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Effect of Humic Acid Through Vermicompost Wash and Naa on Chemical and Biochemical Parameters and Productivity of Linseed

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Abstract

A field experiment was conducted at Botany Section, College of Agriculture, Nagpur to study the effect of different concentrations of humic acid through vermicompost wash on chemical and biochemical parameters and productivity of linseed during *rabi* season of 2015. The experiment was laid out in RBD with eighteen treatments and three replications. The different treatments tested were 25 and 50 ppm NAA and 300, 350, 400, 450 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 were taken at 35 and 55 DAS. Data revealed that foliar sprays of 350 ppm HA + 50 ppm NAA significantly enhanced chlorophyll, NPK content in leaves, oil content in seeds, number of capsules plant^{-1}, number seed capsule^{-1}, 1000 seed weight and ultimately increased yield by 44 and 42 per cent over control. B:C ratio of foliar application of 350 ppm HA through VCW + 50 ppm NAA was calculated as 6.79 as compared to 5.09 for control.

(Key words: Linseed, Humic acid Vermicompost wash and NAA)

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is an industrial oilseed crop grown for both seed and fibre. Almost every part of its plant is commercially utilized either direct or after processing. On small scale, the seed and its oil are directly used for human consumption as flax seed breads, bagels and other baked and fried food stuffs. It is industrial oil and mostly 80 per cent of oil is used for paints, varnishes, a wide range of coating oils, linoleum, a pad and printing inks, leather and soap industries. Linseed is highly nutritious. It is source of complete protein (all 8 essential amino acids), high order linolenic acid (an essential polyunsaturated), complex carbohydrates, vitamins, and minerals. Recent advances in medical research have found linseed as a best herbal source of Omega-3 and Omega-6 fatty acids which have immense nutritional/medicinal effects on human body system.

Humic acid (HA) when externally supplied was observed to increase crop growth and ultimately the yield. It improves the nutritional status of soil and plant system. Humic acid (HA) application had definite input on protein synthesis and nucleic acid synthesis. 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 break down 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. The economic and social potential of livestock in organic agriculture has long been known. In many countries, now a day the major components of organic agriculture are the use of livestock stock such as vermicompost in crop production.

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). Application of growth promoting hormones is a recent technique in this direction. Plant hormones in a broad sense are organic compounds which play an important

role in plant growth development and yield of crops to prevent the fruit and flower drop for a longer period.

MATERIALS AND METHODS

The present investigation was undertaken during *rabi* season of 2015 in RBD with 18 treatments and 3 replications at Experimental farm of Botany Section, College of Agriculture, Nagpur. Plot size of Individual treatment was gross 3.00 m × 1.10 m and net 2.4 m × 1.00 m. Seeds were sown at the rate of 25 kg ha^{-1} by drilling method at a spacing of 30 cm × 5 cm on 5th Nov. 2015 after receiving the sufficient rainfall. Treatments Comprised of T_1 (Control), T_2 (25 ppm NAA), T_3 (50 ppm NAA), T_4 (300 ppm VCW), T_5 (350 ppm VCW), T_6 (400 ppm VCW), T_7 (450 ppm VCW), T_8 (500 ppm VCW), T_9 (300 ppm VCW + 25 ppm NAA), T_{10} (350 ppm VCW + 25 ppm NAA), T_{11} (400 ppm VCW + 25 ppm NAA), T_{12} (450 ppm VCW + 25 ppm NAA), T_{13} (500 ppm VCW + 25 ppm NAA), T_{14} (300 ppm VCW + 50 ppm NAA), T_{15} (350 ppm VCW + 50 ppm NAA), T_{16} (400 ppm VCW + 50 ppm NAA), T_{17} (450 ppm VCW + 50 ppm NAA) and T_{18} (500 ppm VCW + 50 ppm NAA). Spraying of vermicompost wash (VCW) and NAA was done two times at 35 and 55 DAS with hand sprayer on linseed.

The chemical and biochemical parameters *viz.*, total chlorophyll content (mg g^{-1}), nitrogen (%), phosphorus (%) and potassium (%) in leaves and oil content (%) were recorded. Total chlorophyll content of dried leaves was estimated by colorimetric method as suggested by Bruinsma (1982). Nitrogen content in leaves was determined by microkjeldhal's method as given by Somichi *et al.* (1972). Phosphorus content in leaves was determined by vanadomolybdate yellow colour method as given by Jackson (1967). Potassium content in leaves was determined by flame photometer by di- acid extract method given by Jackson (1967). Nitrogen content was determined by micro- kjeldhal's method as given by Somich *et al.*(1972) and same was converted into crude protein by multiplying "N" per cent with factor 6.25. Seed yield $plant^{-1}$ (g), $plot^{-1}$ (kg) and ha^{-1} (q) and harvest Index (%) were recorded. Data were subjected to the statistical analysis by employing the method for RBD as suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

The observations recorded on chemical, biochemical, yield and yield contributing parameters of linseed were statistically analysed and the results obtained are presented under appropriate heading and sub-headings.

Leaf chlorophyll content (mg g^{-1})

Data pertaining to leaf chlorophyll content in leaves of linseed are presented in table 2. Data on leaf chlorophyll content gave significant variations at 55 and 75 DAS. At 35 DAS data regarding chlorophyll content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (35 and 55 DAS). At 55 and 75 DAS significantly highest chlorophyll was found in combination treatment T_{15} (350 ppm HA + 50 ppm NAA) followed by treatments T_{14} (300 ppm HA + 50 ppm NAA) and T_{10} (350 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments. Treatments 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) also gave significantly more chlorophyll content in leaves when compared with control. At 55 DAS chlorophyll content in leaves ranged from 1.77-3.01 mg g^{-1}. At 75 DAS chlorophyll content in leaves ranged from 1.26-2.53 mg g^{-1}. It is obvious from the data that chlorophyll content in leaves was maximum at 35-55 DAS but thereafter, gradual decrease in chlorophyll content was noticed at 75 DAS. Nitrogen is a constituent element in chlorophyll which rapidly increases at vegetative stage, as the nitrogen reserves are in ample quantity at this stage. However, rate of nitrogen mobilization is more to the reproductive part than the rate of nitrogen uptake. Hence, increase in chlorophyll content during 35-55 DAS might be due to increased uptake of N, P, K and other nutrients in early stage of plant growth.

Ameri and Tehranifar (2012) studied the effect of humic acid fertilizer on nutrient uptake (N, P and K) and physiological characteristics of *Fragaria ananassa* var: Camarosa. Treatments included different concentrations of humic acid (0, 10, 20, 30 and 40 ppm) with two methods of application (fertigation and spray). In spray method the highest amount of chlorophyll was observed in 10 and 20 ppm concentration of humic acid. Kapase *et al.* (2014) carried out the field experiment to study 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 leaf chlorophyll content in chickpea.

Leaf nitrogen content (%)

It is observed from data that there was significant variation in leaf N content due to foliar sprays of HA and NAA at various concentrations at 55 and 75 DAS. Data regarding leaf nitrogen

content in linseed are presented in table 2. At 35 DAS data regarding N content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (35 and 55 DAS). Significant variation was observed at 55 and 75 DAS. At 55 DAS N content in leaves ranged from 2.81-5.79 % where as at 75 DAS N content in leaves ranged from 2.38-4.58 %. At 55 and 75 DAS, significantly highest N content 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 + 25 ppm NAA) and T_9 (300 ppm HA + 25 ppm NAA) followed by treatments T_{16} (400 ppm HA + 50 ppm NAA), T_{11} (400 ppm + 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) when compared with control.

The inferences drawn from data that leaf N content was gradually decreased from 55-75 DAS. The decrease in N content might be due to fact that younger leaves and developing organs, such as grains act as strong sink demand and may draw heavily N from leaves (Gardner *et al.*, 1988). The above findings are consonance with the findings of Poonkodi (2003). He stated that decrease in N content in leaves might be due to translocation and utilization of nutrients for flower and pod formation in black gram. At the vegetative period, physiological and metabolic activities are at higher rate and this might be the reason for increase in uptake of nitrogen content in the present study. The principal physiological function of HA may be that they reduce oxygen deficiency in plants, which results in better uptake nutrients (Chen and Aviad, 1990). These might be the reasons for increase in leaf N content in the present investigation. Kapase *et al.* (2014) carried out the field experiment to study 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 leaf N content in chickpea.

Leaf phosphorus content (%)

The data respect to leaf phosphorus are given in table 1. Data showed significant variation at the stages of observations viz., 55 and 75 DAS. At 35 DAS data regarding phosphorus content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (35 and 55 DAS). At 55 and 75 DAS Significantly maximum phosphorus content was recorded in 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) followed by treatments T_9 (300 ppm HA + 25 ppm NAA), T_{16} (400 ppm HA + 50 ppm NAA) and T_{11} (400 ppm HA + 25 ppm NAA) when compared with control and rest of the treatments.

At 55 DAS phosphorus content in leaves ranged from 0.09-0.27 % where as at 75 DAS phosphorus content in leaves ranged from 0.07-0.25%. Phosphorus mobilization in the soil was increased by humic acid by forming humo-phospho complex. This can be easily absorbed by the plants (Balasubramanian *et al.*, 1989). The stimulating activity of humic acid on respiration might have increased the demand for inorganic phosphorus for ATP synthesis, thus leading to increased phosphorus uptake (Smidova, 1960). It is evidence from data that phosphorus content gradually decreased from 55-75 DAS. It might be because of translocation of leaf phosphorus and its utilization for development of food storage organs (Sagare and Naphade, 1987). Khalid and Fawy (2011) observed that foliar application of 0.1 and 0.2% humic acid significantly increased uptake of P in corn. Kapase *et al.* (2014) carried out the field experiment to study 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 leaf P content in chickpea.

Leaf potassium content (%)

Data regarding leaf K content at 35, 55 and 75 DAS are presented in table 1. Data were subjected to statistical analysis and were found significant at 55 and 75 DAS stages of observations. At 35 DAS data regarding K content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (35 and 55 DAS). At 55 and 75 DAS, 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) and T_{11} (400 ppm HA + 25 ppm NAA) expressed their superiority by recording significantly higher potassium content over control and rest of treatments.

At 55 DAS potassium content in leaves ranged from 0.33-0.51%. At 75 DAS potassium content in leaves ranged from 0.25-0.43 %. From the given data it is observed that K content was decreased from 55-75 DAS. Younger plants may be able to uptake nutrients more rapidly than older one. K content in leaf tissue was found higher in 55 DAS mainly due to application of nutrients through VCW and it might also be because of relatively higher physiological activities as the plant tissues were younger

during this stage. At 75 DAS K content in leaves decreased. It might be due to translocation of leaf K and its utilization for grain development in linseed.

Arsode (2013) studied the effect of foliar application of humic acid through cowdung wash and NAA and stated that 50 ppm NAA + 300 ppm HA through cowdung wash significantly increased leaf K content in mustard. Kapase *et al.* (2014) carried out the field experiment to study 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 leaf K content in chickpea. Mosa *et al.* (2015) tested ten treatments i.e. control, sprayed with water, K at 2% as potassium sulphate, Ca at 0.2% as calcium chloride, B at 0.2% as boric acid, H.A. at 5% as humic acid, potassium sulphate + humic acid, calcium chloride + humic acid, boric acid + humic acid, potassium sulphate + calcium chloride + boric acid and potassium sulphate + calcium chloride + boric acid + humic acid on apple. The obtained results showed that potassium sulphate + calcium chloride + boric acid + humic acid combination was the best treatment. This combination had increased K in the two seasons, as compared to the control.

Oil content in seed

Linseed is mainly known as oilseed crop. Although quality of crop products such as oil, protein and sucrose content and appearance is genetically controlled, nutrition of plants can have considerable impact on the expression of quality. It is therefore, essential to judiciously take care on the nutrient supply at grain formation stage. Oil content of seed is one of the considerable factors for seed quality determinations also. Data regarding oil content in seed are given in table 2.

Data showed significant variation by the application of HA and NAA. The range of oil content in seed was 35.18-40.67%. Significantly maximum seed oil was recorded in 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) when compared with control and rest of the treatments. Similarly treatments 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) also found significant over control and rest of the treatments. While 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. The increase in oil content of seed by the application of NAA might be due to increase in synthesis or activation of both the lypolitic enzymes. Increased oil content is a consequence of more synthesis of amino acid and increased conversion of carbohydrates to oil. Foliar application of HA and NAA increases the uptake and availability of nutrients and its further assimilation for biosynthesis of oil. These might be the reasons for increased oil content in seed in the present investigation. The mode of action of humic acid on plant growth can be divided into direct and indirect effects as it affects the membranes resulting in improved transport of nutritional elements, enhanced photosynthesis, solubilization of micro nutrients which ultimately enhances the oil synthesis.

Pawar *et al.* (2008) reported that the 4% cow urine + 50 ppm NAA when sprayed on groundnut increased oil content in kernel over control (RDF). Arsode (2013) studied the effect of foliar application of humic acid through cowdung wash and NAA and stated that 50 ppm NAA + 300 ppm HA through cowdung wash significantly increased oil per cent in mustard.

Number of capsules plant^{-1}

Yield is complex character determined by several traits, internal plant processes and environmental factors. In the present study data on effect of HA source i. e. VCW and NAA on yield and yield contributing parameters viz., number of capsules plant^{-1}, number of seeds capsules^{-1}, 1000 seed weight are given in table 2. Significant and highest number of capsules plant^{-1} was recorded in treatments T_{15} (350 ppm HA + 50 ppm NAA), T_{14} (300 ppm HA + 50 ppm NAA) and T_{10} (350 ppm HA + 50 ppm NAA) when compared with control and rest of the treatments. Treatments 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) also exhibited significantly more number of capsules plant^{-1} when compared with other remaining treatments and control. But treatments T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

Number of seeds capsules^{-1}

Data regarding number of seeds capsules^{-1} gave significant variation and same are presented in table 2. Number of seeds capsules^{-1} increased

significantly and it was maximum 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) and T_{11} (400 ppm HA + 25 ppm NAA) in a descending manner when compared with remaining treatments and T_1 (control). Similarly treatments 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) and T_{18} (500 ppm HA + 50 ppm NAA) showed their significance over control (T_1). While 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 treatment T_1 (control). Higher number of seeds capsules^{-1} might be due to the indirect positive effect of HA on chlorophyll content. The increase in chlorophyll content promotes photosynthetic activities which, in turn, diverts more photo-assimilates towards higher number of seeds capsules^{-1} (Nardi *et al.*, 2002).

1000 seed weight

Data obtained about 1000 seed weight are given in table 2. The 1000 seed weight was significantly maximum 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) and T_{16} (400 ppm HA + 50 ppm NAA). 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 significantly increased 1000 seed weight when compared with remaining treatments and control (T_1). Treatments T_8 (500 ppm HA), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found at par with control (T_1).

Application of humic acid as a foliar spray increases the seed weight due to better mobilization of nutrients to seed. Nardi *et al.* (1999) found that the biological activity of humic acid was attributed to their chemical structure and their functional groups, which could interact with harmonic-binding proteins in the membrane system, evoking a hormone like response. Mac Carthy *et al.* (2001) concluded that humates enhance nutrient uptake, improve soil structure and increase the yield and quality of various oilseed crops. Kapase *et al.* (2014) evaluated the effect of humic acid through vermicompost wash and NAA on chick pea 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 100 seed weight (g).

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} resulted significantly higher number of pods plant^{-1}, 1000 grain weight and grain yield.

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 yield contributing parameters viz., grain yield, number of spikes unit^{-1} area, number of grains spike^{-1} significantly increased with the 1000 ppm humic acid and the forage harvest at the beginning of stem elongation were superior to the other treatments in dual purpose cultivation (forage + grain).

Seed yield plant^{-1} (g) and plot^{-1} (kg)

Data regarding seed yield plant^{-1}and plot^{-1} are given in table 2. 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} and plot^{-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). Humic acid had been shown to stimulate plant growth and consequently yield by acting on mechanisms involved in: 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 capsules plant^{-1}, number of seeds capsules^{-1}, 1000 seed weight and seed yield plant^{-1}. These might be reasons responsible for increase in yield of linseed in the present investigation. 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. Kapase *et al.* (2014) studied the effect of humic acid through vermicompost wash and NAA on chickpea 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 increased seed yield ha^{-1}. 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 significantly higher number of pods plant^{-1}, 1000 grain weight and grain yield. 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 yield contributing parameters viz., grain yield, number of spikes unit^{-1} area, number of grains spike^{-1} significantly increased with the 1000 ppm humic acid and the forage harvest at the beginning of stem elongation were superior to the other treatments in dual purpose cultivation (forage + grain).

From the overall results it can be stated that foliar nutrition through humic source such as VCW and NAA with different concentrations improved chemical and biochemical and yield and yield contributing characters significantly. The highest per cent increased in yield over control was observed in foliar application of 350 ppm HA through VCW + 50 ppm NAA (T_{15}) i.e. 44 %. Next to this treatment foliar spray of 300 ppm HA through VCW + 50 ppm NAA (T_{14}) also enhanced yield 42 % over control.

Data in respect of B:C ratio are presented in table 1. 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 350 ppm HA through VCW + 50 ppm NAA (T_{15}) was calculated as 6.79 as compared to 5.09 for control (T_1).

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Table 1. Effect of humic acid through vermicompost wash and NAA on chemical, biochemical parameters

Treatments	Leaf chlorophyll content (mg g^{-1})			Leaf nitrogen content (%)			Leaf phosphorus content (%)			Leaf potassium content (%)			Seed oil content (%)
	35 DAS	55 DAS	75 DAS	35 DAS	55 DAS	75 DAS	35 DAS	55 DAS	75 DAS	35 DAS	55 DAS	75 DAS	
T_1 (control)	1.02	1.77	1.26	2.30	2.81	2.38	0.05	0.09	0.07	0.24	0.33	0.25	35.18
T_2 (25 ppm NAA)	1.08	1.82	1.37	2.45	3.10	2.80	0.05	0.12	0.08	0.24	0.36	0.28	35.46
T_3(50 ppm NAA)	1.11	1.86	1.46	2.43	3.16	3.12	0.08	0.13	0.10	0.25	0.39	0.29	36.21
T_4 (300 ppm HA through VCW)	1.09	2.32	1.98	2.20	4.28	3.82	0.08	0.17	0.16	0.26	0.44	0.36	37.57
T_5 (350ppm HA through VCW)	1.06	2.33	2.02	2.41	4.37	4.00	0.07	0.18	0.17	0.28	0.46	0.37	37.58
T_6 (400 ppm HA through VCW)	1.10	2.09	1.68	2.35	3.46	3.45	0.08	0.15	0.14	0.24	0.41	0.31	36.71
T_7 (450 ppm HA through VCW)	1.09	1.99	1.63	2.43	3.42	3.35	0.08	0.15	0.14	0.24	0.40	0.30	36.42
T_8 (500 ppm HA through VCW)	1.07	1.94	1.63	2.38	3.28	3.23	0.06	0.15	0.11	0.29	0.39	0.30	36.24
T_9 (300 ppm HA through VCW + 25 ppm NAA)	1.11	2.46	2.09	2.48	4.79	4.31	0.08	0.22	0.20	0.25	0.48	0.39	37.89
T_{10} (350 ppm HA through VCW + 25 ppm NAA)	1.06	2.52	2.33	2.28	4.89	4.36	0.05	0.23	0.21	0.27	0.50	0.40	38.34
T_{11} (400 ppm HA through VCW + 25 ppm NAA)	1.10	2.40	2.06	2.38	4.63	4.05	0.07	0.19	0.18	0.27	0.47	0.38	37.70
T_{12} (450 ppm HA through VCW + 25 ppm NAA)	1.08	2.17	1.91	2.23	3.86	3.76	0.06	0.17	0.15	0.24	0.42	0.34	37.26
T_{13} (500 ppm HA through VCW + 25 ppm NAA)	1.07	2.14	1.89	2.36	3.67	3.62	0.08	0.16	0.15	0.26	0.42	0.32	37.16
T_{14} (300 ppm HA through VCW + 50 ppm NAA)	1.06	2.60	2.38	2.49	5.64	4.44	0.07	0.24	0.21	0.25	0.50	0.41	39.86
T_{15} (350 ppm HA through VCW + 50 ppm NAA)	1.07	3.01	2.53	2.27	5.79	4.58	0.07	0.27	0.25	0.26	0.51	0.43	40.67
T_{16} (400 ppm HA through VCW + 50 ppm NAA)	1.05	2.41	2.08	2.41	4.69	4.08	0.05	0.20	0.19	0.26	0.48	0.39	37.87
T_{17} (450 ppm HA through VCW + 50 ppm NAA)	1.10	2.23	1.94	2.50	4.28	3.76	0.08	0.17	0.15	0.27	0.43	0.34	37.39
T_{18} (500 ppm HA through VCW + 50 ppm NAA)	1.09	2.09	1.79	2.48	3.57	3.53	0.08	0.15	0.14	0.24	0.42	0.32	36.73
SE (m)±	0.03	0.10	0.090	0.13	0.178	0.157	0.011	0.008	0.007	0.017	0.028	0.017	0.700
CD at 5%	-	0.285	0.259	-	0.513	0.451	-	0.022	0.019	-	0.082	0.048	2.010

Table 2. Effect of humic acid through vermicompost wash and NAA on yield and yield contributing parameters of linseed

Treatments	**Number of capsules plant^{-1}**	**Number of seeds capsules^{-1}**	**1000 seed weight (g)**	**Seed yield plant^{-1} (g)**	**Seed yield plot^{-1} (kg)**	**Per cent increase in yield**	**B:C Ratio**
T_1 (control)	40.86	10.04	5.24	2.10	0.300	-	5.09
T_2 (25 ppm NAA)	41.88	10.20	5.30	2.16	0.308	2.6	5.15
T_3(50 ppm NAA)	42.48	10.86	5.52	2.22	0.319	6.3	5.27
T_4 (300 ppm HA through VCW)	67.07	13.51	6.33	2.60	0.392	30.6	6.36
T_5 (350ppm HA through VCW)	70.00	13.53	6.40	2.65	0.402	34	6.48
T_6 (400 ppm HA through VCW)	54.13	12.09	6.12	2.35	0.340	13.2	5.44
T_7 (450 ppm HA through VCW)	53.94	11.71	6.04	2.29	0.327	8.9	5.19
T_8 (500 ppm HA through VCW)	53.74	11.34	5.69	2.26	0.325	8.3	5.13
T_9 (300 ppm HA through VCW + 25 ppm NAA)	72.79	15.00	6.61	2.72	0.418	39.2	6.70
T_{10}(350 ppm HA through VCW + 25 ppm NAA)	77.79	15.83	6.78	2.75	0.420	40	6.69
T_{11}(400 ppm HA through VCW + 25 ppm NAA)	70.47	14.65	6.43	2.68	0.407	35.6	6.43
T_{12}(450 ppm HA through VCW + 25 ppm NAA)	62.24	12.53	6.26	2.49	0.371	23.6	5.82
T_{13}(500 ppm HA through VCW + 25 ppm NAA)	57.84	12.43	6.23	2.45	0.362	20.6	5.64
T_{14}(300 ppm HA through VCW + 50 ppm NAA)	79.14	16.31	6.96	2.76	0.426	42	6.74
T_{15}(350 ppm HA through VCW + 50 ppm NAA)	85.48	16.87	7.18	2.79	0.432	44	6.79
T_{16}(400 ppm HA through VCW + 50 ppm NAA)	72.00	14.78	6.53	2.71	0.417	38.8	6.51
T_{17}(450 ppm HA through VCW + 50 ppm NAA)	63.82	13.02	6.31	2.54	0.381	26.9	5.9
T_{18}(500 ppm HA through VCW + 50 ppm NAA)	54.34	12.41	6.16	2.39	0.348	16	5.36
SE (m)±	3.617	0.763	0.222	0.136	0.019	-	-
CD at 5%	10.395	2.192	0.639	0.381	0.054	-	-

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