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EFFECT OF FERTIGATION PERIOD ON GROWTH, YIELD AND NUTRIENT CONTENT OF STRAWBERRY (*FRAGARIA ANANASSA*) VAR. WINTER DAWN UNDER SUBSTRATE

POOJA R. BHOSALE*, DR. G. M. WAGHMARE AND MAHAVEER SUMAN
Department of Horticulture,
College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani - 431 402 (M.S.), INDIA
e-mail: poojabhosale1992@gmail.com

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***Corresponding author**

ABSTRACT
The experiment was conducted at Department of Horticulture, Marathwada Agriculture University, Parbhani in 50% Shadenet house (18x6 m) during 2014-2015 in Randomized Block Design with five treatments and four replications. The experiments were planted in hanging pipe by using cocopeat as a media. The observations were recorded on effect of fertigation period on growth, yield and nutrient content of strawberry under substrate. The maximum no.of shoot per plant, leaf per shoot, leaf per plant, flowers per plant, maximum no. of picking, yieid per plant and yield per hactor were observed in treatment T_4 (fertigation twice at alternate days) which proves to be the best treatment overall whereas maximum fruit set were recorded in T_2 (fertigation twice in a day). The more increased in electrical conductivity (3.8mS) and pH (7.5mV) recorded in T_2 (fertigation twice in a day) and the relatively lower EC (2.6mS) & pH (6.1mV) recorded in T_5 (fertigation once in a week). The relatively higher N, P, K content in leaf, stem, fruit and lechete was observed in T_2 (fertigation twice in a day) with lowest in T_5 (ferigation once in a week) at the end of experiment.

INTRODUCTION

Strawberry (*Fragaria ananassa*) of family Rosaceae is one of the most important fruit crop of temperate and subtropical region. It is an attractive, lucious, tasty and nutritious fruit with a distinct and pleasant aroma, and delicate flavor. It has a unique place among cultivated worldwide for its berry fruits. The fruit is widely appreciated for its characteristic aroma, bright red color, juicy texture, and sweetness. Strawberries is an aggregate accessory fruit and are consumed in large quantities (Esau, K. 1977). It is a rich source of vitamins, minerals and antioxidant with delicate flavours (Sharma, 2002). In India, overall area suppose to be occupies 1210 ha and productivity 7.66 $MTha^{-1}$. Maharashtra stand first and accounts 1000 ha. area with productivity 9.6 $MTha^{-1}$ (Anonymous, 2015. It can be cultivated in areas having assured irrigation and transport facilities. Very little information is available about the ferigation period in soilless cultivation of strawberry for improving the growth and yield under Maharashtra condition. Hence, considering the need, the present investigation were studied. Some cultivars of strawberry are grown in temperate and subtropical climate also. Temperature plays a critical role in the cultivation of strawberry at a particular place. It requires optimum day temperature of 22°C to 23°C and night temperature of 7°C to 13°C. 'Winter Dawn', is a new and distinct variety of strawberry and it is distinguished by high November through February production of fruit that are medium to large in size and moderately resistant to Botrytis and anthracnose fruit rot diseases. This is a short day cultivar and is a promising candidate for commercial success because it produces high fruit yields during a desirable market window. (Butte Patil 2010).

Soilless agriculture means growing vegetables in greenhouse/ shadenet systems in solid environments and it attracts scientific interest and increased in portions of the world where it has not been common practice with exploitation of local materials for use as growing media with specific physicochemical properties (Ortega *et al*. 1996). Several studies reported the favorable effect that organic materials have on plant growth (Sawan and Eissa 1996, Tehranifar *et al*. 2007), as increased substrate po-rosity and water holding capacity (Hardgrave and Harriman 1995). Cocopeat is an organic material and when using Cocopeat for substrate growing the environment is not harmed. Cocopeat is an excellent substrate for root development and therefore transplanting can be made directly into substrate with no need for any further treatment or agent. Substrates retain nutrient solution reserves, thereby buffering interruptions in water and nutrient supply, and protect roots from temperature fluctuations. In soilless culture, all essential plant nutrients should be supplied via the nutrient solution, with the exception of carbon, taken up from the air as CO_2. To prepare nutrient solutions containing all essential nutrients, inorganic fertilizers are used as nutrient sources, except for iron, which is added in chelated form to improve its availability for the plants. Most fertilizers used to prepare nutrient solutions in soilless/substrate culture are highly soluble inorganic salts but some inorganic acids are also used. (Anon 2013).

Fertigation system where both water and fertilizers are applied together is a common technique for horticultural crop production (Rekha and Mahavishnan, 2008). In many parts

of country, local growers use fertigation in soilless culture system using drip irrigation. However, due to lack of appropriate recommendation and application interval, local growers usually tend to overwater their plants which leads to decrease both water and fertigation use efficiency as well as yield and quality. Therefore, this experiment was practiced to study the fertigation requirement with proper time interval which could be a useful method to improve water and fertigation use efficiency as well as growth and yield of crop.

MATERIALS AND METHODS

The present investigation was undertaken at Department of Horticulture, Vasantrao Naik Marathwada Agriculture University, Parbhani during the year 2014-2015. Parbhani is geographically situated at 409 Mt. altitude from MSL, 19°16' north latitude and 76°47'east longitude and has a subtropical climate with average precipitation at is about 900 mm. The experiment was laid out in Randomized Block Design with five treatments (as T_1- fertigation once in a day; T_2- Ferigation twice in a day; T_3- Fertigation once at alternate day: T_4: Fertigation twice at alternate day; T_5: Fertigation once in a week) and four replications, the plant unit for each treatment consisted of sixteen plants. The experiments were planted in hanging pipe (ht of pipe from ground 1.5 m with 4 cm diameter hole on top of pipe for planting.) by using cocopeat as a media and the various growth and yield parameters as well as nutrient content were studied and calculated by following methods**:**

The shoot number from selected plants was measured in number and mean of five plant was recorded at the time of planting at 20, 40, 60 days after planting. The number of leaf per shoot of a plant was calculated on labelled shoots and mean of five plant were recorded at the time of planting at 20, 40, 60 days after planting. Total number of functional leaf per plant were counted in number at the time of planting, 20, 40 & 60 DAP and mean of selected plants were calculated. Total number of flowers per plant in the growing season were recorded in numbers. The total number of picking of fruits of each treatment were recorded and average was calculated at each interval and end of experiment. Number of fruits per plant counted at the time of harvesting from selected plants of each treatment in each replication were weighed on pan balance and average yield per plant in terms of kilogram was worked out and yield per hector was calculated from total yield per plant multiplying with number of plant per hector and devided the result by 1000 for each treatment in growing season and expressed in kg. at the end of experiment. Total number of flowers which set into fruits are counted for each treatment and per cent fruit set was calculated on the basis of number of flowers emerged.

$$\% \text{ FRUIT SET} = \frac{\text{Fruit no. per plant}}{\text{Female Flower no. per plant}} \times 100$$

The clear supernatant obtained from the suspension used for pH was utilized for the EC measurement using digital conductivity meter (Jackson, 1973). Hydrogen ion activity expressed as pH was measured on digital pH meter. (Jackson, 1973). For plant and lechete analysis the treatment wise oven dried powdered plant samples (leaf, stem, fruit) and lechete sample of strawberry were collected and used for further analysis. (Bhargava and Raghupathi, 2001). The nitrogen content in sample (plant and lechete) was determined by Micro Kjeldhals method (AOAC, 2013). The phosphorus content in sample was estimated spectrophotometrically by vanadomolybdate phosphoric acid yellow colour method (Jackson, 1967) and the potassium content in plant and lechete sample was determined from the diacid extract on flame photometer (Jackson, 1973).

RESULTS AND DISCUSSION

From the observations it was observed that Shoot number plant^{-1} increased progressively throughout the growth stages of strawberry and significantly influenced by fertigation treatment at all growth stages after planting. Significantly highest (20.6) number of shoot plant^{-1} were recorded in treatment T_4 (fertigation twice at alternate day) which found at par with treatment T_2 (18.2) (fertigation twice in a day) followed by (17.8) in T_1 (fertigation once in a day) whereas treatment T_5 (fertigation once in a week) were recorded minimum number of shoot per plant at 60 DAP (Table1). Leaves shoot^{-1} increased continuously to 60 DAP. Data showed the significantly highest number of leaf shoot^{-1} (4.1) in treatment T_4 (fertigation twice at alternate days). Whereas treatment T_5 (fertigation once in a week) was found to be lowest (3.2). Number of leaves plant^{-1} increased progressively from planting upto 60 DAP (Table1). Significantly maximum (84.4) number of leaves per plant was observed in treatment T_4 (fertigation twice at alternate days) over all other treatments. While, minimum (54.4) number of leaves plant^{-1} was recorded in treatment T_5 (Table1). This better growth responce to the T_4 is might be due to proper availability of fertilizer and water through fertigation. In T_1 & T_2 (daily fertigation) leads to more loss of nutrients because of daily fertigation as growing media having 99% water holding capacity. This will be the main reason for low growth parameters in T_1 & T_2. Regarding the T_5 weekly fertigation is reported lowest growth parameter as growth parameters shows better responce to increase fertigation. Quasim *et al.,* (2008) reported the similar results when plant fertigated with 2 days interval gave the highest number of branches, number of leaves.

Number of flowers plant^{-1} increased progressively throughout the growth stages of strawberry, with a slower pace at the initial stages (upto 20 DAP), then increased faster at 21 to 40 and 41 to 60. At 60 DAP it recorded the highest number of flowers plant^{-1}. Number of flowers pant^{-1} significantly affected by the number of treatments and the highest number of flowers (11.2) found in treatment T_4 (fertigation twice at alternate days) which was at par with treatment T_2 (fertigation twice in a day) with (10.6) number of flowers. Lowest number of flowers (9.4) were found in treatment T_5 (fertigation once in a week) which found at par with treatment T_1 and T_3 (Table1). This is may be due to the more number of branches produced by this treatment which result in more carbohydrates synthesis which increased no of flowers. This result is very similar with work of Quasim *et al.*, (2008), in which number of flower was highest in fertigation at 2 days interval and lowest in 6 days interval.

Treatment T_2 (fertigation twice in a day) recorded maximum

Table 1: Effect of ferigation period on growth parameters

	Treatments	Shoot No. Plant^{-1}				No. of Leaves Shoot^{-1}				Number of Leaves Plant^{-1}				Number of Flowers Plant^{-1}		
		at planting	at 20 DAP	at 40 DAP	at 60 DAP	at planting DAP	at 20 DAP	at 40 DAP	at 60	at planting	at 20 DAP	at 40 DAP	at 60 DAP	at 20 DAP	at 40 DAP	at 60 DAP
T_1	Fertigation once in a day	4.6	10.8	12.4	17.8	3.0	3.0	3.0	3.4	13.8	32.4	37.2	60.5	3.5	6.0	9.7
T_2	Fertigation twice in a day	4.7	11.4	13.0	18.2	3.0	3.0	3.0	3.4	14.0	34.2	39	61.8	3.8	7.7	10.6
T_3	Fertigation once at alternate day	4.6	10.3	11.7	17.6	2.6	2.6	2.6	3.3	12.0	26.7	30.4	58	3.4	6.8	9.6
T_4	Fertigation twice at alternate day	4.7	13.0	14.3	20.6	3.0	3.5	3.0	4.1	14.1	45.5	50.1	84.4	4.2	8.3	11.2
T_5	Fertigation once in a week	4.6	9.2	10.8	17.0	2.2	2.2	2.6	3.2	11.8	20.2	29.1	54.4	3.2	6.6	9.4
SEm ±		0.26	0.35	0.59	0.70	0.24	0.20	0.22	0.13	0.84	1.9	2.1	1.7	0.07	0.18	0.24
C.D. at 5%		NS	1.08	1.82	2.17	NS	0.62	NS	0.42	NS	5.7	6.3	5.1	0.22	0.56	0.74

number of fruit set percent (97.5). Treatment T_1 (fertigation once in a day) recorded (97.2) percent fruit set, treatment T_3 (fertigation once at alternate day) recorded (97.1) percent fruit set and T_5 (fertigation once in a week) recorded (97.0) percent fruit set, these all treatments found at par with T_2. Treatment T_4 (fertigation twice at alternate day) recorded minimum (93.4) fruit set percent (Table 2). The mean number of fruit pickings varied significantly with different fertigation treatment. Treatment T_4 (fertigation twice at alternate day) recorded significantly maximum picking (4.3) followed by Treatment T_2 (fertigation twice in a day) with (4.1) number of fruit picking and was found to be at par with each other. Whereas, Treatment T_5 (fertigation once in a week) gave the least number (3.1) of fruit picking (Table2). this might be due to lower number of fruits produced by plant in this treatment and comparatively more days required for fruit maturity.

Regarding the yield per plant (Table2) the fertigation application at T_4 (0.286) found maximum yield plant^{-1}. Similarly treatment T_2 (0.211) also gave the nearly fruit yield plant^{-1} while minimum fruit yield was recorded in treatment T_3 i.e. fertigation once at alternate day. Considering yield per plant the fertigation treatment T_4 (fertigation twice at alternate day) gave the highest yield ha^{-1} (21185) and was found at par with treatment T_2 (17880) (fertigation twice in a day). Ughade and Mahadkar in their experiment shows that the weight of fruits per plant were significantly influenced by fertigation levels and revealed that fertigation level F1 (highest fertigation dose) recorded statistically higher values of number of fruits per plant. However treatment T_3 (fertigation once at alternate day) which was the lowest (15575) yield ha^{-1}. Sharma (2002) stated that increased phosphorous content may be effective in increasing yield and increased potassium level the plant may improve the quality.

In this experiment the EC and pH in all substrate solution increase at the end of experiment (Table3). T_2 (daily twice application of fertilizer) posses the highest pH value (7.5) which is the higher dose treatment and T_5 (fertigation once in a week) posses the lowest pH (6.1). pH of leaching must vary between 5.5-6.5 (Urrestarazu *et al.* 2008) .The result showed that pH of all treatment is already higher at end of experiment. This is due to lack of NO_3 and the form of nitrogen present in the substrate (Hussain 2009). The contribution in the nutrient solution of an acidifying such as fertilizer as NH_4NO_3 allowes for the improvement of the pH. EC of the various solutions in the lechete water also found to be increased. (T_2) daily twice fertigation solution shows the highest EC (3.8) and (T_5) weekly once fertigation shows the lowest EC in this experiment at the end of experiment. A significant rise of drainage EC compaired to those of input solutions causes harmful salinity causing phyto-toxicity (Choi *et al.*, 2011) and impairs the product quality and quantity. Result shows that the range of EC of solution T_3 (fertigation once at alternate day), T_4 (fertigation twice at alternate day), & T_5 (fertigation once in a week) shows the range of ideal EC. This range improve the fruit quality and antioxidant content (De Pascale *et al.*2001) hence this can be used for further experiment period. This increase in EC is might be the result of accumulation of the elements in the substrate following water loss due to transpiration (Silber *et al.*, 2003).

Coming to the nutrient content of strawberry it was observed

Table 2: Effect of fertigation period on yield parameters

Treatment	% fruit Set	No. of picking	Fruit yield plant^{-1}(kg)	Total yield ha^{-1}(kg)
T_1	97.2(80.37)*	3.8	0.199	16991
T_2	97.5(80.90)	4.10	0.211	17880
T_3	97.1(80.20)	3.2	0.189	15575
T_4	99.2(75.11)	4.3	0.286	21185
T_5	96.9(80.03)	3.1	0.197	16545
S.E ±	0.73	0.12	0.022	1541
C.D at 5%	2.25	0.37	0.068	4126

Table 3: Effect of Fertigation Period on EC & pH of Lechete at End of Experiment

Treatment	EC (mS)	pH/mV
T_1	3.6	7.1
T_2	3.8	7.5
T_3	2.9	6.3
T_4	3.5	6.8
T_5	2.6	6.1
S.E ±	0.05	0.18
C.D at 5%	0.14	0.56

Table 4: Effect of fertigation on Nutrient (N,P,K) content of strawberry Fruit, Leaf, Stem and lechete at end of experiment

Treatment	N, P, K Content (%)											
	Leaf			Stem			Fruit			Lechete		
	% N	% P	% K	% N	% P	% K	% N	% P	% K	% N	% P	% K
T_1	3.0	1.2	3.7	1.0	0.4	1.8	3.3	1.3	3.9	3.7	2.9	5.0
T_2	3.2	1.9	4.1	2.0	0.9	2.2	3.5	2.0	4.3	4.3	3.2	5.3
T_3	2.4	0.6	2.2	0.8	0.3	1.4	2.6	1.1	3.0	3.1	1.9	4.1
T_4	2.8	1.0	3.4	0.9	0.4	1.6	3.0	1.2	3.3	3.5	2.5	4.6
T_5	1.8	0.4	2.1	0.5	0.2	0.7	2.0	0.8	2.8	2.8	1.5	3.3
S.E. ±	0.01	0.02	0.08	0.02	0.03	0.06	0.05	0.03	0.08	0.07	0.06	0.07
C.D at 5%	0.04	0.07	0.25	0.06	0.10	0.20	0.14	0.10	0.30	0.20	0.18	0.22

that the higher nutrient content in biomass resulted in an increase in fruit (economic part) content as well. Regarding the nutrient content in strawberry leaf, the summarized data shows the significant difference among the treatments which is given in table 4. The highest nutrients (N,P,K) content in the leaf of strawberry were found in (T_2) fertigation daily twice treatment (3.2%N, 1.9%P, 4.1%K) and the lowest nutrient content were found in (T_5) weekly once fertigation treatment (1.8%N, 0.4%P, 2.1%K). These findings are nearly similar with Jarosz & Konopinska (2010) except the content of K (potassium). In this experiment the per cent K found in more quantity as a result of application of Potassium nitrate at fruiting stage as requirement of strawberry for Potassium at fruiting stage is more. Almaliotis *et al.*, (2002) regarded it as a optimal values. It should be emphasized in the rhizosphere the potassium content was higher than it had been recommended. Yavari *et al.,* (2008) explained this phenomenon as increased nutrient concentration compared to the amount supplied to plant, is a characteristics of growing in organic substrate (like cocopeat). Strawberry stem contain less nutrient content as compared to leaf and fruits. The data given in table 4 showed that percent N, P, K content in stem shows the significant difference with the fertigation treatment and the higher content of N, P, K (2.0%N, 0.9%P, 2.2%K) seen in fertigation twice at alternate day (T_2) and the lowest (0.5%N, 0.2%P, 0.7%K) content seen in weekly fertigation treatment (T_5). The N, P, K concentration is like the leaf N, P, K concentration increased linearly with increased in fertigation period. (Hochmuth *et al*. 1996). The chemical composition of strawberry fruits depends only on the variety. Degree of fruit maturity, and climatic conditions during growing, but it is also determined by cultivation technology and manner of fertilization. (Recamales *et.al.*, 2007). The N, P, K content in strawberry fruits is significantly affected by the fertigation treatment and shows the positive response to all fertigation treatment period. The highest nutrient content in strawberry fruit was reported in daily twice fertigation (T_2) treatment (3.5%N, 2.0%P, 4.3%K). The increased in potassium content was already explained Jarosz & Konopinska (2010) but the concentration of nutrient found in this experiment is more than they reported. They stated the result analysis of fruit chemical composition demonstrated significantly more total nitrogen (1.85% d.m.) and potassium (2.10% d.m.) in the fruit of plant fertilized with higher dose of nitrogen (ie. consider daily application). The same reason might be applicable for fruit nutrient content. Regarding N, P, K content in lechete, fertigation twice in a day (T_2) were shows significantly higher N, P, K content as compare to others treatment, and the lowest (2.8%N, 1.5%P, 3.3%K) NPK content found in weekly fertigation treatment (T_5). Data shows the similar increased and decreased concentration of nutrient according to their fertigation doses, this might be due to the more accumulation of nutrients in media fertigated with more number of fertigation treatments.

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