



Effect of Foliar Application of Fertilizer and Growth Media on vigor of Strawberry

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Abstract

Strawberry (*Fragaria ananassa*), belongs to Rosaceae family, rich in vitamins and minerals. Its growth and development in pots mainly depends on physiochemical properties of the growing media. This research work was conducted to evaluate the effect of various media and NPK fertilizer application on growth of strawberry. The media used was soil, soil+peat moss and peat moss. Foliar application of NPK at weekly interval was done with 4ppm, 6ppm and 8ppm. The research was performed under CRD design with three replications. The results showed that strawberry plant performed better response towards peat moss with 6 and 8 ppm foliar application of NPK. Chlorophyll content was maximum (19.6) at 8ppm while, at vegetative stage it was (23.69) with 6ppm foliar application. Maximum Number of fruits were obtained in soil. Fruit weight leaf area and total soluble salts were recorded in peat moss with 8 and 6 ppm foliar application of NPK. So, plants grown in peat moss growing media showed significant increase in all parameters.

INTRODUCTION

Strawberry (*Fragaria ananassa*) belongs to Rosaceae family of the genus *Fragaria* (Hancock, 1999). The strawberry plant is an herbaceous perennial. Strawberries contains a desirable amount of vitamins, fiber and sugars (Sharma and Sharma, 2004). Vitamin C, Phenolic and flavonoids are also present in strawberry fruit (Hakkinen and Torronen, 2000). Mainly 4.6-6.5 pH is suitable for strawberry (Milosevic, 1997). Pakistan is producing a limited quantity of strawberries. The estimated per acre income of the strawberry is about Rs.100,000 per season (Khushk and Memon, 2005). It is desirable to enhance the yield of horticultural crops not only quantitatively but also qualitatively with ever limiting resource of cultivated lands. (Tariq et al., 2013).

A farmer should know about plant needs and should provide a suitable amount of fertilizer on time. The combination of both increases the growth and efficiently utilizes fertilizer. Plant nutrition is very much important for health and fruit quality. For plant nutrition nutrient content with appropriate ratio play a vital role for plant growth but sometime uptake of nutrient may block even in well supplied nutritional soils.

In early summer plant firstly bloom and then fruit. Vegetative growth starts in summer, after a period of rest. Peat moss used as a soil conditioner which enhance the water holding capacity of soil. Peat moss improves the aeration condition by forming the greater root system, promoted shoot nutrition uptake, strengthened activities of capturing light and increased yield (Du et al., 2007). Along with the media foliar application of fertilizer plays an important role in growth and yield of strawberry plant. To increase nutrient content in certain above-ground plant organism foliar nutrition is important (Swietlik and Faust, 1984). Foliar application of fertilizer usually compensate the deficiency of nutrients. Foliar application of fertilizers is more beneficial than fertilization of the soil. Phosphorus and potassium are required for berry formation (Lieten and Misoten, 1993; Tagliavini et al., 2004). More amounts of phosphorus and potassium content improve berry

quality. For crop growth and yield nitrogen is very much important it affects dry matter and photosynthesis (Yin *et al.*, 2003). Deficiency of nitrogen in strawberry plant reduces carbon allocation to fruits, yield and increases fruit weight (Deng and Woodward, 1998).

Contemporary study was designed to check the effect of growing media and foliar application of fertilizer on the strawberry plant. Cultivar “Chandler” is good in future for better yield of its fruits. In Layyah region farmers are not much familiar with strawberry cultivation. Limited work has been done. Farmers are not known about its nutritional value and net price. So, the present study will guide the farmers for the optimization of production technology of strawberry in Thal region of Layyah by using different media and fertility program.

MATERIALS AND METHODS

The research was conducted out at Green Moon Agricultural farm Karor Lal-Eson (Layyah) in 2017-2018. The Scheme of the experiment was,

Table: 3.1 Three types of media used in experiment along with their conc.

Media	Growth media	Media %age
M1	soil	100
M2	Soil +peat moss	50 +50
M3	Peat moss	100

Table: 3.2 Concentration of NPK Fertilizer (20-20-20)

Treatments	Concentrations
T ₀	0.00
T ₁	4 ppm of NPK
T ₂	6 ppm of NPK
T ₃	8 ppm of NPK

The research was conducted out in a strawberry cv. ‘Chandler’ planted in 24 Dec 2015 at Nursery in pots. The soil in the experimental pots was analyzed for pH, Electrical conductivity (EC) and for its nutrients contents. Each pot contain 1.55kg of soil (M₁) while soil + peat moss contains 1.35 kg in each pot (M₂) and peat moss contains 0.30 kg in each pot (M₃). The runners of the strawberry plants were taken from Green circle company Lahore. Plants were grown in medium size 161 pots with 3 different media. 20 pots included soil, 20 pots included soil +peat moss and only peat moss media contains 121 pots (Table3:1). The experiment was designed in Completely Randomized Design (CRD) with 3 replications. Foliar application of fertilizer via leaves were applied at 15 day intervals from starting to the end of the research. M₁ were applied with 4ppm of NPK, while M₂ were applied with 6ppm and M₃ were applied with 8ppm of NPK (Table3:2). Uniform weeding and irrigation during the research for development of runners and for good growth.

DATA COLLECTION

Vegetative and reproductive parameters were collected for comparison of plant growth under different media and fertilizer.

Vegetative Parameters	Reproductive Parameters
Total no of plants	No of days to initiate first flower
Length of leaves	Number of fruits
Width of leaves	Fruit weight
Leave area	

Yield Parameters

Yield of strawberry was evaluated by the both quantitative and qualitative parameters.

Qualitative Parameter	Quantitative Parameters
Taste	Total soluble salts
Color	Chlorophyll contents

Statistical Analysis

The data was analyzed by using STATISTIX 8.1 and means were compared by using Least significant Difference (LSD) test at 5% probability level (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Statistical analysis of data including leaf area showed significant effect of media and fertilizer (Table 4.2). Maximum leaf area (625.86) was observed in peat moss by 8ppm foliar application of NPK. While, minimum (165.19) were observed in soil with 4ppm foliar application of NPK (Table 4.1). The combination of peat moss media with foliar application of fertilizer increases the stem and leaf area, because direct availability of nitrogen by foliar application to leaves and peat moss media which available all kind of nutrients to the plant roots, make them capable to grow maximum as compared to the soil media.

Table 4.1 Analysis of variance of Leaf Area of strawberry treated with NPK in three media.

Analysis of Variance Table for LA

Source	DF	SS	MS	F	P
Rep	2	8022	4011		
Trt	2	420340	210170	84.29	0.0000
Media	3	128800	42933	17.22	0.0000
Trt*Media	6	23359	3893	1.56	0.2054
Error	22	54853	2493		
Total	35	635373			

Grand Mean 414.42 CV 12.05

Maximum leaf area observed in peat moss with foliar application of NPK. Ogendo *et al.* (2008) reported that peat moss have the sufficient amount of potassium which increased leaf growth and increased the sugar accumulation which promotes the leaf area. Minimum leaf area observed in soil may be due to inadequate amount of macro and micro nutrients in soil conditions. Abu-Zahra and Tahboub (2009) reported the same result. Although foliar application of NPK also play a very significant role in increasing the leaf area. The nitrogen available to plants in two forms the nitrate form (NO_3^-) and the ammonium form (NH_4^+). Nitrogen is essential in component in the synthesis of amino acids and protein in plant. As a fertilizer it stimulates vegetative growth such leaves, petioles and shoots. Heavy application of NPK is not required because it affect dense leaf canopy. NPK levels are controlled to accommodate various growth stages.



Fig: 4.1 leaf area of strawberry plant

Table 4.2 Comparison of means of fertilizer* media on strawberry plant for Leaf Area

Treatment	Mean	
T ₁ M ₁	165.19	E
T ₁ M ₂	240.00	E
T ₁ M ₃	341.47	D

T ₁ M ₄	342.10	D
T ₂ M ₁	345.33	D
T ₂ M ₂	413.25	CD
T ₂ M ₃	473.87	BC
T ₂ M ₄	516.18	B
T ₃ M ₁	485.99	BC
T ₃ M ₂	522.70	B
T ₃ M ₃	501.14	B
T ₃ M ₄	625.86	A

T₁M₁:4ppm,soil

T₁M₂:4ppm,soil+peatmoss

T₁M₃:4ppm,peatmoss

T₂M₁:6ppm,soil

T₂M₂:6ppm,soil+peatmoss

T₂M₃:6ppm,peatmos

T₃M₁:8ppm,soil

T₃M₂:8ppm,soil+peatmoss

T₃M₃:8ppm, peatmoss

Statistical analysis of data including chlorophyll content showed significant effect of media and fertilizer (Table 4.4). Maximum chlorophyll content (19.6) at vegetative stage was observed in peat moss by 8 ppm foliar application of NPK. While, minimum (10.7) were observed in soil with 8ppm foliar application of NPK (Table 4.3). Because phosphorus was unavailable for the plants in soil as compared to peat moss, as much the phosphorus will be present in the plant leaves, more chlorophyll content will be produced.

Table 4.3. Analysis of variance of Chlorophyll content at vegetative stage of strawberry treated with NPK in three media.

Analysis of Variance Table for C

Source	DF	SS	MS	F	P
Rep	2	7.601	3.8003		
Trt	2	12.896	6.4478	2.74	0.0046
Media	3	20.814	6.9381	2.95	0.0552
Trt*Media	6	220.176	36.6959	15.59	0.0000
Error	22	51.779	2.3536		
Total	35	313.266			

Grand Mean 14.739 CV 10.41

Table 4.4 Comparison of means of fertilizer* media on strawberry plant of chlorophyll content at vegetative stage

Treatment	Mean
T ₁ M ₁	15.36 BC
T ₁ M ₂	14.46 BCD
T ₁ M ₃	14.86 BCD
T ₁ M ₄	12.36 DEF
T ₂ M ₁	19.23 A
T ₂ M ₂	11.43 EF
T ₂ M ₃	12.93 CDEF
T ₂ M ₄	13.86 BCDE
T ₃ M ₁	10.70 F
T ₃ M ₂	15.73 B
T ₃ M ₃	19.60 A
T ₃ M ₄	16.30 B

T₁M₁:4ppm,soil T₁M₂:4ppm,soil+peatmoss T₁M₃:4ppm,peatmoss T₂M₁:6ppm,soil
 T₂M₂:6ppm,soil+peatmoss T₂M₃:6ppm,peatmos T₃M₁:8ppm,soil T₃M₂:8ppm,soil+peatmoss
 T₃M₃:8ppm, peatmoss

Statistical analysis of data regarding chlorophyll content at reproductive stage showed significant effect of media and fertilizer (Table 4.6). Maximum chlorophyll (23.69) content at reproductive stage was observed in peat moss by 6 ppm foliar application of NPK. While, minimum (11.13) were observed in soil with 4ppm foliar application of NPK (4.5). Peat moss provides all the nutrients in available form for the plant roots, if we provide foliar support to plant then it could be more vigorous as we can see there is maximum chlorophyll in peat moss media as compared to soil media and by foliar application we can have direct availability of NPK at leaves.

Table 4.5 Analysis of variance of Chlorophyll content at reproductive stage of strawberry treated with NPK in three media.

Analysis of Variance Table for C~01

Source	DF	SS	MS	F	P
Rep	2	13.185	6.5924		
Trt	2	82.166	41.0831	8.42	0.0019
Media	3	109.695	36.5650	7.49	0.0012
Trt*Media	6	258.532	43.0887	8.83	0.0001
Error	22	107.368	4.8804		
Total	35	570.946			

Grand Mean 15.616 CV 14.15

NPK is provided to the plant for maximum growth at reproductive and vegetative stages, chlorophyll content directly relates with phosphorus, as in soil it is not mostly present in free state, because it makes bondings with different micro and macro nutrients, so it became un available for the plant, so to make it available we have to provide the fertilizer in chilated form. But in peat moss due to its macro pores all fertilizers are unable to form bonding with each other but at root zone of plants phosphorus is present in free state so the chlorophyll content will be higher in those plants which are grown in peat moss media as compared to soil media plants, foliar application also supports the increase in chlorophyll content because it is applied directly at the leaf area .



Fig: 4.3 Chlorophyll content in strawberry at reproductive stage

Table. 4.6 Comparison of means of fertilizer* media on strawberry plant for chlorophyll content

Treatment	Mean
T ₁ M ₁	12.25 EF

T ₁ M ₂	11.13 F
T ₁ M ₃	15.40 CDE
T ₁ M ₄	15.28 CDE
T ₂ M ₁	17.79 BCD
T ₂ M ₂	23.68 A
T ₂ M ₃	13.51 EF
T ₂ M ₄	13.06 EF
T ₃ M ₁	18.77 BC
T ₃ M ₂	19.69 B
T ₃ M ₃	12.57 EF
T ₃ M ₄	14.22 DEF

T₁M₁:4ppm,soil T₁M₂:4ppm,soil+peatmoss T₁M₃:4ppm,peatmoss T₂M₁:6ppm,soil
T₂M₂:6ppm,soil+peatmoss T₂M₃:6ppm,peatmos T₃M₁:8ppm,soil T₃M₂:8ppm,soil+peatmoss
T₃M₃:8ppm, peatmoss

Statistical analysis of data regarding number of fruits showed significant effect of media and fertilizer (Table 4.7). Maximum number of fruits (7.21) was observed in soil by 8ppm foliar application of NPK. While, minimum (2.77) were observed in soil with 4ppm foliar application of NPK (4.8).

Table 5.7 Analysis of variance of Number of fruits of strawberry treated with NPK in three media.

Analysis of Variance Table for NF

Source	DF	SS	MS	F	P
Rep	2	2.305	1.1523		
Trt	2	50.058	25.0292	12.70	0.0002
Media	3	3.177	1.0590	0.54	0.6615
Trt*Media	6	16.327	2.7211	1.38	0.2659
Error	22	43.347	1.9703		
Total	35	115.213			

Grand Mean 5.3033 CV 20.47

In 2011 scientist Herencia et al reported that organic media contains phosphorus and nitrogen which increase flower bud initiation and growth. Our results are also similar with their findings. Foliar application of NPK in a sufficient amount fulfill the unique formulation of natural growth promoters, which has proven to substantially increase flowering and fruiting. Phosphorous is important for energy storage and development of fruit. Both the media (peat moss) and foliar application of NPK increased the no of fruits. In our soil available phosphorus was 7, with 8 pH and 128 ds/m Ec which promotes the runners growth in the form of maximum fruits. Deficiency of nitrogen and phosphorus could be indicated by less number of flower and fruits at time of flowering through which flower size decreased and female flower part aborted (Tagliavini et al., 2005).



Fig: 4.4 Number of fruits at different stages

Table.4.8 Comparison of means of fertilizer* media on strawberry plant for number of fruits

Treatment	Mean
T ₁ M ₁	2.77 D
T ₁ M ₂	3.33 BCD
T ₁ M ₃	3.22 CD
T ₁ M ₄	5.67 AB
T ₂ M ₁	5.20 ABC
T ₂ M ₂	5.33 ABC
T ₂ M ₃	6.33 A
T ₂ M ₄	5.33 ABC
T ₃ M ₁	7.21 A
T ₃ M ₂	6.33 A
T ₃ M ₃	6.66 A
T ₃ M ₄	6.22 A

T₁M₁:4ppm,soil

T₁M₂:4ppm,soil+peatmoss

T₁M₃:4ppm,peatmoss

T₂M₁:6ppm,soil

T₂M₂:6ppm,soil+peatmoss

T₂M₃:6ppm,peatmos

T₃M₁:8ppm,soil

T₃M₂:8ppm,soil+peatmo

T₃M₃:8ppm, peatmoss

Statistical analysis of data regarding fruit weight showed significant effect of media and fertilizer (Table 4.9). Maximum fruit weight (23.52) was observed in peat moss by 8ppm foliar application of NPK. While, minimum (5.95) were observed in soil with 4ppm foliar application of NPK (4.10).

Table5.9 Analysis of variance of Fruit weight of strawberry treated with NPK in three media.

Analysis of Variance Table for FW

Source	DF	SS	MS	F	P
Rep	2	21.96	10.978		
Trt	2	632.01	316.006	48.56	0.0000
Media	3	270.53	90.176	13.86	0.0000
Trt*Media	6	64.87	10.812	1.66	0.1778

Error	22	143.15	6.507
Total	35	1132.52	

Grand Mean 12.015 CV 21.23

Peat moss contains favorable amounts of micro and macro nutrients which increased the fruit weight by the formation of carbohydrates. Ripening process in which, fruits play a role for nitrogen and potassium and peat moss have sufficient amount of important nutrients. Peat moss contains micro and macro nutrients in Free State, which could be easily uptake by roots. Potassium relates with ripening of fruits, foliar application of NPK produces the fruit more healthy because of direct availability of potassium, as in the peat moss roots are up taking adequate amount of potassium and by foliar application we can make fruit more vigorous as compared to those plants which are grown in soil media and where less concentration of NPK was applied.

Treatment	Mean	
T ₁ M ₁	5.95	F
T ₁ M ₂	7.09	EF
T ₁ M ₃	10.53	DE
T ₁ M ₄	10.83	DE
T ₂ M ₁	6.66	EF
T ₂ M ₂	8.733	DEF
T ₂ M ₃	10.04	DEF
T ₂ M ₄	12.65	CD
T ₃ M ₁	12.02	CD
T ₃ M ₂	15.97	BC
T ₃ M ₃	23.52	A
T ₃ M ₄	20.15	AB

T₁M₁:4ppm,soil T₁M₂:4ppm,soil+peatmoss T₁M₃:4ppm,peatmoss T₂M₁:6ppm,soil
T₂M₂:6ppm,soil+peatmoss T₂M₃:6ppm,peatmos T₃M₁:8ppm,soil T₃M₂:8ppm, soil+peatmoss
T₃M₃:8ppm,peatmos

Statistical analysis of data regarding Total soluble salts showed significant effect of media and fertilizer (Table 4.11). Maximum TSS (7.99^oBrix) was observed in peat moss by 4ppm foliar application of NPK. While, minimum (5.10^oBrix) were observed in soil with 4ppm foliar application of NPK (4.12).

Table 4.11 Analysis of variance of Total soluble salts of strawberry treated with NPK in three media.

Analysis of Variance Table for TSS

Source	DF	SS	MS	F	P
Rep	2	2.5016	1.25080		
Trt	2	0.6641	0.33205	0.12	0.0037
Media	3	17.5580	5.85265	2.05	0.1360
Trt*Media	6	4.0122	0.66870	0.23	0.9606
Error	22	62.7685	2.85311		
Total	35	87.5044			

Grand Mean 6.7731 CV 20.94

Our findings agree with the work Mahadeen (2009) and Tuzel *et al.* (2003) on strawberry and tomatoes respectively, who reported that there was no effect of media on TSS contents of these crops. Maximum TSS was found in exclusively peat moss media because it provided the micro and macro nutrients to the plant in free state, so it produces more number of seeds in reproductive stage, the minimum amount of TSS was found in soil+ peat moss because when we mixed soil with

peat moss, nature of both media were changed, soil provided some of nutrients to the plants while it also interrupted the peat moss mechanism, which results in less TSS in fruits.

Table.4.12 Comparison of means of fertilizer* media on strawberry plant for TSS

Treatment	Mean
T ₁ M ₁	7.33 AB
T ₁ M ₂	5.10 B
T ₁ M ₃	7.99 A
T ₁ M ₄	6.74 ABC
T ₂ M ₁	7.00 AB
T ₂ M ₂	5.89 DE
T ₂ M ₃	6.61 A
T ₂ M ₄	6.93 E
T ₃ M ₁	7.61 AB
T ₃ M ₂	5.83 DEF
T ₃ M ₃	7.33 A
T ₃ M ₄	6.93 AB

T₁M₁:4ppm,soil T₁M₂:4ppm,soil+peatmoss T₁M₃:4ppm,peatmoss T₂M₁:6ppm,soil
T₂M₂:6ppm,soil+peatmoss T₂M₃:6ppm,peat mos T₃M₁:8ppm,soil T₃M₂:8ppm,peat
mossT₃M₃:8ppm, peat moss

Maximum sweet taste was observed in peat moss with 8ppm foliar application of NPK while, minimum were observed in soil with 4ppm application of NPK. Maximum dark red color was observed in peat moss with 8ppm foliar application of NPK while, minimum were observed in soil with 4ppm application of NPK.

Table.4.13 Comparison of scale chart of taste & Color for media * fertilizer for strawberry plant

Treatment	Taste	Color
T ₁ M ₁	Sweet	Light pink
T ₁ M ₂	Sour	Pink
T ₁ M ₃	Sour	Pink
T ₁ M ₄	Sour	Pink
T ₂ M ₁	Sweet	Red
T ₂ M ₂	Bitter	Light red
T ₂ M ₃	Sour	Light pink
T ₂ M ₄	Sour	Light pink
T ₃ M ₁	Bitter	Dark red
T ₃ M ₂	Sweet	Dark red
T ₃ M ₃	Sweet	Red
T ₃ M ₄	Sweet	Dark red

T₁M₁:4ppm,soil T₁M₂:4ppm,soil+peatmoss T₁M₃:4ppm,peatmoss T₂M₁:6ppm,soil
T₂M₂:6ppm,soil+peatmoss T₂M₃:6ppm,peat mos T₃M₁:8ppm,soil T₃M₂:8ppm,peat
mossT₃M₃:8ppm, peat moss

In strawberry flavor is developed by ripening process. Highest sugar content and flavor is obtained at full ripened stage. However, fruit which is harvested at a stage when not full ripped will be firm enough to be shipped. Now shipping can be improved through new varieties. Due to advancement in post-harvest handling and shipping conditions growers can ship fruit that is riper. Strawberry color could be deep red to red-orange in different varieties. Fruit should be fully colored, without white or green tips. Sepals color is also important. The sepals remain green and healthy. At harvesting stage strawberries are bright in color. Loss in water content causes the fruit to become wilted and dull.

CONCLUSION AND SUMMARY

Strawberry plant showed better results towards peat moss with 6 and 8 ppm foliar application of NPK. Maximum leaf area (625.86) was observed in peat moss by 8 ppm foliar application of NPK. While, minimum (165.19) were observed in soil with 4 ppm foliar application of NPK. Maximum chlorophyll content (19.6) at vegetative stage was observed in peat moss by 8 ppm foliar application of NPK. While, minimum (10.7) were observed in soil with 8 ppm foliar application of NPK. Maximum chlorophyll (23.69) content at reproductive stage was observed in peat moss by 6 ppm foliar application of NPK. While, minimum (11.13) were observed in soil with 4 ppm foliar application of NPK. Maximum number of fruits (7.2100) was observed in soil by 8 ppm foliar application of NPK. While, minimum (2.7767) were observed in soil with 4 ppm foliar application of NPK.

It is therefore, concluded that among all the three medias strawberry plants responded better on peat moss based growing medium with 6 and 8 ppm foliar application of NPK.

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