LR-4788
[1-6]

RESEARCH ARTICLE Legume Research- An International Journal, Volume Issue : ()

Growth and Yield of Blackgram [*Vigna mungo* (L.) Hepper] Crop as Influenced by Humic Acid Application

Swarnali Duary[1], Tufleuddin Biswas[1], Kajal Sengupta[2]

10.18805/LR-4788

ABSTRACT

Background: Among the different grain legumes, blackgram [*Vigna mungo* (L.) Hepper)] is a well-known leguminous crop popular because of its nutritional quality and suitability for multiple cropping systems.

Methods: A field experiment was conducted during *Autumn* season of 2018 and 2019 at Kalyani, Nadia to evaluate the effect of humic acid (HA) application on growth and yield of blackgram crop. The treatments were: Control (sowing of dry seed) (T_1); Seed priming (soaking) in water (T_2); Seed priming in 0.5% humic acid solution (T_3); Seed priming in 1% humic acid solution (T_4); Seed priming in 2% Humic acid solution (T_5); Soil application of humic acid @1 kg/ha (T_6); Soil application of humic acid @ 2 kg/ha (T_7); Soil application of humic acid @1 kg/ha + 10 t compost/ha(T_8); Soil application of humic acid @ 2 kg/ha + 10 t compost/ha (T_9); Foliar application of 0.01% humic acid solution 25 days after sowing (DAS) (T_{10}); Foliar application of 0.05% humic acid solution (25 DAS) (T_{11}); Foliar application of 0.1% humic acid solution (25 DAS) (T_{12}).

Result: Soil application of humic acid along with compost had significant effect on number of pods m^{-2}, though; other yield components such as seeds pod^{-1}, seed index was statistically at par in most occasions. The maximum seed yield (1295.53 kg ha^{-1} and 1298.47 kg ha^{-1} in 2018 and 2019, respectively) was obtained from the treatment T_9 and the second-best treatment was T_8.

Key words: Blackgram, Foliar spray, Grain yield, Humic acid, Seed priming, Seed protein content.

INTRODUCTION

Pulse crops play an important role in food security of country like India where malnutrition is common and ever increasing and they are the quickest means to augment protein production in developing countries. To increase the public awareness about the nutritional benefit of pulse crop and as a part of sustainable food production aimed towards food as well as nutritional security the year 2016 was assigned as "international year of pulse".

Blackgram [*Vigna mungo* (L.) Hepper] ranked third among all pulses in India and contributes to 10% of the national pulse production from an area of 13% of total pulse crop area. Blackgram is rich in nutrients such as protein (25-28%), oil (1-1.5%), carbohydrate (60-65%), essential mineral (K, Ca, Zn), various vitamins (Vit C, B), fibre (3.5-4.5%) and antioxidant compounds that can help to boost the human health (Lavanya *et al*., 2020 and Patial *et al*., 2020). It is also rich in amino acids like methionine, cysteine and lysine. Both production and area under this crop lay decreased during last decade. The targeted production and productivity are possible by way of harnessing the yield gap by growing pulses in new niches *i.e.,* precision farming, quality inputs, soil test based integrated nutrient management and mechanized method of pulse cultivation complimented with generous governmental policies and appropriate funding support to implementing stake holders. Maintenance of soil organic material at a satisfactory level is needed for sustainable and high productivity of crops over long periods (Govindasamy, 2002). Humic acid (HA) is the major component of most of the organic fertilizers and the most active components of soil and organic matter might help to overcome these production constraints in the pulse crops. Humic substances arise from chemical and biological degradation of plant and animal residues and from synthetic activities of micro-organisms (Schnitzer, 1968). It enriches the soil and facilitates fertilizer nutrients to reach their maximum potential in improving plant growth (Nithila *et al*., 2013).

Humic acid helps to increase oxygen uptake resulting in better plant growth. Root growth is improved and consequently uptake of nutrient and water is more efficient. Foliar application of humic acid may reduce the nitrogen application to the soil (Sani, 2014). Humic substances also increase microbial population in soil and help in reducing metal poisoning. MacCarthy *et al.* (1990) and Singaravel *et al.* (1993) stated that the auxin like growth promoting activity of humic acid is the reason of accumulation of more dry matter in the plant. The HA molecule also raised the effect

[1]Centurion University of Technology and Management, Odisha, India.
[2]Bidhan Chandra Krishi Vidyalaya, Mohanpur, Nadia-741 252, West Bengal, India.

Corresponding Author: Swarnali Duary, Centurion University of Technology and Management, Odisha, India.
Email: mailme.swarnaliduary@gmail.com

How to cite this article: Duary, S., Biswas, T. and Sengupta, K. (2022). Growth and Yield of Blackgram [*Vigna mungo* (L.) Hepper] Crop as Influenced by Humic Acid Application. Legume Research. DOI: 10.18805/LR-4788.

Submitted: 11-09-2021 **Accepted:** 20-05-2022 **Online:** 13-07-2022

of fertilization based on N, P, K on plants (Pollhamer, 1993). Keeping all these in view, the present experiment was undertaken to study the influence of humic acid application on growth and yield of blackgram under new alluvial zone of West Bengal.

MATERIALS AND METHODS

The field experiment was conducted at experimental farm, Bidhan Chandra Krishi Viswavidyalaya situated in the new alluvial zone of West Bengal, India, during *autumn* (August-November) season of 2018 and 2019. The experimental farm was situated at 22.93° N latitude, 88.53° E longitude and an altitude of 9.75 m above mean sea level, in the sub-tropical sub-humid climatic zone of eastern India. The soil properties of the experimental site were neutral in reaction (pH 6.72), medium in organic carbon content (0.48%), low in available nitrogen (198.26 kg/ha), high in available phosphorus (31.15 kg/ha) and medium in available potassium (172.52 kg/ha). The experiment was laid out in randomized complete block design (RCBD) with twelve treatments and each treatment was replicated thrice with the variety Pant U-31. The treatments were comprised of; T_1 = Control (sowing of dry seed); T_2 = Seed priming (soaking) in water; T_3 = Seed priming in 0.5% humic acid solution; T_4 = Seed priming in 1% humic acid solution; T_5 = Seed priming in 2% humic acid solution; T_6 = Soil application of humic acid @1 kg/ha (basal); T_7 = Soil application of humic acid @ 2 kg/ha (basal); T_8 = Soil application of humic acid @1 kg/ha + 10 t compost/ha; T_9 = Soil application of humic acid @ 2 kg/ha + 10 t compost/ha; T_{10} = Foliar application of 0.01 % humic acid solution (at 25 DAS); T_{11} = Foliar application of 0.05 % humic acid solution (at 25 DAS); T_{12} = Foliar application of 0.1 % humic acid solution (at 25 DAS). Seed priming was done for 4 hours, thereafter the seeds were dried under shade to remove the surface water. Foliar application of humic acid was done at 25 days after sowing. Different agronomic operation such as weeding, thinning, plant protection measures were same for all the plots.

The crop was raised with only one pre-sowing irrigation for uniform crop stand. Seeds were manually sown (hand dibbled) @ 30 kg ha^{-1} in 2-3 cm depth. Row to row distance was 30 cm within a plot size of 4 m × 3 m. A normal dose of fertilizer was applied @ 10 kg N, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} by using fertilizers like urea, single super phosphate and muriate of potash, respectively. Thinning and gap filling was done at seedlings 20 days after sowing (DAS) so as to maintain optimum and uniform plant population in all the plots.

The morphological characters *viz*., plant height, leaf area index (LAI) and total dry aerial biomass production were recorded. Total leaf area was calculated by area-weight relationship. For dry aerial biomass the above ground plant samples were dried in a hot air oven at a temperature of 65-70°C for 2-3 days till constant mass was obtained. The total chlorophyll content was also estimated (Lichtenthaler *et al*., 1983). Data on pods m^{-2}, seed pod^{-1}, seed index, grain yield (kg ha^{-1}) and harvest index (%) were recorded at the time of harvest. Pods were dried, threshed and weighed with the help of an electronic balance. Grain yield were recorded from the net plot area and converted to kg/ha. Quality parameters like seed protein content obtained by multiplying the nitrogen content with the conversion factor of 6.25 (equivalent to 0.16 g nitrogen per gram of protein) used for converting nitrogen content into protein content.

The experimental data recorded for various parameters under study were subjected to statistically analysed ANOVA given by Gomez and Gomez (1984) to draw a valid conclusion. The variation in the treatments mean was tested by using critical difference (CD) values at 5% level of significance.

RESULTS AND DISCUSSION

Plant height

Plant height is an important index of plant growth at a given time during the growth period. From Table 1 it is revealed that the plant height has positive respond to different humic acid application doses and methods. Soil application of humic acid @ 2 kg ha^{-1} along with farm compost @ 10 t ha^{-1} (T_9) recorded higher plant height (*i.e.,* 45.62 cm) in 2018 and also in 2019 (51.07 cm). However, the minimum plant height was observed in T_1 in 2019 but in 2018, T_2 (receiving N-P-K fertilizers plus seed priming was done with plain water) shows minimum plant height. The plant height was significantly influenced by soil application of humic acid along with compost during both the years.

Soil application and foliar spray of humic acid (HA) significantly increased plant height over other seed treatment and control where no humic acid applied and there is no significant difference between seed priming with control in both the year of experiment. Plant height was recorded more at higher dose of HA at soil with compost. However, seed priming with higher doses of HA (2%) in some cases shows better result than the seed priming with lower doses of HA. The positive effect of humic acid in improving plant height was probably due to synergistic and beneficial effect due to the adequate nutrient availability thus resulted in greater elongation (Singeravel *et al*., 1993). The increased plant height can also justify by Prasad and Prasad (1994) that auxin derivatives are involved in cell division and differentiation ads also expansion through increasing the plasticity thereby enhancing growth and development.

Leaf area index (LAI)

Leaf area Index (LAI), an important growth factor of blackgram crop and data regarding LAI are shown in Table 1. Humic acid treatment adapted in blackgram crop has significant effect on its LAI in both the year of experiments. It is clear that (Table 1) in comparison to other treatments the highest LAI (3.38 and 3.52 respectively in 2018 and 2019) was obtained from T_9 treatment. However, both the control (T_1 and T_2) treatment gives the lower value of LAI in both the year of experiments. The combine effect of HA and compost improved the LAI significantly. Most of the growth stages seed priming was at par with the control and the two control treatments (T_1 and T_2) were at par in both the years.

Higher LAI values might be due to adequate supply of nitrogen that had produced larger leaves and reflected in more photosynthetic area coupled with the increased growth rate, respiration rate and metabolic activity due to humic substances (Saravanan *et al*., 1989).

Dry aerial biomass

Dry aerial biomass is one of the most important parameters and has a marked influenced on final yield realization of a crop. The mean data on dry aerial biomass of blackgram as influenced by different treatments of humic acid is tabulated in Table 1. Soil application of HA with or without compost had a profound effect in increasing the total aerial dry matter production over control and treatments receiving N-P-K and seed priming (T_2). T_9 treatment recorded the highest value of dry aerial biomass in both the years of experiments where HA at 2 kg ha^{-1} was applied in soil along with farm compost at 10t ha^{-1}; the second highest value of dry aerial biomass was recorded in treatment T_8 where HA at 1 kg ha^{-1} was applied in soil along with farm compost at 10 t ha^{-1} and the lowest value was recorded in control treatment (T_1).

Data revealed that foliar application of HA significantly increased the dry aerial biomass over in both 2018 and 2019 and on an average, there was an increase of 37.86 and 37.18% over control in 2018 and 2019, respectively. The results of this experiment are similar with the finding of Khazaie *et al*. (2011). HA was capable of increasing the total amount of dry weight in soybean, peanut and clover plants (Tan *et al*., 1983).

Yield attributes

Yield is complex character determined by several traits internal plant processes and environmental factors. The number of pods per unit area is the most important yield component of any pulse crop. Data pertaining to pod number as influenced by different treatments was tabulated in Table 2. Sole application of humic acid along with compost had significance influence on the number of pods m^{-2} of blackgram crop over control. The highest number of pods m^{-2} was recorded in T_9 (597.34 and 604.23 in 2018 and 2019, respectively). There was no significant difference between T_9 with T_8 (humic acid @ 1 kg ha^{-1} + 10 t compost ha^{-1}).

The number of pods m^{-2} recorded in other treatments of humic acid either through seed priming or foliar spray had some positive effect and the number of pods produced was more than the control treatment T_1. In 2018, T_1 recorded minimum number of pods m^{-2} (491.04) and in 2019 the minimum number of pods m^{-2} (501.91) were recorded at T_2. Hu-shui and Wang (2001) recorded significantly a greater number of pods plant^{-1} in soybean when the crop received foliar spray of HA and komix. Pre-care chickpea seeds with use of HA led to the increased number of pod plant^{-1} (16.7) than non-pre cared seeds (10.2) (Ulukan *et al*. 2012). Increase in pod yield may be attributed to mineralization of nutrients, which leads to improve growth and better partitioning of assimilates to various metabolic sinks (Talavia *et al*., 2007).

Application of humic acid through different methods had no significance differences on the number of seeds pod^{-1} (Table 1) among the treatments in *autumn* season of both the year of experiments. The highest number of seeds pod^{-1} was recorded in T_9 (5.79) where humic acid was applied along with farm compost in 2018 and the corresponding figure in 2019 was 5.95. The treatment T_9 was closely followed by T_6 in 2018 and in 2019, T_9 and T_8 were statistically at par. The minimum number of seeds pod^{-1} was recorded (5.79) in the treatment T_1 in 2018 and in 2019, T_{12} recorded the minimum number (5.48) of seeds pod^{-1}. However, in most

Table 1: Effect of humic acid on growth parameters of blackgram crop during 2018 and 2019.

Treatments details	Plant height (cm)		Leaf area index		Dry aerial biomass (g m^{-2})	
	2018	2019	2018	2019	2018	2019
T_1: Control (sowing of dry seed)	35.46	36.48	2.34	2.26	140.78	114.49
T_2: Seed priming (soaking) in water	34.81	38.59	2.31	2.35	149.16	123.50
T_3: Seed priming in 0.5% HA solution	39.04	42.39	2.46	2.40	174.36	141.87
T_4: Seed priming in 1% HA solution	38.59	43.57	2.58	2.43	182.01	150.40
T_5: Seed priming in 2% HA solution	39.38	41.33	2.71	2.52	186.64	157.01
T_6: Soil application of HA @1 kg/ha (basal)	41.56	47.21	2.92	2.67	193.80	165.56
T_7: Soil application of HA @ 2 kg/ha (basal)	40.93	45.36	2.89	2.95	190.98	172.76
T_8: Soil application of HA @1 kg/ha + 10 t compost/ha	42.94	49.14	3.17	3.33	210.33	185.24
T_9: Soil application of HA @ 2 kg/ha + 10 t compost/ha	45.62	51.07	3.38	3.52	229.22	194.66
T_{10}: Foliar application of 0.01 % HA solution (25 DAS)	39.44	43.14	2.70	2.59	194.08	157.06
T_{11}: Foliar application of 0.05 % HA solution (25 DAS)	39.73	44.01	2.78	2.68	196.37	162.34
T_{12}: Foliar application of 0.1 % HA solution (25 DAS)	40.42	44.82	2.85	2.93	200.84	167.89
SEm (±)	1.42	2.43	1.01	0.04	15.58	9.95
CD at 0.05	4.12	7.02	2.95	0.12	45.21	28.87

HA: Humic acid, DAS: Days after sowing.

occasions there was no significant difference and the treatments were statistically at par.

Yield attributes like seed index (100 grain weight) represents the development and plumpness of grains and is an important index of grain yield. From the Table 2 it is clear that the effect of various humic acid treatments had no significant influence on the seed index of blackgram in both the year of experiments. During 2018 the seed index varied from 3.79 g at T_5 to 3.90 g at T_9. However increased dose of humic acid had no significant effect on the seed index. The seed index varied from 3.59 g at T_6 to 3.84 g at T_9 in 2019. Gaikwad *et al*. (2012) observed that foliar sprays of humic acid @ 400 ppm followed by 350 ppm increased the 100-grain weight (g) in maize.

Grain yield, an end product of interaction between yield components, differed significantly among treatments tested in the investigation. The effect of various treatments had significant influence on the grain yield (Table 3) of blackgram during both the years. The seed yield was significantly superior in all humic acid treated plots over T_1 in 2018. Increased dose of humic acid had a little effect on the seed yield over the lower dose in corresponding method of application. The maximum seed yield recorded was 1295.53 kg ha^{-1} and 1298.47 kg ha^{-1} in 2018 and 2019, respectively in T_9 which was at par with T_8 in both the year of experiment. The minimum seed yield was recorded in T_1 in 2018 (956.17 kg ha^{-1}) and in T_2 in 2019 (1019.40 kg ha^{-1}) where no HA was applied.

Table 2: Effect of humic acid on yield components of blackgram crop during 2018 and 2019.

Treatments details	Pod m^{-2}		Seed pod^{-1}		Seed index (g)	
	2018	2019	2018	2019	2018	2019
T_1: Control (sowing of dry seed)	491.04	505.57	5.35	5.60	3.83	3.79
T_2: Seed priming (soaking) in water	507.01	501.91	5.41	5.54	3.87	3.81
T_3: Seed priming in 0.5% HA solution	512.56	516.35	5.44	5.56	3.84	3. 73
T_4: Seed priming in 1% HA solution	520.92	523.46	5.38	5.86	3.80	3.75
T_5: Seed priming in 2% HA solution	524.48	527.44	5.51	5.77	3.79	3.78
T_6: Soil application of HA @1 kg/ha (basal)	539.31	554.32	5.76	5.63	3.89	3.59
T_7: Soil application of HA @ 2 kg/ha (basal)	529.65	567.37	5.72	5.69	3.81	3.77
T_8: Soil application of HA @1 kg/ha + 10 t compost/ha	577.59	591.85	5.67	5.90	3.88	3.80
T_9: Soil application of HA @ 2 kg/ha + 10 t compost/ha	597.34	604.23	5.79	5.95	3.90	3.84
T_{10}: Foliar application of 0.01% HA solution (25 DAS)	522.12	541.79	5.60	5.57	3.83	3.72
T_{11}: Foliar application of 0.05% HA solution (25 DAS)	528.20	554.54	5.50	5.48	3.85	3.75
T_{12}: Foliar application of 0.1% HA solution (25 DAS)	532.53	560.16	5.74	5.71	3.86	3.82
SEm (±)	15.77	19.83	0.19	0.16	0.02	0.04
CD at 0.05	45.71	57.48	NS	NS	NS	NS

HA: Humic acid, DAS: Days after sowing.

Table 3: Effect of humic acid on grain yield, HI and grain protein content of blackgram crop during 2018 and 2019.

Treatments details	Grain yield (kg ha^{-1})		Harvest index (HI)		Grain protein content (%)	
	2018	2019	2018	2019	2018	2019
T_1: Control (sowing of dry seed)	956.17	1023.32	0.390	0.412	22.24	21.87
T_2: Seed priming (soaking) in water	981.52	1019.40	0.378	0.401	21.66	22.46
T_3: Seed priming in 0.5% HA solution	1020.34	1020.84	0.372	0.391	22.74	22.97
T_4: Seed priming in 1% HA solution	1014.98	1060.31	0.379	0.400	22.52	22.75
T_5: Seed priming in 2% HA solution	1035.66	1072.78	0.373	0.398	23.43	23.67
T_6: Soil application of HA @1 kg/ha (basal)	1158.40	1100.37	0.363	0.370	22.87	23.10
T_7: Soil application of HA @ 2 kg/ha (basal)	1134.28	1164.82	0.345	0.365	25.28	23.55
T_8: Soil application of HA @1 kg/ha + 10 t compost/ha	1230.67	1256.93	0.357	0.376	25.04	25.29
T_9: Soil application of HA @ 2 kg/ha + 10 t compost/ha	1295.53	1298.47	0.359	0.380	25.28	25.53
T_{10}: Foliar application of 0.01% HA solution (25 DAS)	1079.84	1084.11	0.361	0.369	23.43	23.67
T_{11}: Foliar application of 0.05% HA solution (25 DAS)	1068.46	1089.57	0.362	0.362	22.94	23.17
T_{12}: Foliar application of 0.1% HA solution (25 DAS)	1109.85	1141.82	0.360	0.374	24.33	24.57
SEm (±)	23.63	29.24	0.012	0.014	0.69	0.70
CD at 0.05	68.51	84.77	0.035	0.040	1.98	2.00

HA: Humic acid, DAS: Days after sowing.

A critical examination of the data revealed that seed priming with normal water (T_2) brought no significant increase in seed yield of blackgram. Data recorded further revealed that soil and foliar application of humic acid had better influence on seed yield of blackgram than seed priming with humic acid solution. Increase in seed yield of wheat due to spraying humic acid at the stage of development of wheat branch was also reported by (Xudan, 1986) and Ayosou *et al*. (1996) reported humic acid caused remarkable increase of seed yield in barley.

Harvest index (HI) is an indicator of efficiency of crop plants to translocate manufactured food material at source level to the sink or grains. The data pertaining to harvest index are showed (Table 3) that harvest index was significantly affected by different HA treatments in both the years of experimentation. During 2018 the harvest index varied from 0.345 at T_7 to 0.390 at T_1 (control). While in 2019 the harvest index varied from 0.362 at T_{11} to 0.412 at T_1.

Application of humic acid (HA) in blackgram (Table 3) has considerable effect on protein content of seed in both the years. Minimum values of protein content of seed were recorded in T_1 in the year 2019 but in the year 2018 lowest value was obtained in T_2. Similarly seed priming treatments with HA solution (treatment T_3 to T_5) were statistically at par with T_1 and T_2.

The increase in protein content of seed was noticed due to the foliar application of HA over control; the treatments (T_{10} and T_{11}) were at par with T_1 and T_2. Moreover, foliar application of HA with different doses could not bring any significant variation in protein content of seed among themselves but foliar application of HA at higher dose (0.1% solution) showed significant variation in seed protein content during both the years of experimentation.

The protein content increased with the application of HA was reported in maize, sugarcane (Santhi *et al*., 2003), Soybean (Ashraf *et al*., 2005) and Kaya *et al*. (2005) reported that humic acid spraying solution (foliar) has increased protein content in green bean plant.

CONCLUSION

HA is one of the active major present in organic fertilizer as well as soil and organic matter. This study established that application of humic acids increased overall crop performance and productivity of blackgram. Among the different methods, soil application of humic acid was found to be the best, particularly when applied with compost. Therefore, soil application of humic acid @ 2 kg ha^{-1} + 10 t compost ha^{-1} (T_9) might be the best option for increasing productivity and quality of blackgram.

Conflict of interest

The authors declares no conflict of interest.

REFERENCES

Ashraf, M., Nasir, S. and Sarfaraz, T.B. (2005). Biological effect of biofertilizer humic acid on mung bean (*Vigna radiata*). International Journal of Biology and Biotechnology. 3: 737-739.

Ayosou, M., Hernandez, T., Garcia, C. and Pascual, J.A. (1996). Stimulation of barley growth and nutrient absorbtion by humic subtances originating from various organic materials. Biosource Technology. 57: 251-257.

Gaikwad, S.B., Deotale, R.D., Uke, A.P. and Parihar, L.B. (2012). Influence of foliar sprays of humic acid through vermicompost wash on growth, yield and yield contributing parameters of maize. Journal of Soils and Crops. 22(1): 115-121.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2nd Ed.), John Wiley and Sons, Inc. New York. pp. 1-680.

Govindasamy, R. (2002). Scope on the Use of Lignite Derived Humic Subtances for Sustainable Crop Producton. In: National Seminar on Recent Trends on the Use of Humic Subtances for Sustainable Agriculture, Annamalai University, Tamil Nadu.

Hu-shui, X. and Wang, R. (2001). A study on the effect of komix, humic asid containing organic fertilizer as spring soybean. Acta Agriculturae University Jiangxiensis. 23(4): 463-466.

Kaya, M., Atak, M., Khawar, K.M., Cftc, C.Y. and Ozcan, S. (2005). Effect of pre-sowing seed treatment with zinc and foliar spray of humic acid on yield of common bean (*Phaseolus vulgaris* L.). International Journal of Agriculture and Biology. pp. 875-878.

Khazaie, H.R., Rezaie, E.E. and Bannayan, M. (2011). Application times and concentration of humic acid impact on aboveground biomass and oil production of hyssop (*Hyssopus officinalis*). Journal of Medicinal Plants Research. 5(20): 5148-5154.

Lavanya, S.A., Vanniarajan, C. and Souframanien, J. (2020). Study of chlorophyll and macro mutations induced by physical mutagens in blackgram [*Vigna mungo* (L.) Hepper]. Legume Research-An International Journal. 1(5): 311-314.

Lichtenthaler, H.K. and Wellbum, A.R. (1983). Determination of total carotenoids and chlorophylls of leaf extracts in different solvents. Biochem Soc. Trans. 11: 591-592

MacCarthy, P., Clapp, C.E., Malcolm, R.L. and Bloom, P.R. (1990). Humic substances in soil and crop sciences: An Overview. American Society of Agronomy and Soil Science Society of America. pp. 261-271.

Nithila, S., Annadurai, K., Jeyakumar, P., Puppala, N. and Angadi, S. (2013). Humic acid on growth, yield and biochemical properties of field crops with particular reference to peanut: A review. American International Journal of Research in Science, Technology, Engineering and Mathematics. 4(2): 128-132.

Patial, R., Mittal, R.K., Sood, V.K. and Ahmed, S. (2020). Studies on combining ability for seed yield and its related traits in blackgram [*Vigna mungo* (L.) Hepper]. Legume Research. 45(3): 292-298.

Pollhamer, E. (1993). Effect of humic acid, fulvic acid and NPK fertilizers on the quality of winter wheat varieties on chemical free soil. Novenytermeles. 42(5): 447-455.

Prasad, M. and Prasad, R. (1994). Effect of some plant growth regulators in cotton. Indian J. Plant Physiol. 37: 109-110.

Sani, B. (2014). Foliar application of humic acid on plant height in canola. APCBEE Procedia. 8: 82-86.

Santhi, R., Natesan, R., Devarajan, L. and Govindaswamy, M. (2003). Use of Coal Industries Wastes and Products on Crop Production. In Short Course on Ecofriendly Recycling of Organic and Industrial Wastes for sustainable Soil Health. Tamil Nadu Agric. Univ., Madurai.

Saravanan, A., Govindasamy, R. and Chandrasekaran, S. (1989). Effect of Humic Acid on the Yield and Composition of Sugarcane (*Saccharum officinarum* L.) Variety CoC 8506. In: Proceedings of National Seminar on Humic acid in Agriculture. Annamalai University, Tamil Nadu. pp. 235-242.

Schnitzer, M. (1968). Reaction between fulvic acid, a soil hunic compound and inorganic soil constituents. Soil Science Society of America Journal. 33: 75-81.

Singaravel, R., Balasubramanian, N.T. and Govindasamy, R. (1993). Effect of humic acid on sesame (*Sesamum indicum*) growth and yield under two nitrogen levels. Indian Journal of Agronomy. 38(1): 147-149.

Talavia, B.P., Polara, K.B., Mathukia, R.K. and Guolaka, B.A. (2007). Influence of humic acid on growth, yield and quality of summer groundnut (*Arachis hypogea* L.). Advances Plant Science. 20(2): 659-660.

Tan, K.H. and Tantiwiramanond, D. (1983). Effect of humic acids on nodulation and dry matter production of soybean, peanut and clover. Soil Science Society of America Journal. 47: 1121-1124.

Ulukan, H., Bayraktar, N., Oksel, A., Gursoy, M. and Kocak, N. (2012). Agronomic importance of first development of Chickpea (*Cicer arientinum* L.) under semi-arid conditions: II. Seed imbibition. Paktan Journal of Biology Science. 15(4): 192-197.

Xudan, X. (1986). The effect of foliar application of fulvic acid on water use, nutrient uptake and wheat yield. Australian Journal of Agriculture Research. 37: 343-350.