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Water requirement and fertigation in high density planting of apples

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ABSTRACT

The water requirement of crop is essential for understanding irrigation scheduling and efficient water use. The investigation was conducted to study the growth, yield and effect of various fertigation levels and frequencies of high-density apple orchard during 2018-2019 at the experimental research farm of SKUAST-Kashmir, Srinagar. The FAO Penman-Monteith method was used to determine Crop water requirement. Three fertigation levels (75, 100 and 125 per cent of RDF) and three fertigation frequencies (weekly, twice a week and fortnightly) were used in this study. The study revealed that the application of 125 per cent RDF as water-soluble fertilizers through fertigation using drip system applied fortnightly increased the plant height (271.0 cm), tree spread (179.00 cm), plant volume (4.57 m3) and plant girth (30.02 mm). Fruit characters such as average fruit weight (135.80 g) and fruit diameter (9.05 cm) were significantly enhanced due to fortnightly application of 100 per cent RDF as fertilizer (water soluble) through drip. Application of RDF fortnightly (T9) recorded significantly higher fruit yield per tree (16.02 kg) than 125 per cent of RDF (15.19 kg). Irrespective of fertilizer levels, fertigation frequency scheduled fortnightly registered higher fruit yield per tree. Control treatment (T1) recorded the lowest fruit yield per tree (6.11 kg). The increased percentage of fruit yield per tree over lower dose of RDF was 5.46. The results of this study revealed that scheduling drip fertigation with 100 per cent of RDF applied fortnightly could be optimal for getting higher fruit yield per tree.

Keywords: CROPWAT, Crop water requirement, Drip fertigation, Fertigation frequency, Fruit yield, Recommended dose of fertilizer (RDF), Water soluble fertilizer

INTRODUCTION

The major consumer of water is agriculture sector. Share of water in agriculture sector will reduce to 69% from 85% by 2025 (Sivannapan, 15). When precipitation is insufficient water is applied to maintain crop evapotranspiration (ET). Water requirement for crop mainly depends on growth stage, crop type and the climate. The climate and agricultural production is linked intricately making agriculture the most sensitive economic sector to weather changes and climate due to climate change. The effect of these biophysical changes is very complex and uncertain.

CROPWAT model is widely used for water management across the globe. CROPWAT can determine water requirement and required irrigation using soil, crop and climate data. It can be used for irrigation scheduling and to estimate crop performance under rainfed and irrigated areas.

Apple (*Malus domestica* Borkh) belongs to the family Rosaceae (Challice, 3) and is native to South West Asia. It is the most important temperate crop of India with regard to acreage and economic value. Apple is widely cultivated in the world and China is largest (~35%) producer (Westwood, 19; Yarwood, 20; FAO, 5). In India, mainly apple is produced in the Himalayan region of Himachal Pradesh, Jammu and Kashmir, Uttaranchal and in the North Eastern states of Sikkim, Arunachal Pradesh. The temperate fruit bowl is Jammu and Kashmir produce and variety of apples in significant quantity.

Kashmir produces about 70.39 per cent of total apple production in India ((Kaul, 9; Sheikh, 14). It is the principle fruit crop of Jammu and Kashmir with 1.64 lakh hectares under its cultivation with a production of 18.82 lakh tonnes (Horticulture Department of Kashmir, 7). As per the data by Kashmir Horticulture department, total apple production in 2017-18 has been recorded as 18, 82, 774.0 metric tonnes.

Application of nitrogen is the most important mineral nutrient affecting fruit yield and the coloration of fruit (De Angelis *et al*., 4). Fertilizer is the most important input for increasing crop productivity after irrigation and considered 30% of the cost of cultivation (Magen, 10). Fertilizer application in Indian has shown an increasing trend. In 2019 N fertilizer Consumption was 17.63 million metric tonnes (Satista, Inc. 17).

The pressurized irrigation (drip) is an efficient method for water application for horticultural crops (Bar-Yosef, 1; Naira *et al.,* 11). Fertigation is uniform and efficient method for application of fertilizer as compared to conventional method. The success of fertigation depends on fertigation frequency and

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irrigation scheduling. Keeping in view above facts study conducted with aim of modelling of CROPWAT and effect of fertigation level and frequency of high density apple.

MATERIALS AND METHODS

The field experiment was conducted in high density apple of variety Gala Red Lum (*Malus domestica*) on M.9 root stock of uniform age (2 years) at Experimental Research farm at Shalimar Campus, SKUAST- Kashmir, Srinagar during summer 2018. It is located 34°08'30.5″ N latitude and 74°51'42.0″E longitude at an elevation 1586 m above mean sea level. Strip plot design was used in the field study. The soil of the experimental field was classified as silty clay loam comprising 13.49 to 20.85 per cent sand, 46.23 to 57.12 per cent silt and 29.81 to 32.50 percent clay with mean values of 17.17, 51.67 and 31.15 percent, respectively, in surface soils, whereas in subsurface soils these ranged from 19.56 to 20.45 per cent sand, 47.12 to 52.05 per cent silt and 26.71 to 34.10 percent clay with mean values of 20.00, 49.58 and 30.41 percent, respectively. The pH values ranged from 6.2 to 6.3 in the surface layers whereas in the subsurface layers it varied from 6.4 to 6.9 exhibiting slightly acidic to neutral pH in surface layers. The values of electrical conductivity of the soil of experimental field varied from 0.11 to 0.15 dSm^{-1} in surface layers whereas in subsurface layers it varied from 0.13 to 0.24 dSm^{-1} with a mean of 0.13 and 0.18 dSm^{-1} in surface and subsurface layers, respectively.

The experiment was planned with strip plot design with four replications having 90 plants with spacing of 3 ×1 m. Initially the average plant height was about 2.0 m. Three fertigation levels and three fertigation frequencies were included in this study. The treatments details aresummarized in Table 1.

Drip irrigation system was operated in the experimental field for almost two hour duration and the system comprised of operating pressure 1.0 kg cm^{-2}. Fertigation was given using urea through the fertigation tank. Through hydrogen bonding formation urea is soluble in water. Urea remains urea when dissolved in water, it only dissociates in the presence of some enzymes. The quantity of fertilizer under each treatment was calculated to fulfill the recommended dose of urea *i.e*. 100 g per tree for 2-year-old trees according to recommended package of practices. Nitrogen was applied with different treatment rates in the drip irrigated plots as urea mixture, through the fertigation tank in ten equal splits at weekly intervals (i.e., 10 g per plant per dose) in twenty equal splits at biweekly intervals (i.e., 05 g per plant per dose), and in four equal splits of fortnightly intervals (i.e., 25 g per plant per dose).

Table 1: Experiment treatment detail

S. No.	Treatment	Details
1	T_1	Control (without any treatment)
2	T_2	75% RDF twice a week
3.	T_3	100% RDF twice a week
4.	T_4	125% RDF twice a week
5.	T_5	75% RDF once a week
6.	T_6	100% RDF once a week
7.	T_7	125% RDF once a week
8.	T_8	75% RDF fortnightly
9	T_9	100% RDF fortnightly
10	T_{10}	125% RDF fortnightly.

The meteorological data were collected from agro-meteorological station located at SKUAST-K, Srinagar. The latest version of CROPWAT 8.0 edition (2009) was used. This modelis based on Penman-Monteith method. After estimation of reference crop evapotranspiration (ET_0), crop evapotranspiration (ET_c) irrigation scheduling was done (FAO, 5). The model takes meteorological data, soil data and crop growth data as input parameters.

Plants were selected in each treatment and tagged. Different plant parameters and yield attributing characters *viz.* tree height, spread, girth, volume, fruit number, fruit weight, fruit diameter were measured (Plate 1). The tree volume was computed as per the method described by Westwood (19). The number of fruits harvested during the season was computed and the total was expressed as number of fruits per tree. Since harvesting was done at different intervals due to difference in ripening of fruits two randomly selected fruits from each treatment were weighed on a weighing balance and the average weight of fruit was calculated and expressed in g.

RESULTS AND DISCUSSION

Using CROPWAT 8.0 model water requirement was determined for apple crop. The water requirement and irrigation requirement was found to be 2.22 mm twice a week, 9 mm weekly, 19.98 mm fortnightly and 2.16 mm twice a week, 9.26 mm weekly, 19.86 mm, respectively (Fig.1). The weekly water requirement and irrigation requirement of apple is shown in Fig. 2. Twice a week, weekly and fortnightly ETc and irrigation requirements is illustrated in Table 4.

Fertigation frequency and doses affected the growth and yield parameters. The results of all the treatments are presented in Table 2 and 3. The results

Plate 1: Recording of growth and yield attributes of high density apple orchard.

showed significant interaction between various fertilizer doses and fertigation frequencies.

From the Table 3 it is revealed that the plant height, tree spread, plant volume and tree girth increased from 212.0 to 271.0 cm, 121.0 to 179.0 cm, 1.61 to 4.57 m^3 and 24.0 to 30.02 mm respectively, with the application of nitrogen. The highest plant height (271.00 cm), tree spread (179.00 cm), Plant volume (4.57 m^3) and plant girth (30.02 mm) was recorded under treatment T_1(125 % of RDF fortnightly) which was statistically at par with treatment T_9(100 % of RDF fortnightly) plant height 270.0 cm, tree spread 174.0 cm, plant volume 4.27 m^3, and plant girth 30.02 mm.

The lowest plant height (212.0 cm), tree spread (121.0 cm), Plant volume (1.61 m^3) and plant girth (24.00 mm) among the various fertilizer levels was observed in treatment T_2 (75 % of RDF twice a week). However, plant height (203.75 cm), tree spread (113.12 cm), plant volume (1.15 m^3) and plant girth (21.33 mm) was also lower under T_1 (Control). Higher fertilizer doses and fertigation frequency showed better plant growth. The higher doses of fertilizer meet out the plant requirement during the critical growth stage of plant. Also the higher fertigation frequency coincided with the nutrient demand and supplied the nutrients at peak uptake time without any nutrient stress. The results also support by Haneef *et al.* (6); Saroch *et al.* (13); Suresh *et al*. (18). The fruit yield contributing characters and fruit yield showed significant interaction in response to various fertilizer doses and fertigation frequencies.

The average fruit number per plant ranged from 59.0 to 122.0. The highest fruits number per plant (122.0) was recorded in 100 % of RDF fortnightly followed by treatment T_{10} (112.00), T_8 (106.00), T_7 (87.00), T_6(95.0), T_5(80.0), T_4(65.00), T_3(71.00), T_2(59.00). The lowest fruits number per plant was observed under T_1 (48.0). The fruit yield per tree ranged from 7.67 to 16.02 Kg. The highest fruit yield per tree was recorded under T_9

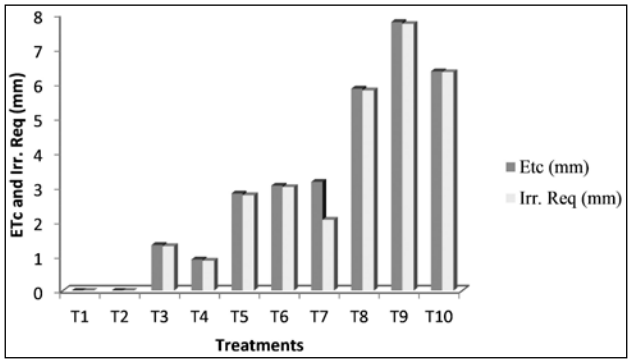

Fig 1. Irrigation requirement and ETc of apple crop under different treatments.

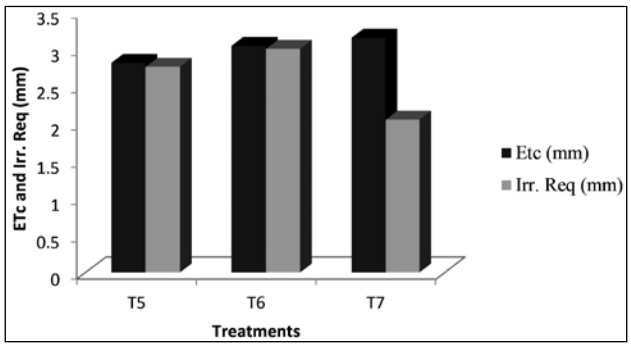

Fig 2. Weekly Irrigation requirement and ETc of apple crop.

Table 2. Twice a week, Weekly and Fortnightly ET_C and Irrigation Requirements.

ET0 Station SKUAST-K Crop Apple Rain Station SKUAST-K Planting date 15/04				
Treatments	Kc	Etc (mm)	Effective rain (mm)	Irrigation requirement (mm)
T_1	0.50	0.0	0.09	0.0
T_2	0.50	0.0	0.55	0.0
T_3	0.54	1.32	0.03	1.29
T_4	0.72	0.90	0.03	0.87
		2.22	0.61	2.16
T_5	0.93	2.81	0.05	2.76
T_6	1.07	3.04	0.04	3.00
T_7	1.08	3.15	1.1	3.50
		9.00	1.19	9.26
T_8	1.08	5.85	0.05	5.80
T_9	1.08	7.78	0.05	7.73
T_{10}	1.08	6.35	0.02	6.33
		19.98	0.12	19.86
		31.2	1.92	29.83

Table 3. Effect of fertigation on growth of high density apple.

Treatments	Plant height (cm)	Tree spread (cm)	Plant volume (m^3)	Plant girth (cm)
T_1	203.75 ± 2.98	113.12 ± 2.46	1.15 ± 0.19	21.33 ± 0.22
T_2	212.00 ± 2.45	121.00 ± 5.16	1.61 ± 0.50	24.00 ± 0.56
T_3	220.00 ± 4.16	138.00 ± 4.69	2.20 ± 0.67	25.20 ± 0.38
T_4	224.00 ± 4.69	143.00 ± 4.39	2.40 ± 0.51	25.40 ± 0.21
T_5	238.22 ± 3.77	150.00 ± 7.70	2.78 ± 0.34	27.12 ± 0.54
T_6	258.00 ± 3.36	161.25 ± 3.50	3.47 ± 0.51	27.60 ± 0.18
T_7-	261.25 ± 4.99	166.00 ± 4.54	3.70 ± 0.69	27.88 ± 0.16
T_8	263.00 ± 7.11	168.00 ± 6.48	3.82 ± 0.51	28.19 ± 0.18
T_9	270.00 ± 5.71	174.00 ± 5.94	4.27 ± 0.79	29.33 ± 0.17
T_{10}	271.00 ± 5.73	179.00 ± 5.77	4.57 ± 0.85	30.02 ± 0.19
CD ($p<0.05$)	7.339	8.112	0.667	0.235
Fertilizer doses × Time interval				

*RDF = Recommended dose of fertilizer (100 grams urea/plant)

Table 4. Fertigation effect on yield.

Treatments	Fruit number per tree	Weight (g)	Diameter (cm)	Yield per tree (Kg)
T_1	48.00 ± 4.54	127.60 ± 0.80	5.82 ± 0.35	6.11 ± 0.56
T_2	59.00 ± 0.81	130.00 ± 0.84	6.30 ± 0.76	7.67 ± 0.51
T_3	71.00 ± 0.78	132.00 ± 0.41	6.92 ± 0.38	9.37 ± 0.40
T_4	65.00 ± 1.63	131.20 ± 0.77	6.50 ± 0.52	8.53 ± 0.21
T_5	80.00 ± 1.82	132.50 ± 1.00	7.20 ± 0.29	10.60 ± 0.27
T_6	95.00 ± 0.81	134.00 ± 0.43	8.02 ± 0.27	12.73 ± 0.49
T_7-	87.00 ± 0.83	133.60 ± 0.74	7.52 ± 0.25	11.62 ± 0.50
T_8	106.00 ± 2.58	135.00 ± 0.85	8.32 ± 0.28	13.90 ± 0.55
T_9	122.00 ± 1.41	135.80 ± 0.93	9.05 ± 0.42	16.02 ± 0.37
T_{10}	112.00 ± 3.35	135.60 ± 0.71	8.77 ± 0.09	15.19 ± 0.45
CD ($p<0.05$)	3.770	0.815	0.463	0.638
Fertilizer doses × Time interval				

*RDF = Recommended dose of fertilizer (100 grams urea/plant)

(16.02 Kg) followed by T_{10}(15.19 Kg), T_8(13.90 Kg), T_7 (11.62 Kg), T_6 (12.73 Kg), T_5 (10.60 Kg), T_4 (8.53 Kg), T_3 (9.37 Kg), T_2 (7.67 Kg). The lowest fruit yield per tree was observed under T_1 (Control) (6.11 Kg).

Higher yield may be ascribed to its complete solubility and availability to the plants, the better NO_3-N distribution within effective root zone enhance the synthesis of metabolites, their translocation, utilization which has been reported by Singh *et al.* (15). Optimum fertilizer timings might have met the nutrient uptake pattern of the plant resulting in higher fruit yield The results also support by Haneef *et al*. (6), Pawar and Dingre (12), Saroch *et al.* (13) *and Bhat et al.* (2). The crop yield under different fertigation treatments is given in Fig. 3.

CROPWAT model can efficiently and effectively estimate the water requirements. Growth parameters were higher under higher doses and fruit yield was significantly higher under all treatments of fertigation over control. The total water requirement was estimated 31.2 mm and irrigation requirement 29.83 mm. Fertigation has shown a substantial improvement in the yield of apple. Treatment T_9 (100% of RDF fortnightly)showed the highest fruit yield of 16.02 kg per plant. Increase in yield could be attributed to direct effect on fertilizing timings at different growth stages of apples. Overall, it can be concluded that 100% RDF was sufficient to support higher fruit yield at an optimum level as higher doses of nitrogenous fertilizer did not contribute substantially to the fruit yield.

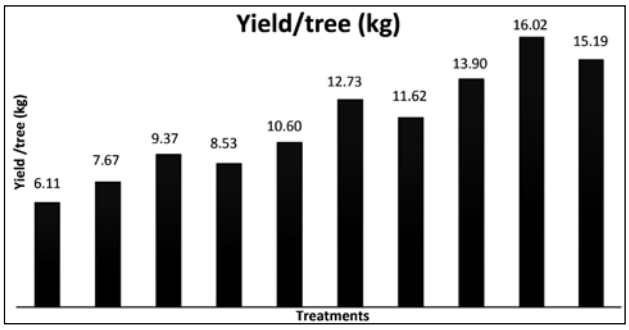

Fig 3. Crop yield under different fertigation treatments.

AUTHORS' CONTRIBUTION

Conceptualization of research (RK); Designing of the experiments (RK and SH); Contribution of experimental materials (SH); Execution of field/lab experiments and data collection (SH); Analysis of data and interpretation (SH); Preparation of the manuscript (RK and SH)

DECLARATION

The authors declare no conflict of interest.

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REFERENCES

1. Bar-Yosef, B. 1999. Advances in fertigation. Adv. Agron. **65**: 1-77.
2. Bhat, S.A., Pandit, B.A., Khan, J.N., Kumar, R. and Jan. R. 2017. Water Requirements and Irrigation Scheduling of maize Crop using CROPWAT Model. Int. J. Curr. Microbiol. App. Sci, **6**: 1662-70. https://doi.org/10.20546/ijcmas.2017.611.199.
3. Challice, J. 1981. Chemotaxonomic studies in the family Rosaceae and evolutionary origins of subfamily Meloideae. *Presita* **53**: 289-304.
4. De Angelis, V., Sanchez, E and Tognetti, J. 2011. Timing of nitrogen fertilization influences color and anthocyanin content of apple (Malus domestica borkh. cv 'Royal Gala') fruits. *Int. J. Fruit Sci.* **11**: 364-75.
5. FAO, 2015. FAO Statistical database (on-line).
6. Haneef, M. Kaushik, R.A. Sarolia, D.K. Mordia, A. and Dhakar, M. 2014. Irrigation scheduling and fertigation in pomegranate cv. Bhagwa under high density planting system. *Indian J. Hortic.* **71**: 45-48.
7. Horticulture Department Kashmir, 2017. http://www.hortikashmir.gov.in.
8. Indian Fertilizer Scenario (IFS). 2013. Department of Fertilizers, Ministry of Chemicals and Fertilizer, GOI.
9. Kaul, G.L. 1997. Horticulture in India-production, marketing and processing. *Indian J. Agric. Econ.* **52**: 561.
10. Magen, H. 1995. An overview of some practical aspects. Fertigation News **40**: 97-100.
11. Naira, A., Sharma, M.K. and Bhat, M. Y. 2012. Micro-irrigation and fertigation in fruit trees. *Env. Ecol. Rev.* **30**: 1252-57.
12. Pawar, D.D and Dingre, S. K. 2013. Influence of fertigation scheduling through drip on growth and yield of banana in Western Maharashtra. *Indian J. Hortic.* **70**: 200-205.
13. Saroch, K., Sandal, S. K. and Ranna, K. 2016. Effect of irrigation scheduling and NK fertigation on productivity of garden peas. *Himachal J. Agric. Res.* **41**: 126-31.
14. Sheikh, S.H. and Tripathi, A.K. 2013. Socio-economic conditions of apple growers of Kashmir valley: A case study of district Anantnag. *Int. J. Edu. Res. Technol.* **4:** 30-39.
15. Singh, D.K., Rajput, T.B.S., Singh, D.K. Sikarwar, H.S., Sahoo, R.N., Ahmad, T., 2006. Simulation of soil wetting pattern with subsurface drip irrigation from line source. *Agric. Water Manag.* **83**: 130-34.
16. Sivannapan, R K. 2009. Development of micro-irrigation in India. Lecture note delivered in Winter School on Micro Irrigation. 4-24 March, 2009, WTC, IARI, New Delhi.
17. Statista, INC. 2019. Statista: the portal for statistics.
18. Suresh, P.M. Kumar, S. Swaminathan, V. Gurusamy, A. and Shivakumar, T. 2018. Influence of drip fertigation on leaf NPK status and yield characters of anola. *Int. J. Chem. Stud.* **6**: 3649-54.
19. Westwood, M.N. 1993. Temperate zone Pomology. Timber press, Portland, Oregaon. **223** p.
20. Yarwood, C.E. 1978. Water and the infection process. In: T.T. Kozlowski (ed.) Water Deficits and Plant Growth, V. Water and Plant Disease. Academic Press, NY: 141-73.

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