industrial wastes such as bagasse ash/pressmud/distillery spentwash with *Rhizobia* in the improvement of crop yield in groundnut-finger millet sequential system without prejudice to soil fertility system. Further, the study brought about the scope of utilization of industrial wastes such as bagasse ash/pressmud/distillery spentwash in agriculture, which could go for a long way in solving the waste management problem faced by sugar industries.

Besides, the study offers a great scope in effective utilization of agro industrial wastes in agriculture and safety disposal of agro industrial wastes. In addition to the above viable benefits, the other indirect benefits by adopting the land application of agro industrial wastes and organic sources are pollution problems due to lack of disposal mechanism in the industrial areas can be reduced thereby reducing accumulation problem in the industries, significant reduction in input costs without reduction in the yield and The economic conditions of the farmers will be improved.

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**REFERENCES**

Akbari, K.N., M.V. Ramdeyputra, G.S. Sutaria, V.D. Vora and D.R. Padmani. (2011). Effect of organics, bio and inorganic fertilizer on groundnut yield and its residue effect on succeeding wheat crop. Legume Res. 34(1): 45-47.

Aulakh, M.S., Garg, A.K. and Kabba, B.S. (2007). Phosphorus accumulation, leaching and residual effects on crop yield from long-term application of bagasse ash in the subtropics. Soil use and Manag. 23: 417-427.

Badawi, F.S.F., A.M.M. Biomy and A.H. Desoky, (2011). Peanut plant growth and yield as influenced by co-inoculation with *Bradyrhizobium* and some rhizo-microorganisms under sandy loam soil conditions. Annl. Agrl. Sci. 56: 17-25.

Banulekha, C. (2007). Eco-friendly utilization of organic rich Biomethanated distillery spentwash and pressmud for maximizing the biomass and quality of Cumbu Napier hybrid fodder (CO-3), M. Sc., (Env. Sci.), Thesis, Tamilnadu Agricultural University, Coimbatore.

Bharath Tejavath (2017). Direct and residual effect of integrated nutrient management in Maize-Groundnut crop sequence in Southern Telangana Region. Ph.D Thesis, Telangana State Agricultural University, Hyderabad.

Chavan, A.P., N.K. Jain and U.V. Mahadkar. (2014). Direct and residual effects of fertilizers and biofertilizers on yield,
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nutrient uptake and economics of Groundnut (Arachis hypogaea L.) - Rice (Oryza sativa) cropping system. Indian J. Agron. 59(1): 53-58.

Choudhary, S.K., M.K. Jat, S.R. Sharma and P. Singh. (2017). Effect of INM on soil nutrient and yield in Groundnut field of semiarid area of Rajasthan. Legume Res. 34(4): 283-287.

Das, K., D.N. Meadhi and B. Guha. (2011). Recycling effect of crop residues with chemical fertilizers to physico-chemical properties of soil and Rice (Oryza sativa) yield. Indian J. Agron. 46: 640-653.

Elaiya Raja, R. and R. Elango. (2017). Studies on composting and recycling of sugar industrial waste. Int. J. Curr. Res. Biol. and Medicine. 2(1): 1-13.

Gabasawa, A.I., H. Mohammed and A.A. Yusuf. (2014). Biological nitrogen fixation and pod yield of Groundnut (Arachis hypogaea L.) as influenced by a salt affected alfisol at Kadawa, Nigeria. Int. J. Pl. and Soil Sci. 3(11): 1479-1489.

India Agristat. (2018). Socio economic statistical information about Agriculture in India, New Delhi.

KambleShivaraj Kumar, M., Gopal Dasar, V. and Gundlur, S.S. (2017). Distillery spentwash production, treatment and utilization in Agriculture-A review. Int. J. Pure and Appl. Biosci. 5(2): 379-386.

Kausale, S.P., Shinde, S.B., Patel, L.K. and Borse, N.S. (2009). Effect of integrated nutrient management on nodulation, dry matter accumulation and yield of summer groundnut at South Gujarat conditions. Legume Res. 32(3): 227-229.

Kumarimanmuthu Veeral, D. and Kalaimathi, P. (2017). Utilization of diluted distillery spentwash as liquid fertilizer for enhancing soil fertility. Int. J. Environ. and Polln. Res., 5(4): 1-3.

Malligawad Lokanath, H. (2010). Effect of organics on the productivity of Groundnut and its residual effects on succeeding Safflower under rainfed farming situations. All India Coordinated Research Project on Groundnut, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India.

Mathivanan, S., Chidambaram, A.L.A. Amalan Robert, G. and Kalaikandhan, R. (2017). Impact of PGPR inoculation on photosynthetic pigment and protein contents in Arachis hypogaea L. J. Sci. and Agric. 1: 29-36.

Nana Ewusi, Alemneh Mensah and Argaw Anteneh. (2015). Rhizobia strain and host legume interaction effects on nitrogen fixation and yield of grain legume: A Naorem Anand Kumar, Udayana Shiva Kumar, Naorem Arunkumar Singh and Selvaraj, C. (2017). Efficacy of distillery spentwash as an economical soil amendment for sodic soils. Bull. Environ. Pharmacol. and Life Sci. 6(3): 23-27.

Paul Sebastian, S., Uddayasoorian, C. and Jayabalakrishnan, R.M. (2009). Influence of amendments on soil fertility status of Sugarcane with poor quality irrigation water. Sugar Tech. 11(4): 338-346.

Pujar AmitM. (2017). Role of integrated nutrient management to sustain productivity of intercropping system. Int. J. Sci. and Engg. Manag. 2(10): 2456-2465.

Rathika, S. and Ramesh, T. (2013). Eco-friendly utilization of waste water in Agriculture. Asian J. Envion. Sci. 8(1): 58-63.

Sankaranarayanan, K. (2018). Nutrientpotential of organic sources for soil fertility management in organic Cotton production. Annual Report, Central Institute of Cotton Research, Coimbatore.

Sarwar Muhammad Aleem, Ibrahim Muhammad, Tahir Muhammad, Ahmad Kafeel, Khan, Zafar Iqbal and Valeem Ehsan Elahi (2010). Appraisal of pressmud and inorganic fertilizers on soil properties, yield and Sugarcane quality. Pakistan J. Bot. 42(2): 1361-1367.

Seleiman, M. F. and Kheir, A.M.S. (2018). Saline soil properties, quality and productivity of Wheat grown with bagasse ash and thioarea in different climatic zones. Chemosphere. 193: 538-546.

Sharma, Pushpa Sardana Virender and Kandola, S.S. (2011). Response of Groundnut (Arachis hypogaea L.) to Rhizobium inoculation. Libyan Agric. Res. Center J. Int. 2(3): 101-104.

Singh, N.J., H.S. Athokpam, K.N. Devi, N. Chongtham, N.B. Singh, P.T. Sharma and S. Dayananda. (2015). Effect of farmyard manure and pressmud on fertility status of alkaline soil under Maize-Wheat cropping sequence. African J. Agri. Res. 10(24): 2421-2431.

Tejavath Bharath. (2017). Direct and residual effect of integrated nutrient management in Maize-Groundnut crop sequence in Southern Telangana Region. Ph.D Thesis, Telangana State Agricultural University, Hyderabad.