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CHEMICAL, BIOCHEMICAL PARAMETERS, YIELD AND YIELD ATTRIBUTING CHARACTERS IN SAFFLOWER AS INFLUENCED BY FOLIAR APPLICATION OF HUMIC ACID AND NAA

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ABSTRACT

In order to investigate influence of foliar application of humic acid at 300, 400 and 500 ppm and NAA at 25 and 50 ppm and their combined effects on chemical, biochemical parameters, yield and yield attributing characters of safflower (*Carthamust inctorus* L.), a field experiment was conducted at farm of Botany section, College of Agriculture, Nagpur during the *rabi* season of 2018-2019. The experiment was arranged in randomized block design and replicated thrice consisting twelve treatments. The foliar sprays at 40 and 70 DAS showed significant changes in all the chemical, biochemical and yield contributing parameters i.e. total chlorophyll content, nitrogen content, phosphorus content, potassium content, oil content, number of capitula plant^{-1}, number of seeds capitulum^{-1}, 1000 seed weight and seed yield plant^{-1}and plot^{-1}.Treatment T_{10} (300 ppm humic acid + 50 ppm NAA) gave significantly higher results in all parameters under study.

(Key words: Safflower, humic acid, NAA, foliar application, chemical, biochemical, yield contributing parameters, yield)

INTRODUCTION

Safflower (*Carthamus tinctorius* L.), is a member of Compositae or Asteraceae family cultivated mainly for its seed, which is used as edible oil. Traditionally, the crop was grown for its flowers, used for colouring and flavouring foods and making dyes, especially before cheaper aniline dyes became available, and in medicines. This is an important plant that its oil has been considered as valuable oil having more than 90% unsaturated fatty acids, especially linoleic and oleic acids (Mundel *et al.,* 1996).

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

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).

MATERIALS AND METHODS

A field experiment consisting twelve treatments with three replications in RBD was conducted during *rabi* 2017-2018 at farm of Botany section, College of Agriculture, Nagpur. Treatments comprised of T_1- Control, T_2- Foliar application of NAA @ 25 ppm, T_3- NAA @ 50 ppm, T_4- humic acid @ 300 ppm, T_5- humic acid @ 400 ppm, T_6- humic acid @ 500 ppm, T_7- NAA @ 25 ppm + humic acid @ 300 ppm, T_8- NAA @ 25 ppm + humic acid @ 400 ppm, T_9- NAA @ 25 ppm + humic acid @ 500 ppm, T_{10}-NAA @ 50 ppm + humic acid @ 300 ppm, T_{11}- NAA @ 50 ppm + humic acid @ 300 ppm and T_{12} NAA @ 50 ppm + humic acid @ 300 ppm.The gross plot size was 1.80 m × 2.40 m and net 1.50 m × 2.00 m with spacing of 45 cm x 20 cm. Two foliar sprays of humic acid and NAA were given at 40 and 70 DAS.In the present study analysis of total chlorophyll and NPK content in safflower leaves were taken on 40, 60, 80 and 100 DAS. Total chlorophyll content of oven 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

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Jackson (1967). Potassium content in leaves was determined by flame photometer by di-acid extract method given by Jackson (1967).The oil content in seeds was estimated by Soxhlets method given by Sankaran (1965).Also, data on number of capitula plant^{-1}, number of seeds capitulum^{-1}, 1000 seed weight and seed yield plant^{-1} and plot^{-1}were recorded after harvest.Data were analysed by statistical method suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Total chlorophyll content

Chlorophyll is green pigment present in chloroplast of all green plant cells and tissues. These are the essentials photosynthetic pigments capable of absorbing light energy for the synthesis of carbohydrates. Chlorophyll content of the plant tissue represents the photosynthetic capacity of plant.

At 60, DAS chlorophyll content in leaves ranged from 1.313 -1.926 mg g^{-1}.Significantly highest chlorophyll content was found in treatment T_{10}(50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid) and T_9(25 ppm NAA + 500 ppm humic acid) over control and remaining treatments. Also treatment T_{12} (50 ppm NAA + 500 ppm humic acid) recorded significantly more chlorophyll when compared with control.

Furthermore, our results are in conformity with the results of Deotale *et al.* (2017), who carried out experiment on effect of foliar sprays of humic acid through vermicompost wash on biochemical parameters of chickpea. The different treatments tested were 25 and 50 ppm NAA and 300, 400 and 500 ppm humic acid through vermicompost wash alone or in combination. Data revealed that foliar sprays of 400 ppm humic acid + 50 ppm NAA significantly enhanced chlorophyll content in leaves when compared with control.

Guddhe *et al.* (2019) carried out a field experiment on sesamum to test the effect of foliar application of humic acid through vermicompost wash and NAA and exhibited that 50 ppm NAA + 400 ppm HA through VCW significantly increased leaf chlorophyll content in sesamum.

Leaf nitrogen content

Nitrogen is key component in mineral fertilizers and has more influence on plant growth, appearance and fruit production or quality than any other essential elements. Nitrogen is an important constituent of protein and protoplasm and essential for the growth of plants. Its shortage leads to chlorosis and stoppage of growth and its presence in moderate doses is essential for plant growth and fruiting. An abundant supply of essential nitrogenous compound is required in each plant cell for normal cell division, growth and respiration.The nitrogen present mostly as protein is constantly moving and under concentration of nitrogen is found in young, tender plant tissues like tips of shoots, buds and new leaves (Jain, 2010).

Leaf nitrogen at 60 DAS was significantly enhanced by the treatment T_{10} (50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid) and T_9 (25 ppm NAA + 500 ppm humic acid) when compared with T_1 (control) and all other treatments. Also treatment T_{12} (50 ppm NAA + 500 ppm humic acid) showed the more nitrogen when compared with control.

At 80 and 100 DAS significantly highest leaf nitrogen content was recorded in treatment T_{10}(50 ppm NAA + 300 ppm humic acid), T_{11} (50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) when compared with treatment T_1 (control).

Metre *et al.* (2013) reported that foliar application of humic acid through cow dung wash @ 350 ppm significantly enhanced leaf nitrogen content in green gram.

Deotale *et al.* (2017) found out that nitrogen content in leaves of linseed was significantly maximum over control when foliar sprays of 350 ppm humic acid through VCW + 50 ppm NAA was given at 35 and 55 DAS.

Gudhhe *et al.* (2019) tested the effect of foliar application of humic acid through vermicompost wash and NAA and noticed that 50 ppm NAA + 400 ppm HA through VCW significantly increased leaf nitrogen content in sesamum.

Leaf phosphorus content

Phosphorus is an important constituent of protoplasm and nucleic acid and protein also, it is essential for the formation of grain.

At 60 DAS significantly more phosphorus content was found in combination treatment T_{10}(50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid) and T_7 (25 ppm NAA + 300 ppm humic acid) when compared with T_1 (control) and other treatments.

Significantly maximum phosphorus content in leaves at 80 and 100 DAS was exhibited in treatment T_{10}(50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11}(50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9(25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid) and T_3 (50 ppm NAA) when compared with T_1 (control) and rest of the treatments.

Our present investigations are also in line with Deotale *et al.* (2017), who found out that combined spray of 350 ppm humic acid + 50 ppm NAA at 35 and 55 DAS recorded significantly more phosphorus content in leaves of linseed.Guddhe *et al.* (2019) confirmed that foliar application of 50 ppm NAA + 400 ppm HA through VCW significantly enhanced P content in sesamum.

Leaf potassium content

Potassium content at 60 DAS was significantly maximum in treatment T_{10} (50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid) and T_3 (50 ppm NAA) when compared with T_1 (control) and rest of the treatments.

Potassium content in leaves at 80 DAS was found significantly more in treatment T_{10} (50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid) and T_7 (25 ppm NAA + 300 ppm humic acid) when compared with control and rest of the treatments. Also the treatment T_8 (25 ppm NAA + 400 ppm humic acid) showed thier significance in potassium content in leaves over control and rest of the treatments. At 100 DAS treatment T_{10} (50 ppm NAA + 300 ppm humic acid) gave significantly highest potassium content in leaves followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid) and T_3 (50 ppm NAA) when compared with T_1 (control) and rest of the treatments.

Our present findings correlates the findings of previous workers Deotale *et al.* (2014), who stated that foliar application of 250 ppm humic acid through cow dung wash and vermicompost wash at 20 and 35 DAS showed their significance in potassium content in leaves of green gram when compared with control (water spray) and rest of the treatments.

Guddhe *et al*. (2019) applied different concentrations of HA through VCW and NAA alone or in combination and found that foliar spray of 50 ppm NAA + 400 ppm HA through VCW significantly enhanced leaf K content in sesamum.

Oil content in seeds

Safflower is mainly known as oilseed crop.Although quality of crop products such as oil, protein and sucrose content and appearance are genetically controlled. The 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 the seed is one of the considerable factors for seed quality determination also.

Oil per cent in seeds differed significantly among different treatments. Treatment T_{10} (50 ppm NAA + 300 ppm humic acid) recorded significantly highest oil per cent (35.83 %) over the control and rest of the treatments. The other treatments such as T_{11} (50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid), T_3 (50 ppm NAA), T_2 (25 ppm NAA) and T_4 (300 ppm humic acid) showed significantly more oil content in seeds when compared with control.

These results are comparable with Arsode (2013), who concluded that the oil per cent in mustard were significantly highest with foliar application of 50 ppm NAA + 400 ppm humic acid followed by 50 ppm NAA + 300 ppm humic acid.

Guddhe *et al*. (2019) indicated that oil content in seeds of sesamummarkedly increased by foliar application of 50 ppm NAA + 400 ppm HA through VCW when sprayed on sesamum increased oil content in seed over control.

Yield and yield contributing parameters

The yield and the yield attributing characters affected by foliar sprays of humic acid and NAA were recorded, analyzed and are presented in the following subheads.

Number of capitulaplant^{-1}

Significantly highest number capitula plant^{-1} was obtained in treatment T_{10} (50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid) and T_7 (25 ppm NAA + 300 ppm humic acid) when compared with control and rest of the treatments. Also, treatments T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid), T_3 (50 ppm NAA) and T_2 (25 ppm NAA) were found significantly superior over control

Similar findings were enlightened by Deotale *et al.* (2017), who observed that there was an increase in number of capsules plant^{-1} when linseed crop was sprayed with 350 ppm humic acid + 50 ppm NAA.

Siddik *et al.* (2015) carried out experiment to examine the response of different levels of foliar application of NAA on yield contributing attributes of sesame. Significantly highest number of pods plant^{-1} was recorded when 50 ppm NAA applied as foliar spray.

Number of seeds capitulum^{-1}

Among all treatments application of 50 ppm NAA + 300 ppm humic acid contributed significantly highest number of seeds in capitulum followed by treatment T_{11} (50 ppm NAA + 400 ppm humic acid). Also, treatments T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid), T_3 (50 ppm NAA), T_2 (25 ppm NAA) and T_4 (300 ppm humic acid) were found significantly superior over control.

The findings regarding number of seeds capitulum^{-1} are in line with observations made by Kapase (2014), who evaluated the effect of different concentrations of humic acid (300, 400 and 500 ppm) through vermicompost wash and NAA (25 and 50 ppm) on chickpea and found that foliar spray of 50 ppm NAA + 400 ppm HA through VCW significantly increased number of seeds pod^{-1} in chickpea.

Siddik *et al.* (2015) used various concentrations of NAA *viz.,* 0, 25, 50 and 75 ppm and recorded that there was significant increase in number of pods plant^{-1} when linseed was sprayed with 50 ppm NAA.

Table 1.Effect of humic acid and NAA on chemical and biochemical parameters in safflower

Treatments	Total chlorophyll content (mg g^{-1})				Nitrogen content(%)				Phosphorus content(%)				Potassium content(%)			
	40 DAS	60 DAS	80 DAS	100 DAS	40 DAS	60 DAS	80 DAS	100 DAS	40 DAS	60 DAS	80 DAS	100 DAS	40 DAS	60 DAS	80 DAS	100 DAS
T_1 (Control)	1.290	1.313	1.495	1.303	2.52	3.15	4.48	2.41	0.228	0.222	0.228	0.224	0.67	0.75	0.86	0.78
T_2 (25 ppm NAA)	1.258	1.536	1.706	1.441	2.62	3.62	5.29	3.22	0.232	0.238	0.260	0.253	0.66	0.81	0.91	0.84
T_3 (50 ppm NAA)	1.298	1.579	1.781	1.529	2.59	3.79	5.33	4.10	0.231	0.240	0.262	0.263	0.69	0.86	0.92	0.88
T_4 (300 ppm HA)	1.282	1.490	1.684	1.435	2.61	3.58	5.08	2.99	0.226	0.233	0.258	0.245	0.73	0.80	0.90	0.82
T_5 (400 ppm HA)	1.278	1.470	1.664	1.412	2.65	3.58	4.95	2.77	0.229	0.229	0.241	0.239	0.71	0.80	0.89	0.82
T_6 (500 ppm HA)	1.441	1.436	1.554	1.314	2.67	3.28	4.75	2.53	0.233	0.224	0.229	0.225	0.73	0.76	0.88	0.78
T_7 (25 ppm NAA + 300 ppm HA)	1.259	1.789	2.010	1.759	2.59	4.37	5.82	4.81	0.238	0.268	0.289	0.274	0.71	0.88	0.94	0.90
T_8 (25 ppm NAA + 400 ppm HA)	1.242	1.737	1.920	1.653	2.67	4.28	5.60	4.47	0.239	0.252	0.285	0.271	0.70	0.87	0.93	0.89
T_9 (25 ppm NAA + 500 ppm HA)	1.273	1.715	1.898	1.645	2.68	4.09	5.53	4.42	0.240	0.249	0.277	0.269	0.69	0.87	0.92	0.89
T_{10} (50 ppm NAA + 300 ppm HA)	1.257	1.926	2.035	1.840	2.67	4.69	5.98	5.14	0.233	0.292	0.299	0.295	0.71	0.91	0.99	0.93
T_{11} (50 ppm NAA + 400 ppm HA)	1.251	1.828	2.028	1.813	2.53	4.63	5.84	5.06	0.229	0.271	0.294	0.289	0.71	0.89	0.95	0.91
T_{12} (50 ppm NAA + 500 ppm HA)	1.262	1.607	1.873	1.624	2.60	3.93	5.46	4.26	0.239	0.242	0.270	0.267	0.67	0.86	0.92	0.88
SE (m) ±	0.082	0.096	0.099	0.100	0.162	0.250	0.255	0.253	0.0147	0.0107	0.0134	0.0124	0.045	0.030	0.02	0.025
CD at 5 %	-	0.281	0.29	0.293	-	0.734	0.746	0.741	-	0.0314	0.0392	0.0363	-	0.087	0.055	0.074

Table 2. Effect of humic acid and NAA on oil content in seeds, yield and yield attributing parameters in safflower

Treatments	Seed oil Content (%)	Number of capitula $plant^{-1}$	Number of seeds $capitulum^{-1}$	1000 seed weight (g)	Seed yield $plant^{-1}$ (g)	Seed yield $plot^{-1}$ (kg)
T_1 (Control)	27.15	9.87	12.80	32.40	14.98	0.299
T_2 (25 ppm NAA)	31.29	16.87	19.67	37.00	19.87	0.397
T_3 (50 ppm NAA)	31.40	18.33	20.80	37.20	20.05	0.401
T_4 (300 ppm HA)	30.72	16.40	18.87	36.60	19.45	0.388
T_5 (400 ppm HA)	30.39	13.60	17.07	34.20	19.39	0.387
T_6 (500 ppm HA)	27.91	11.80	13.93	33.90	18.67	0.373
T_7 (25 ppm NAA + 300 ppm HA)	31.93	28.67	32.07	38.60	21.77	0.435
T_8 (25 ppm NAA + 400 ppm HA)	31.80	26.93	30.87	38.00	21.50	0.430
T_9 (25 ppm NAA + 500 ppm HA)	31.65	24.13	28.67	37.90	21.22	0.424
T_{10} (50 ppm NAA + 300 ppm HA)	35.83	32.47	37.40	39.80	23.45	0.469
T_{11} (50 ppm NAA + 400 ppm HA)	32.47	29.47	34.20	38.60	22.01	0.440
T_{12} (50 ppm NAA + 500 ppm HA)	31.60	19.33	23.13	37.60	20.80	0.415
SE (m) ±	1.14	1.40	1.61	1.12	1.18	0.48
CD at 5 %	3.34	4.09	4.73	3.28	3.46	0.68

1000 seed weight

1000 seed weight was significantly maximum in treatment T_{10} (50 ppm NAA + 300 ppm humic acid) followed by treatments T_{11} (50 ppm NAA + 400 ppm humic acid), T_7(25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid), T_3 (50 ppm NAA), T_2 (25 ppm NAA) and T_4 (300 ppm humic acid) when compared with T_1 (control).

Kapase, (2014) 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 100 seed weight (g).

Siddik *et al*. (2015) claimed that application of 50 ppm NAA as foliar spray significantly increased 1000 seed weight in linseed crop.

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

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

Considering all treatments under study significantly highest seed yield plant^{-1} and plot^{-1}was exhibited in treatments T_{10}(50 ppm NAA + 300 ppm humic acid), T_{11} (50 ppm NAA + 400 ppm humic acid), T_7 (25 ppm NAA + 300 ppm humic acid), T_8 (25 ppm NAA + 400 ppm humic acid), T_9 (25 ppm NAA + 500 ppm humic acid), T_{12} (50 ppm NAA + 500 ppm humic acid) and T_3 (50 ppm NAA) in a descending manner when compared with control and rest of the treatments. Also, treatments T_2 (25 ppm NAA), T_4 (300 ppm humic acid), T_5 (400 ppm humic acid) and T_6 (500 ppm humic acid) also significantly enhanced seed yield plant^{-1} as compared to control and rest of the treatments.

Previous investigation of Parihar *et al.* (2013) about seed yield of mustard were also coincided with our present findings who declared that foliar spray of 400 ppm vermicompost wash significantly enhanced seed yield by 30 per cent in green gram. Jape *et al*. (2013) repored that foliar application 300 ppm humic acid significantly increased pod yield in groundnut.

Guddhe *et al*. (2019) claimed that 50 ppm NAA + 400 ppm HA through VCW significantly enhanced seed yield in sesamum.

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