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Enhancing Physiological and Yield Characteristics of Groundnut (Arachis Hypogaea L.) Through the Application of Different Organic Waste Sources and Biofertilizers, Rhizobia

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Abstract

Background: Research was conducted during the Rabi season of 2018 and the Summer season of 2019 at a farmer's field in Bikaner. The aim was to assess the direct impacts of agro-industrial wastes (such as bagasse ash, pressmud, and distillery spentwash), crop residues, farmyard manure mixed with 50% inorganic sources, with and without the addition of Rhizobia, on various characteristics of groundnut. Twelve treatments were applied in a randomized block design (RBD) with three replications. Results indicated significant effects of the treatments on the growth and yield components of groundnut, including plant height, dry matter production (DMP), leaf area index (LAI) at the flowering stage, number of pods per plant, hundred kernel weight, pod yield, and kernel yield.

Methods: The combination of Pressmud at 12.5 t ha-1 + Rhizobia at 2 kg ha-1 + 50% recommended dose of fertilizer (RDF) (T7) demonstrated the highest performance, followed by the application of distillery spentwash at 100 m3 ha-1 + Rhizobia at 2 kg ha-1 + 50% RDF (T8). Similar results were observed during the Summer season of 2019. This can be attributed to the enhanced availability of nutrients, leading to improved growth and yield attributes of groundnut in both seasons. Additionally, the use of agro-industrial wastes and biofertilizers in cropping sequences can reduce the reliance on costly inorganic fertilizers, thereby converting waste into a resource while maintaining soil health and fertility.

Result: The study highlights the potential for utilizing agro-industrial wastes (bagasse ash, pressmud, and distillery spentwash), organic sources (crop residues and farmyard manure), and biofertilizers (Rhizobia) in agricultural practices.

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 1465 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 2018-2019 (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 B_2

(Pandeeswari and Kalaiarasu, 2019). 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.,* 2019). 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 applicationof 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 arescanty 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, 2019). 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 (Kamble Shivaraj Kumar *et al.,* 2019).

The annual by-product production from these industries areapproximately 7 mt of pressmud, 7.5 mt of molasses, 45 mtof 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 ofnutrients such as P, K, Ca, Mg, S, Zn, Cu, Fe and Mn(Seleiman and Kheir, 2018). Pressmud is a soft, spongy, amorphous and dark brown to brownish material contains50-70 per cent moisture, which is most favorable for soilmicroorganisms and earthworms (Tejavath, 2019). Theeffluents originating from distilleries known as spentwashand strongest organic effluent. Crop residues are the partsor 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 landdegradation. (Sankaranarayanan, 2018). Farmyard manure(FYM) is a mixture of cattle dung, urine, litter or beddingmaterial, portion of fodder not consumed by cattle anddomestic wastes application of farmyard manure improvesthe soil fertility (Choudhary *et al.,* 2019). Biofertilizers ormicrobial fertilizers or microbial inoculants are preparationscontaining live or latent cells of efficient strain of nitrogenfixing microorganisms used for seed or soil application withthe 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 wasteand biofertilizers on the growth yield and yield attributes of groundnut in *rabi*, 2018 and *summer*, 2019 under irrigated condition. 79°40′1.38″ E longitude with an altitude of about 20.65 m above the mean sea level (MSL). W eather 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°Cwith 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 seepageof water and nutrients from one plot to another plot. Channels were laid out to facilitate irrigation. There were twelve treatments involving T_1 – Control, T_2 – Bagasse ash @ 10 tha^{-1} + 50% RDF, T_3 – Pressmud @ 12.5 $t_0 ha^{-1}$ + 50% RDF, T_4 – Diluted distillery spentwash @ 100 m^3 ha^{-1} + 50% RDF, T_5 – Crop residues @ 6.25 t ha^{-1} + 50% RDF, T_6 - T + *Rhizobia* @ 2 kg ha^{-1}, T_7 - T + *Rhizobia* @ 2 kg ha^{-1}, T_8 – T+ *Rhizobia* @ 2 kg ha^{-1}, T_2 – T_4 + *Rhizobia* @ 2 kg ha^{-1}, T_3 –*Rhizobia* @ 2 kg ha^{-1}, T_5 – FYM @ 12.5 t ha^{-1} + *Rhizobia* @

MATERIALS AND METHODS

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 2 kg ha^{-1}, T – 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 was applied @ 12.5 t ha^{-1}, the distillery spentwash was applied after dilution @ 100 m^3 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

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

Treatments		*Rabi*, 2018			*Summer*. 2019		
		Plant height (cm)	DMP (t ha^{-1})	LAI	Plant height (cm)	DMP	LAI (t ha^{-1})
T_1	Control	17.9	1.8	0.67	18.0	1.9	0.66
T_2	Bagasse ash @ 10 t ha^{-1} + 50% RDF	24.0	2.5	1.10	24.8	2.7	1.12
T_3	Pressmud @ 12.5 t ha^{-1} + 50% RDF	24.8	2.65	1.38	24.9	2.7	1.44
T_4	Diluted distillery spentwash @ 100 m^3 ha^{-1} + 50% RDF	24.3	2.5	1.24	24.4	2.7	1.2
T_5	Crop residues @ 6.25 t ha^{-} + 50% RDF	23.8	2.4	0.97	23.8	2.50	0.9
T_6	T_2 + *Rhizobia* @ 2 kg ha^{-1}	25.0	2.7	1.66	25.05	2.8	1.69
T_7	T_3 + *Rhizobia* @ 2 kg ha^{-1}	27.9	2.9	1.93	27.8	2.9	1.95
T_8	T_4 + *Rhizobia* @ 2 kg ha^{-1}	26.5	2.8	1.80	26.6	2.8	1.83
T_9	T_5 + *Rhizobia* @ 2 kg ha^{-1}	24.9	2.7	1.52	25.1	2.7	1.55
T_{10}	*Rhizobia* @ 2 kg ha^{-1}	18.3	2.0	0.82	18.62	2.1	0.84
T_{11}	FYM @ 12.5 t ha^{-1} + *Rhizobia* @ 2 kg ha^{-1}	24.5	2.5	1.51	24.64	2.57	1.54
T_{12}	100% RDF	23.3	2.4	0.95	23.56	2.4	0.97
	SEd	1.18	0.12	0.05	1.51	0.14	1.06
	CD (p = 0.05)	2.45	0.25	0.10	3.02	0.29	0.12

RESULTS AND DISCUSSION

From this, it was revealed that application of pressmud @ 12.5 t ha^{-1} + *Rhizobia* @ 2 kg ha^{-1} + 50% RDF (T) producedthe tallest plants with the plant height of 27.9 and 27.8 cm at 60 DAS during *rabi,* 2018 and *summer*, 2019. This was followed by T (diluted distillery spentwash @ 100 m^3 ha^{-1}+decomposed farmyard manure and broadcasted. The fertilizers were applied to the experimental field as per the recommended manurial schedule of 17:34:54 kg of N, P_2O_5 and K O 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 bunchtype with the duration of 105 days. The groundnut seeds were treated with *Pseudomonas fluorescence* @ 10 g kg^{-1}. Seeds were sown by adopting dibbling method, one seed $hill^{-1}$ at a depth of 3 to 5 cm and spacing of 30 x 10 cm werefollowed as per the recommended agronomic practices. Standard cultural practices were adopted like gap filling at 10 DAS, manual weeding at 20 and 40 DAS. Gypsum was applied at 40th day of sowing followed by earthing up was done. 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 recordedat 12 per cent of moisture. The data on varied growth and yield biometrics *viz.,* plant height, LAI, DMP, number of $podsplant^{-1}$, 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). W herever the results were found significant, the critical differences were worked out at 0.05%probability level.

Rhizobia @ 2 kg ha + 50% RDF) and T_6 (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 (T_1) 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 (T) registered the highest pod number $plant^{-1}$ followed by T (diluted distillery spentwash@ 100 m^3 ha^{-1} + *Rhizobia* @ 2 kg ha^{-1} + 50% RDF) and T_6 (bagasse ash @ 10 t ha + *Rhizobia* @ 2 kg ha^{-1} + 50% RDF).

Among the various agro industrial wastes/FYM tested with and without *Rhozobia*, the treatment T_7 (pressmud @12.5 t ha^{-1} + *Rhizobia* @ 2 kg ha^{-1} + 50% RDF)[7] and T (diluted distillery spentwash @ 100m^3 ha^{-1} +*Rhizobia* @ 2 kg ha^{-1} + 50% RDF)[8] greatly enhanced the growth attributes *viz.,* plantheight, 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*., 2019) and this could have contributed to the favourable growth and development of groundnut as evidenced from the present study.

Table 2: Direct effects of agro industrial wastes and biofertilizers on yield and yield parametersof groundnut.

Treatment		*Rabi*, 2018			*Summer*, 2019		
		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}
T_1	Control	19.9	1020	539	20.1	1148	843
T_2	Bagasse ash @ 10 t ha^{-1} + 50% RDF	26.1	1351	822	26.2	1554	1102
T_3	Pressmud @ 12.5 t ha^{-1} + 50% RDF	23.2	1774	1110	23.9	1621	928
T_4	Diluted distillery spentwash @ 100 m^3 ha^{-1} + 50% RDF	16.3	1496	913	15.8	1374	762
T_5	Crop residues @ 6.25 t ha^{-} + 50% RDF	27.3	1253	733	28.0	1402	1022
T_6	T_2 + *Rhizobia* @ 2 kg ha^{-1}	29.4	1487	1027	30.0	1664	1490
T_7	T_3 + *Rhizobia* @ 2 kg ha^{-1}	27.4	1893	1498	27.4	1696	1257
T_8	T_4 + *Rhizobia* @ 2 kg ha^{-1}	20.1	1690	1252	20.0	1518	830
T_9	T_5 + *Rhizobia* @ 2 kg ha^{-1}	13.4	1308	837	13.4	1235	689
T_{10}	*Rhizobia* @ 2 kg ha^{-1}	19.9	1230	684	20.0	1355	829
T_{11}	FYM @ 12.5 t ha^{-1} + *Rhizobia* @ 2 kg ha^{-1}	24.1	1383	874	24.2	1388	879
T_{12}	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

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 pressmudwas 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) 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 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 (2019).

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 withthe 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 (2019).

CONCLUSION

Based on the above results of the series of laboratory studiesand 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) 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 integration of 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 prejuidice 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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