J. Soils and Crops 28 (1) 108-114, June 2018 ISSN 0971-2836
NAAS Rating - 4.46
Scientific Journal Impact Factor (2017) 4.338

RESPONSES OF HUMIC ACID AND NAA ON MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF PIGEONPEA

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ABSTRACT

The study was carried out to evaluate the foliar sprays of humic acid through vermicompost wash with NAA on the morpho-physiological and yield attributes of pigeonpea cv. PKV-Tara. The field experiment was conducted at the experimental farm of Agricultural Botany section, College of Agriculture, Nagpur during year 2016-17 with three replications and twelve treatments in RBD. The twelve treatments included in this experiment *viz*., 25 and 50 ppm NAA and 300, 400 and 500 ppm humic acid (HA) through vermicompost wash (VCW) alone or in combination. One control (water spray) treatment was also taken. Spraying of HA and NAA alone or in combination were applied at 45 and 65 DAS. Foliar sprays of 400 ppm HA through VCW + 50 ppm NAA followed by 300 ppm HA through VCW + 50 ppm NAA significantly enhanced morpho-physiological parameters *viz*., plant height, number of branches, leaf area, total dry weight, NAR, RGR and yield and yield contributing parameters *viz*., number of pods plant^{-1}, number of seeds pod^{-1},100 seed weight, seed yield ha^{-1} over control. Considering the treatments under study two foliar sprays of 400 ppm HA through VCW + 50 ppm NAA at 45 and 65 DAS was found to be most effective treatment in improving above mentioned parameters of pigeonpea cv. PKV-Tara and ultimately increased yield by 27.41 per cent over control having B:C ratio of 2.49 and can be considered as the most effective and beneficial treatment in pigeonpea.

(Key words: Pigeonpea, vermicompost wash, NAA, morphophysiological and yield attributes)

INTRODUCTION

Red gram is an important pulse crop in India. It is also known as Pigeonpea, Arhar and Tur. Red gram is mainly cultivated and consumed in developing countries of the world. This crop is widely grown in India. India is the largest producer and consumer of red gram in the world.

Red gram is a protein rich staple food. It contains about 22 per cent protein, which is almost three times that of cereals. Red gram supplies a major share of protein requirement of vegetarian population of the country.

Red gram is mainly consumed in the form of split pulse as Dal, which is an essential supplement of cereal based diet. The combinations of Dal-Chawal (pulse-rice) or Dal-Roti (pulse-wheat bread) are the main ingredients in the average Indian diet. The biological value improves greatly, when wheat or rice is combined with red gram because of the complementary relationship of the essential amino acids. It is particularly rich in lysine, riboflavin, thiamine, niacin and iron.

In addition to being an important source of human food and animal feed, red gram also plays an important role in sustaining soil fertility by improving physical properties of soil and fixing atmospheric nitrogen. Being a drought resistant crop, it is suitable for dryland farming and predominantly used as an intercrop with other crops.

Humic acid when externally supplied was observed to increase crop growth and ultimately the yield. It improves the nutritional status of soil and plant system. The high cation exchange capacity of humic acid prevents nutrient from leaching. It absorbs the nutrients from chemical fertilizers and these exchanged nutrients are slowly released to the plant. Humic acid proved many binding sites for nutrient such as calcium, iron, potassium and phosphorus. These nutrients are stored in humic acid molecule in a form readily available to plant and are released when the plants require them, humic acid increases the absorption and translocation of nutrients in plant and ultimately influences yield. Humic acid supply polyphenols that catalyze plant respiration and increases plant growth.

Vermicompost wash is useful as foliar sprays. It is transparent pale yellow biofertilizer. It is a mixture of excretory products and mucous secretion of earth worm (*Lampitomautrii* and *Eiseniafoetida*) and organic micronutrients of soil, which may be promoted as "potent fertilizer" for better yield and growth (Shweta *et al.,* 2005).

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Vermicompost wash is having approximately 1300 ppm humic acid, 116 ppm dissolve oxygen, 50 ppm inorganic phosphate, 168 ppm potassium and 121 ppm sodium (Haripriya and Pookodi, 2005).

NAA (Naphthalene Acetic Acid) is the synthetic auxin with the identical properties to that naturally occurring auxin. It prevents formation of abscission layer and thereby flower drop. It was observed that the growth regulators are involved in the direct transport of assimilates from source to sink (Sharma *et al*., 1989).

NAA is synthetic auxin with identical properties to that of naturally occurring auxin i.e., IAA in plant. Auxin in low concentration promotes cell elongation i.e., growth, but in higher concentration it inhibits the growth.

Application of growth promoting hormones is a recent technique in this direction. Plant hormones in a broad sense are organic compounds which plays important role in plant growth development and yield of the crop to prevent fruit and flower drop for a longer period. Considering the importance of humic acid and NAA the present investigation was undertaken to study the "Physiological responses of humic acid and NAA on morpho-physiological and yield attributes of pigeonpea".

MATERIALS AND METHODS

The field experiment was laid out in Randomized Block Design (RBD) with three replications consisting of twelve treatments at farm of Botany Section, College of Agriculture, Nagpur. Plot size of individual treatment was gross 4.20 m × 4.40 m and net 3.00 m × 4.00 m. Seeds were sown at the rate of 20 to 22 kg ha^{-1} by dibbling method at a spacing of 60 cm x 20 cm on 1st July 2016. Treatments comprised of T_1 (control), T_2 (300 ppm HA), T_3 (400 ppm HA), T_4 (500 ppm HA), T_5 (25 ppm NAA), T_6 (50 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 50 ppm NAA), and T_{12}(500 ppm HA + 50 ppm NAA). Foliar application of these treatments was given at two stages i.e. 45 and 65 DAS on pigeonpea. The data were analysed as per the method suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Plant height

At harvest, treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and treatment T_8 (400 ppm HA + 25 ppm NAA) recorded significantly maximum plant height over control and rest of the treatments. It was also noticed that the treatments like T_7 (300 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA) and T_6 (50 ppm NAA) also increased the plant height over control and remaining treatments.

Humic sources (VCW) exert their influence on foliar transport in number of ways. The foliar application enhances the absorption of nutrients by the leaf at site of application. The above findings are in consonance with the findings of Chen and Solovitch (2003). They found that foliar application of humic substances enhanced shoot growth in different crops *viz.*, wheat, maize, barley, bean etc.

Humic acid is the source of major nutrients viz., NPK. When these nutrients are applied they are quickly absorbed by the vegetative parts and remobilized to other parts. Nitrogen, phosphorus and potassium are concerned with different plant growth functions viz., cell enlargement, greater photosynthetic activity, formation of carbohydrates, translocation of solutes. This might be the reason for increased plant height in the present investigation.

Naphthalene Acetic Acid is a plant growth regulator having high efficiency. It improves the cell splitting and expansion. So, it might be the reason for increase in plant height by foliar application of NAA in combination with HA in pigeonpea.

The data revealed that plant height was increased with the age till its maturity. Gaikwad *et al*. (2012) reported that two foliar sprays of 400 ppm HA through VCW increased plant height in maize.

Arsode (2013) observed that foliar application of 50 ppm NAA + 300 ppm HA through cowdung wash at 30 and 45 DAS significantly enhanced plant height in mustard.

Behzad Sani (2014) tested the effect of foliar application of humic acid (control, 0.5, 1, 1.5 and 2%) on canola sprayed at 3 stages i.e. stem elongation, flowering stage and silique formation stage. The results showed that foliar application of humic acid significantly affected plant height in canola and highest was achieved under 2% foliar application of humic acid and the lowest plant height was obtained under controlled conditions.

Kapase *et al*. (2014) reported the effect of humic acid through vermicompost wash and NAA and found that foliar sprays of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced plant height in chickpea.

Number of branches $plant^{-1}$

The data on number of branches $plant^{-1}$ were recorded at harvest. Significantly maximum numbers of branches $plant^{-1}$ were recorded by the treatments of T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA +50 ppm NAA) when compared with control and rest of the treatments. It was also noticed that the treatments like T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) also increased number of the branches over control and remaining treatments.

It is clear from above data that foliar application of HA and growth hormone alone and in combination increased number of branches $plant^{-1}$. It is known that the HA is a source of micro and macronutrients. These nutrients are quickly absorbed by the plant when HA is sprayed as a foliar spray. Macro nutrients like N, P and K are associated with the different plant processes *viz.,* cell enlargement, translocation of solutes, formation of carbohydrates etc. It is associated with the increase in height and number of branches in the present study.

Osman *et al*. (2013) noticed that nitrogen fertilizer sources and foliar spray of humic acid significantly improved the morpho-physiological characters in rice. Foliar application of humic acid and fulvic acid together led to significant increase in number of tillers m^{-2}.

Arsode (2013) reported that foliar application of 50 ppm NAA + 300 ppm HA through cowdung wash at 30 and 45 DAS significantly increased number of primary branches in mustard.

Kapase (2014) revealed the effect of humic acid through vermicompost wash and NAA and concluded that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced number of branches in chickpea.

Leaf area plant^{-1}

The data on leaf area plant^{-1} were recorded at four growth stages i.e. 45, 65, 85 and 105 DAS. Significant variation with gradual increase (65, 85 and 105 DAS) was noticed regarding leaf area at all the stages of observations. Leaf area at 45 DAS was found non significant because spraying was done on the same day.

At 65 DAS leaf area plant^{-1} was significantly influenced by different treatments. At this stage treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA)in a descending manner noted significantly more leaf area when compared with control and rest of the treatments.

At 85 DAS leaf area plant^{-1} was significantly influenced by different treatments. At this stage treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) exhibited more leaf area in a descending manner when compared with control and rest of the treatments.

At 105 DAS leaf area was significantly higher in treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments under study.

Hence, it can be inferred that when nutrients and hormones applied through foliar spray, might have accelerated the metabolic and physiological activities of plant and put up more growth by assimilating more amount of major nutrients and ultimately increased leaf area of plant in present investigation.

Plant growth regulators are synthesized indigenously by plants, however, several studies demonstrated that plants can respond to exogenous application of these chemicals. An exogenous application of plant growth regulators affects the endogenous hormonal pattern of the plant, either by supplementation of sub-optimal levels or by interaction with their synthesis, translocation or inactivation of existing hormone levels (Arshad and Frankenberger, 1993).

According to Arsode (2013) foliar application of 50 ppm NAA + 300 ppm HA through cowdung wash at 30 and 45 DAS significantly enhanced leaf area in mustard.

Kapase (2014) sprayed humic acid through vermicompost wash and NAA on chickpea and opined that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced leaf area.

Total dry weight plant^{-1}

Dry matter is an important criterion. It determines the source-sink relationship and depends upon the net gain in the processes on anabolism and catabolism of plant. At 45 DAS the data regarding dry matter production were found non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (45 DAS).

At 65 DAS dry matter production was significantly increased by different treatments. At this stage significantly maximum dry matter recorded in treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA) and T_{12} (500 ppm HA + 50 ppm NAA). Similarly treatments T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) also exhibited significantly moderate dry matter when compared with control (T_1) and rest of the treatments.

At 85 DAS the the highest dry matter production was noticed by the treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by treatment T_{10} (300 ppm HA + 50 ppm NAA). Treatments T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) exhibited significantly moderate dry matter over control and remaining treatments under study.

At 105 DAS, foliar application of 400 ppm HA + 50 ppm NAA (T_{11}) resulted in more dry matter followed by treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA).

The inferences drawn from data it is clear that dry matter rapidly increased from 1st to 2nd stage of observation. Dry matter accumulation is a function of leaf area and more leaf area was observed during 45-65 DAS and it is period of maximum photosynthesis and yielded maximum dry matter production.

Dry matter production and its partitioning towards reproductive parts is an important yield attributing character and a basic vegetative phase is essential for the development of reproductive parts. Hormones regulate physiological process and synthetic growth regulators may enhance growth and development of field crops thereby increased total dry mass of a field crop (Das and Das, 1996). Singaroval *et al*. (1993) claimed that increase in dry matter production with humic acid might be due to its direct action on plant growth, auxin activity, contributing to increase in dry matter.

Arsode (2013) confirmed that foliar application of 50 ppm NAA + 300 ppm HA through cowdung wash at 30 and 45 DAS significantly increased dry matter content in mustard.

Motaghi and Nejad (2014) investigated the interactive effect of humic acid and different levels of potassium fertilizer on physiological indices of cowpea. They tried three levels of potassium fertilizer (0, 200 and 300 kg ha^{-1}) and three levels of humic acid (0, 50, 100 ppm). Changes trend of dry matter significantly increased at density of 100 ppm humic acid and 300 kg ha^{-1} potassium.

Kapase (2014) applied humic acid through vermicompost wash and NAA and noted that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced total dry matter production $plant^{-1}$ in chickpea.

Growth analysis

Growth analysis is one of the measures for accessing the seed yield of plant. The physiological basis of yield difference can measured through an evaluation of difference in growth parameters and their impact on yield. The productivity of crop may be related with the parameters such as RGR, NAR and partitioning of total photosynthates into economic and non-economic sink.

Relative Growth Rate

Significantly maximum RGR was recorded in treatment T_{11} (400 ppm HA + 50 ppm NAA) i.e. 0.0983 g g^{-1} while it was lowest in control i.e. 0.0695 g g^{-1} at 45-65 DAS. Treatment T_{11} (400 ppm HA + 50 ppm NAA) gave more RGR followed by treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments under study. Treatments T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) also registered significant more RGR over the control.

During 2nd phase (65-85 DAS) significantly maximum RGR was observed in treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by the treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA) and T_7 (300 ppm HA + 25 ppm NAA) in a descending manner when compared with control and rest of the treatments.

At 85-105 DAS significantly maximum RGR was observed in treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by the treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA). Treatments T_7 (300 ppm HA + 25 ppm NAA) and T_9 (500 ppm HA + 25 ppm NAA) also shown significant performance over the control. The decrease in RGR of plants during the growth season is due to increase of structural tissues in comparison to photosynthetic tissues. (Motaghi and Nejad , 2014).

Kapase (2014) examined the effect of humic acid through vermicompost wash and NAA on chickpea and noticed significantly more RGR by the foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW.

Motaghi and Nejad (2014) investigated the interactive effect of humic acid and different levels of potassium fertilizer and reported that foliar application of 100 ppm humic acid and 300 kg ha^{-1} potassium significantly increased RGR in cowpea.

Net Assimilation Rate

Considering the treatments under study, during 1st phase (45-65 DAS) significantly maximum NAR was noted in treatments T_{11} (400 ppm HA + 50 ppm NAA) and T_{10} (300 ppm HA + 50 ppm NAA) when compared with control and rest of the treatments. Treatments T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA) also gave significantly more NAR over T_1 (control).

At 65-85 DAS significantly maximum NAR was observed in treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), and T_7 (300 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments.

At 85-105 DAS significantly maximum NAR was observed in treatment T_{11} (400 ppm HA + 50 ppm NAA) followed by the treatments T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA), T_8 (400 ppm HA + 25 ppm NAA), T_7 (300 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA) and treatment T_6 (50 ppm NAA) when compared with control and rest of the treatments.

Net assimilation rate (NAR) synonymously called as unit leaf rate, expresses the rate of dry weight increase at any instant on a leaf area basis with leaf representing an estimate of the size of the assimilatory surface area (Gregory, 1926). Decrease in NAR during reproductive phase might be due to decrease efficiency of leaves for photosynthesis as a response to photosynthetic apparatus to increase demand for assimilates by growing seed fraction and sink demand on photosynthetic rate of leaves.

Kapase (2014) checked the effect of humic acid through vermicompost wash and NAA and reported that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced NAR in chickpea.

Motaghi and Nejad (2014) observed the interactive effect of humic acid and different levels of potassium fertilizer and reported that foliar application of 100 ppm humic acid and 300 kg ha^{-1} potassium significantly increased NAR in cowpea.

Seed yield ha^{-1} (q)

Seed yield is the economic yield which is final results of physiological activities of plants. Economic yield is that part of biomass that is converted into economic product (Nichiporvic, 1960).

Significantly maximum seed yield $plant^{-1}$, $plot^{-1}$, ha^{-1} was recorded in treatments T_{11} (400 ppm HA + 50 ppm NAA), T_{10} (300 ppm HA + 50 ppm NAA), T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA) in a descending manner when compared with control and rest of the treatments. Treatments T_7 (300 ppm HA + 25 ppm NAA), T_9 (500 ppm HA + 25 ppm NAA) and T_6 (50 ppm NAA) also exhibited superiority over control (T_1).

The growth hormone reduces flower drop, abscission of flower and ultimately increased seed yield and biomass production in pigeonpea. Hormones play a key role in the long distance movement of metabolites in plant. Auxin has effect on phloem transport. The metabolites and nutrients are moved from leaves and other parts of the plant into the fruits. (Seth and Wareing, 1967).

Humic acid had been shown to stimulate plant growth and consequently yield by acting on mechanisms i.e. cell respiration, photosynthesis, protein synthesis, water nutrient uptake and enzyme activities (Chen *et al.*, 2004) which results into increase in various growth characters *viz.*, plant height, number of branches $plant^{-1}$, leaf area, total dry matter production which are correlated with increase in the number of pods $plant^{-1}$, number of seeds pod^{-1}, 100 seed weight and seed yield $plant^{-1}$. These might be the reasons responsible for increase in yield of pigeonpea in the present investigation.

Arsode (2013) sprayed humic acid through cowdung wash and NAA on mustard and reported that 50 ppm NAA and 300 ppm HA significantly increased seed yield over control and rest of treatments.

Kapase (2014) investigated the effect of humic acid through vermicompost wash and NAA on chickpea and showed that foliar spray of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly increased seed yield ha^{-1}.

Nadimpoor and Mani (2015) investigated the effect of different levels of humic acid and harvest time of forage on the forage and grain yield of dual purpose barley. Data revealed that yield contributing parameters viz., grain yield, number of spikes $unit^{-1}$ area, number of grains $spike^{-1}$ significantly enhanced with the 1000 ppm humic acid and the forage harvest at the beginning of stem elongation.

Harvest Index

Harvest index is the proportion of biological yield represented by economic yield. It is the coefficient of effectiveness or the migration coefficient. Harvest index reflects the proportion of assimilate distribution between the economic and total biomass (Donald and Hamblin, 1976).

The range of harvest index obtained was 24.98 % in control to 33.65 % in treatment receiving 400 ppm HA + 50 ppm NAA (T_{11}). Treatment T_{10} (300 ppm HA + 50 ppm NAA) also increased harvest index significantly when compared with control and rest of the treatments. Next to these two treatments, treatments were T_{12} (500 ppm HA + 50 ppm NAA) and T_8 (400 ppm HA + 25 ppm NAA), these treatments also enhanced harvest index significantly over control.

Yadav *and Bharud* (2009) examined the effects of foliar application of GA (10 ppm), NAA (20 ppm), CCC (25 ppm), BAP (25 ppm), Bioforce (2 ml l^{-1}) and Biopower (2 ml l^{-1}) on kabuli chickpea given at 10-days intervals starting from initiation of flowering. Finally recorded highest values with the application of Bioforce and Biopower for harvest index as compared to control.

Ananthi and Gomathi (2011) reported the effect of foliar application of humic acid with brassinosteroid on green gram and stated that harvest index was favorably enhanced by the foliar spray of 0.1 % humic acid with 0.1 ppm brassinosteroid treatment.

B:C ratio

The analysis of B:C ratio due to expenditure incurred under different treatments of HA through VCW and NAA revealed that highest benefit : cost ratio for foliar application of 400 ppm HA through VCW + 50 ppm NAA (T_{11}) was calculated as 2.49 as compared to 2.0 for control (T_1).

Table 1.Effect of humic acid through vermicompost wash on morpho-physiological parameters

Treatments	Plant height (cm)	Number of branches plant^{-1}	Leaf area plant^{-1} (dm^2)				Total dry weight plant^{-1} (g)			
			45 DAS	65 DAS	85 DAS	105 DAS	45 DAS	65 DAS	85 DAS	105 DAS
T_1 (control)	248.67	15.85	7.13	18.81	33.90	48.82	7.13	29.68	213.39	321.26
T_2 (300 ppm HA)	252.76	16.87	7.56	20.11	36.46	55.17	6.31	30.44	216.91	328.27
T_3 (400 ppm HA)	254.33	17.03	6.58	20.27	37.81	56.48	7.14	31.36	219.28	332.17
T_4 (500 ppm HA)	250.13	16.36	6.72	19.13	36.42	55.12	7.51	30.17	216.01	324.17
T_5 (25 ppm NAA)	255.67	18.37	7.50	20.96	38.17	56.76	6.23	31.82	223.89	336.31
T_6 (50 ppm NAA)	258.46	18.93	7.21	22.10	40.02	57.31	6.31	34.02	227.31	342.96
T_7 (300 ppm HA + 25 ppm NAA)	261.70	22.67	7.46	23.61	42.33	59.79	8.42	38.12	235.58	349.78
T_8 (400 ppm HA + 25 ppm NAA)	264.96	23.50	6.53	24.56	44.18	64.28	6.37	39.19	237.66	352.28
T_9 (500 ppm HA + 25 ppm NAA)	259.38	22.03	6.61	23.37	42.28	57.46	6.81	36.53	232.16	347.12
T_{10} (300 ppm HA + 50 ppm NAA)	268.03	27.76	6.57	25.42	46.17	69.29	6.55	42.82	246.21	356.61
T_{11} (400 ppm HA + 50 ppm NAA)	269.97	28.16	6.89	25.87	46.32	70.06	6.76	45.93	258.16	363.46
T_{12} (500 ppm HA + 50 ppm NAA)	266.71	26.89	7.21	24.69	45.09	68.71	7.25	42.27	242.77	354.19
SE (m) ±	2.239	1.254	0.441	0.982	1.734	3.636	0.44	2.041	4.021	5.775
CD at 5%	6.687	3.745	-	2.936	5.180	10.840	-	6.092	12.006	17.233

Table 2. Effect of humic acid through vermicompost wash on RGR, NAR, seed yield ha^{-1}, harvest index and B:C ratio

Treatments	RGR (g g^{-1} day^{-1})			NAR (g dm^{-2} day^{-1})			Seed yield ha^{-1} (q)	Harvest index (%)	B : C Ratio
	45-65 DAS	65-85 DAS	85-105 DAS	45-65 DAS	65-85 DAS	85-105 DAS			
T_1 (control)	0.0695	0.0763	0.0163	0.1006	0.2823	0.0907	13.64	24.98	2.00
T_2 (300 ppm HA)	0.0719	0.0774	0.0172	0.1036	0.2959	0.1080	14.17	25.93	2.05
T_3 (400 ppm HA)	0.0725	0.0784	0.0183	0.1040	0.2969	0.1096	14.43	26.52	2.08
T_4 (500 ppm HA)	0.0703	0.0765	0.0167	0.1020	0.2924	0.1029	13.75	25.88	1.98
T_5 (25 ppm NAA)	0.0726	0.0794	0.0185	0.1042	0.3022	0.1170	15.29	27.47	2.23
T_6 (50 ppm NAA)	0.0735	0.0799	0.0193	0.1055	0.3066	0.1197	15.64	27.91	2.28
T_7 (300 ppm HA + 25 ppm NAA)	0.0742	0.0818	0.0206	0.1142	0.3339	0.1216	15.8	28.84	2.28
T_8 (400 ppm HA + 25 ppm NAA)	0.0754	0.0825	0.0223	0.1259	0.3345	0.1291	16.26	30.06	2.34
T_9 (500 ppm HA + 25 ppm NAA)	0.0738	0.0807	0.0198	0.1095	0.3202	0.1198	15.71	28.12	2.25
T_{10} (300 ppm HA + 50 ppm NAA)	0.0761	0.0834	0.0238	0.1301	0.3460	0.1355	16.97	31.78	2.44
T_{11} (400 ppm HA + 50 ppm NAA)	0.0783	0.0846	0.0246	0.1365	0.3585	0.1384	17.38	33.65	2.49
T_{12} (500 ppm HA + 50 ppm NAA)	0.0758	0.0827	0.0229	0.1263	0.3392	0.1352	16.84	30.26	2.41
SE (m) ±	0.0012	0.0015	0.0008	0.0032	0.0102	0.00697	3.383	1.129	-
CD at 5%	0.0035	0.0045	0.00239	0.0094	0.0305	0.02079	1.144	3.37	-

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Rec. on 01.05.2017 & Acc. on 25.05.2017