

EFFECT OF DIFFERENT *IN-SITU* SOIL MOISTURE CONSERVATION TECHNIQUES IN MAIZE UNDER SHIWALIK FOOTHILLS OF JAMMU AND KASHMIR

**By
Vikash Kumar
(J-15-M-401)**

Thesis Submitted to Faculty of Postgraduate Studies
In partial fulfilment of the requirements
For the degree of

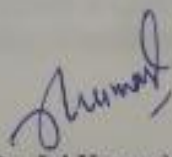
MASTER OF SCIENCE IN AGRICULTURE AGRONOMY



**Division of Agronomy
Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu
Main Campus, Chatha, Jammu 180009
2018**

CERTIFICATE-I


This is to certify that the thesis entitled "**Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir**" submitted in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture (Agronomy)** to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, is a record of bonafide research carried out by **Mr. Vikash Kumar**, Registration No. **J-15-M-401** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that such help and assistance received during the course of investigation have been duly acknowledged.


(Dr. Jai Kumar)
Major Advisor

Place: Jammu

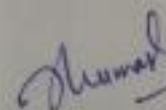
Date: 03/08/2018

Endorsed


Head,
Division of Agronomy
SKUAST-J, Chatha
Date: 06.11.2018

CERTIFICATE-II

We, the members of Advisory Committee of **Mr. Vikash Kumar**, Registration No. **J-15-M-401**, a candidate for the degree of **Master of Science in Agriculture (Agronomy)**, have gone through the manuscript of the thesis entitled "**Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir**" and recommended that it may be submitted by the student in partial fulfillment of the requirements for the degree.



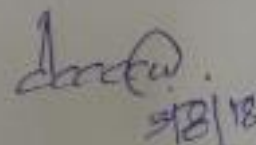
Dr. Jai Kumar
Jr. Scientist, Agronomy
Major Advisor & Chairman
Advisory Committee

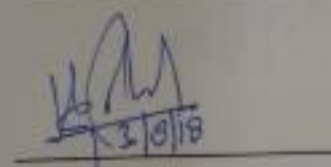
Place: Jammu

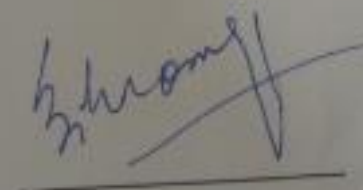
Date: 03/08/2018

Advisory Committee Members:

- 1. Dr. Anil Kumar**
Associate Director Research
ACRA, Rakh-Dhiansar
(Member from Major Subject)
- 2. Dr. Vikas Abrol**
Senior Scientist (Soil Science)
ACRA, Rakh-Dhiansar
(Member from Minor Subject)
- 3. Dr. Bikram Singh**
Professor
Division of PBG
(Dean's Nominee)








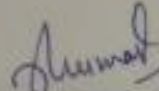
CERTIFICATE-III

This is to certify that the thesis entitled "Effect of different *in-situ* soil moisture conservation techniques in maize under Shivalik Foothills of Jammu and Kashmir" submitted by **Mr. Vikash Kumar**, Registration No. J-15-M-401, to the Faculty Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture (Agronomy)** was examined and approved by the Advisory Committee and External Examiner(s) on 27/09/2018

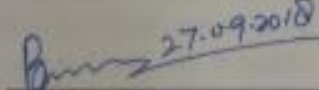

External Examiner

Dr. Manzoor Ahmad Gohai
Sr. Scientist, Agronomy
MRCFC Khudwani, SKUAST


Dr. Jai Kumar
Jr. Scientist, ACRA, Rakh-Dhiansar
(Major Advisor)


27/09/2018

Head
Division of Agronomy


27.09.2018

Dean
FoA
SKUAST-Jammu


08/11/2018

ABSTRACT

Title of the Thesis : **Effect of different *in-situ* soil moisture conservation techniques in maize under Shivalik Foothills of Jammu and Kashmir**

Name of the Student : **Vikash Kumar**

Registration Number : **J-15-M-401**

Major Subject : **Agronomy**

Name & designation of Major Advisor : **Dr. Jai Kumar (Jr. Scientist, ACRA Rakh Dhiansar)**

Degree to be Awarded : **Master of Science in Agriculture (Agronomy)**

Year of Award of Degree : **2018**

Name of University : **Sher-e-Kashmir University of Agricultural Sciences & Technology, Jammu.**

ABSTRACT

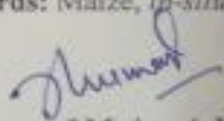
An experiment entitled, “**Effect of different *in-situ* soil moisture conservation techniques in maize under Shivalik Foothills of Jammu and Kashmir**” was conducted at the Research Farm of Advanced Centre for Rainfed Agriculture, ACRA Dhiansar of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during the *Kharif* season of 2016. The soil of the experimental field was sandy loam in texture, near to neutral, low in organic carbon and available nitrogen and medium in available phosphorous and potassium. The experiment was laid out in randomized block design during *kharif* season of 2016 with three replications each. The experiment consisted of 9 treatments *viz.* T₁ - Flat Bed, T₂ - Broad Bed Furrow, T₃- Flat Bed + mulching with *in-situ* raised Dhaincha, T₄-Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, T₅-Flat Bed + mulching with *in situ* raised Sunhemp, T₆- Broad Bed Furrow + mulching with *in-situ* raised Sunhemp, T₇ - Flat Bed + mulching with *Leucaena* prunings, T₈- Broad Bed Furrow + mulching with *Leucaena* prunings and T₉ - Farmer’s practice. The field was ploughed twice with disc harrow followed by planking to prepare a fine seed bed. Plot paths, replication borders and drainage channels were made manually. The plots were leveled before planting of *kharif* maize. However, Broad Bed and Furrow plots were raised using Bed making machine. Hybrid maize variety *Double dekalb* was sown in lines on 5th of July using full dose of P and K along with 2/3rd dose of N as basal dose at the time of sowing through inorganic sources of nutrients *viz.* Urea, DAP and MOP, respectively as per package of practices and remaining Nitrogen was applied just before the application of mulches while in farmers practice only Urea and DAP as inorganic fertilizers were applied in maize crop sown by broadcasting method without following any plant protection measures. However, the seeds of the mulch crops *viz:* Dhaincha and Sunhemp were also sown by broadcasting method at the time of final ploughing as per the technical programme. *Leucaena* prunings (*Ex-situ*) were taken from the plants growing in surroundings 35 DAS at the time of spreading of mulches.

The experimental results revealed that all the soil moisture conservation techniques showed significant results over the other treatments. However, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher plant height, dry weight, number of plants/ m², number of grains/cob, and higher numerical values of NPK uptake in grain and stover and was found to be statistically at par with the treatment (T₅) Broad Bed Furrow (BBF) + mulching with *Leucaena* prunings and Treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp.

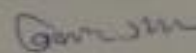
The treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher grain yield (32.81q/ha) alongwith highest net returns, B:C ratio and RWUE (kg/ha-mm) to the tune of ₹ 40755/ha, 1.83 and 5.16 , respectively while the lowest net returns and B:C were recorded in farmer's practice .

Henceforth, based on the one year study , it is concluded that among the different *in-situ* soil moisture conservation techniques in maize, Broad Bed Furrow (BBF) + mulching with *in-situ* raised Dhaincha, provided significantly highest grain yield with maximum net returns, B:C ratio and Rain Water Use Efficiency under rainfed situations which not only helped in conserving the moisture in the soil profile by reducing the evapo-transpiration losses but also enhanced the productivity of maize especially during mid/terminal dry spell situations and can contribute to food security of *kandi belt* farmer's under the Shiwalik Foothills of Jammu and Kashmir.

Key words: Maize, *in-situ* moisture conservation, Broad Bed Furrow and Flat Bed.



Signature of Major Advisor



Signature of the Student

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

The almighty god, the most compassionate and most merciful had blessed me for undertaking this endeavor.

It is my sublime privilege to express my deep sense of reverence and gratitude to my Advisor, Dr. Jai Kumar, Junior Scientist, Advanced centre for rainfed agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology – Jammu for his inspiring and ingenious guidance and constant encouragement which assisted me to overcome every problem that came in my way during the period of this investigation and preparation of this manuscript. I shall always remain indebted to him for his affection ting glances and generously bestowed on me.

I greatly acknowledge the help rendered by Dr. B.C. Sharma, professor and Head (Agronomy) for their able and mature guidance and ever willing help which led the work to its successful accomplishment.

I emphatically extended my heartiest thanks to the worthy members of my advisory committee Dr. Anil Kumar Associate Director Research (Advanced centre for rainfed agriculture), Dr. Vikas Abrol (Senior Scientist, Advanced centre for rainfed agriculture (Soil science) and Dr. Bikram Singh (Professor, Division of Genetics and Plant breeding) for their constant help encouragement and valuable suggestion during the investigation.

I express my sincere thanks to Dr .B.C. Sharma (HOD) Division of Agronomy SKUAST-J for providing me the necessary facilities regarding the laboratory work,

I greatly acknowledge the help rendered by Dr. B.C. Sharma, (Head Division of Agronomy) and Dr. Anil Kumar Associate Director Research (ACRA Rakh Dhiansar) for their able and mature guidance and ever willing help which led this work to its successful accomplishment.

I would be remised if I don't mention the name of the faculty members Dr. Anil Kumar (Professor) Dr. B.R. Bazaya (Associate professor), Dr. Meenakshi Gupta (Associate professor), Dr. R. Puniya (Assistant professor), Dr. Rajiv Bharat (Assistant professor), and Dr. Neetu Sharma (Assistant professor) in the division who taught me the science of Agronomy.

I shall always cherish the sweet memories of the living company and sincere cooperation of my loving colleagues, seniors and juniors, Swati Mehta, Kunzang Dolma, Sunita Devi, Kapilashiv Bazgalia, Rahul Kumar, Krishana Kumar, Girdhari Jakhar, Devender Kumar, Ashwani Kumar,

Ashu Sharma, Vikash Gupta, Ashok Godara, Tundup, Surender Bhada, Raj Singh, and Omprakash for their whole hearted support and constant inspiration during this investigation.

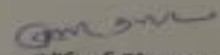
I shall fail in my duty, if I don't thank the non-teaching staff of my department Dr. Dinash Khajuria, Mr. Sumit, and field staff of Advance centre for rainfed agriculture for their help and assistance during the present study.

It is with my personal touch and emotions that I seize this opportunity to express my heartfelt and affectionate gratitude to my parents and family members who were always in my heart and thought. I am gratefully indebted to my beloved godly parents Sh. Mahaveer Parshad and Smt. Silochana Devi, who always been an ideal and torch bearer to me. The eternal blessings and love of my younger brother Vinit Kumar who has always inspired me to achieve very best in life. Without their love, graceful sacrifice and constant inspiration this dream would not have materialized.

Special thanks to my Uncle ji Dr. O.P. Godara, Aunt Mrs. Sunita Devi and to all my lovely sisters and brothers Raveena, Nitesh, Mitali, Amit Kumar, Sumit Kumar, Devender, Hariday, Samresh, Subodh, Pushpender and Harsh whose everlasting blessings, love and affection and untiring efforts brought me here up to

None is forgotten but everyone is not included.

Date: 03/10/2018


Vikash Kumar

CONTENTS

CHAPTER	PARTICULARS	PAGE NUMBER
1	INTRODUCTION	1-4
2	REVIEW OF LITERATURE	5-19
3	MATERIALS AND METHODS	20-32
4	EXPERIMENTAL RESULTS	33-48
5	DISCUSSION	49-55
6	SUMMARY AND CONCLUSION	56-60
	REFERENCES	61-70
	APPENDIX	
	VITA	

LIST OF TABLES

Table No.	Particulars	Page No.
1.	Soil physico-chemical properties of experimental site	
2.	The cropping history of the experimental site	
3.	Gross and net plot size	
4.	Calendar of different cultural operation carried out during experimentation	
5.	Details of method employed for chemical analysis of plant/grain samples	
6.	Effect of different <i>in-situ</i> soil moisture conservation techniques on plant height of maize	
7.	Effect of different <i>in-situ</i> soil moisture conservation techniques on dry matter accumulation of maize	
8.	Effect of different <i>in-situ</i> soil moisture conservation techniques on leaf area index of maize	
9.	Effect of different <i>in-situ</i> soil moisture conservation techniques on crop growth rate of maize	
10.	Effect of different <i>in-situ</i> soil moisture conservation techniques on yield attributes of maize	
11.	Effect of different <i>in-situ</i> soil moisture conservation techniques on grain yield, stover yield, harvest index and RWUE of maize	
12.	Effect of different <i>in-situ</i> soil moisture conservation techniques on moisture per cent of soil three days after every rainfall event (Cummulative)	
13.	Effect of different <i>in-situ</i> soil moisture conservation techniques on pH, EC and OC in soil after harvest of maize	
14.	Effect of different <i>in-situ</i> soil moisture conservation techniques on availability of N, P, K in soil after harvest of maize	
15.	Effect of different <i>in-situ</i> soil moisture conservation techniques on uptake of N, P, K in grains of maize	
16.	Effect of different <i>in-situ</i> soil moisture conservation techniques on uptake of N, P, K in stover of maize	
17.	Effect of different <i>in-situ</i> soil moisture conservation techniques on relative economics of maize	

LIST OF FIGURES

Figure No.	Particulars	After Page No.
3.1	Mean weekly weather parameters recorded during the crop season	
3.2	Layout plan of the experimental field	
4.1	Effect of different <i>in-situ</i> soil moisture conservation techniques on grain yield of maize	

CHAPTER-1

INTRODUCTION

CHAPTER-1

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice which occupies a prominent place in world agriculture due to its wide spread cultivation in tropics, sub-tropics and temperate regions of the world. Maize being grown globally on an area of about 185 million ha with a production of about of 1040 million tonnes. Maize in India is known as 'King of cereals' because of its high production potential and wider adaptability, is cultivated on an area of 8.69 million ha with a production of 21.81 million tonnes and the productivity of 25.09 q/ha (Anonymous, 2016a). The state of Jammu and Kashmir has the distinction of being maize forms the staple diet of majority of the people living in the state and is grown on larger area than wheat and rice while in Jammu region, it is the second most cereal crop after wheat. The total area under maize in Jammu and Kashmir state is 293.86 thousands ha and out of which 230.69 thousand ha lies in Jammu Division, has a production and productivity of 3600 thousand quintals and 17.82 q/ha (Anonymous, 2016b), respectively. Moreover, in Jammu region, the production and productivity of maize is 1444 thousand quintals and 18.00 q/ha (Anonymous, 2016b), respectively.

Maize being the dominant *Kharif* crop of rainfed areas of Jammu province, is seriously suffering due to erratic and unpredictable rainfall, soils being light and medium texture leads to low water holding capacity and the lands are often having uneven topography, the rain water runs off quickly and removes top soil and fertilizers leading to reduction in maize productivity.

Maize is grown on farrowed or slopping lands, largely under Rainfed conditions and thus experience deficit moisture stress at different stages of growth. The uneven distribution of rainfall in time and space often causes dry spells of two weeks or even more resulting in moisture stress conditions during critical stages of maize crop, especially during the cob formation /grain filling stage which is the most critical stage with respect to productivity. Thus the major constraint for establishing a crop is the lack

of adequate moisture in the root zone (Hadda *et al.* 2000; Bhat *et al.* 2004). But due to inadequate, uneven distribution and erratic behaviour of rainfall during growth span of crop resulted in moisture stress. Therefore, it becomes essential to supply water to plant by adopting *in-situ* soil conservation measures for increasing water use efficiency. These causes adoption of *in-situ* moisture conservation practices and enhance productivity under rainfed ecosystem (Subudhi, 2011).

Mulches improve the physical condition and fertility of the soil, check runoff and soil erosion, increase infiltration (Ghosh *et al.* 2006), help in maintaining soil temperature, impede movement of water vapour (evaporation) from soil to air, check weed growth and thereby, reduce evapo-transpiration losses of water (Blevins and Frye, 1993), develop high humidity within the residue mulch (Phillips and Phillips, 1984) and reduce the kinetic energy of impacting rain drops on the soil surface and thus, reduce soil compaction and aggregate disintegration (Mbagwu, 1991). Mulching is one of the useful practice in rainfed areas for controlling erosion, weed growth and conserving moisture as well as nutrients in the soil profile (Sharma *et al.* 2000 and 2005). Studies have shown that mulching with available vegetative materials like dry leaves of Sal trees (*Shorea robusta*), Wild sage (*Lantana camara*), Eupatorium (*Eupatorium adenophorum*) etc, during maize growing season improved moisture conservation and crop productivity (Acharya *et al.* 1998). There is a possibility of biomass production and nutrient cycling through live mulching of *in-situ* grown annual legumes viz. *Sunhemp* and *Dhaincha* as well as perennial leguminous tree viz. *Leucaena leucocephala* as hedge rows along with the field crops which develops canopy cover quickly and might be helpful in conserving the moisture, checking erosion and reducing weed growth beside producing ample quantity of N-rich biomass. *Sunhemp* and *Dhaincha* are fast growing green manure crops and develops canopy cover quickly, which not only help in checking erosion and reducing weed growth but may also helps in conserving the moisture if used as mulch. Introduction of *Leucaena leucocephala* in India in 1970s was hailed as a wonder tree because of its huge potential for production of biomass (20-25 t/ha), N (500 kg N/ha) and suitability for excessive lopping in alley or huge cropping system. Use of *Leucaena* prunings as fodder has not found much favour with farmers due to the presence of mom sine toxin, particularly in the rainy season, but it can be used as mulch because of

succulent biomass rich in N (3-5%) and low C:N ratio. Mulching or incorporation of tender twigs of *Leuceana* has been found beneficial for moisture conservation, meeting N requirement of maize with significant residual effect on soil fertility and productivity of crop (Lehria *et al.* 2006). Hence, there is a dire need to adopt location specific *in-situ* soil moisture conservation technologies by which the area could be ecologically rehabilitated and its production potential could be realized on a sustained basis. Therefore, in order to improve the maize productivity in rainfed areas of Jammu, there is need to conserve moisture in root zone using locally available vegetative biomass as mulch material such as *Dhaincha*, *Sunhemp*, *Leucaena* prunings so as to increase the infiltration by reducing the rate of runoff, temporarily impounding the water on the surface of the soil to increase the opportunity time for infiltration, thereby making water available in the root zone.

Likewise establishment methods such as Broad Bed and Furrow method (BBF), Ridge and Furrow method are also supposed to be beneficial with respect to *in-situ conservation* of soil moisture under rainfed situations where moisture is the limiting factor and rainfall is the only source of water (Channappa and Ashoka, 1992). Concept of Furrow Irrigation Raised Bed method (FIRB) and Broad Bed and Furrow method (BBF) alter the soil physical properties, making better aeration in the soil pores and root zone and better infiltration of water into the soil, thereby resulting in better grain yield (Ratan *et al.* 2005). Broad Bed and Furrow (BBF) system might prove to be an effective land management practice for maximizing infiltration, minimizing erosion and total runoff, facilitating drainage and improving water use efficiency which may be helpful to maize crop during different growth stages in overcoming the moisture stress especially during grain filling / cob formation stage due to early cessation of monsoon rains which otherwise results in drastic decline in maize productivity.

Hence, keeping the above facts in the forefront, a study entitled **“Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir”** is proposed with the following objectives:

1. To find out the most suitable vegetative bio-mass as mulch for *in-situ* moisture conservation for improving maize productivity.

2. To find out the most efficient establishment method for *in-situ* moisture conservation for improving maize productivity.
3. To workout the relative economics of different *in-situ* moisture conservation techniques and establishments methods.

CHAPTER-2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The research work conducted so far in India and abroad and the available information relevant to the research investigation entitled “**Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir**” have been compiled in this chapter under various headings:

2.1 Effect of different *in-situ* soil moisture conservation techniques on growth parameters in *kharif* maize

Khera *et al.* (1976) reported that the mulch increased the height of 27-day plants by 15 cm in 1973 and that of 31 day plants by 19 cm in 1974. At harvest, the crop in the mulched plots averaged about 35 cm taller than that in the unmulched plots. Mulching also increased dry matter per plant by 61 per cent in 17-day plants in 1973 and by 30 per cent in 35-day plants in 1974.

Meelu and Morris (1988) studied the effect of different *in situ* moisture conservation sources different mulch organic materials on maize production and reported that the dry matter production of maize was higher with Dhaincha (8.9 t/ha) followed by Sunhemp (8.1 t/ha), Soybean (6.4 t/ha) and Cowpea (3.3 t/ha) at 60 days after sowing over sole cropping.

Bhagwandin and Bhatia (1998) conducted a field experiment at Bijapur to evaluate the effect of sowing methods and mulching on the intercropping of blackgram with maize under rainfed conditions and reported that plant height was significantly superior in compartmental bunding with 3 m x 3 m distance followed by compartmental bunding of 4.5 m x 4.5 m distance compared to unbounded control.

Ramakrishnan *et al.* (2002) from Coimbatore, Tamil Nadu compared the growth and yield of maize under five different planting techniques *viz.*, compartmental bunding, broad bed and furrows, ridges and furrows, flat bed sowing and flat sowing under moderately well drained, rainfed situation in sandy clay loam soil and reported that the

plants under ridge and furrows planting pattern maintained their superiority in respect of growth characters *i.e.* plant height, LAI and dry matter production.

Sharma *et al.* (2009) conducted an experiment to evaluate the effect of mulching on soil properties under maize-wheat crop rotation and observed that the dry matter accumulation varied from 0.75 to 1.45 t/ha in Sunhemp incorporation plots at 30-35 days of growth which added 21.6 to 41.3 kg N/ha.

Das *et al.* (2013) worked on the *In-situ* moisture conservation and nutrient management practices in fodder-sorghum (*Sorghum bicolor*) and reported that among the five in-situ moisture conservation practices *viz.*, control (flat-bed sowing), ridge and furrow sowing, mini-trenches (1 m × 0.2 m × 0.2 m) at 2 m × 1 m interval, grass/straw/tree leaves mulching @ 8 t/ha and 'Pusa hydrogel' 5.0 kg/ha maximum plant height (135.1 and 207.4 cm) and tillers number/plant (2.7 and 4.3) after 30 and 60 DAS, respectively, were recorded in mini-trenches. Also, number of leaves/plant (33.2), crop canopy diameter/plant (66.8) and leaf to stem ratio (0.54) were the highest in mini-trenches followed by grasses/straw/tree mulch treatments.

Ling *et al.* (2013) observed significantly higher growth rate in the plastic film mulching as compared to the non mulched treatment which was 81 per cent higher during the 6th leaf stage (V6) to 12th leaf stage (V12), 71 per cent higher during the 6th leaf stage (V6) to 12th leaf stage (V12) and 66 per cent higher during the 12th leaf stage (V12) to silking stage (R1) stages in 2010. In 2011, the increases were 265 per cent during the 6th leaf stage (V6) to 10th leaf stage (V10) and 60 per cent during the 10th leaf stage (V10) to silking stage (R1).

Gul *et al.* (2014) concluded that the highest leaf area/plant and plant height were obtained in the hand weeding treatment (4848 cm² and 173 cm) and black plastic mulch (4844 cm² and 172 cm), followed by weeds mulch (4432 cm² and 162 cm), white plastic (4426 cm² and 161 cm) and living mulch (4360 cm² and 154 cm), respectively against 3537 cm² and 152 cm in weedy check.

Yaseen *et al.* (2014) carried out an experiment to study the effect of deficit irrigation and mulch on soil physical properties and growth and yield of maize and

reported that the mulch had significant effect on plant height of maize and the maximum value of plant height (235.2 cm) was found in treatment where straw was applied @ 15 t/ha and minimum plant height of 217.9 cm was in control.

Rajput *et al.* (2014) concluded that the straw mulch recorded significantly higher plant height (215.06 cm) and dry matter accumulation per plant (59.22 g/plant) as compared to all other treatments. However, lowest plant height (207.07 cm) dry matter accumulation 55.08 g /plant) were noticed with control treatment. Interaction between row spacing and mulching for plant height was recorded maximum by paddy straw mulch x 30 cm row spacing and significantly superior over all other interaction levels at harvest.

Singh *et al.* (2014) recorded maximum plant height (209.8 cm at harvest), leaf area index (4.19 at 75 days after sowing), dry matter accumulation (1127.5g/m² at harvest) and crop growth rate (18.26 g/m²/day at 61-75 days after sowing) of maize with the application of FYM mulch as compared to the dry weed bio-mass mulch and other treatments (without irrigation and mulch).

Uttam *et al.* (2015) conducted an experiment at Soil Conservation and Water Management Farm of C. S. Azad University of Agriculture and Technology, Kanpur with 3 moisture conservation practices (one weeding and hoeing by *khurpi* 20 DAS, ridging and furrowing with the help of spade at 20 days after sowing (DAS) in between the crop rows and pre-emergence of atrazine @ 1.0 kg a.i. /ha) and recorded that the growth parameters viz. plant height, stem girth and crop were recorded higher in ridging and furrowing practice than other two moisture conservation practices.

Xu Jie *et al.* (2015) recorded that the amount of dry matter was significantly higher under plastic film mulching conditions as compared to control conditions at each growth stage. The dry matter value at the the eighth leaf stage (V8), the twelve leaf stage (V12), silking stage (R1), and milking stage (R3) stages was 2.0 Mg/ha, 4.4 Mg/ha, 9.6 Mg/ha, and 19.1 Mg/ha, or 77 per cent, 70 per cent, 53 per cent, and 36 per cent higher than the control treatment values, respectively. At harvest, the total dry matter in the plastic film mulching-treated field was 25.0 Mg/ha, or 24 per cent higher than that in the control treatment field (20.2 Mg/ha).

2.2 Effect of different *in-situ* soil moisture conservation techniques on yield and yield attributes in *Kharif* maize

Bhan (1976) conducted a field experiment on the effect of conservation practices and N levels on yield, water use and root developments of rainfed maize and observed the marked improvement in the yield of rain-fed maize due to straw mulch attributed to better root development and soil moisture extraction.

Katama (1979) conducted a field experiment at Agricultural Research Station, Ananthapur (Unpubl) to study the soil and moisture conservation structures and revealed that forming a dead furrow and forming compartments with bund former conserves rain water and improves grain yields of maize by 15-30 per cent.

Hoefler *et al.* (1981) reported that the mulch can decrease soil temperature and retain better root growth in maize in case of coarse textured soil and grain yield was more in loamy sand than sandy loam soil mulching has potential for increasing soil water storage.

Mittal *et al.* (1986) and Vijayalakshmi, (1987) revealed that sowing of maize on ridges and furrows method increased mean maize yield by 59 per cent as compared to the conventional practice of sowing (flat sowing) along the slope.

Simpson and Gumbs (1986) conducted a field experiment to study the effect of mulching and tillage on germination, growth, nutrient uptake and yield of maize and reported that mulched plots gave higher seed weight than non mulched plots in maize. The increased grain yield and 1000 grain weight in ridge-furrow with and without mulch due to favourable effects of moisture conservation on growth and yield attributes.

Srivastava *et al.* (1988) revealed that the ridges and furrows showed 30 per cent increase in grain yield of maize crop as compared to flat bed.

Lal *et al.* (1988) from Pantnagar, Uttranchal in their study to evaluate the effect of three methods of planting *viz.* flat, ridge and raised beds on grain yield of maize reported

highest grain yield (45.3 q/ha) under ridge planting, which was at par with that of bed (42.4 q/ha). Ridge planting and bed planting both methods gave significantly higher grain yield over flat planting (32.9 q/ha).

Brar and Cheema (1988) while conducting an experiment on loamy sand soil at Punjab Agriculture University, Ludhiana deliberately created excess water conditions at 35, 55 and 35+55 days after sowing (DAS) to maize and observed that ridge planting (33.5 q/ha) gave higher grain yield, which was significantly higher than that of conventional planting (31.2 q/ha).

Bhandari *et al.* (1988) while comparing the performance of *Kharif* maize under three methods of planting *viz.* crop sown in normal rows (60 cm), paired rows (30; 90 cm) and skipped rows (120 cm) and reported 4.1 t/ha grain yield under first method of planting, which was significantly higher than those of second methods of planting which were at par with each other. The decrease in grain yield of maize was 11.9 and 20.4 per cent with paired and skipped rows of planting.

Bhagwandin and Bhatia (1998) conducted field experiment at Bijapur to evaluate the effect of sowing methods and mulching on the intercropping of blackgram with maize under rainfed conditions and reported that the broad bed furrow and ridge gave significantly higher test weight, grain yield and fodder yield of maize when compared to flat sowing of Kanpur.

Tisdall and Hodgson (1990) studied the effect of ponding time in ridge and flat planting and reported that the final dry matter yield was 19 to 22 t/ha in ponding of water for 0 to 24 hour in ridge planting as compared to 14 t/ha in 6 hourly ponding water in flat sown crop. Thus, ridge planting produced 5 to 6 t/ha more dry matter than flat planting.

Gupta *et al.* (1990) from Hissar, Haryana observed that under black clay soil condition, ridging proved not only beneficial in improving emergence of maize but also boosted the grain yield by 14-16 per cent over flat sowing.

Radder *et al.* (1991) conducted a field experiment at Bijapur on Compartment bunding-an effective in situ moisture conservation practice on medium deep black soil

and observed that the ridge furrow beds resulted in significantly higher test weight of maize as compared to flat bed sowing.

Singh and Brar (1994) found that mulching significantly increased the grain yield of Maize.

Wicks *et al.* (1994) conducted a field experiment to study the Influence of wheat (*Triticum aestivum*) straw mulch and metolachlor on corn (*Zea mays* L.) growth and yield and observed that the highest soil moisture reserves were observed in plots mulched at 6 and 8 t/ha rates throughout the sampling periods. This might be attributed to the fact that the thick mulch layers protected the soil surface against solar radiation thereby reduced evaporation and enhanced favourable moisture storage.

Patil *et al.* (1994) from Akola, concluded that the broad bed and furrow method and vertical mulch recorded significantly higher total soil moisture content over flat bed upto 60 cm soil profile during *khariif* season with sorghum planting. Likewise, Sharma *et al.* (2000) also reported that mulching during standing crop of maize was more effective in conserving rainwater than at maize harvest.

Vogel (1996) working in North Zimbabwe revealed that ridge planting resulted in prolific, denser and deeper maize root system as compared to ploughing which consequently resulted in higher grain yield (6.6 t/ha) in ridge planting as compared to ploughing (5.1 t/ha).

Sharma *et al.* (1998) reported that the mulching was more beneficial when applied during standing crop of maize, when the soil profile is almost saturated with water. Mulching reduced evaporation flux and allowed redistribution of moisture within the soil profile. Further, mulching also checked runoff from the intermittent rain showers received late in the season, encouraged infiltration and reduced evaporation from soil surface, leading to retention of greater moisture in the soil profile.

Patil (1998) conducted a field experiment to study the effect of different soil moisture conservation methods and noticed significantly higher soil moisture in 60 cm soil profile in the plots laid out with compartment bunding and ridges and furrow

respectively over flat bed. Moreover the effect of different moisture conservation establishment methods in maize and reported that formation of compartmental bunding and ridges and furrows significantly out yielded flat bed during a two year study and the per cent increase was 23 and 26, respectively. Similar trend was observed for straw yield also. Higher yields were observed due to increase in water use efficiency.

Debebe (1999) conducted an experiment on maize in sandy loam soil under excess water conditions and reported significantly better performance of maize crop in respect of growth and yield attributes in ridge planting than flat planting. They observed significant increase @ 11.1 per cent in number of cobs per plant, 7.0 percent increase in number of grains per cob and 2.9 per cent increase in test weight respectively, thus resulting overall 9.9 per cent higher grain yield over flat planting.

Li *et al.* (2000) conducted an experiment during rainy season located in the dry semi-arid regions of north-west China (Gaolan County, Lanzhou, Gansu Province) to evaluate the *In-situ* rainwater harvesting and gravel mulch combination for corn production in the dry semi-arid region of China and reported that corn grain yield based on both area of ridges and furrows occupied treated plots were significantly higher than other non treated plots. Plastic-covered ridge and gravel mulched furrow method of water harvesting was the most successful treatment with more than two times higher grain yields.

Patil and Sheelavantar (2001) studied the effect of different *in situ* moisture conservation practices in maize crop and reported that ridge and furrow method of moisture conservation practice gave the significantly higher yield (1603 kg/ha) of maize as compared to compartment bunding (1276 kg/ha).

Ramakrishnan *et al.*(2002) reported that the plants under ridge and furrow planting techniques maintains their superiority in yield attributes like cob length and number of grains per row of cob which lead to significantly higher grain yield in ridges and furrow (34.6 q/ha) over flat planting (30.2 q/ha).

Musambasi *et al.* (2003) conducted an experiment to study the effect of different establishment methods on the maize productivity and observed that maize sown on ridges provided the maximum grain yield.

Kureel *et al.* (2004) conducted a field experiment to evaluate the effect of fertility levels and moisture conservation practices on maize (*Zea mays* L.) production under rainfed condition and reported that ridging and furrowing practice registered significantly higher values of all yield attributes

Das *et al.* (2004) conducted field experiments to study the effect of moisture conservation practices in maize-rapeseed cropping system and reported that the mulching treatments enhanced soil moisture content by 11.2 ± 2.15 per cent (\pm indicates standard deviation) at depth of 30 ó 40 cm to 20.8 ± 4.5 per cent at depth of 0ó15 cm under Conventional Tillage after RW ragweed mulch application than that under control (no mulching).

Patil and Sheelavantar (2004) from Bijapur reported that increase in grain yield with compartmental bunding was by 26.8 per cent (1570 kg/ha) as compared to flat bed (1238 and 1314 kg/ha, respectively). Further, with adoption of ridge furrow, grain yield increased to the higher extent of 33.9 (1658 kg/ha) and 17.7 per cent (1547 kg/ha) during 1994ó1995 and 1995ó1996 over flat bed, respectively.

Woldetsadik *et al.* (2005) conducted a field experiment during the rainy season to study the effect of nitrogen levels and moisture conservation practices on soil, water, yield and yield components of maize (*Zea mays* L.) in the rift valley of central Ethiopia and observed the highest 17.4 and 24.3 gms, 1000 seed weight were recorded from 20 and 30 kg N/ha at Dera and Melkassa, respectively. Ridge and furrow plus straw mulching gave the highest grain weight as compared with other treatments.

Woldetsadik *et al.* (2005) conducted a field experiment under the rainfed conditions to study the effect of moisture conservation practices on yield and yield components of maize (*Zea mays* L.) and reported that among the different *in situ* moisture conservation practices, ridge and furrow without straw mulching increased the water use efficiency by 30 per cent followed by ridging and furrow plus straw mulching

which increased water use efficiency up to 22.6 per cent at Melkassa. At Dera, ridge and furrow plus straw mulching increased the water use by 67.9 and they also observed that there was non significant difference in harvest index. However the highest value of harvest index was obtained from ridge and furrow plus mulching at both sites.

Bakht *et al.* (2007) concluded that sowing methods had a significant effect on the number of grains per cob and they obtained maximum grains per cob in ridge sowing method as compared to flat sowing method and other sowing methods.

Chopra and Angiras (2008) revealed that raised seed bed and conventional tillage being statistically on par with each other, produced significantly higher values of yield contributing characters (number of rows/cob and 1,000 grain weight) and grain and stover yield of maize than other treatments.

Kumar (2008) conducted a field experiment at Kanpur on the Influence of *in-situ* soil moisture conservation techniques on moisture use efficiency, yield and economics of maize under rainfed condition to study the growth of maize under varying planting methods viz. flat bed and modified bed (ridges and furrow) and reported that maize crop plants grown on modified bed (ridges and furrow) treatment showed significant increase in plant height, 1000 grain weight, grain yield and water use efficiency.

Mbah *et al.* (2010) while working on the influence of different mulch and non mulch materials in maize reported that yield attributes like cob length, cob girth, numbers of seeds per cob, grain and stover yield were significantly influenced by tillage and mulches. All the yield attributes were higher in ridge furrow followed by raised bed over zero tillage. The grain and stover yield were higher with ridge furrow (18.0 and 10.1 per cent, respectively) followed by raised bed (14.5 and 8.6 per cent, respectively).

Sharma *et al.* (2010) conducted a field experiment to study the effect of *in-situ* grown live mulching with legumes viz. sunnhemp (*Crotalaria juncea* L.), Dhaincha (*Sesbania aculeata* Pers.) and cowpea [*Vigna unguiculata* (L.) Walp.], besides weed mulching at 30 and 45 days of maize (*Zea mays* L.) growth on moisture conservation, crop productivity and soil properties in maize-wheat (*Triticum aestivum* L. emend Fiori & Paol.) cropping system and reported that live mulching with intercropped sunnhemp

(*Crotalaria juncea* L.) improves maize productivity by 6 - 9 per cent, residual soil moisture at harvest by 1.6 - 2.9 per cent and yield of following wheat by 13-15 per cent under Doon valley conditions. Also the total system productivity in terms of maize-equivalent yield was the highest with sunnhemp mulching, closely followed by Dhaincha and cowpea grown for seed or green pods. They also concluded that cowpea [*Vigna unguiculata* (L.) Walp.], besides weed mulching at 30 and 45 days of maize (*Zea mays* L.) growth on moisture conservation and crop productivity in maize-wheat (*Triticum aestivum* L. emend Fiori & Paol.) cropping system and reported the maximum amount of soil moisture was conserved with sunnhemp (+3.45 per cent), followed by Dhaincha (+2.90 per cent), and cowpea (+2.05 per cent) in the surface layer over clean cultivation. A similar trend was observed in 15-30 cm depth.

Uwah and Iwo (2011) conducted a two-year field experiment to evaluate the effectiveness of organic mulch on the productivity of maize (*Zea mays* L.) and weed growth and reported that the weight of grains per cob obtained at 6 and 8 t/ha mulch rates across the seasons were statistically at par but higher than other mulch rates (zero t/ha.). The total grain yield produced at 2 and 4 t/ha mulch rates were statistically similar but lower than those obtained at 6 and 8 t/ha rates. Across the seasons, the 6 and 8 t/ha mulch rates produced more than twice the total grain yield obtainable from the unmulched control plots and it was also concluded that the maximum mean per cent soil moisture contents were observed at mulch treatment applied at 8 t/ha in both seasons. The tallest plants were obtained with the highest rate of mulch (8 t/ha) in all sampling periods.

Kannan *et al.* (2013) conducted a field experiment to study Coir pith composting-an alternate source of organic manure for rainfed maize and reported that length of the cob and Stover yield of maize was higher under coir pith compost applied as much as compared to control plot.

Vashishta *et al.* (2013) reported that the highest grain yield was recorded under the treatment with sugarcane mulch (40.60 and 33.51 q/ha) followed by *Leucaena leucocephala* (36.00 and 24.82 q/ha), asoti (33.20 and 22.45 q/ha) and least under control plots (28.10 and 19.04 q/ha) during 2005 and 2006, respectively. The per cent increase in grain yield over control was 44.48 and 75.99; 18.15 and 17.91; and 28.11 and

30.36 under application of sugarcane trash, basooti and subabul, respectively during 2005 and 2006 and the highest grain yield was recorded under the treatment with sugarcane mulch (40.60 and 33.51 q/ha) followed by subabul (36.00 and 24.82 q/ha), basooti (33.20 and 22.45 q/ha) and least under control plots (28.10 and 19.04 q/ha) during 2005 and 2006, respectively and they also reported that the higher soil water retention at various suctions was observed in the plots mulched with the subabul followed by basooti and sugarcane trash and least under control plots.

Zamir *et al.* (2013) observed that maize straw mulch had a significant effect on cobs per plant, grain rows per cob, 1000 grain weight, grain yield, biological yield, stalk yield and harvest index.

Devaranavadi and Bosu (2014) conducted a field experiment to study the effect of different *in-situ* moisture conservation practices in deep clay soils on growth and yield of maize (*Zea mays* L.) under rainfed condition and reported that broad bed furrow was found to be superior practice in terms of cob length (18.09 cm), cob girth (148.75 cm), cob weight (148.75 g), grains per cob (346.50). The mean grain yield for the same treatment was 5431 kg/ha which was more by 23.38 per cent when compared to control.

Yaseen *et al.* (2014) carried out a field study to study the effect of deficit irrigation and mulch on soil physical properties and growth and yield of maize and reported that the maximum value of 1000- grain weight with the corresponding value of 306.50 g was observed in treatment where straw was applied and minimum value of 272.0 g was observed in control treatment.

Uttam *et al.* (2015) concluded from a two seasons study on the performance of moisture conservation practices in Kharif maize on sandy loam soil and reported that higher yields obtained in ridge and furrow method compared to control might be due to higher value of yield attributes and growth parameters.

Ehsanullah *et al.* (2015) conducted an experiment at Faisalabad, Pakistan on tillage practices and sowing methods affect yield and related attributes of maize and reported that grain weight per cob was highest in ridge sown maize under deep tillage while lowest was recorded in flat sowing under minimum tillage. At conventional tillage,

bed sown maize produced maximum grain weight per cob that was statistically alike with the ridge sown maize while flat sown maize gave minimum grain weight per cob. They also revealed that 1000-grain weight was highest in ridge sown maize under deep tillage while the lowest was recorded in flat sowing under minimum tillage while conventional tillage, bed sown maize produced maximum 1000-grain weight that was statistically at par with the ridge sown maize. It was also revealed that harvest index was higher in ridge sown maize under deep tillage while lower was recorded in flat sowing under minimum tillage. At conventional tillage, bed sown maize furnished maximum harvest index and found statistically similar to ridge sowing while flat sown maize gave minimum harvest index.

2.3 Effect of different *in-situ* soil moisture conservation techniques on physico-chemical properties of soil in *kharif* maize

Das *et al.* (2004) concluded that straw mulch increased the yield and yield components of rice and nutrient uptake and also improved the physico-chemical properties of the soil which provided better soil environment for crop growth.

Pervaiz *et al.* (2009) observed that mulch significantly increased N and P concentration in maize shoots. However, K concentration did not significantly increase due to application of mulch.

Das *et al.* (2013) conducted field experiments for four consecutive years (2006-2010) at the Indian Council of Agricultural Research (ICAR), NEH region, Umiam (North Eastern Indian Himalayas), Meghalaya, India to study soil quality as affected by conservation practices in maize-rapeseed cropping system in eastern Himalaya and reported that the mulching treatment increased concentration of available N more in the soil layer of 0-15 cm than that in the soil layer of 15-30 cm. Concentration of available P and K in soil was also significantly influenced by residue-mulching treatment.

Yaseen *et al.* (2014) carried out the study under field condition at the Research Area, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad

during 2011, to study the effect of deficit irrigation and mulch on soil physical properties and growth and yield of maize and shows that in case of mulch, the mean maximum value 0.58 g/kg of soil nitrogen was reported in treatment where straw was applied and minimum 0.46 g/kg was noted in control treatment. Due to mulching nitrogen losses reduced and also its amount increased within the soil because of decomposition of straw mulch.

Sharma and Kumar (2014) reported that availability of macronutrients was significantly higher under the mulch treatments. The contents of available N, P, K, Ca and S were higher with black polyethylene (BP) followed by Pine needles (PN) and Grass mulch (GM) over unmulched (UM-control), respectively which may be attributed to the better hydrothermal regimes, higher organic matter contents and efficient weed control.

Alharbi (2015) found that soil moisture and mulch had a strong indirect influence on the availability of soil nitrogen, phosphorus and potassium. The highest total nitrogen was recorded under mulch with the availability of 100 per cent of the recommended irrigation, while the highest phosphorus and potassium with its availability of moisture up to 70 per cent and 85 per cent, respectively.

2.4 Effect of different *in-situ* soil moisture conservation techniques on relative economics in *kharif* maize

Frye (1986) obtained maximum economic returns when compared with corn grown in corn residue, hairy vetch resulted in additional net returns of \$91, \$157, and \$199 for the 0, 50, and 100 kg/ha fertilizer nitrogen rates, respectively. Thus, they concluded that hairy vetch with 100 kg/ha nitrogen was potentially more economical than corn grown in corn residue with 150 kg/ha fertilizer nitrogen.

Patil *et al.* (1994) studied the relative performance of different moisture conservation techniques and concluded that the maximum net monetary returns of ` 4691/ha were obtained in broad bed and furrows system. However, vertical mulch and ridges and furrows proved to be next most remunerative treatment with the net returns of ` 4572 and ` 4495 /ha, respectively.

Pawar *et al.* (1999) conducted a field experiment at Maharashtra to study of the *in-situ* moisture conservation techniques for rabi sorghum production under dryland condition and concluded that maximum net returns were obtained due to tied ridges (₹12892), ridges and furrows (₹12848) and dead furrows (₹12500) over flat bed (₹10969). The per cent increase was 17.5, 17.1 and 14.0, respectively over flat bed

Hiremath *et al.* (2003) conducted an experiment at College of Agriculture, Dharwad University of Agricultural Sciences, Dharwad Karnataka and reported that tied ridges and compartment bunding recorded significantly higher net returns (₹10055 and ₹9491, respectively) and B: C ratio (1.52 and 1.45, respectively) over flat bed in sunhemp-sorghum cropping sequence. Among the N levels to sorghum application of 50 kg and 25 kg N per ha recorded higher net returns of ₹9333 and ₹8274, respectively.

Sharma *et al.* (2009) reported that the highest net returns of ₹8994 and 11240 and B: C ratios (1.08 and 1.34) (during first and second year) were realized with straw mulching which however, was at par with that of polyethylene mulching and lowest with no mulching (₹6222 and 6105; 0.84 and 0.82).

Sharma *et al.* (2010) conducted a field experiment to study the effect of in situ grown live mulching with legumes viz. sunnhemp (*Crotalaria juncea* L.), Dhaincha (*Sesbania aculeata* Pers.) and cowpea [*Vigna unguiculata* (L.) Walp.], besides weed mulching at 30 and 45 days of maize (*Zea mays* L.) growth on moisture conservation, crop productivity and soil properties in maize-wheat (*Triticum aestivum* L. emend Fiori & Paol.) cropping system and reported that net returns from maize were the highest when it was intercropped with cowpea for seed, followed by Dhaincha and sunnhemp mulching at 30 days.

Jat *et al.* (2015) conducted three field experiments on maize (cv. *Navjot*) during *Kharif* 2000 to 2004 at Maharana Pratap University of Agriculture & Technology, Arjia, Rajasthan to study about efficient moisture conservation practices for maximizing maize

productivity, profitability, energy use efficiency and resource conservation in a semi-arid Inceptisol and observed that the cost of treatments was different due to variation in the cost of hiring human or bullock labour and machinery, which was ` 3462/ha for sowing along the slope; ` 3547/ha for sowing across the slope; ` 4055/ha for ridge and furrow sowing; ` 4150/ha for flat sowing and ridging at 30 DAS; ` 4443/ha for opening of ditches across the slope at 10 m interval; and ` 4527/ha for compartment bunds at 5 m interval.

Uttam *et al.* (2015) conducted a field experiment during two *kharif* seasons of 2011 and 2012 on sandy loam soil to study the performance of moisture conservation practices and row spacing on growth, yield attributes, yield, water use (WU), water use efficiency (WUE) and economics of maize varieties under rainfed condition at C.S. Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh and reported that among moisture conservation practices, ridging and furrowing treatment recorded the highest net return of ` 13031/ha against ` 9280/ha under atrazine and ` 8907/ha under one weeding and hoeing by *khurpi* treatment. Benefit and cost ratio also behaved in the similar manner under different treatments.

Sonpure *et al.* (2017) reported that mulching with chickpea husk (@ 5 t/ha) recorded higher gross monetary return (` 226808/ha), cost of cultivation (` 72825/ha), net monetary returns (` 153983/ha) and B: C (3.11) as compared to the treatment without mulching.

CHAPTER-3

MATERIAL AND METHODS

MATERIAL AND METHODS

The present investigation entitled “**Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir**” was carried out during the *kharif* season of 2016 at the Research Farm of Advanced Centre for Rainfed Agriculture, Rakh Dhiansar of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. The material used, experimental procedures followed and techniques adopted during the course of experimentation have been described in this chapter.

3.1 Experimental Site and Location

Geographically, the experimental site is situated in the sub-tropical Shiwalik foothills of Jammu and Kashmir at latitude of 32° 39' North and longitude of 74° 53' East with an altitude of 332 m above mean sea level. The field experiment was conducted during the *kharif* season of 2016 at the Research Farm of Advanced Centre for Rainfed Agriculture, Rakh Dhiansar of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu.

3.2 Climate

The climate of experimental site was mainly sub-tropical in nature endowed with hot and dry early summers followed by hot and humid monsoon and cold winter. The mean annual rainfall varies from 1050 to 1115 mm of which about 75 per cent is received from June to September. However, the total rainfall and its distribution is subject to large variations. The mean maximum and minimum temperature shows considerable fluctuations during summer and winter. The temperature often rises to as high as 45 °C in the month of May-June, while the temperature touches to 2 °C during winter month especially in December-January.

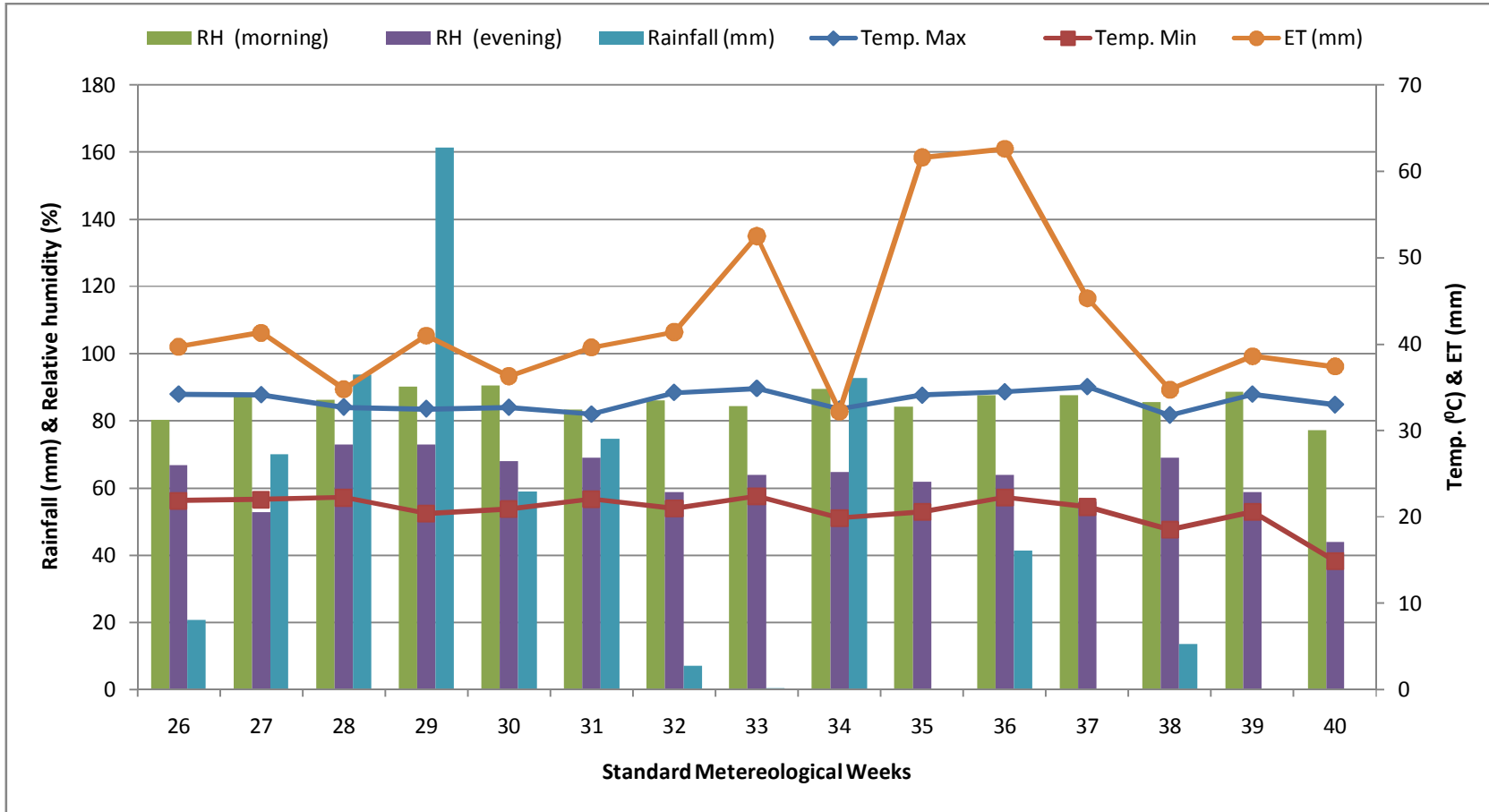
The weather data for crop season was recorded at the metrological observatory located very close to experimental area and has been presented graphically in Fig. (3.1)

and tabulated in Appendix 1. During the crop growth period July 1st to 15th October, 2016, the mean maximum and minimum temperature varied from 31.8 to 35.1^o C and 14.9 to 22.89^o C, respectively. Both minimum and maximum temperature showed the fluctuations throughout the crop growth period. In general, the maximum temperature rises up to 3rd week of September and thereafter decreasing trend was observed up to harvest of the crop. The mean relative humidity varied from 80.3 to 90.6 per cent (morning) and 53 to 69 per cent (evening). The total rainfall was observed during the crop season was 636 mm. Mostly maximum rainfall events occurred during July and first fortnight of August Fig. 3.1. However there were two dry spells of 12 days (18 Aug. - 29 Aug.) and 8 days (15 Sept. - 22 Sept.) observed during the reproductive stage which were more crucial from production point of view. Evapo-transpiration readings taken from the Lysimeter also represented graphically in the Fig. 3.1.

3.3 Soil Characteristics

Before the experiment was laid out, three composite soil samples were collected from the depth of 0-15 cm. These samples were then air dried, processed and subject to analysis for their physico-chemical properties. Likewise, treatment wise soil sampling was also done after harvesting of the crop. The composite soil samples so obtained were air dried ground and passed through 2 mm sieve and were analyzed for different physico-chemical properties of the soil.

The data recorded in respect of physico-chemical properties of the experimental site revealed that the soil of the experimental site was sandy loam in texture, almost neutral, low in organic carbon and available nitrogen, but medium in available phosphorus and potassium (Table 1).



Source: Agromet observatory, ACRA, Rakh Dhiansar

Fig. 3.1: Mean weekly weather parameters recorded during the crop season

3.3.1 Soil moisture per cent

Table 1: Soil physico-chemical properties of experimental site

Parameters	Analytical value	Methods employed
MECHANICAL PROPERTIES		
Sand (%)	64.4	Bouyoucous Hydrometer method (Piper, 1966)
Silt (%)	17.0	
Clay (%)	18.6	
Textural class	Sandy loam	
Chemical properties		
pH	6.90	Suspension of soil and water 1:2.5 with glass calomel electrode (Jackson, 1973)
EC (dS/m)	0.17	Salt bridge measurements from the suspension used for pH determination (Jackson, 1973)
Organic carbon (g/kg)	2.7	Dichromate oxidation of organic matter (Jackson, 1973)
Available N (kg/ ha)	167	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (kg/ha)	14.95	0.5 N Sodium bicarbonate (pH 8.5) (Olsen <i>et al.</i> , 1954)
Available K (kg/ha)	116	Ammonium acetate extraction method (pH 7.0) using flame photometer (Jackson, 1973)

3.4 Cropping History

The details of the crops and the cropping systems followed on the experimental field for the last few years prior to start of the experiment have been given in Table 2.

Table 2: The cropping history of the experimental site

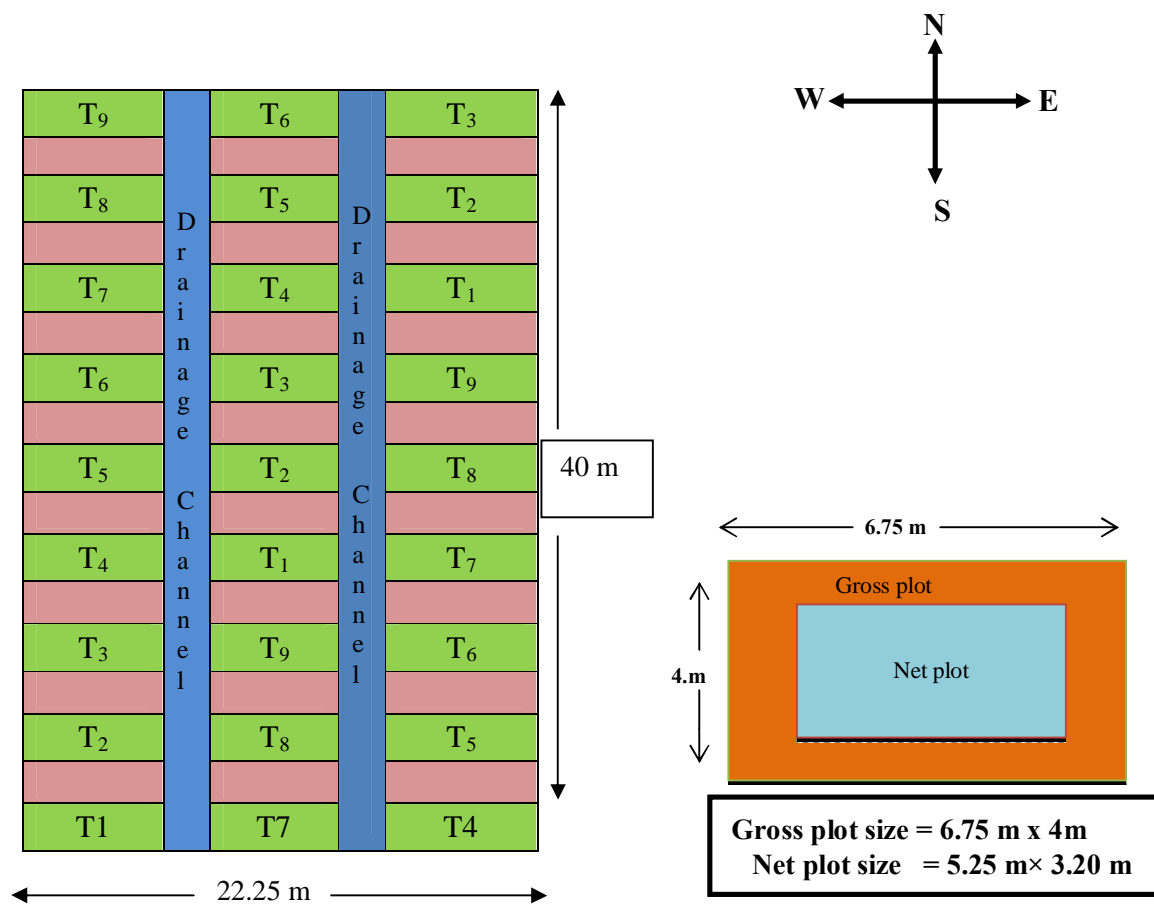
Year	<i>Kharif</i>	<i>Rabi</i>
2012-13	Sesame	Gram
2013-14	Sesame	Gram
2014-15	Maize	Wheat
2016	Experimental crop (<i>Kharif</i> maize)	

3.5 Experimental Details

The experiment was laid out in randomized-block design with nine treatments and three replications as per the layout given in Figure 3.2

3.5.1 Treatment details:

T₁	:	Flat Bed
T₂	:	Broad Bed Furrow
T₃	:	Flat Bed + mulching with <i>in-situ</i> raised Dhaincha
T₄	:	Broad Bed Furrow + mulching with <i>in-situ</i> raised Dhaincha
T₅	:	Flat Bed + mulching with <i>in situ</i> raised Sunhemp
T₆	:	Broad Bed Furrow + mulching with <i>in-situ</i> raised Sunhemp
T₇	:	Flat Bed + mulching with <i>Leucaena</i> prunings
T₈	:	Broad Bed Furrow + mulching with <i>Leucaena</i> prunings
T₉	:	Farmer's practices
Replication	:	3
Treatments	:	9
Variety	:	<i>Double dekalb</i>
Location	:	Research Farm, ACRA Rakh Dhiansar, SKUAST Jammu



Symbol used

T ₁	Flat Bed	T ₅	Flat Bed + mulching with <i>in-situ</i> raised Sunhemp	T ₉	Farmers practies
T ₂	Broad Bed Furrow	T ₆	Broad Bed Furrow + mulching with <i>in-situ</i> raised Sunhemp		
T ₃	Flat Bed +mulching with <i>in-situ</i> raised Dhaincha	T ₇	Flat Bed+ mulching with <i>Leucaena</i> prunings		
T ₄	Broad Bed Furrow +mulching with <i>in-situ</i> raised Dhaincha	T ₈	Broad Bed Furrow+ mulching with <i>Leucaena</i> prunings		

Fig. 3.2: Layout plan of the experimental field

Season : *Kharif* 2016

Situation : Rainfed

3.5.2 Plot size

The crop, gross and net plot sizes are given in Table 3 for *Kharif* maize

Table 3: Gross and net plot size

Crop	Gross plot	Net plot
<i>Kharif</i> maize	6.75m x 4m=27 m ²	5.25 m x 3.20 m= 16.8 m ²

3.6 Details of the field operations

The detail of various cultural operations carried out during the crop growing periods of *kharif* season have been given in Table 4.

Table 4: Calendar of different cultural operation carried out during experimentation.

Operation	Date of operation	Remarks
Field preparation	04-07-16	Primary tillage was done with disc harrow while the secondary tillage operations were done with the help of cultivator
Layout	04 -07-16	Field layout was done manually with the help of rope and liner. However Broad Beds and Furrow were made using Bed making machine.
Fertilizer application	05-07-16	Placement of fertilizer was made manually
Sowing of maize and Mulch crops	05-07-16	Line sowing of maize crop was done manually. However, the seeds of the mulch crops viz: <i>Dhaincha</i> and <i>Sunhemp</i> were sown by broadcasting method at the time of final ploughing while <i>Leucaena</i> prunings (<i>Ex-situ</i>) were taken from the plants growing in surroundings at the time of spreading of mulches
Herbicide application	05-07-16	Application of pre-emergence herbicides
Thinning/gap filling	21-07-16	For maintaining optimum plant population thinning and gap filling was done manually
Cutting and spreading out of mulches	10-08-16	<i>In-situ</i> raised <i>Dhaincha</i> , <i>Sunhemp</i> and <i>Leucaenia</i> prunings (<i>Ex-situ</i>) were cut and spread as mulches as per the technical programme while

Top dressing	10-08-16	First top dressing of urea was done manually
Harvesting of maize	15-10-16	Maize cobs were collected manually
Shelling of maize	18-10-16	Shelling was also done manually

3.6.1 Land preparation

The field was ploughed twice with disc harrow followed by planking to prepare a fine seed bed. Plot paths, replication borders and drainage channels were made manually. The plots were levelled before planting of *kharif* maize. However, Broad Bed and Furrow plots were raised using Bed making machine.

3.6.2 Fertilizer application

The recommended dose of fertilizer for maize 100 kg N, 90 Kg P₂O₅ and 33 Kg K₂O /ha was applied with full dose of P₂O₅ and K₂O in the form of Diammonium Phosphate and Murate of Potash as basal dose and two-third of nitrogen was applied in the form of urea at the time of sowing and remaining one third at 35 DAS just before laying down of mulches under sufficient moisture while in farmers practice only Urea and DAP as inorganic fertilizers were applied in maize sown by broadcasting method without following any plant protection measure.

3.6.3 Sowing

Sowing of *kharif* maize was done manually on 05th July, 2016, with a seed rate of 20 kg/ha. Furrows were opened manually with the help of line markers (4-5cm deep) at row to row distance of 75 cm and maize seeds were sown manually with plant to plant distance of 20 cm. However, the seeds of the mulch crops viz: *Dhaincha* and *Sunhemp* were sown by broadcasting method at the time of final ploughing using the seed rate of 30 kg/ha each. *Leucaena pruning* (*Ex-situ*) were taken from the plants growing in surroundings at the time of spreading of mulches.

3.6.4 Thinning

Thinning was done with the help of *khurpi* to remove the extra plants and maintain plant to plant distance of 20 cm in maize. Efforts were made to remove the weak plants during this operation, wherever, required. Besides, Uprooting of mulch crop

plants germinated 15 cm on both the sides of maize crop is also done to keep the maize plants free from any competition posed by the mulch crops growing in vicinity.

3.6.5 Gap filling

Gap filling was also done at the time of thinning, wherever required, to maintain proper plant population.

3.6.6 Cutting and spreading of mulches

The biomass of the *in-situ* raised mulch crops such as Dhaincha and Sunhemp were cut and spread as mulch in between the rows of maize plants after 35 days of sowing. Likewise *Leucaena* prunings comprising of green leaves and twigs were cut from the surroundings and spread as mulches in between the maize plants after 35 days of sowing as per the technical programme. *In-situ* Sunhemp biomass accumulated on an average about 5/ha, Dhaincha accumulated biomass on an average of 8t /ha and *Leucaena* prunings and twigs biomass spread as mulch comes out to be 6 t/ha.

3.6.7 Herbicide application

Pre-emergence applications of pendimethalin @ 1 kg/ha was done within the 24 hours of sowing of *kharif* maize crop with the help of knapsack sprayer fitted with flat fan T-jet nozzle using a spray volume of 500l/ha to protect the crop from weeds.

3.6.8 Harvesting

3.6.8.1 Harvesting of *kharif* maize

Kharif maize crop was harvested on 15th October 2016. After harvesting from respective net plot area, the bundles were tied, tagged and there after left in respective plots for sun drying in the field. After drying, the bundle weight was taken with the help of spring balance.

3.6.8.2 Threshing

Maize cobs were removed and dried further for about a week and shelled manually with the help of cob shellers. The threshed grains were collected, weighted and

expressed as grain yield in kg/plot. The grain moisture was assessed till 12 per cent moisture was attained and grain yield was calculated in q/ha. The stover yield was recorded after subtracting grain weight from total produce (biological or bundle yield weight) and expressed as stover yield q/ha.

3.7 Observations Recorded

3.7.1 Growth parameters

For all the growth and development studies during the crop growth period five plants were selected randomly and tagged in each plot except for that of leaf area index and dry matter accumulation where plants from border rows were selected for recording observations. The growth parameters were recorded at 30 days after sowing.

3.7.1.1 Plant height

Plant height of all the five tagged plants was measured with the help of meter scale rod from the ground surface to the tip of the upper most fully opened leaf from net plot area of each plot at 30, 60, 90 days after sowing and at harvest. Plant height values were presented in centimeters (cm) and average of all the five plants was taken for statistical analysis.

3.7.1.2 Dry matter accumulation

The samples of all the above ground biomass of the plants cut for calculating dry matter accumulation were chopped, sun dried and thereafter shifted in the oven to dry at a temperature of 70 ± 5 °C till a constant weight was achieved and the average dry matter accumulation per plant was recorded which was expressed as dry weight in g/plant.

3.7.1.3 Leaf area index (LAI)

Leaf area index recorded at 30, 60, 90 DAS and at harvest. All the green leaves were categorized into small, medium and large from the marked 1m row length area and number of green leaves in each category was recorded. Then three leaves from each category were taken and their area was determined with the help of length and breadth method. Leaf length was measured from juncture to tip and the mean width of leaves was

taken from 3 places (one from centre and second from middle of top and centre and third from middle of centre and base). The correction factor of 0.75 was devised by correlating it with graphic method. Total area of the leaves was calculated by multiplying with this factor. The leaf area index of the leaves was calculated by using the following formulae.

Land area/ plant = Row distance x plant distance

Leaf area index (LAI) = $\frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area per plant (cm}^2\text{)}}$

3.7.1.4 Crop growth rate

The increase in plant material/unit time or cumulative crop growth rate (CGR) was calculated as per the formula given by Radford (1967) and was expressed as g/m²/day

Crop Growth Rate (CGR) = $\frac{(W_2 - W_1)}{(t_2 - t_1)}$

Where,

W₂ = Total dry matter of crop plant at the time interval t₂

W₁ = Total dry matter of crop plant at the time interval t₁

3.7.2 Yield and yield attributes of *Kharif* maize

3.7.2.1 Number of plants /m²

At harvest three spots each of one square meter were randomly selected by throwing the one square meter quadrant in the net plot. The number of plants from each randomly selected spot within the net plot were counted and averaged to express number of plants per meter square.

3.7.2.2 Number of cobs/plant

The number of cobs developed on the initially randomly selected five plants for the growth studies were counted and averaged to express the number of cobs.

3.7.2.3 Number of grains/cob

Out of the total number of cobs obtained from five randomly selected plants, five cobs were randomly selected, thrashed and grains so obtained were counted and averaged to express number of grains/cob.

3.7.2.4 1000 grain weight (g)

One thousand grains were randomly taken from the bulk produce of each net plot and were counted and weighed. The weight was expressed as 1000-grains weight in gram.

3.7.2.5 Harvest index

The ratio of economic yield to the biological yield (harvest index) was computed using the following formula as given by (Nichiporovich, 1967).

$$\text{Harvest index (per cent)} = \frac{\text{Economic yield (grains)}}{\text{Biological yield (grain + stover)}} \times 100$$

3.7.2.6 Rainwater use efficiency (kg/ha-mm)

The ratio of the grain yield of maize obtained to the total rainfall received during the crop growing period was computed using the following formula as given

$$\text{Rain Water Use efficiency (kg/ha-mm)} = \frac{\text{Grain yield}}{\text{Total rainfall received during the crop growing period}} \times 100$$

3.8 Chemical analysis

3.8.1 Soil Analysis

After harvesting of each crop the soil samples were taken from 0-15 cm for determination of available nitrogen, phosphorus and potassium. The samples were dried under shade, grounded and passed through 2 mm sieve and were analyzed for nutrients.

3.8.1.1 Available nitrogen

Available nitrogen was determined by modified alkaline permanganate method as described by Subbiah and Asija (1956) and was expressed in kg/ha.

3.8.1.2 Available phosphorus

Available phosphorus was determined using method described by Olsen *et al.* (1954). The intensity of colour developed by ascorbic acid (Watanable and Olsen, 1965) was measured at 760 nm on spectrophotometer and was expressed as P kg/ha.

3.8.1.3 Available Potassium

Available K was extracted with neutral normal ammonium acetate solution as described by Piper (1996) and potassium was determined by flame photometer and expressed as K kg/ha.

3.8.2 Uptake studies in crop

The plant samples were taken at the time of harvesting for estimation of N, P and K concentration. The grains of *kharif* maize were also taken for uptake studies from each plot. The samples were oven dried, then finely ground with electric grinder and analyzed for nitrogen, phosphorus and potassium concentration. The N, P, K uptakes in grain and stover/ha of *kharif* maize samples were calculated by multiplying per cent nutrient content with their respective dry matter accumulation as per the formula given below :

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (per cent)} \times \text{dry matter accumulation (kg/ha)}}{100}$$

Table 5: Details of method employed for chemical analysis of plant/grain samples

S. No.	Nutrient assessed	Method employed
1.	Nitrogen	Modified Kjeldhalø method (Jackson, 1967)
2.	Phosphorus	Vanadomolybdo phosphoric acid yellow colour (Jackson, 1967)

3.	Potassium	Ammonium acetate method (Jackson, 1967)
----	-----------	---

3.9 Economic Studies

3.9.1 Cost of cultivation

Cost of different operations done during the crop growth was worked out separately for each item. The manual and mechanical labour/power engaged for different operations was recorded on per hectare basis and the cost was calculated for different operations by multiplying with the existing market prices. Similarly, cost of all inputs was also calculated. The total cost was calculated by adding the expenditure involved in all kinds of operations as per treatment on per hectare basis in ₹/ha.

3.9.2 Gross returns

The gross returns were calculated by multiplying the total grain and straw yield/ha with prevalent market prices of the items and then were presented on per hectare basis as per treatments.

3.9.3 Net returns

The net returns were computed by deducting the total cost of cultivation from the gross returns as per treatments.

3.9.4 Benefit: Cost Ratio

Benefit: Cost ratio was calculated by dividing the net returns with the cost of cultivation for different treatments.

$$\text{Benefit: Cost Ratio} = \frac{\text{Net Returns (₹/ha)}}{\text{Cost of cultivation (₹/ha)}}$$

3.10 Statistical analysis

The data recorded for various characters were subjected to statistical analysis according to the procedure outlined by Cochran and Cox, 1963. All the comparisons were worked out at 5 per cent level of significance. The analysis of variance (ANOVA) of the experiment was as follows:

Sources of variations	Degree of freedom
Replications (r-1)	$3-1=2$
Treatment(t-1)	$9-1=8$
Error(r-1) (t-1)	$(3-1) (9-1)=16$
Total rt-1	$27-1=26$

CHAPTER-4

RESULTS

RESULTS

The result of the investigation entitled “Effect of different *in-situ* soil moisture conservation techniques in maize under Shivalik Foothills of Jammu and Kashmir” have been described in this chapter through appropriate data, Tables, bar diagram and graphical illustrations, wherever necessary. The observations pertaining to different parameters of the study were analyzed statistically wherever possible and for other parameters of the study mean values have been given. The mean weekly values of weather parameters and input-output costs have been appended in the appendices. The results of the study have been presented under following headings:

4.1 Growth parameters

4.1.1 Plant height

Plant height is an important parameter reflecting the vertical growth of a crop plant. In general, the plant height continued to increase with the advancement of age till harvest under various treatments (Table 6). Different *in-situ* soil moisture conservation techniques significantly influenced the plant height of maize at all the crop growth stages except at 30 DAS where numerical increase in plant height was observed among the different treatments.

Table 6: Effect of different *in-situ* soil moisture conservation techniques on plant height of maize

	Treatments	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T ₁	Flat Bed	61.45	150.55	188.82	190.65
T ₂	Broad Bed Furrow (BBF)	62.1	142.57	180.33	181.79
T ₃	Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	63.5	160.63	198.75	200.17
T ₄	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	65.7	172.81	212.81	214.57
T ₅	Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	63	159.8	195	196.35
T ₆	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	64	168.55	207.35	208.33
T ₇	Flat Bed + Mulching with <i>Leucaena</i> prunings	63.1	158.33	196.33	198
T ₈	Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	64.45	170.35	210.35	212.1
T ₉	Farmer's practice	57.3	132.33	170.15	172.52
	SEm(±)	1.91	1.65	0.91	1.10
	CD (P<0.05)	NS	4.98	2.75	3.34

Among the different *in-situ* moisture conservation treatments at 60 DAS, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher plant height of 172.81 cm which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp with the corresponding values of 170.35 cm and 168.55 cm, respectively which was followed by the treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (160.63cm) which in turn was found to be statistically at par with treatment (T₇) Flat Bed +mulching with *Leucaena* prunings (159.8 cm) and treatment (T₆) Flat Bed +mulching with *in situ* raised Sunhemp (158.33cm). However, the treatment (T₂) Broad Bed Furrow recorded plant height of 142.57cm followed by Flat Bed (150.55 cm). However the lowest plant height was recorded in Farmer's practice (132.33cm). Almost similar trend with respect to plant height was observed at 90 DAS and at harvest.

4.1.2 Dry matter production

Data recorded at various period of growth as influenced by different *in-situ* soil moisture conservation treatments presented in Table 7 reveals that dry matter accumulation continued to increase steadily with time till 60 DAS and thereafter showed a sharp increase up to 90 DAS and followed by a marginal increase up to harvest stage.

Different *in-situ* moisture conservation treatments significantly influenced the dry matter accumulation of maize at all the crop growth stages except at 30 DAS where numerical increase in dry matter was observed among the different treatments.

Table 7: Effect of different *in-situ* soil moisture conservation techniques on dry matter accumulation of maize

Treatments	Dry matter accumulation (g/plant)			
	30 DAS	60 DAS	90 DAS	At harvest
T ₁ Flat Bed	6.1	24.90	100.00	100.70
T ₂ Broad Bed Furrow (BBF)	6.5	31.20	113.70	116.75
T ₃ Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	7.27	39.40	132.20	136.28
T ₄ Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	8.2	48.30	149.20	155.20
T ₅ Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	6.68	36.42	125.80	130.25
T ₆ Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	7.55	45.39	143.50	147.35
T ₇ Flat Bed + Mulching with <i>Leucaena</i> prunings	6.98	38.56	129.75	134.22
T ₈ Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	7.9	46.45	146.35	150.85
T ₉ Farmer's practice	4.9	20.47	85.80	90.24
SEm(±)	0.65	1.88	3.04	3.59
CD (P<0.05)	NS	5.68	9.20	10.87

Among the different *in-situ* moisture conservation treatments at 60 DAS, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher dry matter of 48.30 g/plant which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding values of 46.45 g/plant and 45.39 g/plant, respectively followed by treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (39.40 g/plant) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leucaena* prunings (38.56 g/plant) and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp (36.42 g/plant). However, the treatment (T₂) Broad Bed Furrow recorded dry matter of 31.20 g/plant followed by the treatment (T₁) Flat Bed to the tune of 24.90 g/plant. However the lowest value of dry matter was recorded in Farmer's practice (20.47g/plant).

By and large similar results were obtained with respect to dry matter accumulation reported at 90 DAS and at harvest.

4.1.3 Leaf area index

Leaf area index (LAI) is an important component which determines the amount of solar radiation intercepted by the crop canopy to be utilized for normal metabolic activities of the plants. A perusal of the data presented in the Table 8 reveals that in general the leaf area index continued to increase with the advancement of crop age up to 90 DAS and decreased gradually afterwards, while maximum leaf area index was observed at 90 DAS. *In-situ* moisture conservation treatments significantly influenced the leaf area index at all the growth stages except that observed at 30 DAS, where different treatments failed to show any significant effects with respect to leaf area index.

Table 8: Effect of different *in-situ* soil moisture conservation techniques on leaf area index of maize

Treatments		Leaf area index			
		30 DAS	60 DAS	90 DAS	At harvest
T ₁	Flat Bed	0.93	2.57	3.8	2.56
T ₂	Broad Bed Furrow (BBF)	0.97	2.8	4.04	2.69
T ₃	Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	1.11	3.2	4.4	3.11
T ₄	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	1.25	3.52	4.8	3.52
T ₅	Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	1.03	3.06	4.28	2.96
T ₆	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	1.15	3.32	4.64	3.3
T ₇	Flat Bed + Mulching with <i>Leucaena</i> prunings	1.09	3.14	4.32	3.02
T ₈	Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	1.2	3.45	4.71	3.4
T ₉	Farmer's practice	0.81	2.22	3.5	2.48
	SEM(±)	0.088	0.07	0.07	0.05
	CD (P<0.05)	NS	0.19	0.22	0.15

Among the different *in-situ* moisture conservation treatments at 60 DAS, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher leaf area index of 3.52 which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp with the corresponding values of 3.45 and 3.32, respectively which in turn were significantly superior to leaf area index values obtained with treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (3.2) which in turn was statistically at par with treatment (T₇) Flat

Bed + mulching with *Leucaena* prunings (3.14) and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp (3.06). However, the treatment (T₂) Broad Bed Furrow recorded leaf area index of 2.80 followed by Flat Bed to the tune of 2.57. Significantly lowest value of leaf area index was observed in Farmer's practice (2.22).

By and large similar results were obtained with respect to leaf area index reported at 90 DAS and at harvest.

4.1.4 Crop growth rate

A perusal of data presented in Table 9 reveals that different *in-situ* moisture conservation treatments of maize with respect to crop growth rate showed non-significant results at all the growth stages except that at 60-90 DAS.

Table 9: Effect of different *in-situ* soil moisture conservation techniques on crop growth rate of maize

Treatments		Crop growth rate(g/m ² /day)		
		30-60 DAS	60-90 DAS	90- At harvest
T ₁	Flat Bed	0.627	2.503	0.123
T ₂	Broad Bed Furrow (BBF)	0.823	2.750	0.102
T ₃	Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	1.071	3.093	0.136
T ₄	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	1.337	3.363	0.200
T ₅	Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	0.992	2.979	0.148
T ₆	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	1.261	3.270	0.128
T ₇	Flat Bed + Mulching with <i>Leucaena</i> prunings	1.053	3.039	0.149
T ₈	Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	1.285	3.330	0.150
T ₉	Farmer's practice	0.519	2.178	0.114
	SEm(±)	0.04	0.12	0.06
	CD (P<0.05)	NS	0.37	NS

Among the different *in-situ* moisture conservation treatments at 60-90 DAS, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher crop growth rate of 3.363 g/m²/day which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding values of 3.330 and 3.270 g/m²/day, respectively

which in turn were significantly superior to crop growth rate values obtained with treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (3.093 g/m²/day) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leucaena* prunings (3.039 g/m²/day) and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp (2.979 g/m²/day). However, the treatment (T₂) Broad Bed Furrow recorded crop growth rate values of 2.750 g/m²/day followed by Flat Bed to the tune of 2.503 g/m²/day. Significantly lowest value of crop growth rate was observed in Farmer's practice (2.178 g/m²/day).

Almost similar trend with respect to plant height was observed at 90 DAS and at harvest.

4.2 Yield attributes and yield

Table 10: Effect of different *in-situ* soil moisture conservation techniques on yield attributes of maize

Treatments		No. of plants/m ²	No. of cobs/plant	No. of Grains/cob	Test weight (g)
T ₁	Flat Bed	6.07	1.00	360.33	194.67
T ₂	Broad Bed Furrow (BBF)	6.08	1.00	398.33	203.33
T ₃	Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	6.15	1.07	417.00	215.67
T ₄	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	6.37	1.20	451.33	234.00
T ₅	Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	6.07	1.00	408.67	210.33
T ₆	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	6.15	1.13	441.67	230.33
T ₇	Flat Bed + Mulching with <i>Leucaena</i> prunings	6.07	1.00	412.33	212.00
T ₈	Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	6.30	1.13	448.67	232.67
T ₉	Farmer's practice	5.93	1.00	348.33	190.33
	SEM(±)	0.11	0.05	7.21	3.83
	CD (P<0.05)	NS	NS	21.79	11.59

4.2.1 No. of plants/m²

The data presented in Table 10 reveals that different *in-situ* moisture conservation treatments showed non-significant results with respect to number of plants/m². However, numerically higher number of plants/m² were recorded in the treatments (T₄) Broad Bed

Furrow + mulching with *in-situ* raised Dhaincha, (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp. Whereas lowest number of plants/m² were recorded in Farmer's practice.

4.2.2 No. of cobs/plant

The data presented in Table 10 reveals that different *in-situ* moisture conservation treatments showed non-significant results with respect to number of cobs/ plant. However, numerically higher number of cobs/plants were recorded in the treatments (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp. Whereas lowest number of cobs/plants were recorded in Farmer's practice.

4.2.3 No. of grains/cob

The data presented in Table 10 reveals that among the different *in-situ* moisture conservation treatments, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher number of grains/cob to the tune of 451.33 which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding values of 448.67 and 441.33, respectively which in turn were significantly superior to number of grains/cob values obtained with treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (417.00) which in turn was statistically at par with treatment (T₇) Flat Bed +mulching with *Leucaena* prunings (412.33) and treatment (T₅) Flat Bed +mulching with *in situ* raised Sunhemp (408.67). However, the treatment (T₂) Broad Bed Furrow recorded number of grains/cob to the tune of 203.33 followed by Flat Bed to the tune of 194.67. However the lowest value of number of grains/cob was observed in Farmer's practice (190.33).

4.2.4 Grain yield

The data presented in Table 11 reveals that among the different *in-situ* moisture conservation treatments, significantly higher grain yield to the tune of 32.81 q/ha was

recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding values of 32.35 q/ha and 31.75 q/ha, respectively which in turn were significantly superior to grain yield values obtained with treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (29.1 q/ha) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leucaena* prunings (28.75 q/ha) and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp (28.12 q/ha). However, the treatment (T₂) Broad Bed Furrow recorded grain yield of 27.05 q/ha followed by Flat Bed with the corresponding grain yield value of 25.45 q/ha. However the lowest value of grain yield was observed in Farmer's practice to the tune of 20.5 q/ha.

Table 11: Effect of different *in-situ* soil moisture conservation techniques on grain yield, stover yield, harvest index and RWUE of maize

	Treatments	Yield at harvest (q/ha)		Harvest Index (%)	RWUE (kg/ha-mm)
		Grain	Stover		
T ₁	Flat Bed	25.45	55.99	31.25	4.00
T ₂	Broad Bed Furrow (BBF)	27.05	60.05	31.05	4.25
T ₃	Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	29.1	59.95	32.73	4.58
T ₄	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	32.81	67.26	32.77	5.16
T ₅	Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	28.12	59.05	32.26	4.42
T ₆	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	31.75	64.14	33.11	4.99
T ₇	Flat Bed + Mulching with <i>Leucaena</i> prunings	28.75	61.53	31.85	4.52
T ₈	Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	32.35	66.96	32.57	5.09
T ₉	Farmer's practice	20.5	47.15	30.30	3.22
	SEm(±)	0.52	1.10	0.68	0.13
	CD (P<0.05)	1.58	3.35	N.S.	0.40

4.2.5 Stover yield

The data presented in Table 11 reveals that among the different *in-situ* moisture conservation treatments, significantly higher stover yield to the tune of 67.26 q/ha was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding values of 66.96 q/ha and 64.14 q/ha, respectively which in turn were significantly superior to stover yield values obtained with treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (59.95 q/ha) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leucaena* prunings (61.53 q/ha) and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp (59.05 q/ha). However, the treatment (T₂) Broad Bed Furrow recorded stover yield values of 60.05 q/ha followed by Flat Bed with the corresponding grain yield value of 55.99 q/ha. However the lowest value of stover yield was observed in Farmer's practice (47.15 q/ha).

4.2.6 Harvest index

The data presented in Table 11 reveals that different *in-situ* moisture conservation treatments showed non-significant results with respect to harvest index. However, numerically higher values of harvest index were recorded in the treatments (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp. Whereas lowest value of harvest index was recorded in Farmer's practice.

4.2.7 Rain Water Use Efficiency

The data presented in Table 11 reveals that among the different *in-situ* moisture conservation treatments, significantly higher rain water use efficiency of 5.16 kg/ha-mm was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed

Furrow + mulching with *in-situ* raised Sunhemp with the corresponding rain water use efficiency values of 5.09 kg/ha-mm and 4.99 kg/ha-mm, respectively which in turn were significantly superior to rain water use efficiency values obtained with treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (4.58 kg/ha-mm) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leuceana* prunings (4.52 kg/ha-mm) and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp (4.42 kg/ha-mm). However, the treatment (T₂) Broad Bed Furrow recorded rain water use efficiency value of 4.25 kg/ha-mm followed by Flat Bed to the tune of 3.84. However, the lowest rain water use efficiency value of 3.22 kg/ha-mm was observed in Farmer's practice.

4.3 Moisture per cent at 15 cm and 30cm depth after every rainfall event

Different *in-situ* moisture conservation treatments significantly influenced the moisture per cent at 15 cm and 30 cm depths after every rainfall event.

Among the different *in-situ* moisture conservation treatments 30 DAS, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher values of Moisture per cent at 15 cm and 30 cm depths during all the events which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp followed by treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (39.40 g/plant) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leuceana* prunings and treatment (T₅) Flat Bed + mulching with *in-situ* raised Sunhemp (36.42 g/plant). However, the lowest value of moisture per cent at 15 cm and 30 cm depths after every rainfall event was recorded in Farmer's practice. By and large similar trend was observed with respect to moisture per cent at 15 cm and 30 cm depths after every rainfall event and at harvest.

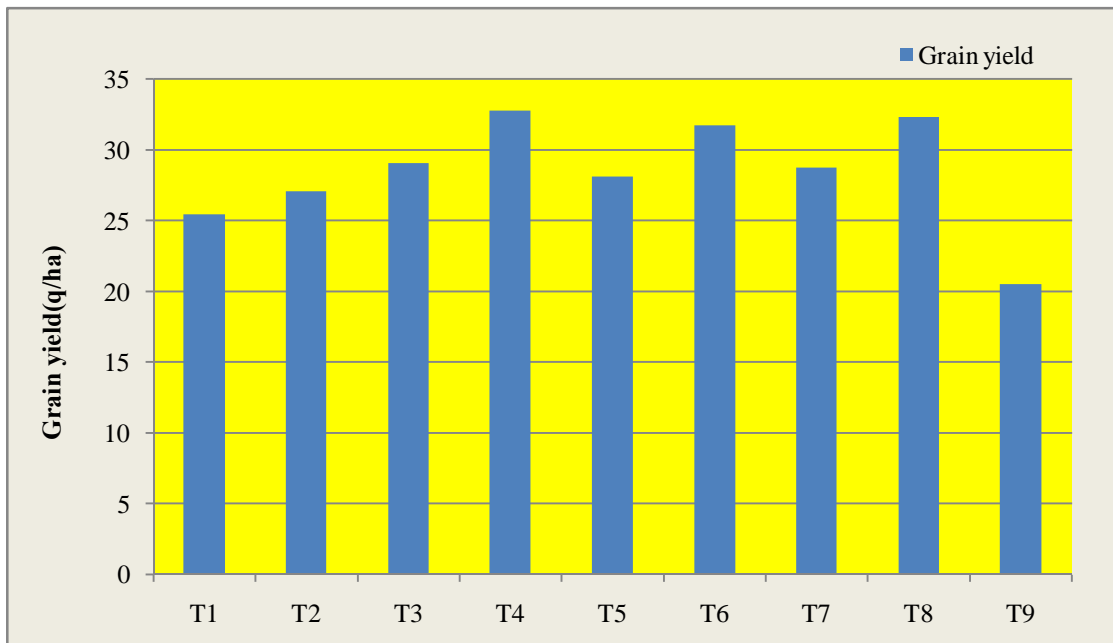


Fig. 4.1: Effect of *in-situ* soil moisture conservation practices on grain yield of maize

T₁: Flat Bed

T₂: Broad Bed Furrow

T₃: Flat bed + mulching with *in-situ* raised Dhaincha

T₄: Broad bed furrow +mulching with *in-situ* raised Dhaincha

T₅: Flat bed +mulching with in situ raised Sunhemp

T₆: Broad bed furrow +mulching with *in-situ* raised Sunhemp

T₇: Flat bed +mulching with *Leuceana* prunings

T₈: Broad bed furrow +mulching with *Leucaena* prunings

T₉: Farmer's practice

Table 12: Effect of different *in-situ* soil moisture conservation techniques on soil moisture per cent three days after every rainfall event (cummulative)

Treatments	Event 1 (Depth in cm)		Event 2 (Depth in cm)		Event 3 (Depth in cm)		Event 4 (Depth in cm)		Event 5 (Depth in cm)		Event 6 (Depth in cm)	
	15	30	15	30	15	30	15	30	15	30	15	30
	Flat Bed	25.60	27.40	29.40	31.07	21.50	22.00	17.90	22.03	11.50	13.55	8.00
Broad Bed Furrow (BBF)	27.10	29.00	30.80	32.62	23.10	24.50	20.50	22.05	13.80	15.60	9.43	10.25
Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	30.40	32.40	33.10	35.00	25.47	27.10	22.00	27.10	16.90	18.30	11.40	12.50
Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	32.43	34.63	35.50	37.74	27.89	29.53	24.49	26.70	19.80	20.81	13.50	14.70
Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	29.60	31.39	32.10	33.66	24.70	26.65	21.95	23.20	15.90	17.40	10.80	11.75
Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	31.90	33.57	34.50	36.30	27.00	29.20	23.75	25.90	19.00	20.00	12.80	13.90
Flat Bed + Mulching with <i>Leucaena</i> prunings	30.00	31.78	32.70	34.30	25.10	26.80	21.55	23.55	16.30	17.90	11.25	12.00
Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	32.80	34.60	34.89	36.90	27.20	29.60	24.85	26.00	19.50	20.00	13.10	14.10
Farmer's practice	25.20	26.95	28.70	30.38	20.80	21.20	16.40	17.80	10.60	11.50	7.00	7.90
SEm(±)	0.49	0.37	0.34	0.46	0.40	0.64	0.54	0.67	0.57	0.55	0.47	0.44
CD (P<0.05)	1.48	1.13	1.20	1.38	1.48	1.90	1.64	1.89	1.71	1.62	1.38	1.28

4.4 Soil fertility changes after completion of experiment

4.4.1 Change in pH, EC and OC

A perusal of the data depicted in the Table 13 reveals that the soil chemical parameters after harvest of crop did not show much of variations and thus failed to show any significant difference among various treatments. The value of pH, EC and OC obtained after harvesting of *kharif* maize crop ranged from 6.63 to 6.82, 0.17 to 0.21 ds/m and 2.8 to 3.0 g/kg, respectively under different *in-situ* moisture conservation treatments.

Table 13: Effect of different *in-situ* soil moisture conservation techniques on pH, EC and OC in soil after harvest of maize

Treatments		pH	EC (dS/m)	OC (g/kg)
T ₁	Flat Bed	6.81	0.21	2.78
T ₂	Broad Bed Furrow	6.82	0.211	2.82
T ₃	Flat Bed+ mulching with <i>in situ</i> Dhaincha	6.79	0.205	2.86
T ₄	BBF+ mulching with <i>in-situ</i> Dhaincha	6.68	0.174	3.0
T ₅	Flat Bed+ mulching with <i>in situ</i> raised Sunhemp	6.65	0.175	2.83
T ₆	BBF + mulching with <i>in-situ</i> raised Sunhemp	6.75	0.181	2.9
T ₇	Flat Bed +mulching with <i>Leucaena</i> prunings	6.77	0.186	2.84
T ₈	BBF+ mulching with <i>Leucaena</i> prunings	6.63	0.194	2.96
T ₉	Farmers practices	6.71	0.201	2.76
	SEm(±)	0.233	0.014	0.119
	CD (P<0.05)	NS	NS	NS
	Initial status	6.9	0.17	2.7

4.4.2 Available N, P and K

The available soil nutrient status data presented in Table 14 reveals that among the different *in-situ* moisture conservation treatments the available N, P and K content of soil after harvest of *kharif* maize crop showed that P and K were not significantly influenced by different *in-situ* moisture conservation treatments. However, available Nitrogen showed significant differences. Among the different *in-situ* moisture conservation treatments, highest value of NPK contents were recorded in treatments (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha with the corresponding values of 213.72 kg/ha, 19.96 kg/ha and 128.3 kg/ha, respectively followed by (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings having NPK values of

211.63 kg, 18.84 kg/ha and 127.5 kg/ha, respectively and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp having NPK values of 196.96 kg/ha, 17.93 kg/ha and 125.6 kg/ha as compared to rest of the treatments. However, the lowest values of NPK were observed in Flat Bed treatment.

Table 14: Effect of different *in-situ* soil moisture conservation techniques on availability of N, P, K in soil after harvest of maize

Treatments		N kg/ha	P kg/ha	K kg/ha
T ₁	Flat Bed	177.68	15.59	123.5
T ₂	Broad Bed Furrow	180.20	16.43	125.8
T ₃	Flat Bed+ mulching with <i>in situ</i> Dhaincha	192.77	14.95	124.39
T ₄	BBF+ mulching with <i>in-situ</i> Dhaincha	213.72	19.96	128.3
T ₅	Flat Bed+ mulching with <i>in situ</i> raised Sunhemp	184.39	15.73	122.9
T ₆	BBF + mulching with <i>in-situ</i> raised Sunhemp	196.96	17.93	125.6
T ₇	Flat Bed +mulching with <i>Leucaena</i> prunings	186.48	15.59	124.0
T ₈	BBF+ mulching with <i>Leucaena</i> prunings	211.63	18.84	127.5
T ₉	Farmers practices	183.76	16.57	125.1
	SEm(±)	7.08	1.103	3.16
	CD (P<0.05)	23.73	N.S.	N.S.
	Initial status	167	14.95	116

4.5 Nutrient uptake

4.5.1 N, P and K uptake by maize grains

The data presented in Table 15 revealed that the nutrient uptake by grain in *kharif* maize was significantly influenced by the different *in-situ* moisture conservation treatments. There was a profound increase in nutrient (NPK) uptake by maize grains due to the different *in-situ* moisture conservation treatments as compared to Farmer's practice. Among the the different *in-situ* moisture conservation treatments, significantly higher NPK uptake in grains was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha with the corresponding values of 69.81 kg/ha, 9.84 kg/ha and 35.60 kg/ha, respectively which was followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings having NPK uptake values of 50.05 kg/ha, 7.11 kg/ha and 23.67 kg/ha, respectively and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp showed NPK uptake values of 49.64 kg/ha, 5.44 kg/ha and 30.15 kg/ha, respectively while significantly lowest

values of NPK uptake to the tune of 22.56 kg/ha, 3.84 kg/ha and 18.12 kg/ha were observed in farmer's practice.

Table 15: Effect of different *in-situ* soil moisture conservation techniques on uptake of N, P, K in grains of maize

Treatments		N kg/ha	P kg/ha	K kg/ha
T ₁	Flat Bed	30.03	4.92	21.63
T ₂	Broad Bed Furrow	40.23	4.91	19.77
T ₃	Flat Bed+ mulching with <i>in situ</i> Dhaincha	46.56	7.86	12.50
T ₄	BBF+ mulching with <i>in-situ</i> Dhaincha	69.81	9.84	35.60
T ₅	Flat Bed+ mulching with <i>in situ</i> raised Sunhemp	32.89	5.72	27.99
T ₆	BBF + mulching with <i>in-situ</i> raised Sunhemp	49.64	5.44	30.15
T ₇	Flat Bed +mulching with <i>Leucaena</i> prunings	34.20	3.96	18.72
T ₈	BBF+ mulching with <i>Leucaena</i> prunings	50.05	7.11	23.67
T ₉	Farmers practices	22.56	3.84	18.12
	SEm±	1.313	0.342	1.92
	CD(P<0.05)	3.971	1.034	5.814

4.5.2 N, P and K uptake by maize stover

The data presented in Table 16 revealed that the nutrient uptake by maize stover was significantly influenced by the different *in-situ* moisture conservation treatments. There was a profound increase in nutrient (NPK) uptake by maize stover due to the different *in-situ* moisture conservation treatments as compared to Farmer's practice. Among the the different *in-situ* moisture conservation treatments, significantly higher NPK uptake in stover was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha with the corresponding values of 44.64 kg/ha, 10.95 kg/ha and 49.91 kg/ha, respectively which was followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings having NPK uptake values of 54.92 kg/ha, 12.40 kg/ha and 40.38 kg/ha, respectively and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp showed NPK uptake values of 47.49 kg/ha, 11.96 kg/ha and 42.53 kg/ha, respectively while significantly lowest values of NPK uptake to the tune of 24.85 kg/ha, 5.33 kg/ha and 32.78 kg/ha were observed in farmer's practice.

Table 16: Effect of different *in-situ* soil moisture conservation techniques on uptake of N, P, K in stover of maize

Treatments		N kg/ha	P kg/ha	K kg/ha
T ₁	Flat Bed	23.60	7.19	29.81
T ₂	Broad Bed Furrow	24.20	8.02	36.10
T ₃	Flat Bed+ mulching with <i>in situ</i> Dhaincha	26.22	9.51	49.24
T ₄	BBF+ mulching with <i>in-situ</i> Dhaincha	44.64	10.95	49.91
T ₅	Flat Bed+ mulching with <i>in situ</i> raised Sunhemp	41.32	7.48	32.00
T ₆	BBF + mulching with <i>in-situ</i> raised Sunhemp	47.49	11.96	42.53
T ₇	Flat Bed +mulching with <i>Leucaena</i> prunings	38.95	6.24	36.77
T ₈	BBF+ mulching with <i>Leucaena</i> prunings	54.92	12.40	40.38
T ₉	Farmers practices	24.85	5.33	32.78
	SEm(±)	2.03	0.77	1.46
	CD (PÖ0.05)	6.12	2.31	4.42

4.6 Relative economics of *Kharif* maize

Relative economics of various *in-situ* soil moisture conservation treatments were worked out to evaluate the most beneficial *in-situ* moisture conservation treatments in maize. The detail of cost of various inputs used in the experiment is given in Appendix-II and the data of gross returns, net returns and benefit: cost ratio as influenced by different *in-situ* moisture conservation treatments are depicted in Table17.

A perusal of the data presented in Table 17 reveals that the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha registered highest net returns of (₹ 40755 /ha) which was immediately followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings, treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp, treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha, treatment (T₇) Flat Bed + mulching with *Leucaena* prunings, treatment (T₅) Flat Bed + mulching, treatment (T₂) Broad Bed Furrow and treatment (T₁) Flat Bed. However, lowest net returns of Rs.22936 /ha was obtained in Farmer's practice.

Table 17: Effect of different *in-situ* soil moisture conservation techniques on relative economics of maize

Treatments		Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T ₁	Flat Bed	19890	49628	29738	1.50
T ₂	Broad Bed Furrow (BBF)	20390	52856	32466	1.59
T ₃	Flat Bed + Mulching with <i>in-situ</i> raised Dhaincha	21240	55930	34690	1.63
T ₄	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Dhaincha	22240	62995	40755	1.83
T ₅	Flat Bed + Mulching with <i>in-situ</i> raised Sunhemp	21740	54272	32532	1.50
T ₆	Broad Bed Furrow (BBF) + Mulching with <i>in-situ</i> raised Sunhemp	22240	60770	38530	1.73
T ₇	Flat Bed + Mulching with <i>Leucaena</i> prunings	21740	55718	33978	1.56
T ₈	Broad Bed Furrow (BBF) + Mulching with <i>Leucaena</i> prunings	22240	62241	40001	1.80
T ₉	Farmer's practice	17449	40385	22936	1.31

Among the different *in-situ* moisture conservation treatments the highest benefit: cost ratio of 1.83 was obtained with the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings, treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding benefit: cost ratio values of 1.80 and 1.73, respectively. However, significantly lower benefit: cost ratio was recorded in Farmer's practice (1.31).

CHAPTER-5

DISCUSSION

DISCUSSION

The experimental results emanating from the field investigation entitled “**Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir**” has been described in the preceding chapter. In this chapter, an attempt has been made to highlight the important findings and to interpret the effect of different *in-situ* moisture conservation techniques by establishing suitable cause and effect relationships in light of available evidences and ancillary data generated during the course of investigation under the following heads:

5.1 Growth Parameters

Growth of *kharif* maize in terms of plant height, dry matter accumulation, leaf area index and crop growth rate at periodic intervals as reported in Table 6, 7, 8 and 9, respectively revealed that almost all the crop growth characters of *kharif* maize showed a pronounced improvement with the application of different *in-situ* moisture conservation treatments.

Among the different *in-situ* moisture conservation treatments, the application of the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings, treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp, treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha, treatment (T₇) Flat Bed + mulching with *Leucaena* prunings and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp, treatment (T₂) Broad Bed Furrow and Flat Bed increased the plant height, dry matter accumulation, leaf area index and crop growth rate of *kharif* maize at all the growth stages which was significantly higher as compared to Farmer's practice except at 30 DAS which didn't show any significant results. However, crop growth rate and leaf area index increased during initial crop growth and grand growth period and then declined and reached to a minimum level at harvest stage. The lowest value of growth parameters were observed in Farmer's practice.

However, application of the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher growth parameter values which was statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp. The increasing trend of growth parameters in terms of the plant height, dry matter accumulation, leaf area index and crop growth rate of *kharif* maize might happened due to the fact that the Broad Bed method and mulching with different organic materials after 35 DAS maintained the soil moisture in these plots under prolonged dry spells during reproductive period, better root development and utilization of resources which otherwise may have responsible for loss of moisture through evapo-transpiration from the cracked surfaces and weeds if not being mulched. These results are in close conformity with the findings of Devaranavadgi *et al.* (2012), Uwah and Iwo (2011) and Woldetsadik *et al.* (2005).

5.2 Yield attributes and yield of *kharif* maize

The significant variations in growth and development of *Kharif maize* further led to marked variations in its yield attributes except for number of plants/m² and number of cobs /plant which showed non-significant results (Table 10). Among the different *in-situ* moisture conservation treatments, application of the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp recorded significantly higher number of grains /cob and test weight due to different moisture conservation practices. This improvement in yield attributing characters of *Kharif* maize might have happened because of Broad Bed method and mulching with different organic materials at 35 DAS maintained the soil moisture in these plots under prolonged dry spells during reproductive period, better root development and utilization of resources which otherwise may have responsible for loss of moisture through evapo-transpiration from the cracked surfaces and weeds thereby resulting in better growth of above and below ground parameters, which encouraged the plant to produce more reproductive part and better development of cob. These results are in close conformity with the findings of Devaranavadgi *et al.* (2012), Uwah and Iwo (2011) and Woldetsadik *et al.* (2005) and Mbah *et al.* (2010).

However, the lowest values with respect to yield attributes were observed in Farmer's practice which might be attributed to application of imbalanced inputs and poor cultivation practices.

5.3 Yield and harvest index of crop

5.3.1 Grains and stover yield of *kharif* maize

Grain yield is resultant of better growth and development of plant, higher net photosynthesis, better translocation and storage of photosynthetics in ideal source-sink relationships, better expression of yield attributes like number of plant /m², cob /plant, grain rows /cob and grains /cob which in this case could have been achieved due to reduction in evapo-transpiration, better soil condition, greater retention of moisture in the soil profile, better root development under Broad Bed Furrow method along with mulching with different organic materials especially during the dry spell situations arising during reproductive stage, thus enabling the crop for maximum utilization of nutrients, moisture, light and space which had influence on growth and yield components. The above results could be corroborated with the findings of Sharma and Acharya (2000) and Sharma *et al.* (1998).

Among the different *in-situ* moisture conservation treatments, the significantly highest grain yield of maize was obtained with the application of treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp (Table 11). The possible reason for the higher grain yield due to different *in-situ* soil moisture conservation could be attributed to better combined effects of Broad Bed Furrow method and organic mulches in terms of grain yield components. This improvement in turn can be ascribed due to maintenance of soil moisture under prolonged dry spells during reproductive period, better soil condition, better root development and utilization of resources which otherwise may have been responsible for loss of moisture through evapo-transpiration from the cracked surfaces and weeds if not being sown on Broad Bed along with mulch material. These results are in close conformity with the findings of Devaranavadi *et al.* (2012), Uwah and Iwo

(2011), Sur *et al.* (1992) and Woldetsadik *et al.* (2005). However, the lowest values with respect to grain yield were observed in Farmer's practice which could be attributed to application of imbalanced inputs and poor cultivation practices.

5.3.2 Harvest index

The data presented in Table 11 reveals that different *in-situ* moisture conservation treatments showed non-significant results with respect to harvest index. However, numerically higher values of harvest index were recorded in the treatments (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp whereas lowest value of harvest index was recorded in Farmer's practice.

5.3.3 Rain Water Use Efficiency

The data presented in Table 11 reveals that among the different *in-situ* moisture conservation treatments, significantly higher rain water use efficiency of 5.16 kg/ha-mm was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding rain water use efficiency values of 5.09 kg/ha-mm and 4.99 kg/ha-mm, respectively which in turn were significantly superior to rain water use efficiency values obtained with treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (4.58 kg/ha-mm) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leucaena* prunings (4.52 kg/ha-mm) and treatment (T₅) Flat Bed +mulching with *in situ* raised Sunhemp (4.42 kg/ha-mm). Therefore, the significant increase in water use efficiency was undoubtedly associated with an increase in moisture conservation and availability under mulched condition, especially during the critical growth period of maize as reported by Woldetsadik *et al.* (2005).

However the lowest rain water use efficiency value of 3.22 kg/ha-mm was observed in Farmer's practice.

5.3.4 Moisture per cent at 15 cm and 30 cm depth after every rainfall event (cumulative)

Different *in-situ* moisture conservation treatments significantly influenced the moisture per cent at 15 cm and 30 cm depths after every rainfall event (Table 12). Among the different *in-situ* moisture conservation treatments 30 DAS, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher values of Moisture per cent at 15 cm and 30 cm depths during all the events which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp followed by treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha (39.40 g/plant) which in turn was statistically at par with treatment (T₇) Flat Bed + mulching with *Leucaena* prunings and treatment (T₅) Flat Bed + mulching with *in situ* raised Sunhemp (36.42 g/plant). However, the lowest value of moisture per cent at 15 cm and 30 cm depths after every rainfall event was recorded in Farmer's practice (Table 12).

5.4 Soil status after the harvest of crop

5.4.1 Change in pH, EC and OC:

The soil chemical parameters after harvest of crop did not show much of variations and thus failed to show any significant difference among various treatments. The value of pH, EC and OC obtained after harvesting of *kharif* maize crop ranged from 6.63 to 6.82, 0.17 to 0.21 ds/m and 0.28 to 0.30 per cent, respectively under different *in-situ* moisture conservation treatments (Table 13).

5.4.2 Available N, P and K

The available soil nutrient status data presented in Table 14 reveals that among the different *in-situ* moisture conservation treatments the available N, P and K content of soil after harvest of *kharif* maize crop showed that P and K were not significantly influenced by different *in-situ* moisture conservation treatments. However, available Nitrogen showed significant differences among the different *in-situ* moisture

conservation treatments. Highest values of NPK contents were recorded in treatments (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp as compared to rest of the treatments. This might have happened due to addition of crop as well as mulched crop root and shoot biomass that remained in the soil which was utilized by microorganisms leading to increase in mineralization process.

5.5 Nutrient uptake

5.5.1 N, P and K uptake by grain of *Kharif* maize

The data presented in Table 15 revealed that the nutrient uptake by grain in *kharif* maize was greatly influenced by the different *in-situ* moisture conservation treatments. There was a profound increase in nutrient (NPK) uptake by maize grains due to the different *in-situ* moisture conservation treatments as compared to Farmer's practice. Among the the different *in-situ* moisture conservation treatments, significantly higher NPK uptake in grains was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp. The possible reason for beneficial effect could possibly be attributed to enhanced nutrient availability due to retention of more soil moisture under prolonged dry spells during reproductive period, better root development and utilization of resources which otherwise may have responsible for loss of moisture through evapo-transpiration from the cracked surfaces and weeds if not being mulched. These results are in close conformity with the findings of Devaranavadi *et al.* (2012), Uwah and Iwo (2011) and Woldetsadik *et al.* (2005).

5.5.2 Periodic N, P and K uptake by stover of *Kharif* maize

The data presented in Table 16 revealed that the nutrient uptake by maize stover was greatly influenced by the different *in-situ* moisture conservation treatments. There was a profound increase in nutrient (NPK) uptake by maize stover due to the different *in-situ* moisture conservation treatments as compared to Farmer's practice. Among the

different *in-situ* moisture conservation treatments, significantly higher NPK uptake in stover was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp. The possible reason for beneficial effect could possibly be attributed to enhanced nutrient availability due to retention of more soil moisture under prolonged dry spells during reproductive period, better root development and utilization of resources which otherwise may have responsible for loss of moisture through evapo-transpiration from the cracked surfaces and weeds if not being mulched. These results are in close conformity with the findings of Devaranavadi *et al.* (2012), Uwah and Iwo (2011) and Woldetsadik *et al.* (2005).

5.6 Relative economics of *Kharif* maize

The economic feasibility and usefulness of a treatment can be effectively adjusted in terms of B: C ratio and net returns. Relative economics of *Kharif* maize depicted in Table 17 Among different *in-situ* moisture conservation treatments, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha registered highest net returns of (Rs. 40755/ha) which was immediately followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings, treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp, treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha, treatment (T₇) Flat Bed + mulching with *Leucaena* prunings, treatment (T₅) Flat Bed + mulching, treatment (T₂) Broad Bed Furrow and treatment (T₁) Flat Bed. However, lowest net return of Rs.21789.00/ha was obtained in Farmer's practice (Sharma *et al.* 2010)

Among the different *in-situ* soil moisture conservation treatments the highest benefit: cost ratio of 1.83 was obtained with the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings, treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp. However, lower benefit: cost ratio was recorded in Farmer's practice.

CHAPTER-6

SUMMARY

AND

CONCLUSIONS

SUMMARY AND CONCLUSION

The field experiment entitled, “**Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir**”, was undertaken at the Research Farm of Advanced Centre for Rainfed Agriculture, ACRA Dhiansar of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during the *kharif* season of 2016 with the following objectives:

OBJECTIVES

1. To find out the most suitable vegetative bio-mass as mulch for *in-situ* moisture conservation for improving maize productivity.
2. To find out the most efficient establishment method for *in-situ* moisture conservation for improving maize productivity.
3. To workout the relative economics of different *in-situ* moisture conservation techniques and establishments methods.

To achieve these objectives, a field experiment comprising of 9 treatments *viz.* T₁- Flat Bed, T₂- Broad Bed Furrow, T₃- Flat Bed + mulching with *in-situ* raised Dhaincha, T₄-Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, T₅-Flat Bed + mulching with *in situ* raised Sunhemp, T₆- Broad Bed Furrow + mulching with *in-situ* raised Sunhemp, T₇- Flat Bed + mulching with *Leucaena* prunings, T₈- Broad Bed Furrow + mulching with *Leucaena* prunings and T₉- Farmer's practice was laid out in randomized block design with three replications during *kharif* season of 2016. The soil of the experimental field was sandy loam in texture, near to neutral, low in organic carbon and available nitrogen and medium in available phosphorous and potassium. The field was ploughed twice with disc harrow followed by planking to prepare a fine seed Bed. Plot paths, replication borders and drainage channels were made manually. The plots were levelled before planting of *kharif* maize. However, Broad Bed and Furrow plots were raised using Bed making machine. Hybrid maize variety *Double dekalb* was sown in line

on 5th of July using full dose of P and K along with 2/3rd dose of N as basal dose at the time of sowing through inorganic sources of nutrients viz. Urea, DAP and MOP, respectively as per package of practices and remaining Nitrogen was applied just before the application of mulches while in farmers practice only Urea and DAP as inorganic fertilizers were applied in maize sown by broadcasting method without following any plant protection measures. However, the seeds of the mulch crops viz: Dhaincha and Sunhemp were also sown by broadcasting method at the time of final ploughing as per the technical programme. *Leucaena* prunings (*Ex-situ*) were taken from the plants growing in surroundings 35 DAS of maize at the time of spreading of mulches.

6.1 Crop Studies

a) Crop Growth

Application of different *in-situ* soil moisture conservation techniques had a well pronounced effect on growth parameters viz. plant height, dry matter accumulation, leaf area index and crop growth rate at almost all stages of maize crop except at 30 DAS. Among the different *in-situ* moisture conservation treatments applied in maize crop, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha recorded significantly higher growth parameter values which was statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp except at 30 DAS which didn't show any significant results. However, significantly lowest values of growth parameters were observed in Farmer's practice.

b) Yield and yield attributes

The significant variations in growth and development of *kharif* maize led to marked variations in its yield attributes except for number of plants/m² and number of cobs/plant which showed non-significant results. Among the different *in-situ* moisture conservation treatments, application of the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp recorded significantly higher number of grains/cob and 1000 grain weight due

to different moisture conservation practices. However, the lowest values with respect to yield attributes were observed in Farmer's practice.

Likewise, Among the different *in-situ* moisture conservation treatments, significantly highest grain and stover yield of maize was obtained with the application of treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp while the lowest values with respect to grain and stover yields were observed in Farmer's practice.

Non-significant results with respect to harvest index were observed in different *in-situ* moisture conservation treatments. However, numerically higher values of harvest index were recorded in the treatments (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha, (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp, whereas lowest value of harvest index was recorded in Farmer's practice.

Significantly higher rain water use efficiency of 5.16 kg/ha-mm was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp with the corresponding rain water use efficiency values of 5.09 kg/ha-mm and 4.99 kg/ha-mm, respectively.

6.2 Soil studies

The physico-chemical properties of soil with respect to pH, EC and OC and available phosphorous and potash after harvest of crop did not show much of variations and thus failed to show any significant difference among various treatments. Moreover, the value of pH, EC and OC obtained after harvesting of *kharif* maize crop ranged from 6.63 to 6.82, 0.17 to 0.21 ds/m and 0.28 to 0.30 per cent, respectively under different *in-situ* moisture conservation treatments. However, available nitrogen showed significant differences among the different *in-situ* moisture conservation treatments. Numerically higher value of NPK contents were recorded in treatments (T₄) Broad Bed Furrow +

mulching with *in-situ* raised Dhaincha, (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp as compared to rest of the treatments.

6.3 Nutrient uptake

Nutrient uptake by maize stover was greatly influenced by the different *in-situ* soil moisture conservation treatments. There was a profound increase in nutrient (NPK) uptake by maize stover due to the different *in-situ* moisture conservation treatments as compared to Farmer's practice. Among the different *in-situ* moisture conservation treatments, significantly higher NPK uptake in stover was recorded in the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was found to be statistically at par with the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings and the treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp.

6.4 Relative economics

Among different *in-situ* moisture conservation treatments, the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha registered highest net returns of ₹ 40744/ha) which was immediately followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings, treatment (T₆) Broad Bed Furrow +mulching with *in-situ* raised Sunhemp, treatment (T₃) Flat Bed + mulching with *in-situ* raised Dhaincha, treatment (T₇) Flat Bed + mulching with *Leucaena* prunings, treatment (T₅) Flat Bed + mulching, treatment (T₂) Broad Bed Furrow and treatment (T₁) Flat Bed. However lowest net returns of ₹ 22936/ ha was obtained in Farmer's practice.

Among the different *in-situ* moisture conservation treatments the highest benefit: cost ratio of 1.83 was obtained with the treatment (T₄) Broad Bed Furrow + mulching with *in-situ* raised Dhaincha which was followed by the treatment (T₈) Broad Bed Furrow (BBF) + Mulching with *Leucaena* prunings, treatment (T₆) Broad Bed Furrow + mulching with *in-situ* raised Sunhemp. Significantly lower benefit: cost ratio was however, recorded in Farmer's practice.

CONCLUSION

On the basis of results of present investigation, it is concluded that among the different *in-situ* soil moisture conservation techniques in maize, Broad Bed Furrow (BBF) + mulching with *in-situ* raised Dhaincha, provided significantly highest grain yield with maximum net returns, B:C ratio and Rain Water Use Efficiency under rainfed situations which not only helped in conserving the moisture in the soil profile but also enhanced the productivity of maize especially during mid / terminal dry spell situations which can contribute to food security of *kandi belt* farmerø under the Shiwalik Foothills of Jammu and Kashmir.

REFERENCES

- Acharya, C.L., Kapur, O.C. and Dixit, S.P., 1998. Moisture conservation for rainfed wheat production with alternative mulches and conservation tillage in hills of north-west India. *Soil Tillage Research*, **46**, 153-163.
- Alharbi, A. 2015. Effect of mulch on soil properties under organic farming conditions in center of Saudi Arabia. *Journal of American Science*, **11**(1):108-115.
- Anonymous, 2016 a. Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Govt. of India. pp 104.
- Anonymous, 2016 b. Digest of Statistics, Govt. of Jammu and Kashmir.
- Bakht, J., Siddique, M. F., Shafi, M., Akbar, H., Tariq, M., Khan, N., Zubair, M. and Yousef, M. 2007. Effect of planting methods and nitrogen levels on the yield and yield components of maize. *Sarhad Journal of Agriculture*, **23**: 553-559.
- Bhagwandin and Bhatia, K. S. 1998. Effect of seed bed configuration and mulches on grain yields of rainfed maize. *Indian Journal of Soil Conservation*, **17**(2): 55-57.
- Bhan, S. 1976. Root development and moisture use of rainfed brown sarson as influenced by agronomic practices. *Indian Journal of Agronomy*, **21**(3): 245-248.
- Bhandari A L, Kapur M Land Rana D. S. 1988. Studies on the economics of planting pattern and fertilizer use in an intercropping system of maize (*Zea mays* L.) and green gram (*Vigna radiata* L.). *International Journal Tropical Agriculture* **6**(1-2): 83-87.
- Bhat, R., Khera, K. L. and Arora, S. 2004. Effect of tillage and mulching on yield of corn in the submountaneous rainfed of Punjab India. *International Journal of Agriculture and Biology*, **6** (1):126-128.
- Blevins, R. L. and Frye, W. W. 1993. Conservation Tillage: An Ecological Approach to Soil Management. *Advances in Agronomy*, **51**, 33-78.
- Brar, H. S. and Cheema, S. S. 1988. Agronomic practices for managing excess water in maize. *Indian Journal Agronomy* **33** (2): 164-66.

- Channappa, T.C. and Ashoka, H.G. (1992). *Indian Journal Soil Conservation*, **20**, 1-8.
- Chopra, P. and Angiras, N. N. 2008. Effect of tillage and weed management on productivity and nutrient uptake of maize (*Zea mays* L.). *Indian Journal of Agronomy*, **53**(1): 66-69.
- Cochran, G. and Cox, G. M. 1963. *Experimental design*. Asia Publishing House, Bombay, India.
- Das, A., Ghosh, P. K., Lal, R., Saha, R. and Ngachan, S. 2013. Soil quality effect of conservation practices in maize-rapeseed cropping system in eastern Himalaya. *Land Degradation Development*.
- Das, K., Medhi, D. N. and Guha, B. 2004. Application of crop residues in combination with chemical fertilizers for sustainable productivity in rice (*Oryza sativa*) - wheat (*Triticum aestivum*) system. *Indian Journal of Agronomy*, **48**(1): 8-11.
- Debebe, G. D. 1999. Evaluation and mitigation of yield losses caused by flooding in maize. M.Sc. Thesis, Department of Agronomy, Punjab Agricultural University, Ludhiana, India.
- Devaranavadi, S. V. and Bosu S. S. 2014. Effect of *in-situ* moisture conservation practices in deep clay soils on growth and yield of maize (*Zea mays* L.) under rainfed condition *Karnataka Journal of Agriculture Science*, **27**(4): 507-510
- Devaranavadi, S.B., Rathod, P., Wali, S.Y. and Madiwalar S.L. 2012. Carbon sequestration potential of tree borne oilseeds for dryland areas of Karnataka *International Journal For Crop Improvement*, **3**: 24-26.
- Ehsanullah, L., Ashraf, U., Ahmad, S., Anjum, E. F., Khan, I. and Ghaffar, A. 2015. Tillage practices and sowing methods affect yield and related attributes of maize. *Asian Journal of Agriculture and Biology*, **3**(1): 8-14.
- Frye, W. W. 1986. Economics of legume cover crops. Soil Science News Views Cooperative Extension Survey University of Kenya. *Collection of Agriculture Department in Agronomy*, **7**: 2.

- Ghosh, P. K., Dayal, D., Bandyopadhyay, K. K. and Mohanty, M. 2006. Evaluation of straw and polythene mulch for enhancing productivity of irrigated summer groundnut. *Field Crops Research* 99: 76-86.
- Gul, B., Khan, B. M., Khan, A. M., and Khan, H. 2014. Impact of tillage, plant population and mulches on phenological characters of maize. *Pakistan. Journal of Botany*, **46**(2): 549-554
- Gupta, R. K., Tomar, S. S. and Tomar, A. S. 1990. Improved soil management practices for maize and sorghum grown in vertisols of central India. *Crop Research Hissar*, **3**(2): 284-86.
- Hadda, M. S., Khera, K .L. and Kukal, S. S. 2000. Soil and water conservation practices and soil productivity in North-Western sub-mountaneous tract of India: A review. *Indian Journal of Soil Conservation*, **28**: 187-192.
- Hiremath, S. M., Hebhi, B. S. and Halikatti, S. I. 2003. Performance of *rabi* sorghum as influenced by nitrogen and *in-situ* soil moisture conservation practices in kharif sunnhemp for green manuring. *Karnataka Journal of Agriculture and Science*, **16**(2): 216-219.
- Hoefler, R. H., Wicks, G. A. and Bumside, O.C. 1981. Grain yields, soil water shortage, weed growth in a winter wheat-corn-fallow rotation, *Agronomy Journal*, **73**: 1066-1071.
- Jackson, M. L. 1967. *Soil Chemical Analysis*. Prentice-Hall of India Pvt. Ltd., New Delhi, 498.
- Jackson, M. L. 1973. *Soil Chemical Analysis*. Prentice-Hall India Limited, New Delhi.
- Jat, M. L., Singh, S., Rai, H. K., Chhokar, R. S., Sharma, S. K., and Gupta, R. K. 2015. Furrow irrigated raised bed (FIRB) planting technique for diversification of rice-wheat system in Indo-Gangetic plains. *Japan Association for International Collaboration of Agriculture and Forestry*, **28**(1): 25- 42.

- Kannan, K., Selvi, V., Singh, D. V., Khola, O. P. S., Mohanraj, R. and Murugesan, A. 2013. *Coir pith composting-an alternate source of organic manure for rainfed maize*. Folder of Central Soil and Water Conservation Research and Training Institute, Research Centre, ICAR, Udhamandalam-643 004, Tamil Nadu.
- Katama Reddy, B. C. 1979. Note on the soil and moisture conservation structures at Agricultural Research Station, Ananthapur (Unpubl).
- Khera, K. L., Khera, R., Prihar, S. S., Sandhu, B. S. and Sandhu, K. S. 1976. Mulch, nitrogen, and irrigation effects on growth, yield, and nutrient uptake of forage corn1. *Agronomy Journal*, **68**(6): 937-941
- Kumar, A. 2008. Growth, yield and water use efficiency of different maize (*Zea mays*)-based cropping systems under varying planting methods and irrigation levels. *Indian Journal of agriculture Science*, 78 (3): 244-247.
- Kureel, S. K. 2004. Effect of fertility levels and moisture conservation practices on maize (*Zea mays* L.) production under rainfed condition. M.Sc. (Ag.) thesis, Department of Soil Conservation and Water Management, C. S. Azad University of Agriculture and Technology, Kanpur.
- Lal, B., Chandra, N. and Yadav, M. S. 1988. Response of waterlogged maize to planting methods and time of nitrogen application. *Indian Journal Agricultura*, **33**(2): 191-93.
- Lehria, S. K., Bali, S. V. and Singh, B. 2006. Effect of green leaf manure of subabul (*Leucaena leucocephala* Lam. De Wit) on maize crop and its residual effect on wheat crop. In: Verma, K. S., Khurana, D.K. and Christersson, L. (eds) *Proceedings of the IUFRO- ISTS-UHF International Conference on World Perspective on Short Rotation Forestry for Industrial and Rural Development*, Nauni, Solan, India, Pp 3166319.
- Li, Xiao-Yan, Gong, Jia-Dong, Wei, Xing-Hu, 2000. In-situ rainwater harvesting and gravel mulch combination for corn production in the dry semi-arid region of China. *Journal of Arid Environments*, (46): 371-382.

- Ling-duo, B., Jian-liang, L., Lin, Z., Sha-sha, L., Xin-ping, C., Shi-qing, Lia., Robert, L., Hill, c. and Ying, Z. 2013. The effects of mulching on maize growth, yield and water use in a semi-arid region. *Agricultural Water Management* 123: 716-78.
- Mbagwu. 1991. Mulching an Ultisol in Southern Nigeria: Effects on Physical Properties and Maize and Cowpea Yield. *J Sci Food Agric* 1991, (57): 517-526
- Mbah, C. N., Nwite, J. N., Njoku, C., Ibeh, L. M., and Igwe, T. S. 2010. Physical properties of an ultisols under plastic film and no mulch and their effect on the yield of maize. *World Journal of Agricultural Sciences*, 6 (2): 160-165.
- Meelu, O. P. and Morris, R. A. 1988. Green manure management in rice based cropping systems. *Proceedings of Symposium on Sustainable Agriculture: The Role of Green Manure Crops in Rice Farming Systems*. International Rice Research Institute, Los Banos, Laguna, Philippines, Pp. 207-222.
- Mittal, S. P., Singh, P., Agnihotri, R. C., Dyal, S. K. N. and Sud, A. D. 1986. Effect of conservation farming practices on runoff, soil loss and yield of maize in Shivalak foot hills. *Indian Journal of Soil Conservation*, 14: 1-6.
- Musambasi, D., Chivinge, O. A. and Mariga, I. K. 2003. Effect of ridging treatment and two early maturing maize cultivars on witch weed density and maize yield under dry land maize based cropping system in Zambabwe. *Crop Research*, 25: 37-45.
- Nichiporovich, A. A. 1967. Aims of research on the Photosynthesis of plants as a factor of productivity. In: Nichiporovich A. A. Photosynthesis of productive system. *Israel Programme Science Trans Jerusalem*, pp: 3-36.
- Olsen, R.S., Cole, V.C., Watanable, F.S. and Dean, L.A. 1954. Estimation of available phosphorous in soils by extracting with sodium bicarbonate. United States Department of Agriculture Circulation, 939: 19-33.
- Patil, S. L. 1998. Response of rabi sorghum to tillage, moisture conservation practices, organics and nitrogen in vertisols of semi-arid tropics. Ph.D. Thesis, *University of Agriculture Science, Dharwad*.

- Patil, S. L. and Sheelavantar, M. N. 2004. Effect of moisture conservation practices, organic sources and nitrogen levels on yield, water use and root development of rabi sorghum (*Sorghum bicolor* (L.) Moench) in the vertisols of semi-arid tropics. *Annals of Agriculture Research*, **21**(1): 32-36.
- Patil, S. L. and Shreelavantar, M. N. 2001. Effect of moisture conservation practices, organic sources and nitrogen levels on yield, water use and root development of rabi sorghum [*Sorghum bicolor* (L.) Moench] in the vertisols of semi-arid tropics. *Annual Agriculture Research*, **21**: 32-36.
- Patil, S. N., Khakare, M. S. and Raut, R. S. 1994. Effect of *in-situ* moistures conservation measures on yield, water consumption, evapotranspiration and water use efficiency of grain sorghum under rainfed condition. *Punjab Rao Krishi Vidyapeetha Research Journal*, **18**(2): 170-172.
- Pawar, R. B., Patil, J. D. and Takate, A. S. 1999. *In situ* moisture conservation techniques for rabi sorghum production under dryland condition. *Journal of Maharashtra agriculture University*, **24**(2): 214.
- Pervaiz, M. A., Iqbal, M., Shahzad, K. and Ul-Hassan, A. 2009. Effect of mulch on soil physical properties and N, P, K concentration in maize (*Zea mays* L.) shoots under two tillage systems. *International Journal of Agriculture & Biology* **11**(2): 119-124.
- Phillips, R. E. and Phillips, S. H. 1984. *No-tillage agriculture: Principles and practices*. Van Norstand and Reinhold, New York. 66686.
- Piper, C. S. 1966. *Soil and plant analysis*. Inter-Science Publishers, INC, New York: 368.
- Radder, G. D., Itnal, C. J., Surkod, V. S. and Biradar, B. M., 1991. Compartment bunding an effective *in situ* moisture conservation practice on medium deep black soil. *Indian Journal of Soil Conservation*, **19** (1&2): 1-5.
- Radford, P. J. 1967. Growth analysis formulae- their use and abuse. *Crop Science*, **7**: 171-175.

- Rajput, B. S., Shukla, N. N., Sen, A. and Singh, R. K. 2014. Row Spacing and Mulching Effect on Growth and Nutrient Uptake of Maize (*Zea mays* L.) under Guava (*Psidium guajava* L.) based Agri-horti System. *Online International Interdisciplinary Research Journal*, **4**(3): 2249-9598,
- Ramakichnan, B. and Sakthivel Nand B. A. 2002. Effect of pre monsoon sowing and land management practices on growth yield parameters and yield of rain fed maize. *Madras Agricultural Journal*, **89**(1-3): 177-179.
- Ratan, R. and Sawal, R. K., 2005. Influence of sirus (ALBIZIA LEBBECK) pods supplementation in sheep production. *Indian Journal of Small Ruminants*, **11**(1): 43-47
- Sharma, A. R., Singh, R., Dhyani, S. K. and Dubey, R. K. 2010. Effect of live mulching with annual legumes on performance of maize and residual effect on following wheat. *Indian Journal of Agronomy*, **55**(3): 177-184.
- Sharma, A.R., Singh, R. and Dhyani, S.K. 2005. Conservation tillage and mulching for optimizing productivity in maize-wheat cropping system in the western Himalayan region. *Indian Journal of Soil Conservation*, **33**(1):35653
- Sharma, J. C. and Kumar, V. 2014. Effect of mulches and nutrient levels on soil hydro-thermal regimes, soil fertility and productivity of cauliflower (*Brassica oleracea* var. *botrytis* L.) in mid-hills of Himachal Pradesh. *Journal of the Indian Society of Soil Science*, **62**(1): 9-17.
- Sharma, N. K., Singh, P. N., Tyagi, P. C. and Mohan, S. C. 1998. Effect of *leucaena* mulch on soil-water use and wheat yield. *Agricultural Water Management*, **35**: 1916200.
- Sharma, N. K., Singh, P. N., Tyagi, P. C. and Mohan, S.C. 2000. Effect of application of *Leucaena* mulch on soil moisture conservation and productivity of rainfed wheat. *Indian Journal of Soil Conservation*, **29** (2):1436147
- Sharma, P., Abrol, V., Sankar, G.R.M. and Singh, B. 2009. Influence of tillage practices and mulching options on productivity, economics and soil physical properties of

maize (*Zea mays* L.) - wheat (*Triticum aestivum*) system. *Indian Journal of Agricultural Sciences*, **79**(11): 865-870.

Sharma, P.K. and C.L. Acharya. 2000. Carry-over of residual soil moisture with mulching and conservation tillage practices for sowing of rainfed wheat (*Triticum aestivum* L.) in north-west India. *Soil and Tillage Research* 57: 43-52. (PDF) *Zero Tillage Impacts on Soil Environment and Properties*. Available from: https://www.researchgate.net/publication/312372050_Zero_Tillage_Impacts_on_Soil_Environment_and_Properties [accessed Oct 02 2018].

Simpson, L. A. and F. A. Gumbs. 1986. Effect of mulching and tillage on germination, growth, nutrient uptake and yield. *Tropical Agriculture*. **63**: 311-315.

Singh, G. and Brar, S. S. 1994. Tillage and nitrogen requirement of wheat (*Triticum aestivum*) sown after rice (*Oryza sativa*). *Indian Journal of Agronomy*, **39**(1): 162-1653.

Singh, K. B., Jalota, S. K. and Gupta, R. K. 2014. Soil water balance and response of spring maize (*Zea mays*) to mulching and differential irrigation in Punjab. *Indian Journal of Agronomy*, **60**(2): 279-284.

Sonpure, B, Sushma., S., Ilhe, S., and Wadile, S. C. 2017. Influence of irrigation scheduling and mulching on yield and economics in summer sweet corn. *International Research Journal of Agricultural Economics and Statistics*, **8**(2): 315-319.

Srivastava, A. K., Ramamohanrao, M.S. and Ramanath, B. 1988. Technology for conservation agronomy of semi-arid black soil (*rabi*) region. *Indian Journal of Soil Conservation*, **16**: 14-21.

Subbiah, B.V. and Asijia, G.L. 1956. A rapid procedure for estimation of available nitrogen in soils. *Current Sciences*, **25**: 259-260.

Subudhi, R. 2011. Effect of conservation trenches on plantation crop in degraded watershed in Kandhamal district of Odisha. *Agrotechnology* 2: 112.

- Sur, H.S., Mastana, P.S and Hadda, M.S. 1992. Effect of rates and modes of mulch application on runoff, sediment and nitrogen loss on cropped and uncropped fields. *Trop. Agriculture*, 69: 319-322.
- Tisdall, J. M. and Hodgson, A. S. 1990 Ridge tillage in Australia: a review, *Soil and Tillage Research* **18**: 127-44.
- Uttam, S. K., Yadav, P. N., Awasthi, U. D., Tripathi, A. K. and Singh, R. K. 2015. Relative impact of *in situ* moisture conservation practices and row spacing on maize (*Zea mays*) varieties under rainfed condition. *Current Advances in Agricultural Sciences*, 7(2): 165-170.
- Uwah, D. F. and Iwo, G. A. 2011. Effectiveness of organic mulch on the productivity of maize (*Zea mays L.*) And weed growth. *The Journal of Animal & Plant Sciences*, **21**(3): 525-530.
- Vashisht, B.B., Sidhu, B.S. Singh, S and Biwalkar, N .2013. Effect of different mulches on soil erosion and carry-over of residual soil moisture for sowing of rabi crop in maize-wheat cropping sequence in rainfed Shivaliks of Punjab *Indian journal of soil conservation*, **41**(2):136-140.
- Vijayalakshmi, 1987. *Technical advances in dryland agriculture*, CRIDA, Hyderabad, Andhra Pradesh, Pp.19-46.
- Vogel, H. 1996. Maize root profiles in gleyic sandy soils as influenced by ridging and ploughing in Zimbabwe. In: *Soil fertility and climatic constraints in dryland agriculture: Proceedings of ACIAR-SACCAR Workshop*, Harare, Zimbabwe (Abstr. in Field Crop Abstracts **49**, Entry No.2958, 1996).
- Watanabe, F. S. and Olsen, S. R. 1965. Test of an Ascorbic Acid Method for Determining Phosphorus in Water and NaHCO₃ Extracts from the Soil. *Soil Science Society of America Journal*, 29: 677-678.
- Wicks, G. A., Crutchfield, D. A. and Burnside, O. C. 1994. Influence of wheat (*triticum estivum*) straw mulch and metolachlor on corn (*Zea mays L.*) growth and yield. *Weed Science*, **42**:141-7.

- Woldetsadik, G., Chinawong, S., Suwanketnikom, R., Juntakool, S. and Pookpakdi, A. 2005. Nitrogen fertilization and moisture Conservation Practices on Maize (*Zea mays* L.) Grown Under Dryland Conditions of Ethiopia Kasketsart. *Journal of Natural Science*. **39**:1-11.
- Xu, Jie., Li, C., Liu, H., Zhou, P., Tao, Z. and Wang, P. 2015. The effects of plastic film mulching on maize growth and water use in dry and rainy years in Northeast China. *Journal pone* **10**(5): 125-781.
- Yaseen, R., Shafi, J., Ahmad, W., Rana, MS., Salim, M, and Qaisrani, S.A., 2014. Effect of deficit irrigation and mulch on soil physical properties, growth and yield of maize. *Environment and ecology research* **2**(3): 122-137.
- Zamir, I. S., Asif, M., Ihtisham-ul-haq, Ashraf, U., Hussain, S. and Khan, M. K. 2014. Maize phenology, yield and its quality is affected by organic mulches and various irrigation regimes. *International Journal of Modern Agriculture*, **2**(3):56-59.
- Zamir, M. S. I., Javeed, H. M. R., Ahmed, W., Ahmed, A. U. H., Sarwar, N., Shehzad, M., Sarwar, M. A. and Iqbal, S. 2013. Effect of tillage and organic mulches on growth, yield and quality of autumn planted maize (*zea mays* l.) And soil physical properties. *Cercetări Agronomice În Moldova*, **2**(54): 228-239.

APPENDIX

Appendix-1

Mean weekly meteorological data during crop season 2016

SMW*	Date & Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
		Max	Min	(morning)	(evening)	
26.	1-7 (July)	34.20	21.89	80.3	67	20.9
27.	8-14 (July)	34.14	22.04	87.4	53	70.3
28.	15-21 (July)	32.73	22.24	86.4	73	93.9
29.	22-28(July)	32.53	20.37	90.3	73	161.4
30.	29(July)-4(Aug.)	32.7	20.9	90.6	68	59.1
31.	5-11(Aug.)	31.9	22.06	83.6	69	74.7
32.	12-18(Aug.)	34.4	21.0	86.1	59	7.2
33.	19-25(Aug.)	34.9	22.4	84.6	64	0.5
34.	26(Aug)-1(Sep)	32.5	19.9	89.6	65	92.9
35.	2-8(Sep.)	34.1	20.6	84.4	62	00
36.	9-15(Sep.)	34.5	22.3	87.6	64	41.5
37.	16-22(Sep.)	35.1	21.2	87.7	56	0.0
38.	23-29(Sep.)	31.8	18.5	85.7	69	13.6
39.	30(Sep)-6(Oct.)	34.2	20.6	88.6	59	0.0
40.	7-15 (Oct.)	33.0	14.9	77.3	44	0.0

SMW* Standard Meteorological Week

Source: Agromet observatory, ACRA, Rakh Dhiansar.

Dry spells		Crop	Stage of the crop
Duration (Days)	Dates & months		
12 days	18 Aug-29 Aug	Maize	Reproductive stage
9 days	15 Sept-22 Sept		

Appendix-II

Operating cost / unit of input used in *kharif* maize cultivation

S. No.	Input	Quantity/ha	Unit	Rate (₹/unit)	Total cost (₹/ha)
1	Land preparation	Double tilling followed by planking	kanal	150	3000.00
2	Layout				
i	Flat Bed	12	Man days	183	2196
ii	BBF	15	Man days	183	2745
3	Seed				
i	Double dekalb	20	kg	128	2560
ii	Dhaicha	30	kg	35	1050
iii	Sunhemp	30	kg	35	1050
4	Seed sowing and fertilizer application				
i	Flat Bed	10	Man days	183	1830
ii	BBF	10	Man days	183	1830
iii	Mulched Plots	11	Man days	183	2013
iv	Broadcast(Farmer's practice)	01	Man days	183	183
5	Fertilizers				
i	Urea	100	kg	5.68	568
ii	DAP	90	kg	24.26	2183
iii	MOP	33	kg	17.00	561
6.	Herbicide				
i	Pendimethalin@1kg/ha Pre-emergence	2.85	kg	460	1311
7.	Herbicide application	2	Man days	183	366
8.	Cutting and spreading of mulches	12	Man days	183	2196
9.	Top dressing	1	Man Days	183	183
10.	Thinning / gap-filling	2	Man days	183	366
11.	Harvesting , Picking and shelling	25	Man days	183	4575
12.	Miscellaneous(Carriage, watch and ward, rent of land)	-	-	-	-

Sale price of the produce

Crop	Grain (₹/q)	Stover (₹/q)
Maize	1510	200

Appendix - III

Analysis of variance of plant height at periodic interval

Source	D.F.	Mean sum Squire			
		30 DAS	60DAS	90DAS	AT
harvest					
Replications	2				
Treatment	8	18.76	540.74	596.01	
581.25					
Error	16	10.98	8.13	2.49	
3.65					
Total	26				

Analysis of variance of Dry matter accumulation at periodic interval

Source	D.F.	Mean sum Squire			
		30 DAS	60DAS	90DAS	AT
harvest					
Replications	2				
Treatment	8	3.04	280.73	1405.32	1513.46
Error	16	1.27	10.59	27.76	38.73
Total	26				

Analysis of variance of Leaf area index at periodic interval

Source	D.F.	Mean sum Squire

		30 DAS	60 DAS	90DAS
AT harvest				
Replications	2			
Treatment	8	0.06	0.55	0.58
		0.41		
Error	16	0.02	0.01	0.02
		0.01		
Total	26			

Analysis of variance of Yield attributes of maize

Source	D.F.	Mean sum Squire			
		No. of Plants/m ²	No. of cobs/ plant	No. of Grains/cob	Test
weight (g)					
Replications	2				
Treatment	8	0.05	0.02	4000.12	
		780.87			
Error	16	0.03	0.01	155.80	
		44.09			
Total	26				

Analysis of variance of Grain yield, Stover yield, Harvest index and RWUE of maize of maize

Source	D.F.	Mean sum Squire		
		Grain yield	Stover yield	Harvest index
RWUE				
Replications	2			
Treatment	8	449588.58	1041442.83	2.50
		1.08		
Error	16	8042.96	36867.82	1.37
		0.05		
Total	26			

Analysis of variance of Available Nitrogen, Phosphorus and Potassium

Source	D.F.	Mean sum Square		
		Nitrogen content	Phosphorus content	Potassium Content
Replications	2			
Treatment	8	518.54	1.11	9.64
Error	16	184.81	3.65	3.77
Total	26			

Analysis of variance of initial status of pH, EC and OC

Source	D.F.	Mean sum Squire		
		pH	EC	OC
Replications	2			
Treatment	8	0.33	0.00	0.02
Error	16	0.16	0.00	0.04
Total	26			

Analysis of variance of Nitrogen, Phosphorus and Potassium uptake in grain

Source	D.F.	Mean sum Squire		
		Nitrogen uptake	Phosphorus uptake	Potassium uptake
Replications	2			
Treatment	8	594.52	11.62	149.96

Error	16	5.18	0.35	101.41
Total	26			

Analysis of variance of Nitrogen, Phosphorus and Potassium uptake in stover

Source	D.F.	Mean sum Squire		
		Nitrogen uptake	Phosphorus uptake	Potassium uptake
Replications	2			
Treatment	8	417.80	19.35	158.82
Error	16	12.30	1.76	6.42
Total	26			

VITA

VITA

Name of the student : Vikash Kumar

Fathers name : Sh. Mahaveer Parshad

Mothers name : Smt. Silochana Devi

Nationality : Indian

Permanent home address : VPO. Chohilanwali Teh. & Dist. Hanumangarh town
Rajasthan.

Educational Qualifications:-

Bachelors Degree : B.Sc. (Hons.) Agriculture

OGPA : 63.1 /10 (6.31/100)

University : Swami Keshwanand Mahavidhalya Gramothan
Vidhapith, Sangria. (SKRAU Bikaner)

Masterø Degree : M. Sc. (Agronomy) Agriculture

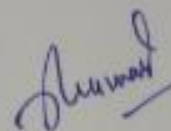
OGPA : 68.9/100 (6.89/10)

University : SKUAST-Jammu

Title of Masterø thesis : **“Effect of different *in-situ* soil moisture conservation techniques in maize (*Zea mays*) under Shiwalik Foothills of Jammu and Kashmir”.**

CERTIFICATE-IV

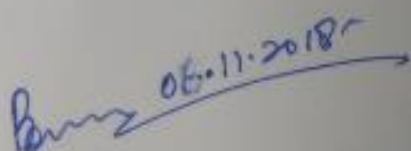
Certified that all the necessary corrections as suggested by external examiner and the advisory committee have been duly incorporated in the thesis entitled "Effect of different *in-situ* soil moisture conservation techniques in maize under Shiwalik Foothills of Jammu and Kashmir" submitted by Mr. Vikash Kumar, Registration No. J-15-M-401.



Dr. Jai Kumar
Jr. Scientist, Agronomy
Major Advisor & Chairman
Advisory Committee

Place: Jammu

Date: 29/10/2018



06.11.2018

Head
Division of Agronomy