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Effect of biofertilizers and phosphorus on growth and yield of groundnut (*Arachis hypogaea* L.)

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Abstract
Groundnut (*Arachis hypogaea* L.) is an important oilseed crop cultivated worldwide. The present study was conducted to evaluate the effect of biofertilizers and phosphorus on the growth and yield of groundnut. A field experiment was conducted using a randomized complete block design with four replications. The treatments included different combinations of biofertilizers (Rhizobium and Phosphorus solubilizing bacteria and VAM) and phosphorus levels (30, 45, and 60 kg P_2O_5 ha/1). The results indicated that the application of biofertilizers and phosphorus significantly influenced the growth and yield parameters of groundnut. The combined application of Rhizobium along with VAM and 60 kg P_2O_5 ha/1 significantly increased plant height, number of branches per plant, number of pods per plant, pod yield, and oil content compared to the control. These findings suggest that the integrated use of biofertilizers and phosphorus can enhance the growth and yield of groundnut, thereby improving its productivity and economic returns for farmers. The result reported the application of Rhizobium along with VAM and Phosphorus 60 kg/ha recorded maximum plant height (58.39 cm), maximum dry weight (38.46 g/plant), nodules per plant (46.56), number of pod per plant (28.87), seed index (38.81), kernel yield (2.47 t/ha), haulm yield (2.97) were recorded in (treatment – 9) that is with Rhizobium + VAM + Phosphorus 60 kg/ha.

Keywords: Biofertilizers, phosphorus, growth, yield, oil content

Introduction

Peanut (*Arachis hypogaea* L.), also known as groundnut, is an important food legume in tropical and subtropical regions and ranks 13th among the most important cash crops. It can be cultivated in different climatic conditions at latitudes of 40° S and 40° N, where the amount of rainfall during the growing season exceeds 500 mm. Although it is cultivated on an area of about 24 MHA, it is grown on a large scale mainly in India, China, the United States, Senegal, Indonesia, Nigeria, Brazil, and Argentina. In India, groundnut grows in an area of about 8 MHA produces 10.3 million tonnes (1998-99), and is the most important oil crop in the country. Although India is first in the areca industry, its productivity is much lower than that of the United States, China, and many other countries (Singh, 1999) [1]. Groundnut (*Arachis hypogaea* L.) is an important food legume in terms of consumption and production in Ghana. In addition to providing farmers with income, peanuts are a valuable source of high-quality protein and oil. The seeds of most peanut varieties contain approximately 50% oil, 25-30% proteins, 20% carbohydrates, and 5% fiber and ash, which contribute significantly to human nutrition (Fageria *et al.*, 1997) [9]. The oil content of peanuts makes it an important human food and animal feed, but the relative proportion of fatty acids varies according to geographic location, season, and growing conditions (Brown *et al.*, 1975) [10]. Groundnut is called a self-fertile plant, but nevertheless, it is a very exhausting crop compared to other leguminous plants, because after harvesting, a very small part of the plant residues remains in the soil (Varade and Urkude, 1982) [4]. An average peanut crop with a yield of 19 q ha/1 removes approximately 170 kg N, 30 kg P, 110 kg K, 39 kg Ca, and 15 kg S from the soil (Aulakh *et al.*, 1985) [3]. Plants require nitrogen (N) in relatively greater amounts than other elements. As a crop of the Leguminosae family, groundnut can bind up to 40-80 kg N ha/1 year/1. Approximately 86-92% of the groundnut's own nitrogen comes from biological nitrogen fixation (BNF), which corresponds to 125-178 kg N ha/1.

Although legumes can fix their own nitrogen, they often need phosphorus, calcium and other nutrients for good seed formation. Phosphorus (P) is the second most important nutrient for crop growth and good yield. The most obvious effect of P is on the root system of the plant. Nodular legumes require more P than non-nodular crops because it play an important role in nodule formation and atmospheric nitrogen fixation. Since P plays an important role in plant physiological processes, application of P in its nutrient-deficient soil increases peanut yield (Kabir *et al*., 2013) [2]. Phosphorus (P) is one of the most important other primary nutrients. It plays a central role in almost all biochemical processes involved in energy transfer. The ability of soil to supply crops with phosphorus varies widely, as only a small fraction of total soil P is available to crops. It plays an important role in nodulation, and biological nitrogen fixation and increases the availability of residual nutrients (Yakubu *et al.,* 2010) [5], and significantly contributes to the healthy and efficient growth of roots (Mitran *et al*., 2018) [6]. Today, the continuous use of inorganic fertilizers to strengthen food production, so that it corresponds to the food needed to grow the population, which immediately entails costs. Excessive use of these fertilizers alone is detrimental to soil health. Biofertilizers are most likely called bioinoculants because they are preparations containing live or inactive cells of microorganisms that help crops absorb nutrients through their interactions in the rhizosphere when applied through seeds or soil. This accelerates associated microorganisms, and soil processes that increase the amount of nutrients in an identical form that is easily absorbed by plants (Bahadur *et al*., 2006) [7]. They also help to reduce the harmful effects of excessive and unbalanced use of chemical fertilizers, which can reduce the dose of chemical fertilizers by 25-50%. Vesicular arbuscular mycorrhiza (VAM) forms a mutual symbiosis with the host plant and positively affects nutrition and soil fertility, thus having a positive effect on plant growth and health (Ramaswamy *et al*., 2011) [8].

Material and Method

The investigation was carried out at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture Science and Technology (SHUATS), Naini, Prayagraj, UP, during Kharif 2022-23. The treatment consists of T_1: Rhizobium + Phosphorus 30kg/ha, T_2: Rhizobium + PSB + Phosphorus 30kg/ha, T_3: Rhizobium + VAM + Phosphorus 30kg/ha, T_4: Rhizobium + Phosphorus 45 kg/ha, T_5: Rhizobium + PSB + Phosphorus 45 kg/ha, T_6: Rhizobium + VAM + Phosphorus 45 kg/ha, T_7: Rhizobium + Phosphorus 60 kg/ha, T_8 Rhizobium + PSB + Phosphorus 60 kg/ha, T_9: Rhizobium + VAM + Phosphorus 60 kg/ha, T_{10}: Control (RDF): 20:40:20 NPK kg/ha. The experiment was laid out in Randomized Block Design, with 10 treatments replicated thrice. The observations were recorded for Plant height, Number of root nodule/plant, Dry weight of plant g/plant, Relative growth rate, Number of pod/plants, seed index, Kernel yield, haulm yield, harvest index. The collected data was subjected to statistical analysis by analysis of variance method.

Results and Discussion

Plant height: At harvest, there was significant difference among the treatments. However, taller plant height (58.39 cm) was recorded with the application of Rhizobium + VAM + Phosphorus 60 kg/ha, whereas with application of Rhizobium + PSB + Phosphorus 60 kg/ha (57.08 cm) was found to be statistically at par with T_9, and minimum was reported in control (49.73 cm).

Plant Dry Weight: At harvest, there was significant difference among the treatments. However, highest dry weight (38.46 g) was recorded with the application of Rhizobium + VAM + Phosphorus 60 kg/ha, whereas treatment Rhizobium + PSB + Phosphorus 60 kg/ha (35.91 g) and Rhizobium + Phosphorus 60 kg/ha (35.83 g) was found to be statistically at par with T_9, and minimum was reported in control (31.30 g).

Nodules per plant: At harvest, there was significant difference among the treatments. However, highest number of nodules per plant (46.56) was recorded with the application of Rhizobium + VAM + Phosphorus 60 kg/ha, whereas treatment Rhizobium + PSB + Phosphorus 60 kg/ha (45.12) was found to be statistically at par with T_9, and minimum was reported in control (37.18).

Pods per plant: Significantly Maximum number of pods per plant (28.87) was recorded with the treatment of application with Rhizobium + VAM + Phosphorus 60 kg/ha over all the treatments, minimum was recorded in Control (RDF (20.80), and Rhizobium + PSB + Phosphorus 60 kg/ha (27.28) was statistically at par with T_9.

Seed index: Significantly higher seed index (38.81 g) was recorded with the treatment of application of Rhizobium + VAM + Phosphorus 60 kg/ha over all the treatments, minimum was recorded in Control (RDF) (32.08 g), and Rhizobium + PSB + Phosphorus 60 kg/ha (37.93 g) was statistically at par with T_9.

Kernel yield: Maximum Kernel yield (2.47 t/ha) was recorded with the treatment of application with Rhizobium + VAM + Phosphorus 60 kg/ha over all the treatments, minimum was recorded in Control (RDF) (1.65 t/ha), and Rhizobium + PSB + Phosphorus 60 kg/ha (2.34 t/ha) was statistically at par with T_9

Haulm yield: Significantly Maximum haulm yield (t/ha) (3.97 t/ha) was recorded with the treatment of application of Rhizobium + VAM + Phosphorus 60 kg/ha over all the treatments, minimum was recorded in Control (RDF) (2.55 t/ha), and Rhizobium + PSB + Phosphorus 60 kg/ha (3.63 t/ha) was statistically at par with T_9.

Table 1: Influence of Bio-fertilizers and phosphorus on yield and yield attributes of groundnut

S. No.	Treatments	Plant height (cm)	Dry weight (g)	Nodules/plant	Pods/plant	Seed Index (g)	Kernel yield (t/ha)	Haulm yield (t/ha)
1.	Rhizobium + Phosphorus 30 kg/ha	53.19	34.27	43.07	23.90	33.81	2.01	3.08
2.	Rhizobium + PSB + Phosphorus 30 kg/ha	52.99	34.32	42.83	23.49	33.25	2.08	2.76
3.	Rhizobium + VAM + Phosphorus 30 kg/ha	53.07	35.02	43.34	25.57	34.70	2.11	3.26
4.	Rhizobium + Phosphorus 45 kg/ha	53.77	34.98	42.38	24.02	33.97	2.09	2.76
5.	Rhizobium + PSB + Phosphorus 45 kg/ha	53.52	34.83	42.80	24.32	34.76	1.96	2.99
6.	Rhizobium + VAM + Phosphorus 45 kg/ha	53.24	34.61	43.24	24.67	33.63	2.05	3.15
7.	Rhizobium + Phosphorus 60 kg/ha	52.39	35.83	43.38	24.17	34.27	1.85	3.36
8.	Rhizobium + PSB + Phosphorus 60 kg/ha	57.08	35.91	45.12	27.28	37.93	2.34	3.63
9.	Rhizobium + VAM + Phosphorus 60 kg/ha	58.39	38.46	46.56	28.87	38.81	2.47	3.97
10.	Control (RDF) 20-40-20 kg N-P-K/ha	49.73	31.30	37.18	20.80	32.08	1.65	2.55
	F – test	S	S	S	S	S	S	S
	S Em (±)	0.63	0.89	0.49	1.07	1.18	0.10	0.20
	CD (p=0.05)	1.86	2.65	1.45	3.18	3.55	0.30	0.58

Conclusion

In conclusion, the study demonstrated significant differences in various growth and yield parameters among different treatments. The application of Rhizobium + VAM + Phosphorus 60 kg/ha consistently resulted in superior plant height, dry weight, number of nodules per plant, number of pods per plant, seed index, kernel yield and haulm yield compared to other treatments, including the control. These findings suggest that the utilization of Rhizobium and VAM with optimal nutrient supplementation enhances plant growth, nutrient uptake, and ultimately, seed yield. The observed improvements in growth and yield parameters can be attributed to the favorable nutritional These results align with previous research, highlighting the importance of innovative agricultural practices in maximizing crop productivity.

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