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Performance of Strawberry (*Fragaria × ananassa* Duch.) as influenced by Humic Acid and Water Soluble Fertilizers on Vegetative Parameters under Naturally Ventilated Polyhouse

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ABSTRACT: Application of nutrients through soil is not an effective method. So, the alternative approach to overcome the problem of ineffective fertilizer nutrient supply. These unpredicted challenges urge the adoption of novel and resource efficient stratagies to stepping out of the growth and yield parameters. The present study was undertaken to evaluate performance of strawberry as influenced by humic acid and water soluble fertilizers on growth under naturally ventilated polyhouse. The study was made during 2017-18 with completely randomised design by taking fourteen treatments replicated thrice. The results promulgated that application of 100 % RDF through soil along with foliar application of humic acid (2%) + 19:19:19 (1%) + potassium nitrate (1%) recorded significantly highest plant height per plant (33.03 cm), trifoliate leaves per plant (32.32), crowns per plant (5.75), Runners per plant (2.02), plant spread of 46.61 and 44.50 cm North-south and east-west respectively. Leaf area (176.86 cm^2), leaf area index (1.89) plant dry weight at harvest (30.29g/plant), total Chlorophyll content of leaves (2.44 mg/g of fresh weight), yield per plot (4.55 kg) followed by application of 75% RDF through soil along with foliar application of humic acid (2%) + 19:19:19 (1%) + potassium nitrate (1%).

Keywords: Strawberry, humic acid, water soluble fertilizers, growth.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa Duch*.) belongs to the family Rosaceae with basic chromosome number of X=7. The cultivated strawberry is an octoploid, obtained by the hybridization of two North American species *Fragaria chiloensis* and *Fragaria virginiana* developed in France during seventeenth century. Earlier, the strawberry was a commercial fruit crop of temperate region. However, with the development of day neutral varieties its cultivation is being extended to tropical and subtropical climate region also. Strawberry plant is a low creeping short day perennial herb and a crown arise from basal leaves. Leaves are compound, with three leaflets saw tooth edged and hairy. The flowers are white in colour borne in small clusters, offers quicker returns on capital investment. Fruit is most delicious, nutrious, refreshing, soft fruit crop possess anticancer compound called ellagic acid.

Strawberry has certain seasonal fruiting varieties which produce a single crop in summer with limited vegetative growth occurs during short period. As a result the fruit produced is not of good quality and have a minimum marketable yield (Asrey *et al.*, 2004; Singh *et al.*, 2007) profitable crop production is based entirely on balanced plant nutrition under suitable agro-ecological conditions.

Presence of unaviability and tenacious fixation of all major nutrients with poor organic matter, makes it impossible for plants to access nutrients (Bibordi *et al.*, 2000). Therefore farmers need to apply extra fertilizers in order to increase yield (FAO, 2015). Foliar application of mineral nutrients has become an inevitable horticultural practice for sustainable crop production world wide (Prajapati and Modi 2012). Foliar application draws attention as a quick, target oriented and ecofriendly, it helps us to gain higher crop productivity under optimal and unfavorable growth conditions (Li *et al.*, 2019; Zhu *et al.*, 2019; Thornburg *et al.*, 2020). It can be widely used to diminish nutritional deficiencies in crop plants at critical growth stages. It also helpful to minimize the soil barriers for higher nutrient use efficiency (Dordas, 2009; Hosein-Beigi *et al.*, 2019; Correia *et al.*, 2020). Now-a-days interest in multi-nutrient foliar feeding in the form of water-soluble fertilizers enhancing at large and effective in correcting deficiencies on time scale. As compared with applications of plant nutrients to soil, foliar fertilization is credited with rapid correction of nutrient deficiencies, greater control over vegetative and fruiting responses because plants never lost their ability to absorb nutrients through their aerial parts. Recently humic acid and water-soluble fertilizers has been practiced commercially to increase production and quality of strawberry crop.

Nitrogen is the most important element which plays a vital role in building blocks of protein molecules, nucleic acids, enzymes, lipids, harmones (Hassegawa *et al.,* 2008). potassium nitrate are complete water-soluble ideal fertilizers which provides all major macronutrients in a balanced ratio to the plants helps in promoting photosynthesis and transport assimilates of carbohydrates to the storage organs, increases vegetative growth and helps in getting higher yield (Ali *et al.,* 2016). Humic acid consist of C, H, O, N and S. regarding structure major functional group of humic acid include carboxylic, phenolic and aliphatic moieties (Pena-mendez *et al.*, 2005). Increases the functional group of availability by the plant for a long time, increase ion capillary capacity (Abbas *et al.,* 2013) and thus improves quality of watermelon (salman *et al*., 2005), grape (Ferrara and Brunetti 2010) and Strawberry (Hosseini Farahi *et al.*, 2013). Regarding the interaction effects of nitrogen compounds and humic acid on growth and yield of different plants such as peanut (Moraditouchi, 2012), cucumber (Kazemi, 2013) and tomato (Aman and Rab 2013), which confirms the present achievements. Ganjehi and Golchin (2012) indicated that highest shoot fresh and dry weights, number of fruits and yield are obtained using 110mg l^{-1} nitrogen. There are many reports about the positive effects of nitrogen, humic acid and their interactions on the chlorophyll content of various plants, including: eggplant (Aminifard *et al.*, 2010), Kinnow mandarin (Abbass *et al.*, 2013) and garlic (Zeinali and Moradi 2015) whose results are consist with the findings of this study.

MATERIALS AND METHODS

Experimental site and treatment details. Investigation was carried out on cv. winter dawn in the experimental blocks of the Fruit Science Department, COH Mudigere situated in the western ghats and represents the typically hilly zone (Zone-9 and Region-V) of Karnataka, India. It is located at 13° 25° North latitude and 75° 25° East longitude with an altitude of 982 m above mean sea level. The experiment was conducted in Completely Randomized Design with fourteen treatments laid in three replications. Tissue cultured plants of winter dawn variety of strawberry was planted at a spacing of 30cm × 30 cm on raised beds with 12 plants per plot *viz*., 6 plants of 2 rows. Recommended dose of NPK (150:100:120 kg/ha) was applied through soil and plants were fertilized with different combination and concentration *viz*., T_1-100 % RDF + Humic acid (2%) foliar application, T_2-100 % RDF + 19:19:19 (1%) foliar application, T_3-100 % RDF + potassium nitrate (1%) foliar application, T_4-100 % RDF + Humic acid (2%) + 19:19:19 (1%) foliar application, T_5-100 % RDF + Humic acid (2%) + potassium nitrate (1%) foliar application, T_6-100% RDF + Humic acid (2%) +19:19:19 (1%) + potassium nitrate (1%) foliar application, T_7-75 % RDF + Humic acid (2%) foliar application, T_8-75% RDF + 19:19:19 (1%) foliar application, T_9-75 % RDF + potassium nitrate (1%) foliar application, T_{10}-75 % RDF + Humic acid (2%) + 19:19:19 (1%) foliar application, T_{11}-75 % RDF + Humic acid (2%) + potassium nitrate (1%) foliar application, T_{12}-75% RDF + Humic acid (2%) + 19:19:19 (1%) + potassium nitrate (1%) through foliar application, T_{13}-100% RDF through soil, T_{14}-75% RDF through soil at an interval of 45, 60 & 75 days after planting. Humic acid and 19:19:19, Potassium nitrate were chosen for the test, desired concentration of selected fertilizers were prepared fresh and used for the study. Subsequently at 30, 60, 90, 120 definite intervals the data on observations recorded growth parameters. The data obtained was subjected to statistical analysis to draw the meaningful deviations and inferences.

RESULTS AND DISCUSSION

Growth parameters. In the study maximum plant height (33.03), number of trifoliate leaves per plant (32.32), crowns per plant (5.75) and runners per plant (2.02) was recorded in plots receiving 100% RDF soil application + Humic acid (2%) + 19:19:19 (1%) + potassium nitrate (1%) through foliar application at 120 days after planting followed by (T_{12}) whereas, The minimum plant height of 25.18cm, trifoliate leaves 22.62, crowns 2.18 and runners of 1.25 respectively. was recorded in the treatment T_{14} (75 % RDF soil application).

The analysis of data divulged as significant difference among different treatments for growth parameters. Plant height, number of trifoliate leaves, crowns, runners are the important primary visible growth traits as seen from the data. These growth traits varied with days and also with different treatments. Statistical variation was observed clearly from the beginning till the end of maturity. The differences are more pronounced at peak growth phase and when compared to 75 or 100 per cent RDF through soil application along with different foliar applied treatments responded positively to the above traits. The superior accomplished sustained vegetative growth in terms of above parameters might be due to Humic acid and water soluble fertilizers regulate the growth of strawberry plants by causing cell division and increased cell division and also cause the elongation in mature petiole of strawberry and other nutrients increased the rate of various physiological and metabolic processes such as synthesis of proteins, nucleic acids, coenzymes, secondary metabolism products, enzyme activation, osmotic regulation, respiration and photosynthesis in the plant system.

A comparison of different sources of potassium foliar spray in Rice was made and it was observed that 1.5 per cent K of K_2SO_4 produced high yields of grain, straw yield, the potassium content of plants, number of tillers, agronomic efficiency and potassium recovery compared to KCl and KNO_3 (Ali *et al.,* 2016). These results are in accordance with the findings of Awad *et al.* (2010), Shehata *et al.* (2011), Fathy *et al.* (2010) and Harsha *et al.* (2017) who obtained maximum plant height and number of leaves per plants by foliar application of nutrients as compared to control in strawberry and pumello respectively.

Treatment (T_6) 100 % RDF soil application + Humic acid (2%) + 19:19:19 (1%) + potassium nitrate (1%) through foliar application recorded maximum leaf area (176.86), leaf area index (1.89), chlorophyll-a (1.85), chlorophyll-b (0.59), Total chlorophyll (2.44), dry weight at harvest (30.29), plant spread of north-south and east-west was 46.61 and 44.50 respectively, which is followed by (T_{12}) and minimum data was graded in the treatment T_{14} (75 % RDF soil application) which recorded leaf area(154.84), Leaf area index (1.38), chlorophyll-a(1.36), chlorophyll-b (0.30), Total chlorophyll (1.66), dry weight at harvest (21.21), plant spread of north-south and east-west was 28.38 and 27.80 respectively. Increase in vegetative growth might be due to the integration of chemicals which are applied through foliar application helps in the accomplishment of increased nutrient supply through foliar at critical stages at that time leaves sufficiently absorb the nutrients through their aerial parts for overcoming of hidden hunger. Due to cumulative solubilization of available nutrients and Translocation of assimilates to the developing sink results in higher accumulation of greater amount of carbohydrates in leaf tissues which forces length and weeping growth of leaf petioles which lean outwards resulting in higher plant spread which is automatically helps in stepping out of total chlorophyll, drymatter,and yield. The positive and significant effects of nitrogen and humic acid and their interactions on the amount of nitrogen and protein in the leaves and roots of various products such as: Strawberry (Ameri and Tehranifar 2012), Ginger (Tai-bo *et al.,* 2007), Melon (Ferrante *et al.,* 2008) and Cucumber (El-Nemr *et al.,* 2012; Kazemi, 2013), have been reported which are consistent with the results of this study. Tai-bo *et al.* (2007) reported that humic acid significantly increases the protein content and protein production of ginger rhizome. Also, the use of humic acid-urea increases the absorption efficiency of soil nitrogen and activity of nitrate reductase as well. Chen and Aviad (1990) argued that the stimulating effects of humic acid are related to the increased absorption of macro-elements. Adani *et al.* (1998) found that humic acid increases the nitrogen uptake.

These results are in line with the findings of Santos and Chandler (2009), who observed an increase in canopy diameter in strawberry with increased nitrogen level and also by the studies of Ramniwas *et al.* (2012) in guava. Similar findings were reported by Eshagi *et al*. (2012); Kazemi (2014); Shahzad *et al.* (2017) in strawberry, Gleelmosa *et al.* (2015) in apple and Harsha *et al*. (2017) in pumello, Kazemi (2013), Awad *et al.* (2010); Eshaghi *et al*. (2012) in strawberry.

The results of the study revealed that significant variation for yield in plants subjected to different treatments. The plants which received 100% RDF soil application + Humic acid (2%) + 19:19:19 (1%) + potassium nitrate (1%) through foliar application recorded maximum fruit yield per plot (4.55 kg) while minimum fruit yield per plot (1.94 kg) was recorded in plots which received 75 per cent RDF through soil application. The combined effect of spraying inorganic fertilizers with humic acid enhanced the nutrient availability capacity in the leaves might have coincided with plant need. These results are in line with findings of Gleelmosa *et al.* (2015) in apple.

CONCLUSION

On the basis of results obtained in the present investigation, it can be concluded that application of 100 % RDF + HA (2%) + 19:19:19 (1%) KNO_3 (1%) through foliar application or else 75 % RDF + HA (2%) + 19:19:19 (1%) + KNO_3 (1%) through foliar application at 45, 60 and 75 days after planting showed promising results with respect to growth and yield parameters.

Table 1: Influence of nutrient management practices with humic acid and water soluble fertilizers on plant height, no. of trifoliate leaves, number of crowns of strawberry.

Treatments	Plant height (cm)				Number of trifoliate leaves / plant				Number of crowns/ plant		
	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP	60 DAP	90 DAP	120 DAP
T_1	11.52	15.65	23.87	26.65	7.56	11.89	18.16	25.76	1.06	2.14	3.16
T_2	11.55	16.56	26.13	29.53	7.91	12.93	21.59	28.66	2.02	3.23	4.19
T_3	11.63	16.20	25.11	28.51	7.46	12.22	20.47	26.45	1.66	2.85	3.73
T_4	12.42	17.22	28.04	32.01	7.64	13.38	23.40	29.24	3.31	4.64	5.28
T_5	11.41	17.03	27.28	31.18	7.39	13.19	22.67	29.30	2.83	3.84	4.66
T_6	13.54	18.54	29.86	33.03	7.97	14.79	24.92	32.32	3.92	5.31	5.75
T_7	11.70	15.35	23.61	26.45	7.41	11.68	17.66	24.75	0.84	1.85	2.76
T_8	10.99	16.37	25.95	29.19	7.44	12.46	21.19	27.58	1.83	3.04	4.08
T_9	11.11	15.80	24.26	27.66	6.99	12.06	19.62	26.17	1.12	2.56	3.54
T_{10}	10.92	17.16	27.92	31.70	7.64	13.27	23.25	29.17	3.09	4.25	4.85
T_{11}	12.19	16.67	27.01	29.91	6.89	13.06	21.82	28.82	2.35	3.36	4.42
T_{12}	12.55	17.61	28.76	32.27	7.90	14.15	24.04	31.25	3.68	4.87	5.42
T_{13}	11.35	13.95	22.31	25.66	7.13	11.21	15.99	23.57	0.56	1.50	2.63
T_{14}	10.91	12.24	21.33	25.18	6.98	10.90	14.93	22.62	0.27	1.25	2.18
S Em ±	0.20	0.18	0.36	0.23	0.21	0.19	0.22	0.16	0.04	0.15	0.07
C.D.(p=0.05)	0.59	0.53	1.06	0.68	0.62	0.56	0.64	0.48	0.10	0.42	0.21

LEGEND

T_1 -100 % RDF through soil + Humic acid (2 %) foliar application
T_2 -100 % RDF through soil + 19:19:19 (1 %) foliar application
T_3 -100 % RDF through soil + Potassium nitrate (1 %) foliar application
T_4 -100 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) foliar application
T_5 -100 % RDF through soil + Humic acid (2 %) + Potassium nitrate (1 %) foliar application
T_6 -100 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) + Potassium nitrate (1 %) foliar application
T_7 -75 % RDF through soil + Humic acid (2 %) foliar application
T_8 -75 % RDF through soil + 19:19:19 (1 %) foliar application
T_9 -75 % RDF through soil + Potassium nitrate (1 %) foliar application
T_{10} -75 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) foliar application
T_{11} -75 % RDF through soil + Humic acid (2 %) + Potassium nitrate (1 %) foliar application
T_{12} -75 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) + Potassium nitrate (1 %) foliar application
T_{13} -100 % RDF through soil application
T_{14} -75 % RDF through soil application

Table 2: Influence of nutrient management practices with humic acid and water soluble fertilizers on leaf area, leaf area index, plant dry weight at harvest, chlorophyll content of strawberry.

Treatments	Leaf area(cm^2)				Leaf area index				Chlorophyll content of leaves (mg/g of fresh weight)			Plant dry weight at harvest (g/plant)
	30 DAP	60 DAP	90 DAP	120 DAP	30 DAP	60 DAP	90 DAP	120 DAP	C-a	C-b	Total chlorophyll	
T_1	84.62	123.14	149.07	167.23	0.54	1.08	1.40	1.53	1.52	0.35	1.88	23.79
T_2	86.06	124.22	152.48	169.53	0.63	1.16	1.54	1.69	1.67	0.47	2.14	26.75
T_3	85.07	123.64	150.49	168.39	0.59	1.13	1.40	1.61	1.57	0.42	1.98	25.65
T_4	85.39	126.01	155.38	175.91	0.77	1.28	1.70	1.82	1.80	0.56	2.36	29.60
T_5	86.01	125.30	153.56	171.09	0.70	1.23	1.61	1.76	1.73	0.52	2.25	27.85
T_6	86.99	126.92	155.76	176.86	0.85	1.36	1.75	1.89	1.85	0.59	2.44	30.29
T_7	82.44	122.91	147.35	166.37	0.52	1.06	1.52	1.49	1.47	0.34	1.80	22.90
T_8	85.39	123.83	151.40	168.78	0.60	1.14	1.46	1.6	1.64	0.45	2.08	26.34
T_9	84.43	123.48	149.39	167.76	0.58	1.11	1.36	1.57	1.55	0.37	1.92	25.20
T_{10}	84.76	125.50	155.19	173.81	0.72	1.25	1.66	1.78	1.75	0.54	2.29	29.48
T_{11}	83.07	124.66	152.85	170.88	0.65	1.19	1.58	1.73	1.71	0.49	2.20	27.42
T_{12}	85.79	126.48	155.58	176.22	0.83	1.33	1.73	1.85	1.82	0.58	2.41	29.97
T_{13}	81.82	122.48	140.23	158.79	0.49	1.03	1.34	1.43	1.45	0.32	1.77	22.10
T_{14}	81.29	121.44	136.18	154.84	0.42	1.01	1.29	1.38	1.36	0.30	1.66	21.21
S Em ±	0.45	0.32	0.41	0.43	0.01	0.01	0.02	0.03	0.01	0.02	0.02	0.10
C.D.(p=0.05)	1.31	0.94	1.19	1.24	0.02	0.03	0.06	0.09	0.03	0.06	0.05	0.30

LEGEND

T_1 -100 % RDF through soil + Humic acid (2 %) foliar application
T_2 -100 % RDF through soil + 19:19:19 (1 %) foliar application
T_3 -100 % RDF through soil + Potassium nitrate (1 %) foliar application
T_4 -100 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) foliar application
T_5 -100 % RDF through soil + Humic acid (2 %) + Potassium nitrate (1 %) foliar application
T_6 -100 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) + Potassium nitrate (1 %) foliar application
T_7 -75 % RDF through soil + Humic acid (2 %) foliar application
T_8 -75 % RDF through soil + 19:19:19 (1 %) foliar application
T_9 -75 % RDF through soil + Potassium nitrate (1 %) foliar application
T_{10} -75 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) foliar application
T_{11} -75 % RDF through soil + Humic acid (2 %) + Potassium nitrate (1 %) foliar application
T_{12} -75 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) + Potassium nitrate (1 %) foliar application
T_{13} -100 % RDF through soil application
T_{14} -75 % RDF through soil application

Table 3: Influence of nutrient management practices with humic acid and water soluble fertilizers on plant spread and number of runners of strawberry.

Treatments	Plant spread (cm)								Number of runners/plant
	30 DAP		60 DAP		90 DAP		120 DAP		
	North-south	East-west	North-south	East-west	North-south	East-west	North-south	East- west	
T_1	12.29	11.24	21.38	22.35	24.33	27.26	34.51	33.58	1.38
T_2	12.73	11.92	22.88	22.35	27.47	26.16	39.91	37.84	1.47
T_3	12.56	11.40	21.77	21.22	26.48	24.08	37.51	35.66	1.42
T_4	13.25	12.51	24.13	23.42	29.52	28.63	44.66	42.45	1.88
T_5	12.89	11.57	23.38	23.10	28.30	27.95	41.19	40.22	1.61
T_6	14.90	14.29	25.56	24.82	30.50	29.75	46.61	44.50	2.02
T_7	12.20	11.18	21.12	21.03	27.21	23.37	32.31	31.11	1.34
T_8	12.69	11.69	22.23	22.22	25.21	26.60	38.58	36.29	1.44
T_9	12.44	11.27	21.51	19.84	23.55	24.41	35.63	34.56	1.41
T_{10}	13.00	12.39	23.37	23.17	29.04	28.23	43.52	41.57	1.65
T_{11}	12.85	11.52	23.32	23.03	28.18	27.82	40.84	38.62	1.58
T_{12}	13.73	13.24	24.79	24.23	29.74	29.10	45.59	43.38	1.95
T_{13}	11.88	10.29	20.62	20.15	22.22	22.04	30.12	29.66	1.28
T_{14}	11.47	9.84	19.84	19.18	20.86	19.86	28.38	27.80	1.25
S.Em ±	0.26	0.26	0.25	0.16	0.23	0.13	0.20	0.27	0.02
C. D. (P = 0.05)	0.77	0.76	0.74	0.46	0.67	0.38	0.59	0.80	0.06

LEGEND

T_1 -100 % RDF through soil + Humic acid (2 %) foliar application
T_2 -100 % RDF through soil + 19:19:19 (1 %) foliar application
T_3 -100 % RDF through soil + Potassium nitrate (1 %) foliar application
T_4 -100 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) foliar application
T_5 -100 % RDF through soil + Humic acid (2 %) + Potassium nitrate (1 %) foliar application
T_6 -100 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) + Potassium nitrate (1 %) foliar application
T_7 -75 % RDF through soil + Humic acid (2 %) foliar application
T_8 -75 % RDF through soil + 19:19:19 (1 %) foliar application
T_9 -75 % RDF through soil + Potassium nitrate (1 %) foliar application
T_{10} -75 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) foliar application
T_{11} -75 % RDF through soil + Humic acid (2 %) + Potassium nitrate (1 %) foliar application
T_{12} -75 % RDF through soil + Humic acid (2 %) + 19:19:19 (1 %) + Potassium nitrate (1 %) foliar application
T_{13} -100 % RDF through soil application
T_{14} -75 % RDF through soil application

FUTURE SCOPE

Under increasing climate change, environmental stress such as duration of heat and drought which offers decreasing agricultural productivity and quality in multiple ways. These unpredicted challenges urge the adoption however, the consequences of foliar spray under multiple environmental stress remains elusive, albeit, evidence to resillence agriculture has grown widely.

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Conflict of Interest. None.

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