SOIL AND WATER CONSERVATION ON SLOPY VERTISOLS OF MEDIUM DEPTH BY SOWING METHODS, VEGETATIVE BARRIER AND CONTOUR BUND

BY

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DISSERTATION

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Affectionately Dedicated To
My Elder Brother
Who Have Strived To Make
My Educational Career

CANDIDATE'S DECLARATION

I hereby declare that the dissertation or any
part there of has not been previously
submitted by me to any
other university or
institution for a
degree or
diploma.

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CERTIFICATE I

This is to certify that **Shri Jadhav Praveen Dattatraya** has satisfactorily prosecuted his course of research for a period of not less than two semesters and that the dissertation entitled " **SOIL AND WATER CONSERVATION ON SLOPY VERTISOL OF MEDIUM DEPTH BY SOWING METHODS, VEGETATIVE BARRIER AND CONTOUR BUND"** submitted by him, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination for the degree of **MASTER OF SCIENCE (Agriculture)** in **Agricultural Chemistry and Soil Science**.

I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any university.

PLACE : **PARBHANI**
DATE : 15/07/2000

(B.G. KARLE)
Research Guide

CERTIFICATE II

This is to certify that the dissertation entitled "**SOIL AND WATER CONSERVATION ON SLOPY VERTISOL OF MEDIUM DEPTH BY SOWING METHODS, VEGETATIVE BARRIER AND CONTOUR BUND**", submitted by **Shri Jadhav Praveen Dattatraya** to the Marathwada Agricultural University, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **Agricultural Chemistry and Soil Science** has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

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Place : Parbhani

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(JADHAV P.D.)

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ABBRIVATIONS

Abbrivations	Full form
BBF	Broad bed and furrows
CB	Contour bund
CI	Cumulative infiltration
cm	centimeter
dsm^{-1}	desi simon per meter
ha	hectare
hr	hour
IR	Infiltration rate
K	Potassium
Kg	Kilogram
m	meter
Mg	Mega gram
mha	million hectare
mm	milimeter
MR	Monetary return
MU	Moisture use
MUE	Moisture use efficiency
N	Nitrogen
N.S.	Non significant
P	Phosphorus
q	quintal
Rs	Rupees
V.B.	Vegetative barrier
^{0}C	degree Celsius
%	percent

INTRODUCTION

CHAPTER -I

INTRODUCTION

Soil and water, the two major natural resources available to the farmer, are essential for crop growth and production. They are meager and limited. The erratic rainfall and soil erosion are major handicaps faced by the farmers. The problem is compounded by high temperature regimes, long period of droughts, improper vegetation cover and nutrient deficiency in soil. Undependable soil moisture availability arising from uncertain rainfall coupled with lack of serious efforts for rain water conservation are the factors of low yield in dry land farming where in farmer is confronted with poor resources, limited input and problems.

The state of Maharashtra, endowed with wide variation of physiographic climate, geology and natural vegetation which are responsible for the development of large variety of soils. As per the soil map prepared, by National Bureau of Soil Survey and Land use planning, Nagpur, from 356 mapped units (Family associates) based on assessment of degradation status of soil. About 3.0 million hectares representing 42.3 percent of the total geographical area of Maharashtra is affected by various kinds of soil degradation problems. Surface runoff is a serious problem of soils on slopy and undulating topography resulting in soil erosion is 11.7 million hectares i.e. 38 percent of total geographical area of the state.

Black soil cover an area of 72.9 mha which constitute almost 22.2 percent of the total geographical area of the country and are mainly distributed in Maharashtra, Madhya Pradesh, Gujrat and Karnataka State under hot and dry, semi-arid to sub-humid monsoonic type of climate. Black soils, are synonymously reffered as vertisols and associated balck soil, inceptisol and entisol. These soil are varied in depth, texture, morphology, colour and are characterised by the presence of montmorillonite clay mineral exhibiting swelling and shrinkege in wet and dry condition, respectively. These soils are clayey with their high cation exchange capicity and water retention, low in organic carbon, nitrogen and zink, low in infiltration rate and prone to water logging, secondary salinity and sodicity. Moisture stress is another important problem as it adversly affect the crop productivity due to prolonged dry spells from Oct. to May and during rainy season (June to Sept.).

Soil erosion refers to wearing away of the Earth's surface by the forces resulted due to wind, water, ice as per the intensity. Erosion has been categorised into sheet, rill, gully erosion. The term soil erosion should be linked with potential productivity of soil for its evaluation. On the basis of field studies soils of Maharashtra are grouped into four erosion classes and majority of the area is under moderately eroded class (66.4 per cent) followed by severe class (27.4 per cent). The soil erosion depends upon the soil depth Maharashtra occupies 26.4 per cent very shallow (10-25 cm), 14.4 per cent shallow and 15.3 per ent slightly deep (50 cm) which are prone to erosion losses of soil and water. The shallow soils which are of coarse textured underlined with soft disintegrated weathered rocks mixed with clay called murrum, which restricts the capillary flow of water in underlying layers. The available water storage capacity of these soils is poor resulting in quick drying of soil and roots remain confined to the surface level with high sub-surface, mechanical impedance. The degree and length of slope are important features of topography concerning in runoff and erosion depending upon soil type.

Present systems of land and water management are open field cultivation, haveli system, Bandhi system and rice bunds are adopted by farmers. A meager research data is available on the technology for appropriate soil and water management. A limited research on land treatment, runoff collection and land use has been conducted under the dry land project, Indo-UK dry farming project, improvement of soil physical condition project of ICAR and ICRISAT. The various practices recommended for soil and water conservation are water diversion bund, terrace system, contour bund, graded bunds, grasssed water ways, vegetative live bund of grasses, contour hedges, ridge-furrow system, broad bed and furrow system across the slope and vertical mulch are some of the practices to mitigate moisture stress on soils with slopy topography.

Vegetative soil and water conservation measures are cheap and one's established they are permanent Vetiver grass planted on contour is recommended is a substitute for graded bunds. Unfortunately with erratic rainfall, free grazing and socio-economic constrains are the major problems.

The farming systems aim at best use of natural resources and minimization of soil and water loss. The range of cropping system depends upon climate, soils, crop characteristics, prescription of the farmers, availability of the resources and economic factors. The inter-cropping involves growing together of two crops of similar maturity but dissimilar in height and canopy. Considerable research data prove superiority of intercropping or strip-cropping over sole cropping of the crop.

In Maharashtra cereals, pulses, oil seed and fibre crops are grown on medium soils with slopy topography. Out of total cropped area 53.6 per cent is cultivated for different cereal crops (sorghum, pearl millet, rice and wheat), 16.1 per cent pulses (pigeon pea, green gram and chick pea), 12.7 per cent fibre crops like cotton, 17.3 per cent oil seed crops and remaining for sugar cane and plantation crop. As per report of NBSS and LUP, Nagpur about 33.9 per cent area is highly suitable for sorghum in Maharashtra. The major constrains limiting the production of sole-cereal cropping or intercropping/strip cropping of legumes with cereal are uncertain erratic rainfall, Low water capacity, shallow soil depth, run-off and soil erosion losses, permeability and improper soil and water management practices. It is important to note that any single practice is insufficient to increase the productivity of crops and strategy needs modification with integrated approach of in situ moisture conservation, adoption of crops management practices, land surface configuration and alternative land use system for stabilizing productivity.

The discussion so far indicates that besides natural factor, improper use of land and adoption of cropping system lead to erosion hazards with low productivity. How land use has a major effect on soil productivity and soil erosion. It is usually the starting point in developing cropping management system for a farm to achieve efficient production and erosion control.

In view of the above and lack of sufficient information on land management practices for efficient cropping system on medium soil with slopy topography, present investigation was under taken to study. "Soil and water conservation on slopy vertisol of medium depth by sowing methods, vegetative barrier and contour bund." on Vertisols of medium depth of 1.5 per cent slope with following objectives.

To study the effect of land configuration and cropping systems on :

1. Physical properties of soil.
2. Chemical properties of soil
3. Runoff and soil losses and
4. Yield of sorghum and pigeon pea.

REVIEW OF LITERATURE

CHAPTER-I

REVIEW OF LITERATURE

Soil and water are two major resources essential for crop growth and production. Efficient management and utilization of these resources are very important to increase the crop production and productivity per unit area. Pertinent literature related to soil and water conservation, measures physical constrains for productivity of soil on slopy topography by land surface configuration and intercropping system is reviewed for the present investigation.

2.1 Effect of land configuration

In India, water erosion is principle reason for land degradation and rainfall is the chief source of energy for the process of soil erosion. In India rainfall is concentrated during mansoon months and during this period land either remain bare have little crop canopy.

On cultivated lands with slopy/rolling topography, runoff problems assume serious dimensions during the periods of intense rain storm. Different land configurations help in moderating the over land flows by reducing velocity of runoff water. Black soil in the semi arid region are highly dispersible having high clay content and dominance of montmorillonite clay. Slow permeability and low infiltration rate result in internal drainage as a results of water stagnation and solution to the problem must lie land and water management practices which increase surface dràinage.

2.1.1 Physico-chemical properties of soil

It is essential that area which can not be provided with irrigation is covered by soil and moisture conservation measures. In order to overcome variable moisture status and drought can limit plant growth at any time during the season. Under such condition crop must able to take full advantage of the period of available moisture to with stand period of stress and to resume growth rapidly when moisture is again available. Conservation practices like bunding, ridging across the slope, BBF across the slope, vegetative barrier across the slope or planting of the crop across the slope are some of the major adopted to reduce soil and water losses by improving physical properties and yield of the crop.

Patil and Bengal (1989) in their experiment on the effect of conservation and cultivation practices for pearl millet under rainfed condition reported that conservation practices (contour and graded ridges) resulted in higher moisture content and were found to effective soil conservation practices for increased yield of pearl millet.

Nalawade (1991) reported that the physical properties like infiltration rate, bulk density and porosity were affected by different land treatment. He reported that the infiltration rate was low with flat bed (0.6 cm/h) system. It was highest in broad bed and furrows (0.65 cm/hr). The infiltration rate was higher after harvest of the crop (Soil bulk density and porosity were increased with time). In general [higher bulk density (1.4 and 1.3) and lower porosity 47 and 50 percent] was observed with flat bed system as compared to broad bed. The highest porosity of (56%) was found in BBF after harvest of groundnut crop.

Barai *et al.* (1991) studied the effect of conservation practices on soil moisture and sorghum yield and noted that increase in soil moisture was 22.5 per cent due to graded contour border. Where as increase in soil moisture of 13.2 per cent in sowing along the contour line as against the sowing along the slope.

Prasad *et al.* (1993) reported that planting castor + green gram across the slope recorded 4.4 and 4.5 per cent more water use and increased water use efficiency by 21 and 10.5 per cent compared with planting along the slope. They further stated that increase water use was due to increase biomass production under better profile moisture condition owing to lower run-off. Similarly the increased organic carbon, available NPK were in the treatment of planting the crop across the slope.

Sagare and Kapgate (1994) reported that a significant and maximum increase in N,P and K removed by cotton was observed due to contour farming as compared to cultivation along graded bund and across the slope.

Awasarmal and Lande (1995) conducted the study on infiltration characteristics of vertisol in flat bed and ridges and furrows during kharif and rabi season before and after rainfall during the year 1985. The infiltration rate due to ridges and furrous was increased (2.4 cm/hr)as compared to flat bed (1.2 cm/hr) even after rainfall of 67.3 mm in september, 1995, at any particular time infiltration rate decreased with rise in initial moisture content.

Sharma and Sastry (1998) studied impact of various land used on initial and final infiltration rates and observed that in the first hour, infiltration rate (cm/hr) falls remarkably under different land uses i.e. 5.90 to 2.20 for grass land 8.33 to 1.66 for agricultural land and 9.63 to 4.43 for land put under Eucalyptus plantation.

Solanke (1998) reported that conservation practices (Broad bed and furrows and vegetative barrier) resulted in higher moisture content also increased infiltration rate, moisture use as compare to control.

2.1.2 Yield

Dryland agriculture is characterised by a higher frequency of uneven distribution of rainfall in time and space. This often causes dry spells of even 2 weeks or more resulting in moisture stress conditions, If these occurs at the critical growth period of crops, the yields are seriously impaired (Virmani *et al.*, 1981). Conservation of moisture is an effective means of checking the overland runoff, causing the water to infiltrate and be stored in the soil profile so that it is made available to the crop diring moisture stress conditions resulting in better growth and yields (Rama Mohan Rao *et al.* 1978 and Dhruva Narayana, 1987). It is an important tool for raising crop yields in rainfed farming system, particularly, when land are slopy (1.5 to 2.5 % slope).

Ram Babu *et al.* (1978) studied conservation practices like field bunding and ridging across the slope and reported that increased crop yield considerably. Mean grain yield differences were statistically significant due to different treatments. Mean maximum yield (3804 kg/ha) was obtained with ridges and furrows formed at the time of sowing. However it was at par with ridges and furrows. Lowest mean yield (2386 kg/ha) was obtained with maize sown across the slope.

Rao *et al.* (1980) reported that contour cultivation alone can increase the sorghum yield by 35 per cent, in gently sloping (73 per cent) lands. Broad beds on 0.3 per cent grade conserve more moisture and give 28 per cent more yield of sorghum.

Bonde *et al.* (1982) observed greater yield of tobacco and cotton when planted on ridges than in flat planting about 7 and 11.4 per cent more yield were obtained of tobacco & cotton respectively in ridges planting as against flat beds.

Mittal *et al.* (1986) reported that the formation of ridges and furrows at sowing reduced mean runoff by 86 per cent and soil loss by 95 per cent and increased mean maize yield by 59 per cent as compared to the conventional practice of sowing along the slope.

Dhruva Narayana (1987) in his review reported that an integrated package of practices such as contour tillage, mechanical measures, consrvation agronomical practices not only reduce the soil erosion losses but also improve the crop yield.

Gutal *et al.* (1988) in their experiment on black soil at Rahuri observed reduction in sunflower grain yield with increase in land slope while contour cultivation across the slope resulted increased in yields.

They further reported that crop yield was more in the treatment where runoff and soil loss are less.

Patil *et al.* (1991) reported that the yield of grain and fodder of sorghum and pigeon pea was significantly superior in broad bed and furrows (BBF) and vertical mulch treatment.

Radder *et al.* (1991) reported that the increase in safflower grain yield was highest (26 per cent) in 4.5 X 4.5 m spaced compartment bund followed by compartment bunding at 3 X 3 m (22 per cent) over unbunded control. Similarly, grain yield of rabi sorghum was increased by 56 and 50 per cent with compartment bunding at 3X3 m and 4.5X4.5 m respectively, over control.

Tripathi and Suraj Bhan (1993) reported that, among the moisture conservation practices, the furrowing + mulching was found to be most efficient in conserving soil moisture and increasing plant canopy and yield. However ridge and furrow beds was better than mulching in terms of yield.

Sagare and Kapgate (1994) reported that high increase in productivity (grain/seed cotton yield, 15.4 and 21.2 percent) was recorded due to contour farming with vetiver key line over cultivation across slope. Highest benefit cost ratio was also notice due to contour farming.

Taley *et al.* (1994) reported that the growth in terms of height and dry matter production was better under sowing along vetiver key line at one meter interval over land shaping and grading and sowing across the slope with sorghum + green gram inter cropping.

Tyagi and Joshi (1994) showed that an integrated application of mechanical and agronomical conservation practices not only reduce the soil and water losses but also improve the crop yields.

Suraj Bhan *et al.* (1995) reported that, among moisture conservation practices, furrowing was found to be most efficient in reducing water use, increasing water use efficiency, root development and yield.

Sachan and Gangawar (1996) showed that among row spacing, narrow spacing (45 cm) was found suitable for significantly increasing the grain yield and stover yield and net return. Where as better yield attributes were observed in wider spacing (60 mm). Among mositure conservation practices weeding, hoeing and earhting was found to be effecient in respect of yield attributes, yield and net returns.

Selvaraju and Ramaswamy (1997) reported that compartment bunding reduce the crop (sorghum and pigeon pea) establishment at other parameter compared to BBF. Marginal yield increase in sorghum (81 kg/ha) under BBF treatment over compartmental bunding might be due to free drainage after soaking the beds under the BBF treatment. How ever, BBF system recorded above 574 kg/ha higher sorghum yield than flat fed land configuration. Further they state that consistence reduction in sorghum yield in flat bed might to be due to low soil moisture than in the BBF.

Arjun Prasad and Ratan Singh (1998) reported that the dust mulch + stover mulch gave 9.0, 6.1 and 2.8 per cent more sorghum grain yield and 32.7, 11.5 and 12.0 per cent more pigeon pea grain yield than no mulch, dust mulch and stover mulch respectively.

Solanke (1998) reported that the land configuration affect the physical properties of the soil and ultimately increases the crop yield.

2.1.3 Runoff water and soil loss

The low and unstable production levels in the existing farming system on Vertisols are due to improper and unscientific land use and crop management practices. Adoption of erosion measures are necessary but generally expensive. The hazards of soil erosion both on site and off-site, could be minimise by adopting control measure which are generally based on the principle of safe disposal of excess surface runoff, slope management through land farming and trapping sediment through bio engineering and engineering measures.

In India Raghunath *et al.* (1967) from their experiments at ootacumund, reported that in the deep lateritic soil of the nilgiris, contour cultivation even on slopes as high as 22 per cent, reduces runoff from 52 to 29 mm (44 per cent) and soil loss from 39 to 14.9 tonnes/ha. (62 per cent).

Anonymous *et al.* (1971) reported that the graded and contour ridges reduced soil loss by 52.1 per cent and 81.7 per cent respectively with ridge treatment along the slope. The contour ridge and graded ridges across the slope cultivation recorded more moisture retention in the soil and reduced runoff and thereby increased the yield.

Bhatiya and Choudhary (1977) reported 50 per cent reduction in runoff and 75 per cent reduction in soil loss with contour farming. Mean maximum (8.5 t/ha) and mean minimum (0.3 t/ha) soil loss occured in sowing along the slope and when ridges and furrows were formed at the time of sowing respectively.

Ram Babu *et al*.(1978) studied conservation practices like field bunding and ridging across the slope reduced runoff and soil loss.

Tejwani (1980) reported that contour cultivation in alluvial soil at Dehradun and Kanpur are very useful in reducing soil and water losses.

Bonde *et al*. (1982) reported that runoff losses were minimum in grass cover and maximum in cotton crop with traditional planting method on flat bed. Ridging across the slope with cotton considerably reduce to 44 per cent runoff water and 52.8 per cent soil loss over traditional method of planting on flat bed.

Mittal *et al*. (1986) reported that formation of ridges and furrows at sowing reduced mean runoff by 86 per cent and soil loss by 95 per cent and increased maize yield by 59 per cent as compare to conventional practices of sowing along the slope.

Dhruvanarayana (1987) in his review reported that mechanical structure is an important component of soil and water conservation programme in any watershed. He also found that an integrated package of practices, Such as conter tillage, mechanical moisture conservation, agronomical practices not only reduce the soil erosion losses but also improve the crop yield.

Gutal *et al*. (1988) reported that countour cultivation minimized runoff than sowing along the slope.

Patil and Bengal (1991) reported that runoff increased with slope and the soil erosion was decreased due th sowing across the slope. Decrease in soil erosion was 32.6 and 32.4 per cent due to sowing across the slope in 1.0 and 1.5 per cent slope respectively. Sowing across the slope reduce mean runoff by 8.7 per cent as compare with sowing along the slope.

Bharad et al. (1992) reported that maximum runoff recorded during the month of July and August and contour cultivation along vetiver key line recorded minimum run off followed by contour cultivation along lencanena key line in both the year.

Kale *et al*. (1993) reported that contour bunding was most effective in reducing the soil loss followed by bench terraces, graded bunding in comparison with control.

Katama Reddi and Padmalatha (1993) repored that it could be possible to reduce soil and water losses by adopting in situ conservation practices like dead furrows at 3.6 m interval across the slope and compartmental bunding.

Tyagi and Joshi (1994) reported that an integrated application of mechanical and agronomical conservation practices not only reduce the soil and water losses but also improve the crop yields.

Solanke (1998) reported that the land configuration and cropping systems reduced the soil and water loss as compared to control.

2.2 Effect of vegetative barrier

Engineering measures consisting of earthen embarkments are considered to costly, apart from requiring regular maintenance as the alternative to these. Live hedges with vertiver grasses as well as local grasses at different intervals are extremely cheap and farmer can also work themselves.

2.2.1 Physico-chemical properties of soil

Jitendra Prasad and Sharma (1972) in their study on the effect of perrennial grass on physical properties of soil and reported that water stable aggregate, porosity, hydraulic conductivity were improve due to perennial grass barrier over control treatment.

Kurian (1973) while comparing effect of vegetative barrier with bench terracing in Nilgiris reported that long bench terrace retains greater moisture than benches of shorter length while vegetative barrier also proved better to retain more moisture in soil profile.

Chatteraji and Maiti (1974) reported that grasses have intensive fibrous root system and have enormous capacity to mechanically bind the soil particle. The root exudates might help in the process of binding soil particle. Further they observed that grassses through their root action improve water stable aggregate of the soil by increasing micro and macro pores and thus increase water infiltration capacity of the soil.

Kannan and Mathan (1993) studied the influence of soil conservation measures and vegetation cover on erosion, runoff and nutrient loss and observed that among the various plantations eucalyptus without any cover recorded highest sediment, runoff and nutrient losses, while lowest was observed in apple plantation on bench terraces with grass as soil cover.

Jayaram and Raizada (1994) reported vegetative measures helped to improved the soil physical properties.

Rane *et al.* (1995) reported that contour farming along *Leucaena leucocephala* hedge rows (gaps filled with sorghum stubbles) and *Vetiveria zizanioides* hedge rows increased available soil moisture by 7.78 and 5.11 mm over across the slope cultivation. The N,P and K uptakes in cotton were also increased by the hedge rows.

Solanke (1998) reported that Broad bed and furrows and vegetative barrier across the slope help to improve the physical properties of soil.

2.2.2 Yield

Balvir Verma (1968) studied the effect of vegetative barrier of perennial grass cover with different cropping system and natural fallow and reported that vegetative barrier treatment helped to increase yield of different crops (Mung, Bajra, Tobacco and Sunhemp) by minimizing the soil and water loss.

Kurian (1973) reported that terracing and vegetative barrier significantly increase yield of potato over table top bench terrace.

Bhatiya and Shrivastava (1976) reported that Mung and Urad developed dense canopies (more than 55 per cent) and protected soil from splash erosion and conserve more moisture and increase crop yield.

Bharad *et al.* (1992) observed maximum grain yield of pearl millet under contour cultivation along vetiver line than cultivation across the slope. They further stated that contour cultivation along the vertiver key line might be due to the formation of dense uniform and continous barrier resulting in high yield of pearl millet.

Gupta and Suraj Bhan (1993) reported that ridge and furrow + vegetative bund increased root growth by 17.7 cm number by 27.2 and root weight by 4.11 gm/plant over control and increased the yield of maize.

Gund and Durgude (1995) reported that the treatment contour bunding + live bunding, contour bunding along and live bunding alone recorded higher grain yield over control.

Munish kumar and Warsi, (1998) studied on impact of various soil and water conservation measures i.e. contour bunding, land levelling, contour furrow and vegetative barriers and reported that this measures was highly effective and resulted in an overall increase of 20 to 25 per cent in yield levels of wheat, barley, pea, lentil, soybean, groundnut and sorghum.

Solanke (1998) reported that vegetative barrier was highly effected and resulted in high grain yield over control.

Subudhi *et al.* (1998) reported that the vegetative barrier enhanced the rainfed rice yield by 93 p.c.over farmer's practice and 49 per cent over no vegetative barrier treatment.

2.2.3 Runoff water and soil loss

Gurmel Singh et al (1967) reported that more soil and water loss in cultivated crops, than natural cover and grass. Among cultivated crops sorghum gives the maximum soil and water loss while groundnut gives minimum soil loss.

Tejwani and Mathur (1967) in their experiment in black soil observed that vegetative cover with grasses reduce runoff and soil loss.

Balvir Verma *et al.* (1968) in their study on runoff with different cropping system and vegetative barrier with different grasses reported that perennial grass cover significant reduce run off water and soil loss over natural fallow and cropping system.

Chatterji and Maiti (1974) reported that grass with dense growth habit particularly ground level reduce both runoff and soil loss. They further reported that the runoff water and soil loss was significantly reduce by growing grass for soil conservation.

Bharad et al.(1992) showed that contour cultivation along vetiver key line recorded minimum runoff and soil loss.

Kannan and Mathan (1993) reported that among the various plantations eucalyptus without any cover recorded highest sediment, runoff while the lowest was observed in apple plantation on bench terraces with grass as soil cover.

Jayaram and Raizada (1994) studied on the vegetative measures for erosion control in vertisol and reported that runoff and soil loss was minimum in groundnut spreading than sole pearl millet.

Gund and Durgude (1995) reported that the lowest runoff and soil loss was observed in contour bunding + live bunding of subabul over control.

Ranade *et al.* (1995) reported that the mechanical and vegetative barriers reduced seasonal runoff by 18.24 per cent. The highest runoff was recorded in a plot with no treatment and 2 per cent slope.

Ranade *et al.* (1997) reported that vegetative barriers was effective in reducing seasonal runoff and soil loss by 20-25 per cent, compared with plots using no control measures.

Solanke (1998) reported that vegetative barrier reduced runoff by 38.88 per cent ànd soil loss 66.18 per cent over control.

Subudhi *et al.* (1998) reported that vegetative barrier reduce runoff by 35 per cent and soil loss by 60 per cent over farmer's practices of broadcasting.

2.3 Effect of cropping system

The cropping system research was mostly focused on evaluation of efficient crops and their varieties for specific agro ecological units. In semi arid tropics, the cropping systems are sequential, relay and intercropping. Intercropping is a viable and profitable proposition for 650-800 mm rainfall reason under vertisols and associated soil with 20-30 weeks effective growing period.

2.3.1 Physico chemical properties of soil.

Goel *et al.* (1968) in their study on sorghum pigeon pea rotation on soil of 1.5 to 3 per cent slope observed that the losses of nutrients were almost doubled with increasing slope.

John *et al.* (1968) pointed that cropping systems affects certain soil properties such as organic matter content, nitrogen level, infiltration rate which have some effect on plant growth. They further stated that cropping system treatments on sandy loam soil had no effect on total pore space, bulk density or water retention characteristics but had increa sed stability of aggregate and infiltration rate.

Gurmel Singh *et al.* (1979) reported that organic matter, nitrogen, phosphor us and potash were greater in pure crop of soybean and compare to strip cropping with maize and soyabean. Similarly strip cropping of maize + soybean considerably reduces nutrient losses of N, P and K than in pure crop of maize.

Trilok Singh *et al.* (1980) reported that when maize crop was intercropped with legumes, improvement in soil structure was observed in judged from decrease in bulk density and increase in hydraulic conductivity, organic carbon and available water.

Singh *et al.* (1980) reported that continuous cropping without addition of organic manure reduces organic carbon and nitrogen. Introduction of legume in sequential cropping is one of the ways to overcome biological constraints and ameliorate organic carbon, total nitrogen, soil aggregation, bulk density and available phosphorus in the soil.

Dongle (1987) observed that cumulative infiltration and final infiltration rate under double cropped soil were higher by 25.7 and 33.7 per cent respectively as compare to monocropping soil.

Patil and Mahendra Pal (1987) reported that intercropping of pearl millet with legume improved bulk density, organic carbon and total nitrogen over sole pearl millet crop. They further reported that improved physico-chemical properties owing to legumes inter crops significantly influenced grain yield of pearl millet.

Solanke (1998) reported that moisture content of soil under cropping systems was more than sole crop.

2.3.2 Yield

Balvir Verma *et al.* (1968) found reduction in biological yield and monetary return from sole crop of bajara and recorded greater biological yield by intercropping bajra with mung.

Gurmel Singh *et al.* (1976) reported that mixed cropping of maize and soybean in alternate sets of rows gave higher net income per unit area than cultivation of maize or soybean as the pure crop.

Gurmel Singh *et al.* (1979) while studying effect of row cropping maize and soybean in strip grown across the slope obtain Rs.300/ha from soybean an against 625 Rs./ha with four rows of maize + 6 rows of soybean. Similarly total biological yield of maize + soybean.

Tirlok Singh *et al.* (1980) observed increase in yield of maize when intercropped with legumes due to the synergistic effects, since the legumes have favourable improved chemical, physical and biological aspects of soil.

Borse *et al.* (1983) reported that 30/70 cm paired row and 30/90 cm three row planting of pulses and oil seed produce more than 90 per cent grain yield of 50 cm uniform row planting.

Ramchandran and Narayana (1988) reported that the per hectare average seed yield to be maximum in maize crop and minimum in ground nut crop and moderate in Ragi crops.

Patil *et al.* (1991) reported that the yield of grain and fodder of sorghum and pigean pea was significantly superior than sole sorghum.

Surajbhan *et al.* (1995) reported that double cropping system, namely balck gram-safflower, cowpea-safflower and black gram - mustard were found significantly superior over mono and intercropping system in productivity, net return and moisture use efficiency.

Arjun Prasad and Ratan Singh (1998) reported that the dust mulch + stover mulch with sorghum + pigeon pea intercropping gave 9.9, 6.1 and 2.8 per cent more sorghum grain yield and 32.7, 11.5 and 12.7 per cent more pigeon pea grain yield than no mulch, dust mulch and stover mulch respectively.

Solanke (1998) reported that the yield of grain and fodder of Bajra and soybean was significantly superior than sole bajra.

2.3.3 Runoff water and soil loss

Kanetkar *et al.* (1960) observed 84.0 and 57.9 tonnes/ ha. soil loss with rabi sorghum across the slope and bajara + pigeon pea intercropping across the slope respectively.

Tejwani and Mathur (1967) are of the opinion that crops have greater influence of rate of soil erosion, cropping system with legumes and cereal when intercropped together reduce the rate of run off and soil erosion.

Gurmel Singh *et al.* (1967) in their run off experiment with different cropping system reported that cultivation of groundnut (cover crop) gave minimum loss of water and soil while sorghum and black gram recorded maximum and intermediate respectively. The water loss was maximum for cultivated fallow.

Singh *et al.* (1967) reported that in their four year study in black soil with 1 per cent slope observed reduction in soil and water loss due to bajara was grown across the slope.

Balvir Verma *et al.* (1968) conducted experiment on evaluation of different cropping system for run off and soil loss and reported that run off water and soil loss significantly reduced. The cover crop treatment reduce run off and soil loss as compare to non-cover crops.

Gurmel Singh *et al.* (1979) reported that soybean had been found to be an effective erosion resisting crop, grown either as pure crop or in mixture with maize.

Bhushan *et al.* (1984) reported that bajra alone gave highest soil loss (6.3 tonnes/ha) which was reduced to 4 tonnes/ha by intercropping of cow pea or mung in bajara.

Singh and Rao (1988) reported that the runoff and soil loss vary with crop and cropping system. Mechanical structures are quite effective in reducing soil loss.

Karad *et al.* (1991) found reduction in run off and soil erosion due to intercropping of sorghum + pigeon pea on vertisols at parbhani.

Kale *et al.* (1992) reporeted that the contour bunding + strip cropping system was found most efficient in reducing runoff by 37.7 percent and soil loss by 57.7 per cent over control.

Prasad *et al.* (1993) observed maximum runoff (32.9 per cent of the rainfall) and soil loss (4.2 t/ha/yr.) under cultivated fallow. Sowing of castor and castor + green gram intercropping across the slope reduced the runoff by 9.20 and 14.20 and soil loss by 17.60 and 25.10 per cent, respectively.

Subudhi and Senapati (1995) reported that runoff (25.6 percent) and soil loss (9-38 t/ha) under cultivated fallow. Sole cropping of pigeon pea, rice and ragi reduced the runoff by 25.0, 27.7 and 29.9 per cent respectively as compared to cultivated fallow.

Mittal *et al*. (1996) observed that intercrops like black gram and green gram in red gram were quite effective in reducing runoff by 11 and 15 per cent and soil loss by 20 and 23 per cent, respectively over sole red gram.

Solanke (1998) reported that reduction in runoff (4.83 per cent) and soil loss (17.90 per cent) due to intercropping of bajra + soybean over bajra sole.

MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

The details of the materials used and the methods followed for conducting the present investigation are described in this chapter.

3.1 Details of the experimental meterials

3.1.1 Experimental site :-

A field experiment in a split plot design, on medium soil (Vertisols) with slopy topography (1.5 per cent slope) was conducted during *Kharif* season of 1999-2000 at Department of Agricultural Chemistry and Soil Science farm, College of Agriculture, Marathwada Agricultural University,Parbhani, with 8 treatments combinations and four replications. The soil was medium in depth, well drained and calcareous developed over weathered basalt. The physico-chemical properties of soil are indicated in Table-1.

3.1.2 Climate and weather condition

Geographically, Parbhani is situated at 19^0 16' north latitude and 76^0 47' east longitude with an elevation of 409 meters above mean sea level. Parbhani has subtropical climate apporximately average rainfall is 830 mm and is distributed over the growing peroid as oftenly observed in most of the areas of Marathwada during *Kharif* which is favourable for excellent crop

Table 1 : Physico-chemical properties of soil from experimental area.

Sr. No.	Particulars	Method followed
A.	**Mechanical analysis**	
1.	Coarse sand (%)	International pipette method (Piper, 1968)
2.	Fine sand (%)	
3.	Silt (%)	
4.	Clay (%)	
5.	Bulk Density (Mgm^{-3})	Core method (Black, 1965)
6.	Infiltration rate (cm/hr)	Double ring infiltro meter method (Black, 1965)
7.	Moisture content (cm)	As per the method described by Singh (1980).
B.	**Physico-chemical properties**	
1.	Soil pH	Glass electrode method using pH meter (Piper, 1950)
2.	Electrical conductivity (dsm^{-1})	Solu Bridge conductivity meter (Jackson, 1973)
3.	Organic carbon (%)	Modified Walkley and Black's method (Jackson, 1973)
4.	Free $CaCO_3$ (%)	Rapid titration method using bromothymol blue and bromocrol green indicator (Puri, 1949).
5.	Available nitrogen (kg/ha)	Alkaline permangnate method (Subbiah and Asija, 1956)
6.	Available P_2O_5 (kg/ha)	Metavandate, Using 0.5M Sodium bicarbonate (Olsen *et al.*, 1954)
7.	Available K_2O (kg/ha)	Flame photometer, using 1N neutral ammonium acetate (Chopra and Kanwar, 1976).

Table 2 : Physico-chemical properties of soil from experimental soil.

Sr. No.	Particulars	Content
A.	**Mechanical analysis**	
1.	Coarse Sand (%)	8.67
2.	Fine Sand (%)	13.43
3.	Silt (%)	22.50
4.	Clay (%)	55.40
5.	Textural class	Clay
B.	**Physico-chemical properties**	
1.	Soil pH	7.9
2.	Electrical conductivity (dsm-1)	0.36
3.	Organic Carbon (%)	0.36
4.	Free $CaCO_3$ (%)	11.3
5.	Bulk density (g/cm^3)	1.29
6.	Infiltration rate (cm/hr)	2.15
7.	Total nitrogen (%)	0.048
8.	Available nitrogen (kg/ha)	192.42
9.	Available phosphorus (kg/ha)	12.10
10.	Available potassium (kg/ha)	382.17

growth. The rainfall is mainly confined to south west mansoon extending from June to September in the region and the average rainy days range from 40 to 50 which is quite suitable for growth during *Kharif* season.

The average maximum temperature *Kharif* ranges (June to September) 30.45°C and 30.06°C in *Rabi* (October to January) 36.25°C in summer (February to May). May is generally the hottest month with miximum temperature reaching above 45°C for a short period of 5-8 days, where as minimum temperature varies between 6.4°C to 23.4°C while humidity varies from 37.2 to74.7%.

3.1.3 Experimental layout

The experiment was laid out in a split plot design with four main plot treatments of soil land configuration with two subplot treatments of cropping systems. These 8 treatments combinatiion were replicated four time. The treatments and other details of the experiment were as below :-

Main plot treatments (Land configuration)

T_1 Sowing across slope(farmer's practice)

T_2 Sowing along contour lines.

T_3 Contour bund at 5 meter interval.

T_4 Vegetative barrier at 10 meter distance.

Para grass (*Brichiaria mutica*)

Sub plot treatments (Cropping system)

C_1 Sorghum sole

C_2 Sorghum + pigeon pea.

Other details of the experiments

1) Total treatment combination	:	8(4T X 2C)
2) Replications	:	4
3) Total plots	:	32

4) Design	:	split plot design	
5) Plot size	:	5.0 X 10.5 m	
6) Strip size	:	5 X 45 m	
7) Sowing methods	:	Drilling	
8) Soil type	:	Medium black soil.	
9) Average soil depth	:	75 cm	
10)Average slope	:	1.5 per cent(East-West direction)	
11) Crop	:	*Kharif* sorghum and pigeon pea	
12) Variety	:	CHS-14	BSMR-736
13) Spacing	:	45 X 15 cm	45 X 15 cm
14) Fertilizer	:	80:40:40	20:50:50kg/ha
15) Date of sowing	:	26-6-99	26-6-99
16) Date of harvest	:	18-10-99	10-01-2000

Calculated quantities of fertilizers viz. urea, 18:18:10 were applied before sowing to the soil in plots uniformly. Half dose of Nitrogen and full dose of phosphorus and potash were applied at the time of sowing and remaining half dose of Nitrogen were applied after one month of sowing. The plan of layout is presented in fig.1.

3.1.4 Seeds and sowing

CSH-14 and BSMR-736 varieties of sorghum and pigeon pea recommended for the region were selected for present investigation. Seeds were drilled as per spacing and gap filling wherever necessary was done and optimum plant population was maintained in each plot. Periodical operations like thinning and weeding were carried out. Due care was taken against insects and pests. The crops were grown under rainfed conditions.

3.2 Pre harvest studies

3.2.1 Collection and preparation of soil

Initial and periodical soil samples at sowing, flowering and harvest of each crops were collected from different treatments, thoroughly mixed, air dried, ground with wooden pestle and mortar and passed through 2 mm sieve for soil analysis. The sieved samples were stored in cloth bags with proper labels. All precautions were taken in all the estimation and analysis particularly G.R. Grade chemicals, uncontaminated glass wares and glass distilled water were used.

3.2.2 Soil and water loss

Periodical observation on collection of run off, soil and water loss were recorded as per rain storms received during the experimentation. After preparatory tillage operation (1 ploughing and 2 harrowing) the field was divided into 8 strips of 5m X 45m along the slope of field. Water collection tank (200 liter capacity) and flow divisioin system (multi slot deviser) were fitted in the soil at sloping end of the field to enable to collect soil and water loss. The multi slot deviser depicted in fig.2. was 250 cm in length with 11 slots of 10 cm width.

3.3 Post harvest studies

1. Total dry matter

Three plants were sampled for each observation from each net plot. After removing the roots, the plants were placed in brown paper bags, properly labelled and dried in oven at 65-70^{0}c. The last constant weight was recorded as dry matter.

2. Grain yield

The grain produce was air dried for two days and weight was recorded.

3. Fodder yield

The weight of fodder was recorded from each net plot after sun drying.

4. Total Monetary return

The total monetary returns from sorghum and pigeon pea were worked out with prevailing market rate and subjected to statistical analysis (sorghum grain Rs.326/q, pigeon pea grain Rs.1623/q., sorghum fodder Rs.80/q.)

5. Moisture use

Moisture use was calculated using following formula :

MU (mm) = Effective Rainfall + (Moisture content at sowing - moisture content at harvest)

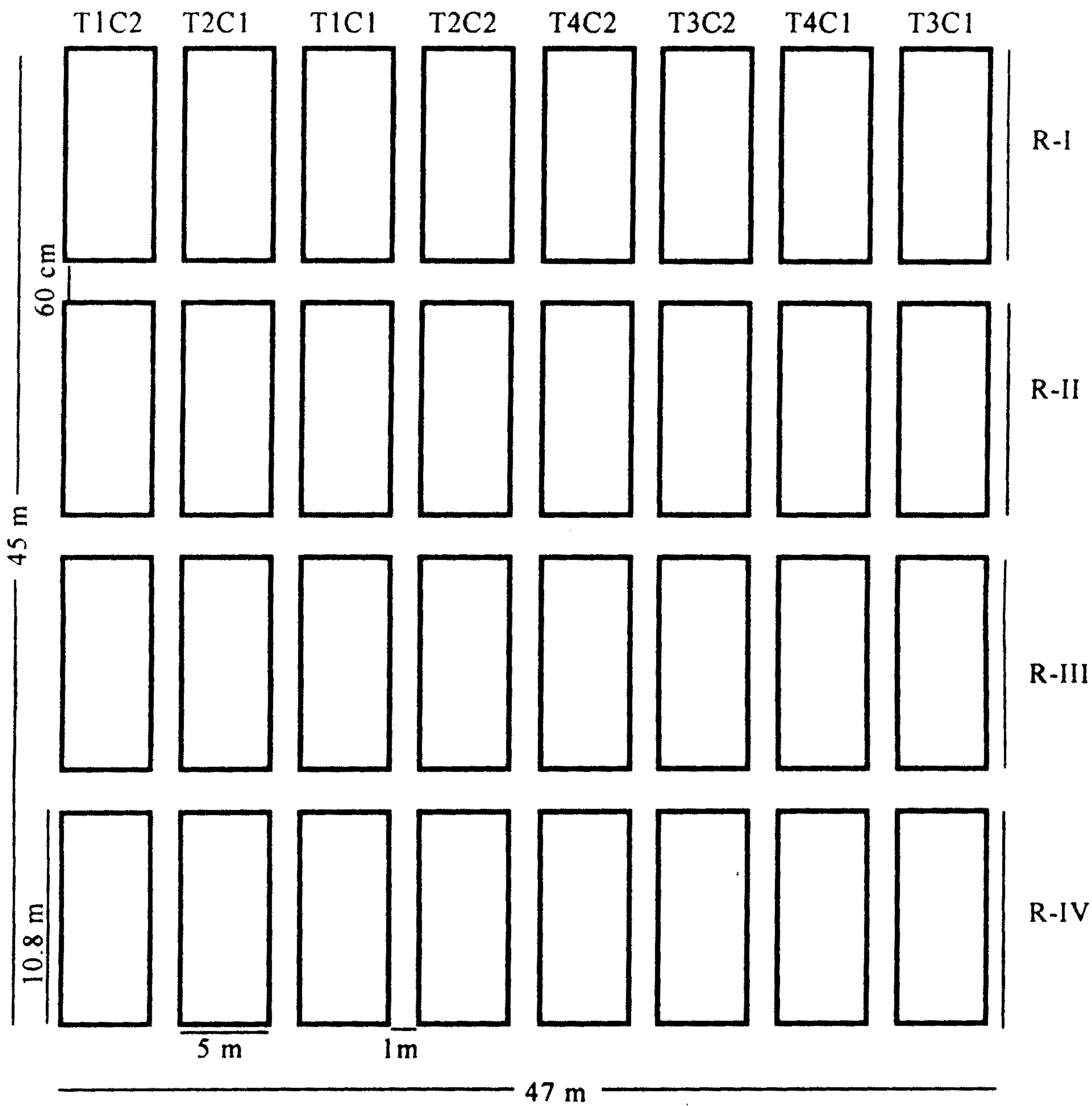
6. Moisture use effeciency

Moisture use effeciency was calculated by using the following formula :

$$MUE(Rs/ha/mm) = \frac{\text{Monetary return (Rs/ha)}}{\text{Consumptive use (mm)}}$$

3.4 Statistical analysis

The results were analysed statistically as per methods given in Statistical Methods for Agricultural worker's by Panse and Sukhatme(1985). Appropriate standard errors were worked out and critical difference at 5% level is given wherever necessary.



T_1	Sowing across slope
T_2	Sowing along contour lines
T_3	Contour bunding at 5 meter interval
T_4	Vegetative barrier after 10 meter distance
C_1	Sorghum sole
C_2	Sorghum + pigeon pea

Fig. 1 : Plan of layout of experimental field.

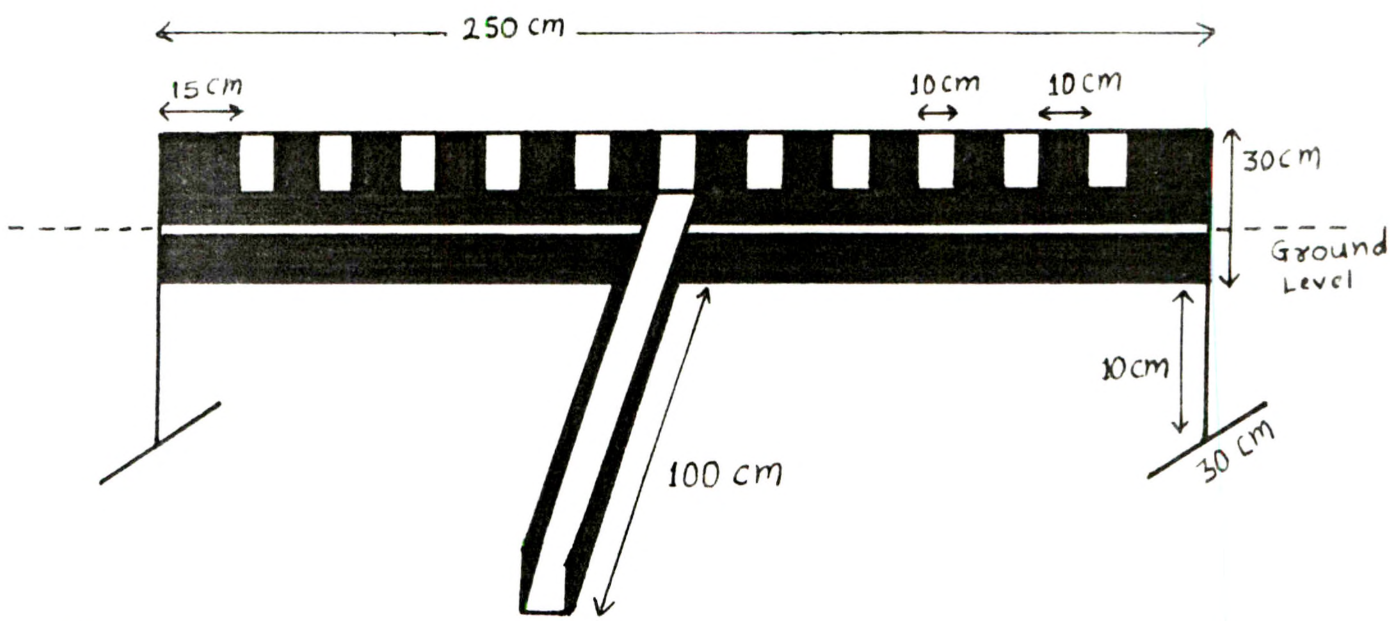


Fig. 2 : Multi slot deviser for runoff collection

RESULTS

CHAPTER-IV

RESULTS

A field experiment was conducted during *Kharif* season of 1999-2000 at Department of Agricultural Chemistry and Soil Science Farm, College of Agriculture, M.A.U. Parbhani with four treatments of land configuration and two cropping systems on medium soil (vertisol) to study the effect of land configuration and cropping system on physical properties of soil, yield of crop and runoff losses of soil and water loss. Periodical observations on moisture content and its distrubution in soil profile, bulk density, infiltration rate at sowing and harvest of the crop were recorded. The available N, P and K were also estimated at sowing, flowering and harvest of the crop. The fodder and seed yield of crop were also recorded in different treatments and were subjected to statistical analysis. The results of present investigation are presented under following heads.

Effect of land configuration and cropping systems on :

1. Moisture content of soil profile
2. Bulk density
3. Cumulative and final infiltration rate
4. Moisture use and moisture use efficiency
5. Available nutrients (N,P and K at sowing, flowering and harvest)
6. Grain and fodder yield
7. Runoff losses of soil and water

Data presented on the analysis of experimental soil in Table-2 indicate that, texturally soil was clay, calcareous (11.3 per cent $CaCO_3$) in nature and moderatly alkaline in reaction. The experimental soil was medium in organic carbon and available phosphorus and high in available potassium. Bulk density of surface layer was 1.27 Mgm^{-3} with 2.15 cm/hr infiltration rate. The experimental site at about 80 cm average soil depth with 1.5 per cent slope towards east-west direction.

4.1 Effect of land configuration and cropping systems on moisture content of soil

The data on soil moisture content (0-45 cm depth) as affected by different treatments, presented in Table-3 and Figure-3 indicate that, the moisture content of soil profile at sowing stage was more or less similar in all the treatments but showed slight numerical increase in T3 and T4 treatments over control. The moisture content of soil profile was increased upto flowering stage of crop and was further reduced at harvest of crop in all the treatments. At flowering T3 and T4 treatments significantly increase moisture per cent over T2 and control treatments. While increases in moisture content due to treatments over control at sowing and harvest of crop were statistically non significant. The effect of cropping system as well as interaction was found to be non- significant to increase moisture content over control. However, intercropping (C2) system showed increase in moisture content over sole cropping system. These increases were not reached to the level of significant. It can be concluded that contour bunding or vegetative barrier along contour line and growing crops with intercropping system on slopy field proved better to conserve sufficient moisture in the soil profile and by checking runoff losses.

Table-3 : Soil moisture content (cm) of soil profile (0-45 cm depth) as affected by different treatments.

	Moisture content (cm)			
	At sowing	At flowering	At harvest	
			Sorghum	Pigeonpea
Treatments				
T_1(S.A.Sl.)	15.48	17.85	12.51	11.39
T_2(S.A.C.L.)	15.97	18.35	12.97	11.84
T_3(S.C.B.)	16.78	19.09	13.62	12.54
T_4(S.V.B.)	16.32	18.62	13.44	12.08
S.E. ±	0.297	0.127	0.276	0.298
C.D. at 5%	N.S.	0.392	N.S.	N.S.
Cropping Systems				
C_1	15.99	18.32	13.03	13.03
C_2	16.29	18.64	13.24	10.89
S.E. ±	0.129	0.129	0.084	0.119
C.D. at 5%	N.S.	N.S.	N.S.	0.367
Interaction (T x C)				
S.E. ±	0.258	0.258	0.168	0.239
C.D. at 5%	N.S.	N.S.	N.S.	N.S.

MCS = Moisture Content at sowing

MCF = Moisture Content at flowering

MCH = Moisture Content at harvest

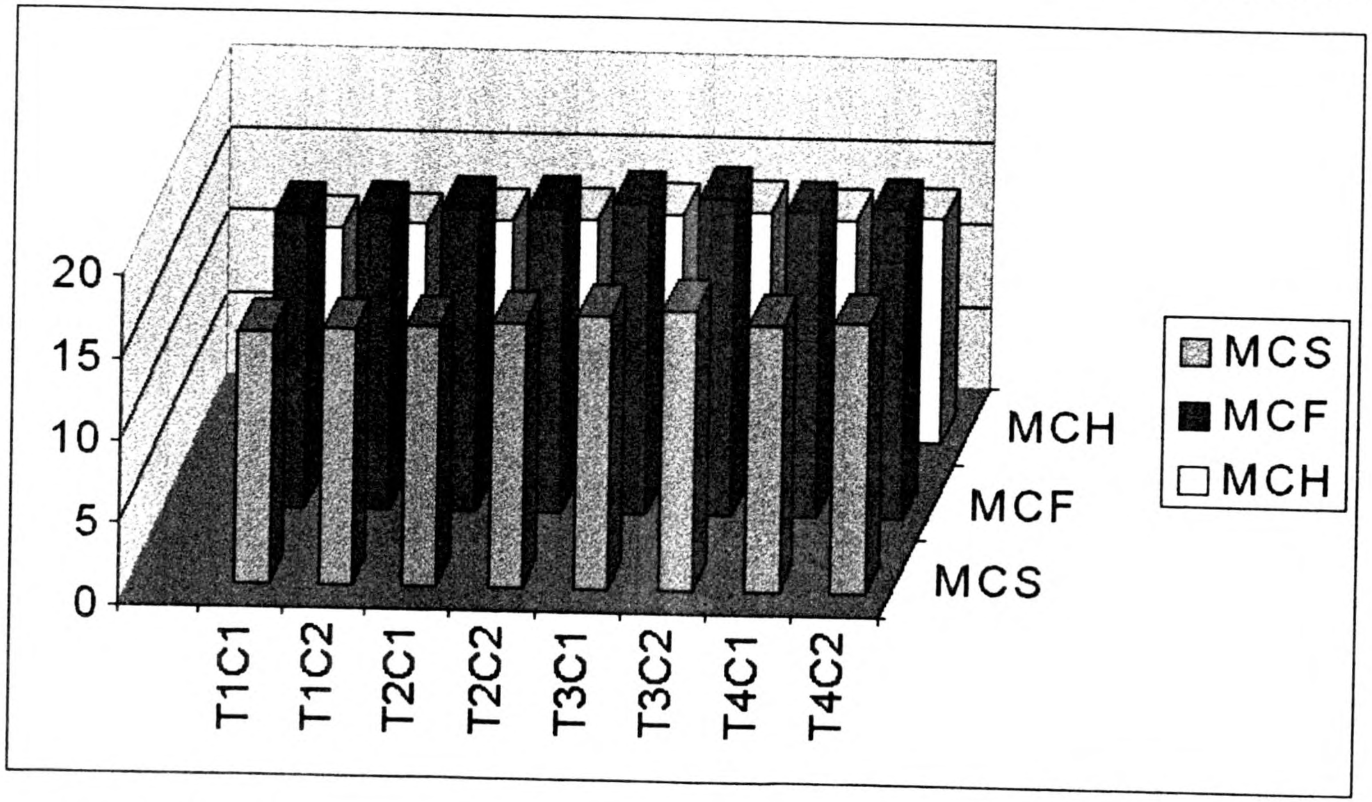


Fig. 3 : Moisture content (cm) of soil profile as affected by different treatments

4.2 Effect of land configuration and cropping systems on bulk density of soil profile.

The bulk density of soil profile as affected by different treatments recorded at various depth as well as sowing, flowering and harvest of crops is presented in Table-4 indicated that the bulk density of soil in all the treatments was increased with depth of soil profile at various stages of sample. Similarly the values of bulk densities in all the treatments as well as at various steps were comparatively greater at harvest of crops than at their sowing stage.

The different land configuration treatments numerically decreased values of bulk density over control. The change in bulk density due to various treatments was not reached to the level of significant. Similarly effect of cropping system as well as their interaction with treatments of land configuration also showed non-significant result in the present investigation.

4.3 Effect of land configuration and cropping systems on cumulative and final infiltration rate.

The cumulative and final infiltration rate recorded at sowing and harvest of the crop presented in Table-5 indicate that the effect of land configuration, cropping systems as well as there interaction was found to be non significant to improve cumulative and final infiltration rate at sowing stage of the crops. The cumulative and final infiltration rate recorded at harvest of crop indicate that T3 and T4 treatments significantly decreased cumulative and final infiltration rate over control treatment. The

Table-4 : **Bulk density (Mgm^{-3}) of soil profile as affected by different treatments.**

Soil depth (cm)		At sowing			AT flowering			At harvest		
		C1	C2	Mean	C1	C2	Mean	C1	C2	Mean
Treatments										
T1	D_1 0-15	1.27	1.26	1.265	1.28	1.27	1.275	1.28	1.27	1.275
	D_2 15-30	1.28	1.27	1.275	1.29	1.28	1.285	1.29	1.28	1.285
	D_3 30-45	1.29	1.28	1.285	1.30	1.29	1.295	1.30	1.29	1.295
T2	D_1 0-15	1.26	1.25	1.255	1.27	1.26	1.265	1.277	1.26	1.26
	D_2 15-30	1.27	1.26	1.265	1.28	1.27	1.275	1.28	1.28	1.28
	D_3 30-45	1.28	1.27	1.275	1.28	1.28	1.28	1.29	1.283	1.286
T3	D_1 0-15	1.25	1.24	1.245	1.26	1.25	1.255	1.26	1.26	1.26
	D_2 15-30	1.26	1.25	1.256	1.27	1.26	1.265	1.27	1.27	1.27
	D_3 30-45	1.27	1.26	1.265	1.28	1.27	1.275	1.28	1.28	1.28
T4	D_1 0-15	1.26	1.25	1.255	1.27	1.26	1.265	1.27	1.27	1.27
	D_2 15-30	1.27	1.26	1.265	1.28	1.27	1.275	1.28	1.28	1.28
	D_3 30-45	1.28	1.27	1.275	1.29	1.28	1.285	1.285	1.29	1.287

	T			C			T x C		
	At Sowing	At Flowering	At Harvest	At Sowing	At Flowering	At Harvest	At Sowing	At Flowering	At Harvest
S.E. ±									
D_1	0.006	0.003	0.006	0.002	0.005	0.002	0.005	0.010	0.004
D_2	0.004	0.004	0.004	0.003	0.004	0.003	0.007	0.009	0.006
D_3	0.002	0.006	0.002	0.003	0.004	0.003	0.006	0.009	0.006
C.D. at 5%									
D_1	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
D_2	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
D_3	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

effect of intercropping was also significant to increase cumulative infiltration at harvest of the crops. The effect of cropping system on final infiltration rate at harvest was found to be non significant. The combined effect of land configuration and cropping system on cumulative and final infiltration rate recorded at sowing and harvest of the crops. It can be concluded that contour bunding or vegetative barrier across the slope on contour line in intercropping system across the slope found better for cumulative and final infiltration rate.

Table-5 : Effect of land configuration and cropping systems on cumulative and final infiltration rate at sowing and harvest of crops.

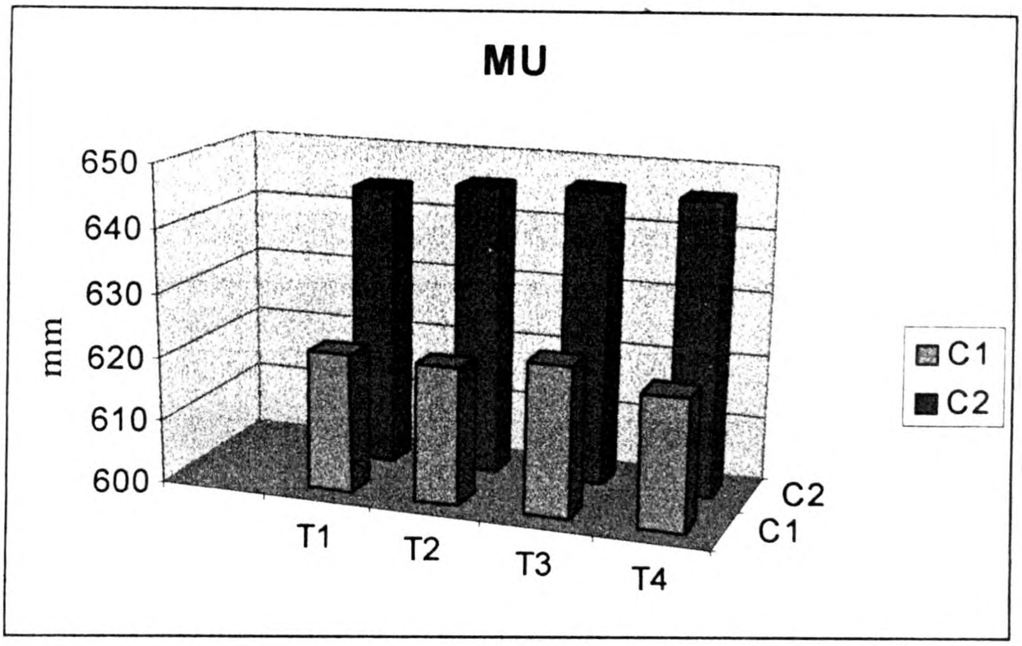
	Cumulative infiltration (cm)		Final infiltration rate (cm/hr)	
	At sowing	At harvest	At sowing	At harvest
Treatments				
T_1 (S.A.Sl.)	28.75	27.83	3.30	3.90
T_2 (S.A.C.L.)	28.50	28.35	3.28	3.71
T_3 (S.C.B.)	27.70	26.00	2.91	3.30
T_4 (S.V.B.)	24.75	24.15	2.28	2.40
S.E. ±	0.870	0.493	0.255	0.272
C.D. at 5%	N.S.	1.518	N.S.	0.839
Cropping systems				
C_1	26.55	23.31	2.88	3.25
C_2	28.30	29.85	3.00	3.40
S.E. ±	0.467	0.487	0.124	0.159
C.D. at 5%	N.S.	1.500	N.S.	N.S.
Interaction (C x T)				
S.E. ±	0.935	0.975	0.249	0.319
C.D. at 5%	N.S.	N.S.	N.S.	N.S.

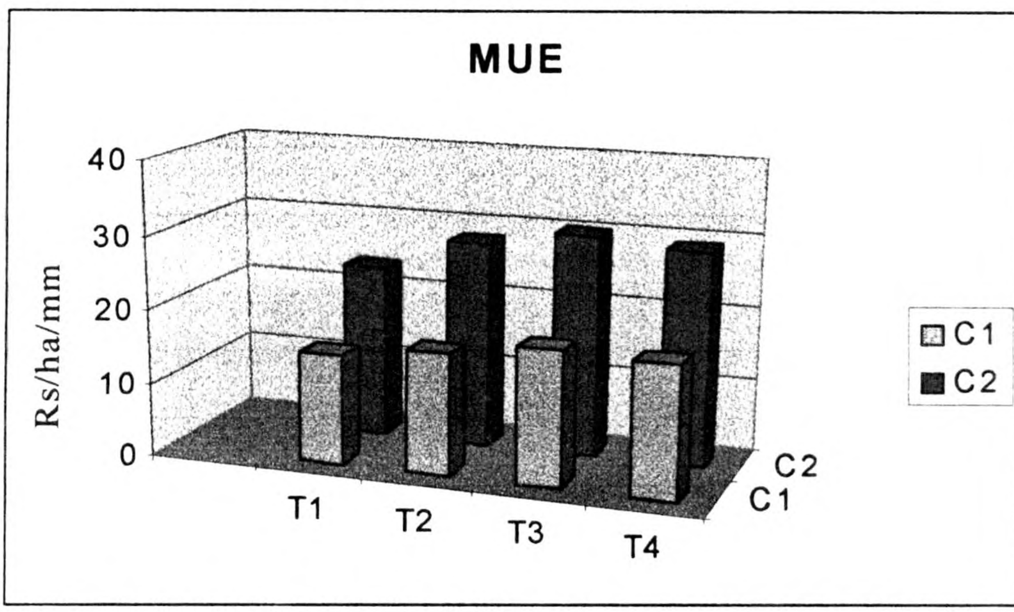
4.4 Effect of land configuration and cropping systems on moisture use and moisture use efficiency.

The data on moisture use and its efficiency as affected by different treatments presented in Table-6 and Figure-4 indicate that, the moisture use as affected by different treatments and their interaction was found to be non significant however the effect of cropping systems on moisture use was reported to be significant. Hence intercropping proved better to imporve the moisture use over sole cropping system. The moisture use efficiency computed in terms of income in Rs/ha/mm indicate that the different treatments of land configuration and cropping systems showed significant results. The effect of treatments interaction on moisture use efficiency was found to be non significant. The intercropping system proved better and significantly increase the moisture use efficiency over sole cropping systems. Among the treatments of land configuration contour bunding (T_3) recorded greater moisture use efficiency among all the treatments as well as over control. The T_2, T_3 and T_4 were on par to enhance moisture use efficiency but were significantly superior over control treatments. Thus it can be concluded that contour bunding or vegetative barrier treatments across the slope with intercropping of sorghum + pigeon pea found beneficial to enhace moisture use efficiency.

Table-6 : Moisture use (mm) and moisture use efficiency (Rs/ha/mm) as affected by different treatments in cropping system.

	Moisture use (mm)	Moisture use efficiency (Rs/ha/mm)
Treatments		
T_1 (S.A.Sl.)	633.10	19.21
T_2 (S.A.C.L.)	633.62	23.54
T_3 (S.C.B.)	635.00	24.47
T_4 (S.V.B.)	633.40	23.51
S.E. +	2.750	0.944
C.D. at 5%	N.S.	2.833
Cropping systems		
C_1	621.99	16.92
C_2	645.58	28.45
S.E. +	2.119	0.806
C.D. at 5%	6.521	2.479
Interaction (T x C)		
S.E. +	4.239	1.612
C.D. at 5%	N.S.	N.S.





C1 - Sorghum Sole

C2 - Sorghum + Pigeon pea

Fig.4 : Moisture use (mm) and Moisture use efficiency (Rs/ha/mm) as affected by different treatments.

4.5 Effect of land configuration and cropping systems on organic carbon

It is evident from Table-7 that the different treatments of land configuration and cropping systems as well as the effect of tretments interaction was found to be non significant to increase the organic carbon content of soil at (surface layer) at sowing and harvest of the crops. At flowering stage all the treatments under study proved better to enhace the organic carbon content of soil. Among the treatments, contour bunding and vegetative barrier significantly increase the organic carbon content of soil over other treatment including control. Similarly intercropping treatment proved better to improve the organic carbon status of soil. The combined effect of interaction was found to be to increase the organic carbon content of soil over control. Among the interaction T_3C_2 recorded better value of organic carbon content over other interaction including control. It can be concluded that land configuration for moisture conservation by contour bund or vegetative barrier across the slope and growing the crops as intercrop proved better to increase the organic carbon content of soil for better moisture conservation, nutrient availability and their by increasing the yield of crops.

Table-7 : Organic carbon content (%) in soil as affected by different treatments at sowing, flowering and harvest of crops.

Cropping System	Treatments				
	T_1	T_2	T_3	T_4	Mean
			Sowing		
C_1	0.380	0.400	0.440	0.420	0.410
C_2	0.390	0.420	0.470	0.430	0.427
Mean	0.385	0.410	0.455	0.425	--
		T	C	T x C	
S.E.±		0.013	0.005	0.008	
C.D. at 5%		N.S.	N.S.	N.S.	
			Flowering		
C_1	0.460	0.485	0.540	0.560	0.511
C_2	0.477	0.520	0.600	0.540	0.534
Mean	0.468	0.502	0.570	0.550	--
		T	C	T x C	
S.E.±		0.010	0.004	0.009	
C.D. at 5%		0.030	0.014	0.028	
			Harvest		
C_1	0.440	0.460	0.520	0.480	0.475
C_2	0.450	0.500	0.550	0.490	0.497
Mean	0.445	0.480	0.535	0.485	--
		T	C	T x C	
S.E.±		0.019	0.008	0.011	
C.D. at 5%		N.S.	N.S.	N.S.	

4.6 Effect of land configuration and cropping systems on available nutrient (N, P and K) status of soil.

The data on the available major nutrients status of soil at sowing, flowering and harvest of crops as affected by different treatments are presented in Table 8, 9 and 10 indicate that at sowing stage the effect of different treatments and their interaction was in constant as well as non significant to improve the availability of nitrogen, phosphorus and potassium. At flowering and harvest stage the effect of treatments was found to be significant to improve the availability of nutrients. Among the treatments. Contour Bunding (T_3) and vegetative barrier (T_4) proved better to record highet availability of nutrients over other interaction including control. Similarly intercropping treatments also proved better to improve availability of nutrients in soil over sole cropping system. The effect of interaction was found to be non significant at harvest for available nitrogen and at flowering and harvest stage for available potash. However the combined effect was positive to improve availability of nitrogen and phosphorus at flowering and at harvest. Among the treatments interaction T_3C_2 and T_4C_2 proved better and have their positive effect to increase the availability of nitrogen, phosphorus and potassium at all the stages of sampling. It can be concluded that growing of crops by intercropping method on slopy field and treatments with contour bund and vegetative barrier across the slope found to be beneficial to improve the availability of major nutrients (N, P and K) throughout the growing period of crops.

Table-8 : Available nitrogen (kg/ha) in soil as affected by different treatments.

Cropping System	Treatments				
	T1	T2	T3	T4	Mean
Sowing					
C_1	195.57	220.76	251.42	231.45	224.80
C_2	210.42	228.82	248.79	242.32	232.58
Mean	202.99	224.79	250.10	236.88	--
		T	C	T x C	
S.E.±		139.86	98.70	197.41	
C.D. at 5%		N.S.	N.S.	N.S.	
Flowering					
C_1	212.12	245.50	267.41	262.87	246.98
C_2	232.17	257.34	278.82	270.51	259.71
Mean	222.14	251.42	273.12	266.69	--
		T	C	T x C	
S.E.±		2.731	0.693	1.387	
C.D. at 5%		8.405	2.135	4.270	
Harvest					
C_1	176.12	223.52	241.71	237.82	219.79
C_2	192.18	230.46	253.71	248.44	223.20
Mean	184.15	226.99	247.71	243.13	--
		T	C	T x C	
S.E.±		3.688	1.374	2.749	
C.D. at 5%		N.S.	N.S.	N.S.	

Table-9 : Available phosphorus (kg/ha) in soil as affected by different treatments.

Sowing

Cropping System	Treatments				
	T_1	T_2	T_3	T_4	Mean
C_1	9.8	12.50	16.78	16.00	14.27
C_2	11.82	14.31	16.34	16.50	15.74
Mean	10.81	13.40	16.56	16.25	--
		T	C	T x C	
S.E.$\pm$		0.174	0.120	0.241	
C.D. at 5%		N.S.	N.S.	N.S.	

Flowering

C_1	12.68	16.40	22.65	19.85	17.89
C_2	14.70	18.37	24.27	20.29	19.40
Mean	13.69	17.38	23.46	20.07	--
		T	C	T x C	
S.E.$\pm$		0.221	0.121	0.243	
C.D. at 5%		0.681	0.374	0.748	

Harvest

C_1	8.2	10.72	16.45	14.12	12.37
C_2	10.10	12.65	18.00	14.47	13.80
Mean	9.15	11.68	17.22	14.29	--
		T	C	T x C	
S.E.$\pm$		0.115	0.086	0.172	
C.D. at 5%		0.356	0.264	0.529	

Table-10 : Available potassium (kg/ha) in soil as affected by different treatments.

Sowing

Cropping System	Treatments				
	T_1	T_2	T_3	T_4	Mean
C_1	392.34	426.54	450.71	430.07	424.91
C_2	417.43	432.66	468.81	441.57	440.12
Mean	404.88	429.60	459.76	435.82	--
		T	C	T x C	
S.E.±		7.622	6.457	12.914	
C.D. at 5%		N.S.	N.S.	N.S.	

Flowering

C_1	424.83	462.44	485.35	460.78	458.35
C_2	447.47	473.34	503.67	472.91	474.34
Mean	436.13	467.89	494.51	466.84	--
		T	C	T x C	
S.E.±		10.103	5.551	11.103	
C.D. at 5%		31.084	17.081	N.S.	

Harvest

C_1	385.15	412.55	427.71	416.54	410.49
C_2	397.71	420.44	443.80	424.56	421.63
Mean	391.43	416.50	435.76	420.55	--
		T	C	T x C	
S.E.±		8.052	3.866	7.733	
C.D. at 5%		24.77	11.89	N.S.	

4.7 Effect of land configuration and cropping systems on dry matter, grain yield and monetary returns.

The grain and fodder yield as well as a monetary returns obtained as affected by different treatments are presented in Table 11 and 12 as well as in Fig. 5. It can be seen from Table-11 that different treatments of land configuration and cropping systems as well as their effect of interaction was found to be positively and beneficial to enhance the dry matter and seed yield of crops harvested at different times. Among the treatments T_3 and T_4 as well as C_2 proved better to imporve the dry matter yield of crops. The combined effect of treatments further increase the dry matter yield. As regards the seed yield of crops T_3 treatment recorded maximum of 28.40 per cent more grain yield of pigeon pea crop and 24.86 percent more grain yield of sorghum crop over control followed by T_4 and T_2 treatments. The combined effect of treatments further increase the grain yield of crops over individual treatments.

The total monetary returns obtained from different treatments presented in Table-12 indicate that greater monetary returns of 26.41 per cent more (Rs. 15446/-) were recorded in T_3 treatment followed by T_4 (22.49 percent) and T_2 (16.23 percent) more over control. It is interesting to note that intercropping treatments (C_2) increased about 70 per cent more significant monetary returns over sole cropping system. The effect of interaction was also found to be significant to increase the monetary returns of crops. Among the treatments T_3C_2 recorded highest monetary returns (Rs. 19442/-) followed by T_4C_2

Table-11 : Total seed yield (kg/ha) and total dry matter (kg/ha) as affected by different treatments.

	Sorghum Sole (C1)		Sorghum + Pigean pea cropping system (C2)			Mean		
	Grain	Fodder	Grain	Fodder	Grain P.P.	Sorghum Grain	Sorghum Fodder	Pigeon pea Grain
T1	1785.18	4175.92	933.33	2220.37	638.88	1359.25	3198.14	638.88
T2	1996.29	4750.00	1101.85	2622.22	764.81	1549.07 (13.96)	3686.11	764.81 (19.71)
T3	2211.11	5305.55	1183.33	2838.88	820.37	1697.22 (24.86)	4072.21	820.37 (28.40)
T4	2153.70	5124.07	1164.81	2772.22	788.88	1659.25 (22.07)	3948.14	788.88 (23.47)
Mean	2036.57	4838.88	1095.83	2613.42	753.23	1566.19	3726.15	753.23

Figures in parenthesis indicate percent increase over control.

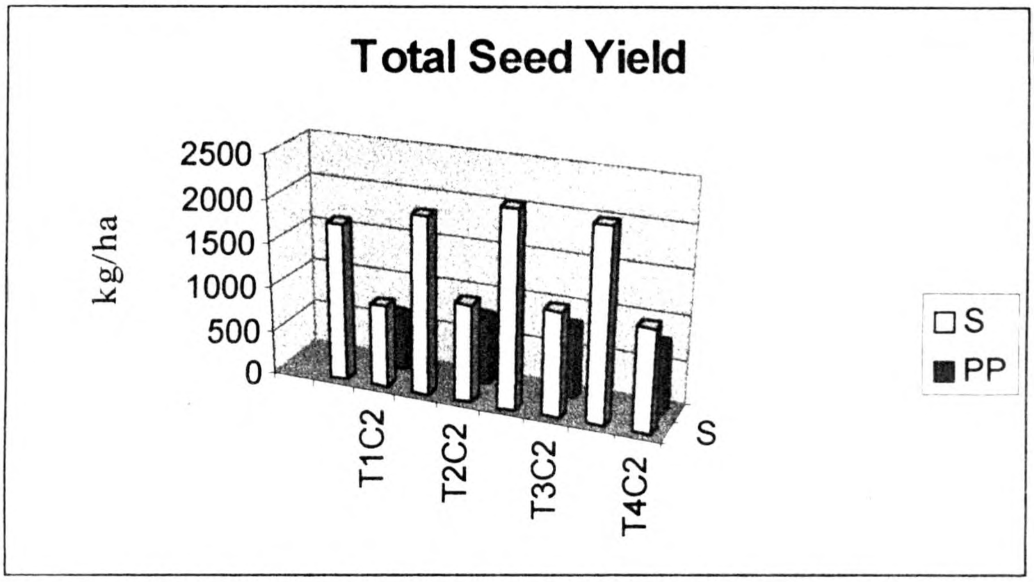
Cropping System	Total dry matter (kg/ha). Treatments				
	T1	T2	T3	T4	Mean
C1	5961.10	6746.30	7514.20	7277.80	6874.80
C2	6150.10	7339.00	7970.90	7769.10	7307.30
Mean	6055.60	7042.70	7742.50	7523.40	--
		T	C	T x C	
S.E.±		218.33	20.177	403.54	
C.D. at 5%		671.76	N.S.	N.S.	

Table 12 : **Total monetary returns(Rs/ha)as affected by different treatments.**

	Monetary returns (Rs./ha)		
	C1	C2	Mean
Treatments			
T1	9252.90	15186	12219
T2	10307	18100	14203 (16.23)
T3	11451	19442	15446 (26.41)
T4	11119	18816	14968 (22.49)
Mean	10532	17886 (70)	
	T	C	T X C
S.E. ±	565.44	468.63	937.27
C.D. at 5%	1739.70	1441.90	2883.70

Figures in parenthesis indicate percent increase over control.

(Rs.18816/-) and T_2C_2 (Rs.18100/-) treatments. The increases in monetary returns were due to interaction were significantly superior over control. The above results clearly indicate that land configuration with contour bunds or vegetative barrier or control for intercropping of crops on slopy field proved better to increase the productivity as well as monetary returns obtained from the crops.



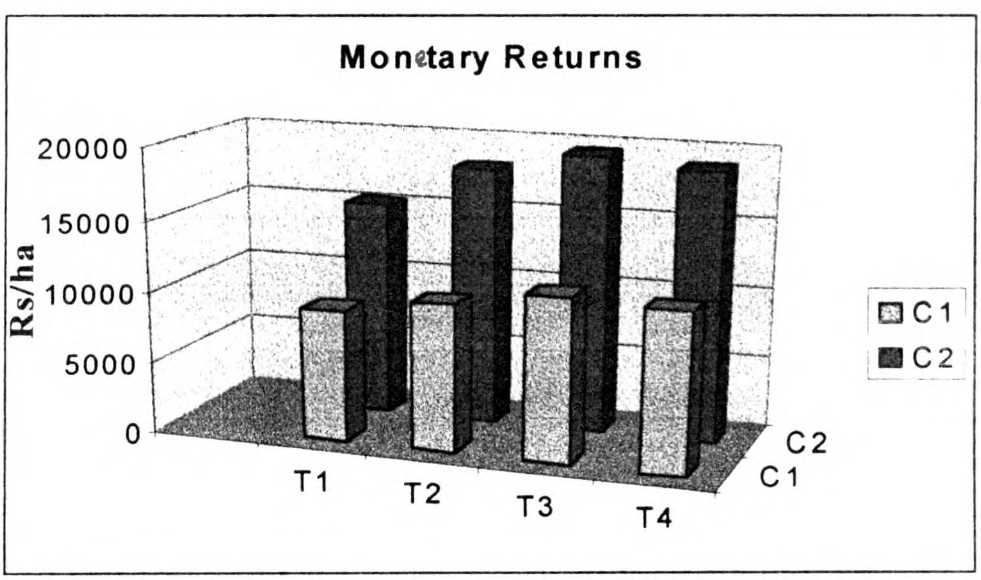


Fig. 5 : Total seed yield (kg/ha) and monetary returns as affected by differnt treatments.

4.8 Effect of land configuration and cropping systems on total runoff water and soil loss.

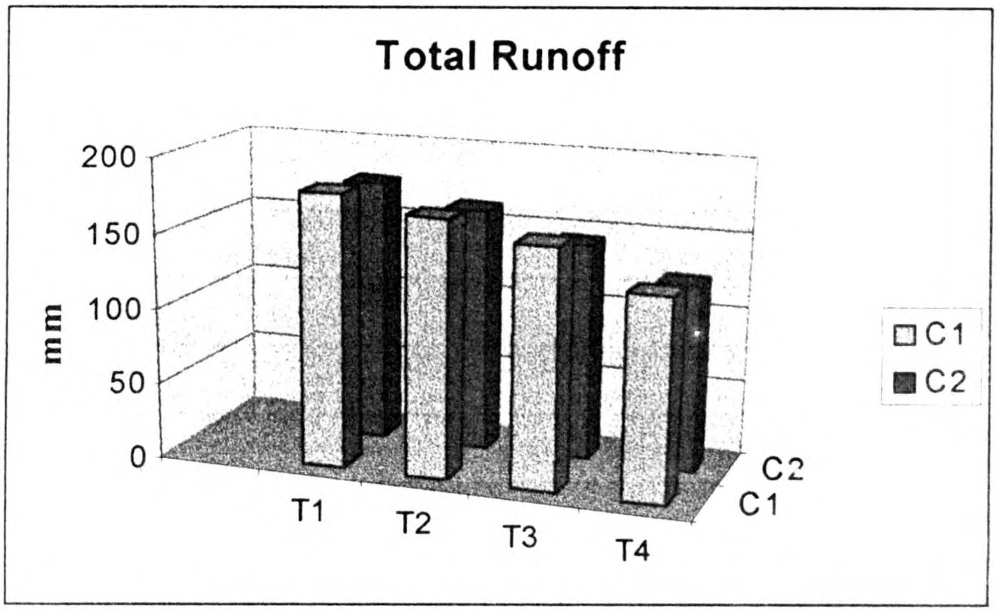
The runoff water loss and soil losses were recorded throughout growing period of crops at different rain storms and the total runoff (mm) and total soil loss (tonn/ha) are reported in Table-13. There were 8 water collection tank fitted in soil with multi slot deviser (Flow devision system) to enable to collect soil and water loss by erosion.

The observation on this parameter could not be replicated as there were only 8 multi slot deviser and tanks instead of 24. Hence the observation recorded in one replication are presented in Table-13. The results indicated that T4 treatment of vegetative barrier along the contour line helped to reduce the soil loss and water losses to the extent of 43 per cent and 30 per cent respectively over control. Similarly intercropping system (C2) treatment minimised soil and water losses to the extent of 8 and 6 per cent respectively over control. The combined effect of treatments helped to reduce the runoff soil and water losses to a greater extend over individual treatments. It can be concluded that land configuration by contour sowing/bunding or vegetative barrier across the slope and intercropping of crops found to be beneficial to minimize soil and water losses from the field for increasing moisture status of soil profile, infiltration rate, there by increasing the ability of nutrients and yield of crops.

Table 13 : Total runoff (mm) and soil loss (tonns/ha) as affected by different treatments.

	Total runoff (mm)			Total soil loss (tonnes/ha.)		
	C1	C2	Mean	C1	C2	Mean
Treatments						
T1	181	175	178	5.6	5.2	5.4
T2	170	162	166	4.8	4.4	4.6
	(6)	(10.4)	(8.28)	(14.28)	(21.42)	(17.85)
T3	158	144	151	3.9	3.5	3.7
	(12.7)	(20.44)	(16.57)	(30.35)	(37.5)	(33.92)
T4	132	123	127	3.3	3.16	3.2
	(27)	(32)	(29.83)	(41.07)	(43.57)	(42.85)
Mean	160	151		4.4	4.05	
		(6)			(8)	

Figures in parenthesis indicate per cent reduction in soil and water loss over control.



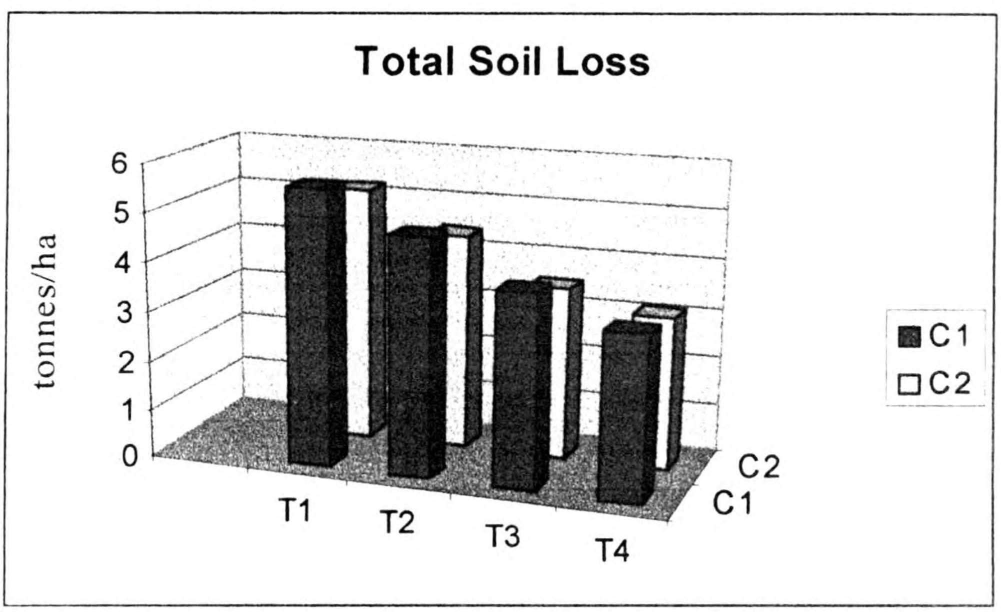


Fig. 6 : **Total runoff (mm) and soil loss (tonnes/ha) as affected by different treatments.**

DISCUSSION

CHAPTER-V

DISCUSSION

Moisture contents (cm) of soil profile (0-45 cm depth)

Data on moisture content of soil profile (0-45 cm depth) as affected by different treatments of land configuration and cropping systems give an indication for significant effect of treatments on moisture content of soil profile at various stages of growth of crops (Sorghum and pigeon pea). Black soils, in general exhibit good runoff potential although there are large scale special and temporal variation depending upon depth surface condition and infiltration characteristics of the soil relief, nature of vegetative cover and rainfall characteristics of the region. The soil on slope are prone to excessive runoff due to uneven and erratic rainfall with high intensive storms. Medium soils on slopy topography generally have low water storage capacity poor aggregation having structural collapse. Under such above mention adverse condition crop must be able to take full advantage of period of available moisture for its better growth. Soil and water conservation practices like contour bund, vegetative barrier across the slope at specific interval as well as planting of crop across the slope proved to be effective to reduce run-off water and soil loss. Vegetative barrier because of their rapid growth rate and dense root system bind soil particles in the root zone of the crop thereby providing live bund across the slope to check excessive runoff. In the present investigation land configuration practices contributes much to improve water infiltration in soil with its proper distributions and soil for prolonged period as well as at various growth stages of crop for their enhanced productivity on slopy land under rainfed condition. The beneficial effects of land configuration practices to improve moisture content of soil profile in vertisol region have also been reported by Patil and Bengal 1969, Barai *et al.* 1991, Nalwade 1991, Sagre and Kapgate 1994, Karle *et al.* 1995 and Solanke 1998.

Cropping systems also helped to improve moisture content of soil profile in the present investigation. Pigeon pea was intercropped with a cereal (sorghum) in strips. Cover crops provide sufficient and broad canopy to prevent dry action of raindrops with the soil particle which interms helps to reduce runoff, soil and water loss. Several benefits are attributed to mixed intercropping for maintainance and biuld up physico-chemical environment of soil as compared to monoculture. Attempt have been made to study the beneficial effects of intercropping in strips, sorghum and pigeon pea over sole crop of sorghum across the slope for improving and maintaining better soil physical environment. Mixed cropping plays an important role in improving and maintaining the soil structure. Beneficial effects of mixed cropping or intercropping of legume with cereal have also been report by Karle *et al.* 1995. and Solanke 1998.

The interaction effects of land configuration and cropping systems on moisture content recorded at flowering and harvest of the crops was found to be significant and promising. Land configuration treatment across the slope and super imposing intercropping treatment mutually helped together for better moisture conservation by rusticating the runoff soil and water losses from field in the present investigation. Similar results on beneficial effects of intercropping alongwith land configuration also reported by Karle *et al.* 1995 and Solanke 1998.

Bulk density of soil profile

Beneficial effects of land configuration and cropping systems was observed in bulk density of soil profile (Table-4) at sowing, flowering and harvest of the crop. Decrease in bulk density was numerical and was not reach to the level of the significance at sowing, flowering and harvest of the crop as well as different treatments and their interaction. The beneficial effects of land configuration and cropping system on bulk density of soil were also reported by John *et al.* 1968, Trilok Singh 1980, Patil and Mehendra Pal 1987, Karle *et al.* 1995 and Solanke 1998.

Cumulative and Final infiltration rate

Infiltration is the process of entry in the soil of water made available at surface as an important process for replenishment of ground water since the availability of moisture for growth of plant as well as the amount of water available for runoff depends on rate of infiltration and under particular condition is directly dependent on it. Infiltration rate is affected by number of factors of which soil moisture, texture and vegetative cover are most significant once evaluation of infiltration rates, under different covers provides comparative account of influence of cover crops on soil moisture availability directly and runoff indirectly. Black soils exhibit runoff potential depending on depth texture, relief, nature of vegetative cover and rainfall of the region. Since slow permeability of black soils limiting moisture conservation, solution to the problem depend on land and water management practices which increase surface drainage and recharge of the soil profile with rain water without accelerating soil erosion. Contour bunding, vegetative barrier and planting across the slope helped to conserve more moisture in soil profile and helped to increase in infiltration rate by creating hindrance to check runoff, soil and water loss. Crop canopy in strip cropping helped to minimize runoff which intern helped to improve water infiltration in the soil. Beneficial effects of land configuration on increase in infiltration rate in the soil are also reported by Karle *et al.* 1995 and synergistic effect of vegetattive barrier on increased infiltration rate was also reported by Chatterji and Maiti 1994, Karle *et al.* 1995 and Solanke, 1998.

The combined effect of cropping system and land configuration at the harvest of the crop was also recorded as positive and significance to enhance cumulative and final infiltration rate. Similar observations on effect of cropping system with infiltration were also reported by John *et al.* 1968, Dongale 1987, Karle *et al.* 1995 and Solanke 1998.

Moisture use and moisture use efficiency

Increased moisture use efficiency as a result of different land configuration treatments, cropping systems and their interaction indicate that soil and water conservation practices on slopy land in sole or intercropping system proved better to enhance water infiltration, its distribution, in soil profile to reflect in crop yield potential by increasing moisture use efficiency of crops under rainfed condition. The effect on moisture use was non significant but combined effect of treatment interaction proved effective and beneficial for profound moisture use efficiency of crop planted in strip or sole across the slope by super imposing different soil and water conservation technique imporve moisutre use efficiency as a result of land configuration, cropping systems and their combined effects was also observed by Kurian 1973, Karle *et al.* 1995 and Solanke 1998.

Available nutreient status in soil

Data on available major nutrients (N, P and K) with organic carbon determine at sowing, flowering and harvest of the crop are presented in (Tabel-7 to 10) give an indication on significant response of cropping system and land configuration to increase the availability of nutrients. Land treatments in both the cropping system maintain better moisture status in the soil profile by improving soil physical environment throughout growing period of crop which helped to solublize the land available nutrients for better growth of crops to increase productivity. Increase availability of nutrients as results of cropping system and land configuration system was also reported by Gurmel Singh *et al.* 1979, Prasad *et al.* 1993, Sagare and Kapgate 1994, Rane *et al.* 1995 and Solanke 1998.

Yield and monetary returns

Beneficial effects on different land configuration system in both the cropping systems are recorded in (Table-11 and 12) and (Fig.5). Different land configuration systems like sowing across the slope, contour bund and vegetative barrier across the slope in both the cropping system helped to conserve more moisture in the soil profile throughout growing period of the crop by improving physical property and checking runoff soil and water loss which interms refelcted in the increased yield of crops with better monetary returns as per prevailing market price of the commodity. The above results are inaccordance with the findings of Bonde *et al.* , 1982, Gutal *et al.*, 1988 and Solanke, 1998.

Runoff water and soil loss

A beneficial effect on checking runoff and soil loss as a result of land configuration treatment and cropping system are presented in Table 13. Black soils in the semi arid region are highly dispersible with poor aggregation, low water storage capacity on rolling topography are subjected to runoff water and soil loss. The nature and physical properties of shallow black soils on slope and climatic condition which they occur, clearly call for different strategy incontrolling erosion. The impact of different types of land management practices, vegetative barriers and sowing methods and crops on runoff and soil loss was studied in the present investigations and results are increasing. Soil erosion by water is the most serious environmental and economic issue of black soil in the semi arid tropic. Accelerated soil erosion is a symptom of land misuse driven by socio economic compulsion. Inspite of following measures runoff can not be reduced to zero as there is limit for intake, rate of safe disposal of excess runoff at low velocity from the farm lands on slopy topography could be achieve by adopting land configuration technique in the intercropping system. The beneficial and promising results to decrease runoff water and soil loss by adopting land configuration system in planting of crop across the slope in strips was also reported by Kanetkar *et al.* 1960, Balvir Verma, 1968, Patil and Bengal, 1991 and Tyagi and Joshi 1994.

The above discussion lead to conclude a comprehensive strategy is required to increase the productivity of aerable lands on slope and which can be achieved by adopting land configuration system in intercropping to increase the productivity of crops with better monetary returns by improving soil physical properties at reduced rates of soil and individual resources.

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

The present investigation was conducted at Department of Agricultural Chemistry and Soil Science Farm, College of Agriculture, Marathwada Agricultural University, Parbhani in *Kharif* season of 1999-2000 to study the effect of land configuration and cropping systems on physical properties of soil and yield of crops on medium soil with slopy topography. The experiment was planned in split plot design using 8 treatment combinations of four land configuration and two cropping systems. The treatments were replicated four time.

The salient finding emanating from the study and conclusion drawn are briefly summarised below.

1. The contour bund of land configuration and vegetative barrier across the slope treatment as well as intercropping of sorghum + pigeon pea (C_2) cropping system significantly increased moisture content of soil profile throughout growing period of crops, their interactions did not much affected the moisture content significantly.
2. The different land configuration's as well as cropping system and their interaction did not much affected significantly the bulk density of soil profile of surface as well as at sub surface layers.
3. The contour bund and vegetative barrier treatment in intercropping of sorghum + pigeon pea across the slope significantly increased the cumulative and final infiltration rate at harvest of the crops.
4. The moisture use was not much affected due to various treatments and their interaction, while moisture use efficiency was significantly

improved by T3, T4 and C2 treatments and T3C2, T4C2 proved better to improve moisture use efficiency by the cropping systems.

5. The contour bund or vegetative barrier across the slope with intercropping of sorghum + pigeon pea found beneficial to improve better yields with good monetary returns on medium soil with slopy topography.

6. Land configuration and cropping systems individually improved availability of nutrient (N, P , K and Organic carbon) at flowering and harvest, while combined effect of treatments proved better for increased availability of N and P at flowering and harvest of the crops.

7. The intercropping of sorghum + pigeon pea as well as contour bund or vegetative barrier treatment across the slope proved better to reduce runoff water and soil loss, while intercropping on contour bund or vegetative barrier treatment combine together further reduce runoff water and soil losses.

8. In brief, it can be concluded that intercropping of sorghum + pigeon pea (legume cover crop) on contour bund or vegetative barrier across the slope or their interaction proved beneficial to improve moisture conservation in soil profile throughout growing period of crops, cumulative and final infiltration rate, moisture use and moisture use efficiency by minimizing runoff water and soil loss for increased productivity of crops with better monetary returns on medium soil with slopy topography under rainfed condition.

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APPENDIX-I

Weekly weather data during crop growth period 1999-2000.

Metr. Week	Date		Rainfall (mm)	Temp0C Max	Min	Humidity A.M.	P.M.
1999							
24	11-17	June	76.4	31.3	22.6	90	70
25	18-24	June	78.4	29.8	22.7	84	70
26	25-1	July	2	32.7	23	72	49
27	2-8	July	61	32.2	23.2	77	57
28	9-15	July	62.8	31.4	23.4	85	61
29	16-22	July	28	30	22.8	85	67
30	23-29	July	3.6	30.7	22.9	79	60
31	30-5	August	120.8	28.1	21.8	88	72
32	6-12	August	26.4	28.3	21.8	82	75
33	13-19	August	0	31.1	22.8	73	60
34	20-26	August	12	31.8	22.4	72	54
35	27-2	Septeber	158.6	31.3	22.1	84	53
36	3-9	September	128.2	29.4	21.4	86	70
37	10-16	September	45.1	28.7	21.4	88	68
38	17-23	September	34.8	29.5	22	85	63
39	24-30	September	16.7	31	22.8	83	63
40	1-7	October	2.8	31.1	21.8	84	58
41	8-14	October	71.8	31.7	21.2	84	56
42	15-21	October	0	31.4	17.7	74	45
43	22-28	October	0	31.1	16.5	76	45
44	29-4	November	0	32	14.3	77	34
45	5-11	November	0	32.5	15.3	74	37
46	12-18	November	0	31.3	11.6	74	27
47	19-25	November	0	28.6	10	75	24
48	26-2	December	0	29.6	9.4	75	25
49	3-9	December	0	28.7	10	76	33
50	10-16	December	0	27	8.1	81	29
51	17-23	December	0	27.6	6.4	79	26
52	24-31	December	0	29	10.7	75	29
2000							
1	1-7	January	0	28	8	76	25
2	8-15	January	0	29.7	10	73	30
3	16-23	January	0	31.2	13.5	75	35
4	24-31	January	0	30.6	11.4	76	27
5	1-7	February	0	31.2	10.7	74	35
6	8-15	February	0	30.5	12.6	72	33
7	16-23	February	0	31	14	68	43
8	24-2	March	14.2	30.7	13.2	77	51
9	3-10	March	0	31.8	13.4	72	28
10	11-18	March	0	34.5	13.2	62	25