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RESPONSE OF HUMIC ACID THROUGH VERMICOMPOST WASH AND NAA ON CHEMICAL, BIOCHEMICAL, YIELD AND YIELD CONTRIBUTING PARAMETERS OF SESAMUM

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ABSTRACT

An experiment was conducted during 2017-2018, to study the effects of foliar application of humic acid through vermicompost wash and NAA on chemical and biochemical parameters and yield of sesamum cv. AKT-64. The experiment was laid down in randomized block design with twelve treatments and three replications at farm of Botany Section, College of Agriculture, Nagpur. The different treatments tested were 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. Foliar application of HA and NAA alone and in combination were applied at 25 and 40 DAS. Foliar application of 50 ppm NAA + 400 ppm HA through VCW and 50 ppm NAA + 300 ppm HA through VCW significantly enhanced chemical and biochemical parameters *viz.*, nitrogen, phosphorus, potassium and chlorophyll content in leaves, number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight, seed yield and oil content in seeds. Seed yield plant^{-1} and plot^{-1} were also significantly enhanced by same treatments when compared with control and rest of the treatments under study. Considering the treatments under study two foliar sprays of 50 ppm NAA + 400 ppm HA or 300 ppm HA through VCW at 25 and 40 DAS were found to be most effective treatments in improving chemical, biochemical, yield and yield contributing parameters of sesamum cv. AKT-64.

(Key words: Sesamum, vermicompost wash, NAA, chemical, biochemical parameters and yield)

INTRODUCTION

Sesame (*Sesamum indicum* L.) an oil seed crop of family Pedaliaceae, is one of the oldest cultivated crop in the world. The genera Sesamum has 37 species of which *Sesamum indicum* is the dominant cultivated species. Sesame seeds are rich in excellent quality of oil (gingelly) about 50% and 20 - 25% of protein.

The most useful property of this oil is its high stability, so that unlike other fats, rancidity does not spoil flavor and destroy vitamins existing in other foods.About 75% of oil from its total production is used for edible purposes in the manufacture of cooking fats, margarine and salad.The remaining 25% is used for soap manufacture, margarine, paints, hydrogenation and as fixative in perfumery. They are also used as a lubricant and illuminant. The oil also contains two new compounds sesamin and sesamolin (0.3 - 0.5%) which are not found in any other oil. Sesamin is used for its synergistic effect in pyrethrin insecticides; addition of a small quantity of this substance markedly increase the effectiveness of fly sprays. Sesamolin on hydrolysis yield sesamol, a powerful antioxidant. Apart from these, it is used as an emollient agent for antibiotics. The seeds and oil cake remaining after oil extraction are an excellent protein rich supplement used as an animal feed-stuff or as manure and contains 6.0-6.2% N, 2.0-2.2% P_2O_5 and 1.0-1.2% of potash.

Humic acid when externally supplied was observed to increase crop growth and ultimately the yield. It includes the nutritional status of soil and plant system. 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 proved many binding sights for nutrients such as calcium, iron, potassium and phosphorus. These nutrients are stored in humic acid molecule in a form of readily available to plant and are released when the plants required them. Humic acid increases the absorbance and translocation of nutrients in plants and ultimately influences

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yield. Humic acid supplies polyphenols that catalyze plant respiration and increases plant growth.

Vermicompost wash is useful as foliar spray. It is transparent pale yellow bio fertilizer. It is a mixture of excretory products and mucous secretion of earthworm (*Lampito mautrii* and *Eisenia foetida*) 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 Poonkodi, 2005).

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 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 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 field experiment on"Effects of foliar application of humic acid through vermicompost wash and NAA on chemical and biochemical parameters and yield of sesamum" was carried out at farm of Botany Section, College of Agriculture, Nagpur during 2017-2018. Plot size of individual treatment was gross 2.10 m × 2.20 m and net 1.50 m × 2.00 m. Seeds were sown at the rate of 1.5 to 2.0 kg ha^{-1} by dibbling method at a spacing of 30 cm x 10 cm on 14th November 2017. Treatments comprised of T_1 (control), T_2 (25 ppm NAA), T_3 (50 ppm NAA), T_4 (300 ppm VCW), T_5 (400 ppm VCW), T_6 (500 ppm VCW), T_7 (25 ppm NAA + 300 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_{10} (50 ppm NAA + 300 ppm VCW), T_{11} (50 ppm NAA + 400 ppm VCW), and T_{12} (50 ppm NAA + 500 ppm VCW). Foliar application of these treatments was given at 25 and 40 DAS on sesamum.

The chemical and biochemical parameters *viz*., leaf chlorophyll, nitrogen, phosphorus and seed protein content were estimated and recorded. Total chlorophyll content of dried leaves was estimated by colorimetric method as suggested by Bruinsma (1982). Nitrogen content in leaves was determined by micro-kjeldhal'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). Oil content in seeds was determined by soxhlet's procedure as given by Sankaran (1965). Seed yield $plant^{-1}$ and $plot^{-1}$ were also recorded in gram (g) and kilogram (kg) respectively.The data were analyzed as per the method suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Chemical and biochemical parameters

The chemical and biochemical studies with respect to chlorophyll, N, P, K content in leaves at different stages of observations as well as protein content in seeds were estimated and data regarding these parameters have been presented here under.

Leaf chlorophyll

The greenness of the leaf is generally considered to be a parameter contributing to yielding ability of the cultivar. Leaves constitute most important aerial organ of the plants, playing a major role in the anabolic activities by means of the so called 'green pigments' or 'chlorophyll' is the sole medium of photosynthetic progress which in turn is the major synthesis pathway operative in plants.

At 25 DAS data regarding chlorophyll content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (25 and 40 DAS).

At 40, 55 and 70 DAS chlorophyll content in leaves ranged from 1.26 - 1.82 mg g^{-1}. In view of the results of table 1 maximum content of chlorophyll was obtained by the application of 50 ppm NAA + 400 ppm VCW (T_{11}) and T_{10} (50 ppm NAA + 300 ppm VCW) followed by treatments T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW), T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW) and T_4 (300 ppm VCW) in a descending manner when compared with control. But treatment T_6 (500 ppm VCW) was found at par with treatment T_1 (control).

It is observed from the data that chlorophyll content in leaves was maximum at 40-55 DAS but thereafter, gradual decrease in chlorophyll content was noticed at 70 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 65-85 DAS might be due to increased uptake of N, P, K and other nutrients in early stage of plant growth.

Arsode (2013) carried a field experiment on mustard to test the effect of foliar application of humic acid through cowdung wash and NAA and exhibited that 50 ppm NAA + 300 ppm HA through cowdung wash significantly increased leaf chlorophyll content in mustard.

Leaf nitrogen content

Nitrogen is the important constituent of protein and protoplasm and essential for plant growth. Nitrogen deficiency causes chlorosis and malfunctioning of the photosynthesis process. Plant cell require adequate supply of N for normal cell division and growth of the plant. Tender shoots, tips of shoots, buds, leaves contains higher nitrogen content (Jain, 2010).

Scrutiny of the data revealed marked effect of foliar spray of HA through VCW and NAA on the nitrogen content of sesamum at 40, 55, and 70 DAS.

At 25 DAS data regarding N content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (25 and 40 DAS). Significant variation was observed at 40, 55 and 70 DAS.

At 40 DAS N content in leaves differed among the treatments and varied ranged from 3.19-4.58 %. The best and significant results were obtained in treatments T_{11} (50 ppm NAA + 400 ppm VCW), T_{10} (50 ppm NAA + 300 ppm VCW), T_{12} (50 ppm NAA + 500 ppm VCW) and T_8 (25 ppm NAA + 400 ppm VCW). Treatments T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) had also stimulatory effect on leaf nitrogen content significantly when compared with control except treatment T_6 (500 ppm VCW).

At 55 DAS N content in leaves ranged from 4.68-5.85%. Significantly maximum increment in N content over control was observed in case of foliar spray of T_{11} (50 ppm NAA + 400 ppm VCW), T_{10} (50 ppm NAA + 300 ppm VCW) and T_{12} (50 ppm NAA + 500 ppm VCW). Treatments T_8 (25 ppm NAA + 400 ppm VCW),T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA) and T_5 (400 ppm VCW) also showed significantly more nitrogen content over control. While treatments T_4 (300 ppm VCW) and T_6 (500 ppm VCW) showed least nitrogen content and found at par with control (T_1).

Among all the treatments T_{11} (50 ppm NAA + 400 ppm VCW) registered the highest N content at 70 DAS. Treatments T_{10} (50 ppm NAA + 300 ppm VCW), T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW), T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA) T_2 (25 ppm NAA) and T_5 (400 ppm VCW) also showed significant performance over the control. But treatments T_4 (300 ppm VCW) and T_6 (500 ppm VCW)) were found at par with control (T_1).

The inferences drawn from data that leaf N content was gradually decreased from 55-70 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 from soil at early stage of crop growth. Similarly HA enhance cell permeability, which in turn made more rapid entry of minerals into root cells and so resulted in higher uptake of plant nutrients. This effect was associated with the function of hydroxyls and carboxyls in these compounds. The principal physiological function of HA may be that they reduce oxygen deficiency in plants, which results in better uptake nutrients (Chen and Aviad, 2004). These might be the reasons for increase in leaf N content in the present investigation.

Deotale *et al*. (2016) reported that foliar application of 50 ppm NAA + 400 ppm HA through VCW followed by 50 ppm NAA and 300 ppm HA through VCW significantly enhanced N content in chickpea.

Leaf phosphorus content

The result revealed significant influence of different treatments on phosphorus content in leaves at all the stages of observation *viz*., 40, 55, and 70 DAS.

At 25 DAS data regarding phosphorus content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (25 and 40 DAS).

At 40 DAS significantly maximum leaf phosphorus content was recorded in treatment T_{11} (50 ppm NAA + 400 ppm VCW). Next to this treatment foliar application of 50 ppm NAA + 300 ppm VCW(T_{10}), 50 ppm NAA + 500 ppm VCW (T_{12}),25 ppm NAA + 400 ppm VCW (T_8), 25 ppm NAA + 300 ppm VCW (T_7), 25 ppm NAA + 500 ppm VCW (T_9), 50 ppm NAA (T_3), 25 ppm NAA (T_2), 400 ppm VCW (T_5) and 300 ppm VCW (T_4) in a descending manner also increased phosphorus content significantly when compared with control and rest of the treatments. But treatment T_6 (500 ppm VCW) was found at par with treatment T_1 (control).

At 55 and 70 DAS application of 50 ppm NAA + 400 ppm VCW increased leaf phosphorus content and this treatments was found significantly superior over rest of the treatments in leaf phosphorus content. Similarly treatments T_{10} (50 ppm NAA + 300 ppm VCW), T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW),T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW), T_4 (300 ppm VCW) and T_6 (500 ppm VCW) in a descending manner also exhibited significant performance over the control (T_1) in leaf phosphorus content.

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.

It is evident from the data that phosphorus content gradually decreased from 55-70 DAS. It might be because of translocation of leaf phosphorus and its utilization for development of food storage organs.

Kapase *et al*. (2014) 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 leaf P content in chickpea.

Leaf potassium content

Potassium an essential macronutrient for plants involved in many physiological processes. It is important for crop yield as well as for the quality of edible parts of crops. Although potassium is not assimilated into organic matter, potassium deficiency has a strong impact on plant metabolism. Plant responses to low potassium involve changes in the concentrations of many metabolites as well as alteration in the transcriptional levels of many genes and in the activity of many enzymes.

Data pertaining leaf K content at 25, 40, 55 and 70 DAS furnished in table 1 revealed that application of HA and NAA correspondingly enhanced K content in leaf.

At 25 DAS data regarding K content was non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (25 and 40 DAS).

It is evident from the data that potassium content at 40 DAS was significantly maximum in treatments T_{11} (50 ppm NAA + 400 ppm VCW) and T_{10} (50 ppm NAA + 300 ppm VCW) over control and rest of the treatments. Concentrations of 50 ppm NAA + 500 ppm VCW, 25 ppm NAA + 400 ppm VCW, 25 ppm NAA + 300 ppm VCW, 25 ppm NAA + 500 ppm VCW, 50 ppm NAA, 25 ppm NAA, 400 ppm VCW and 300 ppm VCW lead to significant increase in potassium content over control except treatment T_6 (500 ppm VCW).

At 55 DAS and 70 DAS significantly maximum increment in leaf potassium content was recorded in treatments T_{11} (50 ppm NAA + 400 ppm VCW) and T_{10} (50 ppm NAA + 300 ppm VCW). Treatments T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW),T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW), T_4 (300 ppm VCW) and T_6 (500 ppm VCW) in a descending manner also showed significant performance over the control (T_1).

From the given data it is observed that K content was decreased at 70 DAS. Younger plants may be able to uptake nutrients more rapidly than older one. K content in leaf tissue was found higher at 40 DAS stage 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 70 DAS K content in leaves decreased. It might be due to translocation of leaf K and its utilization for grain development in sesamum.

Deotale *et al.* (2016) conducted an experiment to study the effect of foliar spray of 50 ppm NAA + 400 pmm HA through VCW on chickpea and found increase in K content in leaves significantly.

Oil content in seeds

Sesamum is mainly known as oilseed crop and oil percentage in seed is one of the important aspect in quality of grain. The data regarding oil content of seed are given in table 1. It is worthy to mention that foliar application with different concentrations of HA and NAA caused significant and stimulatory effect on oil content of seeds.

The most pronounced effect on oil content in seeds was observed in plant exposed to the 50 ppm NAA + 400 ppm VCW and 50 ppm NAA + 300 ppm VCW) when compared with treatment T_1 (control) and remaining treatments under study. While, treatments T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW),T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW), T_4 (300 ppm VCW) and T_6 (500 ppm VCW) also had significant and stimulatory effect on oil content over control (T_1).

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. Increase oil content is a consequence of more synthesis of amino acid and increased conversion of carbohydrate 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 enhanced 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)

Number of capsules plant^{-1}

Number of capsules plant^{-1} differed significantly among the treatments. It varied from a minimum of 25.15 to maximum of 35.21 capsules plant^{-1} among the treatments. Crop supplied with combined application of 50 ppm NAA + 400 ppm HA through vermicompost wash, 50 ppm NAA + 300 ppm VCW, 50 ppm NAA + 500 ppm VCW, 25 ppm NAA + 400 ppm VCW and 25 ppm NAA + 300 ppm VCW recorded significantly higher number of capsules plant^{-1} over control and rest of the treatments. Treatments T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW), T_4 (300 ppm VCW) and T_6 (500 ppm VCW) were found at par with treatment T_1 (control).

Number of seeds capsule^{-1}

Number of seeds capsule^{-1} varied among the treatments and ranged a minimum of 27.32 to a maximum of

30.26. The present study demonstrated that foliar application of VCW and NAA alone or in combination significantly increased the number of seeds capsule^{-1} over control. Among the all treatments tested the highest seeds capsule^{-1} was obtained in treatments T_{11} (50 ppm NAA + 400 ppm VCW) and T_{10} (50 ppm NAA + 300 ppm VCW) over control and rest of the treatments. Among the various tested treatments lowest number of the seeds capsule^{-1} were recorded in treatments T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW), T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW), T_4 (300 ppm VCW) and T_6 (500 ppm VCW) and these treatments were found at par with treatment T_1 (control).

Higher number of seeds pod^{-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 pod^{-1} (Nardi *et al*., 2002).

Test weight

Significant variation in seed size was noticed among the treatments. The highest (3.09 g) and the lowest (2.72 g) 1000 seed weight were recorded in treatments T_{11} and T_1 respectively. The maximum 1000 seed weight was recorded in treatments T_{11} (50 ppm NAA + 400 ppm VCW) and T_{10} (50 ppm NAA + 300 ppm VCW). Rest of the treatments like T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW), T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW), T_4 (300 ppm VCW) and T_6 (500 ppm VCW) were found at par with control (T_1) in test weight.

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.

A field experiment was carried out 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)

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).

Higher seed yield plant^{-1} manifested with foliar spray of 50 ppm NAA + 400 ppm VCW, 50 ppm NAA + 300 ppm VCW and 50 ppm NAA + 500 ppm VCW. Treatments T_8 (25 ppm NAA + 400 ppm VCW), T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW) and T_4 (300 ppm VCW) also increased seed yield plant^{-1} significantly over control except treatment T_6 (500 ppm VCW).

Maximum increment of seed yield plot^{-1} was obtained in treatment 50 ppm NAA + 400 pm VCW (T_{11}). Rest of the treatments viz., T_{10} (50 ppm NAA + 300 ppm VCW), T_{12} (50 ppm NAA + 500 ppm VCW), T_8 (25 ppm NAA + 400 ppm VCW), T_7 (25 ppm NAA + 300 ppm VCW), T_9 (25 ppm NAA + 500 ppm VCW), T_3 (50 ppm NAA), T_2 (25 ppm NAA), T_5 (400 ppm VCW), T_4 (300 ppm VCW) and T_6 (500 ppm VCW) also showed their significance over control (T_1) in respect of seed yield plot^{-1}.

The growth hormone reduces flower drop, abscission of flower and ultimately increased seed yield and biomass production in sesamum. 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.

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,chemical and biochemical characters. These might be the reasons responsible for increase in yield and yield contributing characters of sesamum in the present investigation.

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.

Table 1. Effect of HA through VCW and NAA on chemical and biochemical parameters and yield of sesamum

Treatments	Leaf chlorophyll content (mg g^{-1})				Leaf nitrogen content (%)			
	25 DAS	40 DAS	55 DAS	70 DAS	25 DAS	40 DAS	55 DAS	70 DAS
T_1(control)	1.17	1.26	1.49	1.22	2.30	3.19	4.68	2.54
T_2(25 ppm NAA)	1.27	1.47	1.69	1.44	2.48	3.65	5.18	3.63
T_3(50 ppm NAA)	1.23	1.53	1.74	1.49	2.50	3.80	5.20	4.00
T_4 (300 ppm HA)	1.19	1.37	1.59	1.32	2.47	3.41	4.98	2.86
T_5(400 ppm HA)	1.14	1.42	1.65	1.37	2.40	3.56	5.10	3.19
T_6(500 ppm HA)	1.29	1.32	1.54	1.28	2.48	3.30	4.87	2.70
T_7(25ppm NAA + 300 ppm HA)	1.21	1.61	1.82	1.59	2.46	3.96	5.39	4.05
T_8(25ppm NAA + 400 ppm HA)	1.12	1.68	1.88	1.63	2.46	4.10	5.50	4.20
T_9(25ppm NAA + 500 ppm HA)	1.16	1.56	1.79	1.54	2.49	3.90	5.27	4.03
T_{10}(50ppm NAA + 300 ppm HA)	1.24	1.77	1.98	1.71	2.48	4.44	5.70	4.56
T_{11}(50 ppm NAA + 400 ppm HA)	1.19	1.82	2.04	1.76	2.45	4.58	5.85	5.10
T_{12}(50 ppm NAA + 500 ppm HA)	1.21	1.71	1.92	1.68	2.43	4.25	5.60	4.40
SE (m) ±	0.077	0.026	0.027	0.029	0.155	0.149	0.084	0.216
CD at 5%	-	0.078	0.081	0.087	-	0.437	0.024	0.635

Table 1.Continued

Treatments	Leaf phosphorus (%)				Leaf potassium (%)			
	25 DAS	40 DAS	55 DAS	70 DAS	25 DAS	40 DAS	55 DAS	70 DAS
T_1(control)	0.209	0.215	0.220	0.215	0.58	0.69	0.78	0.69
T_2(25 ppm NAA)	0.209	0.231	0.240	0.235	0.54	0.79	0.91	0.82
T_3(50 ppm NAA)	0.211	0.244	0.249	0.243	0.63	0.81	0.94	0.85
T_4 (300 ppm HA)	0.113	0.224	0.230	0.227	0.56	0.74	0.85	0.76
T_5(400 ppm HA)	0.210	0.234	0.240	0.230	0.61	0.77	0.88	0.78
T_6(500 ppm HA)	0.214	0.220	0.228	0.224	0.57	0.72	0.82	0.73
T_7(25ppm NAA + 300 ppm HA)	0.215	0.255	0.257	0.250	0.60	0.87	0.99	0.91
T_8(25ppm NAA + 400 ppm HA)	0.216	0.257	0.260	0.250	0.62	0.89	1.02	0.94
T_9(25ppm NAA + 500 ppm HA)	0.216	0.252	0.255	0.247	0.55	0.85	0.97	0.88
T_{10}(50ppm NAA + 300 ppm HA)	0.212	0.264	0.287	0.272	0.57	0.96	1.07	0.98
T_{11}(50 ppm NAA + 400 ppm HA)	0.215	0.278	0.298	0.278	0.60	0.97	1.10	1.02
T_{12}(50 ppm NAA + 500 ppm HA)	0.211	0.262	0.280	0.262	0.56	0.92	1.05	0.96
SE(m) ±	0.013	0.00046	0.00044	0.00044	0.037	0.011	0.010	0.007
CD at 5%	-	0.00136	0.0013	0.0013	-	0.032	0.029	0.020

Table 1.Continued

Treatments	Seed oil content (%)	Seed yield plant^{-1}(g)	Seed yield plot^{-1}(kg)
T_1 (control)	46.19	1.61	0.161
T_2 (25 ppm NAA)	47.69	1.84	0.184
T_3 (50 ppm NAA)	47.83	1.92	0.192
T_4 (300 ppm HA)	46.89	1.73	0.173
T_5 (400 ppm HA)	47.27	1.80	0.180
T_6 (500 ppm HA)	46.57	1.69	0.169
T_7 (25ppm NAA + 300 ppm HA)	48.64	2.01	0.201
T_8 (25ppm NAA + 400 ppm HA)	48.86	2.07	0.207
T_9 (25ppm NAA + 500 ppm HA)	48.33	1.97	0.197
T_{10} (50ppm NAA + 300 ppm HA)	49.12	2.17	0.217
T_{11} (50 ppm NAA + 400 ppm HA)	49.36	2.21	0.221
T_{12} (50 ppm NAA + 500 ppm HA)	48.94	2.12	0.212
SE (m) ±	0.99	0.034	0.0005
CD at 5%	2.89	0.100	0.0014

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