INFLUENCE OF MULCHING ON CROP PRODUCTIVITY AND WATER-USE EFFICIENCY OF MAIZE-MAIZE CROPPING SYSTEM

BY

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DEPARTMENT OF AGRONOMY

DOCTOR OF PHILOSOPHY IN AGRONOMY

2016

Regd. No. D/Agro/01/2013-14

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BY

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A THESIS SUBMITTED TO

THE DR. RAJENDRA PRASAD CENTRAL AGRICULTURAL UNIVERSITY, BIHAR, PUSA
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY IN AGRONOMY
2016
DEPARTMENT OF AGRONOMY

DR. RAJENDRA PRASAD CENTRAL AGRICULTURAL UNIVERSITY,
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DEDICATION

This humble effort is

Dedicated

To

The souls of my parents

Phillip Amandu, Regina Safara

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Dated 01/12/2016

Certificate

This is to certify that the work embodied in this thesis entitled "**Influence of mulching on crop productivity and water-use efficiency of maize-maize cropping system**" submitted in partial fulfilment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY IN AGRONOMY** of the faculty of Post-Graduate Studies, Dr. Rajendra Prasad Central Agricultural University, Bihar, Pusa (Samastipur) is a genuine record of the ***bona fide*** research work carried out by **MR. LOMORO PHILLIP MODI AMANDU** under my supervision and guidance.

The results of the investigation reported in this thesis work have not so far been submitted for any other degree or diploma. The assistance and helps received during the course of this investigation and sources of literature have been duly acknowledged.

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Acknowledgement

I offer my thanks to Almighty GOD, the propitious, the Only Creator of the universe, the source of all knowledge and wisdom, who able me to achieve this level of my academic career.

I feel immense pleasure in expressing my deeply sense of gratitude and indebtedness to my supervisor **Dr. Vinod Kumar**, Chief Scientist -cum- Univ. Prof., Department of Agronomy, Dr. Rajendra Prasad Central Agricultural University for his constant valuable guidance, ever ready assistance, keen interest, timely advice, vigilant supervision, jubilant inspiration, persistent encouragement, painstaking efforts and everlasting affection during the entire course of study as well as constructive criticism in the preparation of the manuscript. It has indeed been privilege to work under his supervision and I will indebted to him.

With an overwhelming sense of gratitude I thank to honourable **Dr. Ravi Nandan**, Chairman, Department of Agronomy, DRPCAU, Pusa for his continuous encouragement and sound direction on this research.

I like to express thanks and sincere gratitude to the members of my advisory committee, **Dr. Mukesh Kumar**, Univ. Prof-cum-Chief Scientist., Department of Soil Science, Dr. Rajan Kumar, Jr. Scientist-cum-Asstt. Prof., Department of Agronomy, Dr. Kavita, Jr. Scientist-cum-Asstt. Prof., Department of Botany and Plant Physiology and Dr. Bimla Rai; Professor and Chairperson. Department of Plant Phathology, PGS Dean's Nominee for their kind help, valuable suggestions, constant critical supervision and encouragement during the course of investigation.

I wish express my gratitude to honourable **Dr. R.C. Srivastava**, Vice-chancellor, Dr. Rajendra Prasad Central Agricultural University, Bihar, Pusa for their helpful attitude and providing necessary facilities.

I very grateful to the honourable faculty members of the Department of Agronomy, Dr J.P.Singh, Dr. S.K. Choudhary, Dr. I.B. Pandey, Dr. D.K. Roy, Dr.Vikram Bharati Kumar and Mr. Dharmindra for their co-operation and valuable suggestions during the course of my research work.

I obliged to Dr. Santosh Kumar Singh, Jr. Scientist-cum-Asstt. Prof., Department of Soil Science for his help and encouragement.

I cordially acknowledge my sincere thanks to **Government of India** through **ICCR** for providing scholarship, made me feel here as in homeland and successful completion of this study. Obliged to ICCR, Regional Office, Patna for care and comfort especially by Mr. Shatrughna Sinha and Mr. Manoj Kumar.

I also deeply acknowledge my sincere thanks to senior's, junior's and classmates for they been co-operation and helping at every phase of my work.

All sorts of assistance rendered by staff members of Department of Agronomy and all field workers of Irrigation Water Management are fully acknowledged.

I do not have words at my command to express my gratitude and profound admiration to my affectionate and beloved wife, **Gloria Nyonka** and my princesses **Safara** and **Sara**, for their patience, sacrifice and unlimited supporting.

I am much grateful to my church at Samastipur for their blessing and praying.

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CONTENTS

CHAPTER	PARTICULARS	PAGE
1.	**INTRODUCTION**	1-4
2.	**REVIEW OF LITERATURE**	5-37
3.	**MATERIALS AND METHODS**	38-55
4.	**EXPERIMENTAL FINDINGS**	56-98
4.1	**Growth parameters**	56-60
4.1.1	Plant height (cm)	56-57
4.1.2	Leaf area index	57-58
4.1.3	Plant dry matter production (g/m^2)	58-60
4.2	**Yield attributes**	60-63
4.2.1	Number of cobs/plant	60
4.2.2	Number of rows/cob	61
4.2.3	Number of grains/cob	61-62
4.2.4	100-grain weight (g)	62-63
4.3	**Yield studies**	63-68
4.3.1	Grain yield (q/ha)	63-64
4.3.2	Stover yield (q/ha)	65-66
4.3.3	Stone yield (q/ha)	66-68
4.3.4	Harvest index (%)	68
4.4	**System productivity**	69-72
4.4.1	Grain yield of maize-maize cropping system (q/ha)	69
4.4.2	Water-use efficiency (kg/ha-cm)	69-71
4.4.3	Water productivity (₹/m^3)	71-72
4.5	**Weed study**	72-74
4.5.1	Weed population (no./m^2) at knee high and silking stages	72-73
4.5.2	Weed dry weight (g/m^2) at knee high and silking stages	73-74
4.6	**Soil studies**	74-76

4.6.1	Initial and after harvest (pH, EC, OC %)	74-75
4.6.2	Initial and after harvest soil fertility status	75-76
4.7	**Plant analysis**	76-91
4.7.1	**NPK content (%)**	76-82
4.7.1.1	NPK content (%) in grain	77-78
4.7.1.2	NPK content (%) in stover	78-80
4.7.1.3	NPK content (%) in stone	80-82
4.7.2	**NPK uptake**	82-87
4.7.2.1	NPK uptake by grain	82-83
4.7.2.2	NPK uptake by stover	83-85
4.7.2.3	NPK uptake by stone	85-87
4.7.3	**NPK uptake by maize (grain+stover+stone)**	87-91
4.8	**Periodical soil moisture content**	92-93
4.9	**Economics**	93-98
4.9.1	Cost of cultivation	93
4.9.2	Gross returns	93-94
4.9.3	Net returns	95-96
4.9.4	Benefit: cost ratio	96-98
4.10	**Correlation studies**	98
5.	**DISCUSSION**	99-113
6.	**SUMMARY AND CONCLUSION**	114-121
	BIBLIOGRAPHY	i-xx
	APPENDICES	I-VI

LIST OF TABLES

TABLES NO.	PARTICULARS	AFTER PAGE NO.
3.1	Mechanical analysis of the soil of experimental plot	38
3.2	Chemical properties of soil	38
3.3	Rating chart for evaluating the fertility status of soil	38
3.4	Single value physical constants	38
3.5a	Monthly weather data recorded at Agro meteorological observatory, Pusa during crop season 2013-14.	40
3.5b	Monthly weather data recorded at Agro meteorological observatory, Pusa during crop season 2014-15.	41
3.6	Cropping history of experimental plot	41
3.7	Calendar of cultural work	43
3.8a	Details of irrigation during crop 2013-14	45
3.8b	Details of water application during crop season 2013-14	46
3.9a	Details of irrigation during crop 2014-15	46
3.9b	Details of water application during crop season 2014-15	46
4.1.1a	Plant height (cm) of *rabi* maize at different growth stages as influenced by different treatments	55
4.1.1b	Plant height (cm) of *kharif* maize at different growth stages as influenced by different treatments	55
4.1.2	Leaf area index at silking stage as influenced by different treatments	57
4.1.3a	Plant dry matter production (g) of *rabi* maize at different growth stages as influenced by different treatments	59
4.1.3b	Plant dry matter production (g) of *kharif* maize at different growth stages as influenced by different treatments	59
4.2a	Number of cobs/plant, number of rows/cob, number of grains/cob and 100-grain weight (g) of *rabi* maize as influenced by different treatments	62
4.2b	Number of cobs/plant, number of rows/cob, number of grains/cob and100-grain weight (g) of *kharif* maize as influenced by different treatments	62
4.3a	Grain yield, stover yield, stone yield (q/ha) and harvest index (%) of *rabi* maize as influenced by different treatments	68

4.3b	Grain yield, stover yield, stone yield (q/ha) and harvest index (%) of *kharif* maize as influenced by different treatments	68
4.4.1	Grain yield (q/ha) of maize-maize cropping system	69
4.4.2	Water-use efficiency (kg/ha-cm) and Water productivity (₹/m^3) as influenced by different treatments	71
4.5.1	Weed population (no. of weeds /m^2) as influenced by different treatments	74
4.5.2	Weed dry weight (g /m^2) as influenced by different treatments	74
4.6.1	pH, Electric conductivity and Organic carbon of soil as influenced by different treatments	75
4.6.2	Fertility status of soil as influenced by different treatments	76
4.7.1a	NPK content (%) in grain as influenced by different treatments	78
4.7.1b	NPK content (%) in stover as influenced by different treatments	79
4.7.1c	NPK content (%) in stone as influenced by different treatments	81
4.7.2a	NPK uptake by grain as influenced by different treatments	83
4.7.2b	NPK uptake by stover as influenced by different treatments	84
4.7.2c	NPK uptake by stone as influenced by different treatments	86
4.7.3a	Total NPK uptake by maize crop (grain+stover+stone) as influenced by different treatments (*Rabi*)	91
4.7.3b	Total NPK uptake by maize crop (grain+stover+stone) as influenced by different treatments (*Kharif*)	91
4.8a	Periodical soil moisture content (%) before each irrigation in *rabi* and *kharif* seasons 2013-14	92
4.8b	Periodical soil moisture content (%) before each irrigation in *rabi* and *kharif* seasons 2014-15	92
4.9a	Gross returns, Net returns and B: C ratio as influenced by different treatments (*Rabi*)	97
4.9b	Gross returns, Net returns and B: C ratio as influenced by different treatments (*Kharif*)	97
4.9c	Net returns (₹/ha) and B: C ratio of maize as influenced by different treatments (system pooled)	97
4.10a	Correlation coefficient (r) between grain yield and different yield attributes of *rabi* maize (pooled of two years data)	98
4.10b	Correlation coefficient (r) between grain yield and different yield attributes of *kharif* maize (pooled of two years data)	98

LIST OF FIGURES

FIGURE NO.	PARTICULARS	AFTER PAGE NO.
3.1	Climatology conditions during cropping season 2013-14 and 2014-15	41
3.2	Rainfall data during cropping season 2013-14 and 2014-15	41
3.3	Lay out plan of the experiment field	43
4.1.1a	Plant height (cm) at different growth stages of *rabi* maize as influenced by different treatments	55
4.1.1b	Plant height (cm) at different growth stages of *kharif* maize as influenced by different treatments	55
4.1.2	Leaf area index at silking stage of maize as influenced by different treatments	57
4.1.3a	Plant dry weight (g) at different growth stages of *rabi* maize as influenced by different treatments	59
4.1.3b	Plant dry weight (g) at different growth stages of *kharif* maize as influenced by different treatments	59
4.2a	Yield attributes of *rabi* maize as influenced by different treatments	62
4.2b	Yield attributes of *kharif* maize as influenced by different treatments	62
4.3a	Grain yield, stover yield, stone yield (q/ha) and harvest index (%) of *rabi* maize as affected by different treatments (Pooled data)	68
4.3b	Grain yield, stover yield, stone yield (q/ha) and harvest index (%) of *kharif* maize as affected by different treatments (Pooled data)	68
4.4	Water-use efficiency (kg/ha-cm) and Water productivity (₹ /m^3) as affected by different treatments (Pooled data)	71
4.5.1	Number of weeds/m^2 at knee high and silking stages of maize as influenced by different treatments	74
4.5.2	Weed dry weight (g/m^2) at knee high and silking stages of maize as influenced by different treatments	74
4.6a	Total NPK uptake by *rabi* maize crop (grain+stover+stone) as influenced by different treatments	91
4.6b	Total NPK uptake by *kharif* maize crop (grain+stover+stone) as influenced by different treatments	91
4.7a	Gross and Net returns of *rabi* maize as influenced by different treatments	97
4.7b	Gross and Net returns of *kharif* maize as influenced by different treatments	97

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Registration number	**:**	D/Agro/01/2013-14
Degree to be awarded	**:**	Doctor of Philosophy
Department	**:**	**Agronomy**
Major subject	**:**	Agronomy
Minor subject	**:**	Soil Science
Major advisor	**:**	**Dr. Viond Kumar**
Year	**:**	2016
Title of the Research Problem	**:**	**"Influence of mulching on crop productivity and water-use efficiency of maize-maize cropping system".**
Number of pages	**:**	121+ 30 (Table) + xx (Bibliography) + VI(Appendices)

ABSTRACT

A field experiment was conducted at Irrigation Water Management Research field, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar during *rabi* and *kharif* seasons of 2013-14 and 2014-15 to find out the "Influence of mulching on crop productivity and water-use efficiency of maize-maize cropping system". The soil of experimental site was *Entisol*, sandy loam with pH 8.2, low in organic carbon (0.44%), available N (218.22 kg/ha), available P_2O_5 (18.18 kg/ha), and medium in available K_2O (158.27 kg/ha). The experiment was laid out in a split plot design with 20 treatment combinations in three replications. Four moisture regimes in main plots, *viz*. 0.4, 0.6, 0.8 and 1.0 IW/CPE ratios and five mulches in sub-plots, *viz*. 5 and 10 t/ha each of sugarcane trash and maize stover and no mulch were used.

The results revealed that growth parameters like plant height, dry weight production, yield attributes like number of rows per cob, number of grains per cob and 100- grain weight, yields of grain, stover and stone, soil organic carbon, total N, P & K uptake by the corps, gross and net returns were found to be maximum with moisture regime 1.0 IW/CPE ratio and were significantly superior over 0.4 IW/CPE ratio but were at par with 0.8 IW/CPE ratio. Leaf area index, number of cobs per plant, harvest index, weed population, weed dry weight, pH, EC and

available N, P & K in soil were not influenced by moisture regime in *rabi* maize. Moisture regime did not influence all the parameters in *kharif* maize.

Water-use efficiency and water productivity were influenced significantly due to moisture regime. The maximum water-use efficiency and water productivity were observed with 0.4 IW/CPE ratio in *rabi* maize while there was non-significant difference in Water-use efficiency and water productivity due to moisture regime in *kharif* maize.

Moisture regime of 0.8 IW/CPE ratio recorded the maximum B: C ratio in *rabi* maize but was at par with 1.0 and 0.6 IW/CPE ratios while there was non-significant difference in B: C ratio due to moisture regime in *kharif* maize.

Growth parameters like plant height, dry weight production, leaf area index, yield attributes like number of rows per cob, number of grains per cob and 100- grain weight, yields of grain, stover and stone, water-use efficiency, water productivity, soil organic carbon, available N, P & K, total N, P & K uptake, gross and net returns, and B: C ratio were found to be the maximum with maize stover @ 10 t/ha but were significantly superior over no mulch in *rabi* and *kharif* maize. Number of cobs per plant, harvest index, pH and EC were not influenced significantly due to mulching in *rabi* and *kharif* maize.

Weed population and weed dry weight recorded the minimum with maize stover @ 10 t/ha while the maximum with no mulch in *rabi* and *kharif* maize.

Grain yield was found to be highly significant and positively correlated with all yield attributes and was non-significant and negatively correlated with weed population and weed dry weight in *rabi* and *kharif* maize.

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Chapter -1

INTRODUCTION

1 INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop in the world after wheat and rice, occupying an area of 146 million hectares with production of 685 million tons and average productivity of 4.7 t ha^{-1} (FAOSTAT, 2015). The importance of maize ranges in its wide industrial application besides using as human food and animal feed. It is most mutable crop with wider adaptability in many agro-ecologies and has the highest genetic yield potential among the food grain crops.

In India, maize is cultivated throughout the year in most of states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, pop corn and industrial products. It occupies third rank after rice and wheat, having an area of 9.43 million hectares with production of 24.35 million tons and productivity of 2583 kg ha^{-1} (Agricultural Statistics at a Glance, 2014). Maize in India contributes approximately 7.43 percent in national food basket apart from providing employment in downstream agriculture and industrial sectors.

In Bihar, maize is cultivated in about 0.69 million hectares, which is 7.92 per cent of the maize area in the country. The total production is 2.33 million tons with productivity of 3377 kg ha^{-1}, which is higher than the national average (Agricultural Statistics at a Glance, 2014). Maize in Bihar is cultivated throughout the year primarily in *kharif* and *rabi* seasons as pure crop or intercropped with other crops like potato, pigeon pea, coriander, moong and tobacco.

Contrary to rank of maize among cereals in India, its productivity is below the potential productivity compared to world average or other maize producing countries. Thus, there is necessity to have concrete efforts so as to increase productivity of maize to encounter its potential level. Maize was grown traditionally under rainfed or partially irrigated conditions during rainy season. However, very low productivity of maize during monsoon (*kharif*) season may be attributed to a number of factors such as inadequate distribution of rain, water stresses, weeds infestation and nutrients deficiency. As a result the famers are favouring maize cultivation during winter (*rabi*) and spring/summer seasons, when the cropping conditions are more assured and congenial, and totally under irrigated condition. However, farming of maize during *rabi* season has distinctive advantages which have longer period of growth, higher yield with lower nutrient and water requirement. It suffers less from insect-pest disease attacks and infestation of weeds (Singh, 1998).

Water availability is a major barrier to sustainable agricultural production in many arid and semi arid areas of the world. Presently, water crisis is threatening the sustainability of irrigated crops and in turn food security of the world. The future challenge is to maximize agricultural output and minimize the irrigation water consumption at the same time avoiding crop water deficit. For which, there is need to adopt agronomic management practices that limit evaporation losses, reduce runoff and weed growth, increase infiltration, soil moisture content, organic matter content, facilitate nutrients availability in soil, higher crop productivity and water use efficiency.

For increasing yield and water use efficiency, the most appropriate agronomic management practices are cropping system, mulching and irrigation scheduling in case of maize. The ability of the maize crop to grow in different seasons and high productivity, it gives advantages for inclusion in the cropping system as demand for food is increasing. Surface mulch application presents opportunities for utilizing a range of organic or other wastes that may benefit crop, soil and water relations. Crop residue mulching is a promising management option for decreased soil water evaporation with other benefits at much lower cost and also improved soil health. Crop residue mulch on soil surface reduces evaporation, regulates soil temperature and in later stage after decomposition it increases porosity of the soil, infiltration rate, water holding capacity, root penetration and soil aeration, also contributes to soil organic matter content.

Organic mulch also increases soil fauna and flora activities, suppresses weeds and maintains high crop yield (Khurshid *et al.*, 2006 and Zribi *et al.*, 2015). Mulching benefits yield by improving soil physical conditions, including improved stability in the topsoil (De Silva and Cook, 2003). Mulching can be effective in increasing crop production in water scarcity regions, very useful technique in protecting the roots of the plants from heat, cold and that create congenial condition for the growth, reduce salinity, weeds and higher yield and quality of the crop (Bhardwaj, 2013 and Kumar and Dey, 2011). The higher yield and water use efficiency under surface mulch can be achieved compared to no mulch. Mulches significantly increased water holding capacity, facilitated nutrients absorption, reduced weeds competition and increased plant growth.

Mulching conserve water and improve irrigation efficiency in agriculture, especially in the areas where water resources are limited and regulated. There is a need to measure the irrigation requirement of crop on the basis which consider the relationship between crop, soil and climate. Till now, most of the works on scheduling irrigation of crops were based on either soil or plant parameters. These two scheduling approaches do not incorporate the climatic components. Thus, a practical approach has been used for scheduling of irrigation on the basis of irrigation depth: cumulative pan evaporation known as IW/CPE ratio. This approach incorporates soil, plant and atmospheric continuum in a better way.

As generally, yield increases with increase in irrigation while water use efficiency decrease by increases in irrigation water applied. The more favourable water regime established higher yields and water use efficiency (Huang *et al*., 2005 and Dantas Junior and Chaves, 2014). Water use efficiency is the yield of dry matter as a function of the total water used to produce a crop. Productivity and water use efficiency can be increased by improving irrigation scheduling. Maize crop is sensitive for water stresses which may lead to 50 percent or even in total crop failure depending upon severity of stress. However, frequency and depth of irrigation depend upon climatic condition, soil type, crop variety and organic matter content of the soil (Singh, 1998).

There is a challenge to develop novel technologies that allow maize production to be maintained or increased in the wake of declining water availability. The interactive effect of organic mulches, irrigation and soil characteristics need to be better understood to achieve higher productivity and water use efficiency. By applying organic mulches one could greatly retard the loss of moisture from the soil resulting in higher and uniform soil moisture regime thus resulted in reducing irrigation frequency, better soil environment, increase in organic matter content and increased crop yield. Different quantities of crop residue mulches and moisture regimes need to be studied systematically for higher crop yield and water use efficiency.

Keeping these facts in view, the present investigation entitled “Influence of mulching on crop productivity and water use efficiency of maize–maize cropping system” was planned with the following broad objectives:

(i) To study the influence of mulches and moisture regimes on soil properties.

(ii) To find out the influence of mulches and moisture regimes on soil moisture status.

(iii) To evaluate the influence of mulches and moisture regimes on growth and yield of maize.

(iv) To work out the economics.

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Chapter -2

REVIEW OF LITERATURE

2 REVIEW OF LITERATURE

This chapter presents the review of available literature through which attempts have been made to trace briefly about some of the recent research work done in main line of work pursued both within and outside the country and the knowledge of critical evaluation on the different related aspects of the investigation.

Effect of mulching in cropping systems

The ability of the maize crop to grow in different seasons and high productivity of *rabi*/winter, *spring and kharif* maize give it added advantages for inclusion in the cropping system as demand for more food grows. Water use efficiency and precipitation use efficiency increase with residue management practices that increase precipitation storage efficiency, soil surface alterations that reduce runoff, cropping sequences that minimize fallow periods, and use of appropriate management practices for the selected crop (Nielsen *et al.*, 2005). Water is the most important limiting factor of wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.) double cropping systems (Fang *et al*., 2010).

Fang *et al*. (2007) observed that initial soil water influenced mainly by the irrigation and rainfall in the previous crop season is essential to high yield in such cropping systems.

Kar *et al*. (2006) reported that supplemental irrigation had significant effect on grain yield of dry season crops and with two irrigations mean yields of 1845, 785, 905, 1420, 8050 kg ha^{-1} were obtained with maize (grain), groundnut, sunflower, wheat and potato (tuber), respectively. With four irrigations 214, 89, 78, 81, 54% yield was enhanced over two irrigations in respective five crops. Water use efficiency (WUE) of 13.8, 3.35, 3.39, 5.85 and 28.7 kg ha^{-1} was obtained in maize, groundnut, sunflower, wheat, potato (tuber), respectively with four irrigations.

Nielsen *et al.* (2002) concluded that increasing cropping intensity to two crops in 3 years had little effect on water content at wheat planting and subsequent grain yield , while continuous cropping and elimination of fallow reduced soil water at planting by 11, 8 cm and yield by 450 to 1650 kg ha^{-1}.

Li *et al.* (2013) implied that plant growth in the field is the best way to reduce water loss by evaporation and also for improvement of water use efficiency.

Choudhary and Kumar (2014) reported that the productivity of sequential crops was 18-35% higher with mulch application than no mulch. However, the highest maize yield of 4.25 t ha^{-1} was obtained with maize-groundnut cropping system, followed by maize-pea (4.24 t ha^{-1}).

Effect of mulching on growth, yield attributes and yield of maize

Any grass and straw can be used as mulching materials. The effectiveness of mulch application was depending on the moisture or rainfall availability during the time of mulch applications. Application of mulches also helps the farmers to avoid early establishment of weeds population so that it enhance the chance for maize to exploit the limited available moisture in moisture stress area of Borana lowlands (Taye *et al*., 2015).

Mulching is one of the important agronomic practices in conserving the soil moisture and modifying the soil physical environment. Improving the agronomic practices such as mulching in achieving successful soil and water management practices, definitely increase crop production with reduction of water losses and increase water use efficiency. Mulches create a physical barrier to sunlight to work as a photosynthesis inhibitor to suppress weeds. Some mulch has been proven more effective than hand weeding and herbicides in several studies (Bond *et al*., 2003).

Depending on properties of mulch, such as color and albedo, the mulch may result in either an increase or decrease soil maximum or minimum temperatures, but generally all mulches moderate soil temperature fluctuations (Allison, 1973).The effects that organic mulches have on evaporation may be quantified in the calculation of crop evapotranspiration (ETc) by reducing the amount of soil water evaporation by 5% for each 10% of soil surface that is effectively covered by the mulch (Sadafi, 1991).

Organic mulches may also prove better in the long run as they improve soil organic matter and are environment friendly. Mulches increase the soil temperature, retard the loss of soil moisture and check the weed growth, which are the key factors contributing to the production of groundnut (Ramakrishna *et al*., 2006).

Mulching can be effective in increasing horticultural crop production in water scarcity regions, very useful technique in protecting the roots of the plants from heat, cold and that create congenial condition for the growth, reducing salinity, weeds and for higher yield and quality of the crop (Bhardwaj, 2013).

The benefits of the different types of mulching materials for water conservation are weather-dependent and rely on the balance between the water entering the soil from rainfall and irrigation, and the water leaving the soil by evaporation and transpiration (Zribi *et al.,* 2015).

Chaudhry *et al.* (2004) observed that the irrigation requirement of water was the lowest under the polythene sheet and highest under no mulching. The maximum saving of 45% irrigation water was recorded under polythene sheet followed by 30% under rice straw and 15% in mechanical loosening of soil.

Rice straw mulching had a significant effect on conserving initial soil moisture, reducing weed growth, N uptake, apparent nitrogen recovery and promoting root development and thereby improved grain yield of no-till wheat (Rahman *et al.,* 2005).

Sidhu *et al*. (2007) found that mulch reduced soil evaporation and weed biomass by 60%. Amini *et al*. (2013) concluded that wheat straw mulch could be widely employed in the region which is not irrigated due to its significant effect and its easy implementation. However, straw mulch can only decrease water stress and increase wheat yields to certain degree.

In case of soil physical properties, the maximum mean value of infiltration rate and hydraulic conductivity of 19.4 and 88.33 mm hr^{-1} were observed with treatment combination (711.2 mm × 15 Mg ha^{-1}), respectively while soil bulk density decreased by increasing the mulch rate and minimum value of 1.44 Mg m^{-3} (Yaseen *et al*., 2014).

The mulch probably acted as an insulator, resulting in smaller fluctuations in soil temperature, significantly reduced annual total runoff and increased soil water storage in the top 100 cm of soil profile in the straw mulched than in the control (Liu *et al*., 2014).

Over all, mulches have great agro-ecological potential and they typically conserve the soil, improve the soil ecology, stabilize and improve soil properties (Balakirshnan and Duraisami, 2013).

Todd *et al.* (1991) concluded that the presence of a straw mulch significantly reduced evaporation 0 to 0.1 mm d^{-1} under dryland, 0.5 mm d^{-1} under limited irrigation, and 0.9 to 1.1 mm d^{-1} under full irrigation.

Jalota and Arora (2002) showed that straw mulching in maize, cotton and sugarcane decreased irrigation requirement further by reducing unproductive evaporation losses. Straw mulching (6 t ha^{-1}) reduced soil water evaporation component of ET under medium and coarse textured soils by 18.5 and 13.1 cm in maize, 23.8 and 16.6 cm in cotton and 23.6 and 17.6 cm in sugarcane crops, respectively.

Use of mulch restricted the weed growth and significantly lowered the weed parameters under mulching. Density, dry weight, index and persistency index of weed were lower under mulched plot (7.5/m^2. 4.4 g/m^2, 20.6 and 11.6%), respectively (Choudhary and Kumar, 2014).

Kataria *et al.* (1999) reported that mulches maintained higher soil moisture content at 0-30 cm soil depth. It is due to reduced evaporation losses in the presence of insulating layer that was provided by the mulch between soil surface and the atmosphere.

Mulching could improve the crop stands and increase yield by providing an environment for optimal plant growth. Mulches have been shown to induce higher root growth in comparison with unmulched and rain fed treatments (Kumara and Dey, 2011). Application of straw mulches maintained the availability of soil moisture at a depth of 20 cm to 60 cm and improved crop growth and grain yield of maize (Bana *et al*., 2013).

Growth and yield attributing characters differed significantly due to the application of straw mulch and antitranspirant (Brahma *et al.*, 2007a).

Maggard *et al*. (2012) indicated that tree-based mulch benefits plant growth and survival by maintaining greater soil moisture, decreasing competition from weeds, and moderating soil temperatures compared with not using mulch.

Cook *et al.* (2006) concluded that soil water and soil temperature regimes were positively ameliorated by mulches, thereby improving soil conditions for the development of maize. Mulches improved topsoil water retention compared with no mulch. As wheat straw application rate increased, water retention increased and temperature decreased. Inorganic mulches increased soil temperature.

Ji and Unger (2001) showed that mulches are beneficial for controlling evaporation and conserving water by decreasing the initial evaporation rates and increasing the depth of water movement into the soil.

Uwah and Iwo (2011) reported that plant height and number of leaves per plant were maximized at 8 t ha^{-1} rate, while dry stover yield, weight of grains/cob and grain yield/ha peaked at 6 t ha^{-1} rate. The grain yield obtained at 6 or 8 t ha^{-1} rates were more than double than that of the unmulched control plots.

Ibni Zamir *et al.* (2014) observed that maize straw mulch had a significant effect on plant height, cobs per plant, grain rows per cob, 1000 grain weight, grain yield t ha^{-1}, biological yield t ha^{-1}, stalk yield t ha^{-1} and harvest index.

Mulch increased soil organic matter (1.32 g kg^{-1}) and soil moisture contents (17%), but decreased bulk density (1.35 Mg m^{-3}) and soil strength (464 kPa) compared to control. Greater plant height (2.59 m) and grain yield (10.6 Mg ha^{-1}) were obtained from 14 Mg^{-1} and biological yield (20.7 Mg ha^{-1}) from 7 Mg^{-1} in combination with deep tillage (Pervaiz *et al*., 2009).

Higher yield and better crop growth were observed in the mulched plots as compared to no mulched plots under the same irrigation treatments (Zayton *et al*., 2014). Significantly higher leaf area index, water use efficiency and intercepted photosynthetically active radiation (IPAR) were recorded in the mulched plotsn compared to the non-mulched plots under the same irrigation treatment (Kar and Kumar, 2007).

Wang *et al*. (2014) concluded that a reasonable combination application of straw and chemical fertilizers could make full use of surface soil moisture, inhibit soil evaporation, reduce the ineffective evaporation of crop, and increase rain-use efficiency (RUE) at a different growth period of maize and grain yield.

Mulch application at different growth stage of maize shows significant difference at all the growth stages of maize. The highest and lowest grain yields were obtained from mulch applied at sowing time and no mulch, respectively (Taye *et al*., 2015).

Yi *et al*. (2010) showed that the film mulch treatment significantly accelerated development of the crop plants, and markedly increased the shoot dry matter and grain yield.

Yaseen *et al*. (2014) found that the maximum increase in plant height (11.39 %), biological yield (29.56 %) and grain yield (35.5 %) was observed with treatments combination 711.2 mm × 15 Mg ha^{-1} as compared to control.

The application of organic mulches as a soil cover is effective in improving the quality of soil and increasing crop yield, especially in organic farming (Sinkeviciene *et al*., 2009).

Bhardwaj (2013) reviewed that mulch is used to cover soil surface around the plants to create congenial condition for the growth which may include temperature moderation, reduce salinity and weed control.

Ramakrishna *et al*. (2006) showed that weed scores at 30 DAS and at harvest had significant differences. The unmulched plots had greater weed coverage than the polythene and straw mulched plots. Soil mulching, regardless of its kind, causes a decrease in the number and mass of weeds at the beginning of growing period of vegetables. The application of straw at a 20 t ha^{-1} had higher weed-suppressing effect than 10 t ha^{-1} (Kosterna, 2014).

Subhan ud Din *et al*. (2013) recorded that the maximum dry weed was in no mulch treatment (19. 217 g) while maximum plant height (197.34 cm) and grains cob^{-1} (344.75), thousand grain weight (146.27 g) and grain yield (2252 kg ha^{-1}) were recorded in wheat mulch treatments with mould board ploughing followed by rotavator.

Flood irrigated flat sowing with plastic mulch (FIFM) and furrow irrigated raised bed sowing with plastic mulch (FIRBM) showed significantly 7.84 % and 7.12 % more leaf area index respectively, as compared to flood irrigated flat (FIF) sowing without plastic mulch (control) treatment (Hussain *et al.*, 2015a).

Amini *et al.* (2014) showed that plant height, leaf number, leaf area, biological yield and weed biomass of maize were significantly affected by application of wheat straw mulch.

Zhang and Wang (2013) observed that in saline alkaline soil, straw mulch had a relatively significant enhancing effect on the plant height, LAI and yield of drip irrigated cotton. Especially in the middle and later growth stages, straw mulch can enhance cotton growth, increase LAI and finally raise yield. But in non-saline soil, straw mulch did not have a significant enhancing effect on the plant height, leaf area index and yield of drip irrigated cotton.

Khurshid *et al.* (2006) reported that mulch significantly affected the soil physical properties and growth of maize. The soil moisture contents (18.43%), organic matter contents (0.88%), plant height (217.67 cm), total dry matter (27.18 Mg ha^{-1}), number of cobs per plant (1.06), number of grains per cob (610.55) and 1000-grain weight (398.68 g) of maize were maximum when mulch was applied @ 12 Mg ha^{-1}.

Uwah and Iwo (2011) found that soil moisture reserves were highest at 8 t ha^{-1} mulch rate, followed by 6 t ha^{-1} rate. The unmulched control plots had the highest weed infestation, lowest soil moisture reserves, shortest plants and least number of leaves per plant. They showed that the total weed dry matter yield obtained at the control, was over eleven times higher than the 8 ha^{-1} mulch rate and more than six times above the 6 t ha^{-1} mulch rate.

Saeed and Ahmad (2013) observed that the application of mulch either alone or amended with 0.2% gypsum significantly improved vegetative growth (shoot height, fresh & dry biomass) and reproductive parameters (number of fruits, average fruit length and total fruit weight per plant) under different salinity levels. Mulch alone improved total fruit yield of okra 17%, 13% and 31% over control, 0.15% and 0.3% sea salt solution, respectively.

Among the mulches, significantly higher growth parameters as well as grain yield was recorded with black polythene mulch as compared to other mulch whereas, lower growth attributing characters, yield and economics was noticed under no mulch with weedy check (Awasthy *et al.*, 2015).

Mulching increased soil water content and this led to significant improvement in crop growth and yield determining attributes where water was limiting (Singh *et al.,* 2011b).

Awal and Khan (1999) concluded that water hyacinth and rice straw mulches had significant promotive effects on shoot elongation, root penetration, LAI and dry matter accumulation of maize.

Kobayashi *et al.* (2010) concluded that the utilization of stubble mulch in the production of crops under low rainfall condition such as Sub-Saharan Africa is expected to play beneficial roles such as improving soil moisture condition and plant growth and they implied that mulching with pearl millet stalk residues can be effective for plant growth.

Kaur and Mahal (2016) reported that application of paddy straw mulch @ 6 ha^{-1} significantly increased the plant height, dry weight accumulation, yield attributes and yield, water productivity, net returns and B: C ratio of maize as compared to 3 ha^{-1} and no mulch.

Brahma *et al.* (2007b) showed that growth and yield attributing characters increased significantly due to the application of straw mulch and antitranspirant over control.

Iqbal *et al.* (2003) revealed that wheat straw mulch @ 6.7 Mg ha^{-1} significantly affected the growth of maize as it decreased in fresh weight of shoot, increased in leaf area index and water use efficiency over control.

Khurshid *et al.* (2006) resulted that there was no significant difference in three mulch levels applied, but they were significantly higher than control. The maximum 1000- grain weight of 398.68 g was observed with mulching @ 12 Mg ha^{-1} followed by 390.76 g and 386.16 g with mulching @ 8 and 4 Mg ha^{-1}, respectively, while the minimum of 360.63 g was observed in case of control.

Trash mulching @ 6 tones ha^{-1} led to marginal improvement in shoot population, shoot height, shoot dry matter, cane length, cane girth and cane yield over no mulching (Rana *et al.*, 2003).

Khalak and Kumaraswamy (1992) showed that mulching either with rice straw or polythene recorded significantly higher plant height, dry-matter accumulation/plant, leaf area index and yield compared to no mulch.

Kataria *et al.* (1999) resulted that increase in plant height, number of effective tillers/m^2 and dry matter accumulation were found significantly superior due to application of mulch @ 30 t ha^{-1} on fresh weight basis than no mulch.

Mukherjee *et al.* (2010) found that the use of mulch increased 23–57% yield in comparison to no mulch condition. Among different mulches, rice straw and white polythene significantly increased yield to the tune of around 7 Mg ha^{-1} compared to no mulch condition, while black polythene has the capacity to increase yield by 16 Mg ha^{-1} in expense of less water compared to no mulch.

The retention of rice residues as a surface mulch could be beneficial for moisture conservation and yield and for enhanced water productivity in addition to reducing air pollution and loss of soil organic matter (Singh *et al.*, 2011b).

Sounda *et al.* (2006) found that mulch increased the pod yield of groundnut significantly. The higher yield with mulch was attributed due to conservation of soil moisture and regulation of soil temperature by mulch which led to production of higher yield attributes and ultimately higher pod yield.

Khurshid *et al.* (2006) resulted that there was significant difference in grain yield when mulch was applied @ 12, 8 and 4 Mg ha^{-1} as compared with control but there was non-significant difference between mulch applied @ 8 and 12 Mg ha^{-1}.

The tuber number and weight per plant were increased owing to mulching providing congenial environment for tuber development by maintaining soil temperature and conserving soil moisture (Chandra *et al*., 2002). Straw mulch increased the yield and yield components of rice and nutrient uptake was also improved with the physico-chemical properties of the soil which provided better soil environment for crop growth (Das *et al*., 2003).

Mulching plays an important role mainly in soil moisture conservation and in suppressing weed growth. Higher weed biomass reduction, maximum grain yield, plant height, number of spike bearing tillers, spikelets per spike, grains spike^{-1}, 1000-grain weight, straw yield and biological yield were the highest in rice straw mulch @ 4 t ha^{-1} treated plots (Sarwar *et al*., 2013).

Mulch spread on the whole plot increased the grain yield by 60.5% and dry matter yield by 137.8% as compared to unmulched control (Bhatt *et al*., 2004). Mulching is beneficial for moisture conservation and gave higher yield over no mulching under water scarcity conditions (Sadawarti *et al.*, 2013).

Paddy straw mulching in sugarcane significantly improved the crop yield. Singh and Saini (2011) concluded that rice straw mulching @ 4.0 t ha^{-1} can save irrigation water and could prolong irrigation interval without any risk of reduction in sugarcane yield.

Amini *et al.* (2013) observed that the biological and grain yield of lentil in 2 t ha^{-1} with mulch were greater than that of control treatment. Shafi *et al.*, 2010 revealed that grain and stover yields were increased by 3.31 and 5.39% due to mulch.

Sinkeviciene *et al*. (2009) reported that organic mulches significantly decreased soil temperature and weed density, increased soil moisture content, availability of phosphorus and potassium and crop yield.

Huang *et al*. (2005) concluded that straw mulch can only decrease water stress and increase wheat yields to a certain degree. Li *et al.* (2013) reported that non-mulched plots lost 30.2% and wheat straw mulched plots lost 24.5% of the water received during the maize-growing season to evaporation.

Singh *et al*. (2011b) reported that there was a trend for higher biomass production and grain yield of wheat with mulch during two years of experimentation but there were significant differences only during the first year 2006-2007.

Maize dry matter and grain yield were higher with application of plant residues and N fertilizer over addition of *Leucaena prunings* gave the highest maize grain yield on an *Alfisol* in southern Nigeria during both the years (Tian *et al*., 1993).

Dvorak *et al*. (2012) found that grass mulch had a positive effect on increasing the proportion of tuber size fraction above 56 mm. Use of grass mulch and black textile mulch in colder site (highlands) in both treatments had a positive effect on increasing soil temperatures (by 1.3 and 1.6°C) and tuber yields (by 36.1% and 27.3%) compared with control.

Taye *et al*. (2015) concluded that mulching application at planting and vegetative growth stage had significantly more grain yield and yield components than that of at flowering and grain filling stages.

Application of mulch not only improved the productivity but also reduced the number of irrigations. However, due to the high price of synthetic mulch, the economic gain was the maximum under locally available mulch material i.e. straw and leaf mulch (Masant and Mallik, 2009).

Straw mulch (wheat or paddy) produced more pod (17–24%) and haulm yields (16%) of groundnut than polythene mulch (black or transparent) and no mulch because of favorable soil water and soil temperature. It facilitated earlier seedling emergences, more flower and matured pods, lower bulk density and less weeds. Based on 7-year study, Ghosh *et al*., 2006 concluded that organic mulch is superior to inorganic mulch, produced 17–24% higher yield and provided 0.47 t ha^{-1} nutritionally higher quality fodder and additional profit of Rs. 3935 ha^{-1} over no mulch.

Cai *et al*. (2015) reported that the 3-year average soil water storage within the 200 cm soil depth for the maize straw mulch for the whole year (WSM) was increased as compared to without straw mulch (CK) and maize straw mulch only during growth period (GSM); grain yield increased with straw mulch rate. WSM and GSM increased the average grain yield by 4.4% and 2.0% as compared to CK;

the WUE were also increased in straw mulch treatment; however, there were no significant differences in the grain yield and WUE between the mulch @ 9 000 and 13 500 kg ha^{-1}.

Hussain *et al.* (2015a) concluded that number of grains cob^{-1} up to 41.28 % in furrow irrigated ridge sowing with plastic mulch (FIRBM) and 33.81 % in flood irrigated flat sowing with plastic mulch (FIFM) increased as compared to control. Mulching significantly increased the grain yield up to 6.25 % in FIRBM and 4.17 % in (FIFM).

Bhardwaj (2013) concluded that mulching has various beneficial effects on crop production in arid and semi arid regions including an increase in soil moisture (4.7-12.5%), reduced infiltration rate of water (15.35-18.40%), reduces run off (30- 70.5%) and soil erosion (70-85%), reduces weed growth (90-95%), pest control (15.0- 27.35%), maintain soil temperature (0.5C to 7.0°C higher), increases plant growth (12.3-26.9%) and development (23-37%), increases quality produce and yield (7.5-22%), promotes earlier harvest of the crop (7-15 days), reduces fertilizer leaching and protects the surface of the soil against unfavorable factors.

Mulumba and Lal (2008) demonstrated that mulch rates significantly increased available water capacity by 18–35%, total porosity by 35–46% and soil moisture retention at low suctions from 29 to 70%. At high suctions, no differences in soil moisture content were observed between mulch levels. Soil bulk density was not affected by mulch rate. Also they determined that optimum mulch rates of 4 Mg/ha for increased porosity and 8 Mg/ha for enhanced available water capacity, moisture retention and aggregate stability.

Singh *et al.* (2011a) conducted an experiment on a clay loam soil in Punjab, India and concluded that mulch lowered total soil evaporation over the crop growth season by 35 and 40 mm in relatively high and low rainfall years, respectively and also had higher biomass production and grain yield with mulch but with significant differences only in 2006–2007.

Pervaiz *et al.* (2009) observed that mulch increased soil organic matter (1.32 g kg^{-1}) and soil moisture contents (17%), but decreased bulk density (1.35 Mg m^{-3}) and soil strength (464 kPa) compared to control. Greater plant height

(2.59 m) and grain yield (10.6 Mg ha^{-1}) were obtained from mulch addition @ 14 Mg ha^{-1} and biological yield (20.7 Mg ha^{-1}) from mulch @ 7 Mg ha^{-1} in combination with deep tillage.

Moitra *et al.* (1996) concluded that green and dry straw mulches conserved 1.5% and 13.7% more water than no mulch treatment in the top 500 mm of the soil profile. As compared with the no mulch condition, grain yield was increased by 47%, 43% and 16%, respectively under green, straw and soil dust mulching under low rainfall.

Dry stover yield increased significantly with each increment in mulch rate up to the 6 t ha^{-1} rate but not further. Increasing the mulch rates from zero to 2, 4, 6 and 8 t ha^{-1} resulted in corresponding increase in dry stover yield by 19.0, 34.3, 63.4 and 83.5%, respectively (Uwah and Iwo, 2011).

Organic mulching was effective in conserving soil moisture, buffering drastic changes in soil temperature and increasing crop yield (Naeini and Cook, 2000).

Shen *et al.* (2012) indicated that straw mulching could significantly improve soil moisture content at a depth of 20-80 cm below the ground surface during the anthesis-silking stages; however, at maturity, straw mulching decreased the soil moisture content at depth of 0-60cm below the ground surface.

Sunitha and Kalyani (2012) reviewed that reduction in grain yield of maize due to weed infestation ranged from 40 to 60 percent depending upon the intensity and type of weed flora.

Chakraborty *et al.* (2008) concluded that under limited condition, rice husk (RH) mulching will be beneficial for wheat as it is able to maintain better soil and plant water status, leading to higher grain yield and enhanced water use efficiency.

In the sub-mountainous north western Himalayan region of India, Sharma *et al*. (2010) observed that mulching was very beneficial for enhancing moisture and nutrient conservation, resulting in increased productivity and improved soil condition for the maize.

Masant and Mallik (2009) observed that application of surface mulch enhanced the productivity significantly by improving soil moisture status over no mulch treatment and use of white polythene mulch found to be better compared to black polythene as well as straw and leaf mulch. Tolk *et al*. (1999) reported that mulch increased grain yield by 17%, above biomass by 19% and water use efficiency by 14% compared with bare soil treatments.

Sharma *et al.* (2009) concluded that inadequate moisture supply under no mulching resulted in low grain yield which was due to deleterious effect on most of the physiological process of the crop.

Lal (1974) concluded that increase in grain yield by mulching was attributed primarily to decrease in soil temperature and partly to improve soil moisture regime.

Qamar *et al.* (2015) concluded that wheat yield parameters were significantly higher in Plastic mulch at 4 t ha^{-1} than other mulch materials. Happy seeder and deep tillage along with plastic mulch have positive impact on soil physical properties, root growth, water use efficiency and yield parameters by creating a favorable soil environment.

Rajput *et al.* (2014) observed that mulching treatments improved grain yield significantly and highest grain yield of 52.32 q ha^{-1} was recorded with the application of paddy straw mulch followed by green weed mulch (50.11 q ha^{-1}) and dust mulch (49.38 q ha^{-1}) and all the mulching treatments produced significantly higher grain yield than control (48.39 q ha^{-1}). Kumar (2015) reported that application of straw mulches significantly increased all the growth attributes, grain yield, stover yield and nutrient uptake by maize. He reported that application of straw mulches significantly increased all the growth attributes, grain and stover yields, nutrient content and uptake, protein content, net returns and B: C ratio of maize.

Sharma *et al.* (2009) resulted that mulching significantly increased the maize and wheat yield. The higher grain yield of maize (1.91 t ha^{-1}) and wheat (0.63 t ha^{-1}) was recorded under polyethylene mulch followed by straw mulch

(1.77, 0.61 t ha^{-1}), respectively. This was due to decrease in the evaporation and availability of adequate soil moisture for longer period.

Giri *et al.* (1983) concluded that application of straw mulch significantly increased the yield of grain by 23.9% and straw by 23.1% in wheat grown on unirrigated dryland of northwest India. Yield increase of 55-78% (first season) and 108-142% (second season) were observed in film mulch treatment relative to the control (Mbah *et al*., 2010).

Kataria *et al.* (1999) reported that number of grains per ear, 1000 grain weight, grain yield and straw yield were improved significantly with mulch compared to no mulch.

Singh *et al.* (2014) reported that mulching increased yield, water productivity and profitability while decreasing weed pressure.

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% of the recommended irrigation, while the highest phosphorus and potassium with it availability of moisture up to 70% and 85%, respectively.

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

Application of straw mulch significantly increased the available phosphorus and potassium in the soil and also higher yield and better crop growth which might be due to conservation of soil moisture and reduction of soil temperature by 4 - 6 ºC (Kar and Kumar, 2007).

Decrease in soil pH and soil salinity was slightly pronounced in surface layer compared to subsurface layers in mulched treatments under organic farming system (Alharbi, 2015).

In case of soil chemical properties, the treatment combination of 711.2 mm × 15 Mg ha^{-1} showed highest values of SOC, soil nitrogen, phosphorus and potassium i.e. 0.55 g kg^{-1}, 0.64 g kg^{-1}, 15.48 ppm and 144.67 ppm, respectively

(Yaseen *et al.*, 2014). The use of leaf mulch as a soil cover is effective in improving yield and soil fertility. All the mulched plots significantly increased organic carbon (OC), available nitrogen (N), phosphorus (P) and potassium (K), bacterial and fungal population compared to unmulched plots (Kumar *et al.*, 2014).

Tian *et al*. (1993) concluded that nutrient uptake was enhanced by applications of plant residues. *Leucaena* prunings had the highest effect and increased the mean N, P, and Mg uptake by 96%, 84%, and 50%, respectively while *Acioa* prunings increased K and Ca uptake by 59% and 92%, respectively, over the control on an *Alfisol* in southern Nigeria in 1990 and 1991.

Bhardwaj (2013) reviewed that organic mulches add organic matter and plant nutrients to the soil and improve the physical, chemical and biological properties of the soil after decomposition which in turn increased crop yield. Soil under the mulch remains loose, friable and leading to suitable environment for root penetration.

Chaudhry *et al.* (2004) concluded that a maximum decrease of 53% in EC_e of 0-15 cm soil was observed under mulching treatment T_2 (rice straw), which was followed by T_4 (mechanical loosening of soil) and T_3 (polythene sheet). Conversely, a slight increase in EC_e was found in control plots T_1 (no mulching).

Uwah *et al.* (2012) concluded that mulch application reduced soil bulk density, increased soil moisture retention capacity and lowered weed infestation over no mulch. It also raised the soil pH, organic matter content, total N, available P, exchangeable K, Ca and Mg status of the soil.

Kumar and Dey (2011) concluded that both the mulch materials viz. hey mulch and black polyethylene were effective in enhancing root growth, nutrient uptake, WUE and yield. Application of mulch enhanced the root growth (63%), nutrient uptake (179.2%), WUE (84.4%) and yield (343%) under drip irrigation (DI). However, respective increase under surface irrigation (SI) was 23.6, 83.8, 109.4 and 219.2%.

Balakirshnan and Duraisami (2013) concluded that application of dried weed mulch @ 10 t ha^{-1} recorded highest water holding capacity, available N, P and K in maize as compared to 5 t ha^{-1}.

Das *et al.* (2003) concluded that straw mulch increased the yield and yield components of rice and nutrient uptake and also improved he physico-chemical properties of the soil which provided better soil environment for crop growth.

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.

Shafi *et al.* (2010) concluded that mulch improved stover N uptake by 2.23%. Total soil N and organic matter was non significantly increased by 5.63 and 2.38% due to mulch.

Wheat straw incorporation in green gram had a positive residual effect on wheat yield and nutrient uptake. The incorporation of wheat straw increased NPK uptake by green gram and seed yield (Surya *et al.*, 2000).

***Effect of mulching on water use efficiency*:**

Irrespective of mulching, WUE was highest under moderately wet (CPE_{50}) soil environment. Among different mulches, black polythene was responsible for attaining the highest WUE value (25.1 kg m^{-3}) which declined by 22, 21 and 39% under white polythene, rice straw and no mulch, respectively (Mukherjee *et al.*, 2010).

Chandra *et al*. (2002) revealed that the water use efficiency (WUE) was more (39.9%) with mulch over on mulch. Among the moisture conservation practices, the highest (263 mm) consumptive use of water was observed in M_0-control followed by M_1-straw mulch (248 mm) and M_2-antitranspirant (242 mm). The highest WUE was recorded with M_2- antitranspirant (8.86 kg ha^{-1} mm^{-1}) followed by M_1-straw mulch (8.49 kg ha^{-1} mm^{-1}) and least in M_0-control (8.01 kg ha^{-1} mm^{-1}) (Brahma *et al.*, 2007b).

Ji and Unger (2001) concluded that soil wetting depth increased with increases in mulch rates. Straw mulching has potential for increasing soil water storage from small amounts of precipitation.

Sadawarti *et al.* (2013) found that straw mulching gave higher yield over no mulching in all grades tubers and also higher WUE, net income and higher net returns Rs ha^{-1}.

Wang *et al*. (2014) observed that straw incorporation significantly increased surface soil moisture at the grain filling stage of maize and significantly improved rainfall-use efficiency (RUE) in the whole growth period of maize.

Peng *et al*. (2015) observed that the soil water content in 0-200 cm soil layer increased by 0.7-22.5% in mulched plot compared with control while the WUE increased significantly by 30.6, 32,7 and 24.2% with mulching @ 9 t ha^{-1}, 6 t ha^{-1} and 3 t ha^{-1}, respectively.

Huang *et al*. (2005) stated that straw mulch increased wheat yields significantly during both dry (1997) and wet (1998) years. It increased biomass and grain yield by 37 and 52%, respectively in 1997 and by 20 and 26%, respectively, in 1998. Straw mulch also significantly decreased evapotranspiration, soil water depletion, and increased water-use efficiency.

Hussain *et al.* (2015a) concluded that plastic mulch and different irrigation levels significantly increased the water use efficiency up to 22.43 % in furrow irrigated raised bed sowing with plastic mulch (FIRBM), 10.97 % in flood irrigated flat sowing with plastic mulch (FIFM) and 4.60 % in case of furrow irrigated ridge sowing with plastic mulch(FIRM).

Surface mulch has significant effect in reducing evaporation and decreasing soil salinity level (Yang *et al.*, 2006). They indicated that concrete slab mulch and straw mulch was effective in conserving soil water compared to plastic film mulch which increased soil temperature.

In semiarid farmland at high altitude, mulching ridges can increase soil water content in the 0 to 200-cm soil layer when compared with not mulching (Liu and Siddique, 2015).

Shah (2013) concluded that wheat straw mulch depicted 14.4 and 6.8 % reduction in total amount of water applied; 8.6 and 2.2 % reduction in ETa; 58.2 and 33.1 % increase in soil water storage in comparison with control (no mulch) and farm manure mulch, respectively in wheat season.

Soil quality in terms of increased organic matter content, water retention, infiltration of water and aggregation, and decreased bulk density of the surface soil was improved in the minimum tillage with 3 Mg ha^{-1} crop residue mulch relative to other treatments (Ghuman and Sur, 2001).

Abouziena *et al.* (2015) reviewed that soil mulching raised soil water storage (up to 41%), raised water use efficiency by 14% and cut water loss from 0 to 30 cm soil depth.

Sounda *et al.* (2006) indicated that straw mulches had a positive influence on WUE of groundnut crop. Higher WUE under mulched condition was obtained due to production of higher pod yield and at the same time lower CU of water.

Unger and Jones (1981) suggested that having the mulch in place during the growing season increased the use efficiency of growing season rainfall. Mulch at 8 t ha^{-1} increased water use efficiency of sorghum by 19% over the no mulch treatment.

Shen *et al.* (2012) indicated that under rainfed conditions in northern China, straw mulching could increase the grain yield and water use efficiency of compact-type maize.

Unger (1978) reported that water-use efficiency increased from 55.6 kg/ha-cm for no mulch to 115.0 kg/ha-cm for 12 metric tons mulch/ha.

The addition of mulch was one way of overcoming drought because mulch reduced the rate of evaoptranspiration, increased water use efficiency and soil conservation, reduced evaporation and run off, supplied organic materials, maintained soil aggregation, soil porosity, and weed control (Doring *et al*., 2006).

Application of mulch increased moisture extraction, water use efficiency, grain and straw yield of wheat crop. Incorporation of leaf mulch at 30 days after harvesting of maize crop conserved higher moisture content for wheat sowing (Sharma *et al.*, 1998).

Sharma *et al.* (2009) reported that the highest net returns of Rs 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 (Rs 6222 and 6105; 0.84 and 0.82).

Singh *et al*. (2015) reported that mulching significantly increased yield attributes, grain yield, water-use efficiency, net returns and B: C ratio of *spring* maize over no mulch.

Effect of irrigation on growth, yield attributes and yield of maize

Yi *et al*. (2010) showed that the irrigation treatment induced more rapid development in the vegetative stage than the rainfed treatment and increased the shoot dry matter and grain yield.

Mathukia *et al*. (2014) revealed that irrigation at 0.8 IW:CPE being at par with 1.0 IW:CPE enhanced growth and yield attributes and thereby green cob and fodder yield along with higher net returns and B:C ratio over irrigation at 0.6 IW:CPE.

Singh (2003) reported that plant height, number of leaves per plant, leaf area index and dry matter accumulation were increased significantly with increasing of irrigation frequencies.

Baloch *et al.* (2014) concluded that growth and yield of wheat crop were increased with increase in irrigation frequency. Five irrigations produced maximum growth and yield as compared to four and three irrigations.

Niveditha and Nagavani (2016) observed that plant height, leaf area index and dry matter production of maize were significantly influenced by irrigation regimes. Higher plant height, leaf area index and dry matter production, respectively were recorded under IW/CPE ratio of 1.0 which was at par with IW/CPE ratio of 0.8 while minimum of these characters were obtained with IW/CPE ratio of 0.6.

Under CPE_{25} (five irrigation), tomato crop recorded significantly higher leaf area index over CPE_{50} (two irrigation) and rainfed condition (Mukherjee *et al*., 2010).

Anjum *et al.* (2014) observed that plant height, dry matter weight, grain yield and harvest index were all quadratically related with irrigation frequency. The variables performed better in 2 and 6 day frequency plots compared with those of 4-day plots.

In general, increasing irrigation frequency from 40 mm CPE to 20 mm CPE increased plant height and P uptake and it was highest with 20 mm CPE (Sadawarti *et al.*, 2013).

The amount of irrigation water was equal to 40%, 60%, 80%, 100% and 120% of the potential evapotranspiration (ET_P) values based on class-A pan. The results showed that the vegetative growth parameters were improved as a result of applying higher irrigation levels compared to lower levels (Hassan and Ali, 2014).

Gupta (1991) reported that plant height of maize was significantly affected by irrigation. The height of maize plant increased significantly with increasing levels of irrigation except at 30 and 60 days stages of crop. Maximum plant height of 118.56 cm was recorded with 8 irrigations scheduled at 1.4 IW/CPE ratio while minimum plant height was noticed at 0.6 IW/CPE ratio.

Mathukia *et al*. (2014) indicated that irrigation significantly influenced growth attributes of maize (plant height, leaf area index and dry matter per plant). The highest plant height (173 cm), LAI (3.68) and dry matter per plant (145 g) were recorded with 1.0 IW/CPE ratio which was at par with 0.8 IW/CPE ratio.

Amini and Alami (2013) concluded that irrigation of lentil at 70 mm on the basis of evaporation from class A pan and application of 2 t ha^{-1} mulch was the best combination for lentil growth and production.

Ibni Zamir *et al.* (2014) concluded that maize stalk mulch applied with 7 irrigations enhanced growth and yield of the crop, improved the quality content of the maize grains as well improved soil physical condition.

Awasthy *et al.* (2015) conducted an experiment on silty clay loam soil at Raipur (Chhattisgarh) and revealed that the plant height, number of leaves plant^{-1}, leaf area duration, dry matter production, grain yield, net return and benefit: cost ratio were significantly higher in drip irrigation at 125% PE, which was at par with drip irrigation at 100% PE.

Gupta (1991) concluded that leaf area index, dry matter accumulation and crop growth rate were recorded significantly higher with increasing frequencies of irrigation.

Anjum *et al.* (2014) concluded that plant height, dry matter weight, grain yield and harvest index were all quadratically related with irrigation frequency.

Shinde *et al.* (2014) found that the plant height, dry matter production per plant and 1000 grain weight increased significantly when irrigation scheduled at 0.75 IW/CPE ratio compared with critical growth stages.

Iqbal *et al.* (2003) showed that the maximum plant growth was noted in the case of 100 % crop water requirement followed by 60% crop water requirement and 80% crop water requirement in most of the cases for all the growth parameters studied.

Khalak and Kumaraswamy (1992) concluded that irrigation water given at frequency intervals I.0 IW/CPE and in smaller quantities 20 mm resulted in the improvement of growth attributes, dry-matter accumulation and tuber yield in potato.

Giri and Bandhopadyay (2009) revealed that irrigation did not significantly influence the growth attributes but significantly influenced the yield component, length of cob and grain yield.

Hatlitligil *et al*. (1984) observed that there was only a small benefit to grain and stover yields from the higher soil moisture levels provided in the field experiments because of very favorable rainfall amount and distribution in that year.

Kuscu *et al.* (2013) reported that the full irrigation was the best choice for higher yield and net income. They also suggested that 25% deficit irrigation approach may be a good strategy for increasing water use efficiency when full irrigation was not possible.

Khatun *et al.* (2012) showed that irrigation significantly increased plant height, leaf area index and total dry matter. The highest growth characters were obtained under two irrigations compared to one and no irrigation. Increasing moisture stress resulted in progressively less leaf area, crop growth rate, plant height, shoot dry matter and harvest index (Pandey *et al.*, 2000).

Abbas *et al*. (2005) reported that yield parameters of maize like cobs plant^{-1}, grains cob^{-1} and mean grain weight were influenced significantly by different irrigation schedules. The grain yield increased with increasing irrigation. Maximum grain yield of 7.0 t ha^{-1} was recorded with (-8 bars) irrigation schedule.

Shirazi *et al.* (2011) concluded that irrigation regimes significantly affected yield and yield attributes of maize. The highest grain yield of 6.77 t ha^{-1} was obtained with 0.5 IW/CPE ratio.

Aulakh *et al.* (2013) observed that growth parameters like plant height, number of leaves per plant, leaf area index, dry matter accumulation, crop growth rate and relative growth rate were significantly higher under higher irrigation regimes of 1.25 IW/CPE ratio (three irrigations) in late *kharif* maize.

Djaman *et al.* (2013) concluded that the leaf area index, biomass production, grain yield, and harvest index were significantly affected by the irrigation regimes. Maize yields varied from 9.05 Mg ha^{-1} for the rainfed treatment to 15.5 Mg ha^{-1} for fully irrigated treatment in 2009 and from 11.7 to 15.5 Mg ha^{-1} for the respective treatments in 2010.

Sridhar *et al.* (1991) reported that irrigation at IW/CPE ratio of 1.0 and 1.2 significantly increased all the yield attributes except girth of cob, resulting in higher yield of maize.

Khan and Parvej (2010) reported that mulching practices on maize enhanced the number of ears plant^{-1}, number of seed rows ear^{-1} and seeds row^{-1}, 1000 grains weight, weight of rachis ear^{-1}, grain yield and higher harvest index.

Singh *et al*. (2011b) showed that there was no effect of irrigation treatment in the first year because of well-distributed rains. But in the second year, yield decreased with decrease and delay in the number of irrigations between crown root initiation and grain filling stages.

Tafrishi *et al.* (2013) reported that limited irrigation significantly decreased grain yield and biomass of maize by decrement of water amount.

Bandyopadhyay (1997) reported that a higher rainfall and its good distribution during growing seasons, resulted in sizeable deep drainage and non-significant yield response to irrigation regimes.

Ibni Zamir *et al.* (2014) showed that irrigation levels had a significant effect on plant height, cobs per plant, grain rows per cob, 1000 grain weight, grain yield t ha^{-1}, biological yield t ha^{-1}, stalk yield t ha^{-1} and harvest index. All these characters were the maximum at 7 irrigations.

Tyagi *et al.* (1998) observed that increasing irrigation levels significantly increased the grain and stover yields. The highest grain and stover yields were obtained at 0.4 and 0.6 ID/CPE ratios over that of 0.2 ID/CPE ratio.

Irrigation or a combination of irrigation and straw mulch may be the best option in achieving high crop yields and advancing the sustainable development of the agriculture in the region (Amini *et al*., 2013).

Shinde *et al.* (2014) showed that the irrigation scheduled at 0.75 IW/CPE ratio recorded significantly higher grain yield and stover yield of maize over scheduling of irrigation at critical growth stages.

Singh *et al.* (1997) revealed that dry matter was recorded higher under 1.2 IW/CPE ratio and decreased with decreasing moisture availability under different treatments.

AI-Kaisi *et al.* (1997) concluded that both grain yield and dry matter of wheat increased significantly with the increase in water application rates up to l.0 ET application rate.

Parihar and Tiwari (2003) found that irrigation applied at 1.2 IW/CPE ratio gave significantly higher yield than 0.6 and 0.9 ratios and also total nutrient uptake was positively influenced by irrigation while the WUE decreased with the increase in frequency of irrigation.

Bozkurt *et al.,* (2011) reported that irrigation levels significantly affected yield and yield contributing parameters. The average corn grain yields varied from 1.93 to 10.4 t ha^{-1}. The highest grain yield and yield components were found in 120% of evaporation while the lowest were found in 20% of evaporation treatment.

Gupta (1991) reported that there was significant increase in yield equivalence up to 1.2 ratio (92.84 qha^{-1}) with seven irrigations followed by 1.4 (92.71 qha^{-1}), 1.0 (89.22 qha^{-1}), 0.8 (78.92 qha^{-1}) and 0.6 (63.66 qha^{-1}), respectively.

Bandyopadhyay (1997) reported that yield and yield attributes of wheat were significantly influenced by moisture regimes and were decreased with decrease in number of irrigations. The maximum grain yield of 3111 kg /ha was obtained at 1.2 IW/CPE ratio.

Irrigations scheduled at five critical growth stages of wheat resulted in significantly higher grain yield (2545 kg ha^{-1}) over one, two and three irrigations but was on par with four irrigations (Brahma *et al.*, 2007a).

Shivakumar *et al* (2011) reported that scheduling irrigation for baby corn at 1.0 IW/CPE ratio throughout was desirable to obtain higher baby corn and green fodder yield under assured available irrigation water and frequent irrigation at IW/CPE ratio of 1.0 also recorded higher water use efficiency.

Adamu *et al*. (2014) resulted that significantly higher grain yield, number of grains row^{-1}, 100 seed weight, plant dry weight g $plant^{-1}$, harvest index and lower WUE were at 0.8 IW/CPE ratio (6 irrigations) followed by 4 irrigations at critical stages of maize.

Amandu *et al*. (2015) conducted an experiment at DRPCAU, Pusa and reported that grain, stover and stone yields of maize was influenced significantly due to irrigation regime. The maximum values were recorded at 1.0 IW/CPE ratio which was statistically at par with 0.8 IW/CPE ratio.

Saren and Jana (1999) reported that three irrigations gave maximum seed yield of maize, the increase being 33.5% over rainfed while 10.6 and 16.6% with 1 and 2 irrigations.

Amini *et al.* (2013) showed that among irrigation treatments, the highest grain and biological yield and harvest index of lentil was observed with 40 mm evaporation.

Huang *et al*. (2005) observed that biomass and grain yield of wheat increased with increasing irrigation in two years. The three irrigation levels increased the biomass yield from 34 to 66% in first year and from 34 to 77% in second year. The irrigation levels also increased grain yield from 53 to 102% in first year and from 22 to 57% in second year. Water-use efficiency for biomass and grain yield also increased with increasing irrigation.

Recommended amount of irrigation water along with the adequate supply of macronutrients play an important role in increasing yield and yield components of maize crop (Hussain *et al.*, 2015b)**.**

Singh (2003) observed that in both season, there was significant increase in yield (in terms of maize equivalence) up to 1.25 IW/CPE ratio (129.21 and 148.41 q/ha) with six to seven irrigations followed by 1.00 (124.00 and 142.26 q/ha), 0.75 (114.38 and 130.24) and 0.50 (102.82 and 116.70), respectively, however 1.25 was at par with 1.00 IW/CPE ratio.

Aslam *et al*. (2014) showed that plant height, biological yield, grain yield and harvest index of wheat differed significantly with irrigation scheduling.

Tiapodia and Singh (2013) reported that numbers of plants per plot at harvest, number of grains per cob, 1000 grain weight, biological yield, grain yield and harvest index were significantly affected by different irrigation levels. 6 irrigations were found to be more efficient than 5 and lower irrigation.

Singh *et al.* (1997) resulted that moisture regimes had significant effect on yield and yield attributes of maize. Maximum values were obtained under 1.2 IW/CPE ratio followed by 0.9 + 1.2 IW/CPE ratios.

Hussain *et al.* (2015b) found that irrigation levels significantly affected stem diameter, leaf area index, grain weight per cob, 1000 grain weight, grain yield and biological yield of maize. There showed that full irrigation enhanced leaf area index (2.1), stem diameter (2.00), grain weight per cob (124.71g), 1000- grain weight (0.29 kg).

Saif *et al.* (2003) concluded that the different irrigation levels significantly affected number of plants per plot at harvest, number of grains per cob, 1000 grain weight, biological yield, grain yield and harvest index of maize. Maximum grain yield (7.49 t ha^{-1}) was obtained at 6 irrigations.

Roy *et al*. (2015) revealed that application of irrigation significantly influenced the plant height, dry matter accumulation, leaf area index, number of cobs per plant and number of grains per cob. The maximum values of these components were recorded with IW/CPE ratio of 0.75 in maize.

Khaksar *et al.* (2013) showed that the effect of deficit irrigation and water stress were significant on grain yield of corn. Both grain and biological yields reduced in response to stress intensity. The highest rates of grain and biological yields, harvest index (HI) and water use efficiency (WUE) were obtained in full irrigation treatment.

Payero *et al.* (2008) observed that irrigation significantly affected dry matter production and partitioning into the different plant components (grain, cob and stover) and also significantly affected yields which increased with irrigation up to a point where irrigation became excessive.

Sounda *et al.* (2006) observed harvest index was significantly increased with the increase in irrigation frequency from I_0 (rainfed) to I_4 (four irrigations) and the highest value was recorded in I_3 (three irrigations). However, the lowest harvest index was· always obtained under rainfed condition due to production of lower yield under stress condition.

Hajibabaei and Azizi (2012) reported that there was significant difference on number of grains per cob as influenced by irrigation regimes. The reduction in the number of grains may be due to increasing irrigation periods.

Ko and Piccinni (2009) considered that irrigation management of corn at 75% ET_C was feasible with 10% reduction of grain yield and with increased water use efficiency. The greatest WUE (1.6 g $m^{-2}mm^{-1}$) achieved at 456 mm of water input while grain yield appeared to reach a plateau (~ 8 t ha^{-1}) at less than 600 mm.

The grain yield and biomass yield increased progressively with water application. The highest grain yield and biomass yield of 1.06 t ha^{-1} and 6.95 t ha^{-1} were observed with full irrigation, while the lowest grain yield and biomass yield of 0.71 t ha^{-1} and 3.48 t ha^{-1} were observed in the lowest irrigation treatment as a result of moisture availability that contributed to the yield (Faloye and Alatise, 2015).

Kaur and Mahal (2016) reported that irrigation significantly increased dry matter accumulation, yield attributes, grain yield, net returns and B: C ratio of maize. The maximum values were obtained with 1.0 IW/CPE ratio.

Samghani *et al.* (2015) concluded that the effect of irrigation interval was significant on traits such as plant height, number of pods per plant, test weight for 100 seeds, and pod length. Most of these traits were resulted in an 8-day-irrigation interval.

The higher grain yield observed in five and four irrigation schedules which are due to frequent irrigations provided in these treatments (5 and 4) might have maintained adequate available soil moisture (ASM) in the root zone throughout the crop growth period (Brahma *et al*., 2007a).

Amanullah *et al.* (2010) found that IW/CPE ratio of 1.0 was yielding maximum with 5 irrigations applied at different stages of crop growth and also indicated that the water use efficiency was decreased with the increase of water use or irrigation frequency.

Bello (2008) suggested that optimum production of maize could be realized with rainfed supplementary irrigation. Kresovic *et al*. (2016) indicated that the irrigation regime of 25% water saving (I_{75}) could ensure satisfactory grain yield of maize and increment of WUE.

Kara and Biber (2008) reported that irrigation frequencies significantly affected corn crop yields. The average corn grain yields varied from 7.98 to 29.16 t ha^{-1}. The treatment irrigation at 15% available soil water recorded significantly higher corn grain yield (29.16 t ha^{-1}) compared to irrigation at 50% available soil water (21.59 t ha^{-1}), irrigation at 30% available soil water (19.15 t ha^{-1}) and no irrigation (control) (7.98 t ha^{-1}), respectively.

Haghjoo *et al.* (2013) showed that the irrigation at moisture depletion of 20% from FC had significantly higher grain yield, 1000-kernel weight, grain numbers per ear, harvest index and biological yield than 40, 60 and 80% moisture depletion from field capacity.

Singh and Mohan (1994) concluded that the yield and yield attributes of sugarcane were highest and irrigation efficiency was the maximum when irrigation was applied at IW/CPE ratio of 1.0. Water use efficiency decreased with increase in irrigation levels.

Khatun *et al.* (2012) found that irrigation significantly increased cob length, number of rows cob^{-1}, number of grains cob^{-1}, 1000-grain weight, grain yield, stover yield, biological yield and harvest index. The highest yield and yield attributes were obtained under two irrigations compared to one and no irrigation.

Niveditha and Nagavani (2016) reported that the yield attributes of maize were increased with increase in irrigation levels from 0.6 to 1.0 IW/CPE ratio. IW/CPE ratio of 1.0 produced significantly higher grain and stover yield which was at par with IW/CPE ratio of 0.8.

Irrigation scheduling at 0.8 IW/CPE ratio resulted in significantly the highest grain yield (1677 kg ha^{-1}), protein content (20.85 %) and significantly higher stover yield (4858 kg ha-1) and gave the highest net monetary returns of Rs.37591 ha^{-1} with maximum B:C ratio of 2.34 (Kumbhar *et al.*, 2015).

Aulakh *et al*. (2013) reported that the grain yield under irrigation regimes of 1.25 IW/CPE ratio (three irrigations) and 1.00 IW/CPE ratio (three irrigations) was observed to the tune of 83.1 and 81.2 q/ha, respectively, which were statistically at par with each other but was significantly higher than the grain yield observed under 0.75 IW/CPE ratio (two irrigations) and 0.50 IW/CPE ratio (one irrigation).

Domber *et al.* (2009) indicated that significantly higher seed yield of 1938 kg ha^{-1} was recorded with 0.8 IW/CPE ratio irrigation as compared to 0.4, 0.6 IW/CPE ratios and critical stages.

Gupta (1991) concluded that the total uptake of N, P and K was significantly affected by irrigation. The highest total uptake of N (103.06 kg/ha) and P (39.52 kg/ha) was recorded at 1.0 IW/CPE ratio, while K (83.43 kg/ha) was recorded at 1.4 IW/CPE ratio in maize.

Hussaini *et al.* (2008) reported that irrigation frequency influenced nutrient concentration and accumulation in maize very minimally but increased frequency significantly increased concentration and accumulation for certain nutrients.

Kaur and Mahal (2014) observed that the maximum uptake of N, P and K by grain and straw were obtained with irrigations at 30 mm CPE and they were significantly better than 50 and 70 mm CPE.

Mathukia *et al*. (2014) showed that different irrigation schedules imparted their significant influence on N and P uptake by grain and stover of maize crop. Irrigation at 1.0 IW: CPE ratio registered significantly the highest uptake of N and P and it was at par with 0.8 IW: CPE ratio.

Kumar *et al.* (2000) reported that total uptake of N, P and K nutrients increased significantly with increase in irrigation level. The highest nutrients uptake was recorded with 0.8 IW/CPE compared to 0.4 and 0.6 IW/CPE ratios.

Singh (2003) showed that the uptake of N, P and K by maize was significantly affected by irrigation. The maximum uptake of N (87.25 and 84.12 kg /ha), P_2O_5 (36.57 and 38.31 kg/ha) and K_2O (81.02 and 84.12 kg/ha), respectively in two years were recorded at 1.25 IW/CPE ratio.

Singh *et al.* (1997) resulted that moisture regimes had significant influence on the nutrients uptake at harvest. It was maximum at 1.2 IW/CPE ratio and minimum under 0.6 IW/CPE ratio.

Effect of irrigation on water use efficiency and water productivity

Bharati *et al*. (2007) reported that the highest water use efficiency was recorded at IW/CPE ratio 0.6 and it decreased with increase in IW/CPE ratio for maize + potato intercropping system.

Mukherjee *et al*. (2010) concluded that under limited water supply condition, irrigation with moderate CPE_{50} level is highly desirable instead of high frequency CPE_{25} irrigation. They also noted that WUE decreased with the increase in frequency of irrigation.

Kar and Verma (2005) concluded that water use efficiency was increased linearly with increased number of irrigation up to three irrigations. With four irrigations, the yield was higher but WUE was lower than that of three irrigations which might be due to increased water application resulted in increased crop water use without a corresponding increase of yield for the crop with four irrigations.

Highest WUE (10.74 kg ha^{-1} mm^{-1}) was observed in one irrigation schedule closely followed by 2, 3, 4 and 5 (8.89, 7.86, 7.79 and 6.99 kg ha^{-1} mm^{-1}). The lowest WUE was noticed in five irrigations (6.99 kg ha^{-1} mm^{-1}) irrigation schedule (Brahma *et al.,* 2007b).

Kuscu *et al.* (2013) evaluated the effect of different seasonal irrigation amounts on maize evapotranspiration, grain yield, water use efficiency, and net return in a sub-humid climate during 2007 and 2008 and found that increase in water amounts resulted in relatively higher yield since water deficit was the main yield-limiting factor. Higher values of both WUE and IWUE were obtained when irrigation was scheduled at 75 percent available soil moisture depletion. On the other hand, full irrigation gave the highest net return.

Dantas Junior and Chaves (2014) indicated that the WUE of maize decreases with the increasing amount of water applied via irrigation.

Enhancing water use efficiency of rainfed maize is a requirement for sustainable maize production, particularly in areas prone to low/ drought and erratic rainfall patterns (Asare *et al*., 2011).

Hassan and Ali (2014) reported that irrigation water use efficiency (IWUE) of coriander crop was increased by reducing the irrigation levels.

Tariq and Usman (2009) indicated that the water use efficiency of maize increased with the increase in irrigation depth applied. The water use efficiency ranged from 0.6 kg m^{-3} to 1.9 kg m^{-3}. The maximum average water use efficiency of 1.8 kg m^{-3} was obtained at 0.5 E pan treatment while the minimum average water use efficiency of 0.7 kg m^{-3} was observed in both farmers practice and 1.25 E pan treatment. Maximum yield of 2993 kg ha^{-1} was obtained when plots were irrigated according to 0.75 E pan.

Bozkurt *et al.* (2011) observed that irrigation levels had statistically significant effect on fresh and dry above ground biomass production of corn. The highest water use efficiency (1.77 kg m^{-3}) value was found in 120% evaporation treatment.

Singh *et al.* (2011b) reported that maximum water productivity of wheat occurred in the treatment which received the least irrigation, but this was also the lowest yielding treatment.

Roy *et al*. (2015) reported that irrigation regimes improved grain yield and water-use efficiency of maize significantly and the highest grain yield and water-use efficiency were recorded at IW/CPE ratio of 0.75.

Parthasarathi *et al.* (2013) observed that higher water productivity was recorded in 50% (250 mm) of irrigation water requirement (0.4 IW/CPE ratio) followed by 75% (375 mm) of irrigation water requirement (0.6 IW/CPE ratio) in maize.

Sinclair *et al.* (1975) confirmed that water use efficiency was significantly decreased under water stress conditions when stomatal resistance increased, and they also concluded that management practices for maize which induce moisture stress conditions resulted in increased stomatal resistance, reduced both crop photosynthetic productivity and water use efficiency.

Bandyopadhyay (1997) reported that water-use efficiency of wheat decreased with the decrease in number of irrigations. The highest water-use efficiency of 12.93 kg/ha/mm was observed at 1.2 IW/CPE ratio while the lowest WUE of 12.06 kg/ha/mm was recorded under 0.6 IW/CPE ratio.

Csajbok *et al*. (2014) found that there was negative correlation between the water-use efficiency of maize and the soil moisture content. Higher the moisture content of the soil, lower was the water-use efficiency.

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Chapter -3

MATERIALS AND METHODS

3 MATERIALS AND METHODS

The details of materials used, experimental procedure and the methods followed during the course of present investigation entitled "Influence of mulching on crop productivity and water use efficiency of maize-maize cropping system" have been presented in this chapter.

3.1. Materials

3.1.1. Experimental site

The field experiment was conducted in the AICRP on Irrigation Water Management Research field of Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar during *rabi* and *kharif* seasons of 2013-14 and 2014-15. The experimental plot had fairly uniform topography and the soil was deep and well drained.

3.1.2. Soil of the experimental plot

The soil was of recent in origin and had developed from the sediment brought down by the river Burhi Gandak. The soil was calcareous which was characterized by the presence of 26.8 per cent free calcium carbonate. This has very much affected the physical and chemical properties of soil. The soil of the experimental field was *Entisol*, sandy loam in texture (Table 3.1) with low available N and P_2O_5 and medium in K_2O (Table 3.2). Soil samples of the experimental plot from five different places selected randomly before layout of the experiment were taken from 0-30 cm depth and mixed thoroughly to form a composite sample and were analyzed for different physico-chemical properties following the standard procedure mentioned against their name in Table 3.2. Besides this, samples from three different soil layers 0-30, 30-60 and 60-90 cm depths were also collected to determine the single value physical constant (Table3.4).

The results of the analysis presented in Table 3.1 and 3.2 indicated that the soil of the experimental plot was sandy loam in texture, alkaline in reaction and low in available nitrogen, phosphorus and medium in potassium content.

The soil of the experimental plot was classified for its available nitrogen, phosphorus, potassium and organic carbon as in Table 3.3 as proposed by Muhr *et al*. (1963).

Table 3.1: Mechanical analysis of the soil of experimental plot

Particulars	Value obtained (%)	Method employed
Sand	56.85	International pipette method (Piper, 1966)
Silt	31.35	
Clay	11.8	
Texture	Sandy loam	

Table 3.2: Chemical properties of soil

SI.No.	Particulars	Value obtained	Method adopted
		0-30 cm Depth	
1	Soil pH (1:2.5, soil : water)	8.2	Glass electrode pH meter (Jackson, 1973)
2	EC (dSm^{-1})	0.79	Conductivity bridge (Jackson, 1973)
3	Organic carbon (%)	0.44	Walkley and Black (1934)
4	Available nitrogen (kg/ha)	218.22	Alkaline permanganate method (Subbiah and Asija, 1954)
5	Available phosphorus (P_2O_5 kg/ha)	18.18	Olsen's method (Olsen *et al*., 1954)
6	Available (potassium K_2O kg/ha)	158.27	Flame photometer method (Jackson, 1973)
7	Free $CaCO_3$ (%)	26.8	(Piper, 1966)

Table 3.3: Rating chart for evaluating the fertility status of soil

SI.No.	Nutrients	Low	Medium	High
1	Organic carbon (%)	<0.50	0.50-0.75	>0.75
2	Available N (kg/ha)	<280.00	281.00-560.00	>560.00
3	Available P_2O_5 (kg/ha)	<22.40	22.41-56.00	>56.00
4	Available K_2O (kg/ha)	<140.00	141.00-336.00	>336.00

Table3.4: Single value physical constants

SI.No.	Particulars	0-30 cm Depth	Methods used
1	Field capacity (%)	23.50	Field method (Piper,1950)
2	Permanent wilting point (%)	8.20	Pressure plate method (Richards,1954)
3	Bulk density (g/cc)	1.45	Core method (Emerson, 1925)

3.1.3. Meteorological condition

Dr. Rajendra Prasad Central Agricultural University Farm, Pusa is located in Samastipur district of North Bihar on the Southern and Western bank of the river *Burhi Gandak* at 25° 59´ North latitude and 85° 48´East longitude with an altitude of 52.92 meters above mean sea level. It has sub-tropical and sub-humid monsoon climate. The average rainfall of the area is 1276.1 mm out of which nearly 1026.0 mm is received during the monsoon between June to September. Occasional winter showers sometimes occur during the period between third weeks of December to the first half of January in this region. The hot weather starts from early March up to the end of May. The average maximum temperature during the hottest months of May-June varies between 37.5°C to 40.6°C and the average minimum temperature of the same period is from 17.0°C to 21.8°C, whereas during monsoon period the average maximum temperature is about 33.9°C and the minimum temperature is about 25.3°C. January is the coldest month of the year with an average winter maximum temperature of 21.1°C and average minimum temperature of 7.7°C. Several biots of cold wave condition prevail in the area accompanied by icy wind and dense fog during the month of December and January. Normally temperature starts decreasing from the second fortnight of October and falls minimum at the end of December to early January. Again, it starts rising sharply from the end of February reaching the maximum in May-June. The temperature goes up to 43°C during the month of May having 82 per cent normal humidity at 7 A.M.

3.1.4. Weather condition during crop season

The data on the weather conditions during the crop growing period (December 2013 to October 2015) of present investigation with respect to maximum and minimum temperature, relative humidity and rainfall were obtained from the Agro-meteorology section, DRPCAU, Pusa and have been presented in Table 3.5(a) and 3.5(b) depicted graphically in Fig. 3.1 and 3.2.

The mean maximum temperature in the month of April 2014, May 2014, June 2014, August 2014, September 2014, June 2015, July 2015, September 2015 and October 2015 was higher than the normal temperature in the same months whereas the monthly mean maximum temperature in the other months was lower than the normal temperature during the crop season (Appendix-1(a) and 1(b)). The monthly mean minimum temperature in the months during December 2013 to October 2015 was higher than its normal temperature except in April 2014, October 2014, November 2014, April 2015, May 2015, July 2015, August 2015, September 2015 and October 2015.

The value of monthly mean relative humidity at 7.0 AM was higher than the normal in the months of February 2014, March 2014, February 2015, March 2015, April 2015 and May 2015 whereas the monthly mean relative humidity at 2.0 PM was lower than the normal only in months of April 2014, May 2014, September 2014, November 2014, June 2015, August 2015, September 2015 and October 2015.

Total rainfall during the crop growing period was lower than normal except during February 2014, March 2014, August 2014, October 2014, April 2015, May 2015, July 2015 and August 2015, when rainfall exceeded the normal value.

The weekly meteorological data, daily rainfall and pan evaporation data have been presented in Appendix II (a), II (b), III (a) and III (b)

Table 3.5a: Monthly weather data recorded at Agro meteorological observatory, Pusa during crop season 2013-14.

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm)	Sunshine (hr)
	Maximum	Minimum	7:00 hrs	14:00 hrs			
December	23.5	10.5	91.0	55.0	0.0	1.0	2.5
January	19.4	9.5	90.0	68.0	9.5	0.9	2.1
February	22.3	10.7	90.0	60.0	32.4	1.8	5.0
March	29.9	15.3	83.2	40.7	10.6	4.1	8.2
April	37.1	19.5	68.6	28.3	0.0	6.5	9.3
May	37.6	24.1	72.3	38.3	64.0	7.0	8.7
June	36.0	26.4	83.0	58.0	93.2	4.6	6.9
July	32.5	26.5	89.0	73.0	339.8	3.0	6.5
August	32.7	26.2	91.0	76.0	351.9	3.2	3.8
September	32.5	25.2	90.0	68.0	129.4	3.3	5.8
October	31.5	21.5	90.0	58.0	81.6	2.7	6.6

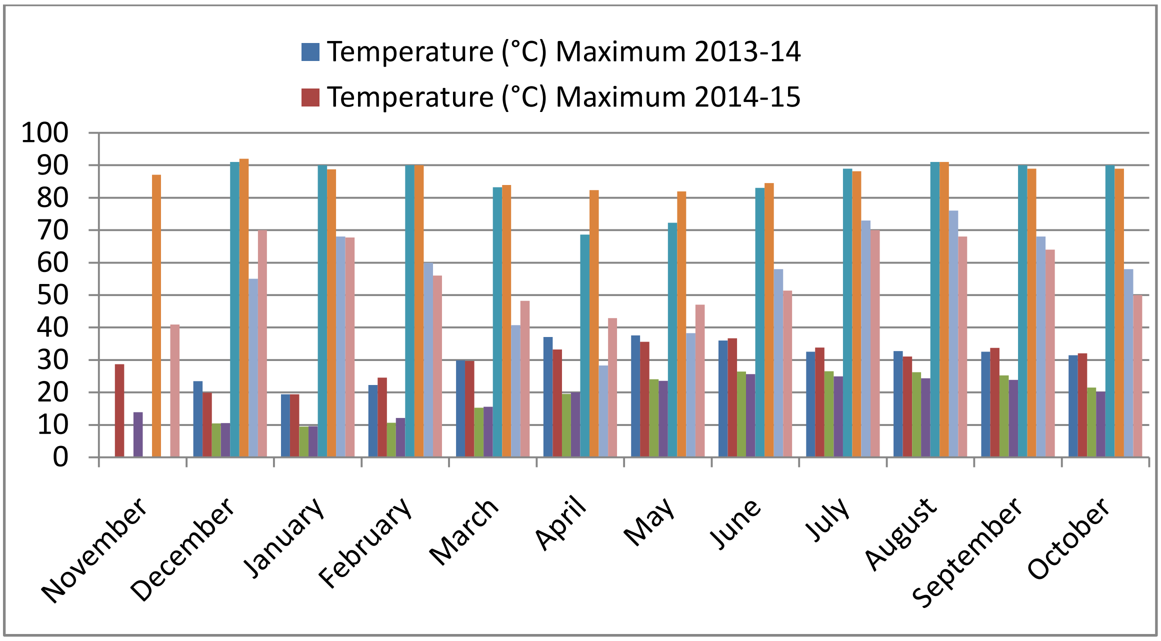


Fig. 3.1. Climatic conditions during cropping season (2013-14 and 2014-15)

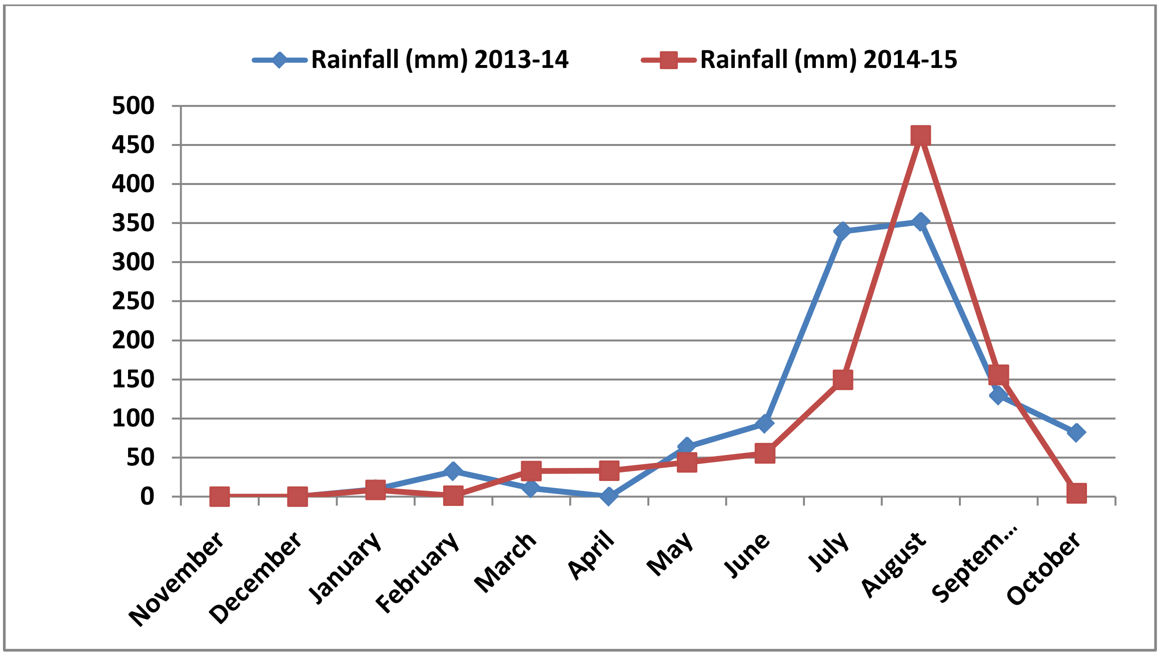


Fig.3.2. Rainfall data during cropping season (2013-14 and 2014-15)

Table 3.5b: Monthly weather data recorded at Agro meteorological observatory, Pusa during crop season 2014-15.

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm)	Sunshine (hr)
	Maximum	Minimum	7:00 hrs	14:00 hrs			
November	28.7	13.9	87.1	40.9	0.0	1.7	5.4
December	19.9	10.6	92.0	70.0	0.0	0.7	1.7
January	19.4	9.6	88.8	67.8	8.4	1.0	2.6
February	24.6	12.1	90.0	56.0	1.2	1.8	4.2
March	29.7	15.6	83.9	48.2	32.6	3.7	7.3
April	33.2	20.0	82.3	42.9	33.2	5.4	7.3
May	35.6	23.6	82.0	47.0	43.8	5.4	7.6
June	36.7	25.6	84.5	51.4	55.4	6.1	7.1
July	33.8	25.0	88.2	70.0	149.6	3.9	5.4
August	31.1	24.4	91.0	68.0	462.4	3.4	4.2
September	33.7	23.9	89.0	64.0	155.8	3.5	6.1
October	32.1	20.2	89.0	50.0	4.2	3.1	7.5

Source: Agro-meteorology section, DRPCAU, Pusa

3.1.5. Pervious Cropping history of the experimental plot

In order to have a general idea of the cropping pattern of the experimental plot, cropping history from the last five years to the year of investigation obtained from the AICRP project record have been presented in the Table 3.6.

Table 3.6: Cropping history of experimental plot

Year	Kharif	Rabi and Summer
2009	Rice	Wheat – Moong
2010	Rice	Sugarcane (main)
2011	Sugarcane (Main)	Sugarcane (Ratoon)
2012	Sugarcane (Ratoon)	Fallow
2013	Rice	Maize (first year experiment)
2014	Maize (first year experiment)	Maize (second year experiment)
2015	Maize (second year experiment)	-

3.2. Experimental details

The experiment was conducted in *rabi* and *kharif* seasons of 2013-14 and 2014-15 in Split Plot Design (SPD) with 20 treatment combinations consisting of four moisture regimes and five mulches, which were as follow:

3.2.1. Treatment details

A. Moisture regime – 4 (main plots)

I_1 – IW/CPE ratio of 0.4
I_2 – IW/CPE ratio of 0.6
I_3 – IW/CPE ratio of 0.8
I_4 – IW/CPE ratio of 1.0

B. Mulch – 5 (sub-plots)

M_1 – Mulching with sugarcane trash @ 5 t/ha
M_2 – Mulching with sugarcane trash @10 t/ha
M_3 – Mulching with maize stover @ 5 t/ha
M_4 – Mulching with maize stover @ 10 t/ha
M_5 – No mulch

3.2.2. Layout plan

The experiment was laid out in Spilt Plot Design with moisture regime in main plot and mulch in sub plot with three replications. The treatments were randomized as per procedure given by Gomez and Gomez (1984). The details of the layout plan of the experimental design showing the allocation of treatments to different plots have been presented in Fig.3.3.

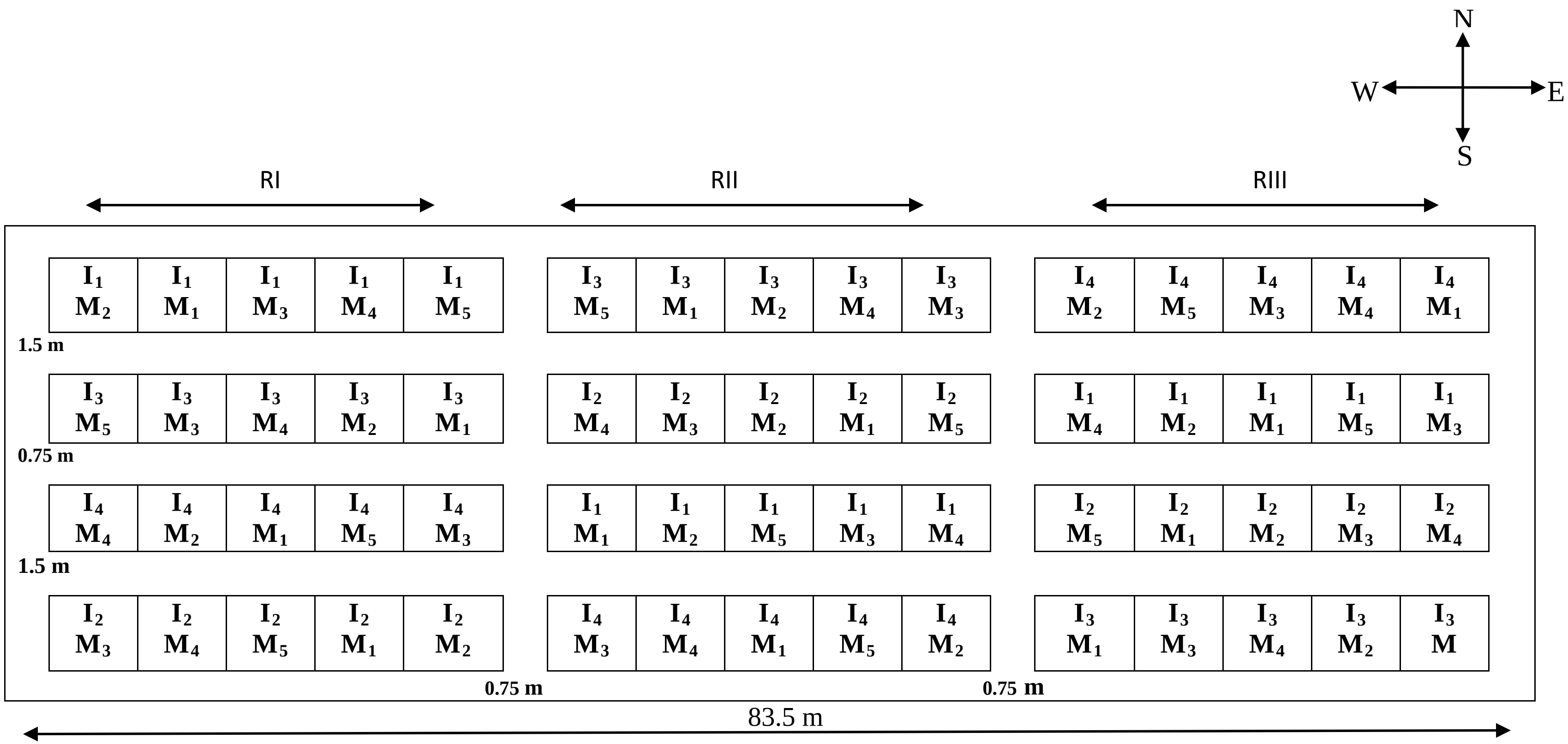
Details of field layout

Location	:	Irrigation Water Management Research field, DRPCAU, Pusa.
Crop	:	Maize
Variety	:	DKC 9120 Hybrid (*rabi*) and DKC 9108 Hybrid (*kharif*)
Design	:	Split plot design
Number of replications	:	3
Treatment combinations	:	20
Gross plot size	:	5.0×4.8 m^2
Net plot size	:	4.0×3.0 m^2
Spacing	:	60×20 cm
Depth of irrigation	:	6 cm
Fertilizer dose	:	150-75-50-25 (N-P_2O_5-K_2O-$ZnSO_4$ kg/ha)

3.3. Description of the maize variety under investigation

3.3.1 DKC 9120

The cultivar "DKC 9120" is a hybrid released by Monsanto India in 2013. It has distinguishing morphological characters like non-lodging, sturdy stem, yellow flint grain and late maturity suitable for *rabi season*.



Treatment Details

A. Moisture regimes - 4 (Main plot)

I_1- IW/CPE = 0.4
I_2- IW/CPE = 0.6
I_3- IW/CPE = 0.8
I_4- IW/CPE = 1.0

B. mulch- 5 (Sub-plot)

M_1-Sugarcane trash @ 5 t/ha
M_2-Sugarcane trash @10 t/ha
M_3-Maize stover @ 5 t/ha
M_4-Maize stover @ 10 t/ha
M_5-No mulch

Design – SPD

Replication – 3
Gross plot size – 5 × 4.8 m^2
Net plot size – 4 × 3 m^2
Width of irrigation channel – 1.5 m
Width of path – 0.75 m
Width of bund – 0.5 m

Fig. 3.3 Layout plan of the experiment

3.3.2 DKC 9108

The cultivar "DKC 9108" is a hybrid released by Monsanto India in 2011. It is non-lodging, sturdy stem, yellow flint grain, medium duration suitable for *summer* and *kharif* seasons.

3.4. Cultivation details

The various cultural operations during the period of experimentation are given in Table 3.7.

Table 3.7: Calendar of cultural work

	Operations	2013-14		2014-15	
		rabi	***kharif***	***rabi***	***kharif***
A	**Pre-sowing operations**				
1	Land preparation	06.12.2013	07.06.2014	01.11.2014	08.06.2015
2	Layout of experiment	13.12.2013	14.06.2014	07.11.2014	15.06.2015
B	**Sowing operations**				
1	Sowing and fertilizer application (basal)	14.12.2013	15.06.2014	08.11.2014	16.06.2015
C	**Post sowing operations**				
1	Gap filling	24.12.2013	25.6.2014	23.11.2014	26.6.2015
2	Weeding	27.02.2014 and 27.03.2014	13.07.2014 and 02.08.2014	10.01.2015 and 24.02.2015	14.07.2015 and 3.08.2015
3	Mulching	04.01.2014	30.06.2014	28.11.2014	1.07.2015
4	Insecticide application	12.02.2014	15.07.2014 and 05.08.2014	07.01.2015	16.07.2015 and 09.08.2015
5	Top dressing of urea	14.01.2014 and 28.03.2014	16.07.2014 and 09.08.2014	08.12.2014 and 26.2.2015	17.07.2015 and 10.08.2015
6	Harvesting	31.5.2014	19.9.2014	25.4.2015	20.9.2015

3.4.1. Land preparation

The experimental area was ploughed with a tractor driven plough and cross harrowing thrice with help of disc harrow and followed by planking. The experiment was laid out as per plan in Fig. 3.3 and plots were levelled. After allocation of treatment, furrows were opened as per row spacing under experiment.

3.4.2. Fertilizer application

The crop was fertilized with recommended dose of 150-75-50-25 kg N, P_2O_5, K_2O and $ZnSO_4$ kg/ha. The source of fertilizers used was Urea (46% N) for nitrogen, DAP (18% N and 46% P_2O_5) for nitrogen and phosphorus and MOP (60% K_2O) for potassium. Full amount of phosphorus, potassium, $ZnSO_4$ and $^1/_3$ of nitrogen were applied as basal dose at the time of sowing. Rest $^2/_3$ of nitrogen was top dressed in two equal splits at knee high and tasseling stages, respectively.

3.4.3. Sowing

Seeds of the hybrid DKC 9120 for *rabi* and DKC 9108 for *kharif* were used. One seed was sown in holes 20 cm apart at depth of 3-4 cm on ridges 60 cm apart on 14 December 2013 and 15 June 2014 during 2013-14 and also on 8 November 2014 and 16 June 2015 during 2014-15. After germination the gaps were filled to maintain desired plant population as given in Table 3.7.

3.4.4. Weeding management

The weeds were controlled by hand weeding. Two hand weedings were done at knee high and tasseling stages during *rabi* and *kharif* seasons in both the years.

3.4.5. Mulching

Maize stover and sugarcane trash were used as mulch materials, after sun dried these were applied between the rows of the crop at the rate of 5 and 10 tons per hectares after plant emergence at 5-6 leaves stage.

3.4.6. Plant protection measures

Usual plant protection measures were adopted to protect the crop from insect pests and diseases as and when required.

3.4.7. Irrigation

Irrigation was applied as per treatments. The details of irrigation scheduling are given in Table 3.8(a) and 3.8(b).

3.4.8. Measurement of irrigation water

The required quantity of irrigation water in each plot was applied through Parshall Flume having a throat width of 7.5 cm installed at the head of the experimental plot. The height in cm was read from the scale on the flume and the corresponding discharge in l/sec was recorded from the flume discharge table (Israelsen and Hansen, 1953). With record of flow of water, area of the plot and depth of irrigation, time required to irrigate the plot was calculated by the following formula.

Time required for irrigation (t) = $\frac{A \times D}{Q}$

Where, A = Area in cm^2

D = Depth of irrigation water (cm)

Q = Discharge cc/sec

The total water use was the sum of irrigation water and effective rainfall occurred during the crop growth period Table 3.9(a) and 3.9(b).

Table 3.8a: Details of irrigation during crop 2013-14

Treatments	**Date of irrigation**			
	Months	***Rabi*/date**	**Months**	***Kharif*/date**
I_1– IW/CPE ratio of 0.4	January	13	June	No irrigation applied
	February		July	No irrigation applied
	March		August	No irrigation applied
	April	01, 24	September	No irrigation applied
	May			
I_2– IW/CPE ratio of 0.6	January	13	June	No irrigation applied
	February		July	No irrigation applied
	March	24	August	No irrigation applied
	April	10, 24	September	No irrigation applied
	May	10		
I_3– IW/CPE ratio of 0.8	January	13	June	No irrigation applied
	February		July	No irrigation applied
	March	17	August	No irrigation applied
	April	01, 14, 24	September	No irrigation applied
	May	06		
I_4– IW/CPE ratio of 1.0	January	13	June	No irrigation applied
	February		July	No irrigation applied
	March	14, 29	August	No irrigation applied
	April	05, 16, 24	September	No irrigation applied
	May	03		

Table 3.8b: Details of water application during crop season 2013-14

Treatments	*Rabi*				*Kharif*	
	Number of irrigation	Water applied (cm)	Effective rainfall (cm)	Total water applied (cm)	Number of irrigation	Effective rainfall (cm)
I_1	3	18	4.02	22.02	No	60.71
I_2	5	30		34.02	No	
I_3	6	36		40.02	No	
I_4	7	42		46.02	No	

Table 3.9a: Details of irrigation during crop 2014-15

Treatments	Date of irrigation			
	Months	*Rabi*/date	Months	*Kharif*/date
I_1– IW/CPE ratio of 0.4	December January February March April	08 20 	June July August September	No irrigation applied No irrigation applied No irrigation applied No irrigation applied
I_2– IW/CPE ratio of 0.6	December January February March April	08 06, 31 	June July August September	No irrigation applied No irrigation applied No irrigation applied No irrigation applied
I_3– IW/CPE ratio of 0.8	December January February March April	08 17 20 09	June July August September	No irrigation applied No irrigation applied No irrigation applied No irrigation applied
I_4– IW/CPE ratio of 1.0	December January February March April	08 10 12, 26 11	June July August September	No irrigation applied No irrigation applied No irrigation applied No irrigation applied

Table 3.9b: Details of water application during crop season 2014-15

Treatments	*Rabi*				*Kharif*	
	Number of irrigation	Water applied (cm)	Effective rainfall (cm)	Total water applied (cm)	Number of irrigation	Effective rainfall (cm)
I_1	2	12	4.26	14.26	No	53.19
I_2	3	18		22.26	No	
I_3	4	24		28.26	No	
I_4	5	30		34.26	No	

3.4.9 . Harvesting

The crop was harvested when the cobs became nearly dry and plants showed physiological maturity (yellowing) from net plot area of each plot with the help of sickle. Border rows were harvested separately. The crops were sun dried properly then shelled and grains removed manually. Finally the yield of grain, stover and stone were recorded on 15 per cent moisture basis.

3.5. Observations recorded

Various observations recorded during the course of investigation are given below:

A. Growth attributes

I. Plant height in cm at 30 days interval
II. Leaf area index at silking stage
III. Dry matter production at 30 days interval

B. Yield attributes and yield

I. Number of cobs/plant
II. Number of rows/ cob
III. Number of grains/cob
IV. 100-grain weight (g)
V. Grain yield (q/ha)
VI. Stover yield (q/ha)
VII. Stone yield (q/ha)
VIII. Harvest index (%)

C. System productivity

I. Water use efficiency (kg/ha-cm)
II. Water productivity (₹/m^3)

D. Weed study

I. Weed population (no/m^2) at knee high and silking stages
II. Weed dry weight (g/m^2) at knee high and silking stages

E. Soil health

Initial organic carbon (%), pH, EC, available N, P & K of soil and at harvest of the crop.

Soil moisture measurement in 0-75 cm depth.

F. Plant analysis

N, P, & K content in grain, stone, straw and uptake.

G. Economics

I. Cost of cultivation (₹/ha)

II. Gross return (₹/ha)

III. Net return (₹/ha)

IV. Benefit :cost ratio

3.6. Methods used for various observations

The technique of "representative sample" was adopted for the observation on various agronomical characters of crop plant at harvest. For observation of growth and yield characters a sample of five plants from each sub-plot was randomly selected from sample row. To collect the above observations out of 8 rows in each sub-plot were left undisturbed till harvest for final yield studies.

3.6.1 Growth parameters

3.6.1.1. Plant height (cm)

The height of five randomly selected plants in each plot were measured in centimeter with the help of a meter scale from the ground level to the growing tip of the plant at 30 days interval up to 150 days after sowing in *rabi* maize and up to 90 days after sowing in *kharif* maize. The average heights of these plants were computed and mean values were recorded.

3.6.1.2. Leaf area index

Leaf area index was measured at silking stage. Five plants were selected from sample rows and only green leaves were counted. From upper, medium and lower leaves, leaf area was calculated by formula: $A = L \times W \times F$, where (A) leaf area cm, (L) maximum length of leaf, (W) maximum width of leaf, and (F) leaf area constant in maize is 0.76 and get their mean multiplied by number of leaves counted. Leaf area index calculated by following formula:

Leaf area index = leaf area per plant/Ground area per plant

3.6.1.3. Dry matter production (g)

The five plant samples randomly selected from border rows, detached from up ground level and were initially dried in the sun and then in the oven at 60°C till constant weight reached. It was at 30 days intervals up to 150 days after sowing in *rabi* maize and up to 90 days after sowing in *kharif* maize. Mean values were recorded.

3.6.2. Yield attributes parameters

3.6.2.1. Number of cobs per plant

At harvest number of cobs per plant of the five randomly selected tagged plants from each plot was counted and their mean values calculated.

3.6.2.2. Number of rows per cob

Numbers of rows per cob in five randomly selected plants were counted and their mean was recorded.

3.6.2.3. Number of grains per cob

The total grains shelled out from the five cobs were counted and their mean was recorded.

3.6.2.4. 100-grain weight (g)

Grains samples were drawn from the five randomly selected tagged plants and dried in sun, and the weight of 100 grains was recorded in gram at about 15 per cent moisture content of the grain.

3.6.3. Yield parameters

3.6.3.1. Grain yield (q/ha)

After shelling of cobs of each net plot, grains were cleaned and sun dried. Then grain weight were recorded in kilogram per plot and was later converted into q/ha to give the grain yield.

3.6.3.2. Stover yield (q/ha)

The stover of each net plot after removal of cobs were sun dried and weighed in kilogram per plot and was later converted into q/ha to give the stover yield.

3.6.3.3. Stone yield (q/ha)

The cobs of each net plot after shelling stone were sun dried and weighed in kilogram then converted into q/ha.

3.6.3.4. Harvest index (%)

The harvest index for each plot was calculated by dividing the economic yield (grain yield, q/ha) to the total biological yield (grain + stover + stone yield, q/ha) and multiplying the factor by 100.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (q/ha)}}{\text{Grain + Stover + Stone yield (q/ha)}} \times 100$$

3.6.4. System productivity

3.6.4.1. Water use efficiency (kg/ha-cm)

It is the expression of the marketable product (grain) obtained by per unit of water applied to the crop. It was calculated with the help of the following formula:

$$\text{Water use efficiency (kg/ha-cm)} = \frac{\text{Yield (kg/ha)}}{\text{Water requirement (cm)}}$$

3.6.4.2. Water productivity (₹/m^3)

Water productivity for each plot was calculated and expressed in ₹/m^3 by using the formula:

$$\text{Water productivity (₹/m}^3\text{)} = \frac{\text{Net return (₹/ha)}}{\text{Total water consumed in m}^3\text{/ha including effective rainfall}}$$

3.6.5. Weed studies

3.6.5.1. Weed population (no/m^2)

Number of weeds at knee high and silking stages were counted from an area of 0.6 m^2 randomly selected in each plot from sample rows.

3.6.5.2. Weed dry weight (g/m^2)

Dry weights of weeds at knee high and silking stages were recorded from an area of 0.6 m^2 randomly selected in each plot from border rows. Weeds enclosed in area of 0.6 m^2 enclosed weeds were carefully uprooted, cleaned and kept in sun for initial drying, after that these weeds were dried in oven at 60°C till the constant weight and the dry weight were recorded in gram.

3.6.6. Soil analysis

3.6.6.1. Organic carbon (%)

Organic carbon percent in the soil at initial and after harvest of the crop was determined by Walkley and Black (1934) method.

3.6.6.2. Soil reaction (pH)

pH at initial and after harvest of the crop was determined in 1:2.5 soil water ratio by glass electrodes pH meter.

3.6.6.3. Electrical conductivity (EC)

Electrical conductivity of the soil at initial and after harvest of the crop was determined by conductivity bridge.

3.6.6.4. Available nitrogen (kg/ha)

Available nitrogen in the soil at initial and after harvest of the crop was measured by alkaline permanganate method as described by Subbaih and Asija (1956).

3.6.6.5. Available phosphorous (kg/ha)

Available phosphorous in the soil at initial and after harvest of the crop was measured by Olsen's method (1954).

3.6.6.6. Available potassium (kg/ha)

Available potassium in the soil at initial and after harvest of the crop was determined by extracting the soil with neutral normal ammonium acetate solution (pH, 7.0) in soil. Potassium was estimated in the extract with the help of flame photometer as described by Jackson (1973).

3.6.7. Plant analysis

After harvest the grain, straw and stone samples were separated and oven dried at 65°C to obtain a constant weight and then finally grinded by electric power grinder. The plant chemical analyses were made as follows:

3.6.7.1. Nitrogen content

The nitrogen content in plant samples of crop at harvest was determined by digesting 0.5 gram of grinded material in concentrated sulphuric acid using copper sulphate and potassium sulphate as catalyst. The digested material was then distilled with 40 percent sodium hydroxide and distillate was collected in boric acid containing the mixed indicator. The content was then analyzed for amount of N in the sample.

3.6.7.2. Phosphorous content

Phosphorous was determined in triacid (HNO_3 + $HClO_4$ + H_2SO_4; 10:4:1) digested materials by vanado molybdate yellow colour method as given by Jackson (1973).

3.6.7.3. Potassium content

Potassium in all triacid digested plant samples was determined with the help of Flame photometer as described by Jackson (1973).

3.6.8. Economics

The treatment wise economic studies were done by calculating the cost invested in cultivation and gross returns per hectare on the basis of prevailing market rate of the inputs and outputs.

3.6.8.1. Cost of cultivation (₹/ha)

Cost of cultivation was worked- out by taking into consideration all the expenses incurred in raising the crop (Appendix- II & III)

3.6.8.2. Gross returns (₹/ha)

Total income of the produce (grain + straw) was estimated at prevailing market rate and thus gross returns were calculated in ₹/ha.

3.6.8.3. Net returns (₹/ha)

Net returns were obtained by subtracting the cost of cultivation from the gross returns estimated by selling the produce (grain + straw) of the individual treatment.

3.6.8.4. Benefit: cost ratio

Benefit: cost ratio was calculated by dividing the net returns with cost of cultivation of the individual treatment.

3.6.9. Statistical analysis

The experimental data were subjected to statistical analysis to find out the differences among the treatments. Gomez and Gomez (1984) method of analysis was followed to calculate the nature and magnitude of the effects revealed by 'F' test. Appropriate standard errors along with critical differences were calculated for the statistical interpretation of the data.

3.6.10. Correlation studies

Correlation coefficient of different yield attributing characters with grain yield was calculated by Pearson's "product moment method" by using the following formula:

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N})(\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

Where,

r	:	Correlation coefficient
$\sum XY$	:	Sum the products of two variables 'X' and 'Y'
$\sum X^2$	:	Sum the square of variable 'X'
$\sum Y^2$	:	Sum the square of variable 'Y'
$\sum$	:	Summation
N	:	Number of pairs of observation on X and Y

Chapter -4

EXPERIMENTAL FINDINGS

4 EXPERIMENTAL FINDINGS

The present investigation was undertaken to study the **“Influence of mulching on crop productivity and water use efficiency of maize-maize cropping system”**. The data recorded on different treatments during the course of investigation were subjected to statistical analysis and the results obtained along with suitable interpretations have been presented and elucidated in the chapter through tables and graphs wherever required. Interaction effects were discussed wherever it was recorded significant.

4.1 Growth parameters

4.1.1 Plant height (cm)

The progressive height of plant at 30 days interval after sowing as affected by different treatments during both years have been presented in Table 4.1.1a and 4.1.1b and also graphically depicted in Fig.4.1.1a and 4.1.1b.

Influence of moisture regime

A perusal of the data reveals that the plant height increased as the plant advanced in age and reached the maximum at 150 days of *rabi* and 90 days of *kharif* maize. Data indicated that no significant difference in plant height was observed due to moisture regime at 30, 60 and 90 days after sowing. This was because of the fact that irrigation based on IW/CPE ratio actually accrued after 90 days of sowing during both years of *rabi* maize (Table 4.1.1a) while a significant increase in plant height was recorded at 120 and 150 days after sowing due to moisture regimes. The maximum height at 120 days after sowing of 212.41 and 214.15 cm, respectively during 2013-14 and 2014-15 were recorded at 1.0 IW/CPE ratio (I_4), and the lowest plant height of 196.05 and 198.21 cm were recorded with 0.4 IW/CPE ratio (I_1) during both the years. However, I_4 was significantly higher than I_2 (0.6 IW/CPE ratio) 200.51 and 204.69 cm and I_1 but was statistically at par with I_3 (0.8 IW/CPE ratio) with the value of 209.13 and 211.34 cm during both the years. There was also parity in height between I_3 and I_2 and also between I_2 and I_1. At 150 days after sowing, it was observed that the highest plant height of 222.71 and 225.91 cm were recorded under 1.0 IW/CPE ratio (I_4) and the lowest plant

Table 4.1.1a Plant height (cm) of *rabi* maize at different growth stages as influenced by different treatments

Treatments	30DAS		60DAS		90DAS		120DAS		150DAS	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime										
I_1- IW/CPE ratio 0.4	25.21	27.63	31.72	34.44	91.89	94.14	196.05	198.21	206.47	206.40
I_2- IW/CPE ratio 0.6	25.33	28.42	32.02	35.19	91.67	94.05	200.51	204.67	210.40	213.66
I_3- IW/CPE ratio 0.8	24.94	27.78	32.52	35.13	91.70	94.09	209.13	211.34	219.23	221.13
I_4- IW/CPE ratio 1.0	25.50	28.34	32.04	34.87	92.28	93.91	212.41	214.15	222.71	225.91
SEm ±	0.67	0.63	0.59	0.67	1.14	1.64	2.54	2.66	3.28	3.07
CD (P=0.05)	NS	NS	NS	NS	NS	NS	8.79	9.20	11.35	10.62
Mulch										
M_1-Sugarcane trash @ 5 t/ha	25.52	27.74	31.87	34.38	91.08	92.53	205.08	207.75	215.44	218.09
M_2-Sugarcane trash @10 t/ha	25.71	28.97	33.21	36.18	94.50	97.50	208.48	211.39	218.43	221.66
M_3-Maize stover @ 5 t/ha	25.65	28.78	32.20	35.71	92.49	94.35	205.95	209.08	216.60	219.25
M_4-Maize stover @ 10 t/ha	26.03	29.10	34.76	37.81	95.53	98.36	210.30	212.35	220.25	223.15
M_5-No mulch	23.31	25.62	28.34	30.46	85.81	87.56	192.81	194.91	202.79	201.73
SEm ±	0.66	0.69	0.56	0.68	1.25	1.39	2.67	2.91	3.45	3.39
CD (P=0.05)	1.89	1.99	1.61	1.95	3.61	4.01	7.69	8.37	9.94	9.77

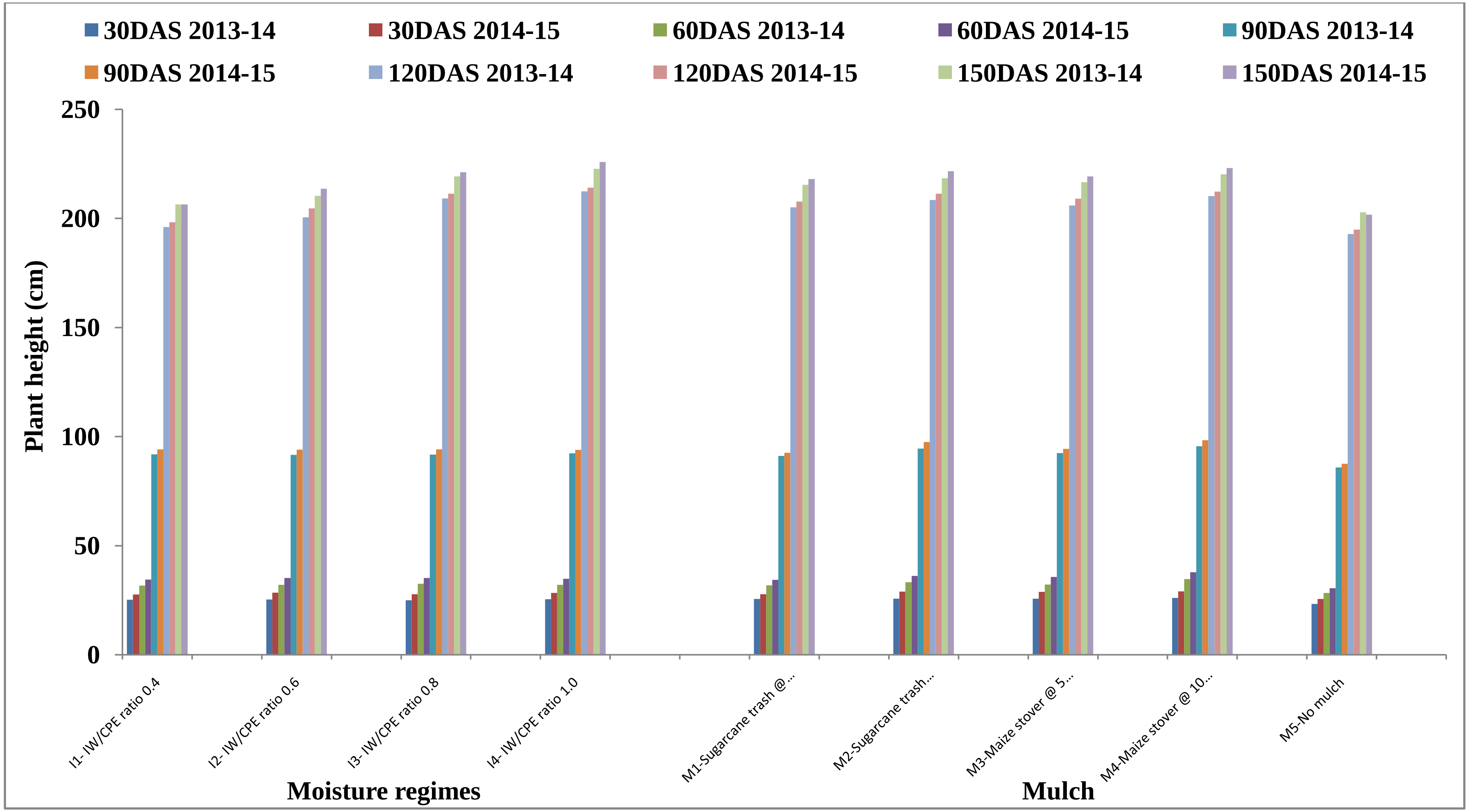


Fig. 4.1.1a Plant height (cm) at different growth stages of *rabi* maize as influenced by different treatments

Table 4.1.1b **Plant height (cm) of *kharif* maize at different growth stages as influenced by different treatments**.

Treatments	30 DAS		60 DAS		90 DAS	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime						
I_1: IW/CPE ratio 0.4	39.26	41.18	138.50	140.75	161.38	163.20
I_2: IW/CPE ratio 0.6	37.93	40.05	142.48	144.73	152.89	154.43
I_3: IW/CPE ratio 0.8	40.38	42.51	138.63	141.00	165.38	167.18
I_4: IW/CPE ratio 1.0	38.37	40.65	142.73	145.09	159.28	161.18
SEm ±	1.29	1.10	2.63	2.48	3.28	3.13
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Mulch						
M_1:Sugarcane trash @ 5 t/ha	39.18	41.08	139.51	141.42	162.03	164.06
M_2:Sugarcane trash @10 t/ha	40.55	43.44	145.63	148.74	168.00	169.96
M_3:Maize stover @ 5 t/ha	39.94	41.79	139.93	142.06	163.40	165.43
M_4:Maize stover @ 10 t/ha	41.50	44.45	148.53	151.64	169.43	171.42
M_5:No mulch	33.75	34.73	129.33	130.61	135.81	136.63
SEm ±	1.10	1.16	2.49	2.54	2.93	2.85
CD (P=0.05)	3.18	3.38	7.16	7.30	8.44	8.21

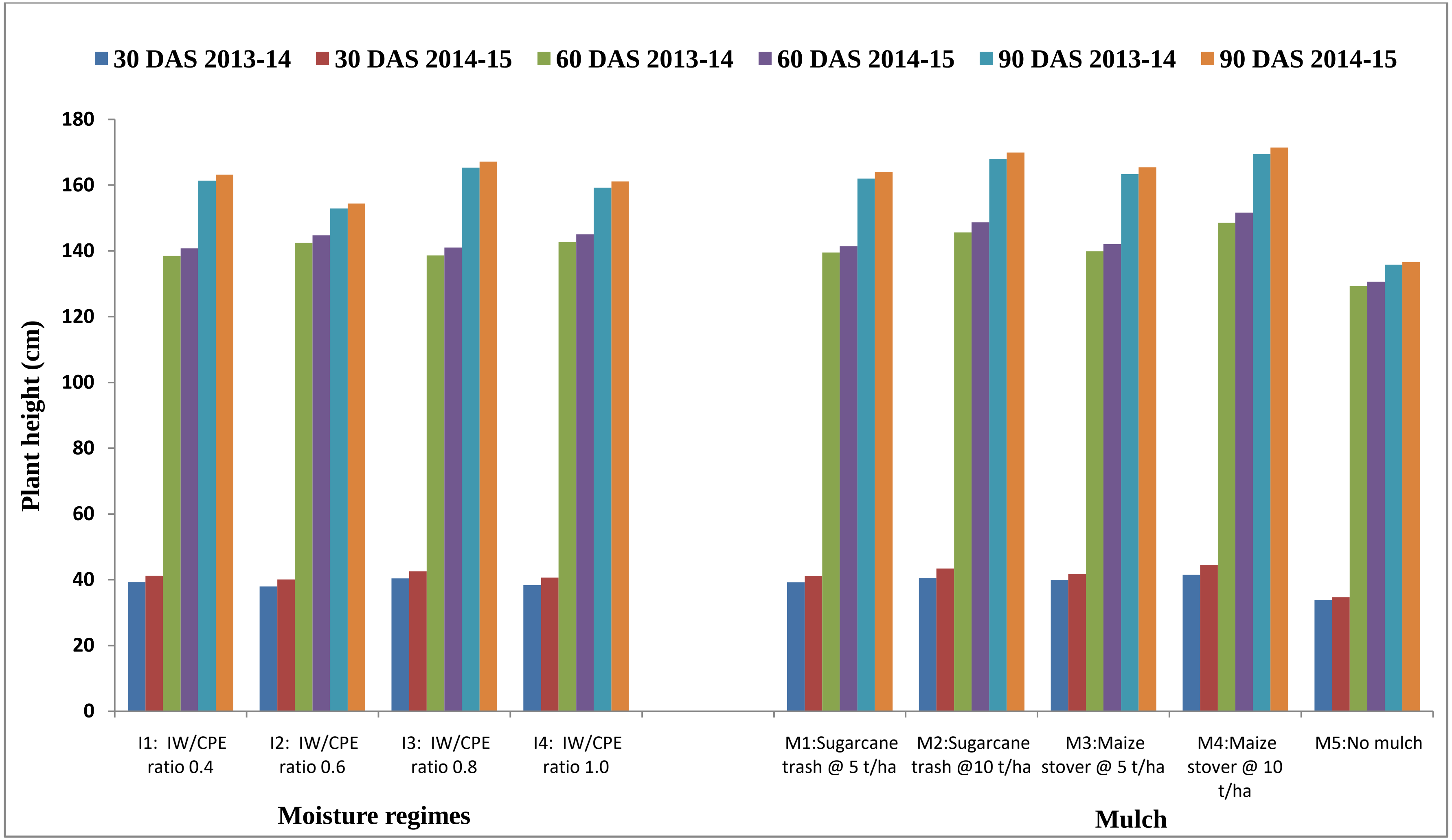


Fig. 4.1.1b Plant height (cm) at different growth stages of *kharif* maize as influenced by different treatments

height of 206.47and 206.40 were obtained under 0.4 IW/CPE ratio (I_1) during 2013-14 and 2014-15. However, I_4 was significantly higher than I_2 and I_1 but was statistically at par with I_3. There was statistical parity between I_3 and I_2 and likewise between I_2 and I_1. Moisture regime did not influence the plant height of *kharif* maize (Table 4.1.1b). This was due to sufficient rainfall during the crop season and no irrigation was applied.

Influence of mulching

Mulching affected the plant height significantly in both *rabi* and *kharif* maize during both the years (Table 4.1.1a and 4.1.1b). Plant height was increased with increase in mulch rate. At 30 days after sowing of *rabi* maize, the maximum height of plant (26.03 and 29.10 cm) were recorded under maize stover @ 10 t/ha (M_4) which was significantly superior to no mulch (M_5) and was statistically at par with other mulched treatments (M_3, M_2 and M_1) and all were significantly superior to M_5 (no mulch) during both the years. At 60 DAS, significantly higher plant height (34.76 and 37.81 cm) were obtained under maize stover @ 10 t/ha as compared to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. Further, there was statistical parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha during both the years. At 90 days after sowing, the highest plant height of 95.53 cm was recorded under maize stover @ 10 t/ha which was found to be significantly superior to sugarcane trash @ 5 t/ha (91.08 cm) and no mulch (85.81 cm) but was at par with sugarcane trash @ 10 t/ha (94.52 cm) and maize stover @ 5 t/ha (92.49 cm) during the first year. However, there was parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. During the second year, significantly maximum plant height of 98.36 cm was obtained at maize stover @ 10 t/ha over maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was statistically at par with sugarcane trash @ 10 t/ha. There was also statistical parity between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha and likewise between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha. Maize stover @ 10 t/ha at 120 and 150 days after sowing recorded significantly higher plant height as compared to no mulch but was at par with other mulch treatments and all were significantly superior to no mulch during both the years.

At 30, 60 and 90 days after sowing of kharif maize (Table 4.1.1b), mulching significantly increased plant height. The maximum plant height of 41.50 and 44.45 cm were recorded under maize stover @ 10 t/ha (M_4) at 30 DAS and the lowest plant height of 33.75 and 34.73 cm were observed at M_5 no mulch (control) during both the year. However, all mulched treatments were at par to each other and were significantly superior to no mulch (control). At 60 DAS, the maximum plant height of 148.53 and 151.64 cm were observed with maize stover @ 10 t/ha which was significantly higher than maize stover @ 5 t/ha (139.93 and 142.06 cm), sugarcane trash @ 5 t/ha (139.51 and 141.42 cm) and no mulch (129.33 and 130.61 cm) but was found to be at par with sugarcane trash @ 10 t/ha (145.63 and 148.74 cm) during both the years. There was also parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. Plant height at 90 days after sowing followed similar pattern of that of plant height at 30 DAS during both the years.

4.1.2 Leaf area index

Observation on leaf area index was taken at silking stage in both *rabi* and *kharif* seasons during both the years. Data were statistically analyzed and presented in Table 4.1.2 and graphically depicted in Fig.4.1.2.

Influence of moisture regime

A perusal of the first and second year data indicated that the influence of moisture regime was found to be non-significant on leaf area index in both *rabi* and *kharif* seasons. This was because of the fact that differences in moisture regimes actually accrued after silking stage in *rabi* maize and enough rainfall was occurred during *kharif* in both the years (Table 4.1.2).

Influence of mulching

Mulching significantly influenced the leaf area index in both *rabi* and *kharif* seasons during both the years of experimentation (Table 4.1.2). In *rabi* maize, the maximum leaf area index of 3.28 and 3.78 were recorded with maize stover @ 10 t/ha (M_4) during first and second year, respectively. M_4 was statistically at par with M_3, M_2 and M_1 during first year and with M_3 and M_2 during second year and all were significantly higher than M_5 (no mulch). The maximum leaf area index of 2.46 and 2.67 was obtained with maize stover @ 10 t/ha (M_4)

Table 4.1.2 Leaf area index at silking stage as influenced by different treatments.

Treatments	*Rabi* Leaf area index (at silking stage)		*Kharif* Leaf area index (at silking stage)	
	2013-14	2014-15	2013-14	2014-15
Moisture regime				
I_1: IW/CPE ratio 0.4	3.08	3.50	2.10	2.26
I_2: IW/CPE ratio 0.6	3.17	3.30	2.05	2.23
I_3: IW/CPE ratio 0.8	3.01	3.48	2.08	2.27
I_4: IW/CPE ratio 1.0	3.15	3.64	2.14	2.32
SEm ±	0.05	0.10	0.05	0.05
CD (P=0.05)	NS	NS	NS	NS
Mulch				
M_1:Sugarcane trash @ 5 t/ha	3.10	3.42	2.07	2.26
M_2:Sugarcane trash @10 t/ha	3.23	3.72	2.31	2.51
M_3:Maize stover @ 5 t/ha	3.11	3.61	2.15	2.35
M_4:Maize stover @ 10 t/ha	3.28	3.78	2.46	2.67
M_5:No mulch	2.80	2.88	1.47	1.57
SEm ±	0.09	0.10	0.05	0.05
CD (P=0.05)	0.27	0.30	0.14	0.14

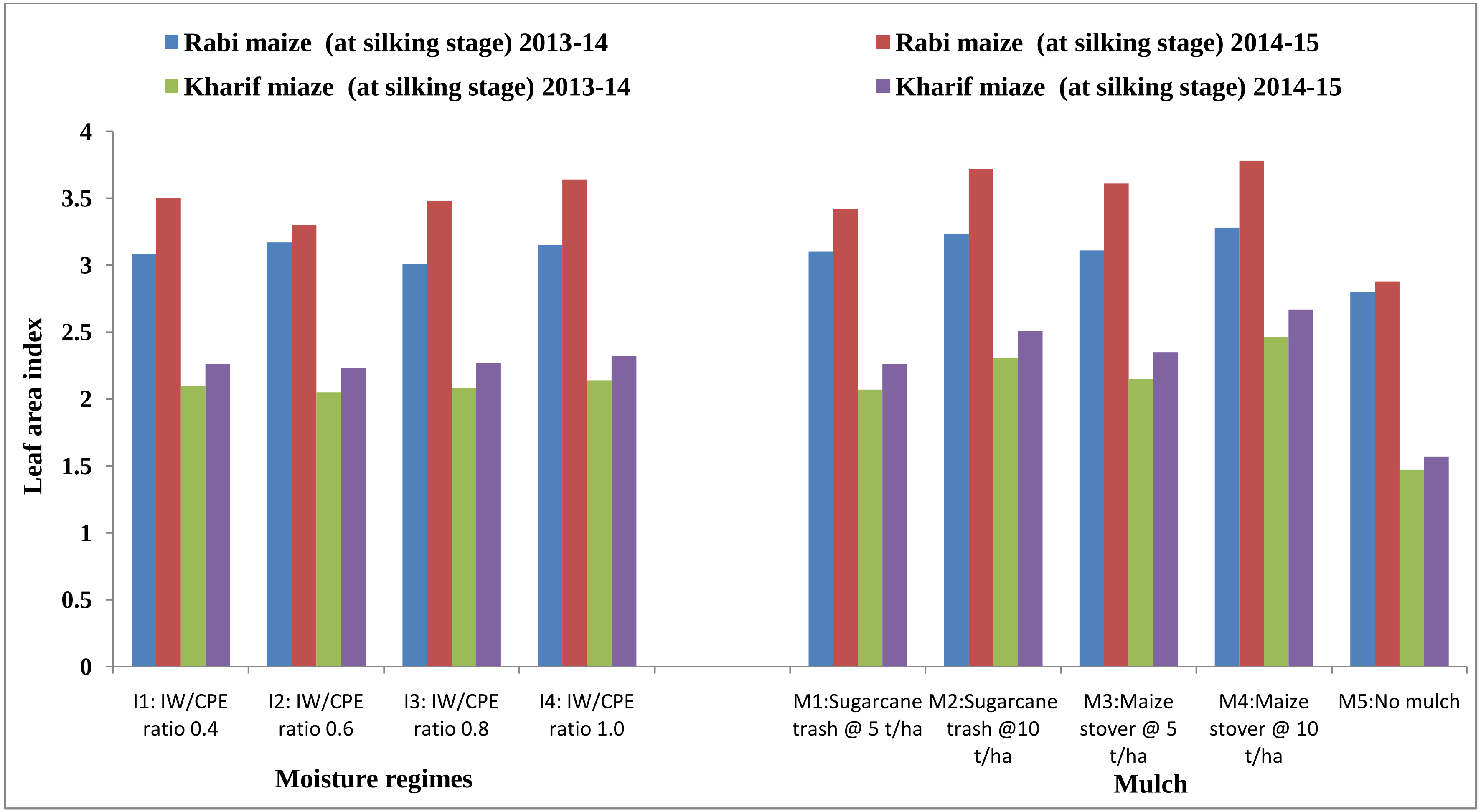


Fig. 4.1.2 Leaf area index at silking stage of maize as influenced by different treatments

and was significantly superior to all other mulched treatments and no mulch in *kharif* maize during both the years. There was also parity between M_3 and M_1 during both the years.

4.1.3 Dry matter production (g)

Mean data with respect to dry matter production recorded at 30 days interval after sowing as influenced by different treatments have been summarized and presented in Table 4.1.3a and 4.1.3b and graphically represented in Fig. 4.1.3a and 4.1.3b.

Influence of moisture regime

A perusal of dry matter production (g/plant) at different growth stages indicated that plant dry matter production continued to increase till the last date of observation. Dry matter production was significantly influenced by different moisture regimes at 120 and 150 DAS. At 120 DAS, the maximum dry matter production of 219.52 and 221.49 g/plant were recorded at 1.0 IW/CPE ratio (I_4). During the first year of experimentation I_4 was significantly superior to I_2 and I_1 but was statistically at par with I_3 while during second year I_4 was statistically at par with I_3 and I_2 and all were significantly superior to I_1. Dry matter production at 30, 60 and 90 DAS showed non-significant difference among different moisture regimes during both the years.

Moisture regime did not influence the plant dry matter production of *kharif* maize during both the years (Table 4.1.3b)

Influence of mulching

Mulching affected the plant dry matter production (g/plant) significantly in both *rabi* and *kharif* maize during both the years (Table 4.1.3a and 4.1.3b). With an increase in mulch rate, there was a corresponding increase in dry matter production at 30, 60, 90, 120 and 150 DAS of *rabi* maize (Table 4.1.3a). The maximum dry matter production (1.96 and 2.43 g/plant) were recorded at 30 DAS under maize stover @ 10 t/ha (M_4) which was significantly superior to sugarcane trash @ 5 t/ha (1.80 and 2.30 g) and no mulch (0.82 and 1.31 g) but was found to be statistically at par with sugar cane trash @ 10 (1.90 and 2.39 g) and maize stover @ 5 t/ha

(1.85 and 2.34 g). Though, all mulch treatments were significantly superior to M_5 (no mulch) during both the years. At 60 days after sowing during the first year, significantly higher plant dry matter production (7.80 g/plant) was obtained with maize stover @ 10 t/ha as compared to other mulch treatments and no mulch. However, all the treatments differed significantly. During the second year, the highest dry matter production (9.73 g/plant) was observed at maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha (7.83 g/), sugarcane trash @ 5 t/ha (7.21 g) and no mulch (3.26 g/plant) but was at par with sugarcane trash @ 10 t/ha (9.01 g). Significantly higher plant dry matter production of 25.61 and 28.57 g were recorded at 90 DAS under maize stover @ 10 t/ha as compared to maize stover @ 5 t/ha (22.07 and 24.15 g), sugarcane trash @ 5 t/ha (21.80 and 23.98 g) and no mulch (16.21 and 18.32 g/plant) but was statistically at par with sugarcane trash @ 10 t/ha (23.90 and 26.63 g) during both the years. There was also parity between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha, and between sugarcane trash @ 5 t/ha and maize stover @ 5 t/ha during the first year while between sugarcane trash @ 5 t/ha and maize stover @ 5 t/ha during the second year. A close perusal of data on plant dry matter production at 120 DAS during both the years, reveals that the maximum dry matter production (211.60 and 219.33 g) were recorded under maize stover @ 10 t/ha which was significantly superior to no mulch (167.45 and 169.53 g) but was statistically at par with other mulch treatments and all were significantly higher than no mulch treatment. At 150 days after sowing, significantly higher plant dry matter production (244.93 and 247.98 g) was obtained with mulching of maize stover @ 10 t/ha as compared to maize stover @ 5 t/ha (234.13 and 236.12 g), sugarcane trash @ 5 t/ha (229.27 and 231.18 g) and no mulch (200.66 and 201.66 g) but was at par with sugarcane trash @ 10 t/ha (236.29 and 239.22 g) during both the years. There was also parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha.

Data in Table 4.1.3b indicated that variation in plant dry matter was significant at 30, 60 and 90 DAS of *kharif* maize. Dry matter production (14.02 and 16.05 g) were recorded at 30 DAS under maize stover @ 10 t/ha which was significantly higher than sugarcane trash @ 5 t/ha (13.24 and 15.23 g) and no mulch (11.49 and 12.63 g) but was found to be non-significant with sugarcane trash @ 10 t/ha (13.70 and 15.83 g) and maize stover @ 5 t/ha (13.64 and 15.72 g)

Table 4.1.3a **Plant dry matter production (g/plant) of *rabi* maize at different growth stages as influenced by different treatments**

Treatments	30DAS		60DAS		90DAS		120DAS		150DAS	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime										
I_1- IW/CPE ratio 0.4	1.66	2.14	5.80	7.42	19.95	22.33	177.70	179.63	208.06	210.14
I_2- IW/CPE ratio 0.6	1.62	2.12	5.45	6.99	22.89	25.37	190.99	209.74	223.13	225.33
I_3- IW/CPE ratio 0.8	1.71	2.21	6.07	7.62	21.72	24.05	211.39	214.58	235.81	238.07
I_4- IW/CPE ratio 1.0	1.67	2.15	6.04	7.58	23.11	25.57	219.50	221.49	249.23	251.39
SEm ±	0.03	0.05	0.15	0.22	0.78	0.77	4.02	4.14	3.98	4.17
CD (P=0.05)	NS	NS	NS	NS	NS	NS	13.92	14.32	13.78	14.45
Mulch										
M_1-Sugarcane trash @ 5 t/ha	1.80	2.30	5.24	7.21	21.80	23.98	204.44	212.546	229.27	231.18
M_2-Sugarcane trash @10 t/ha	1.90	2.39	7.01	9.01	23.90	26.63	209.20	216.07	236.29	239.22
M_3-Maize stover @ 5 t/ha	1.85	2.34	6.30	7.83	22.07	24.15	206.81	214.40	234.13	236.12
M_4-Maize stover @ 10 t/ha	1.96	2.43	7.80	9.73	25.61	28.57	211.60	219.33	244.93	247.98
M_5-No mulch	0.82	1.31	2.86	3.26	16.21	18.32	167.45	169.53	200.66	201.66
SEm ±	0.04	0.04	0.24	0.30	0.64	0.72	4.10	4.31	3.65	3.77
CD (P=0.05)	0.11	0.13	0.68	0.88	1.86	2.09	11.81	12.41	10.52	10.86

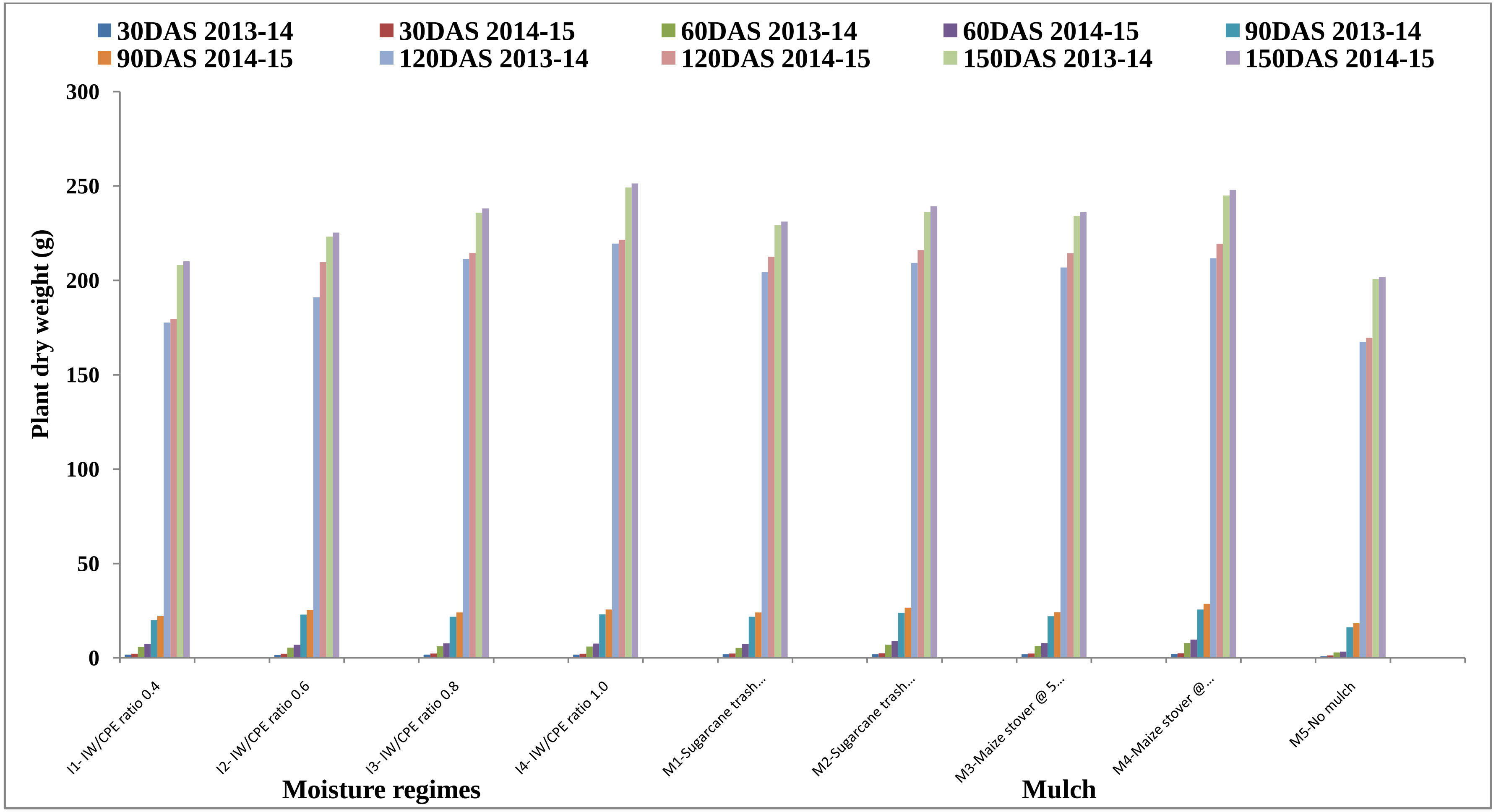


Fig. 4.1.3a Plant dry weight (g) at different growth stages of *rabi* maize as influenced by different treatments

Table 4.1.3b Plant dry matter production (g/plant) of *kharif* maize at different growth stages as influenced by different treatments.

Treatments	30 DAS		60 DAS		90 DAS	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime						
I_1- IW/CPE ratio 0.4	13.22	15.02	128.71	131.53	250.12	252.06
I_2- IW/CPE ratio 0.6	12.62	14.52	126.05	130.45	248.02	250.26
I_3- IW/CPE ratio 0.8	13.68	15.58	129.18	128.72	252.06	254.04
I_4- IW/CPE ratio 1.0	13.36	15.25	128.61	130.55	248.97	252.16
SEm ±	0.26	0.21	2.24	2.11	4.33	3.64
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Mulch						
M_1-- Sugarcane trash @ 5 t/ha	13.24	15.23	128.08	130.17	253.58	254.79
M_2- Sugarcane trash @10 t/ha	13.70	15.83	131.22	133.41	255.79	258.00
M_3- Maize stover @ 5 t/ha	13.64	15.72	128.40	130.87	254.05	256.15
M_4- Maize stover @ 10 t/ha	14.02	16.05	135.05	137.97	257.00	261.97
M_5- No mulch	11.49	12.63	117.95	119.14	228.54	229.63
SEm ±	0.28	0.31	1.93	2.01	4.34	4.47
CD (P=0.05)	0.81	0.88	5.57	5.80	12.50	12.87

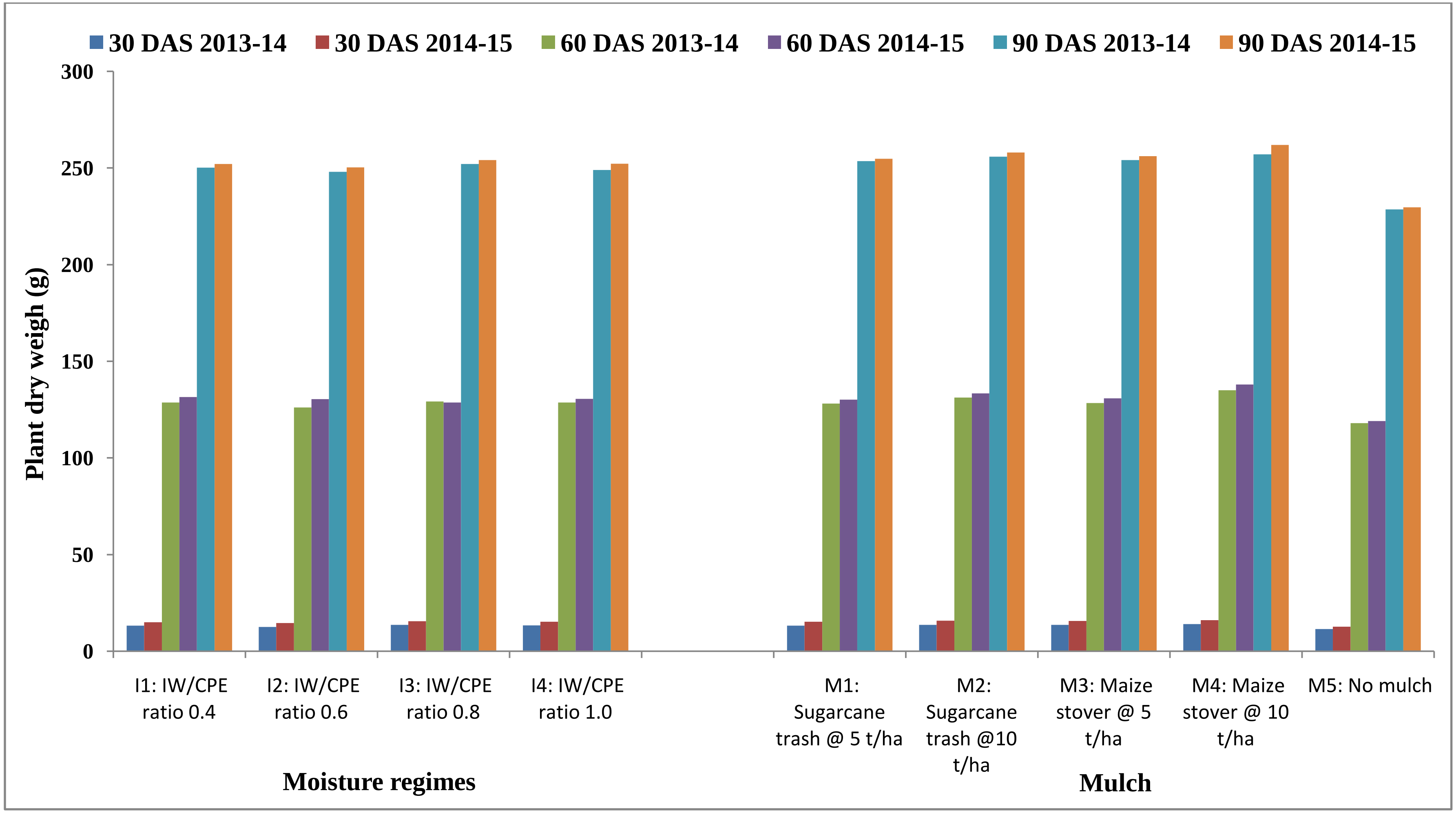


Fig. 4.1.3b Plant dry weight (g) at different growth stages of *kharif* maize as influenced by different treatments

during both the years. There was also non-significant difference among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. At 60 days after sowing, the highest dry matter production of 135.05 and 137.97 g was obtained with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha (128.40 and 130.87 g), sugarcane trash @ 5 t/ha (128.08 and 130.17 g) and no mulch (117.95 and 119.14 g) and at the same time was at par with sugarcane trash @ 10 t/ha (131.22 and 133.41 g) during both the years. There was also parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. The maximum dry matter production (257.00 and 261.97 g) was observed at 90 days after sowing with maize stover @ 10 t/ha which was statistically at par with remaining mulch treatments and all were significantly superior to no mulch treatment during both the years.

4.2 Yield attributes

4.2.1 Number of cobs per plant

Number of cobs per plant as influenced by different treatments was summarized in Table 4.2a and 4.2b.

Influence of moisture regime

A perusal of data of both the years revealed that the moisture regime did not influence the number of cobs/plant of *rabi* maize (Table 4.2a). The maximum number of cobs/plant of 1.05 and 1.07 was found with 1.0 IW/CPE ratio (I_4) and was decreased with decreasing moisture regime from 0.8 and 0.4 IW/CPE ratios in *rabi* maize during 2013-14 and 2014-15.

The moisture regime showed also non-significant influence on number of cobs/plant in *kharif* maize during both the years of experimentation (Table 4.2b).

Influence of mulching

Mulching did not influence the number of cobs/plant in both the *rabi* and *kharif* maize during both the years (Table 4.2a and 4.2b). The maximum number of cobs/plant were recorded with maize stover @ 10 t/ha (M_4) whereas the minimum number of cobs/plant were obtained with no mulch (M_5) in *rabi* and *kharif* maize during both the years.

4.2.2 Number of rows per cob

Observations on number of rows per cob as influenced by irrigation regimes and mulching during the both years have been presented in Table 4.2a and 4.2b and graphically depicted in Fig. 4.2a and 4.2b.

Influence of moisture regime

Moisture regime influenced the number of rows/cob significantly in *rabi* during both the years (Table 4.2a). Significantly higher number of rows/cob (16.09 and 16.67) was recorded with 1.00 IW/CPE ratio as compared to 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio. There was statistical parity between 0.8 and 0.6 IW/CPE ratios and 0.6 and 0.4 IW/CPE ratios. There was non-significant difference in number of rows/cob in *kharif* maize during both the years (Table 4.2b).

Influence of mulching

Mulching significantly influenced the number of rows/cob in *rabi* and *kharif* seasons during both the years of experimentation. In *rabi* maize, the maximum number of rows/cob of 15.73 and 16.28 were recorded with maize stover @10 t/ha (M_4) which was at par with all other mulched treatments and all the mulch treatments were significantly superior to no mulch (M_5) during both the years. In *kharif* maize also similar results were recorded during both the years.

4.2.3 Number of grains per cob

Mean data on number of grains per cob obtained under different treatments have been summarized and presented in Table 4.2a and 4.2b and graphically illustrated in Fig. 4.2a and 4.2b.

Influence of moisture regime

Moisture regime significantly influenced the number of grains/cob in both the years of *rabi* maize (Table 4.2a). The maximum number of grains/cob (365.35 and 369.90) was recorded with 1.00 IW/CPE ratio (I_4) which was found to be statistically at par with 0.8 and 0.6 IW/CPE ratio (I_3 and I_2) and was significantly superior over 0.4 IW/CPE ratio (I_1) during the first year of experimentation. During second year, significantly higher number of grains/cob was recorded with

I_4 as compared to I_2 and I_1 but was statistically at par with I_3. There was statistical parity among I_3, I_2 and I_1 during both the years.

Moisture regime did not influence the number of grains/cob significantly in *kharif* maize during both the years (Table 4.2b).

Influence of mulching

Mulching influenced the number of grains/cob significantly in *rabi* and *kharif* seasons during both the years (Table 4.2a and 4.2b). The highest numbers of grains/cob were recorded with maize stover @ 10 t/ha which was statistically at par with all other mulched treatments and all the mulch treatments were significantly superior to no mulch (M_5).

4.2.4 100-grain weight (g)

Data on 100-grain weight in *rabi* and *kharif* seasons during both the years have been summarized and presented in Table 4.2a and 4.2b and graphically illustrated in Fig. 4.2a and 4.2b.

Influence of moisture regime

100-grain weight in *rabi* maize during the first year was significantly influenced by moisture regime. The highest 100-grain weight of 28.27 was recorded under 1.0 IW/CPE ratio (I_4) as compared to 0.6 and 0.4 IW/CPE ratio (I_2 and I_1) but was statistically at par with 0.8 IW/CPE ratio (I_3). There was statistical parity between I_3 and I_2 and also between I_2 and I_1. During second year significantly higher 100-grain weight was recorded with I_4 as compared to I_1 but was statistically at par with I_3 and I_2. There was statistical parity among I_3, I_2 and I_1 moisture regimes.

There was non-significant difference in 100-grain weight due to moisture regime in *kharif* maize during both the years of experimentation.

Influence of mulching

Mulching significantly improved 100-grain weight of *rabi* maize during both the years (Table 4.2a and 4.2b). The maximum 100-grain weight of *rabi* maize were observed with M_4 (28.34 and 31.00 g) which was significantly higher

Table 4.2a **Number of cobs/plant, number of rows/cob, number of grains/cob and 100-grain weight (g) of *rabi* maize as influenced by different treatments**

Treatments	*Rabi*							
	Number of cobs/plant		**Number of rows/cob**		**Number of grains/cob**		**100-grain weight (g)**	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime								
I_1- IW/CPE ratio 0.4	1.03	1.03	14.68	15.09	333.29	334.62	25.11	27.50
I_2- IW/CPE ratio 0.6	1.04	1.04	15.17	15.64	344.39	346.81	26.86	29.24
I_3- IW/CPE ratio 0.8	1.05	1.05	15.52	15.99	352.42	354.64	27.48	29.27
I_4- IW/CPE ratio 1.0	1.05	1.07	16.09	16.67	365.35	369.90	28.76	31.04
SEm ±	0.01	0.01	0.21	0.24	6.06	6.62	0.54	0.59
CD (P=0.05)	NS	NS	0.74	0.83	20.98	22.92	1.87	2.03
Mulch								
M_1-Sugarcane trash @ 5 t/ha	1.03	1.04	15.43	15.94	350.27	353.36	26.62	28.54
M_2-Sugarcane trash @10 t/ha	1.05	1.06	15.62	16.15	354.70	358.14	27.75	30.24
M_3-Maize stover @ 5 t/ha	1.04	1.05	15.50	16.00	351.94	355.05	26.94	28.99
M_4-Maize stover @ 10 t/ha	1.05	1.06	15.73	16.28	357.07	361.01	28.34	31.00
M_5-No mulch	1.03	1.03	14.54	14.88	330.34	329.89	25.63	27.54
SEm ±	0.02	0.02	0.21	0.24	4.96	5.17	0.59	0.60
CD (P=0.05)	NS	NS	0.61	0.68	14.28	14.89	1.69	1.72

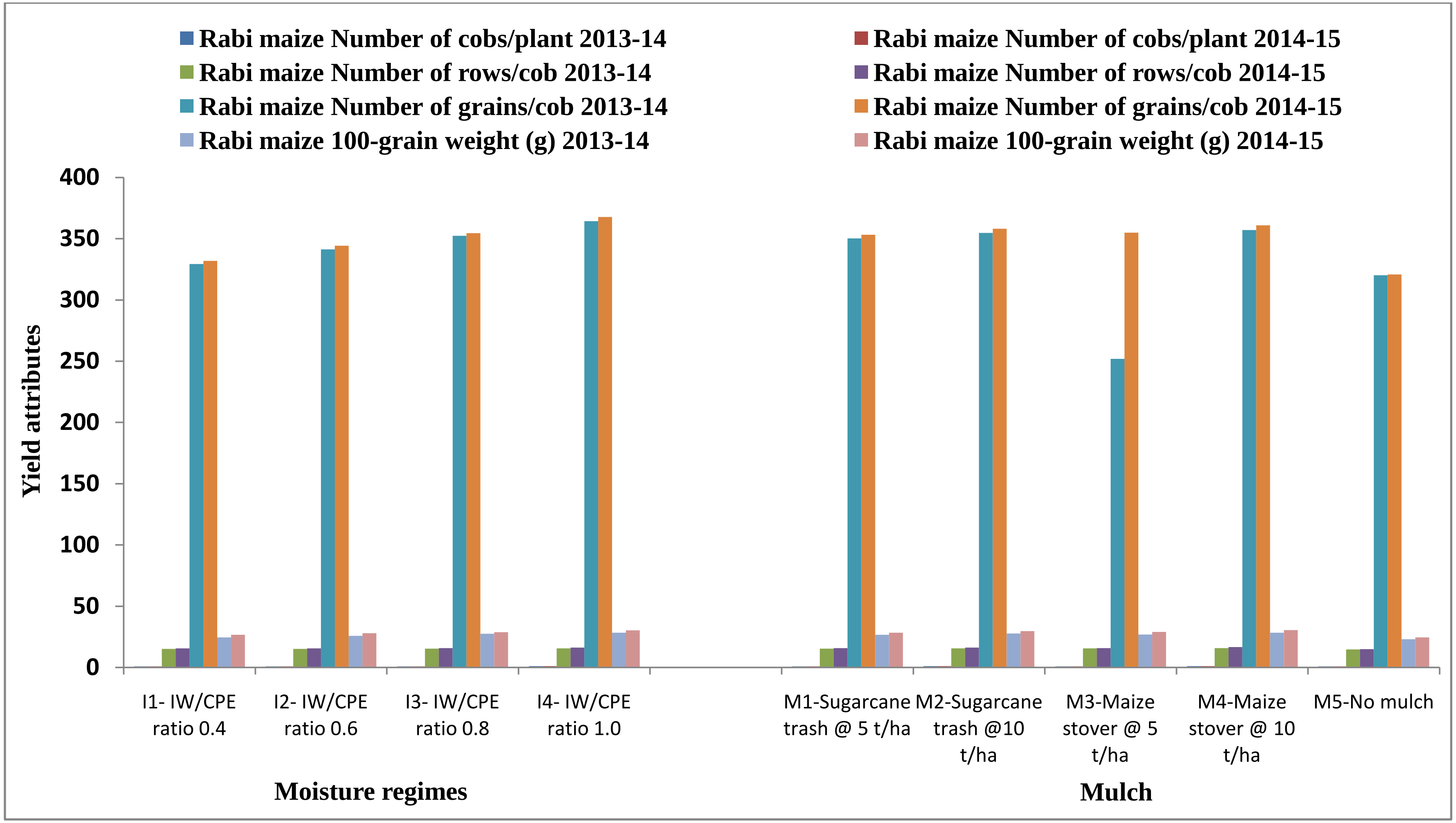


Fig. 4.2a Yield attributes of *rabi* maize as influenced by different treatments

Table 4.2b **Number of cobs/plant, number of rows/cob, number of grains/cob and100-grain weight (g) of *kharif* maize as influenced by different treatments**

Treatments	*Kharif*							
	Number of cobs/plant		Number of rows/cob		Number of grains/cob		100-grain weight (g)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime								
I_1- IW/CPE ratio 0.4	0.95	0.95	12.85	13.81	305.00	309.46	24.74	26.36
I_2- IW/CPE ratio 0.6	0.93	0.93	12.67	13.60	313.56	316.42	25.03	26.57
I_3- IW/CPE ratio 0.8	0.93	0.96	12.95	14.02	317.45	317.55	25.66	27.30
I_4- IW/CPE ratio 1.0	0.95	0.97	12.79	13.75	318.36	324.52	26.09	27.33
SEm ±	0.03	0.03	0.22	0.19	6.01	5.88	0.45	0.46
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Mulch								
M_1-Sugarcane trash @ 5 t/ha	0.93	0.93	12.77	13.74	315.85	317.77	25.17	26.97
M_2-Sugarcane trash @10 t/ha	0.95	0.97	12.97	13.91	321.97	324.96	25.78	27.53
M_3-Maize stover @ 5 t/ha	0.93	0.95	12.89	13.99	317.51	324.57	25.34	26.90
M_4-Maize stover @ 10 t/ha	1.00	1.00	13.27	14.22	327.38	330.92	25.99	28.03
M_5-No mulch	0.88	0.91	12.19	13.11	285.26	286.72	24.64	25.01
SEm ±	0.03	0.03	0.19	0.20	5.85	6.49	0.36	0.40
CD (P=0.05)	NS	NS	0.54	0.59	16.86	18.70	NS	1.14

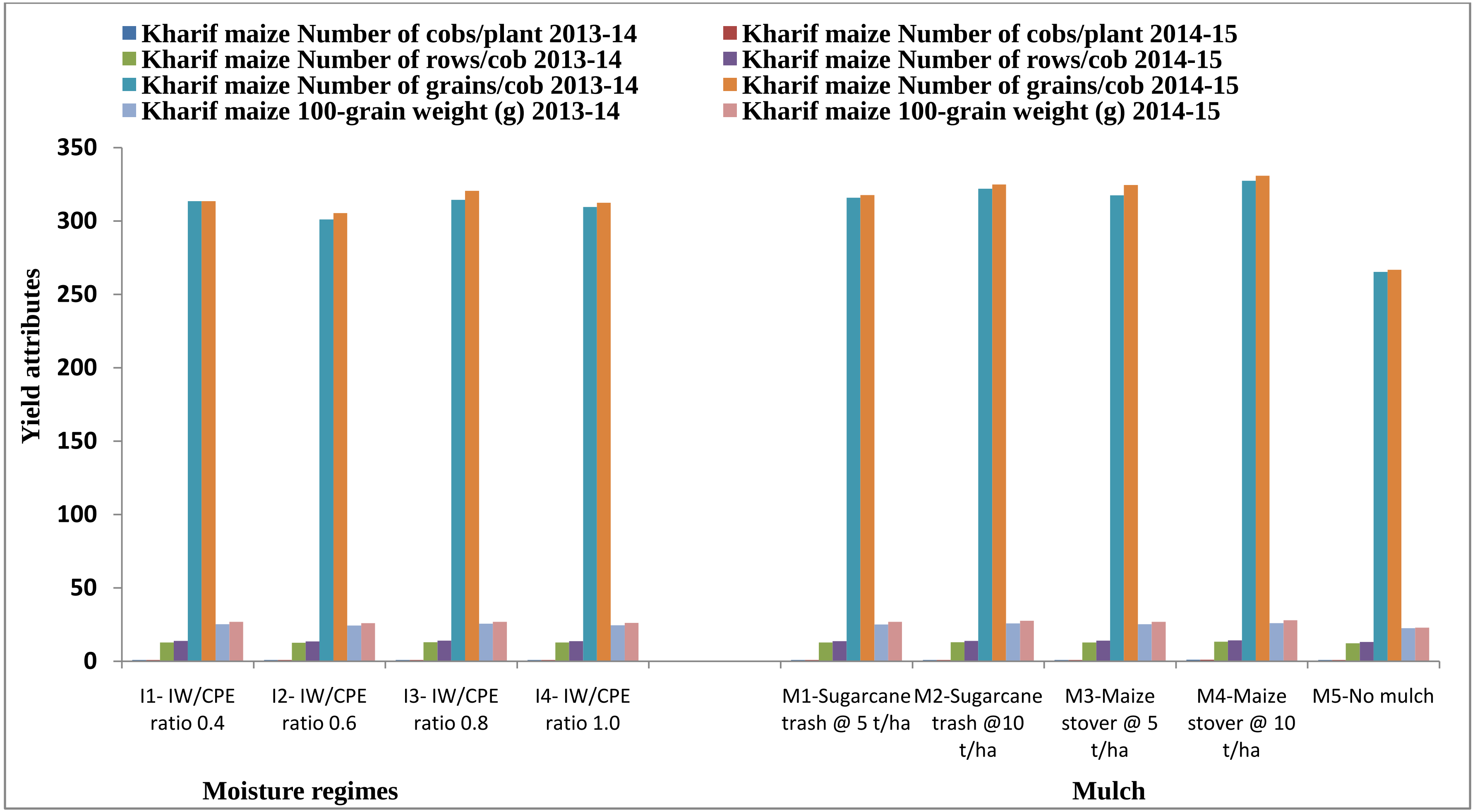


Fig. 4.2b Yield attributes of *kharif* maize as influenced by different treatments

than M_1 and M_5 but was at par with M_3 and M_2. Treatments M_1, M_3 and M_5 were statistically at par during both the years. In *kharif* maize 100-grain weight was found to be non-significant during the first year, while during the second year the maximum 100-grain weight was recorded with maize stover @ 10 t/ha (M_4) which was statistically at par with other mulched treatments and all the mulch treatments were significantly superior to no mulch (M_5).

4.3 Yield studies

4.3.1 Grain yield q/ha

Data on grain yield of maize as influenced by moisture regimes and mulching have been presented in Table 4.3a, 4.3b and 4.3c and graphically illustrated in Fig. 4.3a and 4.3b.

Influence of moisture regime

Grain yield of maize increased significantly with increase in the moisture regime in *rabi* maize during both the years (Table 4.3a). The maximum grain yield of 83.56 and 86.77 q/ha were recorded at 1.0 IW/CPE ratio in both years. The lowest grain yield of 74.26 and 76.97 q/ha were observed with 0.4 IW/CPE ratio, respectively during two years. 1.0 IW/CPE ratio was statistically at par with 0.8 and 0.6 IW/CPE ratios but there was also parity between 0.6 and 0.4 IW/CPE ratios. However, 1.0 and 0.8 IW/CPE ratio were significantly higher than 0.4 IW/CPE ratio during first year while 1.0, 0.8 and 0.6 IW/CPE ratios were significantly superior over 0.4 IW/CPE ratio in second year.

Pooled data indicated that grain yield of *rabi* maize was significantly influenced by different moisture regimes. The maximum grain yield of 85.17 q/ha was recorded under 1.0 IW/CPE ratio which was significantly superior over 0.6 and 0.4 IW/CPE ratio (80.94 and 75.62 q/ha), respectively but was statistically at par with 0.8 IW/CPE ratio (83.86 q/ha). Likewise, 0.8 IW/CPE ratio was at par with 0.6 IW/CPE ratio and significantly higher than 0.4 IW/CPE ratio. In *kharif* maize during both the years (Table 4.3b), there was no significant influence of moisture regimes on grain yield. On the basis of pooled data of *kharif* maize also there was non-significant difference in grain yield due to different moisture regimes.

Influence of mulching

Mulching significantly influenced grain yield of both the *rabi* and *kharif* maize in both the years (Table 4.3a and 4.3b). The highest grain yield in *rabi* maize of 83.33 and 87.30 q/ha during both the years was obtained under maize stover @ 10 t/ha (M_4) which was at par with sugarcane trash @ 10 t/ha (M_3) (81.56 and 85.16 q/ha) and maize stover @ 5 t/ha (M_2) (80.68 and 83.94 q/ha) but there also parity among M_3, M_2 and M_1. However, all mulched treatments were significantly superior to no mulch (M_5).

A perusal of pooled data of *rabi* maize revealed that grain yield was significantly influenced due to mulching. The maximum grain yield of 85.34 q/ha was obtained with maize stover @ 10 t/ha which was statistically at par with sugarcane trash @ 10 t/ha (83.37 q/ha) but sugarcane trash @ 10 t/ha was at par with maize stover @ 5 t/ha (82.31 q/ha) and also maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha (80.74 q/ha) were at par to each other. However, maize stover @ 10 t/ha was significantly superior over maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha, whereas all mulched treatments were significantly higher than no mulch (75.23 q/ha).

Grain yield of *kharif* maize during both the years (Table 4.3b) followed similar trend as that of grain yield in *rabi* maize except all the mulch treatments were at par. Pooled data of grain yield of *kharif* maize varied significantly under different mulches application. Among the mulching, the higher grain yield of 51.78 q/ha was observed under maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (49.21 q/ha) and no mulch (4.61 q/ha) and was statistically at par with sugarcane trash @ 10 t/ha (50.84 q/ha) and maize stover @ 5 t/ha (50.25 q/ha) but sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha were at par to each other. Though, all mulched treatments were significantly superior over on mulch. The interaction influence of moisture regime and mulching was found to be non-significant in both *rabi* and *kharif* maize during both the years and pooled data.

4.3.2 Stover yield q/ha

Observations on stover yield q/ha of maize as influenced by different treatments during two years of experimentation have been summarized and presented in Table 4.3a and 4.3b and graphically depicted in Fig. 4.3a and 4.3b.

Influence of moisture regime

Stover yield of maize increased significantly with increase in the moisture regime in *rabi* maize during both the years (Table 4.3a). The maximum stover yield of 108.33 and 111.23 q/ha were recorded at 1.0 IW/CPE ratio (I_4) in both the years, while the lowest stover yield of 97.33 and 101.15 q/ha were observed with 0.4 IW/CPE ratio (I_1) during 2013-14 and 2014-15, respectively. I_4 was statistically at par with I_3 while I_2 was at par with I_1 but likewise, I_3 was at par with I_2. However, I_4 was significantly higher than I_2 and I_1 in first year of experimentation whereas I_4 was at par with I_3 and I_2 and there was parity among I_3, I_2 and I_1, though, I_4 was significantly higher than I_1 during second year.

On the basis of pooled data, stover yield of *rabi* maize increased significantly with increase in the moisture regime. The highest stover yield of 109.79 q/ha was recorded with 1.0 IW/CPE ratio which was significantly superior over 0.6 and 0.4 IW/CPE ratios recorded 102.58 and 99.25 q/ha, respectively but was at par with 0.8 IW/CPE ratio (106.52 q/ha). There was parity between 0.8 and 0.6 IW/CPE ratios, and likewise between 0.6 and 0.4 IW/CPE ratios.

In *kharif* maize during both the years (Table 4.3b), there was non-significant influence of moisture regime on stover yield. Pooled data on stover yield of *kharif* maize also indicated that there was non-significant influence due to moisture regime.

Influence of mulching

Mulching significantly influenced stover yield of both the *rabi* and *kharif* maize during the two consecutive years (Table 4.3a and 4.3b). In *rabi* maize, the highest stover yield of 107.72 q/ha was recorded with maize stover @ 10 t/ha (M_4) which was statistically at par with sugarcane trash @ 10 t/ha (M_2) (104.53 q/ha) but there was parity among M_2, M_3 and M_1 (104.53, 103.72 and 101.72 q/ha).

However, M_4 was significantly higher than M_3, M_1 and M_5 during first year. All the mulched treatments were significantly superior over no mulch (96.43 q/ha). Similarly during second year, the highest stover yield of 111.39 q/ha was recorded under maize stover @ 10 t/ha (M_4) which was statistically at par with other mulched treatments but sugarcane trash @ 5 t/ha (105.05 q/ha) was at par with no mulch (98.687 q/ha). Though, M_4, M_3 and M_2 were significantly superior over no mulch during second year.

Pooled data of stover yield on *rabi* maize was significantly influenced by mulching. The highest stover yield of 109.57 q/ha was obtained under maize stover @ 10 t/ha which was statistically at par with sugarcane trash @ 10 t/ha (107.08 q/ha) and maize stover @ 5 t/ha (105.08 q/ha) but sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha were statistically at par with each other. Though, all the mulched treatments were significantly superior over at mulch (97.56 q/ha).

In *kharif* maize during both the years (Table 4.3b), the maximum stover yield of 105.36 and 108.07 q/ha were recorded under maize stover @ 10 t/ha (M_4) which was at par with sugarcane trash @ 10 t/ha (M_3), maize stover @ 5 t/ha (M_2) and sugarcane trash @ 5 t/ha (M_1) and all were significantly superior to no mulch (M_5) during both the years.

The pooled data of *kharif* maize as influenced by mulching showed significant variations on stover yield. The maximum stover yield of 106.72 q/ha was recorded with maize stover @ 10 t/ha which was statistically at par with remaining mulched treatments (105.67, 104.78 and 103.13 q/ha) and all were significantly superior over no mulch (94.90 q/ha).

The different moisture regimes and mulching did not cause significant interaction effect with regard to stover yield in both *rabi* and *kharif* maize during both the years and also the pooled data.

4.3.3 Stone yield q/ha

Mean data on stone yield q/ha of maize obtained under different treatments during the two years of experimentation have been summarized and presented in Table 4.3a and 4.3b and graphically illustrated in Fig. 4.3a and 4.3b.

Influence of moisture regime

Stone yield of maize increased significantly with increase in the moisture regime in *rabi* maize during both the years (Table 4.3a). Significantly higher stone yield of 22.30 and 22.61 q/ha was recorded with 1.0 IW/CPE ratio (I_4) as compared to I_3 (20.29 and 20.75 q/ha), I_2 (18.86 and 19.64 q/ha) and I_1 (17.16 and 81.11 q/ha) during both the years. I_2 and I_1 were statistically at par with each other and also I_3 and I_2 during the second year.

Pooled data on stone yield of *rabi* maize showed significant variation on stone yield due to moisture regime. Significantly higher stone yield of 22.47 q/ha was recorded with 1.0 IW/CPE ratio (I_4) as compared to 0.8 IW/CPE ratio (20.53 q/ha), 0.6 IW/CPE ratio (19.26 q/ha) and 0.4 IW/CPE ratio (17.64 q/ha).

Data reveals that there was non-significant influence on stone yield by moisture regime in *kharif* maize during both the years (Table 4.3b). Pooled data in respect of stone yield of *kharif* maize also reveals that there was non- significant influence due to moisture regime.

Influence of mulching

Mulching significantly influenced stone yield of *rabi* and *kharif* maize during both the years (Table 4.3a and 4.3b). In *rabi* maize, significantly higher stone yield of 21.61 and 22.27 q/ha was recorded with M_4 (maize stover @ 10 t/ha) as compared to M_3 (maize stover @ 5 t/ha recording of 19.92 and 20.77 q/ha), M_2 (sugarcane trash @ 10 t/ha recording of 20.45 and 20.70 q/ha), M_1 (sugarcane trash @ 5 t/ha recording of 18.7 q/ha) and no mulch (17.6 q/ha) during both the years. There were statistical parity between M_1 and M_2, M_2 and M_3, and M_1 and M_5.

A perusal of pooled data of *rabi* maize on stone yield showed that there was significant influence due to mulch application. Significantly higher stone yield of 21.94 q/ha was recorded with maize stover @ 10 t/ha (M_4) over all the mulch treatments. There was statistical parity between sugarcane trash @ 10 t/ha (20.59 q/ha) and maize stover @ 5 t/ha (20.36 q/ha) and both were significantly superior to sugarcane trash @ 5 t/ha (19.09 q/ha). However, all the mulch treatments were significantly higher than no mulch (17.89 q/ha).

In *kharif* maize during both the years, mulching significantly influenced stone yield (Table 4.3b). Significantly higher stone yield of 19.78 and 21.19 q/ha were observed with M_4 (maize stover @ 10 t/ha) as compared to M_3 (maize stover @ 5 t/ha) recording 18.30 and 19.59 q/ha), M_1 (sugarcane trash @ 5 t/ha) recording 17.50 and 18.11 and M_5 (no mulch) recoding 14.92 and 16.26 q/ha during both the years. There was statistical parity between M_2 and $M_{3,}$ and also between M_1 and M_3.

Close observation of the pooled data of *kharif* maize on stone yield showed that there was significant difference due to mulching. Significantly higher stone yield of 20.49 q/ha was recorded with M_4 (maize stover @ 10 t/ha) as compared to M_3, M_1 and M_5 but was statistically at par with M_2 (sugarcane trash @ 10 t/ha recoding 19.57 q/ha). There was parity between M_2 and M_3. However, all the mulched treatments were significantly superior over no mulch (15.59 q/ha).

The interaction influence of moisture regime and mulching was non-significant in both *rabi* and *kharif* maize during both the years and pooled data.

4.3.4 Harvest index (%)

Data on harvest index in both the years were gathered on the basis of grain yield and total biological yield and the mean data have been presented in Table 4.3a and 4.3b and graphically depicted in Fig. 4.3a and 4.3b.

A perusal of data in *rabi* and *kharif* during both the years, reveals that there was non-significant influence on harvest index by moisture regime and mulching. On the basis of pooled data in both *rabi* and *kharif* maize on harvest index indicated that there was non-significant difference due to different moisture regimes and mulching.

The interaction was found to be non-significant in both *rabi* and *kharif* maize during both the years.

Table 4.3a **Grain yield, stover yield, stone yield (q/ha) and harvest index (%) of *rabi* maize as influenced by different treatments**

Treatments	*Rabi*											
	Grain yield (q/ha)			**Stover yield (q/ha)**			**Stone yield (q/ha)**			**Harvest index (%)**		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Moisture regime												
I_1- IW/CPE ratio 0.4	74.26	76.97	75.62	97.33	101.18	99.25	17.16	18.11	17.64	39.42	39.22	39.33
I_2- IW/CPE ratio 0.6	79.53	82.34	80.94	100.37	104.80	102.58	18.86	19.64	19.26	39.96	39.92	39.95
I_3- IW/CPE ratio 0.8	82.91	84.80	83.86	105.27	107.75	106.52	20.29	20.75	20.53	39.77	39.82	39.80
I_4- IW/CPE ratio 1.0	83.56	86.77	85.17	108.33	111.23	109.79	22.30	22.61	22.47	38.98	39.40	39.19
SEm ±	1.56	1.32	1.14	1.66	2.53	1.87	0.39	0.52	0.44	0.68	0.53	0.41
CD (P=0.05)	5.41	4.58	3.20	5.74	8.77	4.66	1.34	1.81	1.24	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	79.01	82.48	80.74	101.72	105.05	103.39	18.71	19.44	19.09	39.64	40.03	39.83
M_2-Sugarcane trash @10 t/ha	81.56	85.16	83.37	104.53	109.61	107.08	20.45	20.70	20.59	39.52	39.54	39.53
M_3-Maize stover @ 5 t/ha	80.68	83.94	82.31	103.72	106.45	105.08	19.92	20.77	20.36	39.46	39.78	39.62
M_4-Maize stover @ 10 t/ha	83.33	87.30	85.34	107.72	111.39	109.57	21.61	22.27	21.94	39.18	39.49	39.35
M_5-No mulch	75.74	74.72	75.23	96.43	98.68	97.56	17.58	18.20	17.89	39.87	39.010	39.49
S.Em ±	1.05	1.48	1.30	1.20	2.98	1.62	0.40	0.47	0.34	0.43	0.66	0.44
CD (P=0.05)	3.02	4.27	2.61	3.46	8.59	4.54	1.15	1.36	1.01	NS	NS	NS
Interaction I × M												
SEm ±	2.10	2.96	2.49	2.40	5.96	3.23	0.80	0.95	0.80	0.86	1.32	0.93
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

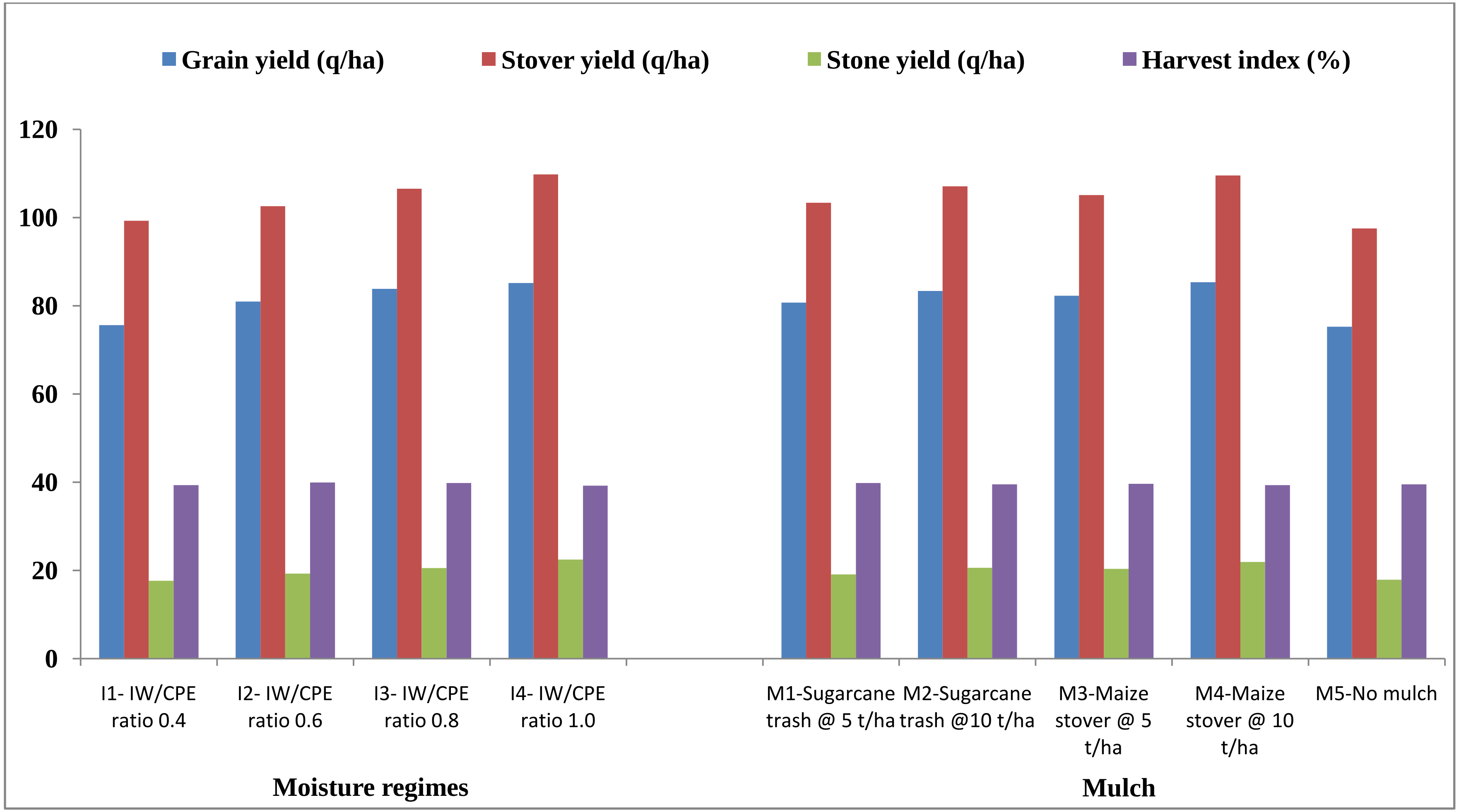


Fig. 4.3a Grain, stover, stone yields (q/ha) and harvest index (%) of *rabi* maize as affected by different treatments (Pooled data)

Table 4.3b Grain yield, stover yield, stone yield (q/ha) and harvest index (%) of *kharif* maize as influenced by different treatments

Treatments	*Kharif*											
	Grain yield (q/ha)			**Stover yield (q/ha)**			**Stone yield (q/ha)**			**Harvest index (%)**		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Moisture regime												
I_1- IW/CPE ratio 0.4	48.17	49.50	48.84	101.82	104.15	102.98	18.00	19.07	18.54	28.69	28.61	28.65
I_2- IW/CPE ratio 0.6	47.92	49.84	48.88	100.06	104.45	102.26	17.45	18.30	17.87	28.99	28.87	28.95
I_3- IW/CPE ratio 0.8	48.80	50.67	49.73	101.66	105.10	103.39	18.07	19.64	18.85	28.94	28.85	28.90
I_4- IW/CPE ratio 1.0	48.02	51.77	49.90	101.11	105.92	103.52	18.09	19.20	18.65	28.72	29.35	29.05
SEm ±	1.51	0.61	0.95	1.99	1.96	1.84	0.32	0.50	0.34	0.43	0.38	0.40
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	47.85	50.57	49.21	101.00	105.26	103.13	17.50	18.11	17.80	28.78	29.06	28.92
M_2-Sugarcane trash @10 t/ha	49.57	52.11	50.84	103.93	107.37	105.67	19.01	20.13	19.57	28.75	29.00	28.87
M_3-Maize stover @ 5 t/ha	48.75	51.75	50.25	102.90	106.65	104.78	18.30	19.59	18.94	28.67	29.08	28.87
M_4-Maize stover @ 10 t/ha	50.42	53.13	51.78	105.36	108.07	106.72	19.78	21.19	20.49	28.69	29.12	28.91
M_5-No mulch	44.55	44.67	44.61	92.61	97.17	94.90	14.92	16.26	15.59	29.28	28.36	28.82
SEm ±	1.02	1.03	0.75	1.85	1.81	1.33	0.50	0.53	0.48	0.33	0.41	0.35
CD (P=0.05)	2.94	2.95	2.17	5.32	5.21	3.65	1.43	1.53	1.03	NS	NS	NS
Interaction I × M												
S.Em ±	2.04	2.05	1.50	3.70	3.62	2.61	0.99	1.06	0.79	0.66	0.82	0.72
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

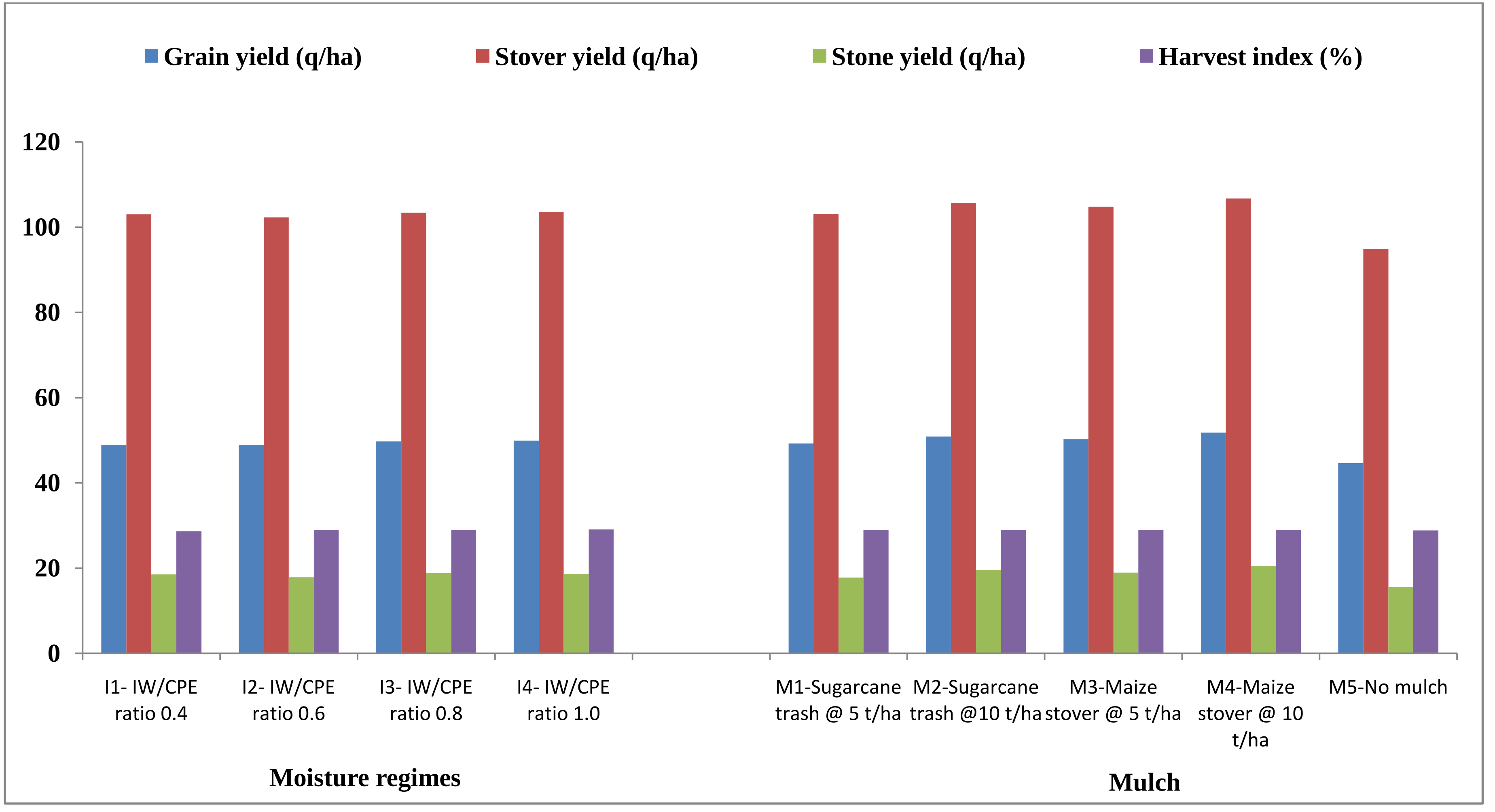


Fig. 4.3b Grain, stover, stone yields (q/ha) and harvest index (%) of *kharif* maize as affected by different treatments (Pooled data)

4.4 System productivity

4.4.1 Grain yield of maize-maize cropping system

Perusal of the system pooled data presented in Table 4.3c shows that the influence of moisture regime was significant. The maximum grain yield of 135.07 q/ha was recorded under 1.0 IW/CPE ratio which was significantly superior to 0.6 IW/CPE ratio (129.82 q/ha) and 0.4 IW/CPE ratio (124.46 q/ha) but was statistically at par with 0.8 IW/CPE ratio (133.59 q/ha). There was also statistical parity between 0.6 and 0.4 IW/CPE ratios.

Observation of the system pooled data of maize on grain yield showed that there was significant difference due to mulching. Significantly higher grain yield of 137.12 q/ha was recorded under maize stover @ 10 t/ha as compared to maize stover @ 5 t/ha (132.56 q/ha), sugarcane trash @ 5 t/ha (129.95 q/ha) and no mulch (119.84 q/ha) but was statistically at par with sugarcane trash @ 10 t/ha (134.21 q/ha). There was also parity between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. Though, all the mulched treatments were significantly superior over no mulch treatment.

4.4.2 Water-use efficiency

Data in respect of water-use efficiency as influenced by moisture regime and mulching during the two years of experimentation have been summarized and presented in Table 4.4.2 and graphically illustrated in Fig. 4.4.1

Influence of moisture regime

Water-use efficiency increased significantly with decrease of moisture regime in *rabi* and *kharif* maize during both the years (Table 4.4.2). In *rabi* maize, the highest water-use efficiency of 337.41 and 473.35 kg/ha-cm were obtained under 0.4 IW/CPE ratio (I_1) and the lowest water-use efficiency of 181.57 and 153.26 kg/ha-cm was recorded at 1.0 IW/CPE ratio (I_4) during both the years. However, 0.4 IW/CPE ratio (I_1) was significantly superior to other moisture regimes.

Pooled data of *rabi* maize on water-use efficiency reveals that 0.4 IW/CPE ratio has significantly higher water-use efficiency of 405.38 kg/ha-cm and

Table 4.4.1 Grain yield (q/ha) of maize as influenced by different treatments (maize-maize system pooled) data

Treatments	Grain yield (q/ha)				
	Moisture regime				
	I_1- IW/CPE ratio 0.4	I_2- IW/CPE ratio 0.6	I_3- IW/CPE ratio 0.8	I_4- IW/CPE ratio 1.0	Mean
Mulch					
M_1-Sugarcane trash @ 5 t/ha	124.28	128.86	132.22	134.44	**129.95**
M_2-Sugarcane trash @10 t/ha	127.88	134.14	137.38	137.46	**134.21**
M_3-Maize stover @ 5 t/ha	127.46	131.86	134.12	136.86	**132.56**
M_4-Maize stover @ 10 t/ha	130.54	136.46	141.00	140.38	**137.12**
M_5-No mulch	112.14	117.80	123.28	126.18	**119.84**
Mean	**124.46**	**129.82**	**133.59**	**135.07**	
	I	M	I×M		
SEm ±	1.34	1.24	2.48		
CD (P=0.05)	3.82	3.26	NS		

decreased significantly 301.90 to 253.59 and 217.42 kg/ha-cm with increasing of IW/CPE ratio from 0.6 to 0.8 and 1.0, respectively.

In *kharif* maize during both the years, moisture regime did not influence water-use efficiency significantly. Pooled data on moisture regimes of *kharif* maize showed that there was non-significant difference on water-use efficiency due to moisture regime.

Influence of mulching

Mulching significantly influenced water-use efficiency of *rabi* and *kharif* maize during both the years (Table 4.4.2). The highest water-use efficiency of *rabi* maize of 250.17 and 369.32 kg/ha-cm were observed in M_4 (maize stover @ 10 t/ha) which was significantly superior to M_1 (sugarcane trash @ 5 t/ha) and M_5 (no mulch) but was statistically at par with M_2 and M_3 during two years of experimentation. There were also parity among M_3, M_2 and M_1, and all the mulched treatments were significantly superior to no mulch (M_5) during both the years.

On the basis of pooled data, water-use efficiency was significantly influenced by mulching. Among the various mulches application, maize stover @ 10 t/ha had significantly higher water-use efficiency of 309.69 kg/ha-cm which was at par with sugarcane trash @ 10 t/ha (302.08 kg/ha-cm) and was significantly superior over maize stover @ 5 t/ha (298.45 kg/ha-cm) and sugarcane trash @ 5 t/ha (292.29 kg/ha-cm) but sugarcane trash @ 10 t/ha was at par with maize stover @ 5 t/ha.

In *kharif* maize, the highest water-use efficiency of 82.72 and 99.87 kg/ha-cm was recorded under maize stover @ 10 t/ha (M_4) which was statistically at par with other mulch treatments and all were significantly superior to no mulch (M_5) during both the years.

Pooled data of *kharif* maize with regard to water-use efficiency indicated that there was significant influence due to mulching. The maximum water-use efficiency of 91.29 kg/ha-cm was recorded with maize stover @ 10 t/ha which was significantly superior over sugarcane trash @ 5 t/ha (86.77 kg/ha-cm) and no mulch (78.53 kg/ha-cm) and it was found to be at par with sugarcane trash @ 10 t/ha (89.63 kg/ha-cm) and maize stover @ 5 t/ha (88.62 kg/ha-cm) but sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha were statistically at par to each other. However, all mulched treatments were significantly superior over no mulch.

No interaction effect was observed between moisture regime and mulching in both *rabi* and *kharif* maize and pooled of each one.

4.4.2 Water productivity

Data recorded with respect to water productivity was statistically analyzed and have been presented in Table 4.4.2 and graphically represented in Fig. 4.4.1.

Influence of moisture regime

Moisture regime significantly influenced water productivity of *rabi* maize in both the years (Table 4.4.2). The maximum water productivity of 28.27 and 41.67 ₹/m^3 were recorded under 0.4 IW/CPE ratio which was significantly higher than 0.6 IW/CPE (19.74 and 33.17 ₹/m^3), 0.8 IW/CPE ratio (17.64 and 26.92₹/m^3) and 1.0 IW/CPE ratio (15.13 and 22.67₹/m^3), respectively during 2013-14 and 2014-15.

On the basis of pooled data of *rabi* maize there was significant influence in water productivity due to moisture regime. The highest water productivity of 34.97 ₹/m^3 was obtained under 0.4 IW/CPE ratio and decreased significantly with increasing IW/CPE ratio of 0.6, 0.8 and 1.0 IW/CPE ratios (26.46, 22.28 and 18.99 ₹/m^3), respectively.

In *kharif* maize, there was non-significant difference in water productivity due to moisture regimes during both the years. Pooled data of *kharif* maize also indicated that there was non-significant difference in water productivity due to different moisture regimes.

Influence of mulching

Mulching significantly influenced water productivity of *rabi* and *kharif* maize in both the years (Table 4.4.2). The maximum water productivity of 21.33 ₹ /m^3 in *rabi* maize was obtained with maize stover @ 10 t/ha which was statistically at par with sugarcane trash @ 10 t/ha (20.65 ₹/m^3) and maize stover @ 5 t/ha

Table 4.4.2 Water-use efficiency (kg/ha-cm) and Water productivity (₹/m^3) as influenced by different treatments

Treatments	Water-use efficiency (kg/ha-cm)						Water productivity (₹/m^3)					
	Rabi			*Kharif*			*Rabi*			*Kharif*		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Moisture regime												
I_1- IW/CPE ratio 0.4	337.21	473.35	405.38	79.04	93.04	86.04	28.27	41.67	34.97	5.01	6.23	5.62
I_2- IW/CPE ratio 0.6	233.81	369.89	301.90	78.61	93.68	86.15	19.74	33.17	26.46	4.96	6.31	5.64
I_3- IW/CPE ratio 0.8	207.12	300.06	253.59	80.05	95.24	87.64	17.64	26.92	22.28	5.15	6.52	5.83
I_4- IW/CPE ratio 1.0	181.57	253.26	217.42	78.76	97.32	88.04	15.31	22.67	18.99	4.98	6.79	5.89
SEm ±	4.66	6.84	4.32	2.49	1.15	1.33	0.44	0.80	0.56	0.14	0.20	0.15
CD (P=0.05)	16.14	23.69	12.79	NS	NS	NS	1.54	2.76	1.94	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	236.74	347.83	292.29	78.49	95.05	86.77	19.87	31.01	25.44	4.98	6.52	5.75
M_2-Sugarcane trash @10 t/ha	244.85	359.31	302.08	81.31	97.95	89.63	20.65	32.14	26.40	5.19	6.73	5.96
M_3-Maize stover @ 5 t/ha	242.04	354.87	298.45	79.97	97.27	88.62	20.56	31.94	26.25	5.17	6.82	6.00
M_4-Maize stover @ 10 t/ha	250.04	369.32	309.69	82.72	99.87	91.29	21.33	33.46	27.40	5.37	6.99	6.18
M_5-No mulch	226.32	314.37	270.34	73.09	83.97	78.53	18.79	26.98	22.89	4.43	5.24	4.84
S.Em ±	3.10	6.02	3.64	1.67	1.93	1.27	0.35	0.86	0.68	0.16	0.22	0.16
CD (P=0.05)	8.92	17.34	9.57	4.82	5.55	3.61	1.01	2.49	1.97	0.45	0.63	0.45
Interaction I × M												
SEm ±	6.19	12.04	9.53	3.35	3.86	1.83	0.70	1.73	1.37	0.31	0.44	0.32
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

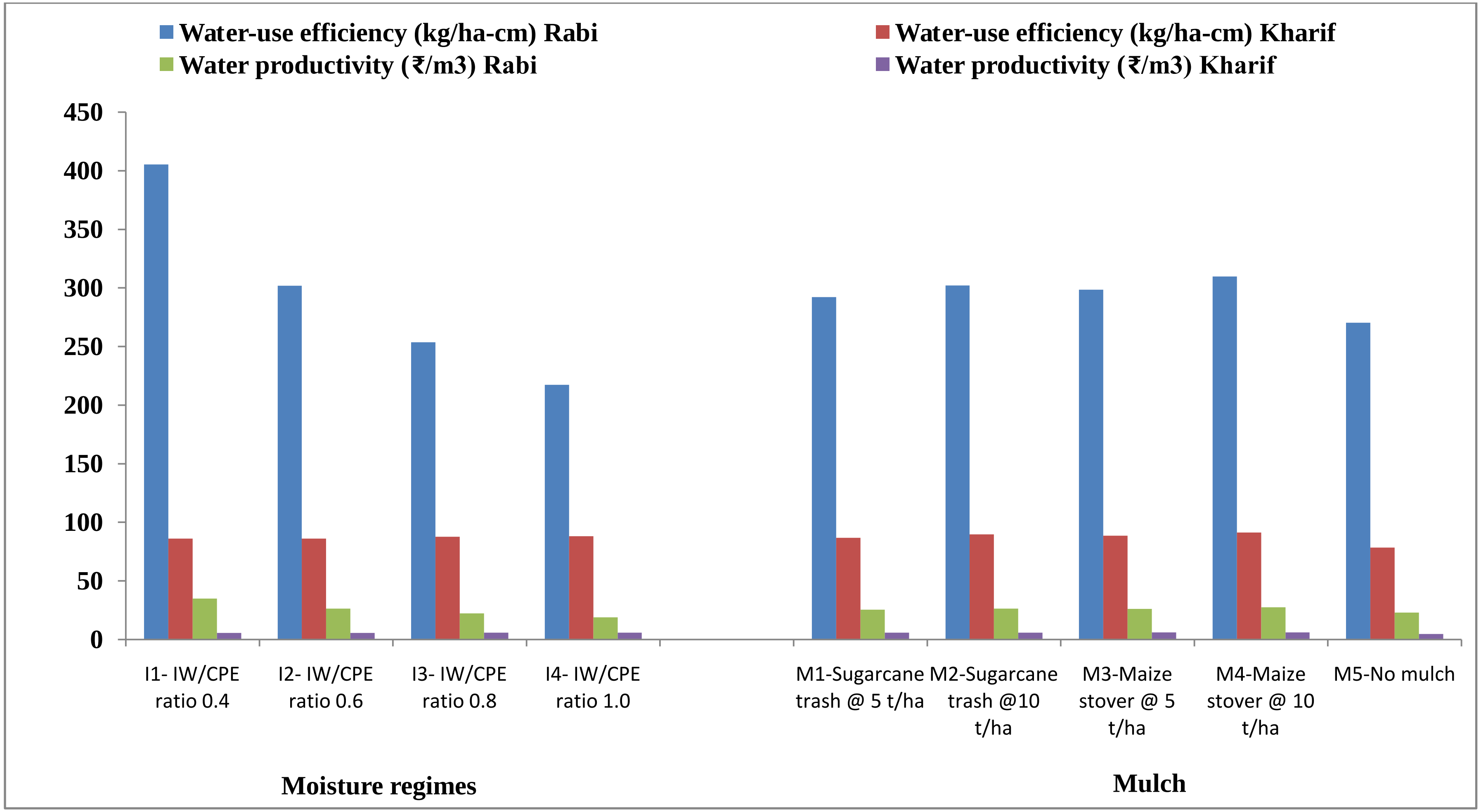


Fig. 4.4.1 Water-use efficiency (kg/ha-cm) and Water productivity (₹/m^3) as affected by different treatments (Pooled data)

(20.56 ₹/m^3) but was significantly superior to sugarcane trash @ 5 t/ha (19.87 ₹ /m^3) and no mulch (18.79 ₹/m^3) during first year while maize stover @ 10 t/ha (33.46 ₹/m^3) was at par with all the mulch treatments and all were significantly higher than non-mulch treatment during second year.

A perusal of pooled data of *rabi* maize revealed that water productively was significantly influenced due to application of mulches. The maximum water productivity of 27.40 ₹/m^3 was recorded with maize stover @ 10 t/ha which was statistically at par with other mulch treatments and all were significantly superior over no mulch (22.89 ₹/m^3).

In *kharif* maize, the highest water productivity of 5.37 and 6.99 ₹/m^3 were recorded with maize stover @ 10 t/ha which was at par with other mulch treatments and they were significantly superior to no mulch during both the years. Pooled data of *kharif* maize followed similar trend of *kharif* during both the years.

No interaction effect was observed between moisture regime and mulching in both *rabi* and *kharif* maize and pooled of each one.

4.5 Weed study

4.5.1 Weed population (no. weeds /m^2)

The mean data in respect of weed population (no. weeds/m^2) at knee high and silking stages as influenced by different treatments have been summarized in Table 4.5.1 and graphically illustrated in Fig. 4.5.1.

Influence of moisture regimes

Influence of moisture regime on number of weeds per unit area (square meter) at knee high and silking stages were found to be non-significant in *rabi* and *kharif* seasons during both the years of experimentation (Table 4.5.1).

Influence of mulching

As the rate of mulch increased, corresponding significant decrease in weed population count was observed at knee high and silking stages of *rabi* and *kharif* maize (Table 4.5.1).

At knee high stage of *rabi* maize during both the years, mulching significantly decreased number of weeds. The least number of weeds of 87.92 and 90.95/m^2 were recorded with maize stover @ 10 t/ha (M_4) which was at par with sugarcane trash @ 10 t/ha (M_2) while the highest number of weeds of 151.77 and 156.96/m^2 were obtained under no mulch (M_5) during 2013-14 and 2014-15, respectively. Number of weeds was decreased significantly by mulching also at silking stage of *rabi* maize during both the years. The least weed count of 64.63 and 66.80/m^2 was observed with maize stover @ 10 t/ha (M_4) which was at par with sugarcane trash @ 10 t/ha (M_2). There was also parity between M_3 and M_2 and similarly between M_3 and M_1 during both the years. The highest weed count of 122.38 and 130.83/m^2 were recorded with no mulch (M_5) and all mulched treatments were significantly lower than no mulch (M_5) during both the years.

At knee high stage of *kharif* maize, mulching significantly reduced number of weeds (Table 4.2.1). The minimum number of weeds of 98.42 and 99.63/m^2 were observed with maize stover @ 10 t/ha (M_4) which was at par with other mulch treatments, while the maximum number of weeds of 228.29 and 226.56/m^2 were recorded with no mulch (M_5). All mulched treatments showed significantly lower number of weeds than no mulch (M_5) during both the years. At silking stage of *kharif* maize during both the years, number of weeds was decreased significantly due to mulching (Table 4.5.1). The lowest number of weeds of 72.41 and 74.33/m^2 were recorded under maize stover @ 10 t/ha (M_4) which was at par with all the mulch treatments, while the highest number of weeds of 129.30 and 131.82/m^2 were observed with no mulch (M_5). All the mulched treatments were significantly lower than no mulch (M_5) during both the years.

4.5.2 Weed dry weight

Weed dry weight at knee high and silking stages as influenced by different treatments are presented in Table 4.5.2 and depicted in Fig.4.5.2.

Influence of moisture regime

Moisture regime did not influence the weed dry weight significantly at knee high and silking stages in *rabi* and *kharif* maize during both the years (Table 4.5.2).

Table 4.5a **Weed population (no. of weeds /m^2) as influenced by different treatments**

Treatments	*Rabi*				*Kharif*			
	Knee high stage		Silking stage		Knee high stage		Silking stage	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime								
I_1- IW/CPE ratio 0.4	110.45	114.21	79.07	82.22	126.17	127.72	84.66	86.59
I_2- IW/CPE ratio 0.6	116.56	120.44	77.59	83.21	124.63	126.60	84.02	86.02
I_3- IW/CPE ratio 0.8	113.63	117.40	84.13	85.83	125.10	127.80	86.00	88.14
I_4- IW/CPE ratio 1.0	113.87	117.82	81.35	85.13	125.40	127.02	84.08	86.29
SEm ±	1.77	1.62	1.87	1.52	2.40	2.48	1.35	1.22
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Mulch								
M_1-Sugarcane trash @ 5 t/ha	122.58	126.62	76.11	79.17	101.13	103.19	75.15	76.97
M_2-Sugarcane trash @10 t/ha	92.15	95.02	67.60	70.27	98.63	101.12	72.54	74.61
M_3-Maize stover @ 5 t/ha	113.75	117.80	72.00	73.43	100.17	102.93	74.05	76.08
M_4-Maize stover @ 10 t/ha	87.92	90.95	64.63	66.80	98.42	99.63	72.41	74.33
M_5-No mulch	151.77	156.96	122.38	130.83	228.29	226.56	129.30	131.82
SEm ±	2.44	2.41	2.50	1.65	2.62	2.41	1.31	1.36
	7.02	6.94	7.20	4.76	7.56	6.95	3.78	3.93

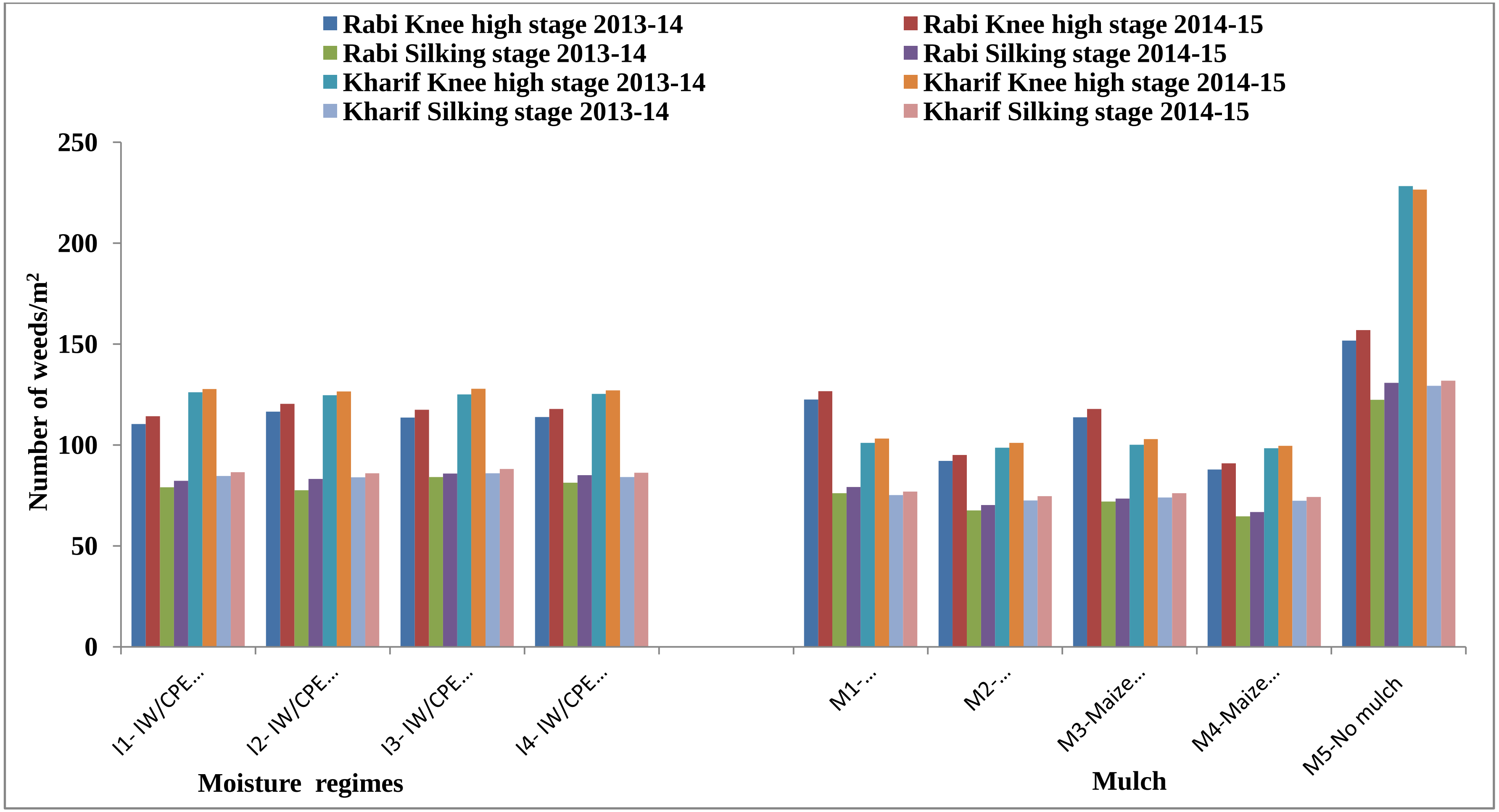


Fig. 4.5.1 Number of weeds/m^2 at knee high and silking stages of maize as influenced by different treatments

Table 4.5b **Weed dry weight (g /m^2) as influenced by different treatments**

Treatments	*Rabi*				*Kharif*			
	Knee high stage		Silking stage		Knee high stage		Silking stage	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime								
I_1- IW/CPE ratio 0.4	12.80	16.40	17.83	18.43	14.53	15.65	10.96	12.47
I_2- IW/CPE ratio 0.6	12.89	16.97	17.45	18.54	13.00	15.31	10.53	12.42
I_3- IW/CPE ratio 0.8	13.11	16.63	18.00	19.76	14.50	16.43	11.38	12.73
I_4- IW/CPE ratio 1.0	12.74	16.60	18.40	19.76	13.60	15.86	10.78	12.98
SEm ±	0.43	0.49	0.42	0.38	0.37	0.46	0.28	0.38
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Mulch								
M_1-Sugarcane trash @ 5 t/ha	13.33	16.92	17.63	19.33	12.22	13.63	8.34	10.18
M_2-Sugarcane trash @10 t/ha	8.92	12.05	16.13	17.44	10.57	12.84	7.68	9.77
M_3-Maize stover @ 5 t/ha	10.58	14.85	16.91	18.06	11.96	13.08	8.11	10.13
M_4-Maize stover @ 10 t/ha	8.08	10.99	15.82	17.00	9.78	12.43	7.38	9.55
M_5-No mulch	23.52	28.45	23.10	23.78	25.02	27.08	23.05	23.62
SEm ±	0.52	0.49	0.68	0.41	0.48	0.49	0.30	0.37
CD (P=0.05)	1.49	1.42	1.95	1.18	1.40	1.41	0.85	1.07

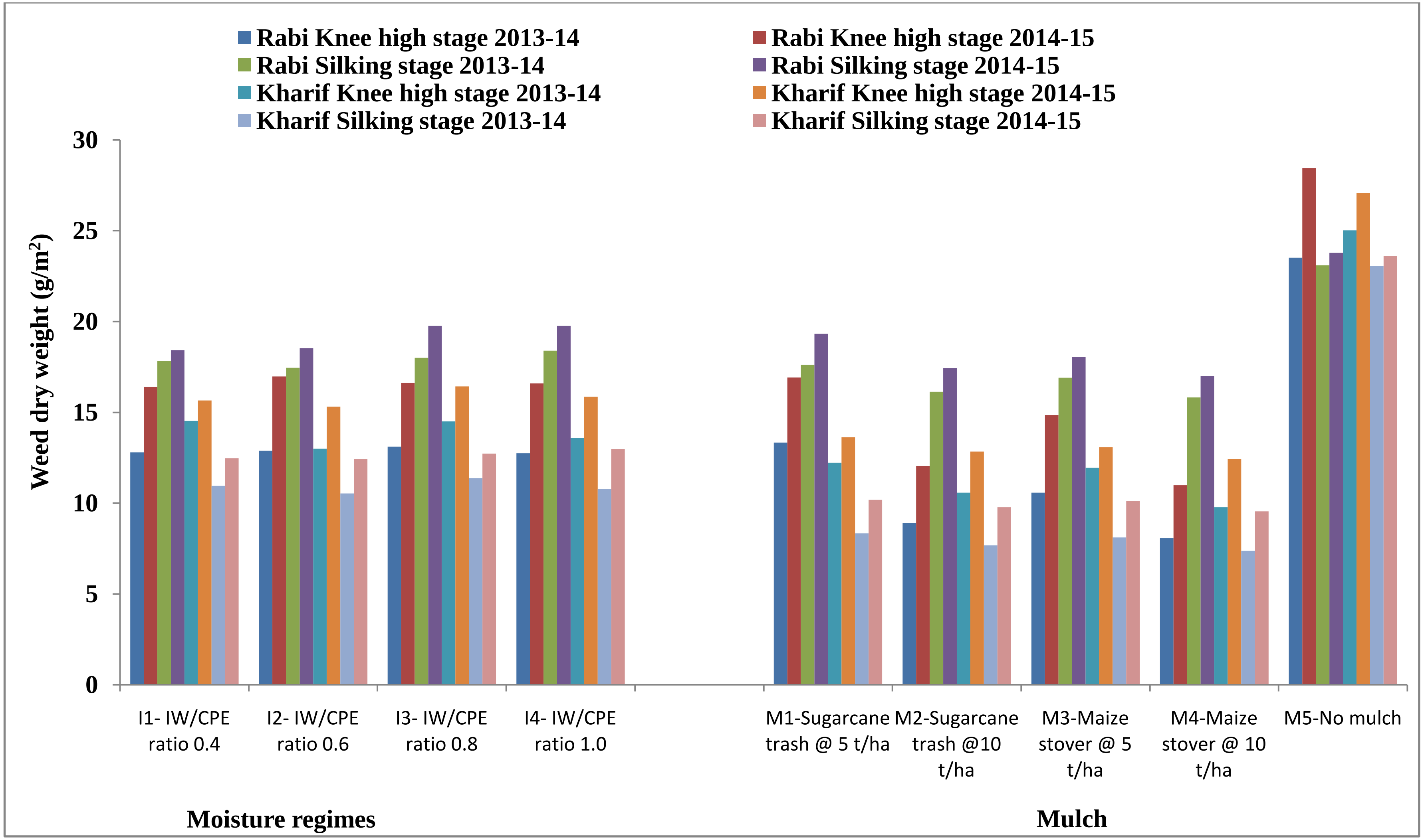


Fig. 4.5.2 Weed dry weight (g/m^2) at knee high and silking stages of maize as influenced by different treatments

Influence of mulching

During both the years of experimentation, mulching significantly influenced the weed dry weight at knee high and silking stages of crop growth in both the *rabi* and *kharif* seasons. At knee high stage of *rabi* maize, the lowest weed dry weight of 8.08 and 10.99 g/m^2 was recorded in maize stover @ 10 t/ha (M_4) which was statistically at par with sugarcane trash @ 10 t/ha (M_2) and both were significantly lower than M_3 and M_1. The highest weed dry weight of 23.52 and 28.45 g/m^2 were obtained under no mulch (M_5). All mulched treatments were significantly lower than no mulch (M_5) during both the years. At silking stage of *rabi* maize, the lowest weed dry weight of 15.82 and 17.00 g/m^2 were observed with maize stover @ 10 t/ha (M_4). All the mulched treatments were significantly lower than no mulch (M_5) during both the years.

At knee high stage of *kharif* maize during both the years (Table 4.5.2), the lowest weed dry weight of 9.78 and 12.43 g/m^2 were recorded with maize stover @ 10 t/ha (M_4) which was at par with sugarcane trash @ 10 t/ha (M_2). There was also parity between M_2 and M_1 and likewise between M_2 and M_3. However, all the mulch treatments were significantly lower than no mulch (M_5). At silking stage of *kharif* maize during both the years, significantly lower weed dry weight of 7.38 and 9.55 g/m^2 was observed with maize stover @ 10 t/ha (M_4) as compared to sugarcane trash @ 5 t/ha(M_1) and no mulch (M_5) during the first year and only no mulch in second year. Though, all the mulch treatments were significantly lower than no mulch (M_5).

4.6 Soil studies

4.6.1 Initial and after harvest (pH, EC, OC %)

The data of initial and after harvest soil samples on pH, EC and OC of both the *rabi* and *kharif* maize as influenced by moisture regimes and mulching during both the years have been presented in Table 4.6.1

Influence of moisture regime

A perusal of data on soil pH, EC and OC after *rabi* and *kharif* maize shows that there was non-significant difference due to moisture regime during both the years. The lowest pH and EC values and the maximum OC were recorded under moisture regimes of 1.0 IW/CPE ratio.

Influence of mulching

The data obtained on pH and EC revealed that there was non-significant influence due to mulching in both *rabi* and *kharif* maize during the two years of experimentation. The minimum pH and EC were obtained in mulching with maize stover @ 10 t/ha.

A close scrutiny of mean data showed that organic carbon content increased with increase in rate of mulch in *rabi* and *kharif* maize during both the years. Mulching significantly influenced organic carbon content of both *rabi* and *kharif* maize. Significantly higher organic carbon content of 0.53% and 0.57% of *rabi* maize was obtained with maize stover @ 10 t/ha as compared to all other mulch treatments and no mulch during both the years. However, all the treatments differed significantly. During the first year, the maximum organic carbon content of 0.55% of *kharif* maize was obtained with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (0.51%), maize stover @ 5 t/ha (0.52%) and no mulch (0.43%) but was statistically at par with sugarcane trash @ 10 t/ha (0.53%). There was also statistical parity among sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha. In second year, organic carbon content followed similar trends as that of *rabi* maize during both the years.

4.6.2 Initial and after harvest soil fertility status

The data of initial and after harvest available N, P_2O_5 and K_2O kg/ha in soil during both the years as was influenced by moisture regime and mulching have been summarized and presented in Table 4.6.2.

Influence of moisture regime

Data on available N, P_2O_5 and K_2O kg/ha in soil after harvest during both the years of *rabi* and *kharif* maize indicated non-significant influence due to moisture regime. The maximum available N, P_2O_5 and K_2O kg/ha were observed with moisture regime of 1.0 IW/CPE ratio.

Table 4.6.1 pH, Electric conductivity and Organic carbon as influenced by different treatments

Treatments	*Rabi*						*Kharif*					
	pH		**EC dS m^{-1}**		**OC (%)**		**pH**		**EC dS m^{-1}**		**OC (%)**	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	8.22	8.20	0.78	0.76	0.48	0.51	8.21	8.19	0.77	0.75	0.50	0.52
I_2- IW/CPE ratio 0.6	8.22	8.20	0.78	0.76	0.49	0.52	8.21	8.19	0.77	0.75	0.51	0.53
I_3- IW/CPE ratio 0.8	8.21	8.19	0.77	0.76	0.50	0.53	8.20	8.19	0.76	0.75	0.51	0.54
I_4- IW/CPE ratio 1.0	8.20	8.19	0.77	0.76	0.51	0.54	8.20	8.18	0.76	0.75	0.52	0.55
SEm ±	0.12	0.12	0.01	0.02	0.01	0.01	0.02	0.11	0.01	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	8.22	8.20	0.78	0.76	0.49	0.54	8.21	8.19	0.77	0.76	0.51	0.54
M_2-Sugarcane trash @10 t/ha	8.20	8.18	0.77	0.75	0.51	0.55	8.19	8.17	0.76	0.74	0.53	0.56
M_3-Maize stover @ 5 t/ha	8.21	8.19	0.78	0.76	0.51	0.55	8.20	8.18	0.77	0.75	0.52	0.56
M_4-Maize stover @ 10 t/ha	8.20	8.17	0.76	0.75	0.53	0.57	8.18	8.16	0.75	0.74	0.55	0.58
M_5-No mulch	8.23	8.23	0.79	0.79	0.44	0.43	8.24	8.23	0.79	0.78	0.43	0.42
SEm ±	0.11	0.11	0.01	0.01	0.01	0.01	0.11	0.11	0.01	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	0.02	0.02	NS	NS	NS	NS	0.03	0.02

	Initial value
pH	8.23
Electric conductivity (EC) dS m^{-1}	0.79
Organic carbon (OC %)	0.44

Influence of mulching

Mulching significantly influenced available N, P_2O_5 and K_2O kg/ha in soil after harvest of both the *rabi* and *kharif* maize during the two years of experimentation (Table 4.6.2). The results showed that available N, P_2O_5 and K_2O content increased with increase in rate of mulch.

The maximum available N content of 231.79 and 235.70 kg/ha of *rabi* maize, during 2013-14 and 2014-15 respectively, were recorded with maize stover @ 10 t/ha which was at par with other mulch treatments and all were significantly superior to no mulch during both the years. The maximum available N content of *kharif* maize followed similar trends as that of *rabi* maize during both the years.

The maximum available P_2O_5 content of 20.60 and 21.29 kg/ha of *rabi* maize were observed with maize stover @ 10 t/ha which was statistically at par with sugarcane trash @ 10 t/ha (19.66 and 20.36 kg/ha) and maize stover @ 5 t/ha (20.28 and 20.81 kg/ha), respectively and both were also at par with sugarcane trash @ 5 t/ha (19.42 and 20.11 kg/ha). However, maize stover @ 10 t/ha recorded significantly higher available P_2O_5 content than sugarcane trash @ 5 t/ha and no mulch during both years. The maximum available P_2O_5 content of *kharif* maize followed similar trends as that of *rabi* maize during both the years.

The highest available K_2O content of 166.65 and 168.00 kg/ha of *rabi* maize were obtained with maize stover @ 10 t/ha which was statistically at par with other mulched treatments and they were significantly superior to no mulch, respectively during both the years. Available K_2O content of *kharif* maize as influenced by mulching followed similar trends of *rabi* maize during both the years

4.7 Plant analysis

4.7.1 N, P & K content (%)

Mean data on N, P & K content (%) in grain, stover and stone after harvest of both the *rabi* and *kharif* maize during both the years of experimentation were statistically analyzed and have been presented in Tables 4.7.1a, 4.7.1b and 4.7.1c.

Table 4.6.2 Fertility status of soil as influenced by different treatments

Treatments	*Rabi* N (kg/ha) After harvest 2013-14	*Rabi* N (kg/ha) After harvest 2014-15	*Rabi* P (kg/ha) After harvest 2013-14	*Rabi* P (kg/ha) After harvest 2014-15	*Rabi* K (kg/ha) After harvest 2013-14	*Rabi* K (kg/ha) After harvest 2014-15	*Kharif* N (kg/ha) After harvest 2013-14	*Kharif* N (kg/ha) After harvest 2014-15	*Kharif* P (kg/ha) After harvest 2013-14	*Kharif* P (kg/ha) After harvest 2014-15	*Kharif* K (kg/ha) After harvest 2013-14	*Kharif* K (kg/ha) After harvest 2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	223.81	228.57	18.91	19.47	162.87	163.27	224.89	228.99	19.15	19.73	163.01	163.49
I_2- IW/CPE ratio 0.6	224.65	228.75	19.18	19.74	163.74	164.50	225.69	229.16	19.43	20.00	164.27	164.75
I_3- IW/CPE ratio 0.8	228.07	232.35	19.94	20.50	164.57	165.48	229.01	232.75	20.18	20.74	164.80	165.72
I_4- IW/CPE ratio 1.0	230.73	233.13	20.50	20.93	167.07	167.78	231.61	233.58	20.74	21.17	167.45	168.11
SEm ±	3.00	3.58	0.46	0.44	3.04	3.17	3.58	3.85	0.46	0.44	2.02	3.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	227.21	232.29	19.42	20.11	165.32	165.84	228.18	232.79	19.72	20.42	165.50	166.09
M_2-Sugarcane trash @10 t/ha	229.25	235.04	20.28	20.81	166.43	167.68	230.52	235.56	20.58	21.12	167.31	167.99
M_3-Maize stover @ 5 t/ha	228.32	232.85	19.66	20.36	165.55	166.05	229.31	233.35	19.96	20.67	165.76	166.38
M_4-Maize stover @ 10 t/ha	231.79	235.70	20.60	21.29	166.65	168.00	233.06	236.21	20.90	21.60	167.67	168.34
M_5-No mulch	217.54	217.63	18.22	18.22	158.85	158.73	217.93	217.68	18.22	18.23	158.19	158.78
SEm ±	3.16	2.97	0.46	0.40	1.97	2.15	3.01	3.04	0.39	0.40	2.20	2.13
CD (P=0.05)	9.11	8.54	1.01	1.14	5.69	6.20	8.67	8.76	1.13	1.14	6.33	6.14

	Initial value
N	218.22
P	18.18
K	158.27

4.7.1.1 N, P & K content (%) in grain

Data recorded with respect to N, P & K content (%) in grain were statistically analyzed and have been presented in Table 4.7.1a.

Influence of moisture regime

Moisture regime significantly influenced NPK content (%) in grain of *rabi* maize during both the years. The maximum N content (%) in grain of 1.153 and 1.170% were recorded under 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio (1.105 and 1.120%) during both the years, whereas, there was statistical parity among 0.8, 0.6 and 0.4 IW/CPE ratios during the first year and between 0.8 and 0.6 IW/CPE ratio and likewise 0.6 and 0.4 IW/CPE ratios during the second year. P content (%) in grain varied between (0.249, 0.259 and 0.197, 0.206 %), respectively during 2013-14 and 2014-15. Significantly higher P content of 0.249 and 0.259% was recorded with 1.0 IW/CPE ratio as compared to other moisture regimes. However, there was statistical parity among 0.8, 0.6 and 0.4 ratios. In *rabi* maize, the maximum K content of 0.241% was obtained with 1.0 IW/CPE ratio which was significantly higher than 0.6 IW/CPE ratio (0.205%) and 0.4 IW/CPE ratio (0.201%) but was statistically at par with 0.8 IW/CPE ratio (0.224%). There was also statistical parity between 0.6 and 0.4 IW/CPE ratios during the first year. K content in grain followed similar trend in second year except that there was statistical parity between 0.8 and 0.6 IW/CPE ratios. The mean data on N, P & K content (%) in grain of *kharif* maize indicated that there was non-significant influence due to moisture regime during both the years.

Influence of mulching

Mulching significantly influenced N, P & K content (%) in grain of *rabi* and *kharif* maize during both the years (Table 4.7.1a). The data indicated that N, P & K content (%) increased with increase in rate of mulch. The maximum N content of 1.127 and 1.142 % in grain of *rabi* maize was obtained with maize stover @ 10 t/ha which was at par with other mulched treatments, and all the mulch treatments were significantly superior to no mulch (1.034 and 1.035%) during both the years. The highest P content (0.238 and 0.249%) in *rabi* maize were recorded under maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (0.218 and 0.229%) and no mulch (0.165 and 0.170%) but was statistically at par with sugarcane trash @ 10 t/ha (0.235 and 0.245%) and maize stover @ 5 t/ha (0.228 and 0.239%). There was also statistical parity between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha during the first year and likewise between sugarcane @ 10 and 5 t/ha during the second year. K content in grain of *rabi* maize during both the years, followed similar trends of that of P content in grain of *rabi* maize during the second year, while N, P & K content (%) of *kharif* maize followed similar way of N content (%) in grain of *rabi* maize during both the years.

4.7.1.2 N, P & K content (%) in stover

The mean data in respect of NPK content (%) in stover of *rabi* and *kharif* maize during both the years as influenced by different treatments have been presented in Table 4.7.1b.

Influence of moisture regime

N content (%) in stover of *rabi* maize was significantly influenced by moisture regime during both the years of experimentation. It increased with increase in moisture regime and the maximum N content (0.356 and 0.375%) was recorded under moisture regime of 1.0 IW/CPE ratio which was statistically at par with 0.8 IW/CPE ratio (0.339 and 0.358 %) and 0.6 IW/CPE ratio (0.328 and 0.345%) and likewise 0.6 IW/CPE ratio was statistical at par with 0.4 IW/CPE ratio. However, 1.0 and 0.8 IW/CPE ratios were significantly superior to 0.4 IW/CPE ratio during both the years.

A perusal of the data on P content (%) in stover of *rabi* maize during both the years of experimentation indicated that P content (%) in stover increased significantly with increase in moisture regime. In first year, the maximum P content of 0.150% was obtained with moisture regime of 1.0 IW/CPE ratio which significantly higher than 0.4 IW/CPE ratio (0.123%) but was statistically at par with 0.8 IW/CPE ratio (0.139%) and 0.6 IW/CPE ratio (0.136%). There was also parity between 0.6 and 0.4 IW/CPE ratios. In second year, significantly higher P content of 0.160 % was recorded at 1.0 IW/CPE ratio as compared to IW/CPE ratio

Table 4.7.1a N, P & K content (%) in grain as influenced by different treatments

Treatments	*Rabi*						*Kharif*					
	N (%)		P (%)		K (%)		N (%)		P (%)		K (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	1.036	1.045	0.197	0.206	0.201	0.206	0.992	0.992	0.301	0.307	0.330	0.334
I_2- IW/CPE ratio 0.6	1.067	1.082	0.200	0.210	0.205	0.211	0.990	0.998	0.302	0.308	0.331	0.335
I_3- IW/CPE ratio 0.8	1.105	1.120	0.221	0.230	0.224	0.228	0.993	1.001	0.303	0.308	0.331	0.335
I_4- IW/CPE ratio 1.0	1.153	1.170	0. 249	0.259	0.241	0.246	0.995	1.003	0.304	0.314	0.333	0.41
SEm ±	0.021	0.021	0.008	0.008	0.005	0.006	0.033	0.032	0.007	0.008	0.009	0.010
CD (P=0.05)	0.073	0.073	0.027	0.026	0.018	0.020	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	1.086	1.101	0.218	0.229	0.221	0.228	0.997	1.006	0.320	0.326	0.326	0.335
M_2-Sugarcane trash @10 t/ha	1.108	1.131	0.235	0.245	0.232	0.237	1.023	1.033	0.333	0.338	0.341	0.346
M_3-Maize stover @ 5 t/ha	1.096	1.116	0.228	0.239	0.228	0.234	1.007	1.017	0.326	0.328	0.340	0.345
M_4-Maize stover @ 10 t/ha	1.127	1.142	0.238	0.249	0.241	0.248	1.041	1.052	0.335	0.346	0.347	0.352
M_5-No mulch	1.034	1.035	0.165	0.170	0.165	0.167	0.894	0.894	0.207	0.208	0.302	0.303
SEm ±	0.017	0.017	0.006	0.006	0.005	0.006	0.035	0.036	0.006	0.007	0.008	0.008
CD (P=0.05)	0.048	0.048	0.017	0.018	0.016	0.017	0.101	0.103	0.017	0.021	0.023	0.022

of 0.6 (0.141%) and 0.4 (0.131%) but was statistically at par with 0.8 IW/CPE ratio (0.148%). There was statistical parity between 0.8 and 0.6 IW/CPE ratios and between 0.6 and 0.4 IW/CPE ratios. Mean data of *kharif* maize related to P content in stover revealed no significant difference due to moisture regime during both the years.

The maximum K content of 0.592% was observed with 1.0 IW/CPE ratio which was significantly higher than 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio (0.553%) during the first year of experimentation. In second year, the highest K content of 0.600% was recorded with 1.0 IW/CPE ratio which was significantly superior to all other moisture regimes. N, P & K content in stover of *kharif* maize during both the years were found non-significant due to moisture regime.

Influence of mulching

Mulching significantly influenced N, P & K content (%) in stover of *rabi* and *kharif* maize during both the years. The maximum nitrogen content of 0.347 and 0.377% in stover of *rabi* maize was recorded with maize stover @10 t/ha as compared to no mulch but was statistically at par with all other mulched treatments during first year, but it was significantly superior to sugarcane trash @ 5 t/ha during the second year. All mulch treatments were significantly superior to no mulch during both the years. The maximum nitrogen content of 0.249 and 0.254% in stover of *kharif* maize was obtained with maize stover @10 t/ha which was significantly higher than sugarcane trash @ 5 t/ha (0.229 and 0.234%) and no mulch (0.205 and 0.204%) but was statistically at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha during both the years. There was also parity among sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha. The maximum P content of 0.148 and 0.161% during *rabi* season were recorded under maize stover @ 10 t/ha which was statistically at par with other mulch treatments and all were significantly superior to no mulch treatment during both the years. Mulching significantly influenced potassium content in *rabi* maize. The highest K content of 0.554 and 0.564% were obtained with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha and no mulch but was statistically at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. There

Table 4.7.1b N, P & K content (%) in stover as influenced by different treatments

Treatments	*Rabi*						*Kharif*					
	N (%)		P (%)		K (%)		N (%)		P (%)		K (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	0.302	0.322	0.123	0.131	0.447	0.455	0.228	0.233	0.104	0.111	0.413	0.417
I_2- IW/CPE ratio 0.6	0.328	0.345	0.136	0.141	0.508	0.516	0.232	0.236	0.106	0.112	0.416	0.420
I_3- IW/CPE ratio 0.8	0.339	0.358	0.139	0.148	0.553	0.561	0.232	0.237	0.107	0.112	0.419	0.424
I_4- IW/CPE ratio 1.0	0.356	0.375	0.150	0.160	0.592	0.600	0.236	0.237	0.107	0.113	0.424	0.425
SEm ±	0.008	0.009	0.005	0.004	0.011	0.011	0.003	0.004	0.003	0.003	0.425	0.012
CD (P=0.05)	0.029	0.031	0.016	0.015	0.039	0.034	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	0.330	0.345	0.135	0.147	0.515	0.525	0.229	0.234	0.107	0.115	0.415	0.421
M_2-Sugarcane trash @10 t/ha	0.340	0.368	0.147	0.159	0.542	0.552	0.239	0.244	0.117	0.122	0.425	0.430
M_3-Maize stover @ 5 t/ha	0.334	0.353	0.138	0.152	0.530	0.540	0.239	0.244	0.115	0.120	0.423	0.429
M_4-Maize stover @ 10 t/ha	0.347	0.377	0.148	0.161	0.554	0.564	0.249	0.254	0.121	0.125	0.438	0.443
M_5-No mulch	0.304	0.308	0.105	0.107	0.483	0.484	0.205	0.204	0.071	0.079	0.384	0.385
SEm ±	0.008	0.010	0.005	0.005	0.011	0.011	0.007	0.007	0.005	0.004	0.010	0.010
CD (P=0.05)	0.023	0.028	0.014	0.015	0.033	0.033	0.020	0.020	0.015	0.012	0.029	0.029

was also statistical parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha during both the years. Phosphorus and potassium content of *kharif* maize followed similar trends as that of phosphorus content in *rabi* maize during both the years.

4.7.1.3 N, P & K content (%) in stone

The data obtained on N, P & K content in stone of *rabi* and *kharif* maize as influenced by moisture regime and mulching have been summarized and presented in Table 4.7.1c.

Influence of moisture regime

A perusal of data reveals that moisture regime significantly influenced the nitrogen content (%) in stone of *rabi* maize while in case of *kharif* maize the effect was non-significant during both the years. The highest N content of 0.150% in stone of *rabi* maize was recorded at 1.0 IW/CPE ratio which was significantly superior to all other moisture regimes during the first year. There was parity between 0.8 IW/CPE ratio (0.139%) and 0.6 IW/CPE ratio (0.132%) and also between 0.6 and 0.4 IW/CPE ratio (0.130%). During the second year, significantly higher N content (0.156%) was recorded at 1.0 IW/CPE ratio as compared to 0.6 IW/CPE ratio (0.140%) and 0.4 IW/CPE ratio (0.135%) but was statistically at par with 0.8 IW/CPE ratio (0.149%). There was also statistical parity between 0.8 and 0.6 IW/CPE ratios and similarly between 0.6 and 0.4 IW/CPE ratios.

Moisture regime exerted significant influence on phosphorus content in stone of *rabi* maize during both the years. The maximum P content of 0.018 and 0.019% were recorded with 1.0 IW/CPE ratio which was significantly higher than all other moisture regimes during both the years but there was statistical parity between 0.8 and 0.6 IW/CPE ratios.

Data exhibited that K content in stone of *rabi* maize was significantly influenced due to moisture regime. The maximum K content in stone of 0.144 and 0.146% were obtained with 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio. There was also statistical parity between 0.8 and 0.6 IW/CPE ratios, and between 0.6 and 0.4 IW/CPE ratios during both the years.

Data on mean of N, P & K content in stone of *kharif* during first year and second year of experimentation indicated that there were non-significant differences due to moisture regimes.

Influence of mulching

N, P & K content (%) in stone of both the *rabi* and *kharif* maize were significantly influenced due to mulching during both the years. N content (%) recorded under maize stover @ 10 t/ha (0.150 and 0.159%) was significantly higher than sugarcane trash @ 5 t/ha (0.137 and 0.145%) and no mulch (0.114 and 0.116%) but was statistically at par with sugarcane trash @ 10 t/ha (0.146 and 0.155%) and maize stover @ 5 t/ha (0.142 and 0.150%) during both the years. There was also statistical parity among sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha. N content in stone of *kharif* maize followed similar trend as that of *rabi* maize during both the years.

Content of P in stone of *rabi* maize differed significantly due to mulch application during first year and second year of experimentation. During first year maize stover @ 10 t/ha was recorded significantly higher content of P (0.019%) over all other mulch treatments and no mulch. Similar pattern was followed during second year. Though, the maximum P content (0.020%) was observed with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha (0.019%), sugarcane trash @ 5 t/ha (0.019%) and no mulch (0.014%) but was at par with sugarcane trash @ 10 t/ha (0.020%). There was also parity between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha.

P content in stone of *kharif* maize varied significantly under application of different mulch during both the years. The highest P content of 0.016 and 0.017% was obtained with maize stover @ 10 t/ha which was significantly superior to all the other treatments during second year but during the first year there was statistical at parity with sugarcane trash @ 10 t/ha.

The data shows that maize stover @ 10 t/ha resulted significantly higher K content (0.148%) as compared to sugarcane trash @ 5 t/ha (0.132%) and no mulch (0.104%) but was at par with sugarcane trash @ 10 t/ha (0.136%) and maize stover 5 t/ha (0.136%) during the first year of experimentation. During second year the

Table 4.7.1c N, P & K content (%) in stone as influenced by different treatments

Treatments	*Rabi*						*Kharif*					
	N (%)		P (%)		K (%)		N (%)		P (%)		K (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	0.130	0.135	0.016	0.017	0.119	0.126	0.174	0.178	0.015	0.015	0.131	0.134
I_2- IW/CPE ratio 0.6	0.132	0.140	0.017	0.018	0.127	0.134	0.177	0.181	0.015	0.015	0.134	0.136
I_3- IW/CPE ratio 0.8	0.139	0.149	0.017	0.018	0.138	0.144	0.177	0.181	0.015	0.016	0.135	0.140
I_4- IW/CPE ratio 1.0	0.150	0.156	0.018	0.019	0.144	0.146	0.177	0.181	0.016	0.016	0.135	0.140
SEm ±	0.0026	.0.0040	0.0003	0.0003	0.0046	0.0031	0.0037	0.0038	0.0004	0.0004	0.0034	0.0038
CD (P=0.05)	0.0090	0.0139	0.0009	0.0010	0.0160	0.0107	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	0.137	0.145	0.018	0.019	0.132	0.140	0.178	0.181	0.015	0.016	0.134	0.139
M_2-Sugarcane trash @10 t/ha	0.146	0.155	0.018	0.020	0.136	0.146	0.189	0.194	0.016	0.016	0.140	0.144
M_3-Maize stover @ 5 t/ha	0.142	0.150	0.018	0.019	0.136	0.142	0.182	0.186	0.015	0.016	0.138	0.141
M_4-Maize stover @ 10 t/ha	0.150	0.159	0.019	0.020	0.148	0.153	0.194	0.198	0.016	0.017	0.143	0.148
M_5-No mulch	0.114	0.116	0.014	0.014	0.104	0.108	0.140	0.140	0.013	0.014	0.114	0.115
SEm ±	0.0044	0.0047	0.0003	0.0003	0.0053	0.0051	0.0055	0.0054	0.0005	0.0004	0.0051	0.0054
CD (P=0.05)	0.0126	0.0134	0.0007	0.0008	0.0160	0.0146	0.0158	0.0157	0.0013	0.0012	0.0147	0.0157

highest K content (0.153%) was recorded with maize stover @ 10 t/ha which was at par with all other mulch treatments and were significantly superior to no mulch.

During both the years, K content in stone of *kharif* maize followed similar trend as that of K content in *rabi* maize during the second year.

4.7.2 N, P & K uptake

4.7.2.1 N, P & K uptake by grain

Uptake of N, P & K (kg/ha) by grain of both the *rabi* and *kharif* maize in both the years as influenced by different treatments was studied after harvest. The data obtained have been statistically analyzed and presented in Table 4.7.2a.

Influence of moisture regime

Uptake of N by grain of *rabi* maize varied significantly due to moisture regime during both the years. Significantly higher uptake of nitrogen (96.40 and 101.81 kg/ha) was recorded with 1.0 IW/CPE ratio as compared to 0.6 IW/CPE ratio (84.61 and 89.16 kg/ha) and 0.4 IW/CPE ratio (76.89 and 80.84 kg/ha) but was at par with 0.8 IW/CPE ratio (91.61 and 95.17 kg/ha). There was also statistical parity between 0.8 and 0.6 IW/CPE ratios during both the years and likewise between 0.6 and 0.4 IW/CPE ratios in second year.

Uptake of P by grain of *rabi* maize was influenced significantly by moisture regime during both the years. The maximum phosphorus uptake of 20.83 and 22.66 kg/ha was obtained with 1.0 IW/CPE ratio which was significantly higher than rest of moisture regimes during both the years. There was significant decrease in P uptake with decrease in IW/CPE ratio up to 0.6 IW/CPE ratio.

Significantly higher K uptake by grain of *rabi* maize (20.20 and 21.50 kg/ha) was recorded by 1.0 IW/CPE ratio as compared to 0.6 IW/CPE ratio (16.34 and 17.48 kg/ha) and 0.4 IW/CPE ratio (14.94 and 15.91 kg/ha) but was statistically at par with 0.8 IW/CPE ratio (18.60 and 19.44 kg/ha) during both the years. There was also statistical parity between 0.6 and 0.4 IW/CPE ratios.

Observations on N, P & K uptake by grain of *kharif* maize reveal that there was non-significant influence due to moisture regime during both the years.

Influence of mulching

Mulching significantly influenced N, P & K uptake by grain of *rabi* and *kharif* during both the years of experimentation. The maximum uptake of nitrogen of 94.08 and 99.91 kg/ha of *rabi* maize were recorded with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (85.77 and 91.05 kg/ha) and no mulch (78.24 and 77.46 kg/ha) but was statistically at par sugarcane trash @ 10 t/ha (90.40 and 96.50 kg/ha) and maize stover @ 5 t/ha (88.39 and 93.79 kg/ha) during both the years. There was also parity among sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha. Phosphorus uptake by grain of *rabi* maize observed similar trend as that of nitrogen uptake by grain of rabi maize during both the years. The highest K uptake by grain of 20.14 kg/ha was recorded under maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha (18.44 kg/ha), sugarcane trash @ 5 t/ha (17.48 kg/ha) and no mulch (12.56 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (18.98 kg/ha). There was also statistical parity between maize stover @ 5 t/ha and sugarcane trash @ 10 t/ha during the first year. Similar trend was followed during the second year but there was statistical parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha.

In case of *kharif* maize, N, P & K uptake by grain was significantly affected by mulching during both the years. The maximum N, P & K uptake was recorded with maize stover @ 10 t/ha which was statistically at par with other mulched treatments and they were significantly superior to no mulch during both the years.

4.7.2.2 N, P & K uptake by stover

The mean data pertaining to N, P & K uptake by stover after harvest of *rabi* and *kharif* maize during both the years under the influence of moisture regime and mulching, have been presented in Table 4.7.2b.

Influence of moisture regime

N uptake by stover of *rabi* maize was significantly influenced by moisture regime during both the years. During first year of experimentation, the maximum N uptake of 38.66 kg/ha was recorded with 1.0 IW/CPE ratio which was

Table 4.7.2a N, P & K uptake by grain as influenced by different treatments

Treatments	*Rabi* N (kg/ha)		*Rabi* P (kg/ha)		*Rabi* K (kg/ha)		*Kharif* N (kg/ha)		*Kharif* P (kg/ha)		*Kharif* K (kg/ha)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	76.89	80.84	14.83	15.98	14.94	15.91	47.23	49.67	14.51	15.37	15.85	16.59
I_2- IW/CPE ratio 0.6	84.61	89.16	15.65	17.39	16.34	17.48	47.63	49.90	14.53	15.55	15.88	16.76
I_3- IW/CPE ratio 0.8	91.61	95.17	18.39	19.70	18.60	19.44	47.69	50.82	14.64	15.78	15.93	16.99
I_4- IW/CPE ratio 1.0	96.40	101.81	20.83	22.66	20.20	21.50	48.36	52.12	14.82	16.27	16.13	17.63
SEm ±	2.09	2.46	0.55	0.62	0.47	0.62	0.88	1.58	0.56	0.51	0.40	0.60
CD (P=0.05)	7.24	8.53	1.91	2.14	1.61	2.16	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	85.77	91.05	17.22	19.02	17.48	18.88	47.59	50.75	15.31	16.48	15.58	16.95
M_2-Sugarcane trash @10 t/ha	90.40	96.50	19.17	20.96	18.98	20.28	50.34	53.99	16.40	17.62	16.82	18.01
M_3-Maize stover @ 5 t/ha	88.39	93.79	18.46	20.16	18.44	19.64	48.92	52.58	15.34	16.95	16.49	17.77
M_4-Maize stover @ 10 t/ha	94.08	99.91	19.89	21.81	20.14	21.61	52.00	55.87	16.90	18.37	17.42	18.70
M_5-No mulch	78.24	77.46	12.40	12.73	12.56	12.52	39.78	39.96	9.17	9.29	13.43	13.53
SEm ±	2.00	2.12	0.50	0.59	0.50	0.49	1.53	1.97	0.58	0.66	0.64	0.61
CD (P=0.05)	5.77	6.12	1.45	1.70	1.43	1.41	4.42	5.68	1.66	1.90	1.85	1.76

significantly superior to 0.6 IW/CPE ratio (32.86 kg/ha) and 0.4 IW/CPE ratio (29.32 kg/ha) but was at par with 0.8 IW/CPE ratio (35.83 kg/ha). There was also statistical parity between 0.8 and 0.6 IW/CPE ratios. N uptake by stover during second year followed a similar trend that of the first year except there was statistical parity between 0.6 and 0.4 IW/CPE ratios.

Moisture regime significantly influenced phosphorus uptake by the stover of *rabi* maize during both the years. Significantly higher P uptake of 16.33 kg/ha was recorded under 1.0 IW/CPE ratio as compared to other moisture regimes during the first year. Further, 0.6 IW/CPE ratio (12.69 kg/ha) was at parity with 0.4 IW/CPE ratio (12.01 kg/ha). In second year, the maximum P uptake by stover (17.93 kg/ha) was recorded under 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio (16.03 kg/ha). There was also statistical parity between 0.6 and 0.4 IW/CPE ratios likewise between 0.8 and 0.6 IW/CPE ratios.

The mean data in relation to potassium uptake by the stover of *rabi* maize during both the years were significantly influenced by moisture regime. The maximum K uptake of 64.20 and 66.97 kg/ha was obtained with 1.0 IW/CPE ratio which was at par with 0.8 IW/CPE ratio (58.31 and 60.64 kg/ha) and both were significantly superior to 0.6 IW/CPE ratio (51.02 and 54.15 kg/ha) and 0.4 IW/CPE ratio (43.29 and 46.07 kg/ha) during both the years.

The mean recorded data with respect to N, P & K uptake by stover of *kharif* maize (Table 4.7.2b) indicated that the differences were not significant due to moisture regime during both the years.

Influence of mulching

N, P & K uptake by stover of maize was influenced by mulching in *rabi* and *kharif* maize during both the years (Table 4.7.2b). In rabi maize, the maximum uptake of N (37.48 and 42.10 kg/ha), P (16.00 and 17.93 kg/ha) and K (59.89 and 63.04 kg/ha) were recorded with maize stover @ 10 t/ha which was statistically at par with sugarcane trash @10 t/ha and maize stover @ 5 t/ha, and likewise sugarcane trash @10 t/ha was at par with sugarcane trash @ 5 t/ha and maize

Table 4.7.2b N, P & K uptake by stover as influenced by different treatments

Treatments	*Rabi*						*Kharif*					
	N (kg/ha)		**P (kg/ha)**		**K (kg/ha)**		**N (kg/ha)**		**P (kg/ha)**		**K (kg/ha)**	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	29.32	32.77	12.01	13.40	43.29	46.07	23.22	24.25	10.61	11.63	41.78	43.50
I_2- IW/CPE ratio 0.6	32.86	36.36	12.69	14.26	51.02	54.15	23.25	24.74	10.62	11.80	42.09	43.95
I_3- IW/CPE ratio 0.8	35.83	38.65	14.67	16.03	58.31	60.64	23.68	25.03	10.94	11.90	42.28	44.60
I_4- IW/CPE ratio 1.0	38.66	42.07	16.33	17.93	64.20	66.97	23.91	25.13	10.96	12.03	42.71	45.38
SEm ±	0.89	1.48	0.37	0.64	1.75	1.93	0.49	0.66	0.30	0.27	1.42	1.35
CD (P=0.05)	3.08	5.12	1.29	2.21	6.06	6.68	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	33.65	36.43	13.71	15.57	52.57	55.48	23.08	24.56	10.70	12.14	41.82	44.26
M_2-Sugarcane trash @10 t/ha	35.66	40.43	15.33	17.49	56.69	60.69	24.84	26.17	12.08	13.15	44.29	46.23
M_3-Maize stover @ 5 t/ha	34.69	37.64	14.38	16.17	55.16	57.68	24.55	25.97	11.78	12.75	43.56	45.71
M_4-Maize stover @ 10 t/ha	37.48	42.10	16.00	17.93	59.89	63.04	26.18	27.47	12.78	13.47	46.06	47.81
M_5-No mulch	29.36	30.71	10.21	10.62	46.71	47.91	18.93	19.77	6.57	7.66	35.33	37.78
SEm ±	1.0	1.58	0.57	0.61	1.82	2.06	1.05	1.01	0.43	0.50	1.49	1.28
CD (P=0.05)	2.87	4.56	1.65	1.77	5.24	5.93	3.03	2.92	1.25	1.44	4.28	3.69

stover @ 5 t/ha. However, all the mulched treatments were significantly superior to no mulch during both the years.

The maximum N uptake by stover of *kharif* maize of (26.18 kg/ha) was obtained with maize stover @ 10 t/ha which was significantly superior over sugarcane trash @ 5 t/ha (23.08 kg/ha) and no mulch (18.93 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (24.84 kg/ha) and maize stover @ 5 t/ha (24.55 kg/ha) during the first year but was found to be at par with other mulch treatments and all were significantly superior to no mulch during second year. The highest P uptake of 12.78 and 13.14 kg/ha were recorded with maize stover @ 10 t/ha which was significantly superior over sugarcane trash @ 5 t/ha and no mulch but was statistically at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. There was also parity between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha during the first year but there was statistical parity with all the mulch treatments and all were significantly superior to no mulch during the second year. The maximum K uptake of 46.06 and 47.81 kg/ha in *kharif* maize were recorded with maize stover @ 10 t/ha which was at par with other mulch treatments and all were significantly superior to no mulch during both the years.

4.7.2.3 N, P & K uptake by stone

The mean data pertaining to N, P & K uptake by stone as influenced by the treatments tested during both the years have been presented in Table 4.7.2c.

Influence of moisture regime

Moisture regime significantly influenced N, P & K uptake by stone of both *rabi* and *kharif* maize during 2013-14 and 2014-15. The maximum N uptake by stone of *rabi* maize (3.38 and 3.51 kg/ha) were recorded with 1.0 IW/CPE ratio which was significantly higher than all other moisture regimes. There was statistical parity between 0.6 IW/CPE ratio (2.50 kg/ha) and 0.4 IW/CPE ratio (2.25 kg/ha) during the first year and likewise between 0.6 and 0.4 IW/CPE ratios (2.78 and 2.48 kg/ha) and also between 0.6 and 0.8 IW/CPE ratios (2.78 and 3.10 kg/ha) during second year.

P uptake by stone of *rabi* maize recorded the maximum values of 0.42 and 0.44 kg/ha under 1.0 IW/CPE ratio which was significantly superior over other moisture regimes. There was statistical parity between 0.8 and 0.6 IW/CPE ratio during the both years.

The maximum K uptake by stone of *rabi* maize (3.13 kg/ha) was recorded with 1.0 IW/CPE ratio which was at par with 0.8 IW/CPE ratio (2.85 kg/ha) and both were significantly superior over 0.6 and 0.4 IW/CPE ratios during the first year. In second year of experimentation, the maximum K uptake of 3.33 kg/ha was obtained with 1.0 IW/CPE ratio which was statistically at par with 0.8 IW/CPE ratio (3.00 kg/ha) and both were significantly superior over 0.6 and 0.4 IW/CPE ratios. Further, 0.6 and 0.4 IW/CPE ratio was statistically at par to each other.

The results of data on N, P & K uptake by stone of *kharif* maize indicated that there were non-significant differences among the treatments due to moisture regime during both the years.

Influence of mulching

Critical analysis of both the years data reveals that mulching significantly influenced the N, P & K uptake by stone of both the *rabi* and *kharif* maize. The maximum N uptake of (3.27 and 3.55 kg/ha) of *rabi* maize was observed with maize stover @ 10 t/ha which was significantly higher than sugarcane trash @ 5 t/ha (2.58 and 2.83 kg/ha) and no mulch (2.03 and 2.11 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (3.00 and 3.22 kg/ha) and maize stover @ 5 t/ha (2.83 and 3.13 kg/ha). Sugarcane trash @ 10 t/ha was also found to be at par with maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha during both the years. During both the years, mulching by maize stover @10 t/ha had recorded maximum P uptake (0.42 and 0.44 kg/ha) which was significantly superior to maize stover @ 5 t/ha (0.38 and 0.40 kg/ha), sugarcane trash @ 5 t/ha (0.34 and 0.36 kg/ha) and no mulch (0.25 and 0.26 kg/ha) but was at par with sugarcane trash @ 10 t/ha (0.39 and 0.41 kg/ha). There was also parity between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. K uptake by stone of *rabi* maize followed similar pattern as that of N uptake during both the years.

The maximum N uptake by stone of *kharif* maize 3.79 kg/ha was recorded under maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (3.11 kg/ha) and no mulch (2.08 kg/ha) but was statistically at par with

Table 4.7.2 c N, P & K uptake by stone as influenced by different treatments

Treatments	*Rabi*						*Kharif*					
	N (kg/ha)		**P (kg/ha)**		**K (kg/ha)**		**N (kg/ha)**		**P (kg/ha)**		**K (kg/ha)**	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Moisture regime												
I_1- IW/CPE ratio 0.4	2.25	2.48	0.30	0.32	2.07	2.30	3.12	3.41	0.26	0.29	2.36	2.50
I_2- IW/CPE ratio 0.6	2.50	2.78	0.34	0.35	2.43	2.65	3.16	3.41	0.27	0.28	2.37	2.57
I_3- IW/CPE ratio 0.8	2.84	3.10	0.36	0.38	2.85	3.00	3.22	3.50	0.28	0.31	2.44	2.71
I_4- IW/CPE ratio 1.0	3.38	3.51	0.42	0.44	3.13	3.33	3.22	3.51	0.28	0.31	2.46	2.77
SEm ±	0.10	0.11	0.01	0.01	0.09	0.11	0.14	0.11	0.01	0.01	0.05	0.08
CD (P=0.05)	0.34	0.39	0.04	0.03	0.32	0.39	NS	NS	NS	NS	NS	NS
Mulch												
M_1-Sugarcane trash @ 5 t/ha	2.58	2.83	0.34	0.36	2.49	2.73	3.11	3.19	0.26	0.28	2.33	2.53
M_2-Sugarcane trash @10 t/ha	3.00	3.22	0.39	0.41	2.83	3.03	3.60	3.90	0.30	0.33	2.66	2.89
M_3-Maize stover @ 5 t/ha	2.83	3.13	0.38	0.40	2.79	2.97	3.32	3.65	0.28	0.31	2.52	2.76
M_4-Maize stover @ 10 t/ha	3.27	3.55	0.42	0.44	3.21	3.42	3.79	4.19	0.32	0.36	2.83	3.14
M_5-No mulch	2.03	2.11	0.25	0.26	1.84	1.97	2.08	2.35	0.20	0.22	1.69	1.86
SEm ±	0.16	0.15	0.01	0.01	0.16	0.16	0.17	0.19	0.01	0.01	0.11	0.13
CD (P=0.05)	0.45	0.43	0.04	0.04	0.45	0.46	0.50	0.55	0.03	0.03	0.31	0.38

sugarcane trash @ 10 t/ha (3.60 kg/ha) and maize stover @ 5 t/ha (3.32 kg/ha) during first year. There was also statistical parity among sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha. In second year of study, the maximum N uptake by stone (4.19 kg/ha) was obtained with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (3.19 kg/ha) and no mulch (2.35 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (3.90 kg/ha) and maize stover @ 5 t/ha (3.65 kg/ha). There was also statistical parity between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha.

Significantly higher P uptake by stone of *kharif* maize was obtained with maize stover @ 10 t/ha (0.32 kg/ha) as compared to maize stover @ 5 t/ha (0.28 kg/ha), sugarcane trash @ 5 t/ha (0.26 kg/ha) and no mulch (0.20 kg/ha) and was statistically at par with sugarcane trash @ 10 t/ha (0.30 kg/ha). There was parity between maize stover @ 5 t/ha and sugarcane trash @ 10 t/ha during the first year. Similar trend was observed during second year except that there was significant difference in P uptake between maize stover @ 10 t/ha and sugarcane trash @ 10 t/ha, maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha.

The maximum K uptake by stone of *kharif* maize (2.83 and 3.14 kg/ha) was recorded with maize stover @ 10 t/ha which was significantly higher than maize stover @ 5 t/ha (2.52 and 2.76 kg/ha), sugarcane trash @ 5 t/ha (2.33 and 2.53 kg/ha) and no mulch (1.69 and 1.86 kg/ha) but was at statistical parity with sugarcane trash @ 10 t/ha (2.66 and 2.89 kg/ha). Further, maize stover @ 5 t/ha was at par with sugarcane trash @ 5 t/ha and likewise, sugarcane trash @ 10 t/ha at par with maize stover @ 5 t/ha during the first year, while there was statistical parity among maize stover @ 10 and 5 t/ha and, maize stover @ 5 t/ha during second year.

4.7.3 Total N, P & K uptake by maize (grain + stover + stone)

The mean computed data obtained on total N, P & K uptake by maize (grain + stover + stone) at harvest as influenced by different treatments during both the years of study have been summarized and presented in Table 4.7.3a and 4.7.3b and Fig. 4.6a and 4.6b.

Influence of moisture regime

Analysis of the data reveals that relatively more uptake of nitrogen was recorded under higher levels of moisture regime during *rabi* maize. Significantly higher N uptake (138.43 and 147.38 kg/ha) was recorded at moisture regime of 1.0 IW/CPE ratio as compared to 0.6 IW/CPE ratio (119.97 and 128.29 kg/ha) and 0.4 IW/CPE ratio (108.46 and 116.09 kg/ha) but the difference between 1.0 IW/CPE ratio and 0.8 IW/CPE ratio (130.28 and 136.93 kg/ha) was found to be non-significant. There was also non-significant difference between 0.8 and 0.6 IW/CPE ratios in second year of experimentation.

On the basis of pooled data presented in Table 4.7.3a clearly shows that total N uptake was increased significantly with the increasing moisture regime. The highest total N uptake (142.91 kg/ha) was obtained at 1.0 IW/CPE ratio which was found to be significant over remaining moisture regimes.

A perusal of data reveals that total phosphorus uptake of *rabi* maize was significantly influenced due to different moisture regimes. The highest total phosphorus uptake was obtained with 1.0 IW/CPE ratio (37.58 and 41.03 kg/ha) which was significantly superior as compared to remaining moisture regimes during both the years. There was non-significant difference between 0.6 IW/CPE ratio (28.68 and 32.60 kg/ha) and 0.4 IW/CPE ratio (27.14 and 29.69 kg/ha).

Pooled data of total P uptake reveals that there was significant influence of moisture regimes on total P uptake. Significantly higher total P uptake of 39.31 kg/ha was recorded with I_4 (1.0 IW/CPE ratio) as compared to I_3 (0.8 IW/CPE ratio), I_2 (0.6 IW/CPE ratio) and I_1 (0.4 IW/CPE ratio) but there was non-significant difference between 0.6 IW/CPE ratio (30.64 kg/ha) and 0.4 IW/CPE ratio (28.42 kg/ha).

Total uptake of potassium was progressively increased with increase in moisture regimes in *rabi* maize during both the years. The highest accumulation of K was recorded at 1.0 IW/CPE ratio (87.58 and 91.81 kg/ha) which was significantly superior to other moisture regimes.

Pooled data reveals that accumulation of K at different moisture regimes increased with increasing level of moisture. Significantly higher K uptake was recorded with 1.0 IW/CPE ratio (89.70 kg/ha) as compared to 0.8 IW/CPE ratio (81.42 kg/ha), 0.6 IW/CPE ratio (72.04 kg/ha) and 0.4 IW/CPE ratio (62.29 kg/ha).

Data on total N, P &K uptake by *kharif* maize during both the years indicated that there were non-significant differences due to moisture regimes. On the basis of pooled data of *kharif* maize (Table 4.7.3b) also there was non-significant difference in total N, P & K uptake due to different moisture regimes.

Influence of mulching

During both the years, data indicated that mulching significantly influenced the total N uptake of *rabi* and *kharif* maize. In the first year, the highest value of total N uptake of *rabi* maize was recorded under maize stover @ 10 t/ha (134.38 kg/ha) which was significantly superior to maize stover @ 5 t/ha (125.91 kg/ha), sugarcane trash @ 5 t/ha (122.00 kg/ha) and no mulch (109.63 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (129.05 kg/ha). There was non-significant difference among treatments of sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. However, all the mulch treatments were significantly superior to no mulch treatment. Similar trend of total N uptake due to mulching was observed during second year, but there was statistical parity between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha and also between sugarcane trash @ 5 t/ha and maize stover @ 5 t/ha.

Pooled data of total nitrogen uptake varied significantly due to mulching. Maize stover @ 10 t/ha (140.20 kg/ha) recorded significantly higher total N uptake than maize stover @ 5 t/ha (130.60 kg/ha), sugarcane trash @ 5 t/ha (126.16 kg/ha) and no mulch (109.96 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (134.60 kg/ha).

In *kharif* maize, significantly higher total N uptake (81.97 and 87.53 kg/ha) was obtained with maize stover @ 10 t/ha than to that of sugarcane trash @ 5 t/ha (73.79 and 78.50 kg/ha) and no mulch (60.78 and 62.08 kg/ha) but was at par with sugarcane trash @ 10 t/ha (78.77 and 84.06 kg/ha) and maize stover @ 5 t/ha (76.80 and 82.19) during both the years. There was non-significant difference among treatments of sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. Pooled data reveals that total N uptake at different mulch rate increased with increasing rate of mulch. Maize stover @ 10 t/ha recorded significantly higher total N uptake (84.75 kg/ha) over maize stover @ 5 t/ha (79.50 kg/ha), sugarcane trash @ 5 t/ha (76.14 kg/ha) and no mulch (61.43 kg/ha) but was at par with sugarcane trash @ 10 t/ha (81.42 kg/ha). There was also parity between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha and likewise between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha.

A perusal data reveals that total P uptake by *rab*i and *kharif* maize was significantly influenced by mulching. The maximum total P uptake of 36.30 and 40.18 kg/ha was recorded in *rabi* maize with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha during both the years. There was non-significant difference between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha and similarly between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. The pooled data of *rabi* maize as influenced by mulching shows significant variation on total P uptake. The highest total uptake of 38.24 kg/ha was obtained with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was found to be at par with sugarcane trash @ 10 t/ha. There was non-significant difference between 5 t/ha and maize stover @ 5 t/ha.

Total P uptake in *kharif* maize during the first year followed similar trend observed in *rabi* maize. During second year, maize stover @ 10 t/ha recorded significantly higher total P uptake (32.20 kg/ha) over sugarcane trash @ 5 t/ha (28.90 kg/ha) and no mulch (17.17 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (31.10 kg/ha) and maize stover @ 5 t/ha (30.02 kg/ha). There was also parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha, however, no mulch was significantly lower than all the mulch treatments. A perusal of pooled data of *kharif* maize revealed that total P uptake was significantly affected due to mulching. Total P uptake obtained under maize stover @ 10 t/ha (31.10 kg/ha) was significantly higher over maize stover @ 5 t/ha (28.71 kg/ha), sugarcane trash @ 5 t/ha (27.59 kg/ha) and no mulch (16.56 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (29.94 kg/ha). Though, there was statistical parity between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha and also between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha but all the mulch treatments were significantly superior to no mulch treatment.

During both the years of *rabi* and *kharif* maize total K uptake was significantly influenced by mulching. During *rabi* 2013-14 maize stover @ 10 t/ha (83.24 kg/ha) was significantly superior over maize stover @ 5 t/ha (76.39 kg/ha), sugarcane trash @ 5 t/ha (72.54 kg/ha) and no mulch (61.11 kg/ha) but was statistically at par with sugarcane trash @ 10 t/ha (78.50 kg/ha). There was statistical parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. Total K uptake during second year followed similar pattern of the first year but there was non-significant difference between sugarcane trash @5 t/ha and maize stover @ 5 t/ha and also between sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. The pooled data of *rabi* maize followed similar trend as that of *rabi* during the second year.

Significantly higher total K uptake of 66.31 and 69.65 kg/ha of *kharif* maize were observed at maize stover @ 10 t/ha as compared to sugarcane trash @ 5 t/ha (59.73 and 63.74 kg/ha) and no mulch (50.45 and 53.17 kg/ha) but was at par with sugarcane trash @ 10 t/ha (63.77 and 67.13nk g/ha) and maize stover @ 5 t/ha (62.58 and 66.25 kg/ha) during both the years. There was parity between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha. All the mulch treatments were significantly superior to no mulch treatment.

On the basis pooled data of *kharif* maize there was significant influence in total K uptake due to mulching. The maximum total K uptake of 67.98 kg /ha was obtained with maize stover @ 10 t/ha and was significantly superior to sugarcane trash @ 5 t/ha (61.74 kg/ha) and no mulch (51.81 kg/ha) but was at par with sugarcane trash @ 10 t/ha (65.45 kg/ha) and maize stover @ 5 t/ha (64.42 kg/ha). There was non-significant difference between maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha. Nevertheless, no mulch treatment recorded significantly lower total the K uptake than all mulch treatments.

Table 4.7.3a **Total N, P & K uptake by maize crop (grain+stover+stone) as influenced by different treatments**

Treatments	***Rabi***								
	N (kg/ha)			**P (kg/ha)**			**K (kg/ha)**		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Moisture regime									
I_1- IW/CPE ratio 0.4	108.46	116.09	112.28	27.14	29.69	28.42	60.30	64.28	62.29
I_2- IW/CPE ratio 0.6	119.97	128.29	124.13	28.68	32.60	30.64	69.79	74.28	72.04
I_3- IW/CPE ratio 0.8	130.28	136.93	133.60	33.42	36.12	34.77	79.76	83.09	81.42
I_4- IW/CPE ratio 1.0	138.43	147.38	142.91	37.58	41.03	39.31	87.58	91.81	89.70
SEm ±	2.46	3.36	1.96	0.67	1.06	0.75	2.07	2.19	1.30
CD (P=0.05)	8.51	11.68	6.79	2.31	3.66	2.60	7.16	7.56	4.52
Mulch									
M_1-Sugarcane trash @ 5 t/ha	122.00	130.31	126.16	31.27	34.95	33.11	72.54	77.08	74.82
M_2-Sugarcane trash @10 t/ha	129.05	140.15	134.60	34.88	38.86	36.87	78.50	84.00	81.25
M_3-Maize stover @ 5 t/ha	125.91	134.56	130.24	33.21	36.72	34.97	76.39	80.29	78.34
M_4-Maize stover @ 10 t/ha	134.83	145.56	140.20	36.30	40.18	38.24	83.24	88.06	85.65
M_5-No mulch	109.63	110.29	109.96	22.85	23.60	23.23	61.11	62.40	61.76
SEm ±	2.81	2.99	2.60	0.68	0.85	0.65	2.23	2.17	1.58
CD (P=0.05)	8.08	8.63	7.50	1.96	2.45	1.88	6.43	6.26	4.56

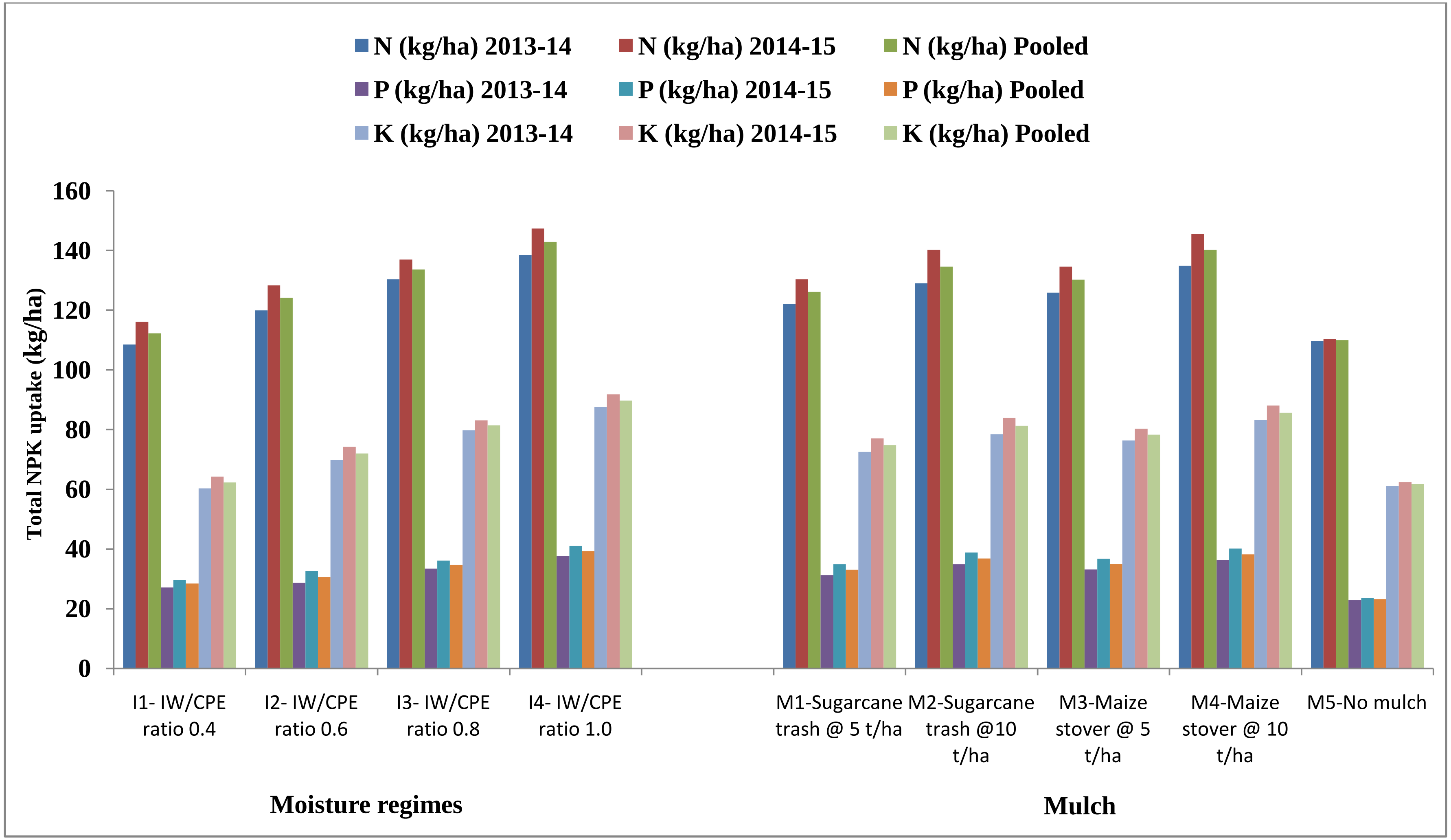


Fig. 4.6a Total NPK uptake by *rabi* maize crop (grain+stover+stone) as influenced by different treatments

Table 4.7.3b **Total N, P & K uptake by maize crop (grain+stover+stone) as influenced by different treatments**

Treatments	*Kharif*								
	N (kg/ha)			**P (kg/ha)**			**K (kg/ha)**		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Moisture regime									
I_1- IW/CPE ratio 0.4	73.57	77.33	75.45	25.38	27.29	26.34	59.99	62.59	61.29
I_2- IW/CPE ratio 0.6	74.03	78.04	76.04	25.42	27.62	26.53	60.34	63.27	61.81
I_3- IW/CPE ratio 0.8	74.59	79.35	76.97	25.85	27.99	26.92	60.65	64.31	62.48
I_4- IW/CPE ratio 1.0	75.49	80.76	78.13	26.06	28.61	27.34	61.29	65.78	63.54
SEm ±	1.14	1.78	1.13	0.63	0.46	0.35	1.84	1.45	1.09
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mulch									
M_1-Sugarcane trash @ 5 t/ha	73.79	78.50	76.14	26.27	28.90	27.59	59.73	63.74	61.74
M_2-Sugarcane trash @10 t/ha	78.77	84.06	81.42	28.77	31.10	29.94	63.77	67.13	65.45
M_3-Maize stover @ 5 t/ha	76.80	82.19	79.50	27.40	30.02	28.71	62.58	66.25	64.42
M_4-Maize stover @ 10 t/ha	81.97	87.53	84.75	30.00	32.20	31.10	66.31	69.65	67.98
M_5-No mulch	60.78	62.08	61.43	15.95	17.17	16.56	50.45	53.17	51.81
SEm ±	2.20	2.21	1.47	0.67	0.85	0.49	1.45	1.53	1.25
CD (P=0.05)	6.34	6.36	4.23	1.93	2.45	1.41	4.17	4.42	3.60

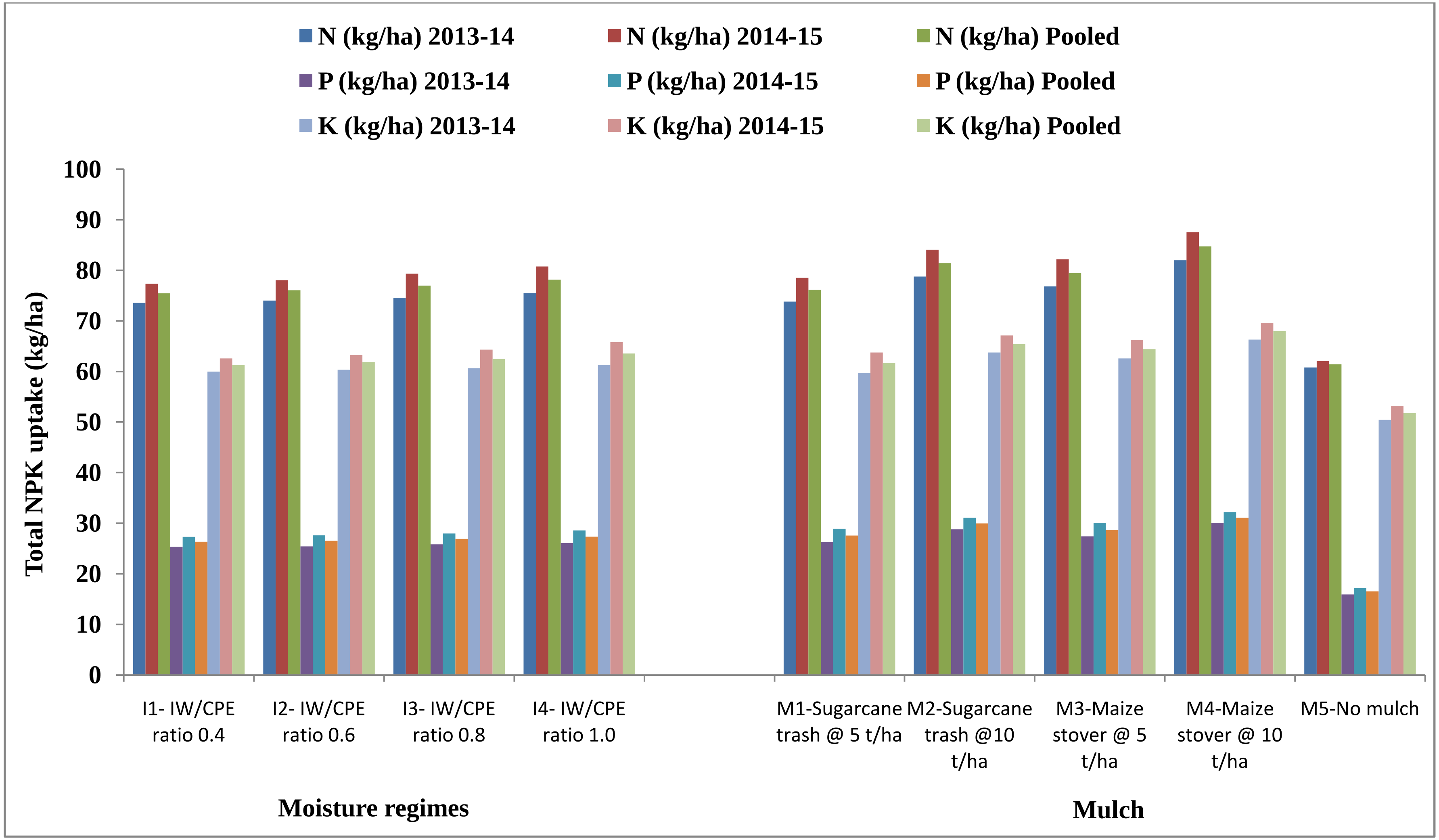


Fig. 4.6b Total NPK uptake by *kharif* maize crop (grain+stover+stone) as influenced by different treatments

4.8 Periodical soil moisture content

Data obtained on soil moisture content in 0-75 cm depth before sowing and each irrigation in different treatments of *rabi* maize have been presented in Table 4.8a and 4.8b.

Mean soil moisture content at the time of sowing was 19.68 and 19.34 percent during 2013-14 and 2014-15, respectively. The range of variation in moisture content under different mulch treatments before first common irrigation was found to be very little in both the years, however, moisture content in no mulch was lesser than all the mulched plots.

Perusal of soil moisture content data on different levels of irrigation during both the years revealed that moisture content was higher at 1.0 IW/CPE ratio which received 7 irrigations during first year and 5 irrigations during second year of experimentation as compared to lower level of irrigation from 0.8 to 0.4 IW/CPE ratios. Moisture content was decreased before each succeeding irrigation as the depth of each irrigation was kept 6 cm and plant water need was increased due to plant growth. There was less variation in moisture content between 1.0 and 0.8 IW/CPE ratios, while there was higher reduction in moisture content at 0.6 and 0.4 IW/CPE ratios.

Soil moisture content data of all the levels of irrigation from 0.4 to 1.0 IW/CPE ratios revealed that there was higher moisture content in mulching @ 10 t/ha as compared to 5 t/ha but the moisture content in no mulch plot was much lower than both the rate of application irrespective of either sugarcane trash or maize stover, while there was comparatively higher moisture content in mulching by maize stover.

Mean soil moisture content at harvest during first year was very high at harvest which was due to 60.6 mm rainfall occurred from 27.05.2014 to 31.05.2014. The higher soil moisture content at harvest had no effect on grain yield of *rabi* maize.

Mean soil moisture content at harvest during second year was 16.09%. Comparatively lower moisture content at harvest which was due to 13.4 mm

Table 4.8a Periodical means soil moisture content (%) before each irrigation in *rabi* and *kharif* seasons 2013-14

rabi									
Treatments	**Moisture at sowing**	**Moisture at 1ST**	**Moisture at 2^{ed}**	**Moisture at 3rd**	**Moisture at 4th**	**Moisture at 5th**	**Moisture at 6th**	**Moisture at 7th**	**Moisture at harvest**
I_1M_1		16.36	14.71	13.46					
I_1M_2		16.51	14.92	13.72					
I_1M_3		16.44	14.82	13.59					
I_1M_4		16.63	15.06	13.89					
I_1M_5		15.93	13.76	12.48					
I_2M_1		16.33	15.44	14.72	14.17	13.58			
I_2M_2		16.49	15.63	14.95	14.42	13.86			
I_2M_3		16.45	15.57	14.87	14.33	13.75			
I_2M_4		16.62	15.79	15.14	14.63	14.09			
I_2M_5		15.91	14.60	13.86	13.29	12.69			
	19.68%								20.97%
I_3M_1		16.35	15.64	15.15	14.77	14.38	13.96		
I_3M_2		16.48	15.82	15.36	14.97	14.58	14.17		
I_3M_3		16.43	15.75	15.28	14.87	14.45	14.02		
I_3M_4		16.60	15.95	15.50	15.08	14.65	14.23		
I_3M_5		15.59	14.86	14.40	13.92	13.40	13.03		
I_4M_1		16.34	15.68	15.23	14.92	14.66	14.39	14.10	
I_4M_2		16.53	15.87	15.43	15.17	14.87	14.60	14.30	
I_4M_3		16.46	15.78	15.32	15.05	14.73	14.45	14.14	
I_4M_4		16.61	15.99	15.56	15.28	14.97	14.73	14.42	
I_4M_5		15.93	15.03	14.56	14.27	13.94	13.65	13.32	
kharif									
Mean	21.24%								22.35%

Table 4.8b Periodical means soil moisture content (%) before each irrigation in *rabi* and *kharif* seasons 2014-15

rabi									
Treatments	**Moisture at sowing**	**Moisture at 1^ST^**	**Moisture at 2^ed^**	**Moisture at 3^rd^**	**Moisture at 4^th^**	**Moisture at 5^th^**	**Moisture at 6^th^**	**Moisture at 7^th^**	**Moisture at harvest**
I_1M_1		15.79	13.48						
I_1M_2		16.00	13.69						
I_1M_3		15.93	13.59						
I_1M_4		16.14	13.84						
I_1M_5		15.31	12.35						
I_2M_1		15.88	14.67	13.54					
I_2M_2		16.07	14.86	13.75					
I_2M_3		16.01	14.77	13.66					
I_2M_4		16.18	15.08	13.88					
I_2M_5		15.45	13.76	12.54					
	19.34%								16.09%
I_3M_1		15.83	15.08	14.41	13.86				
I_3M_2		16.02	15.28	14.60	14.11				
I_3M_3		15.95	15.49	14.32	14.02				
I_3M_4		16.14	15.43	14.74	14.30				
I_3M_5		15.38	14.34	13.63	13.17				
I_4M_1		15.86	15.18	14.67	14.31	13.98			
I_4M_2		16.07	15.36	14.76	14.39	14.05			
I_4M_3		15.99	15.25	14.70	14.35	14.00			
I_4M_4		16.15	14.44	14.81	14.43	14.19			
I_4M_5		15.44	14.47	13.73	13.22	13.06			
kharif									
Mean	21.05%								20.62%

rainfall occurred during 18.04.2015 to 25.04.2015, in the last week of harvest of *rabi* maize. This moisture content did not influence the grain yield of maize.

There was higher soil moisture content due to well distributed rainfall during the cropping season of *kharif* maize.

4.9 Economics

On the basis of prevailing market price gross returns, net returns and benefit: cost ratio was calculated, statistically analysed and data have been presented in Table 4.9a and 4.9b and 4.9c and graphically illustrated in Fig. 4.9a and 4.9b.

4.9.1 Cost of cultivation

Common cost of cultivation, variable treatment cost and total cost of cultivation (₹/ha) at different treatment combinations have been presented in Appendix IVa, IVb, V, VIa and VIb.

4.9.2 Gross returns

Gross returns calculated on the basis of grain yield as per prevailing market price. Data were subjected to statistical analysis and have been presented in Table 4.9a and 4.9b and graphically depicted in Fig. 4.9a and 4.9b.

Influence of moisture regime

There was significant variation in gross returns due to moisture regime in *rabi* maize during both the years. A close perusal of data related to gross returns revealed that the maximum gross returns of 111564 and 112075 ₹/ha during 2013-14 and 2014-15 was recorded with 1.0 IW/CPE ratio which was significantly superior to 0.6 IW/CPE ratio (106025 and 106511 ₹/ha) and 0.4 IW/CPE ratio (99056 and 99510 ₹/ha) but was found to be at par with 0.8 IW/CPE ratio (109850 and 110354 ₹/ha) during both the years.

Pooled data of gross returns indicated that gross returns accrued at 1.0 IW/CPE ratio (111820₹/ha) was significantly superior to 0.6 IW/CPE ratio (99283 ₹/ha) and 0.4 IW/CPE ratio (106268 ₹/ha) but was statistically at par with 0.8

IW/CPE ratio (110102 ₹/ha). There was also parity between 0.8 and 0.6 IW/CPE ratios.

There was non-significant variation in gross returns due to moisture regime during two years of experimentation of *kharif* maize. Pooled data also indicated that gross return was not influenced by different moisture regimes.

Influence of mulching

The influence of mulching on gross returns was noted to be significant in both *rabi* and *kharif* maize during both the years of experimentation. Perusal of data on *rabi* maize showed that maize stover @ 10 t/ha resulted higher gross returns of 111763 and 112275 ₹/ha which was significantly superior to sugarcane trash @ 5 t/ha (105765 and 106249 ₹/ha) and no mulch treatment (98556 and 98007 ₹/ha) but was statistically at par with sugarcane trash @ 10 t/ha (109207 and 109707 ₹/ha) and maize stover @ 5 t/ha (107829 and 108323 ₹/ha). Likewise, sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha were at par among themselves during both the years.

On the basis of pooled data, the highest gross returns of (112019 ₹/ha) with respect to mulching was obtained with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (106007 ₹/ha) and no mulch (98782 ₹/ha) but was at par with sugarcane trash @ 10 t/ha (109458 ₹/ha) and maize stover @ 5 t/ha (108077 ₹/ha). There was also parity among sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha.

The data on gross returns of *kharif* maize followed similar trend as that of *rabi* maize during both the years. Pooled data also indicated that gross returns were significantly influenced by different mulch application. The maximum gross returns of (67983 ₹/ha) was recorded under maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (64614 ₹/ha) and no mulch (58577 ₹/ha) but was statistically at par with sugarcane trash @ 10 t/ha (66758 ₹/ha) and maize stover @ 5 t/ha (65982 ₹/ha). Sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha were at par among themselves.

4.9.3 Net returns

The data obtained on net returns as influenced by different treatments were statistically analysed and have been presented in Table 4.9a, 4.8b and 4.9c and illustrates in Fig. 4.9a and 4.9b.

Influence of moisture regime

A close perusal of data with respect to net returns at different moisture regimes of *rabi* maize during both the years revealed that there was significant variation in net returns due to moisture regime. 1.0 IW/CPE ratio generated the maximum net returns of 72542 and 75548 ₹/ha which was significantly superior to 0.4 IW/CPE ratio (64034 and 65983 ₹/ha) but was statistically at par with 0.8 IW/CPE ratio (71828 and 74827 ₹/ha) and 0.6 IW/CPE ratio (69003 and 71987 ₹ /ha) during both the years.

Pooled data with respect to moisture regime reveals that the highest net returns (74045 ₹/ha) was obtained at 1.0 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio (65009 ₹/ha) but was found statistically similar with 0.8 IW/CPE ratio (73328 ₹/ha) and 0.6 IW/CPE ratio (70494 ₹/ha). There was also parity between 0.6 and 0.4 IW/CPE ratios.

The perusal of data on net returns of *kharif* maize reveals that net returns were not influenced by moisture regime during both the years of experimentation. On the basis of pooled data, there was also non-significant difference on net returns of *kharif* maize due to moisture regime.

System pooled data indicated that net returns was significantly influenced by moisture regime (Table 4.9c). The highest net returns of 107292 ₹/ha was obtained at 1.0 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio (96864 ₹/ha) but statistically at par with 0.8 and 0.6 IW/CPE ratios (106362 and 102406 ₹/ha). There was also parity between 0.6 and 0.4 IW/CPE ratios.

Influence of mulching

Data with respect to mulching of both *rabi* and *kharif* maize reveals that mulch significantly influenced the net returns during both the years. The highest net returns (73747 and 76544 ₹/ha) of *rabi* maize was obtained with maize stover

@ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (68679 and 71398 ₹/ha) and no mulch (62400 and 65036 ₹/ha) and was statistically at par with sugarcane trash @ 10 t/ha (71191 and 73976 ₹/ha) and maize stover @ 5 t/ha (70743 and 73472 ₹/ha). However, there were also statistical parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha during both the years.

Pooled data with respect to mulching reveals that net return followed similar trend as that of the first year and second year of experimentation.

Mulching significantly influenced the net returns of *kharif* maize during both the years (Table 4.9). The maximum net returns of 34534 and 35379 ₹/ha was obtained with maize stover @ 10 t/ha which was significantly higher than no mulch (27088 and 27791 ₹/ha) and was at par with other mulched treatments.

Pooled data on mulch application of *kharif* maize reveals that maize stover @ 10 t/ha has significantly higher net returns (34957 ₹/ha) as compared to all other mulch treatments and all were significantly superior to no mulch treatment (27440 ₹/ha).

On the basis of system pooled data, net returns were significantly influenced by mulching. Maize stover @ 10 t/ha had significantly higher net returns of 110103 ₹/ha as compared to sugarcane trash @ 5 t/ha (102572 ₹/ha) and no mulch (91158 ₹/ha) but was at par with sugarcane trash @ 10 t/ha (106316 ₹/ha) and maize stover @ 5 t/ha (106010 ₹/ha). Further, there was parity among sugarcane trash @ 10 and 5 t/ha, and maize stover @ 5 t/ha.

4.9.4 Benefit: Cost ratio

The data obtained on benefit: cost ratio (B: C ratio) as influenced by different moisture regimes and mulching have been presented in Table 4.9a, 4.8b and 4.9c.

Influence of moisture regime

Close observation of data on B: C ratio of *rabi* indicated that there was non-significant difference due to moisture regime during the first year of experimentation while in second year, the maximum B: C ratio of 2.11 was recorded under 0.8 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio (1.97) but was at par with 0.6 IW/CPE ratio (2.08) and 1.0 IW/CPE ratio (2.07), respectively.

Pooled data reveals that moisture regime exhibited significant variations on B: C ratio. The maximum B: C ratio of (2.00) was obtained under 0.8 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio (1.90) but was at par with 1.0 IW/CPE ratio (1.96) and 0.6 IW/CPE ratio (1.97).

There was non-significant difference in B: C ratio due to different moisture regimes in *kharif* maize during both the years. Pooled data of *kharif* maize related to B: C ratio shows that there was non-significant difference due moisture regime.

System pooled data with regard to B: C ratio (Table 4.9c) indicated that there was non-significant difference due to moisture regime.

Influence of mulching

Data reveals that mulching significantly influenced B: C ratio of *rabi* and *kharif* maize during both the years. In *rabi* maize, the maximum B: C ratio of 1.94 and 2.14 was recorded under maize stover @ 10 t/ha which was at par with other mulch treatments and all were significantly superior to no mulch (1.72 and 1.91) during both the years.

A perusal of pooled data clearly demonstrates that there was significant difference in B: C ratio due to different moisture regimes. Significantly higher B: C ratio (2.04) was recorded with maize stover @ 10 t/ha which was comparable with other mulch treatments and all were significantly superior to no mulch treatment (1.82).

The maximum B: C ratio of 1.04 and 1.08 of *kharif* maize was obtained under maize stover @ 10 and 5 t/ha which were found at par with other mulch treatments and all were significantly higher than no mulch (0.86 and 0.90) during both the years.

Pooled data reveals that mulching showed significant variation on B: C ratio. The maximum B: C ratio of 1.06 was obtained with maize stover @ 10 and 5 t/ha each which was significantly superior to no mulch (0.88) but was at par with

Table 4.9a Gross returns, Net returns and B: C ratio as influenced by different treatments

Treatments	*Rabi*								
	Gross returns (₹/ha)			**Net returns (₹/ha)**			**B: C ratio**		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Moisture regime									
I_1- IW/CPE ratio 0.4	99056	99510	99283	64034	65983	65009	1.83	1.97	1.90
I_2- IW/CPE ratio 0.6	106025	106511	106268	69003	71984	70494	1.86	2.08	1.97
I_3- IW/CPE ratio 0.8	109850	110354	110102	71828	74827	73328	1.89	2.11	2.00
I_4- IW/CPE ratio 1.0	111564	112075	111820	72542	75548	74045	1.86	2.07	1.96
SEm ±	1245	1211	1146	1040	1042	1041	0.02	0.02	0.02
CD (P=0.05)	4307	4191	3966	3598	3607	3603	NS	0.08	0.07
Mulch									
M_1-Sugarcane trash @ 5 t/ha	105765	106249	106007	68679	71398	70039	1.85	2.05	1.95
M_2-Sugarcane trash @10 t/ha	109207	109707	109458	71191	73976	72584	1.87	2.07	1.97
M_3-Maize stover @ 5 t/ha	107829	108323	108077	70743	73472	72108	1.91	2.11	2.01
M_4-Maize stover @ 10 t/ha	111763	112275	112019	73747	76544	75146	1.94	2.14	2.04
M_5-No mulch	98556	99007	98782	62400	65036	63718	1.72	1.91	1.82
SEm ±	1556	1571	1496	1477	1482	1479	0.04	0.04	0.04
CD (P=0.05)	4483	4527	4309	4254	4270	4262	0.10	0.11	0.11

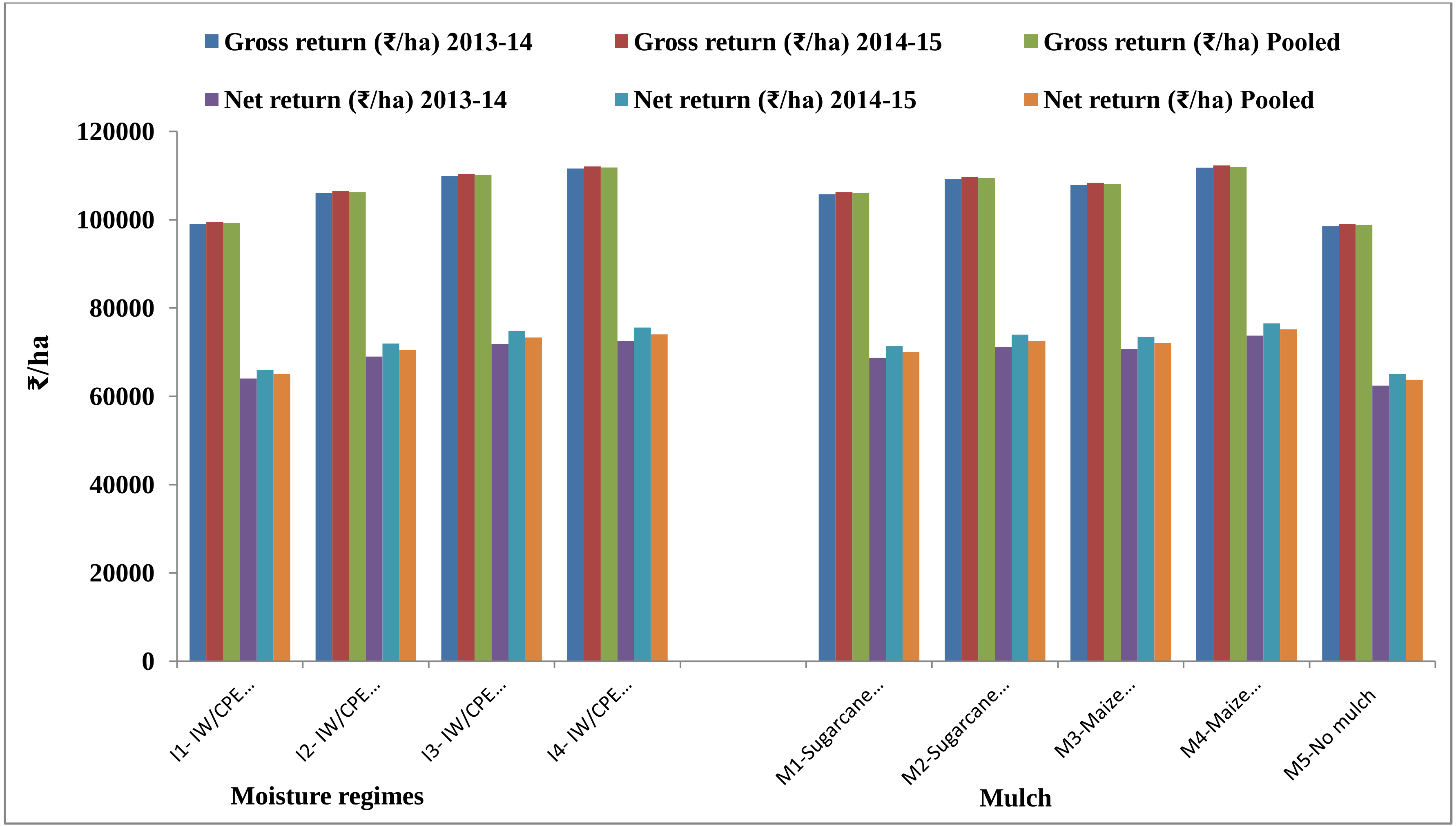


Fig. 4.7a Gross and Net returns of *rabi* maize as influenced by different treatments

Table 4.9b Gross returns, Net returns and B: C ratio as influenced by different treatments

Treatments	*Kharif*								
	Gross returns (₹/ha)			**Net returns (₹/ha)**			**B: C ratio**		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Moisture regime									
I_1- IW/CPE ratio 0.4	63980	64273	64126	31462	32250	31856	0.97	1.01	0.99
I_2- IW/CPE ratio 0.6	64036	64329	64182	31518	32306	31912	0.97	1.01	0.99
I_3- IW/CPE ratio 0.8	65155	65453	65204	32637	33430	33034	1.00	1.04	1.02
I_4- IW/CPE ratio 1.0	65367	65667	65517	32849	33644	33247	1.01	1.05	1.03
SEm ±	1244	1250	1247	1215	1260	1235	0.04	0.03	0.04
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Mulch									
M_1-Sugarcane trash @ 5 t/ha	64466	64761	64614	32142	32922	32533	0.99	1.04	1.01
M_2-Sugarcane trash @10 t/ha	66605	66910	66758	33311	34151	33731	1.00	1.04	1.02
M_3-Maize stover @ 5 t/ha	65831	66132	65982	33507	34293	33900	1.04	1.08	1.06
M_4-Maize stover @ 10 t/ha	67828	68138	67983	34534	35379	34957	1.04	1.08	1.06
M_5-No mulch	58442	58710	58577	27088	27791	27440	0.86	0.90	0.88
SEm ±	985	989	987	976	987	978	0.03	0.03	0.03
CD (P=0.05)	2837	2850	2844	2810	2843	2816	0.09	0.09	0.09

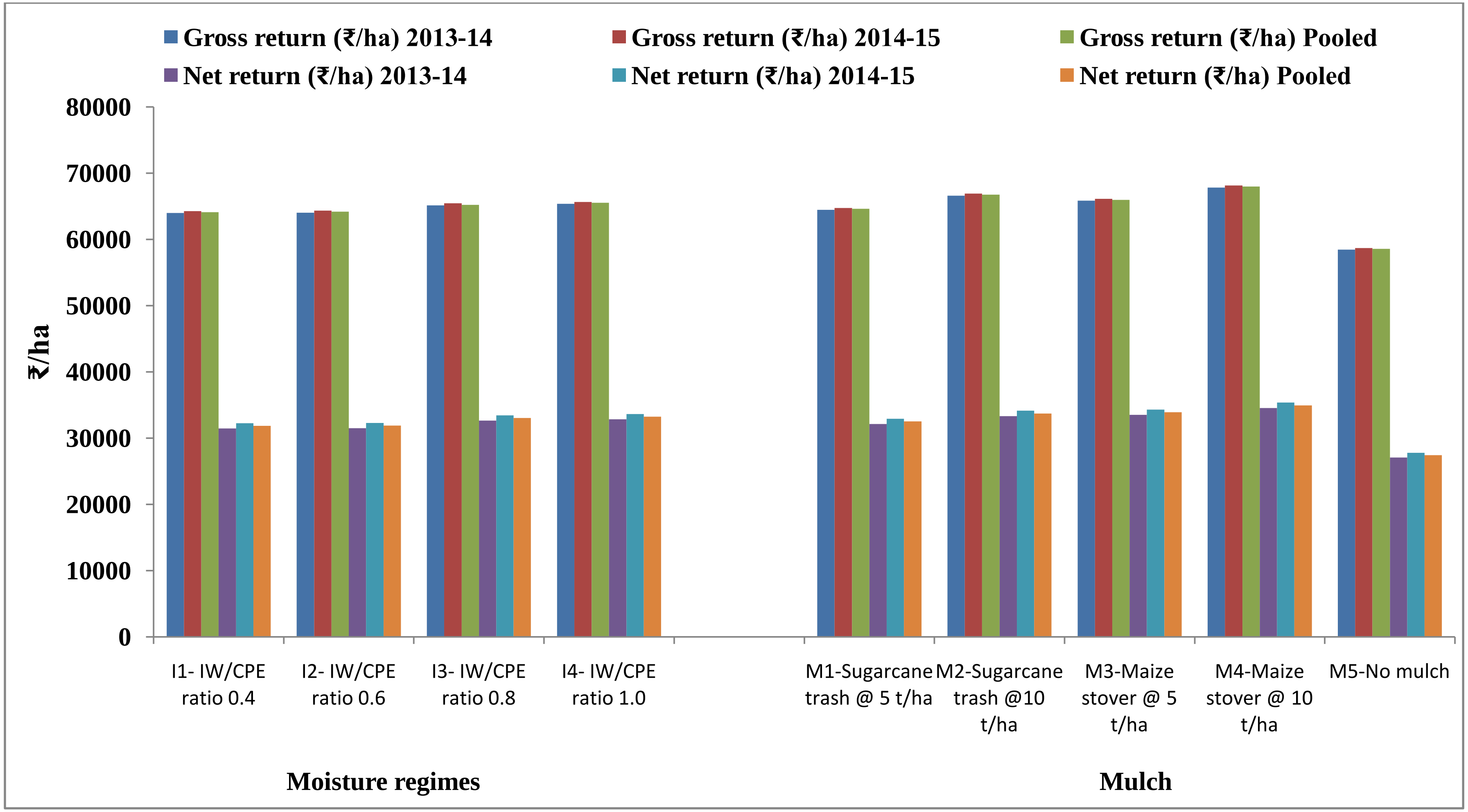


Fig. 4.7b Gross and Net returns of *kharif* maize as influenced by different treatments

Table 4.9c Net returns (₹/ha) and B: C ratio of maize as influenced by different treatments (system pooled)

Treatments	Net returns (₹/ha)					B: C ratio				
	Moisture regime									
	I_1- IW/CPE ratio 0.4	I_2- IW/CPE ratio 0.6	I_3- IW/CPE ratio 0.8	I_4- IW/CPE ratio 1.0	**Mean**	I_1- IW/CPE ratio 0.4	I_2- IW/CPE ratio 0.6	I_3- IW/CPE ratio 0.8	I_4- IW/CPE ratio 1.0	**Mean**
Mulch										
M_1-Sugarcane trash @ 5 t/ha	97006	101506	104932	106846	**102572**	2.90	2.96	3.00	3.00	**2.96**
M_2-Sugarcane trash @10 t/ha	99868	106588	109844	108962	**106316**	2.92	3.02	3.06	2.98	**2.99**
M_3-Maize stover @ 5 t/ha	101176	105446	107408	110006	**106009**	3.04	3.08	3.08	3.10	**3.07**
M_4-Maize stover @ 10 t/ha	103366	109648	114596	112800	**110103**	3.02	3.10	3.20	3.08	**3.10**
M_5-No mulch	82906	88842	95034	97850	**91158**	2.96	2.66	2.78	2.82	**2.70**
Mean	**96864**	**102406**	**106362**	**107292**		**2.88**	**2.96**	**3.02**	**3.00**	
	I	M	I×M			I	M	I×M		
SEm ±	2138	1672	3344			0.06	0.04	0.10		
CD (P=0.05)	7402	4816	NS			NS	0.14	NS		

sugarcane trash @ 10 and 5 t/ha (1.02 and 1.01), respectively. All the mulch treatments were significantly higher than no mulch.

Analysis of maize-maize system pooled data reveals that there was significant influence due to application of mulch. The maximum B: C ratio of 3.10 was recorded with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha (2.96) and no mulch (2.70) and it was found to be at par with sugarcane trash @ 10 t/ha (2.99) and maize stover @ 5 t/ha (2.07). There was parity among sugarcane trash @ 10 and 5 t/ha and maize stover @ 5 t/ha. Nevertheless, all the mulched treatments were significantly higher than no mulch treatment.

4.10 Correlation studies

To know how maize grain yield (Y) associated with different yield attributes, correlation study was done. The yield attributes included in this study were, *viz.* X_1 (Straw yield), X_2 (stone yield), X_3 (plant height at 150 DAS), X_4 (plant dry weight at 150 DAS), X_5 (leaf area index at silking), X_6 (number of cobs/plant), X_7 (number of rows/cob), X_8 (number of grains/cob), X_9 (100-grain weight), X_{10} (number of weeds at knee high), X_{11} (number of weeds at silking), X_{12} (weed dry weight at knee high) and X_{13} (weed dry weight at silking). The correlation coefficient matrix among yield and yield attributes were worked out and the values of correlations have been presented in Table 4.10a and 4.10b.

A close perusal of pooled data of *rabi* and *kharif* maize resulted in Table 4.10a and 4.10b reveal that the grain yield was positively and significantly correlated with all the yield attributes, except weed population and weed dry weight at (knee high and silking stages) which were negatively and significantly correlated.

◈◈◈

Table 4.10a Correlation coefficient (r) between grain yield and different yield attributes of *rabi* maize (pooled of two years data)

		Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Grain yield	**Y**	1.000	.601**	.635**	.587**	.659**	.404**	.269**	.489**	.530**	.534**	-.409**	-.439**	-.399**	-.314**
Straw yield	X_1			.491**	.532**	.485**	.336**	.197*	.547**	.513**	.469**	-.375**	-.358**	-.347**	-.196
Stone yield	X_2				.544**	.707**	.373**	0.146	.596**	.565**	.566**	-.432**	-.363**	-.382**	-.217
Plant height at 150 DAS	X_3					.624**	.433**	.281**	.452**	.526**	.417**	-.408**	-.408**	-.401**	-.295**
Plant DM at 150 DAS	X_4						.482**	.284**	.625**	.635**	.509**	-.538**	-.481**	-.500**	-.361**
Lea area index at silking	X_5							0.162	.487**	.287**	.416**	-.464**	-.430**	-.344**	-.342**
No. of cobs /plant	X_6								.291**	.271**	.181*	-0.151	-0.042	0.016	-0.036
No. of rows/cob	X_7									.630**	.503**	-.360**	-.352**	-.280**	-0.163
No. of grains /cob	X_8										.319**	-.330**	-.313**	-.354**	-0.152
100-grain weight	X_9											-.307**	-.277**	-.199*	-0.127
No. weeds at knee high	X_{10}												.805**	.849**	.717**
No. weeds at silking	X_{11}													.890**	.855**
Weed dry wt. at knee high	X_{12}														.791**
Weed dry wt. at silking	X_{13}														1.000

Table 4.10b Correlation coefficient (r) between grain yield and different yield attributes of *kharif* maize (pooled of two years data)

		Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Grain yield	**Y**	1.000	.727**	.579**	.419**	.246**	.559**	0.139**	.484**	.353**	.430**	-.540**	-.528**	-.512**	-.498**
Straw yield	X_1			.652**	.468**	.337**	.562**	0.178**	.461**	.336**	.317**	-.554**	-.525**	-.488**	-.557**
Stone yield	X_2				.463**	.356**	.675**	.281**	.501**	.379**	.337**	-.564**	-.574**	-.555**	-.560**
Plant height at 150 DAS	X_3					.581**	.692**	.223*	.327**	.392**	.334**	-.718**	-.693**	-.657**	-.701**
Plant DM at 150 DAS	X_4						.550**	.256**	.242**	.500**	.216*	-.584**	-.555**	-.503**	-.535**
Lea area index at silking	X_5							.378**	.490**	.542**	.549**	-.810**	-.802**	-.769**	-.783**
No. of cobs /plant	X_6								.275**	.285**	0.159	-.273**	-.231*	-.236**	-.203*
No. of rows/cob	X_7									.380**	.478**	-.337**	-.334**	-.250**	-.261**
No. of grains /cob	X_8										.306**	-.587**	-.551**	-.494**	-.537**
100-grain weight	X_9											-.360**	-.365*	-.263**	-.295**
No. weeds at knee high	X_{10}												.967**	.925**	.957**
No. weeds at silking	X_{11}													.933**	.952**
Weed dry wt. at knee high	X_{12}														.932**
Weed dry wt. at silking	X_{13}														1.000

Chapter -5

DISCUSSION

5 DISCUSSION

The experimental results presented in previous chapter are discussed in this chapter critically in the light of established scientific principles and available reports and literatures by various scientists in India and abroad on related research in order to understand the ‘cause and effect’ relationship of the various factors taken for study on the production of maize crop under maize-maize cropping system.

In general weather conditions during *rabi* and *kharif* seasons were congenial for growth and development of the crop. In *kharif* season there was good rainfall of 24.6 mm 5 days before sowing during the first year while 19.8 mm 3 days before sowing during second year. There was well distributed rainfall during the crop period in *kharif* season due to which no irrigation was required during both the years.

5.1 Growth parameters

Soil moisture is one of the most important factor affecting the plant growth and yield of maize. Water is the component of physiologically active tissues, essential for maintenance of the turgidity and necessary for cell enlargement and growth. Therefore, it is probable that almost every process occurring in plants is affected by water deficits. Mulching is one of the important agronomic practices in conserving the soil moisture and modifying the soil physical environment. Growth parameters of the plant which are manifested in plant height, leaf area index and dry matter production collectively determine the size of photosynthetic structure and finally the productivity of the crop.

5.1.1 Plant height

In present experiment, plant height was recorded at 30 days periodic interval of both the *rabi* and *kharif* maize. Plant height at 30, 60 and 90 days after sowing of *rabi* maize was not influenced significantly by moisture regimes during both the years. This might be due to fact that moisture regimes based on IW/CPE ratio actually varied after 90 days of sowing in *rabi* season but plant height on later stages (120 and 150 DAS) increased significantly with increase in moisture regime during both the years. The maximum plant height was recorded under 1.0 IW/CPE ratio which was significantly higher than those of 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio. This increase in height may be due to rapid cell division and elongation in presence of adequate moisture as compared to relatively stressed plants. Similar result of increased plant height with increasing moisture regimes was reported by Bharati *et al.* (2007) and Niveditha and Nagavani (2016). Plant height in *kharif* maize at all the stages during both the years was not significantly influenced by moisture regime. This might be due to sufficient rainfall during the crop season.

Mulching had significant influence on plant height in *rabi* and *kharif* maize during both the years. Plant height increased with increase in mulch rate. The maximum plant height at different intervals during *rabi* and *kharif* was recorded under maize stover @ 10 t/ha which was statistically at par with sugarcane trash @ 10 t/ha, maize stover @ 5 t /ha and sugarcane trash @ 5 t/ha, respectively in early and late stages and all the mulched plots were significantly superior over no mulch. This might be due to reduction of evaporation and thereby more moisture retention in mulched treatments which resulted in high available soil moisture in root zone. The results are in conformity with the findings of Kumara and Dey (2011); Rajashekarappa *et al*. (2013) and Ibni Zamir *et al.* (2014).

5.1.2 Leaf area index (LAI)

Leaf area index at silking stage in both *rabi* and *kharif* maize during both the years was non-significant due to different moisture regimes. This was because of the fact that differences in moisture regimes actually accrued after silking stage in *rabi* maize and there was sufficient rainfall during *kharif* maize.

Mulching significantly influenced the leaf area index at silking stage in *rabi* and *kharif* maize during first and second year of experimentation. The maximum LAI was recorded with maize stover @ 10 t/ha in both *rabi* and *kharif* maize which was significantly higher than no mulch during first year, and sugarcane trash @ 5 t/ha and no mulch in second year of *rabi* maize but was statistically at par with other mulched treatments during first year while was at par with sugarcane trash @ 10 and maize stover @5 t/ha in the second year and all the mulched treatments were significantly superior over no mulch treatment. In *kharif* maize, maize stover @ 10 t/ha recorded significantly higher leaf area index as compared to other mulched treatments and all the mulch treatments were significantly superior to no mulch treatments during both the years. This indicated that when crops get proper nourishment and favorable soil physical condition as under mulched surface tended to more vegetative growth of the plants. These findings are supported by Kobayashi *et al*. (2010).

5.1.3 Plant dry matter production

Plant dry matter production is the cumulative of various growth parameters such as plant height, number and size of leaves and stem diameter. Plant dry matter production at initial stages of 30, 60 and 90 days after sowing of *rabi* maize and all intervals of *kharif* maize did not differ significantly due to moisture regimes during both the years but at 120 and 150 days after sowing of *rabi* maize, plant dry matter production showed significant increase with increasing moisture regimes. The maximum dry matter production was observed with 1.0 IW/CPE ratio which was significantly superior to those of 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio. Higher dry matter production could be mainly attributed to increased plant height. Similar observations were reported by Singh (2003); Yi *et al*. (2010) and Anjum *et al*. (2014).

Mulching affected the plant dry matter production significantly in both *rabi* and *kharif* maize. With the increase in mulch rate there was an increase in dry matter production. The maximum plant dry matter production was recorded under maize stover @ 10 t/ha in both *rabi* and *kharif* maize which was significantly superior to maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha at 150 DAS and was at par with sugarcane trash @ 10 t/ha in *rabi* maize while was at par with other mulched treatments at 90 DAS in *kharif* maize. All the mulch treatments were significantly higher than no mulch treatment. This may be due to the fact that mulch improved hydrothermal condition, soil structure, rooting behavior of the crop and also enhanced soil organic matter and soil fertility. Similar findings have been reported by Cook *et al.* (2006) and Kaur and Mahal (2016).

5.2 Yield attributing characters and yield

5.2.1 Yield attributes

Almost all yield attributing characters *viz*. number of rows per cob, number of grains per cob and 100-grain weight of *rabi* maize had been significantly influenced by different moisture regimes except number of cobs per plant which was non-significant due to moisture regime. In case of *kharif* maize all yield attributing characters mentioned were not influenced by moisture regime. Number of cobs per plant in *rabi* and *kharif* maize also did not differ significantly with mulching.

The maximum number of rows per cob of *rabi* maize was recorded with 1.0 IW/CPE ratio which was significantly higher than 0.6 and 0.4 IW/CPE ratios and was statistically at par with 0.8 IW/CPE ratio during both the years. These results are comparable with those of Tafrishi *et al*. (2013) who reported that number of rows per cob was increased with increasing moisture regimes.

In case of number of rows per cob, all the mulching treatments were significantly superior over no mulch in *rabi* and *kharif* maize during both the years. These findings are in accordance with experimental results of Bozkurt *et al*. (2011) Ibni Zamir *et al*. (2014) and Yaseen *et al*. (2014).

Number of grains per cob was influenced significantly by moisture regime and mulching in *rabi* maize. In *rabi* maize, number of grains per cob was increased with increase in moisture regime up to 0.6 IW/CPE ratio during the first year and up to 0.8 IW/CPE ratio during second year. Moisture regime did not show significant influence on number of grains per cob in *kharif* maize during both the years. This finding is in close conformity with those of Saif *et al*. (2003); Abbas *et al*. (2005) Bozkurt *et al*. (2011) and Hussain *et al*. (2015b).

Mulch application significantly influenced number of grains per cob in *rabi* and *kharif* maize during both the years of experimentation. Significantly higher number of grains per cob was recorded with maize stover @ 10 t/ha which was statistically at par with other mulched treatments and all the mulch treatments were significantly superior over no mulch treatment. Similar findings are also reported by Ibni Zamir *et al*. (2014).

The maximum 100-grain weight of *rabi* maize during both the years was registered at 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio during the first year but during second year it was significantly superior to 0.4 IW/CPE ratio and was statistically at par with 0.8 and 0.6 IW/CPE ratios. There was non-significant difference in 100-grain weight of *kharif* maize due to moisture regime during both the years. Increase in 100-grain weight with increase in IW/CPE ratio in *rabi* maize might be due to beneficial effect of sufficient moisture in the soil with 1.0 and 0.8 IW/CPE ratios which gave better growth of crop, efficient dry matter partioning and better translocation to the sink, leading to the formation of large sized grains. This result was in agreement with the results of Tiapodia and Singh (2013); Adamu *et al*. (2014); Hussain *et al.* (2015b); Kaur and Mahal (2016) and Niveditha and Nagavani (2016).

Significantly higher 100-grain weight was recorded with either maize stover or sugarcane trash @ 10 t/ha which was significantly higher than no mulch. The result was in conformity with those of Khurshid *et al*. (2006); Sarwar *et al*. (2013) and Ibin Zamir *et al*. (2014).

5.2.2 Yield studies

The grain yield increased significantly with increase in moisture regimes in *rabi* maize during both the years. The higher grain yield of 83.56 and 86.77 q/ha was recorded with 1.0 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio but was statistically at par with 0.8 and 0.6 IW/CPE ratios. Pooled data of *rabi* maize indicated that 1.0 IW/CPE ratio recorded significantly higher grain yield (85.17 q/ha) as compared to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio. Moisture regime did not show significant influence on grain yield in *kharif* maize during both the years and similarly as in pooled data. This might be due to sufficient soil moisture at all the moisture regimes in *kharif* maize. Increase in the grain yield of *rabi* maize with increase in moisture regimes may be due to sufficient moisture available with higher moisture regimes. These results are in conformity with findings of Abbas *et al*. (2005); Shivakumar *et al* (2011); Kuscu *et al.* (2013) and Amandu *et al*. (2015).

Application of mulch significantly influenced grain yield of *rabi* and *kharif* maize during both the years. Pooled data of *rabi* maize revealed that the maximum grain yield was obtained with maize stover @ 10 t/ha and it was significantly higher over maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. However, all mulched treatments were significantly superior to no mulch. Pooled data of grain yield in *kharif* maize indicated that mulching with maize stover @ 10 t/ha was significantly superior to sugarcane trash @ 5 t/ha and no mulch but was statistically at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. Increase in grain yield of mulched treatments might be due to reduction of evaporation and thereby more retention in mulched plots which resulted in higher available soil moisture in root zone. These results were consistent with the findings of Khurshid *et al.* (2006); Masant and Mallik (2009); Uwah and Iwo (2011); Sadawarti *et al*. (2013); Singh *et al.* (2014); Kumar (2015) and Kaur and Mahal (2016).

In both the years of experiment, 1.0 IW/CPE ratio recorded the higher stover yield of *rabi* maize which was significantly superior to 0.6 and 0.4 IW/CPE ratios during the first year and to 0.4 IW/CPE ratio in second year. Pooled data of *rabi* maize also revealed that the highest stover yield was obtained at 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio. This finding corroborated with that of Saif *et al.* (2003); Payero *et al.* (2008); Khaksar *et al.* (2013) and Faloye and Alatise (2015), who also reported significant increase in stover yield with increase in moisture regimes. Stover yield of *kharif* maize was found to be non-significant due to different moisture regimes during both the years and as well as of pooled data. This might be due to sufficiency of soil moisture during the crop period.

Significantly higher stover yield of *rabi* maize was recorded under mulched treatments as compared to no mulch. Higher stover yield was noticed in maize stover @ 10 t/ha which was significantly higher than sugarcane trash @ 5 t/ha and no mulch but was statistically at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha during the first year. Similar trend in second year except it was at par with other mulched treatments. Pooled data showed that the stover yield was the maximum under maize stover @ 10 t/ha which was significantly higher than sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. Stover yield of *kharif* maize during both the years and pooled data followed similar trend of stover yield in *rabi* maize during the second year. Significant increase in stover yield under mulched treatments might be due to no water stress by increasing soil water storage and decreasing soil evaporation during crop growth and development. Similar observations have been reported by Sharma *et al*. (2010); Shafi *et al*. (2010); Uwah and Iwo (2011) and Kumar (2015).

There was significant influence of moisture regimes on stone yield of *rabi* maize. Stone yield was significantly higher at 1.0 IW/CPE ratio as compared to remaining moisture regimes during both the years and as well as in pooled data. This result is in conformity with Kumar (2005). In *kharif* maize, there was non-significant difference of stone yield due to moisture regime during both the years as well as in pooled data.

Data on stone yield of *rabi* maize during both the years and in pooled data showed that the higher stone yield was recorded under maize stover @ 10 t/ha which was significantly superior over rest of mulched treatments and no mulch. Data of two years and pooled data of *kharif* maize revealed that the maximum stone yield was recorded with maize stover @ 10 t/ha which was significantly higher than maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but it was par with sugarcane trash @ 10 t/ha. The results confirm the findings of Amandu *et al*. (2015).

In the present investigation of both *rabi* and *kharif* maize during 2013-14 and 2014-15 and their pooled data of harvest index was found to be non-significant due to moisture regime and mulching. Kaur and Mahal (2016) also reported similar result.

5.3 System productivity

5.3.1 Grain yield

Pooled data on grain yield of maize- maize cropping system revealed that the highest grain yield was recorded with 1.0 IW/CPE ratio which was significantly superior over 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio. This finding is in favour of the findings of Tafrishi *et al.* (2013) and Adamu *et al*. (2014).

A cursory glance over maize-maize system pooled data indicated that the highest grain yield was recorded under maize stover @ 10 t/ha over maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. Similar results were reported by *Singh et al*. (2015).

5.3.2 Water-use efficiency

Water-use efficiency has been calculated on basis of grain yield and water use including effective rainfall. Water-use efficiency was significantly decreased with increasing moisture regimes from 0.4 to 1.0 IW/CPE ratios in *rabi* maize during both the years. Pooled data on water-use efficiency of *rabi* maize indicated that the highest WUE of 405.38 kg/ha-cm was recorded with 0.4 IW/CPE ratio which was significantly superior over remaining moisture regimes, whereas the lowest water-use efficiency was recorded with 1.0 IW/CPE ratio (217.42 kg/ha-cm) followed by 0.8 and 0.6 IW/CPE ratios. Water-use efficiency in *kharif* maize was observed non-significant difference due to different moisture regimes during both the years and pooled analysis. This is due to the fact that all the treatments received equal amount of moisture by rainfall. Water-use efficiency was increased with decreased moisture regimes in *rabi* maize. This might be due to more consumption of water per unit of grain produced. The results were in accordance with the findings of Dantas Junior and Chaves (2014); Csajbok *et al*. (2014); Roy *et al*. (2015); Singh *et al*. (2015) and Kresovic *et al*. (2016).

Water-use efficiency was significantly influenced by mulching in both *rabi* and *kharif* maize during both the years. The higher water-use efficiency of *rabi* maize was recorded with maize stover @ 10 t/ha which was significantly superior over sugarcane trash @ 5 t/ha and no mulch but was statistically at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. All the mulched treatments were significantly superior over no mulch. Pooled data of *rabi* maize showed that the water-use efficiency was maximum (309.69 kg/ha-cm) with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha.

Maize stover @ 10 t/ha recorded the highest water-use efficiency which was statistically at par with rest of the mulched treatments and all the mulched treatments were significantly higher than no mulch in *kharif* maize during both the year. Pooled data revealed that maize stover @ 10 t/ha recorded the maximum water-use efficiency (91.29 kg/ha-cm) which was significantly superior to sugarcane trash @ 5 t/ha and no mulch. Water-use efficiency was higher in higher quantity of mulch which might be due to optimum environments to plant growth, adequate soil moisture content and increased available nutrients that led to efficient use of soil moisture. The findings are supported by Huang *et al*. (2005); Doring *et al*. (2006); Chakraborty *et al*. (2008); Shen *et al*. (2012); Wang *et al*. (2014); Peng *et al*. (2015); Abouziena *et al*. (2015) and *Singh et al*. (2015).

5.3.3 Water productivity

Water productivity in *rabi* maize during both the years was decreased significantly with increasing moisture regimes from 0.4 to 1.0 IW/CPE ratios. Pooled data also showed similar trend on water productivity. Significantly higher water productivity was recorded with 0.4 IW/CPE ratio as compared to 0.6, 0.8 and 1.0 IW/CPE ratios. Moisture regime did not influence the water productivity in *kharif* maize during both the years and as well as pooled data. Increased water productivity with decreasing moisture regimes in maize were supported by Singh *et al*. (2011b) and Parthasarathi *et al*. (2013).

Water productivity was significantly influenced by mulching in *rabi* and *kharif* maize during both the years as well as of pooled data. On the basis of pooled data the highest water productivity (6.18 ₹/m^3) was recorded with maize stover @ 10 t/ha which was statistically similar to other mulched treatments and all were significantly superior over no mulch treatment. This might be due to more grain yield and less total water expense where mulch was applied as compared to no mulch. This finding is in favour of the findings of Singh *et al*. (2011b) and Kaur and Mahal (2016).

5.4 Weed study

The influence of different moisture regimes was non-significant on weed population at knee high and silking stages in *rabi* and *kharif* maize during both the years of experimentation.

With the increase in amount of mulch corresponding significant decrease in weed population was observed at knee high and silking stages in *rabi* maize and *kharif* maize during both the years. At knee high and silking stages of *rabi* maize, mulching decreased number of weeds significantly. The minimum weed number was recorded with maize stover @ 10 t/ha which was significantly lesser than maize stover @ 5 t/ha and sugarcane trash @ 5 t/ha but was at par with sugarcane trash @ 10 t/ha. The maximum weed number was counted at no mulch which was significantly superior over all mulched treatments. At silking stage of maize, a good cover growth along with mulching significantly decreased weed population. The minimum weed population of *kharif* maize at knee high and silking was counted under maize stover @ 10 t/ha which was at par with other mulched treatments while the highest weed population was recorded under no mulch and it was significantly superior over all the mulched treatments. The result in respect of weed population was in conformity with the results reported by Bond *et al*. (2003); Ramakrishna *et al*. (2006); Sinkeviciene *et al*. (2009); Uwah and Iwo (2011); Bhardwaj (2013); Sarwar *et al*. (2013); Choudhary and Kumar (2014); Kosterna (2014) and Singh *et al.* (2014).

Weed dry weight at knee high and silking stages in both *rabi* and *kharif* maize indicated non-significant differences due to moisture regime during both the years. That was because of all the treatments received equal amount of moisture during the period of study.

Decreasing in amount of mulch significantly increased the weed dry weight at both knee high and silking stages in *rabi* and *kharif* maize during the two years of experimentation. The maximum weed dry weight was recorded with no mulch treatment which was significantly superior over all the mulched treatments. The minimum weed dry weight was obtained with maize stover @ 10 t/ha which was always at par with sugarcane trash @ 10 t/ha or with other mulched treatments. These findings are in agreement with the results reported by Uwah and Iwo (2011); Amini *et al.* (2014) and Choudhary and Kumar (2014).

5.5 Soil studies

5.5.1 pH, EC and OC (%)

The perusal of data clearly indicated non-significant difference in pH, EC and OC % under different moisture regimes in *rabi* and *kharif* maize during both the years of experimentation.

Application of mulch slightly decreased soil pH, and EC but the differences were non-significant in *rabi* and *kharif* maize during both the years while organic carbon content was increased significantly. The highest organic carbon content was recorded with maize stover @ 10 t/ha which was significantly superior to other mulch treatments and the lowest OC % was recorded with no mulch treatment. This might be due to addition of relatively greater amount of crop residue and lower C: N ratio in maize stover as compared to other mulches. The same results were also reported by many researchers like Blalkirshnan and Duraisami (2013); Kumar *et al*. (2014) and Yaseen *et al.* (2014).

5.5.2 Soil fertility status

Soil fertility status *i.e.* available N, P_2O_5 and K_2O kg/ha in soil just after harvest of crop during *rabi* and *kharif* seasons in both the years were increased with increase in moisture regimes but was found to be non-significant.

Mulching regardless of its organic source increased available N, P and K in soil in *rabi* and *kharif* seasons during both the years. Significantly higher available N, P & K were obtained under maize stover @ 10 t/ha which was at par with all the other mulch treatments in case of N and K. In case of P, maize stover @ 10 t/ha was at par with maize stover @ 5 t/ha and sugarcane trash @ 10 t/ha. All the mulch treatments were significantly superior to no mulch. This might be due to positive effect of release of nutrients from decomposing organic mulches and also moderating soil temperature and maintaining soil moisture which helped better N, P & K availability in soil. This result is in accordance with findings of Kar and Kumar (2007); Pervaiz *et al*. (2009); Sinkeviciene *et al*. (2009); Blalkirshnan and Duraisami (2013); Bhardwaj (2013); Kumar *et al.* (2014); Yaseen *et al*. (2014) and Alharbi (2015).

N, P & K content in crop

Moisture regimes significantly influenced nutrient content (N, P and K) in grain, stover and stone. The highest N, P & K content in *rabi* maize were recorded at 1.0 IW/CPE ratio whereas the lowest were obtained under 0.4 IW/CPE ratio during both the years. N, P & K content increased with increase in moisture regimes. This might be due to adequate absorption, translocation and uptake of these nutrients by the crop during its entire crop growth stage. Similar findings have also been reported by Hussaini *et al*. (2008). In *kharif* maize, there was non-significant difference due to moisture regime.

N, P & K content in grain, stover and stone of *rabi* and *kharif* were significantly superior under mulched treatments as compared to no mulch. N, P & K content was higher with higher quantity of mulch. Maize stover @ 10 t/ha recorded the maximum which was mostly at par with other mulch treatments. Similar finding was also reported by Pervaiz *et al*. (2009) and Kumar (2015).

N, P & K uptake by crop

Moisture regime caused significant increase in N, P & K uptake by *rabi* maize while non-significant variation in N, P & K uptake by *kharif* maize during both the years. Pooled data showed that total N uptake of *rabi* maize was the maximum of 142.91 kg/ha under 1.0 IW/CPE ratio which was significantly higher than all other moisture regimes. Total N uptake by crop was increased with increase in moisture regimes. This might be due to the fact that plants uptake the nutrients with water and N is mobile in soil solution thus more moisture in soil caused more N uptake by plants. This finding is similar to that of Singh (2003); Parihar and Tiwari (2003); Yaseen *et al*. (2014) and Mathukia *et al*. (2014).

N uptake by grain, stover and stone of *rabi* maize was the maximum with respect to mulching with maize stover @ 10 t/ha as compared to sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. In *kharif* maize N uptake in all the mulch treatments were at par to each other and was significantly superior to no mulch. A cursory glance over pooled data revealed that maize stover @ 10 t/ha had maximum total N uptake in *rabi* and *kharif* maize which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. This finding is in close conformity to that of Pervaiz *et al*. (2009); Shafi *et al*. (2010); Yaseen *et al*. (2014) and Kumar (2015).

There was significant influence of moisture regime on P uptake of *rabi* maize but was non-significant in *kharif* maize during both the years. Higher phosphorus uptake in grain, stover and stone was observed during both the years with 1.0 IW/CPE ratio over remaining moisture regimes. Pooled data of total P uptake as influenced by moisture regime followed similar trend of P uptake by different crop parts in *rabi* and *kharif* maize. This is in consonance with the findings of Parihar and Tiwari (2003).

Perusal of pooled data revealed that there was significant difference in total P uptake by crop in both *rabi* and *kharif* maize. Significantly higher total P uptake in *rabi* and *kharif* maize was obtained with maize stover @ 10 t/ha as compared to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. This might be due to the fact that mulching improved the total P uptake. The results were corroborated with the finding of Kumar (2015).

The perusal of pooled data clearly indicated that total K uptake by *rabi* maize was increased significantly with increase in moisture regimes but there was non-significant difference in total K uptake by *kharif* maize. The higher total K uptake by *rabi* maize was obtained with 1.0 IW/CPE ratio as compared to 0.8, 0.6 and 0.4 IW/CPE ratios. Similar view was also given by Parihar and Tiwari (2003).

Pooled analysis indicated that the higher total K uptake was obtained with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. Total K uptake by *kharif* maize also followed similar trend.

Higher total K uptake with mulching might be due to better root establishment, translocation and absorption of K from soil which led to higher growth and yield. Similar results were obtained by Kumar (2015).

Economics

Pooled data revealed that gross returns, net returns and B: C ratio were significantly influenced due to different moisture regimes in *rabi* maize but was non-significant in *kharif* maize. Significantly higher gross returns of 111820 ₹/ha was recorded with 1.0 IW/CPE ratio as compared to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio. This was due to higher grain yield obtained with 1.0 and 0.8 IW/CPE ratios. The moisture content (Table 4.8a and 4.8b) at these ratios was always higher than 50 per cent of field capacity.

The maximum net returns of 74045 ₹/ha was obtained with 1.0 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio but was at par with 0.8 and 0.6 IW/CPE ratios.

Perusal of maize-maize system pooled data revealed that the maximum net returns of 107292 ₹/ha was recorded with 1.0 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio but was statistically at par with 0.8 and 0.6 IW/CPE ratios.

The higher value of B: C ratio of 2.00 was recorded with 0.8 IW/CPE ratio which was significantly higher than 0.4 IW/CPE ratio but was at par with 1.0 IW/CPE ratio and 0.6 IW/CPE ratio. Maize-maize system pooled data revealed that there was non-significant influence on B: C ratio due to moisture regime.

In present investigation, pooled data indicated that mulching significantly influenced gross returns, net returns and B: C ratio in *rabi* and *kharif* maize. The maximum gross returns in *rabi* and *kharif* was recorded with maize stover @ 10 t/ha and it was significantly higher than sugarcane trash @ 5 t/ha but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. This might be due to higher yield potential of maize crop under favorable condition provided by maize residue. Though, a difference in yield was not much between mulches.

In *rabi* and *kharif* maize the maximum net returns was recorded with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha and no mulch and was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha in *rabi* maize while in *kharif* maize all the mulch treatments were significantly superior to no mulch and were at par with other mulch. Pooled data of maize-maize cropping system showed that the higher net returns of 110103 ₹/ha was obtained with maize stover @ 10 t/ha which was significantly superior over sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. These results are in accordance with the findings of Kumar (2015) and Singh *et al*. (2015).

The higher B: C ratio of *rabi* and *kharif* maize was recorded with maize stover 10 t/ha and it was at par with other mulch treatments, however, all the mulch treatments were significantly higher than no mulch. On the basis of maize-maize system pooled data, the higher B: C ratio was obtained with maize stover @ 10 t/ha and it was significantly superior to sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. Similar results were reported by Sharma *et al.* (2009); Sharma *et al*. (2011) and *Singh et al*. (2015).

Correlation studies

Correlation between grain yield and other yield attributing characters exhibit the relative importance of different yield attributes in producing the final yield because the yield of crop is directly affected by the yield attributing characters.

The study clearly exhibited positive and significant correlation between grain yield and yield attributing characters. The result showed that higher plant height, greater dry matter, large leaf area index, number of cobs per plant, number of rows per cob and number of grains per cob contributed to higher yield. Weed population and weed dry weight exhibited negative and significant correlation with grain yield. This was due to competition with weed for solar radiation, nutrients and moisture. Gupta (1991) also noticed the same trend from his experiment in maize.

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Chapter -6

SUMMARY AND CONCLUSION

6 SUMMARY AND CONCLUSION

The present experiment was conducted during *rabi* and *kharif* seasons of 2013-14 and 2014-15 at Irrigation Management Research field of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar) to find out the Influence of mulching on crop productivity and water-use efficiency of maize–maize cropping system.

The soil of experimental field was calcareous which was characterized by the presence of 26.8% free calcium carbonate with pH of 8.2. It was moderately fertile being low in organic carbon (0.44%), available nitrogen (218.22 kg/ha), available phosphorus (18.18 kg/ha) and medium in available potassium (158.27 kg/ha). The experiment was laid out in a split plot design, replicated thrice. Four moisture regimes, based on irrigation water (IW): cumulative pan evaporation (CPE) ratio, *viz*. 0.4, 0.6, 0.8 and 1.0 were used in main plot and five mulches, *viz*. 5 and 10 t/ha of sugarcane trash and maize stover along with no mulch (control) were used in sub-plot. Two hybrid varieties of maize DKC 9120 and DKC 9108 were used for *rabi* and *kharif* maize, respectively.

The salient findings of the investigation which have been presented and discussed in the preceding chapter are briefly summarized here under:-

1. Maximum plant height was recorded with 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio at 120 and 150 DAS of *rabi* maize during both the years. Plant height at early stages of *rabi* maize and all stages of *kharif* maize were non-significant due to moisture regime. Among the different mulch application maize stover @ 10 t/ha recorded the maximum plant height which was almost at par with other mulch treatments and all the mulch treatments were significantly superior to no mulch in *rabi* and *kharif* maize during both the years.
2. Dry matter production per plant increased consistently with advancements in plant's age till harvest. At 150 DAS, the maximum plant dry matter (249.23 and 251.39 g) was obtained under 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio

during both the years of *rabi* maize while in *kharif* maize there was no influence of moisture regime on plant dry matter per plant. Maize stover @ 10 t/ha had maximum plant dry matter which was significantly higher than maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha at 150 DAS of *rabi* maize during both the years. Maize stover @ 10 t/ha was significantly superior over no mulch and was at par with other mulch treatments at 90 DAS of *kharif* maize during both the years. However, all the mulch treatments were significantly superior to no mulch.

3. There was no influence of moisture regime on leaf area index in both *rabi* and *kharif* maize during both the years. However, significant influence of mulching on leaf area index was noticed. Maize stover @ 10 t/ha attained significantly higher leaf area index as compared to no mulch and was at par with the remaining mulch treatments in first year of *rabi* maize. Similar trend was followed during the second year except it was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. Leaf area index in *kharif* maize with 10 t/ha maize stover was significantly superior over remaining mulch treatments and no mulch during both the years.
4. All the yield attributing characters as number of rows/cob, number of grains/cob, 100-grain weight except number of cobs/plant were significantly influenced by different moisture regimes and mulching in *rabi* maize while these yield attributes were non-significant due to moisture regime under *kharif* maize. 1.0 IW/CPE ratio recorded significantly higher number of rows/cob as compared to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio during both the years. The maximum number of grains/cob and 100-grain weight obtained with 1.0 IW/CPE ratio while minimum with 0.4 IW/CPE ratio. All the yield attributing characters investigated were found to be the maximum with maize stover @ 10 t/ha which was almost at par with other mulched treatments and all were significantly superior over no mulch in *rabi* and *kharif* maize during both the years.
5. On the basis of pooled data maximum grain yield (85.17 q/ha) of *rabi* maize was obtained with 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio. There

was non-significant difference in grain yield of *kharif* maize due to different moisture regimes. Similarly on system basis 135.59 q/ha recorded the maximum grain yield at 1.0 IW/CPE ratio which was significantly superior to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio. On the basis of the two years pooled data, the maximum grain yield was recorded with maize stover @ 10 t/ha (85.34 q/ha) in *rabi* maize and (51.78 q/ha) in *kharif* maize which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha in *rabi* maize while was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha in *kharif* maize. On the basis of pooled data of maize-maize system, maize stover @ 10 t/ha had recorded the maximum grain yield of 137.12 q/ha which was at par with sugarcane trash @ 10 t/ha (134.21 q/ha) but was significantly superior to maize stover and sugarcane trash @ 5 t/ha and no mulch.

6. On the basis of pooled data the stover yield of maize was enhanced with increasing moisture regimes. Maximum stover yield of *rabi* maize was recorded under 1.0 IW/CPE ratio which was significantly superior over 0.6 and 0.4 IW/CPE ratios but was statistically at par with 0.8 IW/CPE ratio. Moisture regime did not influence the stover yield of *kharif* maize. Maize stover @ 10 t/ha produced the maximum stover yield of 109.57 and 106.72 q/ha in *rabi* and *kharif* maize, respectively which was significantly superior to sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha in *rabi* maize but at par with other mulched treatments in *kharif* maize. All the mulch treatments were significantly higher than no mulch.
7. The highest stone yield of 22.47 q/ha of *rabi* maize was obtained with 1.0 IW/CPE ratio as compared to remaining moisture regimes. Moisture regime did not produce any significant influence on stone yield of *kharif* maize. Significantly higher stone yield of *rabi* maize was recorded with maize stover @ 10 t/ha as compared to the rest of mulched treatments and no mulch. In *kharif* maize, maize stover @ 10 t/ha was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha.

8. There was non-significant difference in harvest index due to different moisture regimes and mulching in *rabi* and *kharif* maize during both the years.
9. Water-use efficiency and water productivity were significantly influenced due to different moisture regimes and application of mulch. Water-use efficiency and water productivity decreased with increasing moisture regimes. On the basis of pooled data the maximum value of water-use efficiency and water productivity of *rabi* maize were recorded with 0.4 IW/CPE ratio and was decreased with increase in moisture regimes. There was non-significant difference in water-use efficiency and water productivity of *kharif* maize due to moisture regime. Maize stover @ 10 t/ha recorded the maximum water-use efficiency of 309.69 kg/ha-cm of *rabi* maize which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. Water-use efficiency of *kharif* maize with maize stover @ 10 t/ha recorded significantly higher as compared to sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/h. The maximum water productivity of 27.40 and 6.18 ₹/m^3 of *rabi* and *kharif* maize, respectively was recorded under maize stover @ 10 t/ha which was at par with other mulch treatments and all were significantly superior over no mulch.
10. There was non-significant difference in weed population and weed dry weight at knee high and silking stages of *rabi* and *kharif* maize due to different moisture regimes during both the years of experimentation. Weed population and weed dry weight differed significantly under different mulch application in *rabi* and *kharif*. Minimum weed population was recorded with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha during both the years of *rabi* maize. Weed population in *kharif* maize was the lowest with maize stover @ 10 t/ha and was at par with other mulch treatments. All the mulch treatments recorded significantly lower weed population than no mulch treatment. Weed dry weight recorded minimum under maize stover @ 10 t/ha while the maximum obtained with no mulch in *rabi* and *kharif*.

11. pH, EC and organic carbon content were not differed significantly due to different moisture regimes after harvest of *rabi* and *kharif* maize. Maize stover @ 10 t/ha recorded significantly higher organic carbon of *rabi* maize as compared to the rest of mulch treatments and no mulch during both the years. After the harvest of *kharif* maize organic carbon followed similar trend that of *rabi* maize except in the first year it was at par with sugarcane trash @ 10 t/ha. Mulching did not produce any significant influence on pH and EC after the harvest of *rabi* and *kharif* maize.
12. Soil fertility status was not differed significantly due to moisture regime after harvest of *rabi* and *kharif* maize. Among mulch application, maize stover @ 10 t/ha recorded the highest NPK status which was almost at par with other mulched treatments. However, all the mulch treatments were significantly superior over no mulch.
13. The highest NPK content in *rabi* maize was recorded at 1.0 IW/CPE ratio which was almost at par with 0.8 IW/CPE ratio while moisture regime did not cause significant difference in NPK content of *kharif* maize during both the years. The maximum NPK content in crop were noticed with maize stover @ 10 t/ha which was almost at par with other mulched treatments and all were significantly superior to no mulch in *rabi* and *kharif* maize during both the years.
14. N, P & K uptake by *rabi* maize increased significantly with increase in moisture regimes. The highest N, P & K uptake was recorded at 1.0 IW/CPE ratio which was mostly significantly superior to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio. There was non-significant difference in N, P & K uptake by *kharif* maize due to moisture regime. Under different mulch application the maximum N, P & K uptake was noticed with maize stover @ 10 t/ha by *rabi* and *kharif* maize while the lowest was recorded with no mulch during both the years.
15. Based on pooled data of the two years total uptake by *rabi* maize also increased significantly with increase in moisture regimes. Significantly maximum total N, P & K uptake was obtained at 1.0 IW/CPE ratio as compared to the rest of moisture regimes. Moisture regime did not cause significant difference in total N, P & K uptake by *kharif* maize. Maximum total uptake of N (140.20 kg/ha) P_2O_5 (38.24 kg/ha) and K_2O (85.65 kg/ha)

by *rabi* maize was observed with maize stover @ 10 t/ha which was significantly superior to maize stover @ 5 t/ha, sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha. N, P & K uptake by *kharif* maize followed similar trends that of *rabi* maize except it was almost at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha.

16. Gross return of *rabi* maize increased with increasing moisture regimes. On the basis of pooled data of the two years, significantly higher gross return of 111820 ₹/ha was obtained at 1.0 IW/CPE ratio as compared to 0.6 and 0.4 IW/CPE ratios but was at par with 0.8 IW/CPE ratio while that of *kharif* maize there was no significant difference due to moisture regime. Significantly higher gross return of 112019 ₹/ha of *rabi* maize and 67983 ₹/ha of *kharif* maize was obtained with maize stover @ 10 t/ha which was significantly superior to sugarcane trash @ 5 t/ha and no mulch but was at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha.
17. On the basis of pooled data of two years of *rabi* maize, 1.0 IW/CPE ratio generated significantly highest net returns of 74045 ₹/ha as compared to 0.4 IW/CPE ratio and was at par with 0.8 and 0.6 IW/CPE ratios. Net returns of *kharif* maize were not influenced significantly due to moisture regime. Net returns of maize-maize cropping system were the maximum at 1.0 IW/CPE ratio which was significantly superior to 0.4 IW/CPE ratio but was at par with 0.8 and 0.6 IW/CPE ratios. The highest net returns of 75146 ₹/ha of *rabi* maize was recorded with maize stover @ 10 t/ha which was significantly superior over sugarcane trash @ 5 t/ha and no mulch but was statistically at par with sugarcane trash @ 10 t/ha and maize stover @ 5 t/ha. The maximum net returns of *kharif* maize were recorded with maize stover @ 10 t/ha as compared to no mulch but was at par with all the mulch treatments. Net returns of maize-maize cropping system were similar to that of *rabi* maize.
18. 0.8 IW/CPE ratio recorded significantly higher B: C ratio (2.00) of *rabi* maize as compared to 0.4 IW/CPE ratio but was at par with 1.0 and 0.6 IW/CPE ratios while there was non-significant difference in B: C ratio of *kharif* maize due to moisture regime on the basis of pooled data of two years and system of maize-maize cropping. Maize stover @ 10 t/ha

19. recorded significantly higher B: C ratio of 2.04 of *rabi* maize over no mulch but was at par with all the mulch treatments. In *kharif* maize the maximum B: C ratio was obtained with maize stover @ 10 and 5 t/ha (1.06) which was at par with sugarcane trash @ 10 and 5 t/ha and all were significantly higher than no mulch. In maize-maize cropping system B: C ratio followed similar trend that of *rabi* maize.
20. Grain yield was found to be highly significant and positively correlated with all the yield attributes except weed population and weed dry weight in *rabi* and *kharif* maize during both the years.

Conclusion

i. There was non-significant improvement in organic carbon and soil fertility status in terms of N, P and K due to moisture regime while significant improvement in organic carbon and soil fertility status in terms of N, P and K were observed with maize stover @ 10 t/ha which was at par with other mulch treatments.

N, P and K uptake by *rabi* maize were increased with increase in moisture regimes. 1.0 IW/CPE ratio recorded the maximum value which was at par with 0.8 IW/CPE ratio, while uptake by *kharif* maize was not influenced by moisture regime. Application of mulch improved N, P and K content and uptake by *rabi* and *kharif* maize as compared to no mulch.

ii. Moisture content was higher at 1.0 IW/CPE ratio as compared to lower level of irrigation from 0.8 to 0.4 IW/CPE ratios. There was less variation in moisture content between 1.0 and 0.8 IW/CPE ratios, while there was higher reduction in moisture content at 0.6 and 0.4 IW/CPE ratios. There was higher moisture content in mulching @ 10 t/ha as compared to 5 t/ha but the moisture content in no mulch plot was much lower than both the rate of application irrespective of either sugarcane trash or maize stover, while there was comparatively higher moisture content in mulching by maize stover.

Water-use efficiency and water productivity were maximum with moisture regime of 0.4 IW/CPE ratio in *rabi* maize while there was non-significant difference in *kharif* maize due to moisture regime. Application of either maize stover or sugarcane trash @ 10 t/ha recorded maximum water-use efficiency and water productivity in both *rabi* and *kharif* maize.

iii. Moisture regime at 1.0 IW/CPE ratio recorded better crop growth, yield attributes and yield of *rabi* maize but was comparable with 0.8 IW/CPE ratio. Moisture regime did not influence crop growth of *kharif* maize. Mulching with maize stover and sugarcane trash @ 10 t/ha was found to provide a good crop growth, yield attributes and yield during *rabi* as well as *kharif* maize.

Weed population and weed dry weight were non-significant due to different moisture regimes in both *rabi* and *kharif* maize. Mulching suppressed weeds due to that less weed population and dry weight were observed under mulches as compared to no mulch.

iv. The maximum net returns of *rabi* maize was obtained with 1.0 IW/CPE ratio while maximum B: C ratio was recorded at 0.8 IW/CPE ratio which was at par with 1.0 and 0.6 IW/CPE ratios but that of *kharif* maize was non-significant due to good rainfall. Maize stover @ 10 t/ha generated the highest net returns as well as B: C ratio but was at par with maize stover @ 5 t/ha and sugarcane trash @ 10 t/ha in *rabi* maize while was it par with other mulch treatments in *kharif* maize.

Recommendations

- Irrigation at 0.8 IW/CPE ratio could be a better moisture regime to save water, improve nutrients uptake, optimize yield, net return and B: C ratio of *rabi* maize, no need for applying irrigation in *kharif* maize if well distributed rainfall occurs.
- Mulching with maize stover and sugarcane trash @ 10 t/ha in *rabi* maize improve soil health, reduce weed population, maximize yield as well as net returns and B: C ratio while in *kharif* maize either maize stover or sugarcane trash @ 5 t/ha may be applied.

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APPENDICES

APPENDIX-Ia

Meteorological data (December 2013 to October 2014)

Month and Year	Temperature (°C)						Relative humidity (%)						Rainfall (mm)		
	Maximum			Minimum			At 7 AM			AT 2 PM					
	Actual	Normal	DN	Actual	Normal	DN	Actual	Normal	DN	Actual	Normal	DN	Actual	Normal	DN
Dec., 2013	23.5	24.5	-1.0	10.5	9.6	0.9	91.0	92.0	-1.0	55.0	47.0	8.0	0.0	7.0	-7.0
Jan., 2014	19.4	22.6	-3.2	9.5	7.9	1.6	90.0	92.0	-2.0	68.0	49.0	19.0	9.5	10.7	-1.2
Feb., 2014	22.3	25.9	-3.6	10.7	10.3	0.4	90.0	89.0	1.0	60.0	41.0	19.0	32.4	13.4	19.0
Mar., 2014	29.9	31.3	-1.4	15.3	15.0	0.3	83.2	83.0	0.3	40.7	32.0	8.7	10.6	5.5	5.1
April, 2014	37.1	36.1	1.0	19.5	20.4	-0.9	68.6	77.0	-8.4	28.3	30.0	-1.7	0.0	15.8	-15.8
May, 2014	37.6	36.6	1.0	24.1	23.7	0.4	72.3	80.0	-7.7	38.3	41.0	-2.7	64.0	108.0	-44.0
June, 2014	36.0	35.4	0.6	26.4	25.5	0.9	83.0	86.0	-3.0	58.0	55.0	3.0	93.2	153.4	-60.2
July, 2014	32.5	32.7	-0.2	26.5	25.7	0.8	89.0	91.0	-2.0	73.0	69.0	4.0	339.8	346.2	-6.4
Aug., 2014	32.7	32.5	0.2	26.2	25.7	0.5	91.0	91.0	0.0	76.0	71.0	5.0	351.9	294.9	57.0
Sept., 2014	32.5	32.4	0.1	25.2	25.2	0.0	90.0	91.0	-1.0	68.0	69.0	-1.0	129.4	233.8	-104.4
Oct., 2014	31.5	32.0	-0.5	21.5	21.7	-0.2	90.0	90.0	0.0	58.0	57.0	1.0	81.6	74.7	6.9

Source : Agro-meteorology section, DRPCAU, Pusa (Bihar),
Actual : Recorded during experimental period,
Normal : Average of past 40 years,
DN : Deviation from normal

APPENDIX-Ib

Meteorological data (November 2014 to October 2015)

Month and Year	Temperature (°C)						Relative humidity (%)						Rainfall (mm)		
	Maximum			Minimum			At 7 AM			AT 2 PM					
	Actual	Normal	DN	Actual	Normal	DN	Actual	Normal	DN	Actual	Normal	DN	Actual	Normal	DN
Nov., 2014	28.7	28.9	-0.2	13.9	14.9	-1.0	87.1	90.0	-2.9	40.9	46.0	-5.1	0.0	12.7	-12.7
Dec., 2014	19.9	24.5	-4.6	10.6	9.6	1.0	92.0	92.0	0.0	70.0	47.0	23.0	0.0	7.0	-7.0
Jan., 2015	19.4	22.6	-3.2	9.6	7.9	1.7	88.8	92.0	-3.2	67.8	49.0	18.8	8.4	10.7	-2.3
Feb., 2015	24.6	25.9	-1.3	12.1	10.3	1.8	90.0	89.0	1.0	56.0	41.0	15.0	1.2	13.4	-12.2
Mar., 2015	29.7	31.3	-1.6	15.6	15.0	0.6	83.9	83.0	0.9	48.2	32.0	16.2	32.6	5.5	-22.4
April, 2015	33.2	36.1	-2.9	20.0	20.4	-0.4	82.3	77.0	5.3	42.9	30.0	12.9	33.2	15.8	17.4
May, 2015	35.6	36.6	-1.0	23.6	23.7	-0.1	82.0	80.0	2.0	47.0	41.0	6.0	43.8	108.0	64.2
June, 2015	36.7	35.4	1.3	25.6	25.5	0.1	84.5	86.0	-1.5	51.4	55.0	-3.6	55.4	153.4	-98.0
July, 2015	33.8	32.7	1.1	25.0	25.7	-0.7	88.2	91.0	-2.8	70.0	69.0	1.0	149.6	346.2	196.6
Aug., 2015	31.1	32.5	-1.4	24.4	25.7	-1.3	91.0	91.0	0.0	68.0	71.0	-3.0	462.4	294.9	167.5
Sept., 2015	33.7	32.4	1.3	23.9	25.2	-1.3	89.0	91.0	-2.0	64.0	69.0	-5.0	155.8	233.8	-78.0
Oct., 2015	32.1	32.0	0.1	20.2	21.7	-1.5	89.0	90.0	-1.0	50.0	57.0	-7.0	4.2	74.7	-70.5

Source : Agro-meteorology section, DRPCAU, Pusa (Bihar),
Actual : Recorded during experimental period,
Normal : Average of past 40 years,
DN : Deviation from normal

APPENDIX-IIIa

Daily pan evaporation and precipitation (mm) data during the crops season December 2013 – October 2014

Date	Dec., 2013		Jan., 2014		Feb., 2014		Mar., 2014		April, 2014		May, 2015		June, 2014		July, 2014		Aug., 2014		Sept., 2014		Oct., 2014	
	PE	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**	**PE**	**P**
1	1.8	0.0	0.1	0.0	1.0	0.0	2.2	10.6	8.0	0.0	5.4	0.0	2.8	0.0	2.0	0.0	4.2	0.0	3.0	2.4	2.7	0.0
2	1.5	0.0	1.4	0.0	1.0	0.0	1.6	0.0	7.2	0.0	7.7	0.0	5.2	0.0	OFF	97.2	4.2	0	3.5	0.0	2.8	0.0
3	1.6	0.0	2.0	0.0	1.0	0.0	2.4	0.0	6.2	0.0	6.7	0.0	5.3	0.0	3.8	5.6	3.4	0.0	4.2	0.0	2.9	36.2
4	1.6	0.0	1.2	0.0	0.5	0.0	3.1	0.0	5.6	0.0	4.0	1.3	4.2	0.0	1.5	18.4	2.8	3.6	4.2	0.0	2.4	0.0
5	1.6	0.0	1.0	0.0	0.6	0.0	2.2	0.0	4.8	0.0	4.8	0.0	3.4	0.0	5.0	44.8	5.4	4.4	2.8	0.0	2.8	0.0
6	1.4	0.0	0.8	0.0	1.7	0.0	3.2	0.0	4.8	0.0	4.8	0.0	3.6	0.0	3.8	45.2	4.4	5.6	3.2	0.0	3.0	0.0
7	1.6	0.0	1.4	0.0	2.7	0.0	3.0	0.0	4.3	0.0	5.3	0.0	4.0	0.0	2.6	0.0	3.4	0.0	3.5	0.0	-	0.0
8	1.0	0.0	1.4	0.0	2.1	0.0	4.1	0.0	3.8	0.0	6.2	0.0	6.4	0.0	2.8	0.0	2.2	6.0	4.9	9.0	3.0	0.0
9	1.4	0.0	0.8	0.0	2.8	0.0	3.6	0.0	6.6	0.0	6.2	0.0	5.4	0.0	2.8	1.0	5.6	21.2	4.9	0.0	2.1	0.0
10	0.8	0.0	0.6	0.0	3.6	0.0	3.5	0.0	7.4	0.0	9.9	0.0	9.2	24.6	2.3	0.0	3.8	11.6	3.2	0.0	3.4	0.0
11	1.0	0.0	0.5	2.1	2.6	0.0	2.1	0.0	5.9	0.0	8.4	0.0	4.3	0.0	2.4	0.0	1.9	1.0	5.1	26.2	3.2	0.0
12	1.2	0.0	0.8	3.2	1.4	0.0	3.3	0.0	6.4	0.0	8.8	0.0	4.4	0.0	3.0	0.0	3.8	0.0	3.0	9.4	3.7	0.0
13	1.4	0.0	0.6	0.0	2.6	0.0	2.9	0.0	5.0	0.0	7.7	0.0	3.6	0.0	4.6	0.0	1.8	0.6	3.0	13.0	1.7	3.2
14	1.2	0.0	0.4	0.0	1.4	8.4	4.4	0.0	5.9	0.0	10.5	0.0	7.2	0.0	4.3	0.0	0.4	95	1.9	0.0	1.7	4.0
15	0.6	0.0	0.2	0.0	1.2	15.0	4.0	0.0	5.9	0.0	11.6	0.0	6.2	0.0	4.2	0.4	OFF	121.2	3.2	1.2	6.5	38.2
16	0.6	0.0	0.2	0.0	0.2	6.2	4.4	0.0	6.0	0.0	11.0	0.0	3.6	10.2	2.5	2.2	2.2	37.0	2.2	1.0	2.6	0.0
17	0.8	0.0	0.6	0.0	1.2	0.0	3.6	0.0	5.6	0.0	9.4	0.0	5.4	0.0	2.7	8.4	2.1	1.2	3.1	0.0	2.8	0.0
18	0.6	0.0	0.6	0.0	2.9	0.0	3.1	0.0	7.6	0.0	7.4	0.0	2.8	0.0	1.3	4.0	2.5	0.0	3.5	4.6	3.8	0.0
19	0.6	0.0	1.0	4.2	2.0	0.0	3.0	0.0	6.3	0.0	7.5	0.0	2.8	1.2	5.5	60.6	2.7	0.0	6.6	40.2	3.0	0.0
20	0.8	0.0	1.4	0.0	2.0	0.0	5.2	0.0	8.4	0.0	6.4	0.0	4.7	0.2	2.8	1.0	2.3	1.0	3.6	3.6	3.2	0.0
21	1.8	0.0	0.6	0.0	1.8	0.0	5.2	0.0	9.8	0.0	5.8	0.0	4.5	4.2	1.4	2.6	0.9	4.0	2.6	0.0	2.7	0.0
22	1.2	0.0	0.3	0.0	1.9	0.0	3.8	0.0	5.6	0.0	8.3	0.0	1.8	16.2	3.9	3.5	2.4	1.4	2.1	0.0	2.3	0.0
23	1.4	0.0	0.2	0.0	0.7	1.4	4.2	0.0	8.4	0.0	8.0	0.0	3.6	8.6	3.1	9.0	2.2	0.0	2.6	0.0	2.4	0.0
24	0.8	0.0	0.6	0.0	1.1	0.0	3.8	0.0	9.4	0.0	7.5	0.0	4.6	0.0	1.7	2.0	3.3	10.1	2.4	0.0	2.5	0.0
25	0.6	0.0	1.4	0.0	3.2	0.0	3.0	0.0	9.6	0.0	8.7	0.0	4.6	0.0	0.3	29.1	4.2	17.4	2.8	2.6	2.2	0.0
26	0.9	0.0	2.2	0.0	2.1	0.0	3.4	0.0	8.6	0.0	4.8	2.1	4.4	0.0	1.8	0.0	3.3	9.6	3.0	16.2	1.1	0.0
27	0.4	0.0	1.6	0.0	2.8	0.6	4.5	0.0	6.3	0.0	6.8	9.0	4.0	0.0	2.8	4.8	2.2	0.0	4.1	0.0	1.4	0.0
28	0.2	0.0	1.2	0.0	1.2	0.8	6.2	0.0	6.7	0.0	5.0	43.8	5.5	0.0	2.2	0.0	1.7	0.0	3.9	0.0	2.3	0.0
29	0.6	0.0	0.6	0.0	-	-	8.0	0.0	5.6	0.0	2.6	0.0	4.5	0.0	4.4	0.0	9.4	0.0	2.0	0.0	2.3	0.0
30	0.2	0.0	0.8	0.0	-	-	11.0	0.0	5.4	0.0	3.0	0.0	4.8	28.0	5.1	0.0	3.8	0.0	1.3	0.0	1.8	0.0
31	0.2	0.0	0.5	0.0	-	-	9.6	0.0	-	-	6.1	7.8	-	-	5.6	0.0	4.2	0.0	-	-	1.9	0.0

PE-Pan evaporation and P-Precipitation

APPENDIX-IIIb

Daily pan evaporation and precipitation (mm) data during the crops season November 2014 – October 2015

Date	Nov.,2014		Dec.,2014		Jan., 2015		Feb., 2015		Mar., 2015		April, 2015		May, 2015		June, 2015		July, 2015		Aug., 2015		Sept., 2015		Oct., 2015	
	PE	P	PE	P	PE	P	PE	P	PE	P	PE	P	PE	P	PE	P	PE	P	PE	P	PE	P	PE	P
1	1.7	0.0	0.6	0.0	0.6	0.0	1.3	0.0	1.7	0.0	3.4	0.0	4.0	0.0	5.8	0.0	3.1	0.0	3.2	1.0	3.6	8.8	2.9	0.0
2	2.0	0.0	0.6	0.0	2.1	0.0	1.4	0.0	1.9	1.4	4.7	0.0	4.9	0.0	6.3	0.0	3.3	26.0	3.3	2.2	3.9	16.6	3.4	0.0
3	1.7	0.0	0.1	0.0	1.0	5.4	1.2	0.0	1.3	9.4	6.9	0.0	4.4	0.0	10.3	0.0	4.4	0.0	3.3	0.0	4.8	17.6	4.0	0.0
4	1.8	0.0	0.2	0.0	0.4	2.0	1.8	0.0	1.9	0.0	4.5	0.0	5.9	0.0	9.8	0.0	3.7	0.0	2.9	0.0	2.2	0.0	3.6	4.2
5	1.9	0.0	0.8	0.0	1.2	0.0	2.9	0.0	3.4	0.0	3.1	0.0	6.0	0.0	6.2	0.0	4.1	0.0	3.8	0.0	4.4	18.6	3.2	0.0
6	2.0	0.0	0.1	0.0	1.2	0.0	1.8	0.0	4.1	0.0	4.2	0.6	5.8	0.0	7.2	0.0	1.6	0.0	6.1	1.6	3.7	0.0	3.5	0.0
7	1.8	0.0	0.3	0.0	0.5	0.0	1.8	0.0	3.4	0.0	5.2	0.0	5.3	0.0	7.6	0.0	1.1	1.0	3.4	28.4	3.8	0.0	4.3	0.0
8	1.9	0.0	1.1	0.0	0.8	0.0	2.1	0.0	4.0	0.0	4.0	0.0	5.9	0.0	8.0	0.0	3.5	20.8	3.7	0.0	6.2	50.6	2.9	0.0
9	2.0	0.0	0.7	0.0	1.0	0.0	2.3	0.0	3.2	0.0	6.4	0.0	5.9	0.0	7.8	0.0	7.8	42.0	3.9	9.4	3.2	0.0	3.8	0.0
10	2.0	0.0	0.9	0.0	1.2	0.0	2.1	0.0	2.0	0.0	8.7	0.0	5.4	0.0	8.0	0.0	4.8	5.2	3.9	0.0	3.9	0.0	3.9	0.0
11	2.0	0.0	0.6	0.0	0.8	0.0	2.6	0.0	5.7	0.0	6.5	0.0	6.1	4.0	7.6	0.0	2.4	0.0	3.6	11.6	3.4	0.0	4.1	0.0
12	2.1	0.0	1.6	0.0	0.5	0.0	2.2	0.0	4.7	0.0	5.3	0.0	5.2	0.0	5.6	0.0	2.8	0.0	3.5	2.2	3.0	0.0	3.4	0.0
13	2.1	0.0	1.0	0.0	0.7	0.0	2.0	0.0	4.2	0.0	3.6	0.0	3.9	11.2	6.6	19.8	3.4	0.0	5.2	0.0	3.3	0.0	3.2	0.0
14	2.1	0.0	0.5	0.0	0.3	0.0	2.3	0.0	4.0	0.0	4.9	0.0	4.3	0.0	1.9	0.0	2.7	0.0	4.9	0.0	4.0	0.0	3.6	0.0
15	2.1	0.0	0.5	0.0	0.5	0.0	1.4	0.0	4.4	0.0	7.4	0.0	6.0	0.0	5.4	0.0	3.4	2.6	4.2	0.0	3.7	0.0	3.7	0.0
16	1.6	0.0	1.3	0.0	0.7	0.0	2.0	0.0	3.4	0.0	4.2	0.0	4.4	0.0	6.6	0.0	1.6	11.8	4.2	9.2	3.3	0.0	3.8	0.0
17	1.6	0.0	0.9	0.0	0.6	0.0	1.4	0.0	0.8	2.2	5.8	0.0	5.2	0.0	5.8	0.0	1.6	7.8	2.5	1.0	3.4	0.0	3.2	0.0
18	1.8	0.0	1.9	0.0	0.6	0.0	1.6	0.0	4.7	0.0	7.4	6.2	6.0	0.0	7.2	2.4	3.3	0.0	3.8	26.4	3.7	0.0	2.8	0.0
19	1.2	0.0	1.4	0.0	0.9	0.0	2.1	0.6	4.7	0.0	4.7	0.0	6.4	0.0	6.5	0.0	4.9	0.0	6.6	47.6	3.5	0.0	3.3	0.0
20	1.7	0.0	1.2	0.0	0.8	0.0	2.2	0.0	5.0	0.0	5.4	0.0	5.8	7.0	7.0	0.0	5.4	0.0	10.7	141.2	4.5	0.0	2.6	0.0
21	1.9	0.0	1.2	0.0	0.7	0.0	1.6	0.0	3.8	0.0	4.3	0.0	4.2	0.0	9.7	0.0	5.2	0.0	13.0	175.0	3.8	4.0	2.4	0.0
22	1.5	0.0	1.2	0.0	1.0	0.0	1.5	0.0	4.6	0.0	5.5	0.0	5.0	0.0	7.8	0.0	6.1	0.0	1.7	0.0	3.3	29.8	2.6	0.0
23	1.5	0.0	0.5	0.0	1.3	0.0	1.3	0.0	4.9	0.0	5.5	0.0	5.4	0.0	4.3	0.0	3.0	7.6	1.8	0.0	1.1	0.0	3.5	0.0
24	1.9	0.0	0.0	0.0	2.4	0.0	1.2	0.0	4.8	0.0	5.4	0.0	6.4	0.0	4.6	0.0	3.3	0.0	2.6	0.0	2.0	9.8	3.8	0.0
25	1.7	0.0	0.6	0.0	1.7	0.0	1.5	0.0	3.7	0.0	7.1	7.2	7.0	0.0	4.2	0.8	1.5	0.6	3.9	0.0	3.4	0.0	2.6	0.0
26	1.4	0.0	0.4	0.0	1.6	0.0	1.4	0.0	3.9	0.0	5.3	1.2	5.8	0.0	4.8	0.0	4.4	11.2	3.5	0.0	4.6	0.0	2.4	0.0
27	1.5	0.0	0.5	0.0	0.4	0.0	3.0	0.0	4.4	0.0	5.0	0.0	5.2	21.6	3.7	12.2	6.3	0.0	2.5	5.6	3.6	0.0	2.4	0.0
28	1.0	0.0	0.6	0.0	0.5	0.0	1.6	0.6	5.1	0.0	4.9	0.0	5.2	0.0	1.7	20.2	4.6	0.0	3.2	0.0	3.5	0.0	2.4	0.0
29	1.0	0.0	0.3	0.0	1.5	0.0	-	-	3.9	0.0	6.5	18.0	4.8	0.0	1.7	0.0	6.0	13.0	4.0	0.0	3.2	0.0	2.5	0.0
30	0.9	0.0	0.4	0.0	1.6	1.0	-	-	4.1	0.0	4.8	0.0	5.7	0.0	3.5	0.0	5.2	0.0	2.9	0.0	3.1	0.0	2.8	0.0
31	-	-	0.4	0.0	1.7	0.0	-	-	4.2	19.6	-	-	5.6	0.0	-	-	5.2	0.0	3.2	0.0	-	-	1.6	0.0

PE-Pan evaporation and P-Precipitation

APPENDIX – IIa

Weekly weather data 2013-14 of Pusa, Samastipur

Standard Week No.	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm)	Sunshine (hrs.)
	Max.	Min.	Max.	Min.			
49	27.2	11.1	90	41	0.0	1.5	6.7
50	24.4	10.3	91	49	0.0	1.0	2.5
51	22.9	11.2	89	59	0.0	0.9	0.6
52	18.8	9.7	93	77	0.0	0.5	0.0
1	21.3	9.0	87	58	0.0	1.3	3.6
2	18.1	9.0	92	68	5.3	0.7	0.5
3	18.8	9.6	91	75	4.2	0.7	2.7
4	20.0	10.5	92	66	0.0	1.1	2.7
5	17.6	8.9	91	75	0.0	0.8	1.1
6	24.2	10.4	88	51	0.0	2.3	7.0
7	20.4	10.8	89	62	29.6	1.6	5.3
8	24.0	10.8	90	55	1.4	1.8	6.0
9	24.0	10.8	90	55	1.4	1.8	6.0
10	26.7	11.7	88	42	0.0	3.1	7.2
11	30.3	15.0	88	41	0.0	3.7	9.0
12	31.7	16.6	81	39	0.0	4.0	9.0
13	34.6	18.3	70	28	0.0	7.2	9.4
14	35.0	19.1	78	36	0.0	5.2	7.8
15	36.8	17.4	65	28	0.0	6.0	9.6
16	37.8	20.3	61	23	0.0	7.0	9.7
17	38.9	21.1	69	24	0.0	7.8	9.9
18	36.2	23.9	76	51	1.3	5.5	8.3
19	40.5	24.3	63	27	0.0	7.5	9.0
20	40.7	24.5	65	25	0.0	9.1	10.8
21	37.3	25.0	78	38	11.1	7.1	8.8
22	32.4	23.7	83	57	51.6	4.3	6.8
23	37.2	27.2	85	57	24.6	5.2	7.2
24	37.1	26.4	77	52	10.2	5.0	8.8
25	34.5	25.6	86	66	30.4	3.5	4.7
26	35.2	26.7	86	68	28.0	4.3	5.2
27	31.3	25.8	91	76	211.2	3.3	0.8
28	34.5	27.6	88	70	1.4	3.4	4.6
29	32.5	26.5	88	77	82.3	2.9	14.1
30	31.6	26.0	89	68	44.9	2.4	6.9
31	34.7	27.3	86	67	8.0	4.4	8.1
32	33.1	26.7	90	79	45.4	3.6	4.7
33	30.2	25.3	94	82	255.0	2.0	1.6
34	32.7	25.8	91	78	43.5	2.7	2.4
35	31.6	26.0	89	71	8.6	3.5	3.4
36	33.6	26.1	89	65	9.0	4.0	8.8
37	31.7	25.0	94	74	50.8	3.1	3.7
38	33.0	24.8	92	71	48.4	3.4	5.4
39	32.2	24.5	91	65	18.8	2.8	5.4
40	32.8	23.6	91	62	36.2	2.8	7.7
41	33.0	24.1	91	65	7.2	2.7	5.3
42	30.1	19.3	91	52	38.2	3.5	7.9
43	30.5	19.6	90	53	0.0	2.0	6.0
44	30.0	18.3	91	53	0.0	1.9	3.5
45	30.7	17.0	89	45	0.0	1.9	7.1
46	28.5	13.2	84	35	0.0	1.9	5.6
47	27.7	11.6	86	34	0.0	1.6	6.0
48	26.0	11.7	88	55	0.0	1.0	2.4

APPENDIX – IIb

Weekly weather data 2014-15 of Pusa, Samastipur

Standard Week No.	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm)	Sunshine (hrs.)
	Max.	Min.	Max.	Min.			
45	30.7	17.0	89	45	0.0	1.9	7.1
46	28.5	13.2	84	35	0.0	1.9	5.6
47	27.7	11.6	86	34	0.0	1.6	6.0
48	26.0	11.7	88	55	0.0	1.0	2.4
49	20.6	13.6	94	76	0.0	0.5	0.7
50	21.6	12.0	91	67	4.2	0.9	1.1
51	20.9	8.5	92	61	0.0	1.2	4.5
52	15.3	7.8	91	77	0.0	0.4	1.1
1	21.0	12.1	86	72	7.4	1.0	1.4
2	18.1	8.7	88	73	0.0	0.8	1.7
3	16.2	7.1	90	71	0.0	0.7	1.7
4	21.6	9.5	90	58	0.0	1.3	5.4
5	22.1	9.5	88	52	1.0	1.5	5.5
6	22.9	10.1	90	55	0.0	2.2	6.4
7	24.3	11.6	88	53	0.0	1.8	3.7
8	27.4	15.5	93	62	0.6	1.6	1.3
9	25.3	16.2	91	65	11.4	1.8	2.4
10	27.6	11.4	78	39	0.0	3.7	8.6
11	28.9	14.9	86	49	2.2	3.7	7.3
12	31.9	15.3	80	33	0.0	4.5	9.7
13	32.9	20.5	89	51	19.6	4.1	6.3
14	34.0	19.2	83	36	0.6	4.7	7.1
15	33.1	19.2	76	35	0.0	6.1	7.2
16	34.1	20.9	83	44	6.2	5.3	7.5
17	32.2	20.6	85	55	26.4	5.7	6.7
18	34.8	23.4	76	52	0.0	5.1	9.3
19	40.5	24.3	63	27	15.2	5.4	5.1
20	40.7	24.5	64	25	7.0	5.4	7.3
21	37.2	25.0	82	42	21.6	5.6	8.7
22	31.1	23.7	83	57	0.0	6.2	8.3
23	35.8	23.2	77	43	0.0	7.8	7.6
24	37.1	26.4	77	52	19.8	5.6	6.3
25	34.5	25.6	86	66	2.4	6.7	9.3
26	35.5	26.5	85	68	33.2	3.2	3.6
27	33.7	25.3	89	78	47.8	3.1	3.3
28	33.5	25.2	87	75	49.8	3.9	5.3
29	34.5	25.1	83	63	19.6	4.0	6.1
30	34.4	25.2	88	64	32.4	4.2	6.0
31	34.0	24.5	86	60	3.2	3.8	4.9
32	34.9	24.5	91	58	53.2	4.0	4.8
33	33.3	24.3	93	75	84.2	4.5	5.0
34	31.8	24.1	93	77	316.2	5.3	2.6
35	33.7	25.0	91	69	31.0	3.3	5.7
36	34.0	24.1	87	66	86.8	4.0	4.7
37	34.8	25.0	92	64	0.0	3.5	6.9
38	32.6	24.5	91	74	33.8	3.3	5.5
39	33.5	22.1	88	53	9.8	3.3	7.9
40	34.7	22.2	90	51	4.2	3.6	8.6
41	33.8	21.4	90	52	0.0	3.6	8.3
42	32.6	21.6	90	54	0.0	3.1	6.6
43	32.7	17.4	89	41	0.0	2.8	7.9
44	30.5	17.1	90	48	0.0	2.5	6.7

APPENDIX – IVa

Common cost of cultivation of maize (₹/ha) during 2013-14

SI.No.	Particulars	Quantity	Rate (₹)		Amount (₹)	
			Rabi	kharif	rabi	kharif
1	Land preparation Ploughing and planting by tractor a) One ploughing by MB plough b) One ploughing by disc harrow c) One ploughing by rotavator	3 cross	1000/-	1000/-	3000/-	3000/-
2	Cost of seed	20 kg/ha	350/kg	350/kg	7000/-	7000/-
3	Seed treatment (Carbendazin)	40 g	100/100g	100/100g	40/-	40/-
4	Sowing	10 Labours	176/-	184/-	1760/-	1840/-
5	Cost of fertilizer (150 : 75 :, 50 kg /ha) and 25kg $ZnSO_4$	Urea-262.3 kg DAP-163 kg MOP-83.3 kg $ZnSO_4$- 25kg	5.8 /kg 25.6/kg 17.8/kg 40/kg	5.8 /kg 25.6/kg 17.8/kg 40/kg	1521/- 4173/- 1483/- 1000/-	1521/- 4173/- 1483/- 1000/-
	Fertilizer application	4 Labours	176/-	184/-	704/-	736/-
					8881/-	8913
6	Weeding and earthing up	15 Labours	176/-	184/-	2640/-	2760/-
7	Plant protection insecticide					
	a) Gaucho	50 ml	143/-	143/-	143/-	143/-
	b) Furadan	7 kg	90/kg	90/kg	630/-	630/-
	c) Labour	2 labour	176/-	184/-	352/-	368/-
					1125	1141
8	Harvesting	10 Labours	176/-	184/-	1760/-	1840/-
9	Shelling					
	a) Shelling machine	Hire charge	1000/ha	1000/ha	1000/-	1000/-
	b) Labour charge	5 Labours	176/-	184/-	880/-	920/-
10	Cleaning, drying & storage	10 Labours	176/-	184/-	1760/-	1840/-
11	Land rent		500/-	500/-	500/-	500/-
				Total	**30346/-**	**30794/-**

APPENDIX – IVb

Common cost of cultivation of maize (₹/ha) during 2014-15

SI.No.	Particulars	Quantity	Rate (₹)		Amount (₹)	
			Rabi	***kharif***	***rabi***	***kharif***
1	Land preparation Ploughing and planting by tractor a) One ploughing by MB plough b) One ploughing by disc harrow c) One ploughing by rotavator	3 cross	1000/-	1000/-	3000/-	3000/-
2	Cost of seed	20 kg/ha	350/kg	350/kg	7000/-	7000/-
3	Seed treatment (Carbendazin)	40 g	100/100g	100/100g	40/-	40/-
4	Sowing	10 Labours	186/-	194/-	1860/-	1940/-
5	Cost of fertilizer (150 : 75 :, 50 kg /ha) and 25kg $ZnSO_4$ Fertilizer application	Urea-262.3 kg DAP-163 kg MOP-83.3 kg $ZnSO_4$- 25kg 4 Labours	5.8 /kg 25.6/kg 17.8/kg 45/kg 186/-	5.8 /kg 25.6/kg 17.8/kg 45/kg 194/-	1521/- 4173/- 1483/- 1125/- 744/-	1521/- 4173/- 1483/- 1125/- 776/-
					9046/-	9078
6	Weeding and earthing up	15 Labours	186/-	194/-	2790/-	2910/-
7	Plant protection insecticide a) Gaucho b) Furadan c) Labour	 50 ml 7 kg 2 labour	 143/- 90/kg 186/-	 143/- 90/kg 194/-	 143/- 630/- 372/-	 143/- 630/- 388/-
					1145/-	1161
8	Harvesting	10 Labours	186/-	194/-	1860/-	1940/-
9	Shelling a) Shelling machine b) Labour charge	 Hire charge 5 Labours	 1000/ha 186/-	 1000/ha 194/-	 1000/- 930/-	 1000/- 970/-
10	Cleaning, drying & storage	10 Labours	186/-	194/-	1860/-	1940/-
11	Land rent		500/-	500/-	500/-	500/-
Total					**31031/-**	**31479/-**

APPENDIX – V

Variable treatment cost of maize (₹/ha) during 2013-14

SI.No.	Particulars	Quantity	Rate (₹)		Amount (₹)	
			Rabi	***kharif***	***Rabi***	***kharif***
1	Treatment cost of Irrigation					
	I_1	3	1000/-	0/-	3000/-	0/-
	I_2	5	1000/-	0/-	5000/-	0/-
	I_3	6	1000/-	0/-	6000/-	0/-
	I_4	7	1000/-	0/-	7000/-	0/-
2	Treatment cost of mulching					
	M_1	5 Labours	176/-	184/-	880/-	920/-
	M_2	10 Labours	176/-	184/-	1760/-	1840/-
	M_3	5 Labours	176/-	184/-	880/-	920/-
	M_4	10 Labours	176/-	184/-	1760/-	1840/-
	M_5	No labour	0/-	0/-	0/-	0/-

Variable treatment cost of maize (₹/ha) during 2014-15

SI.No.	Particulars	Quantity	Rate (₹)		Amount (₹)	
			Rabi	***kharif***	***Rabi***	***kharif***
1	Treatment cost of Irrigation					
	I_1	2	1000/-	0/-	2000/-	0/-
	I_2	3	1000/-	0/-	3000/-	0/-
	I_3	4	1000/-	0/-	4000/-	0/-
	I_4	5	1000/-	0/-	5000/-	0/-
2	Treatment cost of mulching					
	M_1	5 Labours	186/-	194/-	930/-	970/-
	M_2	10 Labours	186/-	194/-	1860/-	1940/-
	M_3	5 Labours	186/-	194/-	930/-	970/-
	M_4	10 Labours	186/-	194/-	1860/-	1940/-
	M_5	No labour	0/-	0/-	0/-	0/-

APPENDIX – VIa

Total cost of cultivation per hectare at different treatment combination *rabi* maize

Treatments	Common cost of cultivation		Treatment cost		Total cost of cultivation	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
I_1M_1	30346/-	31031/-	3880/-	2930/-	34226/-	33961/-
I_1M_2	30346/-	31031/-	4760/-	3860/-	35106/-	34891/-
I_1M_3	30346/-	31031/-	3880/-	2930/-	34226/-	33961/-
I_1M_4	30346/-	31031/-	4760/-	3860/-	35106/-	34891/-
I_1M_5	30346/-	31031/-	3000/-	2000/-	33346/-	33031/-
I_2M_1	30346/-	31031/-	5880/-	3930/-	36226/-	34961/-
I_2M_2	30346/-	31031/-	6760/-	4860/-	37106/-	35891/-
I_2M_3	30346/-	31031/-	5880/-	3930/-	36226/-	34961/-
I_2M_4	30346/-	31031/-	6760/-	4860/-	37106/-	35891/-
I_2M_5	30346/-	31031/-	5000/-	3000/-	35346/-	34031/-
I_3M_1	30346/-	31031/-	6880/-	4930/-	37226/-	35961/-
I_3M_2	30346/-	31031/-	7760/-	5860/-	38106/-	36891/-
I_3M_3	30346/-	31031/-	6880/-	4930/-	37226/-	35961/-
I_3M_4	30346/-	31031/-	7760/-	5860/-	38106/-	36891/-
I_3M_5	30346/-	31031/-	6000/-	4000/-	36346/-	35031/-
I_4M_1	30346/-	31031/-	7880/-	5930/-	38226/-	36961/-
I_4M_2	30346/-	31031/-	8760/-	6860/-	39106/-	37891/-
I_4M_3	30346/-	31031/-	7880/-	5930/-	38226/-	36961/-
I_4M_4	30346/-	31031/-	8760/-	6860/-	39106/-	37891/-
I_4M_5	30346/-	31031/-	7000/-	5000/-	37346/-	36031/-

APPENDIX – VIb

Total cost of cultivation per hectare at different treatment combination *kharif* maize

Treatments	Common cost of cultivation		Treatment cost		Total cost of cultivation	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
I_1M_1	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_1M_2	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_1M_3	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_1M_4	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_1M_5	30794/-	31479/-	0/-	0/-	30794/-	31479/-
I_2M_1	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_2M_2	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_2M_3	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_2M_4	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_2M_5	30794/-	31479/-	0/-	0/-	30794/-	31479/-
I_3M_1	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_3M_2	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_3M_3	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_3M_4	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_3M_5	30794/-	31479/-	0/-	0/-	30794/-	31479/-
I_4M_1	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_4M_2	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_4M_3	30794/-	31479/-	920/-	970/-	31714/-	32449/-
I_4M_4	30794/-	31479/-	1840/-	1940/-	32634/-	33419/-
I_4M_5	30794/-	31479/-	0/-	0/-	30794/-	31479/-