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Response of irrigation, fertigation and mulching on plant growth and fruit yield of strawberry

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ABSTRACT

Vegetative growth parameters (crown height, petiole length, the number of leaf/plant, plant spread, total chlorophyll, plant fresh and dry weight), root parameter (root fresh & dry weight, root volume, root length, root number) and fruit yield characteristics were estimated under different irrigation (I) (120, 100, 80, 60 % ETc) levels, fertigation doses (F) (100, 80, 60 % SDF) and type of mulches (M) (Straw mulch, Black-black, Silver-black and Red-black) alone and their interaction (IxM, IxF, FxM and IxFxM). All vegetative and root parameters improved with irrigation applied at 100% ETc level followed by 80% ETc which were significantly higher than 60% and 120% ETc levels. However, marketable fruit yield was improved in the plants irrigated at 100 and 80% ETc level by 19.6 and 15.5 percent respectively as compared to 60 % ETc (I_4) level. Besides, NPK nutrients applied through fertigation *viz*. 80% of SDF (44Kg N: 32Kg P_2O_5: 40Kg K_2O/acre) significantly produced higher fruit yield and plant biomass by 14.23 and 36.6 percent, respectively over fertigation with 60% of SDF. Strawberry plants mulched with Silver-black considerably improved vegetative growth and fruit yield/plant than Black-black, Red-black and Straw mulches. It is concluded that strawberry irrigated through drip irrigation system at 80 % ETc level, fertigation at 80% of SDF and mulched with Silver-black significantly improved fruit yield under climatic conditions of north India.

Keywords: *Fragaria* × *ananassa*, drip irrigation, vegetative growth parameters.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is a shallow rooted plant, and requires frequent irrigations with less amount of water to maintain optimum soil moisture for quality fruit production (Kachwaya *et al*., 4). Precise management of irrigation and fertilizer schedule plays a crucial role in improving the productivity and nutrient use efficiency (NUE). Fertigation through drip irrigation system tends to distribute the plant nutrients uniformly in the root zone, where most of the active roots are concentrated, and thus enhancing the nutrient use Imamsaheb *et al*., 3 and Reddy *et al.,* 10). In fertigation, nutrient use efficiency could be as high as 90 percent as compared to 40 to 60 percent in conventional methods (Solaimalai *et al*., 12), with reduced loss of fertilizers through leaching (10 per cent over 50 per cent in conventional method) (Raina *et al*., 8). The shrinking of land holdings, workforce ratio, depletion of water table, increase in the fertilizer prices, haunting energy crisis, ever growing population and fast degradation of natural resources further put emphasis on to improve water and fertilizer use efficiency. Optimum use of water and fertilizer through drip system make possible to harness high crop yield, simultaneously ensuring a healthy soil and environment (El-Sawy *et al.,* 2). Mulching is commonly practiced in strawberry cultivation to keep the fruit fresh, and protects it from direct contact with the soil to avoid fruit diseases. This practice is also known for moderation of hydrothermal regime and increases water use efficiency (Verma and Acharya, 14). Besides, mulching protects the plants and their roots against extreme temperature fluctuation, suppress weeds and helps to conserve water in fruit production and quality attributes. In this regard, water use efficiency (WUE) is crucial and should be promoted without any compromise with fruit quality and yield. In general, combinations of polyethylene mulch and fertigation considerably promote plant vegetative and root growth which likely contributes to the enhancement of fruit yield. Drip irrigation scheduling followed from the estimation of crop coefficient from local climatic meteorological data noticeably conserved irrigation water without showing any influence on strawberry production (Lozano *et al*., 6). To evaluate the effect of drip irrigation, fertigation and mulching on plant vegetative, root growth and fruit production, the present study was planned.

MATERIALS AND METHODS

The present investigations were conducted from October to April months of the years 2015-2016 and 2016-2017 at the experimental field of Department of Soil Water & Engineering (SWE),

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Punjab Agricultural University Ludhiana situated at latitude 30° 4' N longitude 75° 5' E at 256 m above sea level. The present experiment was laid out in Factorial Split Plot Design and replicated thrice, consisting of four levels of irrigation viz. I_1:120, I_2:100, I_3:80 and I_4 60% of crop evapotranspiration (ETc), three level of fertilizers F_1:100, F_2:80 and F_3: 60 % of standard dose fertigation (SDF) and four different type of mulches (M_1: Straw mulch, M_2: Black-black, M_3: Silver-black and M_4: Red-black mulch). There were twelve combinations in main plot as I_1F_1, I_1F_2, I_1F_3, I_2F_1, I_2F_2, I_2F_3, I_3F_1, I_3F_2, I_3F_3, I_4F_1, I_4F_2 and I_4F_3 and in sub main plot, different mulches (25 µm) namely M_1: Rice Straw @ 6 Mt/ha, M_2: Silver-black, M_3: Black-black and M_4: Red-black were used. Standard dose of fertilizers: 55 N: 40 P: 50 K Kg/acre were applied through drip irrigation in split doses at 4 days intervals. During period of strawberry cultivation, irrigation was applied on the basis of daily calculation. It depends upon crop evapotranspiration and crop factor. Crop coefficient (Kc) i.e. 0.40 (0 to 30 DAP) and 0.85 (30 DAP up to harvest) for strawberry cultivation were used for calculation crop evapotranspiration (ETc) as per FAO Penman-Monteith (ETc= ETo×Kc). The model used FAO Penman-Monteith equation to calculate reference evapotranspiration (Allen *et al.,* 1). Runners of 'Chandler strawberry plants were transplanted at 30 cm × 30 cm spacing during IInd fortnight of October in both the years. Vegetative growth parameters were estimated from tagged five plants/replication. Strawberry was harvested at physiological maturity and average fruit yield was calculated by adding the fruit weight after each picking starting from mid-January to end March. Pooled data was analyzed for variance by using the package of SAS (V 9.3, SAS Institute Inc., Cary, NC, USA). The statistical differences among drip irrigation, fertigation and mulch levels and their interactions on plant and root characteristics and fruit yield were tested with Fisher's least significant difference ($P \leq 0.05$) using analysis of variance.

RESULTS AND DISCUSSION

Different levels of irrigation, fertigation and mulching materials significantly improved plant growth of strawberry *cv*. Chandler (Table 1). Fertigation ensured regular and adequate supply of irrigation water and nutrients that might have contributed to the more incremental growth of strawberry plants (Kachwaya *et al*., 5). During the period of study, plant subjected to different levels of fertigation confirmed significant enhancement in crown height (1.60 cm), petiole length (12.60 cm), number of leaves/ plant (19.18), total chlorophyll content (2.02 mg g^{-1}), plant spread (27.62 cm E-W and 24.52 cm N-S), fresh weight (139.53 g) and dry weight (39.09 g) while irrigated at 80 % ETc (I_3). Similarly, plants fertigated with 100 % of SDF (F_1) through drip irrigation system substantially put forth more vegetative growth in terms of crown height (1.84 cm), petiole length (13.08 cm), number of leaves/plant (19.06), total chlorophyll content (2.21 mg g^{-1}), plant spread (28.01 cm E-W, 24.85 cm N-S), and plant fresh weight (141.35 g). Drip irrigation has been reported to enhance the vegetative growth of strawberries by improving the water use efficiency (Renquist *et al*., 11). Plants mulched with Silver black, Red-black and Black-black also promoted growth-related parameters than those of with straw mulched plants which might be due to maintenance of favourable soil moisture regime, providing better environment for plant growth. Such beneficial effects of mulches on vegetative growth and configurations have also been reported by (Kachwaya *et al.,* 5)

The significant difference in fruit yield/plant was obtained when Chandler strawberry plants were applied with different fertigation levels. Fruit yield/ plant to the tune of 229.07 g was significantly higher with NPK applied at 80% SDF (F_2) after four days intervals during cropping season than the yield at 100% of SDF and 60% of SDF (p= 7.83). Thus, the plants supplied with F_1 produced 14.2 per cent higher yield than plants fertigated with low doses of NPK (F_3). Similar results were also observed by Martinsson *et al*. (7) while studying the impact of different fertilizers on fruit yield and quality in strawberries. On the contrary, it is not inevitable that increased in plant growth with N fertilization is correlated positively to more strawberry production. Plants irrigated at 80% ETc showed highest fruit yield of 229.96 g/plant; whereas it was lowest (184.73 g) with I_4 (drip irrigation at 60% ETc). Fertigation with higher doses of NPK in strawberry plants supplied with F_1 and F_2 treatments significantly improved plant biomass by 39.1 and 36.6 %, respectively as compared with the plants supplied with F_3 and these in turn improved fruit production as also explained in Table 1. The drip irrigation at 0.8V (volume of water applied to 80 percent ET crop) gave considerably more fruit yields to the tune of 166.3 q ha^{-1} than surface irrigation method in kiwifruit under Himachal Pradesh. Plants mulched with the plastic sheet (25 µ) and drip irrigation further raised fruit yield to 232.5q ha-^{1} (Rana *et al*., 9).

The plants mulched with Silver-black (M_3) registered highest (254.04 g/plant) fruit yield followed by Red-black mulch (207.17 g/plant). However, lowest fruit yield to the tune of 173.10 g/plant was found in M_1 (straw mulch) treatment (Table 1).

Table 1: Effect of drip irrigation, fertigation and mulching on growth parameters of strawberry cv. Chandler (two years pooled data).

Treatments	Crown height (cm)	Petiole length (cm)	Number of leaf/ plant	Total chlorophyll (mg g^{-1})	Plant spread (cm)		Plant fresh weight (g)	Plant dry weight (g)	Fruit yield/ plant (g)
					E-W	N-S			
Irrigation level (ETc*)									
I_1 (120 %)	1.31^{c}	11.24^{b}	15.80^{c}	1.82^{c}	26.45^{b}	23.23^{b}	128.19^{b}	36.27^{b}	204.55^{c}
I_2 (100 %)	1.44^{b}	12.47^{a}	17.84^{b}	1.87^{b}	27.35^{a}	24.14^{b}	129.93^{b}	36.65^{b}	218.70^{b}
I_3 (80 %)	1.60^{a}	12.60^{a}	19.18^{a}	2.02^{a}	27.62^{a}	24.52^{a}	139.53^{a}	39.09^{a}	229.96^{a}
I_4 (60 %)	1.13^{d}	10.01^{c}	12.84^{d}	1.60^{d}	24.70^{c}	21.63^{c}	124.65^{c}	30.79^{c}	184.73^{d}
LSD (p=0.05)	0.05	0.42	0.50	0.03	0.71	0.54	2.28	0.60	9.04
Fertigation level (SDF**)									
F_1 (100%)	1.84^{a}	13.08^{a}	19.06^{a}	2.21^{a}	28.01^{a}	24.85^{a}	141.35^{a}	41.69^{a}	202.91^{b}
F_2 (80%)	1.29^{b}	10.87^{b}	15.93^{b}	1.71^{b}	25.80^{b}	22.73^{b}	135.24^{b}	40.03^{b}	229.07^{a}
F_3 (60%)	0.98^{c}	10.79^{b}	14.26^{c}	1.51^{c}	25.78^{b}	22.56^{b}	115.13^{c}	25.38^{c}	196.47^{c}
LSD (p=0.05)	0.04	0.36	0.43	0.02	0.62	0.47	1.98	0.52	7.83
Mulching									
M_1 (Straw mulch)	1.26^{c}	10.86^{c}	15.09^{c}	1.71^{d}	25.71^{b}	22.59^{b}	128.99^{b}	33.78^{c}	173.10^{d}
M_2 (Black-black)	1.39^{b}	11.41^{b}	16.30^{b}	1.84^{bc}	26.36^{a}	23.30^{a}	130.67^{ab}	35.93^{b}	203.63^{c}
M_3 (Silver-black)	1.45^{a}	12.14^{a}	17.21^{a}	1.95^{a}	27.05^{a}	23.92^{a}	132.92^{a}	37.22^{a}	254.04^{a}
M_4 (Red-black)	1.38^{b}	11.90^{ab}	17.06^{a}	1.81^{c}	26.99^{a}	23.71^{a}	129.71^{b}	35.83^{b}	207.17^{b}
LSD (p=0.05)	0.04	0.50	0.81	0.03	0.94	0.71	2.15	0.77	12.15
Interaction									
IxF	0.08	0.72	0.86	0.05	1.23	0.93	3.95	1.04	15.66
IxM	NS	NS	NS	NS	NS	NS	NS	1.54	24.31
FxM	NS	NS	NS	NS	NS	NS	NS	1.34	21.05
IxFxM	0.14	NS	NS	NS	NS	NS	NS	NS	42.10

Interactive effect of drip irrigation and fertigation (I × F) was significant for various plant growth parameters as given in Table 1.1. Maximum (2.27 cm) crown height, number of leaves/ plant (20.97), total chlorophyll (2.51 mg^{-1}), plant spread (28.21 cm E-W and 25.28 cm N-S), plant fresh weight (155.13 g) and dry weight (49.14 g) were observed in I_3F_1 (drip irrigation at 80% ETc + fertigation at 100% SDF). Number of leaves/plant was statistically at par with I_2F_1 and plant spread was significantly at par with I_3F_1. Higher petiole length of 13.79 cm was recorded in I_2F_1 (drip irrigation at 100% ETc + fertigation at 100% SDF) which was statistically at par with I_1F_1, I_2F_1 and I_3F_1 and it was minimum in I_4F_3 (drip irrigation at 60 % ETc + fertigation at 60% SDF). The interaction between drip irrigation and mulching (I × M) showed significant and positive relationships for plant dry weight (Fig 1a). Plant mulched with Silver-black and fertigation at 80 % ETc (I_3M_3) had the maximum (40.18 g) plant dry matter which was statistically at par with (I_3M_1) (Fig 1a, b). However, interaction of drip irrigation, fertigation and mulching (IxFxM) combinations for crown height was statistically significant; being maximum (2.52 cm) in $I_3F_1M_3$ (drip irrigation at 80 % ETc + fertigation at 100 % SDF + Silver-black mulch) followed by $I_3F_1M_2$ (2.33 cm); and $I_3F_1M_4$ & $I_3F_2M_1$ (2.22 cm) (Fig. 1c). The use of fertigation along with polythene mulch has also been reported to enhance the plant growth due to change in microclimate and high soil moisture content near the root zone (Lazano *et al*., 6).

The moderation of hydrothermal regimes of soil under different levels of drip irrigation, fertigation and mulching treatments showed statistically significantly affect different root growth parameters (Table 2). Mulches along with drip irrigation provided optimum moisture to strengthen the root structure, proliferation and also released the precise quantity of nutrient to root zone, helping for the enhancement of fruit productivity and quality-related attributes. Maximum

Table 1.1: Interactive effect between drip irrigation, fertigation and mulching on growth parameters of strawberry cv. Chandler (two years pooled data).

Treatments	Crown height (cm)	Petiole length (cm)	Number of leaf/ plant	Total chlorophyll (mg g^{-1})	Plant spread (cm)		Plant fresh weight (g)	Plant dry weight (g)	Fruit yield/ plant (g)
					E-W	N-S			
I_1F_1	1.84^{b}	13.29^{a}	18.67^{b}	2.24^{b}	28.99^{ab}	25.57^{ab}	145.87^{b}	44.09^{c}	222.07^{b}
I_1F_2	1.11^{e}	10.35^{de}	14.99^{e}	1.68^{h}	25.27^{f}	22.26^{de}	128.43^{d}	37.76^{e}	182.85^{fghi}
I_1F_3	0.98^{f}	10.07^{d}	13.76^{f}	1.54^{i}	25.08^{f}	21.86^{ef}	110.27^{g}	26.98^{h}	208.74^{bcde}
I_2F_1	1.89^{b}	13.79^{a}	20.48^{a}	1.94^{e}	29.05^{a}	25.95^{a}	127.81^{de}	36.57^{f}	182.79^{fghij}
I_2F_2	1.39^{d}	12.01^{bc}	17.54^{c}	1.89^{f}	26.53^{de}	23.42^{cd}	137.80^{c}	45.74^{b}	272.89^{a}
I_2F_3	1.05^{e}	11.62^{c}	15.50^{de}	1.77^{g}	26.48^{def}	23.05^{cde}	124.18^{e}	27.63^{h}	200.41^{c}
I_3F_1	2.27^{a}	13.70^{a}	20.97^{a}	2.51^{a}	28.21^{abc}	25.28^{ab}	155.13^{a}	49.14^{a}	209.69^{bc}
I_3F_2	1.55^{c}	11.73^{bc}	19.23^{b}	2.00^{d}	27.69^{abcd}	24.64^{b}	147.56^{b}	42.43^{d}	270.62^{a}
I_3F_3	0.99^{f}	12.37^{b}	17.35^{c}	1.57^{i}	26.96^{cd}	23.64^{c}	115.89^{f}	25.71^{i}	209.56^{bcd}
I_4F_1	1.35^{d}	11.55^{c}	16.13^{d}	2.14^{c}	25.79^{e}	22.58^{cdef}	136.60^{c}	36.98^{ef}	197.09^{cdef}
I_4F_2	1.12^{e}	9.39^{ef}	11.94^{g}	1.48^{j}	23.65^{g}	20.60^{g}	127.18^{de}	34.19^{g}	189.93^{fg}
I_4F_3	0.91^{f}	9.09^{f}	10.45^{h}	1.18^{k}	24.66^{fg}	21.69^{efg}	110.17^{g}	21.21^{j}	167.18^{f}
LSD (p=0.05)	0.08	0.72	0.86	0.05	1.23	1.23	3.95	1.04	42.10

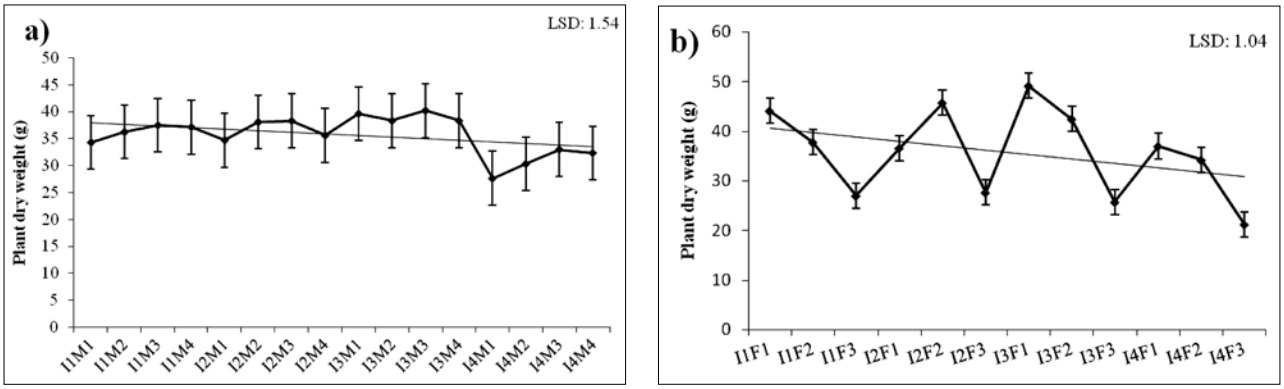

Fig 1a&b: Interaction between effect of drip irrigation, fertigation and mulching (I × M & I × F) on plant dry weight (g) of strawberry cv. Chandler (two years pooled data) Vertical bars represent SE ±.

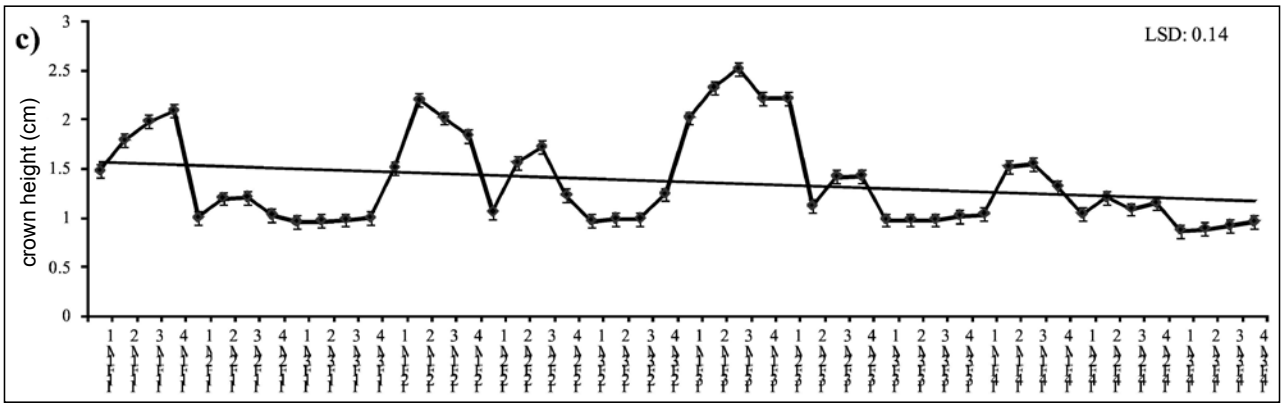

Fig 1 c: Interaction between effect of drip irrigation, fertigation and mulching on crown height (cm) of strawberry cv. Chandler (two years pooled data) Vertical bars represent SE ±.

Table 2: Effect of drip irrigation, fertigation and mulching on root parameters of strawberry cv. Chandler (two years pooled data).

Treatments	Root fresh weight (g)	Root dry weight (g)	Root volume (cc)	Root length (cm)	Number of roots	
					(<0.20 mm)	(>0.20 mm)
			Irrigation level (ETc*)			
I_1 (120 %)	19.65^c	2.69^c	18.30^d	10.39^d	101.38^c	75.11^b
I_2 (100 %)	23.29^b	3.87^b	20.27^c	12.57^c	104.39^b	86.69^a
I_3 (80 %)	24.95^a	4.46^a	26.04^a	17.64^a	110.29^a	86.99^a
I_4 (60 %)	17.85^d	1.96^d	24.42^b	16.03^b	92.46^d	63.79^c
LSD (p=0.05)	0.51	0.06	0.61	0.59	0.61	0.61
			Fertigation level (SDF**)			
F_1 (100%)	24.52^a	4.09^a	27.42^a	13.88^b	99.20^b	77.92^b
F_2 (80%)	22.05^b	3.23^b	21.73^b	19.20^a	116.01^a	89.58^a
F_3 (60%)	17.74^c	2.41^c	17.62^c	9.39^c	91.19^c	66.93^c
LSD (p=0.05)	0.44	0.05	0.53	0.51	0.53	0.53
			Mulching			
M_1 (Straw mulch)	16.79^d	2.68^c	17.69^c	10.15^d	47.21^d	75.53^d
M_2 (Black-black)	22.51^b	3.33^b	23.40^b	15.17^b	116.76^b	79.54^b
M_3 (Silver-black)	24.05^a	3.59^a	24.81^a	16.47^a	125.28^c	81.06^a
M_4 (Red-black)	22.38^c	3.38^b	23.14^b	14.85^c	119.27^a	76.44^c
LSD (p=0.05)	0.72	0.07	0.76	0.47	0.78	0.79
			Interaction			
IxF	0.87	0.11	1.06	1.02	1.05	1.16
IxM	NS	0.15	NS	NS	1.56	1.77
FxM	NS	0.13	NS	0.81	1.35	1.53
IxFxM	NS	0.26	NS	NS	2.70	3.06

values of these parameters *viz*. root fresh & dry weight, root volume, root length and number of roots/ plant and thickness were recorded under I_3 (drip irrigation at 80 % ETc), F_1 (fertigation at 100 % SDF) and M_3 (Silver-black mulch) followed by irrigation at I_2 (100 % ETc level), F_2 (fertigation at 80 % SDF) and M_2 (Black-black mulch), while it was minimum under I_4 (60 % ETc), F_3(60 % SDF) and M_1 (Straw mulch) levels.

The effect of interaction (I × F) showed positive and significant results for root fresh and dry weight (g), root volume, root length and the number of roots/ plant (Table 2.1). In general, maximum root fresh weight of 27.27 g was attained in plots irrigated at 100 % ETc + fertigated at 100% SDF (I_2F_1), which was statically at par with I_2F_1 and I_3F_2; whereas, higher dry matter of 5.15 g was recorded in I_2F_1 followed by I_3F_1 and I_3F_2. It is also evident from Table 2.1 that integrated effect on root volume was recorded higher in I_4F_1 (30.60 cc) which was statistically at par with I_3F_1 (30.16 cc). However, maximum root length (22.26 cm) was observed in I_4F_1 without any significant effect with treatment I_3F_2. Furthermore, the number of roots/plant (< 20 mm and > 20 mm) was maximum (126.77 and 98.87, respectively) in I_3F_2 followed by I_2F_2 (109.41 and 92.05, respectively) due to the availability of favourable environment for its proper growth and development (Table 2.1).

Further, interaction effect of F × M on root parameters was statistically significant for both the years of study. The plant fertigated with 100 % of SDF and mulched with Silver-black (F_1M_3) showed the highest root dry matter content (4.37 g) which was statistically at par with F_1M_2 (Fig. 2c). Root length and root numbers reflected as the significant contribution for nutrient uptake which ultimately affected fruit yield/plant, vegetative growth and fruit production parameters. However, maximum root length of 22.17 cm, number of roots (< 20 mm and > 20 mm thickness) of 145.01 and 95.74, respectively were observed under F_2M_3 (fertigation at 80 % SDF

Table 2.1: Interactive effect between drip irrigation, fertigation and mulching on root parameters of strawberry cv. Chandler (two years pooled data).

Treatments	Root fresh weight (g)	Root dry weight (g)	Root volume (cc)	Root length (cm)	Number of roots	
					(<0.20mm)	(>0.20mm)
I_1F_1	23.56^{d}	3.63^{d}	22.64^{d}	9.93^{g}	93.75^{h}	69.22^{h}
I_1F_2	19.08^{g}	2.74^{e}	17.27^{g}	14.37^{d}	120.06^{a}	89.93^{cd}
I_1F_3	16.31^{i}	1.70^{g}	14.98^{i}	6.87^{i}	90.33^{j}	66.19^{i}
I_2F_1	27.27^{a}	5.15^{a}	26.29^{b}	11.26^{f}	103.11^{e}	88.94^{d}
I_2F_2	24.61^{c}	3.91^{c}	18.39^{f}	18.10^{b}	109.41^{c}	92.05^{b}
I_2F_3	18.00^{h}	2.56^{f}	16.14^{h}	8.35^{h}	100.66^{f}	79.08^{e}
I_3F_1	26.98^{ab}	5.04^{a}	30.16^{a}	17.94^{bc}	108.79^{cd}	88.46^{d}
I_3F_2	26.65^{ab}	4.47^{b}	26.65^{b}	22.07^{a}	126.77^{a}	98.87^{a}
I_3F_3	21.21^{e}	3.87^{c}	21.31^{e}	12.89^{e}	95.32^{g}	73.63^{g}
I_4F_1	20.27^{f}	2.53^{f}	30.60^{a}	16.37^{c}	91.13^{i}	65.06^{i}
I_4F_2	17.84^{h}	1.82^{g}	24.61^{c}	22.26^{a}	107.79^{d}	77.47^{f}
I_4F_3	15.45^{j}	1.52^{h}	18.06^{fg}	9.47^{g}	78.45^{k}	48.84^{j}
LSD (p=0.05)	0.87	0.11	1.06	1.02	1.05	1.16

+ Silver-black mulch) than F_2M_2 (fertigation at 100 % SDF + Black-black mulch) as shown in Fig. 2d. Furthermore, combined effect of drip irrigation and mulching (I × M) showed the significant effect on root dry weight registering its highest value in I_3M_3 (drip irrigation at 80 % ETc + Silver-black mulch) (Fig. 2a). However, interaction in treatment IxFxM with respect to dry weight (5.42 g) was recorded higher in $I_3F_1M_3$ as compared to other combination (Fig. 2c); whereas, plant irrigated with 80 % ETc + fertigated at 80% SDF + mulched with Silver-black ($I_3F_2M_3$) showed maximum number of root (thickness & thinness) and values were 156.67 and 103.01 in Fig. 2 b. The similar effect of fertigation along with polythylene mulch has also been reported by (Yuan *et al.,* 15).

Interactive relationship of irrigation, fertigation and mulching treatments (IxF, FxM, IxM and IxFxM) on fruit yield/plant varied significantly during the consecutive years. The highest pooled values for fruit yield (361.91 g/plant) was obtained in $I_2F_2M_3$ (drip irrigation 100% ETc + fertigation 80% SDF + Silver-black mulch) followed by $I_3F_2M_3$ (344.48 g/ plant) and $I_3F_2M_2$ (320.12 g/plant) (Fig. 1f). However, interactive effect of drip irrigation and mulching (IxM) on fruit yield/plant was better in I_3M_3 (80% ETc and Silver-black mulch) than other treatments (Fig. 1d, e). The influence of IxF combinations on fruit yield/plant was statistically significant being maximum in I_2F_2 (272.89 g/ plant) followed by I_3F_2 (270.62 g/ plant) and I_1F_1 (222.07 g/plant) (Table 1.1). These results are also in corroborated with the findings of Tekinel *et al.,* (13) and Yuan *et al.,* (15), who also recorded significant increase in fruit yield of strawberry under optimum level of drip irrigation and fertigation along with different type of mulches used.

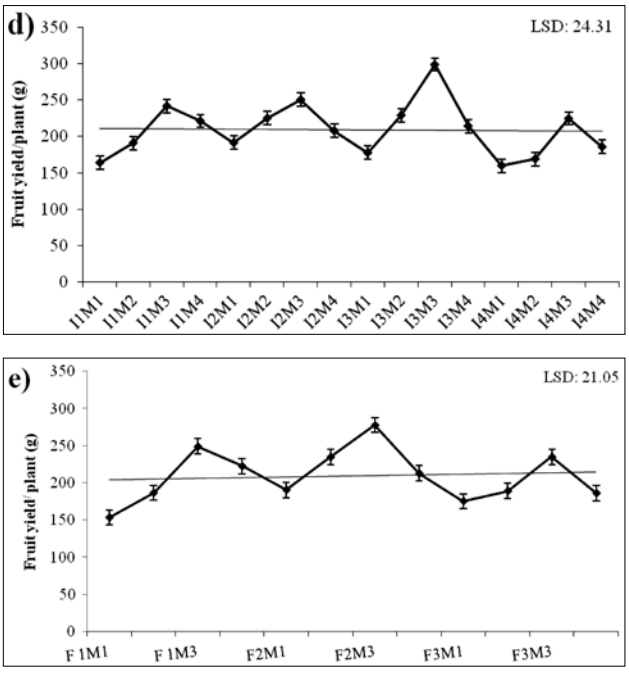

Fig 1d & e: Interaction between effect of drip irrigation, fertigation and mulching on crown height (cm) of strawberry cv. Chandler (two years pooled data) Vertical bars represent SE ±.

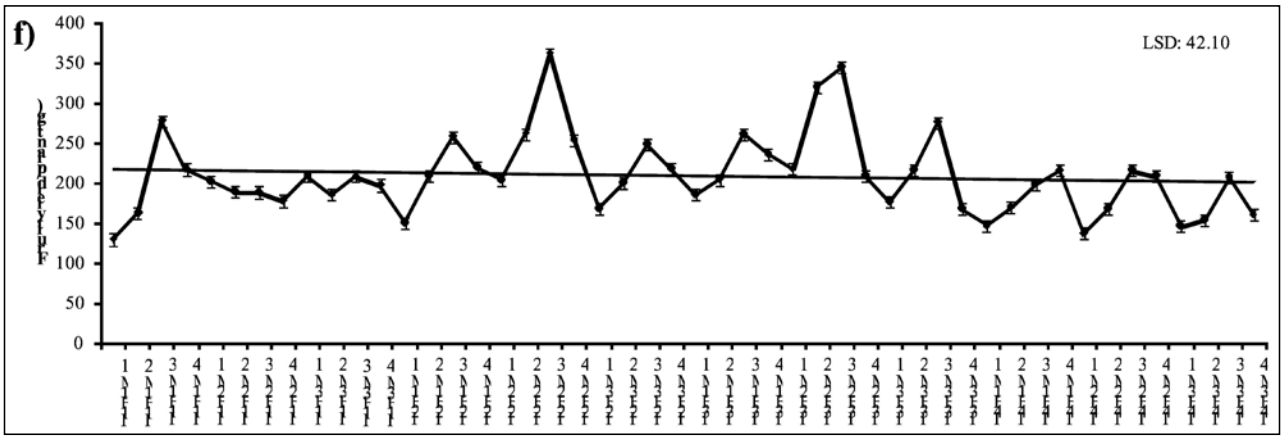

Fig 1f: Interaction between effect of drip irrigation, fertigation and mulching on fruit yield/plant (g) of strawberry cv. Chandler (two years pooled data) Vertical bars represent SE ±.

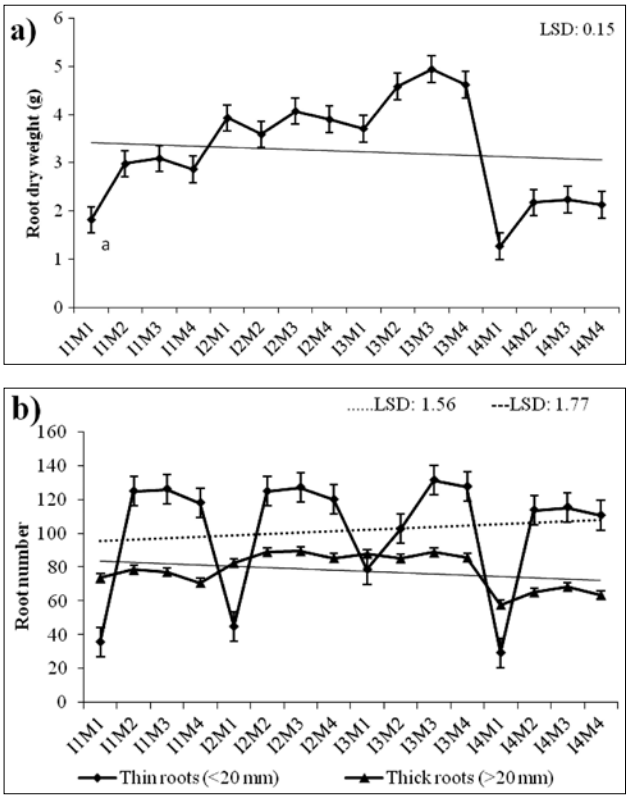

Fig 2a & b Interactive relationship between drip irrigation and mulching (I × M) on root dry weight and root number of strawberry. Vertical bars represent SE ±.

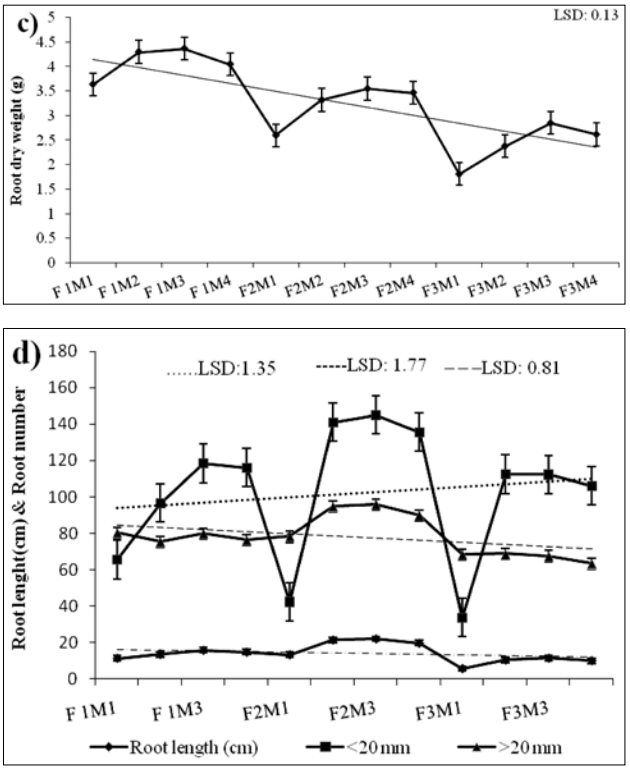

Fig 2c & d Interactive relationship between fertigation and mulching (F × M) on root dry weight and root number of strawberry. Vertical bars represent SE ±.

The results revealed that plant vegetative, root growth and marketable fruit yield were enhanced with the combined effect of drip irrigation at 80% ETc + fertigation at 100 % SDF along with plant mulched with Silver-black mulch over other combinations; whereas, interactive relation between $I_3F_2M_3$ (drip irrigation at 80 % ETc + fertigation at 80 % SDF + Silver-black mulch) showed higher yield/plant as compared to other combinations. Hence, it can be concluded from the present studies that, application of 80% SDF through drip irrigation system at 80% ETc level and plants mulched with 25µ (Silver-black mulch) produced maximum fruit yield/plant higher economics returns of strawberry *cv*. Ch|andler.

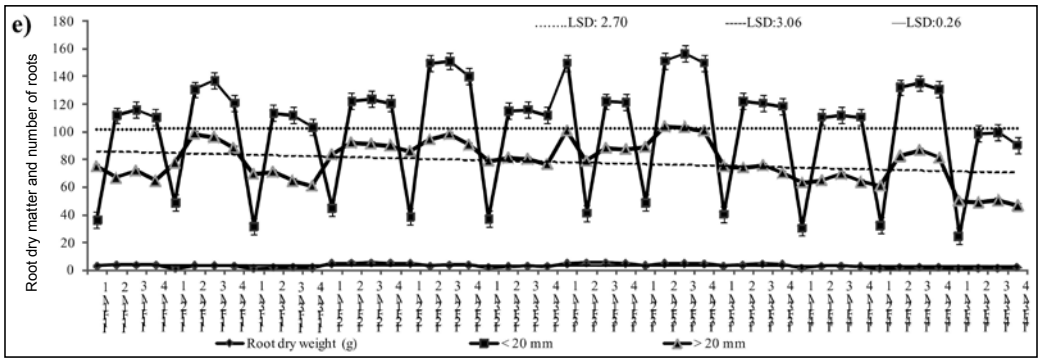

Fig 2e: Interaction relationship between drip irrigation, fertigation and mulching (I × F × M) on root dry weight (g) and root number of strawberry. Vertical bars represent SE ±.

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