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EFFECT OF DIFFERENT CONCENTRATIONS OF HUMIC ACID AND NAA ON MORPHO - PHYSIOLOGICAL PARAMETERS AND YIELD OF LINSEED

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ABSTRACT

A field experiment laid out in randomized block design was conducted to investigate the effect of different concentrations of humic acid and NAA on yield and yield components of linseed at the experimental farm of Agricultural Botany Section, College of Agriculture, Nagpur during year 2015-16. Two foliar sprays of humic acid through vermicompost wash and NAA were given at 35 and 55 DAS. Five concentrations of humic acid (300, 350, 400, 450 and 500 ppm) and two concentrations of NAA (25 and 50 ppm) individually and in combination were tested. Foliar application of 350 ppm HA through VCW + 50 ppm NAA followed by 300 ppm HA through VCW + 50 ppm NAA significantly enhanced plant height, number of branches, leaf area, dry weight, RGR, NAR, seed yield ha^{-1} and harvest index.

(Key words: Linseed, humic acid through vermicompost wash, NAA, foliar spary)

INTRODUCTION

Among *rabi* oilseed crops in India, linseed happens to occupy the second position i.e. next to rapeseed-mustard in importance from the view point of area as well as production. It is such a valuable crop that every part of the plant has specific economic importance. Its seeds when crushed yield oil. Due to its dying properties, the oil is used in paints, varnishes and polymer industries (Gill, 1987). Stem yields fibre of good lusture, tensible strength and durability having good blending property. The left over cortical tissue serve as source of wax and raw material for paper industry. Linseed oil is a rich source of linolenic acid (40-60%), an Omega 3 fatty acid which has anti-inflammatory action in the treatment of arthritis. It has also quality in lowering down the cholesterol level in mammals. Lignan present in oil has anti-carcinogenic effect.

The high cation exchange capacity of humic acid prevents nutrients from leaching. It absorbs the nutrients from chemical fertilizers and these exchanged nutrients are slowly released to the plant. Humic acid is the product of breakdown of organic matter. 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 spray. It is transparent pale yellow biofertilizer. It is a mixture of excretory products and mucous secretion of earth worm *(Lampito mautrii* and *Eisenia fetida)* and organic micronutrients of soil, which may be promoted as "potent fertilizer" for better yield and growth (Shweta *et al*., 2005). 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). Vermicompost wash is having N-0.29%, P-0.042%, K-0.143%, Ca-0.186%, Mg- 0.11%, S-0.058%, Fe 0. 466 ppm, Mn 0.406 ppm, Zn 0.11 ppm, Cu 0.18 ppm. (Anonymous, 2007).

NAA (Naphthalene Acetic Acid) is the synthetic auxin with the identical properties to that naturally occuring 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).

This experiment aimed to investigate the effect of foliar applications of humic acid through vermicompost wash and NAA on morpho-physiological parameters and yield of linseed.

MATERIALS AND METHODS

The experiment was conducted in 2015-16 in experimental farm of Agricultural Botany Section, College of Agriculture, Nagpur in RBD with three replications and eighteen treatments. The studied factors included five concentrations of humic acid through vermicompost wash (300, 350, 400, 450 and 500 ppm) and two concentrations of NAA (25 and 50 ppm) used as foliar spray alone or in combinations like T_2 (25 ppm NAA), T_3 (50 ppm NAA), T_4 (300 ppm HA through VCW), T_5 (350 ppm HA through VCW)), T_6 (400 ppm HA through VCW)), T_7 (450 ppm HA through VCW)), T_8 (500 ppm HA through VCW), T_9 (300

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ppm HA through VCW + 25 ppm NAA), T_{10} (350 ppm HA through VCW + 25 ppm NAA), T_{11} (400 ppm HA through VCW + 25 ppm NAA), T_{12} (450 ppm HA through VCW + 25 ppm NAA), T_{13} (500 ppm HA through VCW + 25 ppm NAA), T_{14} (300 ppm HA through VCW + 50 ppm NAA), T_{15} (350 ppm HA through VCW + 50 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{17} (450 ppm HA through VCW + 50 ppm NAA) and T_{18} (500 ppm HA through VCW + 50 ppm NAA) with T_1 (control). PKV-NL-260 cultivar of linseed was used in the experiment. Observations on plant height and number of branches were recorded at the time of harvesting. Leaf area and dry weight of plant were recorded at 35, 55 and 75 DAS stages. RGR and NAR also calculated at 35-55 and 55-75 DAS stages. Seed yield ha^{-1} were recorded. Harvest index was also calculated.

RESULTS AND DISCUSSION

Plant height

Height is an important measure of growth. It is one of the visiable measurements and is a function of internodes and leaf emergence. Since, leaves are born on stem, leaf area development and biomass production shows a close relationship with plant height.

At harvesting treatments T_{15} (350 ppm HA + 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA), T_{10} (350 ppm HA + 25 ppm NAA), T_9 (300 ppm HA + 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA), T_4 (300 ppm HA) , T_{17} (450 ppm HA + 50 ppm NAA), T_{12} (450 ppm HA + 25 ppm NAA) and T_{13} (500 ppm HA + 25 ppm NAA) recorded significantly maximum plant height over control and rest of the treatments. Similarly, treatments T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA), T_7 (450 ppm HA), T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) also noted significantly more plant height when compared with control.

Number of branches plant^{-1}

Branches are the site of the leaves, flower and capsules formation. Hence, they are closely associated with the photosynthetic activity and yield of plant. So, number of branches is a desirable attribute for higher biomass production and yield.

The data on number of branches plant^{-1} were recorded at harvesting. Significantly maximum numbers of branches were recorded by the treatments of T_{15} (350 ppm HA + 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA), T_{10} (350 ppm HA +25 ppm NAA), T_9 (300 ppm HA+ 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA) and T_4 (300 ppm HA) followed by treatments T_{17} (450 ppm HA + 50 ppm NAA), T_{12} (450 ppm HA + 25 ppm NAA), T_{13} (500 ppm HA + 25 ppm NAA), T_{18} (500 ppm HA + 50 ppm NAA) when compared with control and rest of the treatments. But treatments T_6 (400 ppm HA), T_7 (450 ppm HA), T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found at par with control.

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 plant height and number of branches in the present study.

Growth hormone like NAA when applied as foliar spray it enhances physiological and metabolic activities of plant and also enhances the uptake of nutrients from soil which helps in overall plant growth and ultimately increases the yield.

Leaf area plant^{-1}

Leaf area depends upon the number and size of leaves. Leaf area play important role in absorption of light, radiation and using it in photosynthesis process. Leaf size is influenced by light, moisture and nutrients. Hence, yield is dependent on leaf area of crop.

The data on leaf area plant^{-1} were recorded at three growth stages i.e. 35, 55 and 75 DAS. Significant variations were observed at 55 and 75 DAS. At 55 DAS leaf area plant^{-1} was significantly influenced by different treatments. The range of leaf area recorded was 1.43-2.33 dm^2. At this stage treatments T_{15} (350 ppm HA + 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA), T_{10} (350 ppm HA + 25 ppm NAA), T_9 (300 ppm HA + 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA), T_4 (300 ppm HA) and T_{17} (450 ppm HA + 50 ppm NAA) in a descending manner noted significantly more leaf area when compared with control and rest of the treatments. Similarly treatments T_{12} (450 ppm HA + 25 ppm NAA) and T_{13} (500 ppm HA + 25 ppm NAA) also increased leaf area significantly over control and rest of the treatments under study. Treatments T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA), T_7 (450 ppm HA), T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found at par with control.

At 75 DAS leaf area plant^{-1} was significantly influenced by different treatments. The range of leaf area recorded was 1.45-2.83 dm^2. At this stage treatments T_{15} (350 ppm HA + 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA), T_{10} (350 ppm HA + 25 ppm NAA), T_9 (300 ppm HA + 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA), T_4 (300 ppm HA) and T_{17} (450 ppm HA + 50 ppm NAA) exhibited more leaf area in a descending manner when compared with control and rest of the treatments. Similarly treatments T_{12} (450 ppm HA + 25 ppm NAA), T_{13} (500 ppm HA + 25 ppm NAA), T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA) and T_7 (450 ppm HA) also recorded more leaf area when compared with control. But treatments T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found at par with control.

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 35 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 (35 and 55 DAS).

At 55 DAS dry matter production was significantly increased by different treatments. The range of dry matter recorded was 2.05-4.50 g. At this stage significantly maximum dry matter recorded in treatments T_{15} (350 ppm HA + 50 ppm NAA) and T_{14} (300 ppm HA + 50 ppm NAA). Next to this, treatments T_{10} (350 ppm HA + 25 ppm NAA), T_9 (300 ppm HA + 25 ppm NAA) and T_{16} (400 ppm HA + 50 ppm NAA) recorded significantly maximum dry matter accumulation in a descending manner when compared with control and rest of the treatments. Similarly treatments T_{11} (400 ppm HA + 25 ppm NAA),T_5 (350 ppm HA), T_4 (300 ppm HA),T_{17} (450 ppm HA + 50 ppm NAA) T_{12} (450 ppm HA + 25 ppm NAA), T_{13} (500 ppm HA + 25 ppm NAA) ,T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA) and T_7 (450 ppm HA) also exhibited significantly moderate dry matter when compared with control (T_1) and rest of the treatments. Treatments T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found at par with T_1 (control).

At 75 DAS the range of dry matter production was 2.70-8.10 g. At this stage treatments T_{15} (350 ppm HA + 50 ppm NAA) stood first in rank and significantly increased dry matter over control and rest of the treatments under study. Similarly treatments T_{14} (300 ppm HA + 50 ppm NAA) stood second in rank and also recorded significantly maximum dry matter over control and rest of the treatments. Treatments T_{10} (350 ppm HA + 25 ppm NAA) and T_9 (300 ppm HA + 25 ppm NAA) also showed their significance over control and remaining treatments. Next to these two treatments, treatments T_{16} (400 ppm HA + 50 ppm NAA),T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA) and T_4 (300 ppm HA) also recorded significantly more dry matter over control and rest of the treatments under study. Treatments T_{17} (450 ppm HA + 50 ppm NAA),T_{12} (450 ppm HA + 25 ppm NAA), T_{13} (500 ppm HA + 25 ppm NAA),T_{18} (500 ppm HA + 50 ppm NAA),T_6 (400 ppm HA),T_7 (450 ppm HA) and T_8 (500 ppm HA) exhibited significantly moderate dry matter over control and remaining treatments under study. Treatments T_3 (50 ppm NAA) and T_2 (25 ppm NAA) recorded minimum dry matter and remained at par with treatment T_1 (control).

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 55-75 DAS and it is period of maximum photosynthesis and yielded maximum dry matter production.

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.

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

The highest rate of RGR indicates the ability of maximum dry matter for development. The increment in RGR might be associated with maximum leaf area expansion and growth of stem and root. Increment in NAR is related with the increase in total dry weight of plant unit^{-1} of leaf area.

At 35-55 DAS all treatments gave significant variation in respect of RGR when compared with control except treatments T_3(50 ppm NAA) and T_2 (25 ppm NAA). Significantly maximum RGR was recorded in treatment T_{15} (350 ppm HA + 50 ppm NAA) and T_{14} (300 ppm HA + 50 ppm NAA) followed by treatments T_{10} (350 ppm HA + 25 ppm NAA) and T_9 (300 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments under study. Similarly treatments T_{16} (400 ppm HA + 50 ppm NAA),T_{11} (400 ppm HA + 25 ppm NAA),T_5 (350 ppm HA), T_4 (300 ppm HA), T_{17} (450 ppm HA + 50 ppm NAA), T_{12} (450 ppm HA + 25 ppm NAA) and T_{13} (500 ppm HA + 25 ppm NAA) also gave significantly more RGR in a descending manner when compared with control (T_1) and rest of the treatments under observations. Treatments T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA),T_7 (450 ppm HA) and T_8 (500 ppm HA) were also found significantly superior over T_1 (control) and treatments T_3(50 ppm NAA) and T_2 (25 ppm NAA).

During 2nd phase (55-75 DAS) significantly maximum RGR was observed in treatments T_{15} (350 ppm HA + 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA),T_{10} (350 ppm HA + 25 ppm NAA) and T_9 (300 ppm HA + 25 ppm NAA) in a descending manner when compared with control and rest of the treatments. Similarly treatments T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 35 ppm NAA),T_5 (350 ppm HA) T_4 (300 ppm HA), T_{17} (450 ppm HA + 50 ppm NAA), T_{12} (450 ppm HA + 25 ppm NAA) and T_{13} (500 ppm HA + 25 ppm NAA) also registered significantly more RGR over control and rest of the treatments. Next to these seven treatments, treatments T_{18} (500 ppm HA + 50 ppm NAA),T_6 (400 ppm HA) and T_7 (450 ppm HA) also exhibited significantly more RGR over treatments T_8 (500 ppm HA),T_3 (50 ppm NAA),T_2 (25 ppm NAA) and T_1 (control).

The decrease of RGR of plants during the growth season is due to increase of structural tissues in comparison to photosynthetic tissues. (Motaghi and Nejad , 2014).

Net Assimilation Rate

NAR is closely connected with photosynthetic efficiency of leaves, but it is not a pure measure of photosynthesis. NAR depends upon the excess dry matter gained, over the loss in respiration. It is increase in plant dry weight unit^{-1} area of assimilatory tissue unit^{-1} time.

Considering the treatments under study, during 1st phase (35-55 DAS) significantly maximum NAR was noted in treatments T_{15} (350 ppm HA + 50 ppm NAA) and T_{14} (300 ppm HA + 50 ppm NAA) when compared with control and rest of the treatments. Treatments T_{10} (350 ppm HA + 25 ppm NAA), T_9 (300 ppm HA + 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA), T_4 (300 ppm HA), T_{17} (450 ppm HA + 50 ppm NAA), T_{12} (450 ppm HA + 25 ppm NAA), T_{13} (500 ppm HA +25 ppm NAA), T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA), T_7 (450 ppm HA) and T_8 (500 ppm HA) in a treatments descending manner also gave significantly more NAR over T_1 (control), T_2 (25 ppm NAA) and T_3 (50 ppm NAA).

At 2nd phase (55-75 DAS) significantly maximum NAR was observed in treatments T_{15} (350 ppm HA + 50 ppm NAA) and T_{14} (300 ppm HA + 50 ppm NAA) when compared with control and rest of the treatments. Similarly treatments T_{10} (350 ppm, HA + 25 ppm NAA) and T_9 (300 ppm HA + 25 ppm NAA) also registered significantly maximum NAR over control and rest of the treatments. Moreover, treatments T_{16} (400 ppm HA + 50 ppm NAA),T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA), T_4 (300 ppm HA), T_{17} (450 ppm HA + 50 ppm NAA), T_{12} (450 ppm HA + 25ppm NAA),T_{13} (500 ppm HA +25 ppm NAA) and T_{18} (500 ppm HA + 50 ppm NAA) also recorded significantly more NAR over control and remaining treatments. Treatments T_6 (400 ppm HA), T_7 (450 ppm HA), T_8 (500 ppm HA) and T_3 (50 ppm NAA) also noted moderate and significant NAR over treatments T_2 (25 ppm NAA) and T_1 (control).

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. El-hendi *et al.* (2011) also opined that as the plant gets older NAR decreases due to leaves aging and their shadows on each other and decrease of active photosynthetic area.

Motaghi and Nejad (2014) investigated the interactive effect of humic acid at different levels of potassium fertilizer on physiological indices of cowpea. The studied factors include three levels of potassium fertilizer (0, 200 and 300 kg ha^{-1}) and three levels of humic acid (0, 50, 100 ppm). Leaf area index, dry weight, RGR and NAR increased at density of 100 ppm humic acid and 300 kg ha^{-1} potassium.

Kapase (2013) studied the effect of humic acid through vermicompost wash and NAA and reported 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, number of branches, leaf area, total dry matter production plant^{-1}, RGR and NAR in chickpea.

Seed yield ha^{-1}

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 ha^{-1} was recorded in treatments T_{15} (350 ppm HA + 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA), T_{10} (350 ppm HA + 50 ppm NAA), T_9 (300 ppm HA + 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 25 ppm NAA),T_5 (350 ppm HA), T_4 (300 ppm HA), T_{17} (450 ppm HA + 50 ppm NAA) and T_{12} (450 ppm HA + 25 ppm NAA) in a descending manner when compared with control and rest of the treatments. But, treatments T_{13} (500 ppm HA + 25 ppm NAA),T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA), T_7 (450 ppm HA), T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found at par with T_1 (control).

The growth hormone reduces flower drop, abscission of flower and ultimately increased seed yield and biomass production in linseed. Hormones play a key role in the long distance movement of metabolites in plant. Auxin have 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).

Arsode (2013) studied the effect of foliar application of 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.

Waqas *et al.* (2014) conducted triplicate field experiment to evaluate the different concentrations of humic acid on yield components of mung bean. The treatments comprised of three methods of humic acid application i. e. seed priming with 0% (water soaked), 1%, 2% humic acid solution, foliar spray with 0.01%, 0.05% and 0.1% humic acid solution and soil application of humic acid 3 kg ha^{-1} and resulted increase in yield significantly.

Kapase (2013) evaluated the effect of humic acid through vermicompost wash and NAA on chickpea and stated 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}.

A field experiment was conducted by Nadimpoor and Mani (2015) to investigate the effect of different levels of humic acid and harvest time of forage on the forage and grain yield of dual purpose barley. Data showed that grain yield significantly increased with the 1000 ppm humic acid.

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

Table 1 . Effect of humic acid through vermicompost wash and NAA on plant height plant^{-1}, number of branches plant^{-1}, leaf area (dm^2), dry weigh plant^{-1} (g), RGR and NAR in linseed

Treatments	Plant height palnt^{-1}	Number of branches plant^{-1}	Leaf area (dm^2)			Dry weight (g)			RGR(g g^{-1} day^{-1})		NAR(g dm^2 day^{-1})	
			35 DAS	55 DAS	75 DAS	35 DAS	55 DAS	75 DAS	35-55 DAS	55-75 DAS	35-55 DAS	55-75 DAS
T_1 (control)	29.97	3.24	0.98	1.43	1.45	1.48	2.05	2.70	0.0162	0.0137	0.0239	0.0224
T_2 (25 ppm NAA)	36.73	3.5	0.85	1.45	1.63	1.58	2.23	2.95	0.0172	0.0139	0.0289	0.0234
T_3(50 ppm NAA)	36.87	3.58	1.00	1.52	1.65	1.56	2.38	3.42	0.0211	0.0181	0.0330	0.0327
T_4 (300 ppm HA through VCW)	43.78	5.03	0.99	1.96	2.59	1.35	3.26	5.50	0.0440	0.0261	0.0663	0.0493
T_5 (350ppm HA through VCW)	44.38	5.20	1.01	2.05	2.69	1.38	3.33	5.70	0.0440	0.0268	0.0672	0.0501
T_6 (400 ppm HA through VCW)	41.01	3.71	1.01	1.75	2.22	1.49	2.60	4.10	0.0278	0.0227	0.0411	0.0378
T_7 (450 ppm HA through VCW)	40.26	3.70	1.01	1.72	2.19	1.47	2.55	3.97	0.0275	0.0221	0.0404	0.0363
T_8 (500 ppm HA through VCW)	39.44	3.60	0.99	1.57	1.69	1.39	2.40	3.50	0.0273	0.0188	0.0401	0.0337
T_9 (300 ppm HA through VCW + 25 ppm NAA)	46.01	6.00	0.98	2.19	2.73	1.38	3.70	6.59	0.0493	0.0288	0.0772	0.0589
T_{10} (350 ppm HA through VCW + 25 ppm NAA)	47.54	6.08	1.00	2.24	2.75	1.40	3.90	6.95	0.0549	0.0288	0.0812	0.0611
T_{11} (400 ppm HA through VCW + 25 ppm NAA)	44.81	5.20	1.00	2.10	2.72	1.43	3.48	5.97	0.0444	0.0269	0.0690	0.0517
T_{12} (450 ppm HA through VCW + 25 ppm NAA)	42.92	4.54	1.01	1.91	2.43	1.48	3.03	5.00	0.0358	0.0250	0.0547	0.0454
T_{13} (500 ppm HA through VCW + 25 ppm NAA)	42.22	4.43	1.01	1.83	2.42	1.40	2.85	4.70	0.0355	0.0250	0.0524	0.0436
T_{14} (300 ppm HA through VCW + 50 ppm NAA)	48.18	6.67	1.00	2.29	2.81	1.40	4.30	7.69	0.0561	0.0290	0.0930	0.0664
T_{15} (350 ppm HA through VCW + 50 ppm NAA)	48.88	6.81	0.96	2.33	2.83	1.30	4.50	8.10	0.0621	0.0293	0.1035	0.0698
T_{16} (400 ppm HA through VCW + 50 ppm NAA)	45.74	5.47	0.92	2.15	2.72	1.36	3.60	6.20	0.0486	0.0271	0.0770	0.0535
T_{17} (450 ppm HA through VCW + 50 ppm NAA)	42.99	4.57	0.99	1.94	2.53	1.54	3.19	5.30	0.0364	0.0253	0.0584	0.0473
T_{18} (500 ppm HA through VCW + 50 ppm NAA)	41.87	4.23	0.98	1.78	2.27	1.49	2.73	4.40	0.0302	0.0238	0.0462	0.0413
SE (m)±	2.294	0.303	0.056	0.136	0.127	0.13	0.136	0.272	0.0019	0.00079	0.0034	0.0019
CD at 5%	6.592	0.870	-	0.390	0.364	-	0.391	0.783	0.0056	0.00226	0.0098	0.0054

Table 2. Effect of humic acid through vermicompost wash and NAA on seed yield ha^{-1}, per cent increase in yield, B:C ratio and harvest index in linseed

Treatments	Seed yield ha^{-1} (q)	Per cent increase in yield	B:C Ratio	Harvest index
T_1 (control)	12.50	-	5.09	40.13
T_2 (25 ppm NAA)	12.83	2.6	5.15	40.45
T_3(50 ppm NAA)	13.29	6.3	5.27	40.95
T_4 (300 ppm HA through VCW)	16.33	30.6	6.36	44.33
T_5 (350ppm HA through VCW)	16.75	34.0	6.43	45.11
T_6 (400 ppm HA through VCW)	14.16	13.2	5.44	42.56
T_7 (450 ppm HA through VCW)	13.62	8.9	5.19	42.32
T_8 (500 ppm HA through VCW)	13.54	8.3	5.13	41.41
T_9 (300 ppm HA through VCW + 25 ppm NAA)	17.41	39.2	6.70	45.73
T_{10} (350 ppm HA through VCW + 25 ppm NAA)	17.50	40.0	6.69	46.46
T_{11} (400 ppm HA through VCW + 25 ppm NAA)	16.95	35.6	6.48	45.23
T_{12} (450 ppm HA through VCW + 25 ppm NAA)	15.45	23.6	5.82	42.99
T_{13} (500 ppm HA through VCW + 25 ppm NAA)	15.08	20.6	5.64	42.83
T_{14} (300 ppm HA through VCW + 50 ppm NAA)	17.75	42.00	6.74	46.55
T_{15} (350 ppm HA through VCW + 50 ppm NAA)	18.00	44.00	6.79	47.10
T_{16} (400 ppm HA through VCW + 50 ppm NAA)	16.36	38.8	6.51	45.30
T_{17} (450 ppm HA through VCW + 50 ppm NAA)	15.87	26.9	5.90	43.27
T_{18} (500 ppm HA through VCW + 50 ppm NAA)	14.5	16.0	5.36	42.73
SE (m) $\pm$	0.89	-	-	0.481
CD at 5%	2.65	-	-	1.383

reflects the proportion of assimilate distribution between the economic and total biomass (Donald and Hamblin, 1976).

The rang of harvest index obtained was 40.13 % in control to 47.10 % in treatment receiving 350 ppm HA+ 50 ppm NAA (T_{15}). The treatments T_{15} (350 ppm HA+ 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA) and T_{10} (350 ppm HA + 25 ppm NAA) increased harvest index significantly when compared with control and rest of the treatments. Next to these three treatments, treatments were T_9 (300 ppm HA + 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm HA + 25 ppm NAA), T_5 (350 ppm HA) and T_4 (300 ppm HA). These treatments also enhanced harvest index significantly over control and rest of the treatments. Similarly treatments T_{17} (450 ppm HA + 50 ppm NAA), T_{12} (450 ppm HA + 25 ppm NAA), T_{13} (500 ppm HA + 25 ppm NAA), T_{18} (500 ppm HA + 50 ppm NAA), T_6 (400 ppm HA) and T_7 (450 ppm HA) also exhibited more harvest index when compared with control and rest of the treatments. But treatments T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were remained at par with control in harvest index.

Humic acid rich in both organic and mineral substances which are essential to vegetative growth of plant, it might be the reason for improvement in morpho-physiological parameters like plant height, number of branches, leaf area, dry matter and ultimatly increase in yield and HI in the present investigation.

Considering the different concentrations applied, two foliar sprays of 350 ppm HA through VCW + 50 ppm NAA at 35 and 55 DAS stood first in rank and significantly enhanced all parameters under study when compared with control and rest the treatments. This treatment increased yield by 44% having B:C of 6.79.

Hence, the two foliar sprays of 350 ppm HA through VCW + 50 ppm NAA at 35 and 55 DAS can be considered as the effective nutrient management treatment form all the treatments under study.

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