

**“EFFECT OF DIFFERENT SOIL MANAGEMENT
PRACTICES ON MOISTURE CONSERVATION IN SOILS
UNDER ARID FRUITS”**

**BY
SHISHPAL POONIA
(99A69D)**

**Dissertation submitted to the Chaudhary Charan Singh
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of the requirements for the degree of:**

**Doctor of Philosophy
in
Soil Science**



**COLLEGE OF AGRICULTURE
CCS HARYANA AGRICULTURAL UNIVERSITY
HISAR - 125 004 (HARYANA)**

2005

**Dedicated
to
my
Beloved parents**

CERTIFICATE - I

This is to certify that this dissertation entitled **“Effect of different soil management practices on moisture conservation in soils under arid fruits”** submitted for the degree of **Doctor of Philosophy** in the subject of **Soil Science** of the **CCS Haryana Agricultural University, Hisar**, is a bonafide research work carried out by **Shish Pal Poonia** under my supervision and that no part of this dissertation has been submitted for any other degree.

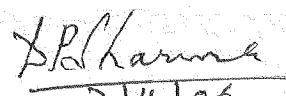
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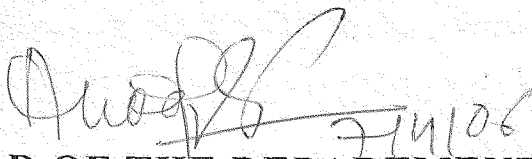

(Dr. Milakh Raj)¹⁰⁶
Major Advisor,
Sr. Soil Physicist & Chief Scientist
Dry Land Agriculture
Department of Agronomy
CCS Haryana Agricultural University,
Hisar – 125004, India

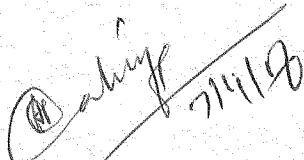
CERTIFICATE - II

This is to certify that this dissertation entitled “Effect of different soil management practices on moisture conservation in soils under arid fruits” submitted by Shish Pal Poonia to CCS Haryana Agricultural University, Hisar in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** in the subject of **Soil Science**, has been approved by the Student’s Advisory Committee after an oral examination on the same.


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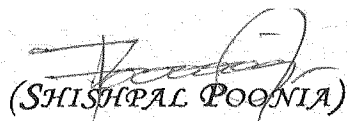
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(SHISHPAL POONIA)

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Introduction

World population of 6 billion is expected to reach 8 billion by the year 2025 and 9.4 billion by 2050 of which 3 billion reside in arid and semiarid environments. India will experience the largest growth in population of 575 million by 2050. Therefore, meeting basic demands for this unprecedented large population will be major challenge to agricultural scientists and land managers.

In India, about 10% of total geographical area covering 30 m/ha of hot desert, located in parts of Rajasthan, Gujrat, Punjab, Haryana, Andhra Pardesh and Karnatka comes under sandy soils including sand dunes. These arid and semiarid zones with high rates of population growth, urbanization and industrialization will be limiting agricultural development in next 25 years. Large quantity of fresh water supply will be diverted from agriculture to municipal and industrial sectors in the region. In order to overcome water shortage and to satisfy the increasing water demand for agricultural development, efficient rain water harvesting is becoming important in such areas.

About 19 percent of Haryana's total geographical area (44212.89 km²), predominately in south-western districts falls in arid ecosystem (Ahuja *et al.*, 1988). This area is predominantly under rainfed agriculture where water is a major limiting factor in crop production. The annual average rainfall in this region ranges between 300-500 mm. Apart from variation in the total seasonal rainfall, the region experiences large

variability in date of commencement of the monsoon rains as well as in the distribution of the rainfall within the crop growing season.

These regions are characterized by sparse vegetation resulting in acute shortage of food, fodder and fuel. Traditional and subsistence oriented cropping pattern leads to low economic returns.

There is an extreme scarcity of water in such areas. The deeper ground water is mostly brackish, so the crop growing season depends on the rainfall distribution, water storage also and its release characteristics of the soil as crops extract stored moisture after rains.

In the absence of vegetative cover, this tract is gradually spreading to the adjoining areas. Stabilization of these deserts through vegetation is the only answer to this severe problem. Alley cropping may be a system to achieve this, in which crops are grown in alley's formed by tree rows of fruit trees or shrubs (Buresh, 1995). Agronomic management of crops and trees becomes important to optimize the production and minimize the risk of crop failure. Secondly, prunings of fruit trees are either used as mulch, fodder or fuel. This system for such areas has potential to sustain adequate food productions with lower agricultural inputs while conserving the resource base.

The *in situ* water harvesting techniques can be used for growing trees in such a way that each tree has its own micro-catchment area. Runoff water can also be stored in tanks during the rains and the same can be utilized when fruit trees show moisture stress during dry months. The crops selected for such area must be such in which maximum growth takes place during the period of maximum water availability in soil.

Horticulture based farming systems have also assumed great importance in recent years. In addition to fuel from the pruned wood, trees provide fruits. In some cases fodder for animals and leaf litter can be used as mulch to protect the top soil from the impact of rain and reduce evaporation losses of water.

In recent years many reports dealing with stabilization of sand dunes by growing the perennial forest plants have appeared in literature but there is a strong need for developing relationship of rainfall intensity and its duration (i) with water harvesting and soil erosion (ii) conserving soil and water through residue management and (iii) improving water use efficiency through development and adoption of efficient methods of water harvesting in these soil under arid fruits.

Therefore, the present investigation was planned with the following objectives:

1. To study the effect of rainfall intensity and duration on runoff in relation to different slopes and pond sediment thickness.
2. To investigate effect of mulches on moisture distribution under arid fruits.
3. To evaluate the simultaneous effect of soil slope and mulching on moisture depletion by 15 years old *Ber* trees.
4. To study the vertical distribution of irrigation water and nitrate-N as a function of time.

Review of Literature

The literature pertaining to the investigation entitled “Effect of different soil management practices on moisture conservation in soils under arid fruits” has been reviewed in this chapter. Scanty and piecemeal work has been done on this aspect in India and abroad. An effort has been made to review the aforesaid parameters from whatever literature is available on different practices under appropriate headings as under.

- 2.1 Rain-water runoff/harvesting and soil loss.
- 2.2 Moisture conservation through different mulching materials.
- 2.3 Moisture conservation through surface manipulations.
 - 2.3.1 Moisture conservation and distribution in soil.
 - 2.3.2 Effect of *in-situ* conserved moisture on fruit quality.
- 2.4 Leaching/transportation of nitrogen in soil.

2.1 Rain-water runoff/harvesting and soil loss

Rainwater harvesting/runoff mainly depends upon intensity and duration of rainfall and soil surface characteristics.

Young and Wiersma (1973) conducted a laboratory experiment using loam, silt loam and (control) sandy loam soils through simulated rainfall and concluded that at 4.6 cm/hr rain for 165 min with 9.0% soil slope, soil loss initially was very high as 40 g/min, 30 g/min and 64 g/min with loam, silt loam

and sandy loam soil, respectively, reaching this peak at 10 min, 15 min and 25 min of rain and thereafter it decreased.

Quansah (1981) from a laboratory experiment using four soils, *viz.* graded sand, sand, clay loam, clay; four slopes as 0.0, 3.5, 7.0 and 14.0% and four intensities 5, 8, 11 and 14 cm/hr and reported that the variation in the amount of soil detached and transported between the soil types may be accounted for by examining the particle size distribution; of to soils which according to Wishmier *et al.* (1971) is a major determinant of the susceptibility of soils to erosion with fine sand being the least resistant to erosion (Baver, 1966) and detachment increases as the fine sand content of the soils increase. The magnitude of increase depends upon rainfall intensity and soil slope. Clayey soils erode in the form of discrete aggregates larger in size than the sand grains. Clay soils detached once as aggregates become a part of the non-cohesive population, the transport of which is function of the properties of the separates. The amount of soil transported from each soil type may follow the forces binding the particles.

Soil erosion increases with increase in soil slope and rain fall intensity (Quansah, 1981).

Nalatwadmath *et al.*, (2004) while studying rainfall runoff soil loss relationship in vertisols reported that per cent runoff of rainfall increased from 44.7 to 56.7 with increase in soil slope from 0.5 to 2 %, the corresponding soil loss increased from 23.2 to 29.9 kg/ha/mm (average of 13 years). They further observed that runoff percentage and soil loss were negatively correlated with the lengths of plot.

Xiao-Yanhi *et al.* (2004) harvested natural rain water through six different surface treatments in North-West China.

The surface treatment included two basic types i.e. earthen (natural loess slope, cleared loess slope) and barrier type surface treatments (concrete, asphalt fiberglass, plastic film and gravel covered plastic film). This study showed that runoff and runoff efficiency of earthen surface treatments were closely related to rainfall intensity, while runoff from barrier surface treatments was related with the amount of rainfall. Rain water harvested with earthen treatment was 9-13%, whereas under barrier treatments it ranged between 46-81% from total rainfall. Runoff and soil loss for three soils with differing mineralogy was reported by Ber-Hur and Wakindiki (2004) under simulated rainfall (8 cm/hr.) with soil slope of 9, 15, 20 and 25%. The total runoff as a per cent of rainfall ranged from 24 to 18%, 65 to 43% and 50 to 35% from the kaolinitic, clay smectite and sandy loam smectite soils, respectively. Total soil loss ranged from 0.32 to 0.45 and 1.14 to 3.93 kg/m for the kaolinitic and smectitic soils, respectively.

Patil *et al.* (2004) conducted a six years field experiment on medium black clay soils with 30 m x 1.65 m plot having 1% slope. Total rain 859.9 mm caused runoff of 316.5 mm and soil loss of 3.57 t/ha, whereas rainfall of 115.4 caused runoff 21.81 mm and soil loss 0.88 t/ha. and 264.2 mm rainfall caused 46.8 mm runoff and 2.12 t/ha soil loss.

Deshmukh *et al.* (2005) from field experiment on sandy loam soil reported that soil loss rate was 945.13, 3093.23 and 4969.13 mg/m²/min at 0%, 2% and 4% land slopes, respectively for 9.0 cm/hr. rainfall intensity.

Frauenfeld and Truman (2004) undertook laboratory experiment to evaluate the effect of rainfall intensity on loamy sand (4% slope) and sandy clay loam soil (7% slope) and

concluded that under constant rainfall intensity (0.95 mm/min) the total soil loss and runoff were 0.33 kg/m²/h and 48.8 mm/h, 0.59 kg/m²/h and 43.89 mm/h for loamy sand and sandy clay loam soil, respectively.

Nalatwadmath *et al.* (2004) from 13 years field experiment with natural rainfall concluded that the runoff was 155.8, 175.1 and 192.4 mm corresponding to soil slope of 0.5%, 1.0% and 2.0%, respectively.

2.2 Moisture conservation through different mulching materials.

Decreasing soil water evaporation is one means of improving water conservation. Soil water loss with time as affected by simulated tillage to depths of 2.5 and 7.5 cm. was measured from soil column in a constant room temperature. Tilling was done at 1, 4, 7 and 18 days after irrigation and observed that tillage effectively terminated 1st stage drying and evaporative losses were reduced by tilling as compared to control. Highest reduction of evaporation was associated with earliest tilling which showed over 50% reduction in evaporation losses for more than 22 days after tilling. Evaporation reduction was only slightly better with 7.5 cm than with 2.5 cm tillage (Willis and Bond, 1971).

Singh *et al.* (1976) conducted field study on sandy loam soil with five mulching treatments of no mulch, wheat straw @ 12.5 t/ha, transparent polyethylene, transparent polyethylene covered with wheat straw @ 12.5 t/ha and white opaque polyethylene and observed that the opaque polyethylene mulches and polyethylene + straw mulches had conserved almost an equal quantity of water (3 cm/20 cm soil) after 16

days of sowing but at 31 day stage the water contents were 2.7 and 2.2 cm as compared to 1.4 cm in control.

Gupta *et al.* (1976) collected eighteen soil profiles from different locations of North-West Himalayas, representing four soil orders, three bio-sequences and five climo sequences to determine water retention characteristics and concluded that the clay content alone had no significant effect on water retention in any of sequences studied.

Gill and Prihar (1983) conducted a laboratory column study using sandy loam soil and concluded that cultivation reduced evaporation, though cultivated layer dried more rapidly than the corresponding depths of uncultivated soil, but the layers below the loosened soil always had more water in cultivated soil than in uncultivated and in 12 cm than in 6 cm cultivation.

Chaudhary *et al.* (1985) reported two years of water depletion from field capacity in soil between the surface and a depth of 90 cm. from pre-sowing irrigation under no mulch, straw mulch, black polyethylene mulch and polyethylene covered with straw mulch and values were 14.4, 12.4, 8.7 and 9.2 cm, respectively.

Sandhu *et al.* (1987) conducted three years field experiment with no mulch and mulching with rice straw @ 6 Mg/ha and observed that mulch induced water conservation for whole growing season varied from 16 to 33 mm with IW/CPE of 0.6 and 7 to 37 mm with 0.9 ratio in soil profile from 0-180 cm depth. It was further reported that straw mulching saved 23 cm irrigation water for comparable yield of sorghum.

Gupta and Acharya (1993) conducted a field experiment using different mulching materials i.e. transparent and black polyethylene mulches, pine needles and eupatorium

mulch as straw and no mulch and concluded that the cumulative loss in water content was maximum under no mulch and least under black polyethylene followed by transparent polyethylene, pine needles and grass mulched treatments. Similar studies were also conducted by Mittal *et al.* (1997), Arika and Lenga (2000) and Singh *et al.* (2004).

Whereas studies of Feng-Min *et al.* (2004) revealed that polyethylene mulch did not save the moisture after 60 days of sowing and further upto harvesting time. This indicated that although the mulch depressed soil water evaporation in mulched treatments, film mulching does not increase soil water content in the latter growth period, since it promoted plant growth which leads to greater transpiration and greater soil water consumption.

Thomas *et al.* (2005) concluded that mulching did not affect moisture significantly due to preventing rain from penetrating into soil in cases of frequent but small rainfall or possibly, the heavy rainfall shortly before sampling may also have nullified any moisture conserving effects of straw mulch.

2.3 Moisture conservation and distribution through surface manipulation

2.3.1 Moisture conservation and its distribution

2.3.2 Effect of *in-situ* conserved moisture on fruit yield and quality

2.3.1 Moisture conservation and its distribution

An experiment on three dryland crops viz. cowpea, grain sorghum, sun flower under no tillage and stubble mulch tillage showed that residual water contents at harvest were 28 to 93 mm greater under cowpea as compared to sorghum and this

additional water was confined to soil depths between 0.5 and 1.7 meter. Soil depths of 1.0 to 1.8 m were the most important source of stored water for sorghum and sunflower towards the end of season (Moroke *et al.* (2005). This study showed that a rotation of cowpea with sorghum or sunflower would permit the stratified use of soil water stored in deeper profile. Root length density was significantly high in subsoil under sorghum and sunflower in lateral growing season as compared to surface soil.

Singh *et al.* (2004) from an eight year experiment under plum fruits trees with three mulching treatments reported that in hay mulched fruits trees, *in situ* soil moisture conservation was 1.74 to 8.20% higher than that of un-mulched trees.

Nath *et al.* (2005) undertook a study in Lichi orchard to see the effect of different methods of *in-situ* water harvesting. It was observed that water harvested through full moon terracing resulted in early panicle initiation in Lichi trees.

Similar study conducted by Hernandez *et al.* (2005) with different vegetable cover mulching revealed that significantly higher moisture was conserved in summer and spring as compared to conventional tillage upto 60 cm. soil depth whereas effect of mulching was found non-significant in autumn season.

Shaikh *et al.* (2004) shown in a field experiment that groundnut saved the moisture under polyethylene mulch. Whereas Tiwari *et al.* (1998) compared the black as well as transparent polyethylene sheet as mulch and concluded that 100% irrigation requirement met through drip irrigation along with black plastic mulch gave the highest yield with minimum water loss from soil profile.

Zhong-Kui *et al.* (2005) compared evaporation losses from different levels of moisture regime with plastic mulching and suggested that plastic mulching could decrease evaporation from soil by 55%, if minimum soil water content was maintained 60% of field capacity.

Ehrler *et al.* (1978) from water harvesting experiment concluded that after 43.5 mm of rain, moisture penetrated the soil depth upto 140 cm after application of dust suppressant oil in micro catchments as compared to 40 cm moisture penetration in control, where water was harvested from slope only. The jojoba yield increased significantly with harvested rainwater.

Douing *et al.* (2005) could not observe significant effect of straw mulch on moisture saving in potato growing fields.

Yadav *et al.* (1999) reported that the flux direction was upward in summer season. It was in deepest layer under tree and in control was above the field capacity.

Yadav (1996) studied the profile moisture status under different trees in a desert ecosystem in summer and rainy season. Profile moisture status was highest under control followed by *Prosopis cineraria*, > *Azadirachta indica*, > *Albizia lebbek*, > *Dalbergia sissoo* > *Acacia tortilis* in both the seasons.

Pine recorded a slow and gradual decrease in soil moisture content in 40 cm to 185 cm depth range but the upper 15-40 cm layer was as poor in moisture content as under *Eucalyptus* in a depth range of 145-185 cm (Jha and Rathore 1981).

Mishra and Dabral (2005) studies root distribution on 22 years old trees of lichi to show that maximum root diversity was found at 0-90 cm radial distance which decreased gradually

with increased radial distance upto 180-270 cm from the tree trunk. The maximum dry weight of root was observed at 0-30 cm depth from the soil surface which significantly decreased with increase in depth.

Hebbi *et al.* (2005) revealed that tied ridges (29.2%) and compartment bunding (128.7%) recorded higher moisture as compared to flat bed (27.4%) after 76.5 mm of rain, whereas after 30.7 mm rainfall the difference in soil moisture was less than 0.5% in all the treatments.

2.3.2 Effect of *in-situ* conserved moisture on fruit yield and quality.

Mulches have been shown to exert significant effect on fruit yield, total soluble solids and acidity (Badiyala and Aggarwal, 1981). The increase in yield with polyethylene and pine needles over control was 68 and 33% respectively. The TSS was highest (9.4) under polyethylene, which were 1.10 and 1.12 times than that under pine needles and control respectively.

The study of Tiwari *et al.* (1998) also revealed 72% increase in Okra yield under polyethylene as compared to control. Similar study, under ground nut, conducted by Shaikh *et al.* (2004) showed significantly higher yield under polyethylene, followed by sugarcane straw and no mulch.

Significantly higher yield per tree (59.1 kg) in full moon terracing coupled with paddy straw mulching which was at par with half moon terracing + paddy straw mulching (51.1 kg/tree), full moon terracing + paddy straw mulching (49.6 kg/tree). No practices significantly affected fruit quality *viz.* acidity, TSS and total sugars (Nath *et al.*, 2005).

Where as Sharma and Chandel (2005) noticed significant effect on total sugars and acidity of apricot fruits

under different irrigation regimes. In other study no significant effect was observed on wheat yield when irrigation applied between 50% and 85% of minimum soil water control. (Zhong Kui *et al.*, 2005)

2.4 Nitrogen movement in soils

Singh *et al.* (1984) studied the leaching losses of urea in dry and wet soil as affected by irrigation water in *plexi-glass* columns. Urea leached upto 30 cm with 5.0 and 7.5 cm of irrigation water, whereas 10 and 15 cm of water penetrated urea to deeper layers.

Joshi and Dass (1983) revealed that on an alluvial sandy soils wetting front, NO_3^- displacement depths increased with heavier irrigation.

Tewatia (1986) studied the transportation of urea with four different water application rates. The results showed that after 24 hours of urea application, urea moved upto maximum depth of 30 cm.

Kumar *et al.* (1990) in soil column studied the movement of urea applied on soil surface and mixed in 0-5 cm, 5-10 and 10-15 cm depth, in initially wet and dry soils and concluded that when water was applied immediately after addition of urea, it was moved with water front but lagged behind the water front in initially wet soil. The depth of penetration of urea was more in initially wet soil, in similar study it was also concluded that urea and urea derived-N into soil increased with increasing initial soil moisture content but was restricted to the upper 7 cm depth of soil column. At all soil moisture contents, 60-65% of urea derived N recorded in the top 2 cm of soil column. (Antil *et al.*, 1992).

Balane *et al.* (1998) measured $\text{NO}_3^- - \text{N}$ leaching under three different rainfall intensities in soil columns using KNO_3 as nitrate source. The total amount of rainfall was 10 cm. the result of this study indicated that the highest rainfall intensity at 5.0 cm/hr resulted in largest amount of leachate through the soil column, indicating the effect of soil micro pores flow.

Chinkuyu and Kanwar (1999) studied $\text{NO}_3^- - \text{N}$ leaching through undisturbed soil column. Five different irrigations totaling 36.5 cm of de-ionized water were applied with three different rates of time and revealed that concentration of $\text{NO}_3^- - \text{N}$ in leachate increased with increasing level of irrigation event for columns.

Malik *et al.* (1984) conducted a column study to evaluate simultaneous transport of surface water applied $\text{NO}_3^- - \text{N}$ slug with infiltrating water and concluded that percentage of added $\text{NO}_3^- - \text{N}$ retained in the surface layers decreased with reduction in clod size in column. Salt peaks moved with water front. Neverth less, there was hydro-dynamic dispersion to time of about 42% of the added $\text{NO}_3^- - \text{N}$ depths.

Materials and methods

The details about experimental site, materials used and techniques adopted in investigation are reported in this chapter.

Site description:

The study was conducted at RRS Balsamand and Dryland Agriculture Research Farm, CCS HAU, Hisar.

RRS Balsamand of CCS HAU, Hisar is situated between $28^{\circ}59'$ to $29^{\circ}49'$ N latitude and $75^{\circ}11'$ to $76^{\circ}18'$ E longitude at an elevation of 215.2 m above the mean sea level, 25 km, away from main campus on Hisar – Bhadra Road.

DLA Research Farm of CCS HAU, Hisar is situated at latitude $29^{\circ}10'$ N and $75^{\circ}46'$ E longitude at an elevation of 215.0 meter above mean sea level.

Hisar and Balsamand tract is characterized by the semi-arid climate. The summers are very hot and dry with the cold winters and humid warm monsoon months. The mean maximum and minimum temperature shows wide-range of fluctuations during summer and winters. Winter temperature near freezing point accompanied by frost may be recorded in December and January. The average annual rainfall is 380 mm which is unevenly distributed in the year. The rainfall is mainly restricted to monsoon months of July to September and few showers of cyclonic rains during December to January or late spring are received.

Physico-chemical properties of soils:

The soils of the study area at Balsamand are deep (200m) and sandy having a calcic layer at varying depths of 1-10 m (Bhardwaj; 1998) and are classified in *torripsamments*, *ustipsamments* according to 7th approximation. Physico-chemical properties of soil are presented in Table 1. Soils of DLA Research Farm are derived from Indo-Gangetic alluvium which is very deep and sandy loam in texture and has characteristics impregnation of calcium carbonate at a depths of 100 cm. Physical properties of these soil are given in Table 2.

Table 1: Physico-chemical properties of soil of RRS, Balsamand

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural class	Db (Mg/m ³)	pH (1:2)	CEC cmol /kg ¹	Ks *
0-15	93.6	1.0	5.4	Sand	1.51	8.8	6.3	13.9
15-30	93.3	1.2	5.5	Sand	1.51	8.7	6.6	12.5
30-45	92.4	1.5	6.1	Sand	1.57	8.7	6.4	12.8
45-60	93.3	1.3	5.4	Sand	1.59	8.6	6.6	14.2
60-75	93.6	1.4	5.0	Sand	1.52	8.6	6.1	13.5
75-90	93.2	1.1	5.7	Sand	1.50	8.5	6.0	14.6

* Saturated hydraulic conductivity cm hr⁻¹

Table 2: Physical properties of DLA Research farm, Hisar

Depth (cm)	Textural class	Lime-layer	Db (Mg/m³)	F.C. (%)
0-10	SL	-	1.52	24.76
10-20	SL	-	1.55	25.01
20-30	SL	P	1.59	26.30
30-40	LS	-	1.43	20.21
40-50	LS	-	1.41	21.32
50-60	LS	-	1.42	21.30
60-70	LS	-	1.44	24.00
70-80	LS	-	1.30	23.95
80-90	LS	-	1.44	23.70
90-100	LS	-	1.46	23.70
100-110	LS	-	1.45	23.00
110-120	LS	-	1.46	23.00
120-130	LS	-	1.45	24.72
130-140	LS	-	1.44	24.17
140-150	LS	-	1.46	24.50
150-160	LS	-	1.45	24.37

Methods used for soil sample analysis

Following methods were employed for physico-chemical analysis.

- Mechanical analysis was done by hydrometer method. (Day, 1956).
- pH was determined in 1:2.5 soil water suspension using glass electrode pH meter following the method out lined by Jackson (1958).
- Bulk-density (D_b) was determined by core method (Singh, 1980).

- CEC was determined by neutral normal ammonium acetate as outlined by Jackson (1958).
- Saturated hydraulic conductivity (k_s) was determined in soil core with constant head permeameter (Malik *et al.* 1985).
- EC of soil water extract (1:2) was estimated with the help of solubridge conductivity meter (Richards, 1954).
- Organic carbon was determined by Walkley and Black's Rapid Titration method (Piper, 1966).
- The $\text{NO}_3^- - \text{N}$ was determined by distillation procedure as mentioned by Keeney and Nelson (1982).
- The water retention capacity of soils was determined by pressure plate apparatus by maintaining 0.1, 0.33 and 15.0 bars pressure. (Richards *et al.*, 1947).
- CaCO_3 was determined using Puri's volumetric method.
- Infiltration rate was measured by closed top infiltro-meter (Malik *et al.*, 1984).

EXPERIMENTAL DETAILS:

1. Effect of land slope, pond sediment thickness, rainfall intensity and its duration on water run off/harvesting

This experiment was conducted at RRS Balsamand under controlled conditions with artificial rainulator (Chaudhary *et al.*, 1978) fabricated in work-shop, Department of Farm power & machinery college of Agriculture Engineering and Technology, CCS HAU, Hisar.

Rainulator consisted of hypodermic needles (stainless steel) as drop formers of 20 and 24 gauges with tips pointed upwards fixed in the holes drilled 7.5 cm. apart in a GI pipe,

1.27 cm i.d and 6 m long. Bottom of needles was grinded to give round shape and it was fitted with help of Araldite. Each bank (GI pipe) accommodated 69 needles (Plate 1). A spray unit was formed of two banks fitted with identical gauges, mounted one meter apart on a supporting frame at a height of 3.0 meter from the ground surface to attain a terminal velocity of natural rainfall. Both banks were freely adjustable and kept inclined towards each other to ensure uniform rainfall distribution on micro plots. Water was supplied to each bank from a constant head water tanks placed at height of 10 meters through a 2.5 cm dia polyethylene pipe. The water supply was regulated with the help of a pressure regulator and pressure gauge was also fitted to polyethylene pipe line. The spray units were operated at different pressure with different gauges of needles to maintain desired intensity as mentioned in table 3.

Table 3: Rainfall characteristics and volume of water collected with rainulator

Needle gauge	Pressure (kg/cm ²)	Rainfall intensity (cm/hr.)	Volume of water collected (litres)		
			10 min	20 min	30 min
24	0.24	2.8	20.91	41.82	62.73
24	0.30	5.2	28.56	57.12	85.68
20	0.30	8.4	90.50	181.00	271.50

EXPERIMENTAL TREATMENTS:

Slope (%) : 0, 3.0, 4.5, 6.0

Pond sediments (t ha⁻¹) : 0, 100, 200, 300

Rainfall intensity (cm hr⁻¹) : 2.8, 5.2, 8.4

Rainfall duration (min.)	: 10, 20, 30
Plot size (m ²)	: Gross 2 x 6
Replication	: Three

Four slopes i.e. 0, 3.0, 4.5 and 6.0% were created in plots of 2 m wide and 6 m long, pond silt as per treatment was mixed with the help of spade in 10 cm surface soil layer. Soil bunds, 15 cm high were made around each plot to define the catchment area to maintain the accuracy of runoff measurements.

Blank trial run for simulated rainfall of 8 cm hr⁻¹ intensity was applied to each plot initially to create uniform soil condition for further experimentation.

Runoff from each plot, intensity and duration was collected in buckets covered with plastic sheet to avoid evaporation losses of collected runoff. After completion of one duration for each plot total runoff water was mixed well in a 50 litre capacity tub and representative suspension sample was collected for estimation of sediment load. Two rain gauges were used to record the amount and intensity of rainfall.

To maintain uniform condition throughout the experiment for fair comparison of results, first ten minutes rainfall was followed by another 10 minutes duration to make 20 minutes cumulative rainfall followed by another 10 minutes rainfall to make cumulative 30 minutes rainfall.

Soil samples from different depths were collected before and after desired rainfall, from the plots to determine soil moisture (w/w) under different treatment combinations. Runoff samples were analyzed by oven dry method to determine the sediment out flow rate from different treatments.

2. Effect of different mulching materials on water-conservation in soils under arid fruits

Treatments:

Mulches: Control, Soil mulch, Crop residues, Polyethylene sheet.

Pond silt : 200 t/ha i.e. (140 kg per tree)

Plot size: 7 m² (circular, r=1.5m)

Depth of irrigation : 7.5 cm

No. of irrigations: 5

Irrigation applied at ID/CPE 0.75

This experiment was conducted at same site as in experiment 1 under already established 8 year old fruit trees viz. *Ber* (*Zizyphus mauritiana*), *Aonla* (*Embilica officinalis*), *Anar* (*Pumica granatum*) having uniform growth in same species.

Four mulching treatments viz. un-mulched (T₁), soil mulch (T₂), straw mulch (T₃) and polyethylene sheet mulch (T₄) were applied for individual trees and all the four treatments were also applied to a single tree to avoid variation of trees, if any, (plate 2) by dividing its basin into four equal parts and sides were also rotated in replications to reduce the tree shadow errors.

Treatments were laid out in randomized block design with three replications. Soil mulch was created by manual stirring dry soil surface with blade hoe, for straw mulch a mixture of litter fall of *Prosopis cineraria* (Khejri)+ *Acacia sp.* (Kikar) and mustard straw (1:4 ratio) was spread in layer of about 5 cm over the basin/area for complete coverage so that no direct sun light could reach soil surface (plate 3). In plastic



Plate 1: Spray unit



Plate 2: Different mulching treatments in *ber*



sheet mulch treatment, transparent sheet of 40 gauge thickness was cut in equally two piece of 4 meter length in half moon shape, to fit the tree trunk and cover the entire tree basin. The un-mulched tree basins were kept weed free by pulling weeds manually to serve a control. One tree as control without amending pond silt was also applied parallel irrigation for each species.

Before applying all the treatments, the basin of trees were ploughed with a spade to make it weed free as well as mix the pond silt and fertilizer into 10 cm surface soil layer. In all the treatments recommended doses of N through urea and P through single super phosphate were applied. 7.5 cm irrigation was applied through tractor drawn tanker and measured with a metallic water meter.

Soil moisture content was measured gravimetrically at 15 cm interval upto 90 cm soil depth before each irrigation. Final sampling was done at proper time without irrigation for moisture determination.

Exp. 3. Effect of different soil surface manipulation on moisture conservation

Treatments:

Absolute control (without tree)

Control (No manipulation)

Mulching (Polyethylene)

Out ward slope (5.0%)

Out ward slope (5%) and trenching

Out ward slope (5%) with mulching in trench.

The experiment was conducted on fruit bearing 15 years old *Ber* (*Zizyphus mauritiana* L.) trees at on DLA Research Farm, Hisar. The physico-chemical properties of experimental field are given in Table 1. The observations were recorded for one fruiting season on *ber* cultivar Umran.

Individual effect of 5 methods of *in-situ* water conservation through soil manipulation was studied. A total of six treatments viz. Absolute control i.e. no tree (A), control i.e. no manipulation (T_0), outward slope (5%) + polyethylene mulching (T_1), out ward slope only (T_2), outward slope + trenching (50 x 30 cm) 2 m away from trunk (T_3) and outward slope + Trenching + FYM mulching (5 cm thick) in trench (T_4).

The uniform trees were selected and pruned by adopting standard methods of pruning during May and fertilized with recommended doses of N and P fertilizers only. The moisture conservation treatments were super-imposed before commencement of monsoon of 2003.

For moisture content estimation four access tubes (2 meter long) were installed with the help of augur kit especially made for this purpose upto 190 cm depth. Better contact of access tubes with soil was ensured by applying 10 litres of water around each tube. These tubes were installed 1 meter and 2 meter away on both sides of tree trunk. The observations started after 15 days of tube installation. Soil moisture recorded (0-160 cm depths with 10 cm segments of soil depths) with moisture meter (Diviner 2000) was taken from Oct. 18, 2003 to March 11, 2004 with 15 days interval. Soil moisture was also determined gravimetrically for calibration of instrument.

Exp. 3(a). Effect of conserved moisture on fruit quality of *Ber*

This part of experiment was carried out in the post-harvest laboratory of department of Horticulture, College of Agriculture, CCS HAU, Hisar. Fruit samples were collected at maturity (pale yellow in colour). Details of materials used and methods adopted are described below:-

3(a). I. Total soluble Solids (TSS):

Total soluble solids was measured with the help of hand refracto-meter (0-32⁰ brix) and expressed as per cent total soluble solids.

Pulp of ten fruits were randomly selected from composite sample of one kilogram fruits and crushed for extracting juice.

3(a). II. Acidity:

Fruit acidity was estimated by the method of AOAC (1980). 0.1 N (NaOH) solution and phenolphthalein were used as reagent and indicator respectively, for determination of acidity.

Fruit pulp from a random sample of five fruits from each tree in each replication was macerated with distilled water (1:5) and titrated against 0.1 N (NaOH) using phenolphthalein (2 drops) as an indicator.

The end point was marked by appearance of pink colour. Acidity was expressed in terms of citric acid in percentage.

3(a) III. Ascorbic acid:

Method suggested by AOAC (1980) was followed for estimation of ascorbic acid.

Reagents:

- (i) Buffer : Metaphosphoric acid (3%)
- (ii) Dye (2,6 dichlorophenol indophenol) : 50 mg
Sodium hydrogen carbonate : 42 mg
Final volume : 200ml
- (iii) Standard ascorbic acid solution – 50mg/50ml

Extraction:

The samples were prepared by macerating 5 g of fruit pulp by adding 3% metaphosphoric acid. The extract was filtered and final volume was made to 25 ml.

Two ml of aliquot was titrated against 2,6 dichlorophenol indophenol dye solution till the light pink colour was obtained. The results were expressed as mg ascorbic acid/100g fruit pulp.

3(a). 4: Total Sugar:

Total sugar was estimated by the method of Yemm and Willis (1954) using Anthrone reagent.

Extraction:

500 mg pulp of fresh fruits was homogenized in 10 ml distilled water and it was well shaken and then it was centrifuged at 5000 rpm for 10 minutes. The supernatant was separated. The residue was further mixed with 10 ml 80% acetone and shaken well. It was again centrifuged and the supernatant was pooled with the first supernatant. The residue was extracted two times more with 80% acetone in the same manner and the supernatant was pooled and then total volume was made to 100 ml. The pooled supernatant was used for determination of total sugars.

Reagents:

Anthrone reagent (0.2%): it was prepared fresh by dissolving 200 mg of anthrone in 100 ml of conc. H_2SO_4 .

Estimation:

0.1 ml aliquot was taken from the supernatant and it was evaporated to dryness in a test tube by keeping it in oven. After cooling, it was dissolved in 1 ml distilled water and 5 ml 0.2% Anthrone reagent was added to it. Then it was kept in boiling water bath for 10 minutes.

The OD was recorded at 620 nm against reagent blank. The standard curve was prepared using graded concentrations of sucrose. The values were expressed in g per 100g fresh weight.

3(a). 5: Phenols:

Total phenols were estimated by the method of Amorium *et al.*, (1977), using Folin-ciocalteu's phenol reagents.

Extraction:

The extract obtained for total sugars was also used for the determination of total phenols.

Reagents;

Folin-ciocalteu's phenol reagents (1N) sodium carbonate solution (20%): It was prepared by dissolving 20 g sodium carbonate in 100 ml distilled water.

Extraction:

One ml aliquot was taken from the extract and to it 4 ml distilled water was added. To this 0.5 ml Folin-ciocalteu's reagent was added and mixed properly. After 5 minutes, 0.5 ml of 20% Na_2CO_3 solution was added. It was mixed vigorously and made to 10 ml with distilled water. The optical density was

read at 750 nm against reagent blank. Standard curve was made using graded concentrations of tannic acid. The values were expressed in g/100g fresh weight.

Exp. 4: To study the vertical movement of water and N as a function of time

The bulk soil sample (0-15 cm) was collected from RRS Balsamand. The physico-chemical properties of the experimental soil have been presented in Table-1. The effect of different levels of $\text{NO}_3^- - \text{N}$ on leaching was studied in *plexi-glass* columns in laboratory with following treatments.

N-levels: 100, 200, 300 (mg N kg^{-1} soil)

Depth of irrigation: 7.5 cm

Soil sampling

(i) Immediate (Just after infiltration of 7.5 cm irrigation water).

(ii) 24 hours after completion of 7.5 cm irrigation.

N source: KNO_3

Replication: Three

Initial soil water content: 4.5% (V/V)

Each column (90 cm in length 5 cm I.D.) was closed at bottom by perforated *plexi-glass* sheet. 0-90 cm marking scale made of graph paper was pasted on one side of column. The soil in column was packed, by tapping on a wooden table, upto a height of 80 cm with bulk density of $1.50 \pm 0.01 \text{ mg m}^{-3}$.

The details about column filling, fertilizer application and soil sampling from columns are given below.

Desired soil bulk-density in column was maintained by successive adding of weighed amount of soil required to fill

5 cm depth of column. The doses of nitrogen were on weight basis of 0-5 cm surface soil. Potassium nitrate (KNO_3) was applied as slug in known amount of water. Volume of water used in dissolving potassium nitrate was subtracted from volume of water calculated for 7.5 cm irrigation.

The 7.5 cm irrigation was applied through a constant head of 2 cm, maintained by an inverted measuring flask. The advancement of wetting front as a function of time was recorded till completion of infiltration of desired depth of water. Then columns were laid horizontally on table and soil segments of 5 cm depth each, were collected upto wetting front with the help of an iron rod with flattened front end.

Another column after plugging with rubber cork was kept for 24 hours to allow equilibration and redistribution of soil moisture along with nitrogen. Soil sampling was done in the same manner as mentioned above.

The soil samples were divided into 2 parts, one part was used for moisture estimation gravimetrically and second part was utilized for determination of $\text{NO}_3^- - \text{N}$ using Kjeldahl distillation procedure as mentioned by Bremner (1965).

Results and Discussion

The results and discussion of the present investigation entitled “Effect of Different Soil Management Practices on Moisture Conservation in Soils Under Arid Fruits” have been presented in this chapter. Four experiments were conducted to fulfill the approved objectives.

Exp. 1. Effect of land slope, pond sediment thickness, rainfall intensity and its duration on water runoff/harvesting

The results obtained in this experiment are presented in table 4, 5 and 6. The perusal of data in table reveal that there was significant increase in runoff with each increase in level of pond silt from 0-300 t/ha. The mean values of runoff were 0.44, 12.19, 31.02 and 44.32 litres/plot in 0, 100, 200 and 300 t/ha pond silt treatment, respectively (Table 4).

Table 4: Effect of pond silt (PS) and slope on runoff in litres/plot (6.5m²)

Pond silt (t/ha)	Slope (%)			Mean
	3	4.5	6	
0	0.00	0.00	1.33	0.44
100	4.60	10.30	21.66	12.19
200	12.31	32.76	47.99	31.02
300	30.20	38.33	64.42	44.32
Mean	11.78	20.35	33.83	

C.D. (0.05) PS (A)– 1.06 Slope (B) – 0.92,
AxB – 1.85

The results show that application of pond silt has significant effect on runoff generation. Similarly increasing land slope also significantly enhanced the runoff and it was highest (33.83 litres/plot) under 6% land slope (table 4). The interaction of silt level and slope on runoff generation was found to be significant. In the absence of pond silt addition, no improvement in runoff was observed. When pond silt was added, significant influence on runoff was recorded with each level of slope.

The mean values of runoff were 4.37, 18.19 and 43.39 litres/plot in 10, 20 and 30 minute duration of rainfall, respectively (table 5). The results show that as the duration of rainfall increased, runoff also increased significantly. It was further observed that interaction of pond silt and rainfall duration had significant effect on runoff.

Table 5: Effect of pond silt and duration on water runoff litres/plot (6.5m²)

Pond silt (t/ha)	Duration (min)			
	10	20	30	Mean
0	0.00	0.00	1.33	0.44
100	0.83	8.93	26.80	12.18
200	5.61	28.17	59.20	30.99
300	11.06	35.65	86.24	44.32
Mean	4.37	18.19	43.39	

C.D. (0.05) Duration (C) – 0.92 AxC – 1.85

The interaction effect of land slope and rainfall duration generated runoff through out the experiment which was significantly higher with each slope i.e. 11.78 ltrs to 33.83 ltrs with increase in soil slope from 3% to 6% (table 6).

Table 6: Effect of slope and duration on runoff litres/plot (6.5m²)

Slope (%)	Duration (min)			Mean
	10	20	30	
3	1.97	8.28	25.08	11.78
4.5	3.77	17.25	40.02	20.35
6.0	7.38	29.03	65.07	33.83
Mean	4.37	18.19	43.39	

C.D. (0.05) – BxC -1.60

The progressive increase in runoff with increase in slope is attributed to increased energy of moving water with slope which allows water to move with higher velocity and water gets small time for infiltration in soil. Similar results were reported by Singh *et al.* (1979) and Nalatwadmath *et al.* (2004). Increased runoff with increased amount of pond silt is due to reduction in capacity of sandy soil to infiltrate the water in it. Silt particles in pond silt which created blockage of macro pores of sandy soil through which maximum water infiltrates. These results are supported by study of Ber-Hur and Wakindiki (2004). Rainfall of 8-10 cm/hr. intensity is receives for smaller duration. Results of this study suggest that fields treated with 200-300 t/ha pond silt with slope of 4.5% can produce 15-16% of the rainfall as runoff. The harvested water can be utilized for moisture build up in soil profile at active root zone for arid fruits. At this rainfall intensity maximum of 45% of runoff can be harvested with 30 min duration of rainfall when 6% slope is added pond silt @ 300 t/ha which show that if 50% addition in catchment provided to arid horticulture. It may help in recharging of the soil profile for future need of the fruit plants. The maximum runoff 123.3 litres/plot was recorded at 6 percent slope in 30 minutes rainfall duration with 300 t/ha pond silts (See Appendix A-i, ii and iii).

Data in table 7 show that there was significant increase in soil erosion with each increase in level of pond silt from 0-300 t/ha. The mean values of soil erosion were 1.17, 29.21, 70.04 and 177.16 g/plot in 0, 100, 200 and 300 t/ha pond silts treatment, respectively. Application of pond silt has significant effect on soil erosion. Similarly increasing land slope also significantly increased the soil erosion and it was highest (134.13 g/plot) under 6% land slope. The interaction of silt level and slope on soil erosion was found to be significant. In the absence of pond silt soil erosion was not observed. Pond silt significantly influenced soil erosion at each level of slope.

Table 7: Effect of pond silt and slope on soil erosion (g/ 6.5m²)

Pond silt (t/ha)	Slope (%)			Mean
	3.0	4.5	6.0	
0	0.00	0.00	3.51	1.17
100	6.65	20.10	60.89	29.21
200	22.91	40.90	146.32	70.04
300	82.33	123.31	325.83	177.16
Mean	27.97	46.08	134.13	

C.D. (0.05) A – 1.75, B – 1.51, AxB – 3.03

The mean values of soil erosion were 20.94, 63.96 and 123.28 g/plot in 10, 20 and 30 minutes duration of rainfall respectively (table 8). The results show that each successive rainfall duration increased soil erosion significantly. It was further observed that interaction of pond silt and rainfall duration had significant effect on soil erosion.

Table 8: Effect of pond silt and rain duration on soil erosion (g/ 6.5m²)

Pond silt (t/ha)	Duration (min)			Mean
	10	20	30	
0	0.00	0.00	3.51	1.17
100	2.37	24.16	61.11	20.21
200	25.35	80.72	104.06	70.04
300	56.06	150.96	324.45	177.61
Mean	20.94	63.96	123.28	

C.D. (0.05) C- 1.51 AxC – 2.93

The combined effect of land slope and rainfall duration decreased the sediment load in per unit volume of runoff which was significantly lower with each decrease in soil slope from 6% to 3% (Table 9).

Table 9: Effect of slope and rain duration on soil erosion (g/6.5m²)

Slope (%)	Duration (min)			
	10	20	30	Mean
3.0	6.29	25.54	55.08	27.97
4.5	12.63	48.77	76.83	46.08
6.0	43.91	120.56	237.94	134.13
Mean	20.94	64.96	123.28	

C.D. (0.05) BxC – 2.63

The progressive increase in soil erosion with increase in slope is attributed to increased energy of moving water with slope which detached soil particles and moved with higher velocity of moving water. Similar results were reported by Singh *et al.* (1979) and Nalatwadmath (2004).

The results of sediment load in grams per litre are presented in table-10. There was significant increase in sediment load (g/ltr) in runoff with each increase in level of pond silt from 0-300 t/ha. The mean values of sediment were 0.29, 1.78, 2.63 and 3.95 g/ltr in 0, 100, 200 and 300 t/ha pond silt treatment, respectively, found significant different with each other. Sediment load increased significantly (1.53 - 3.10 g/l) increase in slope from 3.0 to 6.0 percent slope and pond silt combinedly did not affect sediment load significantly.

Table10: Effect of pond silt and slope on runoff sediment load (g/ltr)

Pond silt (t/ha)	Slope (%)			
	3.0	4.5	6.0	Mean
0	0.00	0.00	0.87	0.29
100	1.11	1.38	2.85	1.78
200	2.19	2.46	3.24	2.63
300	2.83	3.44	5.58	3.95
Mean	1.53	1.82	3.10	

C.D. (0.05) A = 0.120, B = 0.104, AxB = N.S.

The mean values of sediment load were similar (2.13-2.22 g/l) in 10, 20 and 30 minute duration of rainfall (Table 11). The results show that when the duration of rainfall increased from 10 to 20 rain duration, sediment load increased from 2.14 to 2.22 g/ltr whereas it further decrease with increased in duration.

Table 11: Effect of Pond silt and rain duration on runoff sediment load (g/ltr)

Pond silt (t/ha)	Duration (min)			
	10	20	30	Mean
0	0.00	0.00	0.87	0.29
100	0.95	2.39	2.00	1.78
200	3.14	2.58	2.15	2.63
300	4.48	3.95	3.48	3.95
Mean	2.14	2.22	2.13	

C.D. (0.05) C – N.S., AxC = 0.208

The data presented in table 12 show that as duration increased at same level of slope both at 3.0 and 4.5%, sediment load increased upto 20 min but at 30 minutes rainfall duration it decreased as compared to 20 min. Whereas at 6% slope it decreased initially (upto 20 min.) and then increased.

Table 12: Effect of slope and rain duration on runoff sediment load (g/ltr)

Slope (%)	Duration (min)			
	10	20	30	Mean
3.0	1.42	1.75	1.43	1.53
4.5	1.65	2.04	1.77	1.82
6.0	3.34	2.87	3.19	3.13
Mean	1.42	1.75	1.43	

C.D. (0.05) BxC = 0.18

The progressive increase in sediment load with increase in slope is attributed to increased energy and volume of moving water with slope which eroded the soil particles with higher velocity and volume of runoff water. Similar results were reported by Singh *et al.* (1979) and Nalatwadmath *et al.* (2004).

Moisture distribution in soil profile before and after three rainfall intensity each was tested and moisture status in soil is presented in appendix (A-iv to A-vi)). The data in appendix shows the moisture build up in the soil profile in the lowest intensity 2.8 cm/hr. ranged from 1.35 to 1.42 cm of water depth which shows that almost 100% water applied in the form of rainfall can be accounted for similarity with rainfall intensity of 5.4 cm/hr. the moisture built up in soil profile ranged from 2.18 cm to 2.8 cm when rain intensity was increased to 8.4 cm/hr soil moisture observed from 3.35 cm to 4.02 cm.

Exp. 2: Effect of different mulching materials on water conservation in soils under arid fruits

Decreasing soil water evaporation is one method of improving water conservation. Mulches are known to reduce water loss from soil surface. The results of this experiment presented in table 13 indicate that soil moisture storage increased significantly with mulches in the presence of pond silt.

Table 13: Effect of different type of mulching and irrigation on moisture storage under *ber* trees

Sr. N.	Type of Mulching	No. of Irrigation				Mean
		1	2	3	4	
		Treatments on different trees				
1.	Control (No. pond silt)	6.67	6.83	4.80	3.70	5.50
2.	Control	6.85	7.10	5.10	3.87	5.73
3.	Soil mulch	8.93	10.09	7.80	6.78	8.40
4.	Crop residues mulch	9.00	10.50	8.37	7.65	8.88
5.	Polyethylene mulch	10.52	11.53	8.41	9.01	9.87
	Mean	8.39	9.21	6.90	6.20	
C.D. (0.05) mulching (A) – 0.40, Irrigation (B) – 0.36						
		Treatments on one tree				
1.	Control	6.33	7.64	3.37	4.96	5.58
2.	Soil mulch	7.35	8.17	4.09	5.95	6.39
3.	Crop residues	8.03	8.97	5.39	6.38	7.19
4.	Polyethylene mulch	8.70	9.60	6.83	8.85	8.50
	Mean	7.60	8.60	4.92	6.54	
C.D. (0.05) A and B – 0.42						

The difference between soil moisture stored in control (no pond silt) and control with pond silt amendment is non significant (Table 13) in *ber* trees. If we compare the other mulches treatments with both the controls the soil moisture storage increased significantly. The maximum soil moisture storage is under polyethylene mulch (10.52 cm/90cm) after 1st irrigation. The similar results were obtained by Chaudhary *et al.* (1985). Different mulches followed the order of polyethylene mulch > crop residues > soil mulch > control as shown in table 13. It may be due to the fact that polyethylene mulch was more effective in reducing evaporation losses by forming relatively more impermeable vapors barrier at the soil surface as compared with crop residue mulch which being porous allowed diffusion

Sr. N.	Type of mulching	No. of Irrigation				Mean
		1	2	3	4	
		Treatments on different trees				
1.	Control (No. pond silt)	7.40	6.75	4.00	3.00	5.29
2.	Control	7.54	6.90	4.22	3.10	5.44
3.	Soil mulch	8.63	8.88	5.94	4.95	7.10
4.	Crop residue	9.27	9.78	6.17	6.74	7.99
5.	Polyethylene mulch	10.96	10.66	8.14	7.80	9.39
	Mean	8.76	8.59	5.69	5.12	
C.D. (0.05) mulching (A) – 0.44, Irrigation (B) – 0.40						
		Treatments on one tree				
1.	Control	6.44	7.47	4.98	4.70	5.90
2.	Soil mulch	8.38	8.77	6.61	6.60	7.59
3.	Straw	9.77	9.82	7.18	7.66	8.61
4.	Polyethylene mulch	10.70	10.68	8.33	8.32	9.51
	Mean	8.82	9.19	6.78	6.82	
C.D. (0.05) A and B – 0.54						

Table 15: Effect of mode of mulching and irrigation on *in-situ* moisture storage under anar trees

Sr. N.	Type of mulching	No. of Irrigation				Mean
		1	2	3	4	
		Treatments on different trees				
1.	Control (No. pond silt)	6.70	6.93	6.14	5.89	6.42
2.	Control	6.83	7.01	6.22	6.01	6.52
3.	Soil mulch	7.75	7.70	7.59	7.70	7.69
4.	Crop residue	8.72	9.03	8.77	8.74	8.82
5.	Polyethylene mulch	9.29	9.70	9.66	9.51	9.54
	Mean	7.86	8.07	7.68	7.57	
C.D. (0.05) mulching (A) – 0.47, Irrigation (B) – N.S.						
		Treatments on one tree				
1.	Control	6.90	7.50	7.01	6.53	6.99
2.	Soil mulch	7.90	9.58	7.48	6.06	8.26
3.	Straw	9.10	9.99	8.57	8.47	9.03
4.	Polyethylene mulch	9.74	10.28	9.12	9.7	9.63
	Mean	8.41	9.34	8.05	8.11	
C.D. (0.05) A and B – 0.44						

Exp. 3: Effect of different soil surface manipulation on moisture conservation

The fruit yield of *ber* trees under different soil surface manipulation practices is given in table 16. The maximum fruit yield of 134.0 kg per tree was obtained when a circular trench (50x30 cm) constructed at a distance 2.0 m from the tree trunk was covered with 5 cm layer of FYM and the area between the tree trunk and the trench was provided with an outward slope of 5%.

Table 16: Effect of different surface manipulations on fruit yield of *ber* trees

Treatments	Yield (kg/tree)
Control (no manipulation)	99.5
Outward slope only	111.0
Outward slope + trench	119.0
Outward slope + FYM in trench	134.0
Outward slope + polyethylene (r=1 m)	102.1

C.D. (0.05) - 11.9

This was followed by fruit yield of 119.0 kg of *ber* per tree in the soil manipulation practice which consisted of trench and outward slope but without any FYM layer. The fruit yield in the best treatment was about 34% higher than the control (no manipulation). The increased fruit yield under different soil surface manipulation practices was due to enhanced soil moisture storage in the active root zone. Ehrler *et al.* (1978) also reported an increase in water content in the root zone of Zozoba plants under soil surface manipulation for individual plants micro-catchment. Nath *et al.* (2005) reported increased Litchi yield for surface manipulation practice of full moon terracing and paddy straw mulching. Similar results have been reported by Singh *et al.* (2004) and Shaikh *et al.* (2004). However, Thomas *et al.* (2005) reported that straw mulch did not increase the yield of potato.

The results of this experiment of 34% higher yield in the best treatment as compared to control indicates a substantial potential of soil surface manipulation practices in enhancing the *ber* fruit production under rainfed condition in the arid and semi arid regions.

The effect of different surface manipulation practices on the quality of *ber* fruits is reported in Table 17.

Table 17: Effect of different surface manipulation practices on fruit quality

Treatments	TSS (%)	Acidity (%)	Ascorbic Acid (mg/100g)	Total sugar (%)	Starch (%)	Phenol (%)
T ₀	19	0.165	110.50	10.30	0.137	0.112
T ₁	17	0.185	105.20	9.53	0.146	0.131
T ₂	14	0.204	93.49	8.45	0.167	0.138
T ₃	13	0.230	89.35	8.23	0.192	0.144
T ₄	13	0.225	88.00	8.00	0.211	0.150
C.D. (0.05)	1.74	0.013	5.95	1.64	0.015	0.012

Data on effect of moisture conservation practices on *ber* fruit quality reported in Table 17 indicate that TSS was significantly higher with control (no manipulation). TSS (total soluble solids) content was as higher as 19% in control. Whereas TSS content in fruits having polyethylene + slope and FYM in Trench + Slope treatments was found at par (13%) to each other. Ascorbic acid remained significantly higher with control as compared to other all surface manipulations. Similarly total sugar content followed the same trend.

Acidic content observed was also significantly higher for both FYM applied in trench + slope (0.230%) and polyethylene with one meter radius around tree trunk + slope (0.225%) as compared to control, slope only and trench with slope trees.

FYM in trench and polyethylene with slope was significantly higher for fruit starch content (0.192-0.211%).

Phenol content in fruits harvested from trees having polyethylene mulching along with out ward 5% slope (0.15) was

significant higher as compared to slope with trench (0.138), slope only (0.131) and no amendment (0.112%). Whereas slope only and slope with trench was found at par to each other.

The overall results of fruit quality is supported by Badiyala and Aggarwal (1981), Nath *et al.* (2005), Sharma and Chandel (2005) and revealed that sugar content in fruits decreased, acidity increased significantly with the increase in soil moisture level, however, TSS content was not influenced significantly by irrigation in fruits.

Exp. 4: Movement and distribution of $\text{NO}_3^- \text{N}$ in soil column

Water front advance, as a result of the application of 7.5 cm of water in *plexi-glass* column filled with sandy soil, was observed to proceed at a decreasing rate, for a period of 14 minutes (Fig. 1).

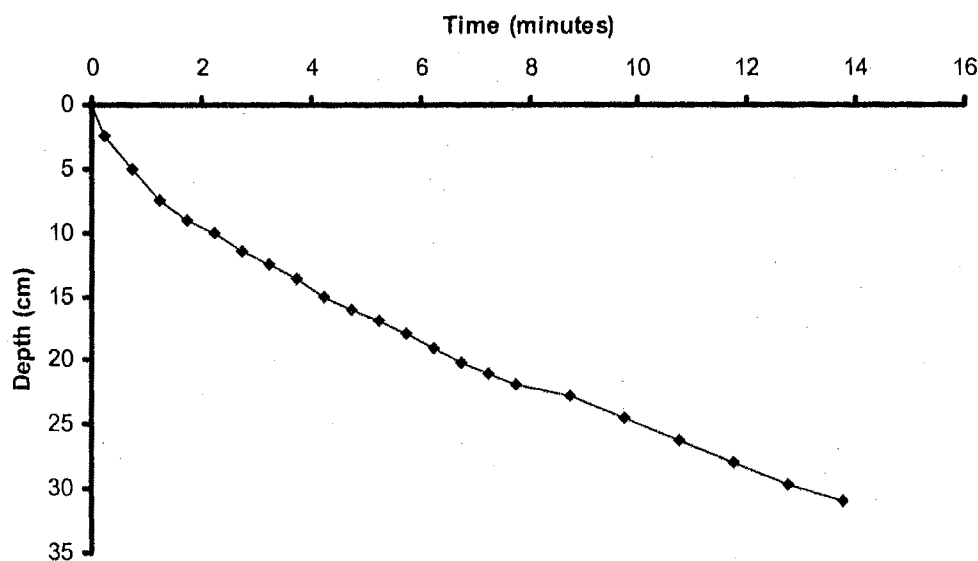


Fig. 1 Water front advance as a function of time for sandy soil during the column experiment

The rate of water front advance decreased from an initial rate of 10 cm/min to 1.3 cm/min in advancement of water.

front during the period of about 14 minutes traveled to a depth of 31.0 cm (fig. 1).

The fact that water front moved to a distance of 31.0 cm in 14 minutes suggested that the mobile element in the sandy soils are susceptible to fast leaching, particularly if heavy rainfall occurs. This observation has an important implication for nitrogenous fertilizer management in sandy soil used in the study. The fact that $\text{NO}_3^- - \text{N}$ concentration was substantially higher at the end of the water front suggests that $\text{NO}_3^- - \text{N}$ continues to move downward with increased concentration in the deeper layer. These findings further suggests that lower doses of fertilizers must be applied in sandy soils. Although not studied in the current investigation, the results obtained for $\text{NO}_3^- - \text{N}$ concentration suggests that N fertilizer requirement in sandy soils must be managed through split doses. In the light of results it is suggested that the fertilizer management through split doses becomes particularly critical if rainwater harvesting as suggested in experiment 1 is to be implemented.

The results are comparable with findings of Malik *et al.* (1984).

The observed concentration of $\text{NO}_3^- - \text{N}$ immediately after the infiltration of applied water is shown in Table 18.

Table 18: Concentration of $\text{NO}_3^- - \text{N}$ with depth in soil column immediately after infiltration of water at different level of NO_3^- solution slugs

Depth (cm)	Soil Moisture (%)	Level of $\text{NO}_3^- - \text{N}$ (ppm)		
		100	200	300
		$\text{NO}_3^- - \text{N}$ observed		
0-5	22.2	18.4	24.6	38.4
5-10	20.7	15.5	22.9	36.8
10-15	20.1	18.8	26.3	49.4
15-20	20.2	26.9	39.8	55.9
20-25	19.1	30.8	51.8	59.5
25-30	18.6	38.3	78.4	98.3
30-35	7.1	27.8	30.7	39.0

In general the $\text{NO}_3^- - \text{N}$ concentration increased with increasing depth for all the three doses (*viz.* 100, 200 and 300 ppm) except near the end of the water front. The $\text{NO}_3^- - \text{N}$ concentration at a particular depth increased with increasing dose of $\text{NO}_3^- - \text{N}$ in the applied water. The moisture content in soil decreased with increasing depth of soil profile. The maximum decrease in soil moisture was observed near the end of the water front indicating that not enough free water was available for flow at this depth. Substantially lower moisture content at the end of water front suggests that the lowest concentration of $\text{NO}_3^- - \text{N}$ at the end of water front was due to decreased amount of water that reached to that depth.

The difference in $\text{NO}_3^- - \text{N}$ concentration at different depths increased with increasing depth as the applied dose increased from 100 to 300 ppm.

The observed $\text{NO}_3^- - \text{N}$ concentration in the soil column after 24 hours is also shown in Table 19.

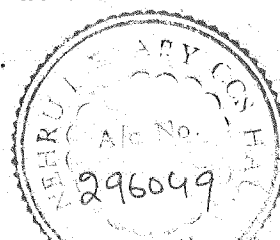


Table 19: Concentration of $NO_3^- - N$ with depths in soil column 24 hours after application of irrigation

Depth (cm)	Moisture (%)	$NO_3^- - N$ Conc. (ppm)		
		100	200	300
0-5	14.10	14.7	20.1	31.4
5-10	14.30	13.4	16.4	28.2
10-15	13.81	13.6	16.3	29.4
15-20	12.89	14.8	25.1	31.6
20-25	12.70	17.6	24.7	33.4
25-30	12.85	19.2	27.6	35.1
30-35	11.79	19.8	28.0	37.2
35-40	10.84	22.6	28.4	37.0
40-45	9.37	24.3	30.6	39.0
45-50	8.37	26.2	36.2	45.1
50-55	6.27	41.8	61.7	73.2

The $NO_3^- - N$ concentration increased with increasing soil depth and increasing dose of $NO_3^- - N$ in the applied water. The $NO_3^- - N$ concentration at the end of water front was substantially higher than that observed just above the end of the water front. Similar results were also observed by Tewatia, 1986; Parramassium *et al.* 1997; Malik *et al.*, 1984. Antil *et al* (2002) revealed that $NO_3^- - N$ increased with soil depth and maximum (60 ppm) concentration was from 21-24 cm layer of soil.

CHAPTER –V

Summary

To evaluate the “Effect of different soil management practices on moisture conservation in soils under arid fruits” four experiments (three field and one laboratory) were conducted during 2002-03 and 2003-04 at Regional Research Station, (CCS HAU, Hisar) Balsamand and Dryland Research Farm and Laboratory Deptt. of Soil Science, CCS HAU, Hisar.

- i) Effect of land slope, pond sediment thickness, rainfall intensity and its duration on water runoff/harvesting. The treatments comprised of four slopes (0, 3, 4.5 and 6%), four levels of pond silt (0, 100, 200 and 300 t/ha), three rainfall intensities (2.8, 5.4 and 8.4 cm/hr) and three rainfall duration (10, 20 and 30 minutes). The gross plot size was 2m x 6m with three replications.

The results of this investigation indicate that:

- o Run-off significantly increased as pond silt increased. Similarly, land slope also significantly enhanced the runoff. The effect of pond silt and slope on runoff generation was found to be significant. In the absence of pond silt no runoff generated at all duration of rain fall except 30 min rainfall at 6% slope. The interaction between pond silt and rainfall duration had significant effect on runoff.

Soil erosion significantly increased as level of pond silt increased from 0 to 300 t/ha. Land slope also increased

significantly the soil erosion. Slope and pond silt level also increased soil erosion. With no amendment of pond silt, lower soil erosion was observed as compared to application of pond silt @ 300 t/ha.

Amendment of pond silt from 0 to 300 t/ha significantly increased the sediment load of runoff. Similarly slope also increased sediment load at same level of pond silt.

Reversely from runoff and soil erosion, sediment load of runoff water was decreased with increase in rainfall duration from 20 min to 30 min. The interaction effect of rainfall duration and soil slope on sediment out flow from micro-plots showed decreasing trend with increased level of pond silt.

- ii) The maximum soil moisture storage was found under polyethylene mulching and followed by crop residue mulch > soil mulch > control in both the cases, when all treatments were applied to single trees as well as different trees in all species.
- iii) Effect of different soil surface manipulation on moisture conservation was studied with six treatments absolute control (without tree), control (no manipulation), polyethylene mulching, outward slope 5%, outward slope and trenching and outward slope with mulching in trench.

Maximum yield was obtained from the tree having outward slope + FYM in trench followed by slope + trench, trench only, slope + polyethylene and control. Where as total soluble solids observed highly significant under control followed by slope only, slope + trench and both, FYM in trench & polyethylene mulch with outward slope. Same trend followed in case of fruit quality for ascorbic acid and

total sugar content. The maximum content of starch and acidity were observed under FYM in trench and slope alongwith polyethylene mulch treatment trees. Maximum Phenol content was recorded under polyethylene mulch.

- iv) Laboratory experiment “vertical movement of nitrogen as a function of time” consisting of three nitrogen level i.e. 100, 200 and 300 mg/kg soil and 7.5 cm depth of irrigation was conducted in *plexi glass* column in laboratory of Deptt. of Soil Science, CCS HAU, Hisar.

The rate in advancement of water front decreased from an initial rate of 10 cm/min to 1.3 cm/min. The fact that water front moved to a distance of 31.0 cm in 14 minutes suggests that the mobile element in the sandy soils are susceptible to fast leaching particularly if heavy rainfall occurs.

In general $NO_3^- - N$ concentration increased with increasing depth for all the three doses (viz. 100, 200 and 300 ppm) except near the end of the water front. The $NO_3^- - N$ concentration at a particular depth increased with increased dose of $NO_3^- - N$ in the applied water. The moisture content in the soil decreased with increasing depth of soil. The maximum decrease in soil moisture was observed near the end of the front.

Conclusion

- Runoff was significantly increased with increasing level of pond silt, land slope percentage and rainfall duration. About 45 per cent of rain water can be harvested at 8.2 cm/hr rainfall intensity and 6% soil slope amended with pond silt @ 300 t/ha.
- Maximum soil loss was observed with 8.2 cm/hr rainfall intensity at 6 per cent slope amended with @ 300 t/ha pond silt.
- Maximum soil moisture was conserved under polyethylene mulch as compared to other mulching i.e. residue mulch, soil mulch and control.
- Trenching with outward slope (5%) and FYM in trench was found most suitable soil manipulation technique to improve the fruit yield and quality.
- The $\text{NO}_3^- - \text{N}$ concentration was maximum at the end of water front, suggest that lower dose of nitrogenous fertilizer must be applied in sandy soil at one time.

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Appendix A-II
Effect of pond silt, slope and rainfall (8.2 cm/hr.) duration on rain water runoff (litres)

Duration (min)	Pond silt (t/h)											
	0			100			200			300		
	Slope											
10	3.0	4.5	6.0	3.0	4.5	6.0	3.0	4.5	6.00	3.0	4.5	6.00
	-	-	-	-	-	2.5	1.7	6.1	9.05	6.2	9.0	18.00
20	-	-	-	-	2.4	6.9	17.5	8.8	29.1	46.66	22.0	33.0
30	-	-	-	4.0	11.4	24.0	45.0	26.5	63.1	88.00	62.4	73.0
												123.30

C.D. 0.05 AxBxC = 3.20

Appendix A-II
Effect of pond silt, slope and rainfall duration on soil erosion (g/plot)

Duration (min)	Pond silt (t/h)											
	0			100			200			300		
	Slope											
10	3.0	4.5	6.0	3.0	4.5	6.0	3.0	4.5	6.0	3.0	4.5	6.0
	-	-	-	-	-	7.12	4.45	17.00	54.60	20.73	33.53	113.94
20	-	-	-	4.56	16.12	51.80	18.96	69.60	153.60	66.67	109.37	276.84
30	-	-	10.53	15.40	44.20	123.75	45.34	136.10	230.76	159.60	227.05	586.71

C.D. - 5.26

Effect of ponds, sore and saturation on second (g/ft)

Duration (min)	Pond silt (t/h)															
	0				100				200				300			
	Slope															
10	3.0	4.5	6.0	3.0	4.5	6.0	3.0	4.5	6.0	3.0	4.5	6.0	3.0			
	-	-	-	-	-	2.85	2.68	2.83	3.90	3.00	3.80	6.64	6.64			
20	-	-	-	1.90	2.33	2.96	2.16	2.40	3.20	2.95	3.43	5.33	5.33			
	-	-	2.62	1.45	1.82	2.75	1.75	2.16	2.63	2.55	3.11	4.79	4.79			

Q. 3.20

Moisture distribution (mean) in soil profile after rain (2.8 cm/hr.) application on research plots

Sr. No.	Pond silt x slope	Intensity cm/hrs	Area covered (m ²)	Depth (cm)	B.D. (g/cm ³)	Moisture (%)		Moisture (difference)	Water (cm)
						Pre	Post		
1	2	3	4	5	6	7	8	9	10
1	0 X 0.0%	2.82	0.89x5	0-15	1.51	3.56	6.62	3.06	1.0444
				15-30	1.51	4.8	5.8	1	0.3413
									1.3855

Continue...

2	0X3.0%	2.92	0.86&5.0	0-15 15-30	1.51 1.51	3.54 3.89	6.72 4.88	3.18 0.99	1.0852 0.3378 1.4231
3	0X4.5%	2.84	0.88&5.0	0-15 15-30	1.51 1.51	3.12 4.11	6.35 4.9	3.23 0.79	1.1023 0.2696 1.3719
4	0X6.0%	2.88	0.87&5.0	0-15 15-30	1.51 1.51	3.25 4.47	6.7 5.2	3.45 0.73	1.1773 0.2491 1.4265
5	100 X 0%	2.82	0.89 & 5	0-15 15-30	1.51 1.51	3.4 4.02	6.4 5.12	3 1.1	1.0238 0.3754 1.3992
6	100X3.0%	2.82	.86&5	0-15 15-30	1.51 1.51	3.35 3.98	6.7 4.77	3.35 0.79	1.1432 0.2696 1.4128
7	100X4.5%	2.82	0.86&5	0-15 15-30	1.51 1.51	3.35 4.5	7.02 4.99	3.67 0.49	1.2524 0.1672 1.4196
8	100X6.0%	2.84	0.88&5	0-15 15-30	1.51 1.51	3.54 3.75	7 4.25	3.46 0.5	1.1808 0.1706 1.3514
9	200X0.0%	2.94	0.85 x 5	0-15 15-30	1.51 1.51	3.3 4.77	7.21 5.13	3.91 0.36	1.3343 0.1229 1.4572

Continue...

10	200X3.0%	2.92	0.86X5	0-15 15-30	1.51 1.51	3.75 4.44	7.2 5.2	3.45 0.76	1.1773 0.2594 1.4367
11	200X4.5%	2.54	0.85X5	0-15 15-30	1.51 1.51	3.5 3.55	7.3 3.95	3.8 0.4	1.2968 0.1365 1.4333
12	200X6.0%	2.82	0.70X5	0-15 15-30	1.51 1.51	3.4 3.26	6.9 3.86	3.5 0.6	1.1944 0.2048 1.3992
13	300X0.0%	2.90	0.86X5	0-15 15-30	1.51 1.51	3.11 4.21	7.1 4.41	3.99 0.2	1.3616 0.0683 1.4299
14	300X3.0%	2.90	0.86X5	0-15 15-30	1.51 1.51	3.25 4.62	7.2 4.8	3.95 0.18	1.348 0.0614 1.4094
15	300X4.5%	2.92	0.86X5	0-15 15-30	1.51 1.51	3.74 4.41	7.02 5.32	3.28 0.91	1.1193 0.3105 1.4299
16	300X6.0%	2.90	0.86 x5	0-15 15-30	1.51 1.51	3.85 4.54	7 5.56	3.15 1.02	1.075 0.3481 1.4231

1.3 x 5 = 6.5 m² area

Appendix A-V

Moisture distribution in soil profile after rain (5 – 6 cm/hr.) application on research plots

Sr. No.	Pond silt x slope	Area covered (m ²)	Intensity	Depth (cm ³)	B.D. (g/cm ³)	Moisture (%)		Moisture different (%)	Water (cm)
						Pre	Post		
1	2	3	4	5	6	7	8	9	10
1	0 X 0.0%	0.60x5	5.7	0-15 15-30 30-45	1.51 1.51 1.58	3.01 3.75 3.06	7.05 5.13 5.44	4.04 1.38 2.38	1.37869 0.470939 0.891215 2.740844
2	0 X 3.0%	0.59x5	5.92	0-15 15-30 30-45	1.51 1.51 1.58	3.2 3.97 3.27	7.01 5.27 4.7	3.81 3 1.43	1.300201 1.02378 0.535478 2.859458
3	0 X 4.5%	0.59x5	5.92	0-15 15-30 30-45	1.51 1.51 1.58	3.4 3.47 3.32	7.08 5.88 4.9	3.68 2.41 1.58	1.255837 0.822437 0.591647 2.66992
4	0 X 6.0%	0.59X5	5.92	0-15 15-30 30-45	1.51 1.51 1.58	3.31 3.98 4	7.41 6.89 4.74	4.1 2.91 0.74	1.399166 0.993067 0.264239 2.656472

Continue...

5	100 X 0%	0.60X5	5.7	0-15 15-30 30-45	1.51 1.51 1.58	3.37 3.9 4.55	7.4 6.3 5.6	4.03 2.4 1.05	1.375278 0.819024 0.393183 2.587485
6	100X3.0%	0.60X5	5.7	0-15 15-30 30-45	1.51 1.51 1.58	3.7 3.67 4.59	7.01 6.9 5.45	3.31 3.23 0.86	1.129571 1.10227 0.322036 2.553876
7	100X4.5%	.59X5	5.92	0-15 15-30 30-45	1.51 1.51 1.58	4 3.57 3.62	7.67 6.45 5.12	3.67 2.88 1.5	1.252424 0.982829 0.56169 2.796943
8	100X6.0%	0.60X5	5.7	0-15 15-30 30-45	1.51 1.51 1.58	3.9 3.55 3.7	7.49 6.15 5.05	3.59 2.6 1.35	1.225123 0.887276 0.505521 2.61792
9	240X0.0%	0.73X5	4.7	0-15 15-30 30-45	1.51 1.51 1.58	3.53 4.7 3.5	7.4 6.98 4.01	3.87 2.28 0.51	1.320676 0.778073 0.190975 2.289724
10	200X3.0%	0.71X5	4.82	0-15 15-30 30-45	1.51 1.51 1.58	4.3 4.15 4.29	7.88 6.46 5.06	3.58 2.31 0.77	1.221711 0.788311 0.288334 2.298356

Continue...

11	200X4.5%	0.71X5	4.82	0-15 15-30 30-45	1.51 1.51 1.58	4.47 4.1 4.08	7.61 6.58 5.07	3.14 2.48 0.99	1.071556 0.846325 0.370715 2.288597
12	200X6.0%	0.71X5	4.82	0-15 15-30 30-45	1.51 1.51 1.58	4.8 3.87 3.44	7.6 6.04 5.21	2.8 2.17 1.77	0.955528 0.740534 0.662794 2.358856
13	300X0.0%	0.71X5	4.82	0-15 15-30	1.51 1.51	3.64 3.79	8.01 5.87	4.37 2.08	1.491306 0.709821 2.201127
14	300X3.0%	0.72X5	4.76	0-15 15-30	1.51 1.51	3.34 4.7	8.19 6.26	4.85 1.56	1.655111 0.532366 2.187477
15	300 X 4.5	0.71X5	4.82	0-15 15-30	1.51 1.51	3.15 4.6	8.03 6.5	4.88 1.9	1.665349 0.648394 2.313743
16	300X6.0%	0.72X5	4.76	0-15 15-30	1.51 1.51	3.29 4.85	7.99 6.9	4.7 2.05	1.603922 0.699583 2.303505

Appendix A-VI

Moisture distribution in soil profile after rain (8 - 10 cm/hr.) application on research plots

Sr. No.	Pond silt x slope	Load (g/l)	Run-off (cm/ltr)	Depth (cm)	B.D. (g/cm ³)	Moisture (%)		Moisture difference (%)	Water (cm)
						Post	Pre		
1	2	3	4	5	6	7	8	9	10
1	0 X 0.0%	0		0-15	1.51	7.62	3.41	4.21	0.95146
				15-30	1.51	7.12	4.29	2.83	0.63958
				30-45	1.58	6	3.02	2.98	0.70626
				45-60	1.59	6.2	3.41	2.79	0.66123
				60-75	1.52	7.38	5.67	1.71	0.38988
				75-90	1.5	7.74	5.27	2.47	0.55575
									3.90416
2	0 X 3.0%	0		0-15	1.51	7.42	3.59	3.83	0.86558
				15-30	1.51	7.81	4.5	3.31	0.74806
				30-45	1.58	6.71	3.21	3.5	0.8295
				45-60	1.59	6.46	3.47	2.99	0.71162
				60-75	1.52	8.85	5.64	3.21	0.73188
									3.88664

Continue..

6	100X3.0%	1.9 1.35	0.17 (0) (2.4) (11.4)	0-15 15-30 30-45 45-60 60-75 75-90	1.51 1.51 1.58 1.59 1.52 1.5	7.32 7.65 6.55 6.63 7.9 6.1	3.22 4.38 3.92 4.36 5.46 5.16	4.1 3.27 2.63 2.27 2.44 0.94	0.9266 0.73902 0.62331 0.54026 0.55632 0.2115 3.59701
7	100X4.5%	2.33 1.83	0.37 (0) (6.9) (24.15)	0-15 15-30 30-45 45-60 60-75	1.51 1.51 1.58 1.59 1.52	7.07 7.32 6.48 7.7 5.3	3.25 4.81 3.33 3.16 4.27	3.82 2.51 3.15 4.54 1.03	0.86332 0.56726 0.74655 1.08052 0.23484 3.49249
8	100X6.0%	2.85 2.8 2.75	0.7 (2.5) (17.5) (45.0)	0-15 15-30 30-45 45-60 60-75 75-90	1.51 1.51 1.58 1.59 1.52 1.5	7.22 7.94 6.81 7.55 6.27 4.75	3.91 4.84 4.26 3.74 5.24 4.03	3.31 3.1 2.55 3.81 1.03 0.72	0.74806 0.7006 0.60435 0.90678 0.23484 0.162 3.35663

Continue..

9	200X0.0%		0-15	1.51	7.38	3.99	3.39	0.76614
			15-30	1.51	7.13	4.84	2.29	0.51754
			30-45	1.58	6.22	4.34	1.88	0.42488
			45-60	1.59	7.3	3.74	3.56	0.80456
			60-75	1.52	8.33	5.24	3.09	0.69834
			75-90	1.5	7.92	5.93	1.99	0.44974
					6.66	6.05	0.61	0.13786
								3.79906
10	200X3.0%	0.4	0-15	1.51	7.58	3.99	3.59	0.81134
	2.62	(1.70)	15-30	1.51	7.13	4.84	2.29	0.51754
	2.16	(8.75)	30-45	1.58	6.22	4.34	1.88	0.44556
	1.74	(26.15)	45-60	1.59	7.34	3.74	3.6	0.8568
			60-75	1.52	7.49	4.24	3.25	0.741
			75-90	1.5	7.66	6.93	0.73	0.16425
								3.53649
11	200X4.5%	0.97	0-15	1.51	7.21	4	3.21	0.72546
	2.8	(6.1)	15-30	1.51	7.41	4	3.41	0.77066
	2.4	(29.10)	30-45	1.58	6.49	4.34	2.15	0.50955
	2.16	(63.10)	45-60	1.59	7.3	3.7	3.6	0.8568
			60-75	1.52	5.73	5.17	0.56	0.12768
								2.99015

Continue..

12	200X6.0%	3.9 3.2 2.63	1.35 (14.00) (48.00) (88.00)	0-15 15-30 30-45	1.51 1.51 1.58	7.66 7.34 5.6	3.25 4.02 2.61	4.41 3.32 2.99	0.99666 0.75032 0.70863 2.45561
13	300X0.0%			0-15 15-30 30-45 45-60 60-75 75-90	1.51 1.51 1.58 1.59 1.52 1.5	7.52 7.57 7.04 6.8 8.1 5.26	3.72 4.64 4.04 3.74 5 4.2	3.8 2.93 3 3.06 3.1 1.06	0.8588 0.66218 0.711 0.72828 0.7068 0.2385 3.90556
14	300X3.0%	3 2.95 2.55	0.96 (6.20) (22.66) (62.60)	0-15 15-30 30-45	1.51 1.51 1.58 1.59	7.6 7.25 6.4 6.55	3.18 3.56 3.31 4.2	4.42 3.69 3.09 2.35	0.99892 0.83394 0.73233 0.5593 3.12449
15	300X4.5%	3.7 3.31 3.11	1.12 (9.00) (33.04) (73.04)	0-15 15-30 30-45 45-60	1.51 1.51 1.58 1.59	7.81 7.71 6.85 6.96	3.57 4.32 4.98 3.9	4.24 3.39 1.87 3.06	0.95824 0.76614 0.44319 0.72828 2.89585
16	300X6.0%	6.33 5.33 4.77	1.89 (18.00) (52.30) (123.30)	0-15 15-30 30-45	1.51 1.51 1.58	7.73 7.14 5.68	3.41 3.92 4.17	4.32 3.22 1.51	0.97632 0.72772 0.35787 2.06191

Appendix 3-1

Soil moisture (mm) distribution under different treatments at 1 and 2 m away from tree trunk in ber.
Absolute Control

Depth(Cm)	18-Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11-Mar
0 - 10	6.92	6.49	5.89	6.37	8.54	6.77	6.37	6.70	8.49	6.80	6.31	5.42	5.38
10--20	8.39	7.76	7.42	7.47	8.50	7.94	7.54	7.92	8.03	8.29	7.49	6.77	6.98
20 - 30	7.69	7.42	7.04	7.48	6.82	7.18	7.08	7.58	7.10	7.60	7.62	7.47	7.93
30 - 40	8.38	8.25	8.04	8.94	8.45	9.03	9.03	8.82	8.86	9.57	9.26	9.26	9.58
40 - 50	9.73	9.59	9.84	10.72	10.22	10.66	10.75	10.81	10.31	10.82	10.34	10.80	10.84
50 - 60	12.55	12.62	13.02	13.80	13.33	14.00	14.08	13.26	13.33	13.97	13.51	13.93	13.85
60 - 70	17.71	18.36	18.32	19.41	19.68	17.96	19.03	18.50	19.03	18.93	18.90	19.31	18.75
70 - 80	19.34	19.46	20.34	20.41	20.12	19.66	19.78	19.58	19.83	19.69	19.63	20.06	19.21
80 - 90	18.43	18.27	18.91	18.99	18.68	17.87	18.20	18.40	17.88	18.26	18.39	18.53	17.96
90 -100	18.43	17.96	18.37	19.04	18.21	17.72	17.84	18.11	18.16	17.88	17.95	18.11	17.17
100 -110	22.59	22.03	22.69	22.92	21.84	21.29	21.86	21.89	22.06	21.85	21.89	21.94	21.72
110 -120	26.83	26.65	26.76	27.17	26.17	26.95	26.51	26.60	26.34	26.31	26.19	26.03	25.83
120 -130	25.22	25.25	25.45	25.72	24.96	25.54	25.18	25.62	25.24	24.98	24.93	24.64	24.49
130 -140	26.35	26.09	25.93	26.93	25.76	26.53	26.63	26.04	26.01	25.90	25.85	26.13	25.70
140 -150	26.66	25.97	25.90	26.81	25.94	25.87	25.80	25.83	25.90	25.98	26.02	26.10	25.23
150 -160	26.15	26.12	25.84	26.74	26.05	25.93	25.92	26.01	26.10	26.07	26.02	25.91	25.58
	281.38	278.29	279.77	288.92	283.28	280.89	281.61	281.68	282.68	282.90	280.30	280.39	276.20

Control 1m

Depth(Cm)	18 Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mar
0 - 10	7.28	6.78	6.05	6.52	8.18	7.54	7.21	8.16	8.98	8.31	8.15	7.21	7.21
20- 30	9.51	8.66	8.18	8.55	8.43	8.62	8.52	8.52	9.32	11.60	13.70	13.89	14.43
20 - 30	13.65	12.76	12.49	13.11	12.36	12.85	13.13	14.08	13.72	17.73	19.48	19.67	20.09
30 - 40	15.99	15.54	16.21	18.13	17.55	18.13	18.66	19.56	18.90	20.75	21.54	21.56	21.96
40 - 50	17.46	17.76	18.91	20.95	20.02	20.24	20.61	21.17	20.47	21.85	23.02	22.30	22.94
50 - 60	20.05	20.51	21.44	23.22	22.00	22.42	22.13	22.88	21.66	23.03	24.33	24.02	24.72
60 - 70	23.44	23.00	23.64	25.03	23.72	24.30	23.85	24.58	23.48	23.62	23.05	23.42	23.71
70 - 80	22.62	22.69	22.91	24.05	22.57	23.30	22.70	23.47	22.45	23.89	22.14	22.27	21.83
80 - 90	22.08	22.11	22.36	22.81	21.62	22.31	21.83	22.44	21.55	21.93	21.89	21.64	21.31
90 -100	22.59	22.94	22.89	23.25	22.35	22.64	22.54	23.05	22.59	21.98	21.84	21.47	20.99
100 -110	21.80	21.39	21.85	21.92	21.01	21.66	21.37	21.57	21.17	21.12	22.00	21.39	20.99
110 -120	22.40	21.96	22.89	23.00	21.78	22.47	22.45	22.38	21.28	22.95	24.41	21.25	23.48
120 -130	25.45	24.86	25.78	25.84	25.02	25.40	25.38	25.31	24.54	24.92	25.34	25.02	24.43
130 -140	25.31	24.85	25.90	26.19	25.11	26.19	25.38	25.43	24.54	20.49	19.79	19.39	18.90
140 -150	20.33	19.97	20.27	20.69	19.56	20.69	19.99	19.71	19.28	19.67	19.53	18.83	19.08
150 -160	18.74	18.36	18.76	19.06	18.13	19.06	18.08	18.29	17.73	19.25	21.41	20.74	20.88
	308.69	304.14	310.53	322.32	309.41	251.88	313.84	320.60	311.66	323.10	331.61	324.08	326.96
Average	303.7505	300.81	303.93	309.05	303.71	278.07	271.14	316.18	307.02	313.63	318.13	309.72	310.21

Control 2m.

Depth(Cm)	18 Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mach
0 - 10	7.46	6.87	6.70	6.66	9.35	7.36	7.13	9.69	8.65	7.58	6.95	5.95	5.83
10--20	9.86	8.73	8.59	8.54	9.79	8.90	8.66	8.85	9.38	9.30	9.00	8.19	8.13
20 - 30	12.90	12.07	12.30	12.90	13.21	13.15	13.18	13.69	13.80	14.41	14.70	14.75	15.21
30 - 40	16.83	17.24	18.68	20.12	20.08	20.09	20.09	21.22	20.72	21.25	22.38	21.80	21.91
40 - 50	18.95	19.78	21.23	21.31	21.79	21.21	21.40	22.08	21.47	21.55	22.19	21.77	21.27
50 - 60	19.08	19.44	20.10	20.79	20.08	19.81	19.86	20.57	19.79	19.92	19.96	19.77	19.16
60 - 70	19.51	19.46	19.65	16.76	19.48	19.20	19.18	19.80	18.83	20.75	18.96	18.60	18.31
70 - 80	16.24	16.42	16.60	15.05	16.76	16.08	16.47	17.09	15.67	16.47	15.99	15.87	14.54
80 - 90	14.57	14.72	15.19	22.35	15.65	15.07	15.28	15.82	14.81	15.19	19.08	14.82	14.41
90 -100	22.11	21.77	22.67	24.82	22.62	22.04	22.21	23.23	22.39	21.76	21.97	21.69	21.12
100 -110	24.77	24.68	25.31	26.84	24.97	24.41	24.40	25.13	24.11	24.08	24.24	24.08	23.37
110 -120	26.56	26.56	27.03	28.49	26.93	26.58	26.37	26.87	14.81	26.17	21.72	26.25	25.91
120 -130	27.99	27.90	28.21	28.86	28.21	27.77	27.82	28.15	22.39	27.53	27.26	27.44	26.86
130 -140	27.93	28.05	28.92	5.70	28.61	27.95	27.85	28.56	24.11	27.90	27.72	27.75	27.47
140 -150	23.91	21.77	22.67	24.82	22.62	22.72	22.45	23.50	26.28	22.39	22.66	22.44	21.80
150 -160	27.88	24.68	25.31	26.84	24.97	21.50	21.29	21.75	27.44	21.17	21.35	20.93	20.02
	316.57	263.70	271.19	259.18	277.52	313.84	313.66	326.01	304.67	317.45	316.14	312.11	305.32

Control 2m.

Depth(Cm)	18 Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mach
0 - 10	7.23	6.66	6.24	6.49	8.46	6.96	6.70	8.53	7.16	7.04	6.72	5.26	5.63
10--20	9.95	8.62	8.16	8.34	8.60	8.38	8.30	8.46	8.60	9.27	8.79	7.57	8.08
20 - 30	13.76	12.52	12.63	12.95	12.93	13.49	13.47	14.65	13.30	15.24	15.75	13.87	16.70
30 - 40	16.79	16.90	18.10	19.78	20.13	21.21	20.84	21.86	19.45	21.52	22.57	21.36	23.02
40 - 50	21.24	22.06	23.44	25.05	24.37	25.08	24.20	25.04	23.81	24.86	25.49	24.70	21.26
50 - 60	21.98	22.30	23.61	24.65	23.75	24.50	23.54	24.07	23.55	24.00	24.35	23.88	23.83
60 - 70	24.15	24.23	25.43	26.19	25.37	25.54	24.83	25.04	25.10	25.12	24.99	24.29	24.46
70 - 80	25.39	25.77	27.22	27.47	26.43	22.14	25.65	26.04	25.76	25.98	25.88	25.02	24.90
80 - 90	25.48	25.60	26.89	26.93	26.28	21.87	25.53	26.10	25.59	25.60	25.97	25.23	24.81
90 -100	24.80	24.60	25.31	25.37	25.22	24.64	24.43	24.98	24.92	24.25	24.18	24.49	23.65
100 -110	25.51	25.00	25.87	25.81	25.84	25.25	24.98	25.39	25.46	24.69	24.60	24.55	24.17
110 -120	26.18	25.83	25.61	26.71	26.46	26.08	25.80	26.31	26.12	25.72	25.79	25.73	25.05
120 -130	28.17	28.23	28.11	28.80	28.67	28.48	28.26	29.06	28.47	28.01	28.31	27.56	27.78
130 -140	27.41	28.45	27.35	27.02	26.07	24.55	24.08	24.90	26.23	23.65	24.04	23.14	23.42
140 -150	27.03	28.15	27.50	25.95	22.57	19.05	18.81	19.28	23.54	18.29	18.56	18.08	18.33
150 -160	28.07	28.23	28.10	25.06	23.05	21.34	21.08	21.46	24.55	20.51	20.88	20.24	20.61
	353.17	353.14	222.90	284.56	282.52	338.55	340.48	351.16	315.81	343.76	346.87	334.98	335.71

Average	334.87	308.42	247.04	271.87	280.02	326.20	327.07	338.59	152.33	330.60	331.50	323.54	320.51
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Continue.....

Trench + FYM 2m

Depth(Cm)	18 Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mar
0 - 10	7.52	6.94	6.09	6.46	7.39	7.00	6.50	8.07	8.26	7.04	6.32	5.37	5.25
10--20	9.98	8.98	8.25	8.19	7.64	8.42	7.99	8.49	9.43	8.90	8.27	7.24	7.20
20 - 30	14.07	12.24	12.04	12.49	11.90	12.96	12.72	13.77	14.37	13.88	14.08	13.97	14.56
30 - 40	16.66	16.27	17.49	18.70	17.69	19.08	18.73	19.86	21.12	20.07	20.48	18.79	20.32
40 - 50	19.08	19.61	22.01	23.11	21.19	22.31	21.67	22.78	23.97	22.73	22.77	22.60	23.22
50 - 60	23.46	24.23	25.72	26.34	25.05	25.42	25.12	25.86	23.79	25.15	25.43	25.20	21.08
60 - 70	25.86	25.97	26.97	27.23	25.55	22.11	25.71	22.22	25.04	25.45	21.55	25.64	26.19
70 - 80	28.02	27.45	28.27	28.55	26.77	27.37	26.79	27.66	25.57	26.77	27.11	26.98	27.38
80 - 90	24.37	23.93	24.53	24.55	24.07	24.18	23.71	7.60	25.17	23.40	23.58	23.25	23.22
90 -100	22.86	22.72	23.28	23.22	22.60	23.19	22.65	23.36	24.95	22.34	22.49	22.07	21.64
100 -110	22.54	22.41	22.77	22.84	22.11	22.47	22.24	23.03	25.18	22.20	22.27	21.61	21.18
110 -120	23.40	23.27	23.67	23.78	22.96	23.47	22.98	23.78	26.04	23.03	22.96	22.60	22.21
120 -130	25.00	24.83	25.40	25.75	24.52	25.28	24.86	25.01	26.89	24.83	24.50	24.20	24.32
130 -140	24.57	24.60	25.39	25.84	24.41	25.19	25.12	24.81	23.37	24.45	24.44	24.08	23.88
140 -150	17.50	17.28	17.54	17.52	16.76	17.07	16.92	17.04	18.48	16.57	16.46	16.03	15.92
150 -160	20.97	20.68	21.05	20.92	20.30	20.81	20.51	21.09	20.70	20.10	20.12	19.70	19.65
	325.84	321.41	330.47	335.49	320.93	326.35	324.20	314.44	342.33	326.91	322.84	319.34	317.21

Trench + FYM 2m

Depth(Cm)	18 Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mach
0 - 10	8.92	7.73	7.17	6.66	10.65	9.03	8.27	12.21	10.98	8.21	8.15	8.91	6.24
20 - 30	9.95	8.99	8.80	8.07	9.48	9.44	9.07	9.36	10.31	9.44	8.25	9.20	7.66
20 - 30	12.54	11.75	11.92	11.82	11.67	12.38	12.57	13.27	13.27	13.00	13.22	12.49	13.68
30 - 40	17.05	16.77	17.80	18.86	18.76	19.63	19.35	20.49	19.66	20.05	20.56	19.00	21.20
40 - 50	18.91	19.51	20.84	21.42	20.88	21.55	21.32	22.21	21.20	21.58	22.14	21.05	22.91
50 - 60	20.53	20.96	21.74	21.80	21.14	21.63	21.32	23.09	21.17	21.44	21.54	21.49	22.69
60 - 70	21.61	22.00	22.42	22.20	21.62	22.04	21.96	23.67	21.58	21.85	22.69	22.15	22.97
70 - 80	23.49	23.68	24.18	23.53	23.19	23.67	23.43	24.92	23.06	23.28	23.97	23.67	23.71
80 - 90	25.00	24.94	25.63	24.99	24.11	24.90	24.74	25.92	24.42	24.57	24.65	24.90	24.20
90 - 100	25.54	25.37	26.02	25.40	24.76	25.48	25.18	26.07	24.86	25.18	26.72	25.51	24.20
100 - 110	25.68	25.45	26.40	25.72	25.22	25.81	25.59	26.16	25.57	25.54	27.35	25.86	24.58
110 - 120	24.63	24.09	25.17	24.53	23.89	24.34	24.11	24.78	24.23	24.08	26.05	24.54	23.02
120 - 130	25.48	24.86	25.92	24.99	24.85	25.05	24.77	25.57	24.94	24.63	25.34	25.13	23.85
130 - 140	25.89	25.31	26.32	25.78	25.28	25.81	25.26	26.19	25.48	25.15	22.83	25.39	24.58
140 - 150	22.97	22.22	23.16	22.69	22.19	22.75	22.02	23.03	22.20	21.68	22.25	22.47	21.18
150 - 160	18.88	18.83	19.01	19.45	18.57	19.18	18.34	19.08	18.12	17.80	19.41	18.79	17.72
	327.05	322.46	332.50	327.90	326.26	332.70	327.31	346.02	331.05	327.50	335.12	330.53	324.40
Average	326.45	321.94	331.48	331.70	323.59	329.53	325.76	330.23	336.69	327.21	328.98	159.67	320.81

Trench+slope 1m

Depth(Cm)	18 Oct.	31-Oct	15-Nov	8-Dec	19Dec.	22 Dec.	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mach
0 - 10	7.68	6.84	6.66	6.63	6.00	5.51	6.00	10.32	9.27	7.54	6.51	5.53	4.83
20-30	9.05	7.89	7.61	7.29	7.10	7.08	7.10	9.81	9.06	8.26	7.24	6.15	5.55
20 - 30	8.90	8.01	7.85	7.52	7.42	5.28	7.42	5.42	7.20	7.14	7.00	6.21	5.70
30 - 40	9.84	9.31	9.33	8.81	8.00	7.06	8.00	7.40	8.04	7.98	7.91	7.34	6.98
40 - 50	13.74	13.45	13.58	13.48	13.10	16.73	13.10	17.24	12.21	11.97	12.01	11.22	10.59
50 - 60	15.38	15.22	15.48	15.57	14.47	21.53	14.32	21.87	14.17	14.07	14.05	13.54	12.83
60 - 70	16.42	16.59	16.78	16.89	15.95	25.10	15.84	25.41	15.67	15.54	15.56	15.25	14.43
70 - 80	17.78	17.78	18.11	17.99	17.56	28.18	17.14	28.61	17.02	16.98	16.50	16.98	15.70
80 - 90	17.96	18.05	18.70	18.49	18.35	30.45	18.10	30.22	17.71	17.79	17.38	17.65	16.55
90 -100	18.79	18.93	19.23	18.92	18.96	30.79	18.25	31.19	18.12	18.22	17.81	17.55	17.68
100 -110	19.41	19.68	19.93	19.11	19.38	32.28	18.88	32.81	18.80	18.68	18.45	18.70	18.80
110 -120	18.60	19.15	19.23	18.30	18.88	30.62	18.18	31.48	18.24	18.51	18.06	19.35	18.82
120 -130	19.56	20.40	20.80	21.44	22.42	39.47	21.93	41.60	22.53	22.92	23.03	22.51	22.11
130 -140	20.76	21.88	21.94	21.00	21.31	36.47	20.66	37.21	20.67	20.78	20.70	20.36	22.07
140 -150	20.97	22.80	22.03	21.71	21.61	38.15	21.37	38.33	21.14	21.33	21.08	21.69	20.05
150 -160	21.56	23.82	22.78	22.22	22.36	40.11	22.20	40.50	22.06	22.17	22.00	22.58	22.55
	256.38	259.81	260.05	255.37	252.86	394.81	248.48	469.42	251.91	249.87	245.29	242.59	235.23

Trench+slope 1m

Depth((m)	18 Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21J	38385	10-Feb	18-Feb	1-Mar	11Mach
0 - 10	8.59	7.20	7.03	6.86	9.70	8.29	8.08	8.70	9.86	8.00	6.73	6.54	5.55
20-30	8.75	7.68	7.52	7.29	7.48	7.45	7.54	7.07	8.85	7.85	6.96	6.85	5.86
20 - 30	8.54	7.79	8.07	7.87	7.86	7.40	7.51	7.41	7.26	6.80	6.39	6.81	6.34
30 - 40	9.65	8.95	9.48	9.15	9.23	8.72	8.87	8.32	8.58	8.36	7.55	7.04	7.74
40 - 50	12.40	11.93	12.13	11.55	11.67	11.30	11.51	11.67	11.05	10.78	10.98	10.40	10.05
50 - 60	13.12	12.88	13.10	12.44	12.51	12.25	12.34	14.64	11.99	11.85	12.21	11.79	11.71
60 - 70	14.52	14.46	14.88	14.38	14.44	14.38	14.77	14.88	14.17	14.15	14.39	14.28	14.53
70 - 80	16.07	16.03	16.78	16.43	16.69	16.84	16.96	16.18	16.84	16.91	17.24	17.36	17.54
80 - 90	17.71	17.57	18.58	19.09	19.21	19.30	19.66	18.39	19.15	18.78	19.11	19.75	19.69
90 -100	20.10	20.13	21.36	21.97	22.05	21.96	21.25	19.28	21.76	21.37	21.61	22.07	21.83
100 -110	21.80	21.85	23.37	23.75	23.61	23.70	23.36	20.26	23.31	22.90	23.11	23.45	22.95
110 -120	22.54	22.35	23.29	23.55	23.72	23.67	23.36	18.82	23.42	22.90	23.00	22.71	22.27
120 -130	23.93	23.71	23.86	24.22	24.20	24.55	24.47	23.22	24.23	23.87	23.80	23.11	22.87
130 -140	26.12	25.66	26.31	26.70	26.25	26.34	26.08	25.37	21.45	25.11	25.52	25.32	24.94
140 -150	26.44	26.29	27.11	27.14	22.61	22.86	22.56	26.16	26.10	26.07	26.20	25.58	25.33
150 -160	26.24	25.86	26.93	26.87	22.59	22.40	22.22	26.81	25.95	25.94	25.79	25.58	25.00
	276.51	270.34	279.81	279.28	273.83	271.42	270.52	267.20	273.98	271.64	270.60	268.65	264.18
Average	266.45	265.08	269.93	267.32	263.34	333.11	259.50	338.31	262.95	260.76	257.94	255.62	249.71

Trench +slope 2 m

Depth(Cm)	18 Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mach
0-10	6.90	6.65	6.18	6.48	7.24	5.52	5.32	8.40	6.75	6.60	4.33	3.99	3.74
10-20	7.63	7.27	6.61	6.82	6.32	5.67	5.57	5.78	6.32	6.44	4.71	4.29	4.06
20-30	8.50	7.84	7.25	7.39	6.55	5.78	5.80	5.11	5.94	6.68	4.90	4.70	4.51
30-40	9.86	8.81	8.19	8.30	7.42	6.73	6.70	6.02	6.64	7.63	5.51	5.06	4.96
40-50	13.23	11.85	11.60	11.68	10.65	10.48	10.00	9.37	9.15	10.89	8.74	8.50	7.84
50-60	16.27	14.77	14.77	15.07	13.65	13.70	13.30	12.34	11.88	13.97	11.73	11.25	11.12
60-70	16.20	15.13	14.69	14.78	13.80	13.76	13.54	12.58	12.00	14.05	11.86	11.51	11.39
70-80	16.92	16.29	15.75	15.78	14.99	14.77	14.71	13.88	13.27	15.15	13.32	12.82	12.88
80-90	18.31	18.03	17.66	17.87	17.15	16.40	16.69	16.09	15.36	17.06	15.81	15.76	15.49
90-100	19.00	18.43	18.37	18.41	17.79	17.49	17.62	16.98	16.78	17.87	16.98	17.31	16.53
100-110	19.10	18.57	18.64	18.99	18.49	18.25	18.43	18.46	17.58	18.50	17.66	17.85	17.30
110-120	17.39	16.94	17.14	17.92	17.34	16.81	17.24	17.02	17.12	17.21	16.34	16.31	15.58
120-130	22.13	21.63	22.09	22.75	21.76	21.11	21.91	21.42	21.35	21.79	20.27	20.05	19.96
130-140	24.63	24.18	24.81	25.28	24.18	23.67	24.17	23.57	23.70	24.24	22.47	22.11	22.14
140-150	25.48	25.62	25.60	26.13	25.20	24.70	24.87	24.36	24.40	25.15	23.17	23.34	23.46
150-160	25.97	26.30	26.34	22.25	21.85	25.33	21.41	20.78	21.14		23.58	22.64	22.73
	267.53	258.33	255.69	255.91	244.35	240.17	237.29	232.17	229.39		221.38	217.50	213.69

Trench +slope 2 m

Depth(Cm)	18-Oct	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11-March
0-10	7.83	7.12	6.95	6.61	8.27	7.22	6.98	7.28	6.95	5.92	5.37	4.66	4.25
20-30	9.19	8.52	8.13	7.65	7.55	7.35	7.31	7.96	6.74	6.65	6.40	5.92	5.56
20-30	9.97	9.23	8.84	8.32	8.17	7.99	7.92	8.63	7.41	7.56	7.61	7.48	6.95
30-40	12.15	11.40	11.63	11.19	11.02	10.69	10.75	11.26	10.15	10.18	10.08	9.73	8.97
40-50	12.85	12.38	12.20	11.75	10.68	11.96	12.18	12.00	11.62	11.74	11.61	10.56	11.10
50-60	14.87	14.85	14.84	14.82	14.36	15.34	15.80	14.98	14.96	10.79	15.27	15.34	15.12
60-70	15.94	16.24	16.26	16.75	16.42	16.21	16.77	16.37	16.94	17.48	17.24	17.38	16.93
70-80	16.12	16.29	16.73	17.28	16.51	16.80	16.89	16.66	17.43	17.77	17.55	17.03	16.92
80-90	18.36	18.45	18.18	18.30	18.48	19.14	18.58	18.50	19.28	19.67	19.44	18.56	18.03
90-100	21.40	21.22	21.06	20.93	20.04	20.86	20.01	20.79	21.71	21.93	21.58	21.13	20.24
100-110	23.02	22.67	22.53	22.30	22.03	21.89	21.05	22.21	22.76	22.87	22.52	22.02	20.80
110-120	23.98	23.49	23.53	22.67	22.61	22.55	21.55	22.91	23.27	23.24	23.08	21.72	21.19
120-130	25.39	25.03	25.02	23.87	23.96	23.78	22.75	24.26	23.02	22.99	22.46	22.58	22.38
130-140	26.71	26.47	26.26	25.93	25.67	24.97	24.08	25.73	19.94	20.14	23.68	23.61	23.61
140-150	26.44	26.00	26.20	26.67	25.78	23.90	23.63	25.52	23.93	24.61	24.47	24.20	24.20
150-160	25.03	25.14	25.19	25.57	25.31	24.99	24.90	25.16	25.25	25.69	25.34	25.42	25.69
	289.24	284.49	283.54	280.62	276.85	275.64	271.15	280.22	271.37	269.22	273.70	267.35	261.95
Average	278.39	271.41	269.62	268.27	260.60	257.90	254.22	116.09	250.38	134.61	247.54	242.42	237.82

Trench+slope 1m

18

Depth(Cm)	Oct.	31-Oct	15-Nov	8-Dec	19Dec.	22 Dec.	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11Mach
0 - 10	7.68	6.84	6.66	6.63	6.00	5.51	6.00	10.32	9.27	7.54	6.51	5.53	4.83
20-30	9.05	7.89	7.61	7.29	7.10	7.08	7.10	9.81	9.06	8.26	7.24	6.15	5.55
20 - 30	8.90	8.01	7.85	7.52	7.42	5.28	7.42	5.42	7.20	7.14	7.00	6.21	5.70
30 - 40	9.84	9.31	9.33	8.81	8.00	7.06	8.00	7.40	8.04	7.98	7.91	7.34	6.98
40 - 50	13.74	13.45	13.58	13.48	13.10	16.73	13.10	17.24	12.21	11.97	12.01	11.22	10.59
50 - 60	15.38	15.22	15.48	15.57	14.47	21.53	14.32	21.87	14.17	14.07	14.05	13.54	12.83
60 - 70	16.42	16.59	16.78	16.89	15.95	25.10	15.84	25.41	15.67	15.54	15.56	15.25	14.43
70 - 80	17.78	17.78	18.11	17.99	17.56	28.18	17.14	28.61	17.02	16.98	16.50	16.98	15.70
80 - 90	17.96	18.05	18.70	18.49	18.35	30.45	18.10	30.22	17.71	17.79	17.38	17.65	16.55
90 -100	18.79	18.93	19.23	18.92	18.96	30.79	18.25	31.19	18.12	18.22	17.81	17.55	17.68
100 -110	19.41	19.68	19.93	19.11	19.38	32.28	18.88	32.81	18.80	18.68	18.45	18.70	18.80
110 -120	18.60	19.15	19.23	18.30	18.88	30.62	18.18	31.48	18.24	18.51	18.06	19.35	18.82
120 -130	19.56	20.40	20.80	21.44	22.42	39.47	21.93	41.60	22.53	22.92	23.03	22.51	22.11
130 -140	20.76	21.88	21.94	21.00	21.31	36.47	20.66	37.21	20.67	20.78	20.70	20.36	22.07
140 -150	20.97	22.80	22.03	21.71	21.61	38.15	21.37	38.33	21.14	21.33	21.08	21.69	20.05
150 -160	21.56	23.82	22.78	22.22	22.36	40.11	22.20	40.50	22.06	22.17	22.00	22.58	22.55
	256.38	259.81	260.05	255.37	252.86	394.81	248.48	409.42	251.91	249.87	245.29	242.59	235.23

Trench+slope 1 m

Depth(Cm)	18-Oct	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21J	38385	10-Feb	18-Feb	1-Mar	11Mach
0 - 10	8.59	7.20	7.03	6.86	9.70	8.29	8.08	8.70	9.86	8.00	6.73	6.54	5.55
20-30	8.75	7.68	7.52	7.29	7.48	7.45	7.54	7.07	8.85	7.85	6.96	6.85	5.86
20 - 30	8.54	7.79	8.07	7.87	7.86	7.40	7.51	7.41	7.26	6.80	6.39	6.81	6.34
30 - 40	9.65	8.95	9.48	9.15	9.23	8.72	8.87	8.32	8.58	8.36	7.55	7.04	7.74
40 - 50	12.40	11.93	12.13	11.55	11.67	11.30	11.51	11.67	11.05	10.78	10.98	10.40	10.05
50 - 60	13.12	12.88	13.10	12.44	12.51	12.25	12.34	14.64	11.99	11.85	12.21	11.79	11.71
60 - 70	14.52	14.46	14.88	14.38	14.44	14.38	14.77	14.88	14.17	14.15	14.39	14.28	14.53
70 - 80	16.07	16.03	16.78	16.43	16.69	16.84	16.96	16.18	16.84	16.91	17.24	17.36	17.54
80 - 90	17.71	17.57	18.58	19.09	19.21	19.30	19.66	18.39	19.15	18.78	19.11	19.75	19.69
90 -100	20.10	20.13	21.36	21.97	22.05	21.96	21.25	19.28	21.76	21.37	21.61	22.07	21.83
100 -110	21.80	21.85	23.37	23.75	23.61	23.70	23.36	20.26	23.31	22.90	23.11	23.45	22.95
110 -120	22.54	22.35	23.29	23.55	23.72	23.67	23.36	18.82	23.42	22.90	23.00	22.71	22.27
120 -130	23.93	23.71	23.86	24.22	24.20	24.55	24.47	23.22	24.23	23.87	23.80	23.11	22.87
130 -140	26.12	25.66	26.51	26.70	26.25	26.34	26.08	25.37	21.45	25.11	25.52	25.32	24.94
140 -150	26.44	26.29	27.11	27.14	22.61	22.86	22.56	26.16	26.10	26.07	26.20	25.58	25.33
150 -160	26.24	25.86	26.93	26.87	22.59	22.40	22.22	26.81	25.95	25.94	25.79	25.58	25.00
	276.51	270.34	279.81	279.28	273.83	271.42	270.52	267.20	273.98	271.64	270.60	268.65	264.18

Average	266.45	265.68	269.93	267.32	263.34	333.11	259.50	338.31	262.95	260.76	257.94	255.62	249.71
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Polyethylene 2m

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Depth(Cm)	18-Oct.	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11-Mar
0 - 10	7.64	7.12	6.37	6.65	7.16	6.86	6.66	7.25	7.77	7.24	6.72	5.59	5.36
10--20	9.52	8.54	7.84	7.83	6.97	7.19	7.17	7.66	7.51	7.77	7.67	6.84	6.59
20 - 30	8.76	8.23	7.50	7.66	6.88	7.02	6.89	7.37	6.85	7.12	7.08	6.70	6.59
30 - 40	11.72	10.94	10.29	10.47	9.56	9.51	9.50	10.07	9.57	9.98	9.74	9.76	10.32
40 - 50	13.14	12.33	11.97	12.20	11.50	11.75	12.03	12.83	12.70	13.74	14.00	14.58	15.78
50 - 60	13.30	13.28	13.46	15.07	14.80	15.24	15.44	16.19	16.91	17.59	17.40	18.21	17.62
60 - 70	15.92	16.01	17.21	18.22	18.10	18.30	18.64	18.89	18.73	19.20	19.13	19.31	19.46
70 - 80	16.55	16.92	17.54	18.34	18.05	18.27	18.36	18.57	18.61	18.88	18.41	18.60	18.60
80 - 90	17.03	17.99	18.44	18.25	17.86	18.27	17.72	18.30	18.61	18.39	18.39	17.79	18.13
90 - 100	16.55	17.87	17.87	17.52	17.20	17.99	16.88	17.32	17.45	16.93	17.31	17.26	17.31
100 - 110	16.46	17.94	17.65	17.87	17.10	17.58	16.88	16.93	17.66	17.24	17.76	16.46	16.76
110 - 120	15.13	15.46	14.61	16.27	15.75	15.02	15.01	15.48	15.08	14.96	15.60	14.34	14.28
120 - 130	23.27	23.71	23.86	24.39	23.81	23.28	23.20	23.39	23.92	24.05	24.47	22.74	23.02
130 - 140	24.49	24.49	24.53	25.03	24.38	24.38	24.02	24.18	24.31	24.60	24.27	23.71	23.71
140 - 150	24.77	24.68	24.47	25.22	24.55	24.67	24.34	24.81	24.40	24.69	24.38	24.26	23.91
150 - 160	24.88	24.71	24.67	25.28	24.50	24.87	24.46	24.95	24.37	24.75	24.44	24.37	24.02
	259.13	260.22	258.27	266.28	258.16	260.20	257.21	264.20	264.46	267.11	266.77	260.54	261.48

Polyethylene 1m

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Depth(Cm)	18-Oct	31-Oct	15-Nov	8-Dec	19-Dec	3-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11-Mar
0 - 10	7.08	6.70	6.16	6.56	8.36	7.57	7.07	7.89	8.27	7.66	6.79	5.74	5.53
10-20	9.15	8.33	7.61	7.91	7.21	7.93	7.83	8.10	8.31	8.68	8.24	7.21	6.95
20 - 30	9.13	8.21	7.42	7.81	6.95	7.34	7.15	7.48	7.05	7.32	7.34	6.87	6.64
30 - 40	12.64	11.51	10.69	10.82	9.78	9.93	10.02	10.21	11.97	10.08	10.08	9.96	9.77
40 - 50	13.35	12.60	11.85	12.06	11.01	11.45	11.38	11.71	11.24	11.33	11.38	11.33	11.29
50 - 60	14.43	13.54	12.96	13.08	12.11	12.69	12.55	13.16	12.63	13.35	13.68	14.58	15.43
60 - 70	14.95	14.55	14.14	14.64	14.07	15.49	15.72	17.27	17.80	18.73	19.25	20.06	20.61
70 - 80	16.18	16.03	16.12	17.82	17.62	19.03	19.00	19.88	19.92	19.92	20.43	20.27	20.30
80 - 90	19.54	19.78	20.35	21.79	21.41	21.98	21.78	22.40	22.23	22.25	22.49	22.16	22.24
90 - 100	20.54	20.81	21.26	22.59	22.44	22.34	22.13	22.84	22.59	22.78	22.63	22.21	22.21
100 - 110	23.68	23.90	24.33	25.46	24.82	25.22	24.89	25.48	25.36	25.33	25.17	24.87	24.78
110 - 120	27.36	27.36	28.05	28.89	28.13	28.36	27.98	28.50	28.31	28.47	28.19	28.00	27.88
120 - 130	29.31	29.28	29.71	30.53	29.61	30.13	29.61	30.13	29.89	34.32	29.67	29.46	29.39
130 - 140	29.43	29.40	29.81	30.56	29.67	30.09	29.61	29.91	29.70	29.89	29.58	29.30	29.17
140 - 150	29.56	29.59	29.78	30.43	29.45	30.00	29.52	29.82	29.54	29.89	29.49	29.23	29.01
150 - 160	30.88	30.70	31.00	31.69	30.54	31.06	30.64	30.97	30.76	30.79	30.77	30.39	30.10
	307.22	302.30	301.23	312.65	303.16	310.62	306.88	315.76	315.57	320.81	315.18	311.64	311.32

Polyethylene 1m

Depth(Cm)	18-Oct	31-Oct	15-Nov	8-Dec	19-Dec	1-Jan	10-Jan	21-Jan	2-Feb	10-Feb	18-Feb	1-Mar	11-May
0-10	8.30	7.42	6.45	6.64	9.25	7.71	7.38	7.14	9.06	7.23	6.29	5.78	5.62
10-20	11.59	9.30	8.03	8.11	8.09	8.44	8.37	8.14	8.15	8.25	7.74	7.14	7.07
20-30	11.43	9.12	8.11	8.34	7.81	7.99	8.08	8.01	8.25	7.99	7.98	7.53	7.64
30-40	14.14	12.55	11.72	12.19	12.21	12.51	13.39	13.49	13.65	14.12	14.37	14.66	15.34
40-50	17.32	17.35	18.30	19.93	20.18	20.42	20.95	21.57	21.34	22.08	22.24	22.94	23.37
50-60	22.22	25.50	24.44	25.67	25.22	25.22	25.44	26.53	26.72	26.57	26.50	26.86	26.95
60-70	26.71	27.09	27.53	27.73	27.23	27.28	27.52	28.19	27.70	28.28	28.13	28.13	28.06
70-80	28.14	28.36	28.80	28.78	28.31	28.20	28.51	29.07	29.05	29.19	28.81	28.57	28.50
80-90	28.42	28.45	28.83	28.84	28.41	28.26	28.38	28.19	29.00	29.04	28.53	28.41	28.31
90-100	28.05	27.96	28.30	28.29	27.75	27.71	27.70	28.47	28.83	28.57	27.88	27.78	27.66
100-110	27.81	27.63	27.95	27.92	27.60	27.31	27.18	28.13	28.22	27.88	27.36	27.53	27.53
110-120	29.31	29.06	29.68	29.72	27.59	29.05	28.82	30.02	29.35	29.48	29.04	29.04	29.14
120-130	29.31	29.00	29.43	29.57	29.00	28.89	28.70	29.80	28.08	29.29	28.94	28.89	28.89
130-140	28.73	28.57	28.83	29.16	28.53	28.58	28.25	29.29	29.05	28.66	28.41	28.44	28.82
140-150	28.17	28.14	28.20	28.56	27.85	28.20	27.82	28.85	28.20	28.06	27.91	27.75	28.75
150-160	28.08	28.08	28.29	28.53	27.82	28.08	27.73	29.07	29.77	28.15	28.16	27.97	28.96
	367.72	363.58	362.87	367.97	362.87	363.86	364.23	373.95	374.42	372.85	368.29	367.43	370.60
Average	337.47	332.94	332.05	340.31	333.02	337.24	335.55	344.85	344.99	346.83	341.74	339.53	340.96

ABSTRACT

Title of thesis : Effect of Different Soil Management Practices on Moisture Conservation in Soils Under Arid Fruits

Full name of degree holder : Shish Pal Poonia

Admission No. : 99A69D

Name and Address of Major Advisor : Dr. Milakh Raj
Sr. Soil Physicist & Chief Scientist
Dry Land Agriculture
Department of Agronomy
CCS Haryana Agricultural University,
Hisar – 125004, India

Degree awarding University/Institute : CCS HAU, Hisar 125004 (Haryana) INDIA

Major Award : Soil Science

Number of words in Abstract : 250

Year of award of degree : 2006

An abstract of the thesis submitted in partial fulfillment of the requirements for the degree of Ph. D. in subject of Soil Science of the CCS Haryana Agricultural University, Hisar.

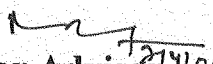
The study included both field as well as laboratory experiment. Field experiment on "Effect of Different Soil Management Practices on Moisture Conservation in Soils Under Arid Fruits" was conducted at Regional. Research Station (CCS HAU, Hisar) Balsamand and Dryland Research Farm, CCS HAU, Hisar during 2002-03 and 2003-04. The field study consisted of three experiments

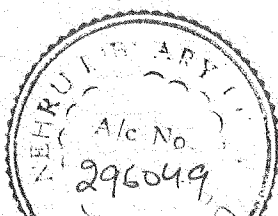
- i) Effect of land slope, pond sediment thickness, rainfall intensity and its duration on water runoff/harvesting. The treatments comprised of four slope (0, 3, 4.5 and 6%), three levels of pond silt (100, 200 and 300 t/ha), three rainfall intensity (2.8, 5.4 and 8.4 cm/hr) and three rainfall duration (10, 20 and 30 minutes). The gross plot size was 2m x 6m with three replication.
- ii) Effect of different mulches on water conservation in soil under arid fruits with four mulches (control, soil mulch, crop residue and polyethylene. The plot size was 7 m² in circular shape. Depth of irrigation was 7.5 cm at ID/CPE of 0.75. Pond silt was added @ 200 t/ha.
- iii) Effect of different soil surface manipulation on moisture conservation was studied with six treatments absolute control (without tree), control (no manipulation), Polyethylene mulching, outward slope 5%, outward slope and trenching and outward slope with mulching in trench.

- iv) Laboratory experiment “vertical movement of nitrogen as a function of time” consisting of three nitrogen level i.e. 100, 200 and 300 mg/kg soil and 7.5 cm depth of irrigation was conducted in *plexi glass* column in laboratory of Deptt. of Soil Science, CCS HAU, Hisar.

The results of this investigation indicate that:

- Run-off significantly increased as pond silt increases. Similarly, land slope also significantly enhanced the runoff. The effect of pond silt level and slope on runoff generation was found to be significant.
- Soil erosion significantly increased as level of pond silt increased from 0 to 300 t/ha. Land slope also increased significantly the soil erosion.
- Amendment of pond silt from 0 to 300 t/ha significantly increased the sediment load of runoff.
- Reversely from runoff and soil erosion, sediment load of runoff water was decreased with increase in rainfall duration from 20 min to 30 min.
- The maximum soil moisture storage was found under polyethylene mulching and followed as crop residue mulch > soil mulch > control.
- Maximum yield was obtained from the tree having outward slope + FYM in trench followed by slope + trench, trench only, slope + polyethylene and control.
- The rate in advancement of water front decreased from an initial rate of 10 cm/min to 1.3 cm/min.
- In general $\text{NO}_3\text{-N}$ concentration increased with increasing depth for all the three doses (viz. 100, 200 and 300 ppm) except near the end of the water front.


Major Advisor 27/10/06




Signature of Degree Holder