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Effect of Humic Acid from Vermicompost and Commercial Source on Growth, Yield and Quality of Groundnut (*Arachis hypogea* L.)

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ABSTRACT

A pot culture experiment was conducted in the year 2017 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad to study the impact of soil and foliar application of humic acid from vermicompost and commercial source on growth, yield and quality parameters of groundnut variety GPBD-4 by adopting Completely Randomized Block Design with thirteen treatments and three replications. The highest plant height (36.83 cm), LAI (0.96) and relative chlorophyll content (34.82) was recorded in the treatment which received soil application of humic acid from vermicompost @ 20 kg ha^{-1} in combination with the foliar spray of 0.2% at 30 DAS. Similar trend was observed in yield and quality parameters of groundnut. Significantly highest number of pods plant^{-1} (24.00), pod yield plant^{-1} (14.80 g plant^{-1}), oil content (46.12%) and crude protein content (25.38%) was also recorded in the same treatment. The results revealed that there is a statistical increase in the periodical observation, yield and quality of groundnut with the additional application of humic acid extracted from vermicompost over the recommended package of practice.

Keywords Growth, Yield, Quality parameter, Vermicompost, Humic acid.

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INTRODUCTION

Agriculture is highly dependent on the use of chemical fertilizers, but the excess use of high analysis fertilizers leads to depletion of macro and micronutrients in soil (Abebe *et al.* 2022). Imbalanced nutrients application causes micronutrient deficiencies in soil viz., zinc, boron and iron which are limiting the crop productivity. Organic manures contain all the nutrients though in lower concentration and hence maintain optimum soil, physical, chemical and biological environment (Bhatt *et al*. 2019). Plant growth promoting substances like humic acids are often novel and potential tools to provide substantial benefits to agriculture. Efficient use of organic wastes can be useful for the extraction of humic substances.

Due to its significance in preserving soil fertility, organic matter is known as the "Life of Soil," and its depletion poses a serious threat to future food security (Chaitra *et al.* 2018). Hence, there is a need to improve the soil fertility in a sustainable manner by utilizing locally available organic sources. Since transportation and application of organic manures is a laborious process, use of humic substances extracted from locally available organic wastes in crop production is a better option (Lanno *et al.* 2022).

Groundnut plays a major role in bridging the vegetable oil gap in the country. But the current average yield level is very low as compared to what is being obtained in most of the groundnut growing countries. In India, the reasons for low groundnut yield are the use of low yielding varieties, poor soil fertility and nutrient management (Polthanee *et al.* 2021). Groundnut productivity in Karnataka is low due to several production constraints which include poor and imbalanced nutrition and growing crop on marginal lands. Groundnut performs better in yield and quality when good cultivar is grown under optimum nutrient management practices. Therefore, it is most essential to pay a great attention to the nutrition of groundnut to enhance its productivity (Kumar *et al.* 2016).

MATERIALS AND METHODS

A pot culture experiment was conducted in an Alfisol at MARS, Dharwad. The experiment was laid out in Completely Randomized Design (CRD) with thirteen treatments and three replications.

Treatment details

T_1: Recommended package of practice (RPP)
T_2: Soil application of HA @ 10 kg ha^{-1}
T_3: Soil application of HA @ 20 kg ha^{-1}
T_4: Foliar application of HA @ 0.1 % at 30 DAS
T_5: Foliar application of HA @ 0.2 % at 30 DAS
T_6: Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.1 % at 30 DAS
T_7: Soil application of HA @ 20 kg ha^{-1} + Foliar application of HA @ 0.1 % at 30 DAS
T_8: Soil application of HA @ 10 kg ha^{-1} + Foliar application of HA @ 0.2 % at 30 DAS
T_9: Soil application of HA @ 20 kg ha^{-1} + Foliar application of HA @ 0.2 % at 30 DAS
T_{10}: Foliar application of commercial HA @ 0.1 % at 30 DAS
T_{11}: Foliar application of commercial HA @ 0.2 % at 30 DAS
T_{12}: Soil application of commercial HA @ 10 kg ha^{-1}
T_{13}: Soil application of commercial HA @ 20 kg ha^{-1}

Note : RPP = *Rhizobium* seed treatment, FYM: 7.5 t/ha, 25:50:25 N: P_2O_5: K_2O kg/ha, respectively, Gypsum: 500 kg/ha, $ZnSO_4$: 25 kg/ha, $FeSO_4$: 25 kg/ha.
HA: Humic acid extracted from vermicompost
Commercial HA: Potassium humate
RPP is common for all the treatments.

Growth parameters

The height of two plants @ 30 DAS, 60 DAS and maturity were measured in cm from the base to tip of the plant and average height of the plant was calculated and expressed in cm. Greenness or relative chlorophyll content was measured by using SPAD (Soil Plant Analytical Development) chlorophyll meter in five fully opened leaves from the top of plants and average value was recorded. Area of the leaf was measured by following disc method as suggested by Vivekanandan *et al.* (1972). 25 discs of known size were taken through cork borer from randomly selected leaves from the plant. Both discs and remaining leaf blades were oven dried at 75^0 C for two days and leaf area was calculated by using the formula.

$$LA = \frac{Wa \times A}{W_b}$$

LA - Leaf area per plant
A - Area of discs (dm^2)
Wa - Weight of all leaves + discs
Wb - Weight of 25 discs

Leaf area index was calculated by using following formula as suggested by Sestak *et al.* (1971).

$$LAI \frac{LA}{P}$$

Where,

LAI = Leaf area index
LA = Leaf area
P = Land area

Greenness or relative chlorophyll content was measured by using SPAD (Soil Plant Analytical Development) chlorophyll meter in five fully opened leaves from the top of plants and average value was recorded.

Yield and yield attributes

The total number of pods produced was counted in two plants and average was worked out. The dry weight of pods from each plant was obtained by using electronic balance and pod yield was recorded and expressed in g plant^{-1}.

Quality parameters

Kernel oil content was determined by Nuclear Magnetic Resonance spectrometer against a standard reference sample and expressed in per cent (Anon 1975). Crude protein content of the kernel was determined by multiplying nitrogen concentration of the kernel with 6.25 (Mariotti *et al.* 2008).

RESULTS AND DISCUSSION

The results on the effect of humic acid application on growth parameters of groundnut. Plant height, leaf area index (LAI) and relative chlorophyll content (SPAD value) are given at Table 1. Significantly highest plant height at 30 DAS (22.77 cm), 60 DAS (29.50 cm) at harvest (36.83 cm), LAI @ 35 DAS (0.96), 65 DAS (3.88) and relative chlorophyll content at 40 DAS (34.82) were observed in the treatment which received soil application of humic acid extracted from vermicompost @ 20 kg ha^{-1} in combination with the foliar spray of 0.2% humic acid at 30 DAS (T_9), which was on par with the soil application of humic acid extracted from vermicompost @ 20 kg ha^{-1} in combination with the foliar spray of 0.1% humic acid at 30 DAS (T_7). The lowest observation was recorded in the treatment with the application of RPP alone (T_1).

Vegetative and reproductive growth stages of plants play an important role in realizing potential yield of crop. Sub-optimal growth may result in adverse effect on yield attributes (Burgess *et al.* 2023). In the present investigation, the data indicated that there was significant improvement in the plant height, leaf area index and chlorophyll content of groundnut due to combined soil and foliar application of humic acid, respectively @ 20 kg ha^{-1} and 0.2% as compared to other treatments including control. This might be due to better cell division, cell elongation and in-

Table 1. Effect of soil and foliar application of humic acid on growth of groundnut.

Treatments	Plant height (cm) @ 30 DAS	@ 60 DAS	@ harvest	Leaf area index (LAI) @ 35 DAS	@ 65 DAS	Relative chlorophyll content (SPAD values) @ 40 DAS
T_1: RPP (control)	17.00	20.00	24.50	0.53	2.59	31.50
T_2: SA of HA @ 10 kg ha^{-1}	21.73	26.17	31.17	0.83	3.29	33.30
T_3: SA of HA @ 20 kg ha^{-1}	22.00	27.50	31.67	0.86	3.40	33.70
T_4: FA of HA @ 0.1 % @ 30 DAS	18.03	24.33	29.00	0.62	3.07	32.00
T_5: FA of HA @ 0.2 % @ 30 DAS	17.70	25.50	29.67	0.78	3.19	32.67
T_6: SA of HA @ 10 kg ha^{-1} + FA of HA @ 0.1 % @ 30 DAS	20.83	27.33	32.83	0.89	3.43	34.00
T_7: SA of HA @ 20 kg ha^{-1} + FA of HA @ 0.1 % @ 30 DAS	22.43	28.50	35.00	0.95	3.62	34.50
T_8: SA of HA @ 10 kg ha^{-1} + FA of HA @ 0.2 % @ 30 DAS	21.43	27.83	33.00	0.93	3.54	34.31
T_9: SA of HA @ 20 kg ha^{-1} + FA of HA @ 0.2 % @ 30 DAS	22.77	29.50	36.83	0.96	3.88	34.82
T_{10}: FA of commercial HA @ 0.1 % @ 30 DAS	17.80	23.00	28.00	0.75	2.90	31.70
T_{11}: FA of commercial HA @ 0.2 % @ 30 DAS	17.90	24.50	29.50	0.76	3.19	32.42
T_{12}: SA of commercial HA @ 10 kg ha^{-1}	20.67	25.50	30.33	0.79	3.25	33.02
T_{13}: SA of commercial HA @ 20 kg ha^{-1}	22.40	26.83	31.17	0.86	3.31	33.68
SEm ±	0.39	0.48	0.57	0.02	0.05	0.39
CD @ 0.05	1.15	1.40	1.66	0.05	0.15	1.14
CV	3.39	3.24	3.20	3.93	2.77	2.05

RPP – Recommended package of practice, SA – Soil application, FA – Foliar application, HA – Humic acid, RPP is common for all the treatments, DAS – Days after sowing.

creased physiological processes which contribute to greater plant height (Kaiser and Scheuring 2020). The improvement in growth characteristics of groundnut in response to humic acid application was due to the presence of growth promoting substances like Indole acetic acid (IAA), gibberlins and auxins in its structure which are directly involved in cell respiration, photosynthesis, oxidative phosphorylation, protein synthesis and various enzymatic reactions. Similar results were reported by Thakur *et al.* (2013) in sunflower crop and Shahein *et al.* (2014) in lettuce crop. Higher N content in humic acid extracted from vermicompost, might have resulted in higher plant height. Since, N is one of the essential nutrients for growth and development of plants, the increase in the supply of nitrogen to plants might have accelerated the activation of enzymes involved in photosynthesis, carbohydrate metabolism, protein synthesis and production of growth promoting substances. Humic substances have a direct action on plant growth by influencing metabolic process such as nucleic acid synthesis, ion uptake and regulation of hormone levels (Trevisan *et al.* 2010). Application of humic acid to the crop along with adequate nutrients supply resulted in cell elongation, increase in leaf area index and hence increased growth in groundnut.

The chlorophyll content of groundnut leaves at 40 DAS as indicated by SPAD values was significantly higher in the treatment with soil application of humic acid @ 20 kg ha^{-1} along with foliar spray of 0.2% humic acid at 30 DAS as compared to other treatments including control. Humic acid contains nitrogen and humic acid application might have increased the availability of native nitrogen, magnesium. Since these elements are involved in the chlorophyll formation, their supply to plants might have increased chlorophyll content in groundnut leaves. Similar observations were recorded by Nardi *et al.* (2002) and Meganid *et al.* (2015) in common bean.

The results on the effect of humic acid application on yield and quality parameters of groundnut are given at Table 2. The results showed significantly highest number of pods per plant (24.00), pod yield plant^{-1} (14.80 g), Oil content (46.12%) and crude protein content (25.38%) with the soil application of humic acid from vermicompost @ 20 kg ha^{-1} along with foliar spray of 0.2% humic acid at 30 DAS (T_9). The highest enzymes activity in the T_9 treatment was on par with T_7 treatment which received combined soil and foliar application of humic acid from vermicompost, respectively @ 20 kg ha^{-1} and 0.1% concentration. Lowest number of pods plant^{-1} (15.33), pod yield plant^{-1} (10.52 g), oil content (43.10%) and

Table 2. Effect of soil and foliar application of humic acid on yield and quality of groundnut.

Treatments	Number of pods (plant^{-1})	Pod yield (g plant^{-1})	Oil (%)	Crude protein (%)
T_1: RPP (control)	15.33	10.52	43.10	21.00
T_2: SA of HA @ 10 kg ha^{-1}	18.00	13.20	44.45	23.42
T_3: SA of HA @ 20 kg ha^{-1}	19.27	13.50	45.03	23.87
T_4: FA of HA @ 0.1 % @ 30 DAS	17.00	12.50	43.54	22.31
T_5: FA of HA @ 0.2 % @ 30 DAS	17.67	12.70	43.97	23.00
T_6: SA of HA @ 10 kg ha^{-1} + FA of HA @ 0.1 % @ 30 DAS	19.67	13.80	45.23	24.06
T_7: SA of HA @ 20 kg ha^{-1} + FA of HA @ 0.1 % @ 30 DAS	23.21	14.50	45.67	24.94
T_8: SA of HA @ 10 kg ha^{-1} + FA of HA @ 0.2 % @ 30 DAS	20.33	13.50	45.53	24.50
T_9: SA of HA @ 20 kg ha^{-1} + FA of HA @ 0.2 % @ 30 DAS	24.00	14.80	46.12	25.38
T_{10}: FA of commercial HA @ 0.1 % @ 30 DAS	16.67	12.20	43.42	21.88
T_{11}: FA of commercial HA @ 0.2 % @ 30 DAS	17.00	12.40	43.77	22.75
T_{12}: SA of commercial HA @ 10 kg ha^{-1}	17.67	12.80	44.27	23.19
T_{13}: SA of commercial HA @ 20 kg ha^{-1}	18.33	13.10	44.63	23.63
SEm ±	0.50	0.17	0.53	0.42
CD @ 0.05	1.47	0.50	1.55	1.22
CV (%)	4.69	4.47	2.08	3.11

RPP – Recommended package of practice, SA – Soil application, FA – Foliar application, HA – Humic acid, RPP is common for all the treatments, DAS – Days after sowing.

crude protein (21.00%) were recorded in T_1 (RPP alone) treatment.

Yield being a complex character, is the sum of many morphological and biological events that occur during the crop growth and development. Combined soil and foliar application of humic acid resulted in greater variation in growth parameters and yield attributing characters of groundnut crop leading to different yield levels. With this background, the results of the present investigations are critically discussed here.

Pod yield of groundnut differed significantly due to humic acid application. The data indicated that significantly higher number of pods (24.00 pods plant^{-1}) and hence pod yield (14.80 g plant^{-1}) were recorded in T_9 with soil application of humic acid @ 20 kg ha^{-1} plus foliar spray of 0.2% humic acid at 30 DAS over all the treatments including control. Presence of higher amount of carboxylic and phenolic hydroxyl groups in humic acid and lesser aromatic nature of humic acid might have increased the nutrient absorption, translocation and increase in physiological processes thus resulting in better growth and development of crop. Humic acids act as growth regulators and enhance stress tolerance in plants. These results are in agreement with those of Selim *et al.* (2012) who reported that increasing humic acid application rates up to 120 kg ha^{-1} enhanced the plant growth and tuber production in potato.

Yield and yield attributes indirectly depend on growth parameters like plant height, leaf area index, leaf area index and chlorophyll content. Yield attributes of groundnut significantly differed due to humic acid application. Significantly higher number of pods per plant (24.00) and pod yield plant^{-1} (14.80 g plant^{-1}) were recorded in the treatment with combined soil and foliar application of humic acid, respectively @ 20 kg ha^{-1} and 0.2% and was at par with soil application of humic acid @ 20 kg ha^{-1} supplemented with 0.1% foliar spray at 30 DAS. The improvement in yield attributing parameters in groundnut might be correlated to the better establishment, improvement in the availability of plant nutrients and efficient translocation of photosynthates. This work is in conformity with Muralidharan *et al.* (2002) in sugarcane and Nandakumar *et al.* (2004) in rice.

The quality of seed is as important as the seed yield in pulses and oil seeds. The quality of the produce depends on the inherent genetic makeup and environmental factors. Among the different factors and under assured irrigation, application of humic acid plays an important role in physiological and biochemical processes of plant in determining the yield and quality of the produce.

Oil content of groundnut was significantly influenced by the soil and foliar application of humic acid. The higher kernel oil content of 46.12% was observed in the treatment with soil application of humic acid from vermicompost @ 20 kg ha^{-1} plus foliar spray of 0.2% at 30 DAS and was on par with T_7 that received combined soil and foliar application of humic acid, respectively @ 20 kg ha^{-1} and 0.1%. The spectacular increase in the oil content of groundnut under combined soil and foliar application of humic acid was due to the effect of humic acid application. Along with nitrogen and phosphorus, humic acid also contains sulfur. Hence, its application to soil increases the availability of sulfur both from added and native sources. Sulfur along with magnesium is involved in oil synthesis. Hence, higher oil content in kernels was noticed in humic acid receiving treatments when compared to control. Humic acid also plays a major role in several enzyme activity which in turn contributed to increased oil content in groundnut kernels. Vijayalakshmi and Mathan (1997) also reported significant effect of humic acid on oil content in sunflower. Similar result was also recorded by Vasudevan *et al.* (1998) in sunflower. The oil content was lowest in control which was devoid of humic acid.

Crude protein content in groundnut kernel differed significantly due to soil and foliar application of humic acid to groundnut. Among the different treatments, combined soil and foliar application of humic acid from vermicompost, respectively @ 20 kg ha^{-1} and 0.2% recorded higher crude protein content of 25.38% and was statistically similar to T_7 that received soil application of humic acid from vermicompost @ 20 kg ha^{-1} plus foliar spray of 0.1% humic acid. This is because kernel crude protein content is a nitrogen dependent quality parameter and is directly related to N content of groundnut kernels. Application of humic acid which contains N along with sulfur might have improved the crude protein content of kernels because nitrogen is an essential component of protein. It is involved in the synthesis of aminoacids and plant hormones which are the precursors of protein synthesis. Thenmozhi *et al.* (2004) reported increase in the crude protein content in groundnut kernels with the combined application of humic acid @ 20 kg ha^{-1} along with 100% recommended dose of fertilizer over control. The results can be correlated with the findings of Saadati and Baghi (2014) in chickpea and Deotale *et al.* (2014) in greengram.

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