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Name of R&D Scheme	**Standardization of Drip Irrigation and Fertigation Schedules with and without mulch in Fruit Crops (Apple and Apricot) of Himalayan Region.**
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3. **Project title**: Standardization of Drip Irrigation and Fertigation Schedules with and without mulch in Fruit Crops (Apple &Apricot) of Himalayan Region

4. **Financial details**. Sanctioned cost: Rs. 16,12,044/-

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5. **Original objectives and methodology as in the sanctioned proposal**.

Objectives:

1. To determine the drip irrigation and fertigation schedules with and without mulch for apple and apricot fruit crops.

2. To study the effect of drip irrigation and fertigation on weed incidence, nutrient content of soil and plant and on growth, yield and quality of apple and apricot.

Methodology

I. Field Trials

Drip Irrigation and fertigation:-

Field trials on apple and apricot will be executed at the experimental farm of the Department of Soil Science and Water Management, UHF. Solan , at Krishi Vigyan Kendra Rohru (Shimla), and at Farmers field Vill. Pajol, (Shimla), wherein, following treatments will be tried:

Drip irrigation

T_1: Surface irrigation (Conventional Practice)

T_2: Drip irrigation equal to100% Etc.

T_3 Drip irrigation equal to 80% Etc

T_4: Drip irrigation equal to 60% Etc

Fertigation

T_5: Soil fertilization with 100% Recommended dose (RD)

T_6: Drip fertigation with 100% RD.

T_7: Drip fertigation with 80% RD

T_8: Drip fertigation with 60% RD

These treatments will be tried in mixed factorial Randomized Block Design with and without mulch. The treatment combinations will be as follows:

Irrigation/fertigation	Mulch* (M_1)	Without Mulch(M_0)
T_1: Surface irrigation (Conventional Practice)	T1M1	T1M0
T_2: Drip irrigation equal to100% Etc.	T2M1	T2M0
T_3 Drip irrigation equal to 80% Etc	T3M1	T3M0
T_4: Drip irrigation equal to 60% Etc	T4M1	T4M0
T_5: Soil fertilization with 100% Recommended dose (RD)	T5M1	T5M0
T_6: Drip fertigation with 100% RD (100% Etc)	T6M1	T6M0
T_7: Drip fertigation with 80% RD (80% Etc)	T7M1	T7M0
T_8: Drip fertigation with 60% RD (60% Etc)	T8M1	T8M0

* Black polyethylene mulch of 100 μ thickness will be used, Block mulch will be tried.

RD (Recommended dose):

Apple; N: 700gm/tree

P_2O_5: 350 gm/tree

K_2O: 700gm/tree

Apricot; N: 500gm/tree

P_2O_5: 250 gm/tree

K_2O: 500gm/tree

No. of Replications: 5 (Each replication will comprise a unit five trees).

Mode of fertigation

a) Water soluble fertilizer will be used for fertigation.NPK nutrients will be applied through Polyfeed Muriate of potash and urea fertilizers

b) Fertigation will be done in 10 equal split applications at weekly intervals starting w.e.f. Feb-March of the year.

c) Soil fertilization: Full dose of P and K fertilizer will be applied in tree basins in December, half dose of N in spring before flowering and remaining half after one month of first application.

II. Observations to be recorded

i. Uniformity coefficient:

Emission uniformity of the drip system will be determined at the start and termination of trials during each year of the study at all the locations.

ii. Soil Parameters

a) Soil moisture content: Soil moisture content at different depths up to 45 cm under different treatments will be determined at periodical intervals.
b) Soil temperature: Soil temperature at 0-5, 5-10, 10-15 and 15-30cm soil depth under different treatments will be recorded at periodical intervals

c) Soil nutrient content: Available NPK content of soil under different treatments before execution of trial and after crop harvest during each year of the study will be determined.

iii. Nutrient distribution:

a) Available NPK: Depth wise distribution of available NPK content will be determined under different treatments.

b) The vertical and lateral distribution of NH_4-N and NO_3-N: It will be studied in apricot only. Soil samples will be drawn at 0-2.5, 2.5-15, 15-30 30-45 cm and 45-60 cm depths to study the vertical distribution. For lateral distribution, soil samples for such depths will be drawn below the emitter and at a distance of 15, 30 and 45 cm away from emitters. Under conventional soil fertilization treatments, soil sampling will be done at a distance of 45, 60, 75 and 90 cm away from tree trunk.

III. Leaf Analysis: Leaf samples collected from experimental trees will be analyzed for their NPK content.

IV Tree Growth Parameters: The observations on fruit set will be recorded at the stage of petal fall. Data on annual shoot growth, trunk girth, tree height, and tree spread (EW and NS) and tree canopy volume will be recorded during each year of the study.

V. Yield and quality characteristics of fruits: the data on fruit yield and quality characteristics (fruit weight, volume, fruit pressure, acid content, TSS, reducing and non–reducing sugars of apple and apricot fruits will be recorded during each year of the study.

6. Any changes in the objectives during the operation of the scheme. No

7. All data collected and used in the analysis with sources of data. Field trials

Methodology actually followed (observations, analysis, results and inferences): Field trials were executed to determine the drip irrigation and fertigation schedules with and without mulch for apple and apricot fruit crops and to study the effect of drip irrigation and fertigation on soil hydrothermal regimes, nutrient distribution in soil , leaf NPK content, crop growth, yield and quality during 2011-2015 as per treatments at the locations specified in the original methodology.

Plate1. An overview of experimental Apple Orchard at KVK, Rohru

Plate 2. Application of Black Plastic mulch in Apple tree basins

Plate 3. An overview of experimental Apricot Orchard at UHF Solan

8. Results and Discussion

8.1 Effect of drip irrigation and fertigation on soil hydrothermal regimes, nutrient distribution and content in soil and plants, crop growth, yield and quality

Uniformity Co-efficient: The uniformity co-efficient of the drip system came out to be 93-94% before and after the experiment which indicated that there was uniform application of water and fertilizers in the experimental plants.

Table-1: Depth wise distribution of Av. Soil Moisture under different treatments during the active growth period in apple*

Treatments	Soil Depth (cm)	Soil Moisture(%)											
		Without Mulch						With Mulch					
		Months						Months					
		March	April	May	June	July	Mean	March	April	May	June	July	Mean
DI-100%Etc	0-15	23.5	24.2	21.7	20.5	22.8	22.5	24.2	25.1	22.9	21.4	23.5	23.4
	15-30	21.8	22.5	20.3	18.2	20.5	20.6	22.4	23.3	21.5	19.1	22.2	21.7
	30-45	18.3	18.8	17.2	17.1	19.9	18.3	19.1	19.5	18.4	18.9	20.5	19.2
DI-80%Etc	0-15	24.2	25.1	20.9	19.8	21.8	22.4	25.4	26.2	22.3	21.4	23.5	23.7
	15-30	22.4	23.3	19.7	17.6	20.6	20.7	23.2	23.8	20.1	18.4	21.5	21.4
	30-45	19.1	19.5	16.5	16.5	19.2	18.2	20.2	20.3	16.9	16.7	19.8	18.7
DI-60%Etc	0-15	16.2	17.4	17.2	17.5	17.7	17.2	17.8	18.9	18.6	18.9	18.7	18.5
	15-30	15.8	15.5	14.4	14.1	13.8	14.7	16.6	16.4	15.2	14.9	14.4	15.5
	30-45	13.8	14.1	13.8	14.6	14.3	14.1	14.6	15.3	15.1	15.8	15.2	15.2
SI	0-15	17.5	17.5	15.7	16.2	17.4	17.0	19.8	18.2	16.3	17.1	18.5	18.0
	15-30	18.3	19.2	18.2	17.4	22.8	19.1	18.7	19.8	18.7	18.1	23.4	19.7
	30-45	25.4	24.2	23.6	22.8	26.2	24.4	25.9	24.7	24.3	23.7	26.8	25.1
RF	0-15	9.8	9.4	9.1	8.6	9.2	9.2	10.2	9.8	9.5	9.1	9.8	9.7
	15-30	9.4	9.1	8.5	8.1	8.4	8.7	10.1	9.5	9.1	8.4	8.6	9.1
	30-45	8.2	7.6	6.8	7.1	7.6	7.5	8.7	8.2	7.3	7.5	8.2	8.0

***Average value of 3 years data** **DI- Drip irrigation; SI-Surface irrigation; RF- Rainfed**

Table-2: Depth wise distribution of Av. Soil Moisture under different treatments during the active growth period in apricot*

Treatments	Soil Depth (cm)	Soil Moisture(%)									
		Without Mulch					With Mulch				
		Months					Months				
		February	March	April	May	Mean	February	March	April	May	Mean
DI-00%Etc	0-15	21.8	22.1	20.5	19.7	21.0	23.2	23.4	21.8	21.2	22.4
	15-30	21.5	21.7	20.3	19.4	20.7	22.6	22.8	21.6	21.6	22.2
	30-45	19.3	19.2	17.5	17.2	18.3	20.5	20.6	18.8	19.0	19.7
DI-80%Etc	0-15	19.2	19.6	19.2	18.5	19.1	20.5	21.0	20.1	19.7	20.3
	15-30	19.0	19.4	18.6	18.2	18.8	20.3	20.8	19.8	19.4	20.1
	30-45	18.5	18.7	17.4	16.6	17.8	19.8	20.1	18.5	18.1	19.1
DI-60%Etc	0-15	15.6	15.5	14.7	14.0	15.0	16.8	16.4	15.1	14.8	15.7
	15-30	15.4	15.2	14.2	13.5	14.6	15.9	15.6	14.7	14.2	15.1
	30-45	14.1	13.7	13.1	12.8	13.4	14.7	14.3	13.8	13.5	14.1
SI	0-15	16.3	16.4	15.5	14.3	15.6	17.1	16.9	16.2	14.8	16.2
	15-30	18.5	18.4	17.2	16.5	17.6	19.4	19.1	17.8	16.7	18.2
	30-45	22.4	21.7	21.5	20.7	21.6	23.6	22.9	22.8	21.5	22.7
RF	0-15	10.5	9.8	9.1	8.4	9.5	11.2	10.3	9.6	9.2	10.1
	15-30	10.1	9.4	8.5	7.8	9.0	10.8	10.1	9.2	8.3	9.6
	30-45	9.7	8.2	7.3	6.4	7.9	10.1	8.6	7.8	6.9	8.4

***Average value of 3 years data** **DI- Drip irrigation; SI-Surface irrigation; RF- Rainfed**

Soil moisture

Over the entire active growth period, in apple, soil moisture content under drip irrigation treatment (DI-100) was markedly higher in the upper soil depths ie 0-15 cm (22.5%) and 15-30 cm (20.6%),) as compared to surface irrigation (SI) , wherein lower soil depths 30-45 cm, registered higher values (24.4%) under unmulched conditions. Similarly, in apricot , soil moisture content under drip irrigation treatment (DI-100) was markedly higher in the upper soil depths ie 0-15 cm (21.0%) and 15-30 cm (20.7%),) as compared to surface irrigation (SI) , wherein lower soil depths 30-45 cm, registered higher values (21.6 %) under unmulched conditions. The pattern of moisture distribution was same under mulched conditions. The higher soil moisture in the surface (0-30 cm) soil layers under drip irrigation may be attributed to the fact that water was applied at bi-weekly intervals in smaller quantities, which remained confined in the upper layers only. Whereas, due to the large volume of water applied at a time under surface irrigation, higher hydraulic gradient was created which resulted in more rapid downward movement of water, thus, resulting into higher moisture content in the lower soil depths. Application of plastic mulch resulted in 4-6 per cent unit higher soil moisture as compared to un mulched condition which may be attributed to the fact that evaporation rates of soil moisture got reduced due to coverage of soil surface under mulch.

Table 3: Depth wise distribution of Av. Minimum Soil Temperature under different treatments during the active growth period in apple*

Months	Soil depth (cm)	Soil temperature(°C)					
		DI-100%Etc		SI		RF	
		M0	M1	M0	M1	M0	M1
March	0-15	9.2	12.4	9.1	12.2	8.5	11.3
	15-30	12.0	14.2	11.8	13.5	11.2	13.5
	30-45	12.8	14.9	12.6	14.8	12.0	14.5
April	0-15	14.5	18.9	14.3	18.6	13.7	17.8
	15-30	16.8	19.2	16.6	18.8	16.6	18.8
	30-45	18.6	21.4	18.4	20.6	17.8	19.2
May	0-15	19.2	21.6	19.0	21.5	18.6	21.5
	15-30	20.4	22.5	20.1	22.7	20.0	21.9
	30-45	21.2	23.3	21.1	23.5	20.5	22.2
June	0-15	22.3	24.5	22.2	24.4	21.7	23.8
	15-30	23.1	25.3	23.0	25.2	22.6	24.1
	30-45	23.6	25.7	23.4	25.5	22.8	24.4
July	0-15	23.2	25.4	23.1	25.7	22.6	24.6
	15-30	23.5	25.7	23.3	25.5	22.8	24.9
	30-45	24.4	26.8	24.2	26.6	23.2	25.5

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 4: Depth wise distribution of Av. Maximum Soil Temperature under different treatments during the active growth period in apple*

Months	Soil depth (cm)	Soil temperature(°C)					
		DI-100%Etc		SI		RF	
		M0	M1	M0	M1	M0	M1
March	0-15	12.5	13.6	12.7	13.9	13.1	13.8
	15-30	12.7	13.3	12.9	13.5	12.9	13.6
	30-45	13.8	14.1	13.9	14.3	14.1	14.5
April	0-15	19.2	20.8	19.4	21.1	19.6	21.5
	15-30	19.0	20.4	19.2	20.6	19.3	20.8
	30-45	19.4	19.8	19.6	20.2	19.8	20.5
May	0-15	24.3	21.5	24.5	21.7	25.6	22.2
	15-30	23.6	21.8	23.8	22.1	24.6	23.4
	30-45	22.4	21.2	22.5	21.6	22.8	21.2
June	0-15	28.5	25.7	28.8	26.1	29.6	26.3
	15-30	26.7	24.4	26.8	24.6	27.4	25.2
	30-45	24.4	23.8	24.6	23.8	25.8	23.4
July	0-15	29.6	27.7	28.3	27.8	29.5	28.3
	15-30	26.9	25.5	27.2	25.7	28.1	27.4
	30-45	24.7	23.8	24.5	23.2	25.3	24.5

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 5: Depth wise distribution of Av. Minimum Soil Temperature under different treatments during the experimental period in apricot*

Months	Soil depth (cm)	Soil temperature(°C)					
		DI-100%Etc		SI		RF	
		M0	M1	M0	M1	M0	M1
Feb	0-15	8.5	11.2	8.2	11.5	8.0	10.5
	15-30	9.1	11.4	9.5	11.7	9.1	11.4
	30-45	9.3	11.8	9.7	12.3	9.3	11.6
March	0-15	11.2	14.2	11.7	14.5	10.1	13.6
	15-30	11.6	15.4	11.8	14.7	10.5	13.8
	30-45	12.4	16.1	12.2	15.8	11.2	14.1
April	0-15	17.2	20.4	17.4	20.6	16.4	19.2
	15-30	18.5	20.6	18.2	20.4	17.2	19.6
	30-45	18.7	21.7	18.8	21.9	17.6	20.1
May	0-15	21.3	22.5	21.6	22.8	20.5	22.7
	15-30	22.5	23.3	22.7	23.5	22.1	23.4
	30-45	23.3	24.1	23.6	24.7	22.7	24.3

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 6: Depth wise distribution of Av. Maximum Soil Temperature under different Treatments during the experimental period in apricot*

Months	Soil depth (cm)	Soil temperature(°C)					
		DI-100%Etc		SI		RF	
		M0	M1	M0	M1	M0	M1
Feb	0-15	15.2	16.4	15.4	16.5	15.6	16.7
	15-30	14.5	15.3	14.7	15.5	14.8	15.6
	30-45	13.3	14.5	13.4	14.7	13.6	14.8
March	0-15	21.2	22.4	21.4	22.5	21.5	22.7
	15-30	20.4	21.6	20.6	21.7	20.7	21.9
	30-45	19.1	20.4	19.3	20.6	19.5	20.8
April	0-15	25.1	23.6	25.3	23.7	25.4	23.8
	15-30	23.6	22.1	23.8	22.4	24.1	22.6
	30-45	23.2	22.5	23.5	22.1	23.8	22.4
May	0-15	30.8	28.6	31.1	28.2	31.4	28.6
	15-30	29.4	27.2	29.6	27.8	29.8	28.7
	30-45	28.2	27.1	28.4	27.6	28.6	27.5
	0-15	29.6	27.3	29.8	27.1	29.6	27.3
	15-30	26.9	25.1	26.6	24.8	26.4	25.1
	30-45	24.7	23.3	24.5	23.7	24.8	23.5

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Soil temperature

A perusal of the data in Table reveals that over the entire growth period, in apple, the minimum temperature ranged between 9.2-24.4, 9.1-24.2 and 8.5-23.2 C whereas maximum temperature ranged between 12.5-29.6, 12.7-28.8 and 13.1-29.6 C under drip irrigation, surface irrigation and rainfed treatments without mulch, respectively. The corresponding values under mulch for minimum temperature were 12.4-26.8, 12.2-26.6 and 11.3-25.5 C while maximum temperature ranged between 13.6-27.7, 13.9-27.8 and 13.8-28.3 C. In apricot, the minimum temperature ranged between 8.5-23.3, 8.2-23.6 and 8.0-22.7 C whereas maximum temperature ranged between 15.2-30.8, 15.4-31.1 and 15.6-31.4 C under drip irrigation, surface irrigation and rainfed treatments without mulch, respectively. The corresponding values under mulch for minimum and maximum temperature were 11.2-24.1, 11.5-24.7, 10.5-24.3 C and 16.4-28.6, 16.5-28.2 and 16.7-28.7 C, respectively. Both under apple and apricot, the average minimum temperature decreased with increasing soil depth whereas maximum temperature did not follow such trend irrespective of the treatments under unmulched as well as mulched conditions. Application of mulch raised the minimum soil temperature by 2-3^{o}C over unmulched conditions in the upper (0-15 and 15-30 cm) and lower (30-45cm) soil depths. Whereas, decrease in av. maximum temperature was more pronounced in the upper 0-15 cm soil depths (irrespective of treatments) under mulched conditions. These results may be attributed to the fact that due to the low thermal conductivity of the plastic mulch, there is more absorption of the incident radiation while energy transmission is less. Moreover, the bad conductance of the air between plastic mulch and soil surface decreased the heat flux in the soil which cooled the soil during daytime and warmer in the night. Mulch application appreciably increased the minimum and maximum soil temperature during the early growth period (Feb-April). Whereas, increase in the minimum and decrease in the maximum temperature was recorded towards the end of growing season (May-July) over unmulched conditions under drip irrigation, surface irrigation and rainfed treatments. It may be ascribed to the fact that due to the thermal insulation provided by the black plastic mulch on soil surface, seasonal changes in soil temperature were much less than overlying air temperature.

Table 7: Weed population (count/ m^2) during active growth period in apple*

Months	**April**		**May**		**June**		**July**		**Mean**	
Treatments	**M0**	**M1**	**M0**	**M1**	**M0**	**M1**	**M0**	**M1**	**M0**	**M1**
DF-100%Etc +100%RD NPK	8.5	1.2	8.7	1.0	9.2	1.5	9.8	1.2	9.05	1.2
DF-80%Etc +80%RD NPK	8.0	1.0	8.5	1.2	8.7	1.3	9.0	1.0	8.5	1.1
DF-60%Etc +60%RD NPK	7.5	1.2	8.2	1.0	8.4	1.2	8.6	1.4	8.1	1.2
Conventional fertilization(SI)	22.0	1.4	23.0	1.3	23.5	1.0	26.0	1.2	23.6	1.2
Conventional fertilization(RF)	7.0	1.0	7.5	1.2	7.8	1.5	8.4	1.0	7.6	1.1

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 8 : Weed population (count m^{-2}) during active growth period in apricot*

Months	April		May		June		July		Mean	
Treatments	**M0**	**M1**	**M0**	**M1**	**M0**	**M1**	**M0**	**M1**	**M0**	**M1**
DF-100%Etc +100%RD NPK	12.7	1.4	13.0	1.2	14.1	1.3	14.4	1.5	13.5	1.3
DF-80%Etc +80%RD NPK	12.2	1.2	12.8	1.5	13.5	1.0	14.0	1.3	13.1	1.2
DF-60%Etc +60%RD NPK	11.5	1.0	11.4	1.3	11.2	1.2	12.6	1.1	11.6	1.1
Conventional fertilization(SI)	23.1	1.4	22.6	1.1	23.8	1.5	24.2	1.4	23.4	1.3
Conventional fertilization(RF)	9.0	1.2	10.3	1.0	10.8	1.1	11.4	1.2	10.3	1.1

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

A perusal of the data in Table 7&8 reveals that both in apple & apricot, the weed population varied markedly under different drip irrigation, surface irrigation and rainfed treatments over the entire active growth period. Under unmulched conditions, the mean weed population in the treatments of DF-100%Etc +100%RD NPK, DF-80%Etc +80%RD NPK, DF-60%Etc+60%RD NPK, Conventional fertilization(SI) and Conventional fertilization (RF) was found to be 9.05, 8.5, 8.1, 23.6, 7.6 and 13.5, 13.1, 11.6, 23.4,10.3 per m^2 in apple & apricot, respectively. The corresponding values under mulched conditions were 1.2, 1.1, 1.2, 1.2 1.1 and 1.3, 1.2,1.1, 1.3, 1.1 per m^2. The minimum weed population under mulched conditions in all the treatments may be attributed to the fact that black plastic mulch acted as a barrier to the passage of sunlight through to the soil surface which resulted in withering of weeds both in case of apple and apricot.

Table 9 : Depth wise distribution of Available N, P and K (ppm) after crop harvest in apple*

Treatments	Soil Depth (cm)	N			P			K		
		Before execution	After crop harvest		Before execution	After crop harvest		Before execution	After crop harvest	
			M0	M1		M0	M1		M0	M1
DF-100%Etc +100%RD NPK	0-15	128.4	133.4	135.8	31.0	38.5	39.1	125.2	140.3	141.6
	15-30	119.2	129.0	130.5	21.6	24.8	25.3	123.4	132.5	134.9
	30-45	107.5	111.5	113.2	8.4	8.4	8.5	119.6	122.0	123.0
	45-60	104.1	112.3	114.0	6.5	6.5	7.1	108.8	109.5	112.2
DF-80%Etc +80%RD NPK	0-15	127.6	131.2	133.5	30.6	37.8	37.7	125.6	138.3	141.5
	15-30	118.8	127.0	128.0	21.5	24.7	24.5	123.8	133.7	136.9
	30-45	107.3	110.5	112.5	8.2	8.2	8.2	118.4	119.2	120.4
	45-60	104.6	109.9	110.0	6.7	6.7	6.9	107.6	108.0	111.2
DF-60%Etc +60%RD NPK	0-15	129.1	123.1	125.0	30.4	37.5	37.8	126.2	130.2	131.4
	15-30	118.4	122.5	124.5	21.3	24.3	24.4	123.4	126.3	128.5
	30-45	107.1	110.8	111.3	8.1	8.3	8.5	117.8	118.5	119.7
	45-60	103.7	105.2	106.5	6.7	7.1	6.9	106.9	107.5	110.7
Conventional fertilization(SI)	0-15	128.6	132.2	133.0	28.1	35.3	35.8	125.3	136.8	138.4
	15-30	119.1	126.5	128.1	20.1	25.5	25.2	123.6	135.7	136.8
	30-45	107.5	124.3	125.5	8.0	8.0	8.3	118.4	134.7	135.3
	45-60	104.6	125.8	125.6	7.5	7.5	7.4	107.7	127.4	128.3
Conventional fertilization(RF)	0-15	128.2	139.6	140.8	27.8	34.3	34.1	126.1	157.6	158.4
	15-30	118.6	127.8	129.1	19.5	24.1	24.2	123.7	139.0	140.2
	30-45	107.3	109.0	108.4	7.8	8.1	8.2	118.3	121.4	124.6
	45-60	103.9	105.3	104.3	6.5	7.0	7.1	109.5	111.0	112.1

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 10 : Depthwise distribution of Available N, P and K (ppm) after crop harvest in apricot*

Treatments	Soil Depth (cm)	N			P			K		
		Before execution	After crop harvest		Before execution	After crop harvest		Before execution	After crop harvest	
			M0	M1		M0	M1		M0	M1
DF-100%Etc +100%RD NPK	0-15	146.8	172.4	173.8	19.5	25.8	26.5	124.4	149.2	150.4
	15-30	132.5	148.4	149.6	16.4	17.2	17.6	118.2	128.4	129.6
	30-45	128.3	135.1	136.8	10.8	11.2	11.4	111.6	115.8	116.4
	45-60	123.7	127.4	128.1	9.4	9.6	9.8	104.8	106.5	107.7
DF-80%Etc +80%RD NPK	0-15	145.4	162.6	16428	18.7	23.8	24.1	125.2	141.3	142.5
	15-30	132.1	143.4	144.9	16.2	17.5	17.8	117.8	128.0	129.2
	30-45	127.7	134.2	135.7	10.5	11.4	12.2	112.2	114.5	115.7
	45-60	122.5	127.6	128.3	9.2	9.3	9.5	105.1	106.4	107.6
DF-60%Etc +60%RD NPK	0-15	146.1	157.5	158.8	18.5	24.5	25.7	125.7	138.6	139.4
	15-30	131.5	138.7	139.9	15.8	16.5	17.2	117.6	122.1	123.5
	30-45	127.2	129.3	130.0	10.1	11.2	11.5	111.8	117.4	118.6
	45-60	123.8	125.5	126.8	9.1	9.5	9.8	105.6	106.3	107.1
Conventional fertilization(SI)	0-15	145.0	164.5	165.5	20.8	27.5	28.2	124.5	140.1	141.6
	15-30	132.3	158.2	159.7	14.6	16.8	17.2	118.2	132.5	133.3
	30-45	127.6	146.6	147.2	10.80	12.5	13.1	112.4	124.6	125.4
	45-60	123.2	137.3	138.1	9.2	9.7	9.9	104.4	105.8	106.4
Conventional fertilization(RF)	0-15	146.5	169.8	171.2	19.5	28.4	28.7	124.1	137.2	138.1
	15-30	131.8	142.4	144.8	16.8	16.3	16.7	117.5	134.8	135.4
	30-45	127.7	139.8	141.6	10.4	11.2	11.8	111.3	130.5	131.1
	45-60	124.1	129.4	131.1	9.1	9.3	9.8	105.1	106.4	107.6

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Vertical distribution of N, P and K in apple and apricot

Available N

The data enumerated in Table reveal that under unmulched conditions, the available N contents in the treatment drip fertigation (DI-100) were found to be 133.4, 129.0,111.5 ,112.3 ppm at 0-15, 15-30, 30-45 ,45-60 cm soil depths, respectively. The corresponding values under Conventional fertilization with surface irrigation and Conventional fertilization with rainfed condition were noted to be 132.2,126.5, 124.3,125.8 and 139.6,127.8,109.0 and 105.3 ppm , respectively. In case of apricot, the available N contents in the treatment drip fertigation (DI-100) were found to be 172.4,148.4,135.1 and 127.4 ppm at 0-15, 15-30, 30-45 ,45-60 cm soil depths, respectively. The corresponding values under Conventional fertilization with surface irrigation and Conventional fertilization with rainfed condition were noted to be 164.5,158.2,146.6,137.3 and 169.8, 142.4,139.8 and 129.4 ppm, respectively. Both under apple and apricot, higher amount of available N in the upper soil depths (0-30cm) under drip fertigation may be ascribed to the fact that owing to application of small quantities of water frequently in surface layers, moisture content was noted to be higher which resulted in higher concentration of available N. Whereas, in Conventional fertilization with surface irrigation, higher hydraulic gradient created in soil due to heavy volume of water applied at a time resulted in more downward movement of nitrogen thereby leading to higher availale nitrogen contents in deeper soil layers. Among the different ferigation levels, maximum available nitrogen

contents were noted in the treatment of drip fertigation with 100% RD followed by drip fertigation with 80% RD and drip fertigation with 60% RD which is in line with the fact decreasing levels of N application decreased the available N status of the soil. Application of plastic mulch did not appreciably affect the soil available N content in the treatments under study.

Available P

A perusal of the data in Table revealed that in apple under unmulched conditions, the available P contents in the treatment DF-100 at 0-15, 15-30, 30-45 ,45-60 cm soil depths were recorded to be 38.5,24.8,8.4,6.5 ppm, respectively. Such values under Conventional fertilization with surface irrigation and Conventional fertilization with rainfed condition were noted to be 35.3, 25.5,8.07.5 and 34.3,24.1,8.1 and 7.0 ppm, respectively. In case of apricot, the available P contents in the treatment drip fertigation (DI-100) were found to be 25.8,17.2,11.2,9.6 ppm at 0-15, 15-30, 30-45 ,45-60 cm soil depths, respectively. The corresponding values under Conventional fertilization with surface irrigation and Conventional fertilization with rainfed condition were noted to be 27.5,16.8, 12.5, 9.7 and 28.4,16.3 ,11.2 and 9.3 ppm, respectively. In all the treatments under study, higher P content recorded in the upper soil depths (0-30cm) is attributed to immobile nature of P coupled with fixation or conversion to non-soluble form which resulted in somewhat restricted movement of P down the soil profile. These results further corroborate from the fact that surface layers under the treatments drip fertigation(DF-100), Conventional fertilization with surface irrigation and Conventional fertilization with rainfed condition registered appreciable increase in available P content over the initial status in the surface layers (0-30cm) with almost negligible increase in lower soil depths (30-60cm) before execution of the experiment. Application of plastic mulch did not appreciably affect the soil available N content in the treatments under study.

Available K

In apple, the data on vertical distribution of available K in soil under unmulched conditions reveal that treatment drip fertigation (DI-100) recorded 140.3,132.5,122,109.5 ppm available K at 0-15, 15-30, 30-45 ,45-60 cm soil depths, respectively. The corresponding values under Conventional fertilization with surface irrigation and Conventional fertilization with rainfed condition were noted to be 136.8,135.7,134.7,127.4 and 157.6,139.0, 121.4, 111.0 ppm, respectively. In case of apricot, the available K contents in the treatment drip fertigation (DI-100) were found to be 149.2,128.4,115.8,106.5 ppm at 0-15, 15-30, 30-45 ,45-60 cm soil depths, respectively. The corresponding values under Conventional fertilization with surface irrigation and Conventional fertilization with rainfed condition were noted to be 140.1, 132.5, 124.6, 105.8 and 137.2,134.8,130.5,106.4ppm, respectively. It becomes apparent from these results that in case of fertigation, available K was more confined to upper soil layers (0-30cm) whereas reverse trend was there in conventional fertilization with surface irrigation. Among the different ferigation levels, maximum available nitrogen contents were noted in the treatment of drip fertigation with 100% RD followed by drip fertigation with 80% RD and drip fertigation with 60% RD which is corroborated from the fact the available K decreased with decreasing levels of K application especially in the surface layers of the soil. Thus, vertical distribution of available K followed the same pattern as that of available N and the reasons attributed for the same. Application of plastic mulch did not appreciably affect the soil available K content in the treatments under study.

Table 11 : Vertical and lateral distribution of NO_3-N (ppm) under different treatments after crop harvest in apricot*

Treatments	Soil depth (cm)	Below emitter		Distance from emitting point					
				15 cm		30 cm		45 cm	
		M0	M1	M0	M1	M0	M1	M0	M1
DF-100%Etc +100%RD NPK	0.0-2.5	77.8	78.2		79.7	61.5	61.7	54.3	54.5
	2.5-15	81.4	81.6	83.1	83.5	69.3	69.5	57.1	57.3
	15-30	68.1	68.4	71.5	71.7	60.6	60.8	45.6	45.8
	30-45	64.0	64.5	69.3	69.6	42.5	42.7	33.5	33.7
	30-45	62.3	63.1	66.8	67.1	35.5	35.7	28.5	28.7
DF-80%Etc +80%RD NPK	0.0-2.5	74.6	74.8	70.3	70.5	55.742.5	55.9	54.4	54.6
	2.5-15	79.3	79.5	74.1	74.4	66.8	67.0	59.1	59.3
	15-30	62.8	63.3	65.5	65.7	60.4	60.6	53.7	53.9
	30-45	60.4	61.4	62.9	63.2	52.6	52.8	41.8	42.0
DF-60%Etc +60%RD NPK	0.0-2.5	74.5	74.7	76.4	76.7	68.4	68.6	61.3	61.5
	2.5-15	78.3	78.6	79.8	80.2	70.1	70.4	62.6	62.8
	15-30	62.7	62.9	68.6	68.8	61.3	61.5	52.8	53.0
	30-45	59.4	59.7	63.2	63.5	54.6	54.8	43.5	43.7
Conventional fertilization(SI)	0.0-2.5	58.3	58.5	57.5	57.8	56.8	57.0	56.2	56.4
	2.5-15	61.5	61.7	59.2	59.4	57.4	57.6	61.1	61.3
	15-30	71.7	71.9	68.6	68.8	67.2	67.4	66.4	66.7
	30-45	76.2	76.4	73.4	73.5	71.6	71.9	71.2	71.5
Conventional fertilization(RF)	0.0-2.5	63.6	63.8	62.5	62.8	63.7	63.9	62.5	62.7
	2.5-15	83.3	83.5	80.3	80.6	79.4	79.7	78.3	78.5
	15-30	68.8	68.9	68.6	68.7	65.6	65.8	64.7	64.9
	30-45	61.4	61.6	60.1	60.4	62.8	63.0	62.4	62.6

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 12 : Vertical and lateral distribution of NH_4- N under different treatments after crop harvest in apricot*

Treatments	Soil depth (cm)	Below emitter		Distance from emitting point					
				15 cm		30 cm		45 cm	
		M0	M1	M0	M1	M0	M1	M0	M1
DF-100%Etc +100%RD NPK	0.0-2.5	69.4	69.6	60.7	60.9	49.8	49.9	40.4	40.6
	2.5-15	68.6	68.8	57.2	57.4	43.2	43.4	39.2	39.4
	15-30	43.3	43.7	37.9	38.1	30.5	30.7	26.7	26.9
	30-45	39.0	39.3	30.8	31.0	22.7	22.9	22.5	22.7
DF-80%Etc +80%RD NPK	0.0-2.5	66.4	66.7	57.7	57.8	39.4	39.6	36.7	36.9
	2.5-15	65.6	65.8	49.6	49.9	37.1	37.3	31.2	31.5
	15-30	36.2	36.5	33.2	33.3	28.0	28.4	25.0	25.2
	30-45	32.8	33.0	29.5	29.7	23.5	23.7	22.8	23.1
DF-60%Etc +60%RD NPK	0.0-2.5	59.3	59.6	45.2	45.4	38.9	39.2	34.0	34.4
	2.5-15	59.0	59.3	42.0	42.2	36.5	36.7	32.4	32.6
	15-30	39.4	39.6	30.7	30.9	28.6	28.8	25.1	25.3
	30-45	32.6	32.8	25.7	25.8	22.4	22.6	22.5	22.7
Conventional fertilization(SI)	0.0-2.5	44.3	44.6	46.4	46.6	44.5	44.7	45.0	45.4
	2.5-15	61.7	61.8	62.7	62.8	62.2	62.4	61.4	61.6
	15-30	49.9	50.0	51.5	51.9	50.5	50.8	49.6	49.8
	30-45	37.5	37.7	38.3	38.5	36.0	36.3	38.1	38.4
Conventional fertilization(RF)	0.0-2.5	53.4	53.6	51.6	51.8	51.8	52.0	51.4	51.6
	2.5-15	54.5	54.8	55.0	55.3	55.2	55.4	54.5	54.7
	15-30	40.7	40.9	42.1	42.4	41.6	41.8	41.0	41.3
	30-45	36.4	36.6	36.7	36.8	36.5	36.7	35.2	35.4

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Vertical and lateral distribution of NO_3-N after crop harvest in apricot

The data enumerated in the table on vertical distribution of NO3-N under unmulched conditions revealed that the treatment of Fertigation (DF-100 WSF) registered 77.8, 81.4, 68.1, 64.0 ppm of NO3-N at 0.0-2.5, 2.5-15, 15-30, 30-45 cm soil depths below the emitter, respectively. The corresponding values under Surface irrigation with conventional fertilization were 58.3,61.5,71.7,76.2 and 63.6,83.3,68.8,61.4 ppm respectively. These results indicate that under fertigation treatments, the NO3-N was confined to the surface soil layers due to the presence of high moisture zone because of frequent application of water in small quantities. Whereas, higher NO3-N content under Surface irrigation with conventional fertilization in the deeper layers may be ascribed to the higher hydraulic gradient thereby resulting in the leaching of NO3-N under surface irrigation. The data in Table further indicate that under drip and fertigation treatments, NO3-N content in general was higher at a distance of 15 cm away from the emitter as compared to distance of 30 cm and 45 cm away from the emitter. The lower NO3-N content below the emitter might be due to the fact that the conversion of NH4-N to NO3-N was retarded in a consistent wet zone below the emitter.

Vertical and lateral distribution of NH_4- N in soil after crop harvest in apricot

The data enumerated in the table on vertical distribution of NH_4- N under unmulched conditions revealed that the treatment of Fertigation (DF-100 WSF) registered 69.4, 68.6, 43.3, 39.0 ppm of NH4-N at 0.0-2.5, 2.5-15, 15-30, 30-45 cm soil depths below the emitter, respectively. The corresponding values under Surface irrigation with conventional fertilization were 44.3, 61.7, 49.9, 37.5 and 53.4,54.5, 40.7, 36.4 ppm,

respectively. These results indicate that under fertigation and conventional fertilization with surface irrigation treatments, most of the NH4-N was confined to the surface soil layers. The higher NH4-N content in the upper soil layer may be attributed to the fact that NH4-N are less mobile due to their strong adsorption on the soil colloids., hence are subjected to less vertical movement. The data in Table further indicate that under fertigation treatments, NH_4-N content was maximum below the emitter and it decreased at a distance of 15, 30 and 45 cm away from the emitter. This may be ascribed to a consequence of hydrolysis of urea and saturation of the soil volume adjacent to the point source during most of the irrigation period.

Table 13: Effect of different treatments on leaf N, P and K content in apple*

Treatments	N (%)			P (%)			K (%)		
	M_0	**M1**	**Mean**	**M_0**	**M1**	**Mean**	**M_0**	**M1**	**Mean**
DF-100%Etc +100%RD NPK	2.38 (1.54)	2.60 (1.61)	2.49 (1.57)	0.25 (0.50)	0.26 (0.50)	0.26 (0.50)	1.58 (1.26)	1.67 (1.29)	1.63 (1.28)
DF-80%Etc +80%RD NPK	2.25 (1.50)	2.45 (1.56)	2.35 (1.53)	0.25 (0.49)	0.26 (0.50)	0.26 (0.50)	1.50 (1.22)	1.62 (1.27)	1.56 (1.24)
DF-60%Etc +60%RD NPK	1.90 (1.37)	2.00 (1.44)	1.95 (1.39)	0.25 (0.48)	0.26 (0.49)	0.26 (0.49)	1.16 (1.07)	1.29 (1.13)	1.22 (1.10)
SI+ Conventional fertilization	2.00 (1.41)	2.20 (1.48)	2.10 (1.44)	0.21 (0.45)	0.23 (0.47)	0.22 (0.46)	1.25 (1.11)	1.40 (1.18)	1.33 (1.15)
RF+ Conventional fertilization	1.70 (1.30)	1.90 (1.37)	1.80 (1.34)	0.19 (0.43)	0.20 (0.44)	0.20 (0.44)	1.10 (1.04)	1.22 (1.10)	1.16 (1.07)
Mean	2.05 (1.43)	2.23 (1.49)		0.23 (0.47)	0.25 (0.50)		1.31 (1.14)	1.44 (1.20)	
Lsd	T	0.07		NS			0.06		
	M	0.04		NS			0.04		
	TXM	0.05		NS			0.05		

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 14 : Effect of different treatments on leaf N, P and K content in apricot*

Treatments	N (%)			P (%)			K (%)		
	M_0	**M1**	**Mean**	**M_0**	**M1**	**Mean**	**M_0**	**M1**	**Mean**
DF*-100%Etc +100%RD NPK	2.87 (1.69)	3.10 (1.76)	2.98 (1.72)	0.27 (0.51)	0.28 (0.52)	0.27 (0.51)	2.95 (1.71)	3.17 (1.78)	3.06 (1.74)
DF-80%Etc +80%RD NPK	2.78 (1.66)	3.00 (1.73)	2.89 (1.70)	0.25 (0.50)	0.27 (0.51)	0.26 (0.50)	2.90 (1.70)	3.11 (1.76)	3.00 (1.73)
DF-60%Etc +60%RD NPK	2.45 (1.56)	2.62 (1.61)	2.54 (1.59)	0.23 (0.47)	0.25 (0.50)	0.24 (0.48)	2.54 (1.59)	2.75 (1.65)	2.64 (1.62)
SI+ Conventional fertilization	2.58 (1.60)	2.78 (1.66)	2.68 (1.63)	0.23 (0.47)	0.25 (0.50)	0.24 (0.48)	2.70 (1.64)	2.89 (1.70)	2.79 (1.68)
RF+ Conventional fertilization	2.35 (1.53)	2.50 (1.58)	2.43 (1.55)	0.19 (0.43)	0.20 (0.44)	0.19 (0.43)	2.52 (1.58)	2.72 (1.64)	2.62 (1.61)
Mean	2.60 (1.61)	2.80 (1.67)					2.72 (1.65)	2.92 (1.71)	
Lsd	T	0.07		NS			0.06		
	M	0.04		NS			0.03		
	TXM	0.08		NS			0.05		

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Leaf Nutrient (NPK) Status

A perusal of the data on (Table) reveals that in apple , maximum leaf N, P and K content 2.49, 0.26 and 1.63 per cent was recorded in the treatment drip fertigation at 100% Etc and with 100% RD (DF-100) whereas c6nventional soil fertilization with surface irrigation and soil fertilization under rainfed conditions registered 2.10, 0.22 and 1.33 and 1.80, 0.20 and 1.16 per cent leaf N, P and K under unmulched conditions, respectively. In apricot, maximum leaf N content of 2.98, 0.27 and 3.06% was recorded in the treatment drip fertigation at 100% Etc and with 100% RD whereas c6nventional soil fertilization with surface irrigation and soil fertilization under rainfed conditions registered 2.68, 0.24 and 2.79 and 2.43, 0.19 and 2.62% leaf N, P and K under unmulched conditions, respectively. The data was also subjected to statistical analysis which revealed that leaf N and K content did not vary significantly between the treatments DF-100 and DF-80 with significant variations over rest of the treatments. Fertigation X mulch interactions followed the same trend. Whereas, main effects of mulch were statistically significant. (Table). The higher leaf N and K under fertigation may be the result of higher N and K uptake because of direct application of fertilizers frequently with small quantities of water through drip irrigation in the root zone with minimum leaching losses. Higher NO3-N and K content in 0-30 cm soil layers also contributed to higher leaf N and K content under fertigation. Application of plastic mulch significantly increased the leaf N and K content because of better soil hydrothermal regimes which helped in better uptake of applied nitrogen and potassium. However, there were no significant difference in leaf P content under unmulched as well as mulched conditions among all the treatments tried.

Table 15: Effect of different treatments on increase in trunk girth, annual shoot growth (ASG) and tree height in apple*

Treatments	Trunk girth (%)			ASG (cm)			Tree height (cm)		
	M_0	M1	Mean	M_0	M1	Mean	M_0	M1	Mean
T1(SI)	2.20 (1.48)	2.42 (1.56)	2.31 (1.51)	35.2	40.1	37.7	39.6	44.2	41.9
T2(DI-100% ETc)	2.65 (1.62)	2.84 (1.69)	2.74 (1.65)	41.5	47.7	44.6	46.2	53.5	49.8
T3(DI-80% ETc)	2.60 (1.61)	2.80 (1.67)	2.70 (1.64)	39.1	46.2	42.6	42.8	50.1	46.5
T4 (DI-60% ETc)	2.37 (1.54)	2.62 (1.61)	2.49 (1.57)	21.8	27.3	24.6	25.4	33.1	29.3
T5 (RF)	2.10 (1.44)	2.32 (1.52)	2.21 (1.48)	20.2	26.5	23.4	21.1	28.3	24.7
T6 (DF-100%RD NPK)	2.68 (1.63)	2.90 (1.70)	2.79 (1.67)	43.5	49.3	46.4	49.5	56.8	53.2
T7 (DF-80%RD NPK)	2.62 (1.61)	2.86 (1.69)	2.74 (1.65)	39.6	46.5	43.0	46.2.	53.6	49.9
T8 (DF-60%RD NPK)	2.40 (1.54)	2.66 (1.63)	2.53 (1.59)	24.4	30.7	27.6	29.4	36.7	32.6
Mean	2.45 (1.56)	2.67 (1.63)		33.1	39.2		35.5	44.5	
lsd	T		0.09		5.27				5.84
	M		0.04		3.86				3.42
	TXM		0.05		5.15				6.62

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 16: Effect of different treatments on increase in trunk girth, annual shoot growth (ASG) and tree height in apricot*

Treatments	Trunk girth (cm)			ASG (cm)			Tree height (m)		
	M_0	M1	Mean	M_0	M1	Mean	M_0	M1	Mean
T1(SI)	72.5	72.7	72.6	25.3	27.5	26.4	5.7	5.9	5.8
T2(DI-100% ETc)	72.8	73.00	72.9	35.8	38.3	37.1	6.3	6.6	6.4
T3(DI-80% ETc)	72.6	72.8	72.7	35.6	37.9	36.8	6.2	6.5	6.3
T4 (DI-60% ETc)	72.4	72.5	72.4	31.1	32.5	31.8	5.7	5.9	5.8
T5 (RF)	71.0	71.2	71.1	21.2	24.7	22.9	5.1	5.4	5.2
T6 (DF-100%RD NPK)	73.5	73.6	73.5	36.5	38.8	37.6	6.4	6.7	6.5
T7 (DF-80%RD NPK)	73.2	73.3	73.2	35.8	38.1	37.0	6.3	6.6	6.4
T8 (DF-60%RD NPK)	73.0	73.2	73.1	31.5	32.8	32.1	5.8	6.2	6.0
Mean				31.6	33.3		5.9	6.2	
lsd	T	NS		4.51		NS			
	M	NS		1.55		NS			
	TXM	NS		1.18		NS			

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Tree Growth Characteristics : The data enumerated in Table reveal that in apple, the treatment T6M1 (drip fertigation at 100% RD) registered maximum increase in trunk girth (2.79%), maximum annual shoot growth (46.4cm) , tree height (53.2cm), EW and NS- tree spread (51.6 and 46.0 cm) and canopy volume (5.2 cm^3) whereas respective minimum values(2.21%),(23.4cm),(24.7cm) ,(24.4 and 21.3cm) and (2.12 cm^3) and were recorded in the treatment (Rainfed with conventional fertilization). The, values, however, did not differ significantly among the treatments drip irrigation at 100% of Etc and 80% of Etc ie (DI-100 and DI-80) and drip fertigation at 100% RD and 80% RD ie (DF-100 and DF-80) with significant differences over rest of the treatments. Interaction effects of Treatments X Mulch followed the same trend. Whereas, Main effects of mulch were found to be statistically significant. Similarly, in apricot, the treatment T6M1 drip fertigation at 100% RD (DF-100) registered maximum increase in trunk girth (73.5), maximum annual shoot growth (37.6) , tree height (6.5), EW and NS- tree spread (6.83 and 6.88cm) and canopy volume (148.65) whereas respective minimum values (71.1),(22.9),(5.2),(5.59 and 5.65) and (98.60)were recorded in the treatment T5M0 (Rainfed with conventional fertilization). The, values, however, did not differ significantly among the treatments drip irrigation at 100% of Etc and 80% of Etc ie (DI-100 and DI-80) and drip fertigation at 100% RD and 80% RD ie (DF-100 and DF-80) with significant differences over rest of the treatments. Interaction effects of Treatments X Mulch followed the same trend. Whereas, Main effects of mulch were found to be statistically significant. Better growth characteristics of the apple and apricot under drip irrigation and fertigation may be attributed to uniform higher moisture distribution in the soil, availability of soil moisture and nutrients during the critical growth stages and higher nutrient uptake. Whereas, due to application of heavy volume of water under surface irrigation with conventional

fertilization, there was loss of water and nutrients due to deep percolation beyond root zone which resulted in lesser growth characteristics. The higher growth parameters under mulch may be ascribed to better soil hydrothermal regimes and higher nutrient uptake due to lesser weed population.

Table 17 : Effect of different treatments on increase in tree spread and canopy volume in apple*

Treatments	EW-spread(cm)			NS-spread(cm)			Canopy volume (m3)		
	M_0	M1	Mean	M_0	M1	Mean	M_0	M1	Mean
T1(SI)	40.2	45.4	42.8	35.4	40.1	37.8	3.1	3.5	3.3
T2(DI-100% ETc)	47.6	53.2	50.4	42.1	47.9	45.0	4.2	4.7	4.5
T3(DI-80% ETc)	43.2	50.5	46.9	39.6	42.4	41.0	3.4	3.9	3.7
T4 (DI-60% ETc)	24.5	29.7	27.1	21.2	26.4	23.8	2.4	2.7	2.6
T5 (RF)	22.0	26.8	24.4	19.5	23.1	21.3	1.8	2.4	2.1
T6 (DF-100%RD NPK)	48.0	55.2	51.6	43.4	48.5	46.0	4.8	5.5	5.2
T7 (DF-80%RD NPK)	44.8	51.1	47.9	40.1	45.4	42.8	3.6	4.8	4.2
T8 (DF-60%RD NPK)	25.1	30.5	27.8	22.4	27.7	25.1	2.8	3.2	3.0
Mean	36.9	42.8		32.9	37.7		3.3	3.8	
lsd	T	6.63		5.12			0.65		
	M	4.78		4.55			0.44		
	TXM	5.12		4.73			0.88		

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 18: Effect of different treatments on increase in tree spread and canopy volume in apricot*

Treatments	EW-spread(cm)			NS-spread(cm)			Canopy volume (m3)		
	M_0	M1	Mean	M_0	M1	Mean	M_0	M1	Mean
T1(SI)	5.60	5.77	5.68	5.68	5.85	5.76	104.50	110.00	107.25
T2(DI-100% ETc)	6.64	6.85	6.74	6.70	6.91	6.80	132.65	147.80	140.22
T3(DI-80% ETc)	6.60	6.78	6.69	6.65	6.83	6.74	130.40	146.00	138.20
T4 (DI-60% ETc)	6.35	6.52	6.43	6.41	6.58	6.49	125.85	140.50	133.17
T5 (RF)	5.50	5.68	5.59	5.56	5.75	5.65	94.70	102.50	98.60
T6 (DF-100%RD NPK)	6.73	6.94	6.83	6.78	6.99	6.88	140.50	156.80	148.65
T7 (DF-80%RD NPK)	6.67	6.84	6.75	6.73	6.88	6.80	138.40	154.35	146.37
T8 (DF-60%RD NPK)	6.42	6.63	6.52	6.47	6.69	6.58	134.60	146.50	140.55
Mean	6.31	6.50		6.37	6.56		125.20	138.10	
lsd	T	0.18		0.13			1.22		
	M	0.15		0.15			0.94		
	TXM	0.12		0.17			1.86		

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 19 : Effect of different treatments on fruit yield and quality parameters in apple*

Treatments	Yield(t/ha)			Fruit weight (gm)			Fruit volume(cc)			Fruit Pressure (Kg/cm^2)		
	M0	M1	Mean	M0	M1	Mean	M0	M1	Mean	M0	M1	Mean
T1(SI)	10.8	11.9	11.4	107.2	109.0	108.1	94.8	106.2	100.5	7.9	8.1	8.0
T2(DI-100% ETc)	11.6	13.4	12.5	115.5	119.2	117.4	108.8	110.0	109.4	8.1	8.2	8.2
T3(DI-80% ETc)	11.3	13.1	12.2	105.6	114.4	110.0	97.5	109.4	103.5	7.9	8.1	8.0
T4 (DI-60% ETc)	9.4	10.5	9.9	91.0	102.8	96.9	85.1	96.0	90.6	8.0	8.0	8.0
T5 (RF)	10.6	11.4	11.0	79.5	82.2	80.9	72.4	76.8	74.6	7.8	7.9	7.9
T6 (DF-100%RD NPK)	12.2	13.8	13.0	129.2	142.8	136.0	115.2	122.5	118.9	8.1	8.2	8.2
T7 (DF-80%RD NPK)	11.8	13.5	12.6	118.6	132.4	125.5	106.8	114.3	110.6	7.9	8.1	8.0
T8 (DF-60%RD NPK)	9.6	11.2	10.4	102.4	113.8	108.1	93.1	101.0	97.1	8.0	8.0	8.0
Mean	10.9	12.3		106.1	114.6		96.7	104.5		8.0	8.1	
Lsd	T		1.12			9.11		8.71				NS
	M		0.90			5.15		6.94				NS
	TXM		0.95			11.32		8.11				NS

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Table 20 : Effect of different treatments on fruit yield and quality parameters in apple (Farmers' Field)

Treatments	Yield(t/ha)			Fruit weight (gm)			Fruit volume(cc)			Fruit Pressure (Kg/cm2)		
	M0	M1	Mean	M0	M1	Mean	M0	M1	Mean	M0	M1	Mean
T1(SI)	11.2	11.9	11.6	110.4	113.7	112.0	96.4	108.2	102.3	8.0	8.1	8.0
T2(DI-100% ETc)	14.3	15.8	15.1	118.1	121.5	119.8	110.5	112.3	111.4	8.1	8.2	8.1
T3(DI-80% ETc)	13.8	15.2	14.5	108.4	119.2	113.8	108.5	111.4	109.9	8.0	8.1	8.0
T4 (DI-60% ETc)	9.7	10.8	10.3	94.2	97.8	96.0	88.4	99.0	93.7	8.0	8.0	8.0
T5 (RF)	11.2	11.8	11.5	82.6	86.7	84.7	75.5	78.7	77.1	7.8	7.9	7.8
T6 (DF-100%RD NPK)	14.8	16.1	15.5	132.4	135.8	134.1	118.1	125.7	121.9	8.1	8.2	8.1
T7 (DF-80%RD NPK)	14.6	15.4	15.0	121.2	125.6	123.4	116.8	120.2	110.6	8.0	8.1	8.0
T8 (DF-60%RD NPK)	9.8	11.4	10.6	105.7	109.4	107.6	97.1	101.2	97.1	7.9	8.0	7.9
Mean	12.4	13.6		109.1	113.7		101.4	107.0		7.9	8.0	
Lsd	T	1.38		9.11			7.71			NS		
	M	0.90		4.55			5.24			NS		
	TXM	1.12		11.32			8.11			NS		

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed **M0: Unmulched; M1: Mulched**
***Average value of 3 years data**

Table 21: Effect of different treatments on fruit yield and quality parameters in apricot*

Treatments	Yield(t/ha)			Fruit weight (gm)			Fruit volume(cc)			Fruit length(mm)		
	M0	M1	Mean	M0	M1	Mean	M0	M1	Mean	M0	M1	Mean
T1(SI)	8.3	8.6	8.5	19.1	20.3	19.7	11.1	11.8	11.4	23.5	26.1	24.8
T2(DI-100% Etc)	9.4	9.7	9.5	20.7	21.8	21.2	13.8	14.5	14.1	28.8	31.5	30.1
T3(DI-80% ETc)	9.1	9.5	9.3	19.0	20.1	19.6	13.6	14.2	13.9	27.2	30.4	28.8
T4(DI-60% ETc)	7.0	7.6	7.3	18.2	18.8	18.5	9.3	9.8	9.5	24.4	26.8	25.6
T5(RF)	7.7	8.6	8.2	16.3	17.6	16.9	8.4	9.3	8.8	17.8	20.2	19.0
T6(DF-100%RD NPK)	9.6	10.1	9.9	21.0	22.5	21.7	14.6	15.2	14.9	30.5	33.2	31.9
T7(DF-80%RD NPK)	9.3	10.0	9.7	19.5	20.7	20.1	14.2	14.9	14.5	29.8	32.7	31.3
T8(DF-60%RD NPK)	7.2	8.0	7.6	18.7	20.0	19.3	9.5	10.3	9.9	24.2	26.4	25.3
Mean	8.4	9.0		19.0	20.2		11.8	12.5		25.8	28.4	
Lsd	T		1.11			1.13		2.65				3.25
	M		0.50			1.15		0.72				2.18
	TXM		0.38			0.95		0.40				2.34

DF- Drip fertigation; SI- Surface irrigation; RF-Rainfed
M0: Unmulched; M1: Mulched
***Average value of 3 years data**

Fruit Yield and Quality Characteristics

The data presented in Table reveal that in apple, significantly maximum average fruit yield (13 t/ha), fruit weight (125.9gm), fruit volume (118.9cc) and fruit pressure of (8Kg/cm^2) was recorded under the treatment T6 (DF-100) whereas minimum average fruit yield (11.0 t/ha), fruit weight (82.6gm), fruit volume (74.6 gm) and fruit pressure (7.9Kg/cm$^{2)}$ were recorded under the treatment T5 (RF+CF).The values of fruit yield did not differ significantly among the treatments drip irrigation at 100% of Etc and 80% of Etc ie (DI-100 and DI-80) and drip fertigation at 100% RD and 80% RD ie (DF-100 and DF-80) with significant differences over rest of the treatments. Whereas, significant differences were there for fruit weight and volume among all the treatments under study. Interaction effects of Treatments X Mulch followed the same trend. Whereas, Main effects of mulch were found to be statistically significant for fruit yield, weight and volume. Similarly, at Farmers' Field, maximum average fruit yield (15.5 t/ha), fruit weight (134.1gm), fruit volume (121.9cc) and fruit pressure (8.1 Kg/cm^2) was recorded under the treatment T6 (DF-100) whereas minimum average fruit yield (11.5 t/ha), fruit weight(84.7gm), fruit volume (77.1 cc) and fruit pressure (7.8 Kg/cm^2) were recorded under the treatment T5 (RF+CF). In apricot, again the significantly maximum average fruit yield(9.9 t/ha), fruit weight(21.7gm), fruit volume (14.9 cc) and fruit length of (31.9 mm) was recorded under the treatment T6 (DF-100) whereas minimum average fruit yield(8.2 t/ha), fruit weight(16.9gm), fruit volume(8.8gm) and fruit length (19mm) were recorded under the treatment T5 (RF+CF) (Rainfed with conventional fertilization). The, values of fruit yield did not differ significantly among the treatments drip irrigation at 100% of Etc and 80% of Etc ie (DI-100 and DI-80) and drip fertigation at 100% RD and 80% RD ie (DF-100 and DF-80) with significant differences over rest of the treatments. However, significant differences were there for fruit weight and volume and length between the treatments under study. Interaction effects of Treatments X Mulch followed the same trend. Whereas, Main effects of mulch were found to be statistically significant. Comparatively, higher fruit yield and quality characteristics under the treatments of drip irrigation and fertigation over surface irrigation and rainfed

conditions with conventional fertilization may be ascribed to the fact that drip irrigation provides frequent irrigation coupled with continuous replenishment of moisture and nutrients through fertigation when fertilizers were applied in splits. This condition might have aided in better mobilization of nutrients and also the adequate soil moisture ensured increase in total NPK uptake, higher photosynthetic rate and lesser loss of water through evapo-transpiration which ultimately had a favorable effect on fruit yield and quality characteristics. On the other hand in surface irrigation with conventional fertilization, large quantities of water were applied at a time which caused higher leaching losses of nutrients, mainly nitrogen, due to deep percolation of water while under rainfed conditions, the plants remained under continuous moisture and nutrient stress due to non-availability of irrigation water. These conditions adversely affected the magnitude of fruit yield and quality characteristics under surface irrigation and rainfed conditions with conventional fertilization.

8.2 Drip irrigation and Fertigation schedules in apple and apricot

Table 22: Nos. of irrigation, fertigation (100%RD) and total water to be applied/tree under drip Irrigation (100% Etc) in apple

Months	Water applied/irrigation (litres)	Nos. of irrigation	Nos. of fertigation	Total Water to be Applied (litres)
March	11	8	2	88
April	13	8	2	104
May	16	8	2	128
June	17	8	2	136
July	15	8	2	120

Table 23: Nos. of irrigation, fertigation (100%RD) and total water to be applied/tree (100%Etc) under drip irrigation in apricot

Months	Water applied/irrigation (litres)	Nos. of irrigation	Nos. of fertigation	Total Water to be Applied (litres)
March	11	8	2	88
April	13	8	2	104
May	16	8	2	128
June	17	8	2	136

9. Conclusions/ Recommendations: (Based on Results & Discussion given from Table 1 to Table 23)

From the project studies conducted, it is concluded that both in apple and apricot, 18-20% % increase in fruit yield can be achieved under fertigation besides better quality crop. To get a yield level of 13t/ha in apple and 9.9t/ha in apricot, the crops should be drip irrigated at 80% Etc with fertigation @ 80% of the recommended dose of NPK fertilizers (Table 19&21). For that purpose, drip irrigation and fertigation schedules are given in Table 22 & 23. surface (0-30 cm) soil moisture contents under drip irrigation were higher under drip irrigation as compared to surface irrigation and rainfed conditions. Application of black plastic mulch resulted in moderation of soil hydro-thermal regimes and checking of weed growth which proved to be beneficial for plant growth. Soil and leaf nutrient (NPK) values were found to be higher under fertigation than conventional fertilization. The study suggests that

10. How do the conclusions/recommendations compare with current thinking :

The conclusions/recommendations have proved the superiority of drip irrigation and fertigation over conventional surface irrigation conditions/ rainfed cultivation and fertilization so as to maximize crop yield and quality.

11. Field tests conducted. Yes. (The field tests were conducted in the field of farmer named Sh. Partap Chauhan, V. Pajol, near Huli, Teh. Kotkhai, Distt. Shimla (HP). The results of the trials were found to be authentic which has encouraged the aforesaid farmer and farmers of the adjoining areas to adopt the technology generated in the project on large scale by covering more area of his field with black plastic mulch and drip irrigation. Sh. Partap Chauhan also interacted with Sh. SK Gangwar, the then Diector (R&D), MOWR, GOI, during his visit in 2016 to the trial site and gave favourable inputs with regard to the technologies of the project applied in his field)

12. Software generated, if any. No

13. Possibilities of any patents/copyrights. No

14. Suggestions for further work:

Studies may be conducted on effect of reflective plastic mulch and drip irrigation and fertigation.