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Original Research Article

Combined effect of Humic Acid through Vermicompost wash and NAA on Biochemical Parameters and Productivity of Linseed

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Keywords

Linseed, Humic acid through vermicompost wash, NAA and foliar spray

A B S T R A C T

A research trial was conducted during *rubi* 2015-16 to elucidate the effect of humic acid (HA) and NAA to determine the chemical, biochemical parameters and productivity of linseed. The eighteen treatment included different concentrations of humic acid (300, 350, 400, 450 and 500 ppm) and NAA (25 and 50 ppm) individually and in combinations applied under randomized block design (RBD) replicated thrice. All the chemical, biochemical and yield attributes significantly influenced by the foliar spraying taken at 35 and 55 DAS of humic acid through vermicompost wash and NAA and obtained results revealed that treatment T_{15} (350 ppm HA through VCW + 50 ppm NAA) as the most effective one compared with the control (water spray) and other treatments. This treatment gave the inimitable outcomes concerning on leaf chlorophyll, leaf NPK, harvest index and ultimately increasing seed yield plant^{-1}, plot^{-1}, ha^{-1} by 44 percent comparing with the rest of the treatments and control . B:C ratio also calculated. The data obtained in this study conveyed that foliar spraying of HA (350 ppm HA through vermicompost wash) with NAA (50 ppm) helps to improve the uniform crop stand, plant growth, seed yield and quality of linseed by organically at low cost.

Introduction

Flax plant (Linum usitatissimum L.) is an important plant, and has been grown in many different countries as fiber, seed or double purpose plant (fibers and seeds). Flax is grown in Egypt as dual purpose crop. Flax seeds show a very high antioxidant activity and are increasingly proposed as an important source for oil and antioxidants. There is no doubt that the need of traditional edible oils will be increased due to the growth of population over the world. Flax seeds produce a vegetable oil known as flaxseed or linseed oil. The oil quality is usually valued according to the content of essential fatty acids (EFAs) (Johnson *et al.*, 2008). Omega 3, 6, 9 groups of fatty acids are necessary for good health. The high level of Omega-3 fatty acids consumed by Eskimos reduced triglycerides, blood pressure and atherosclerosis (Morris, 2004). Omega-3 and omega- 6 fatty acids are used to create cell membranes and hormones that regulate the hormonal cycles. Flax seed has a high ratio of α-linolenic (omega-3) to linoleic (omega-6) fatty acids, and it is one of the richest sources of omega-3 fatty acid. Treatment with 1 g per day of Omega-3 fatty acid reduced the occurrence of cardio-vascular diseases and sudden cardiac death (Johnson *et al.*, 2008).

The use of humic acid (HA) is a promising natural resource to be utilized as an alternative for increasing crop production. Humic acids make important contributions to improve soil stability, fertility, improves seed quality that lead to exceptional plant growth and nutrient uptake. Humic acid is an effective agent to use as a compliment to fertilizer which is mostly used for soil reclamation which reduces the harmful effects of synthetic fertilizers and some other chemicals from the soil. It also has the potential for the economization of water and fertilizers. Approximately 65-70% of organic matter in the soil mainly is derived from humic and fulvic acid substances.

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).

Keeping in view the importance of Linseed in global oil crops, a research project was done to determine the potential of HA combination with NAA to affect growth, nutrient content and yield of Linseed.

Materials and Methods

Research work was conducted at the farm of Agricultural Botany Section, College of Agriculture, Nagpur during year 2015-16. Linseed (PKV-NL-260 cultivar) was sown by drilling method at the rate 25 kg ha^{-1}. Plot was 3.30 m^2 (3 × 1.10 m). A experimental design used was a randomized block with three replications.

Humic acid through vermicompost wash and NAA were sprayed as alone and mixture 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 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) two times at 35 and 55 days after sowing. Control plants (T_1) were sprayed with water. Observations on Leaf chlorophyll, leaf NPK were recorded at 35, 55 and 75 DAS stages. Seed yield plant^{-1}, plot^{-1}, ha^{-1} and harvest index were recorded. B:C ratio also calculated.

The chlorophyll content in plant sample was estimated by colorimetric method as suggested by Bruinsma (1982). The nitrogen content in the plant sample was analyzed by Micro-kjeldhal method given by Somichi *et al*. (1972). Phosphorus content estimated by vanadomolybdate yellow colour method as given by Jackson, (1967). Potassium content estimated by flame photometer by di-acid extract method given by Jackson (1967). 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 various parameters governing to chemical-biochemical parameters and productivity of linseed was statistically analyzed and the results obtained are presented under appropriate heading and sub-headings. At 35 DAS data regarding leaf chlorophyll, N, P, K content were non significant because foliar sprays of HA and NAA of different concentrations were given from this stage onwards (35 and 55 DAS).

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

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.

The data on leaf chlorophyll content give significant variation at 55 and 75 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), 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) in a descending manner when compared with control and rest of the treatments.

At 55 DAS chlorophyll content in leaves ranged from 1.77-3.01 mg g^{-1} where 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 (%)

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).

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. At 55 DAS N content in leaves ranged from 2.81-5.79 % where 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 and rest of the treatments. A 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 from soil at early stage of crop growth.

Similarly HA enhance cell permeability, which turn made for a 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, 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 (%)

At 55 DAS phosphorus content in leaves ranged from 0.09-0.27 % where at 75 DAS phosphorus content in leaves ranged from 0.07-0.25%. 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.

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 (%)

At 55 DAS potassium content in leaves ranged from 0.33-0.51% where at 75 DAS potassium content in leaves ranged from 0.25-0.43 %. 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),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) gave significantly maximum leaf potassium content over rest of the treatment.

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.

Table.1 Effect of humic acid through vermicompost wash and NAA on leaf chlorophyll, nitrogen, phosphorus and potassium content

Treatments	Leaf chlorophyll (mg g^{-1})			Leaf nitrogen (%)			Leaf phosphorus (%)			Leaf potassium (%)		
	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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
CD at 5%	-	0.285	0.259	-	0.513	0.451	-	0.022	0.019	-	0.082	0.048

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

Treatments	Seed yield $plant^{-1}$ (g)	Seed yield $plot^{-1}$ (kg)	Seed yield ha^{-1} (q)	Per cent increase in yield	B:C Ratio	Harvest Index (%)
T_1 (control)	2.10	0.300	12.50	-	5.09	40.13
T_2 (25 ppm NAA)	2.16	0.308	12.83	2.6	5.15	40.45
T_3(50 ppm NAA)	2.22	0.319	13.29	6.3	5.27	40.95
T_4 (300 ppm HA through VCW)	2.60	0.392	16.33	30.6	6.36	44.33
T_5 (350ppm HA through VCW)	2.65	0.402	16.75	34	6.48	45.11
T_6 (400 ppm HA through VCW)	2.35	0.340	14.16	13.2	5.44	42.56
T_7 (450 ppm HA through VCW)	2.29	0.327	13.62	8.9	5.19	42.32
T_8 (500 ppm HA through VCW)	2.26	0.325	13.54	8.3	5.13	41.41
T_9 (300 ppm HA through VCW + 25 ppm NAA)	2.72	0.418	17.41	39.2	6.70	45.73
T_{10} (350 ppm HA through VCW + 25 ppm NAA)	2.75	0.420	17.50	40	6.69	46.46
T_{11} (400 ppm HA through VCW + 25 ppm NAA)	2.68	0.407	16.95	35.6	6.43	45.23
T_{12} (450 ppm HA through VCW + 25 ppm NAA)	2.49	0.371	15.45	23.6	5.82	42.99
T_{13} (500 ppm HA through VCW + 25 ppm NAA)	2.45	0.362	15.08	20.6	5.64	42.83
T_{14} (300 ppm HA through VCW + 50 ppm NAA)	2.76	0.426	17.75	42	6.74	46.55
T_{15} (350 ppm HA through VCW + 50 ppm NAA)	2.79	0.432	18.00	44	6.79	47.10
T_{16} (400 ppm HA through VCW + 50 ppm NAA)	2.71	0.417	16.36	38.8	6.51	45.30
T_{17} (450 ppm HA through VCW + 50 ppm NAA)	2.54	0.381	15.87	26.9	5.9	43.27
T_{18} (500 ppm HA through VCW + 50 ppm NAA)	2.39	0.348	14.50	16	5.36	42.73
SE (m) $\pm$	0.136	0.019	0.89	-	-	0.481
CD at 5%	0.381	0.054	2.65	-	-	1.383

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

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 Mojaddam (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).

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 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.

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 etc. This might be also one of the reason for increase in yield and HI in the present investigation.

From the overall results it can be concluded 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.

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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