Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]

बाजरा [*पेनीसेटम ग्लुकम* (एल.) आर. बीआर. इमेण्ड़ स्टन्ट्ज] की वृद्धि, उपज, एवं गुणवत्ता पर नमी संरक्षण प्रक्रियाओं एवं जिंक उर्वरीकरण का प्रभाव

Saroj Kumari Yadav

Thesis

Master of Science in Agriculture

(Agronomy)

2018

Department of Agronomy
S.K.N. COLLEGE OF AGRICULTURE, JOBNER - 303 329
SRI KARAN NARENDRA AGRICULTURE UNIVERSITY, JOBNER

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Thesis

Submitted to the

Sri Karan Narendra Agriculture University, Jobner

in partial fulfilment of the requirements for

the degree of

Master of Science

in the

Faculty of Agriculture

(Agronomy)

by

Saroj Kumari Yadav

2018

Sri Karan Narendra Agriculture University, Jobner

S.K.N. College of Agriculture, Jobner

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This is to certify that **Ms. Saroj Kumari Yadav** of the Department of **Agronomy,** S.K.N. College of Agriculture, Jobner has made all corrections /modifications in the thesis entitled **"Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]"** which were suggested by the external examiner and the advisory committee in the oral examination held on ____________. The final copies of the thesis duly bound and corrected were submitted on ____________ are enclosed herewith for approval.

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ACKNOWLEDGEMENTS

I take great pleasure to express my sincere and intense sense of gratitude to my esteem advisor, **Dr. B.L. Dudwal**, Asstt. professor, Department of Agronomy, S.K.N. College of Agriculture, Jobner for his invaluable and engrossing guidance and immense zeal of hard work caring attitude, incessant encouragement and moral support throughout the course of investigation and preparation of manuscript without which this work would not have been the light of the day.

I am highly thankful to members of my advisory committee namely **Dr. A.C. Shivran**, Professor, Department of Agronomy, **Dr. S.R. Naga**, Professor, Department of Soil Science and **Dr. Pratibha Manohar,** Asstt. Professor, Department of Statistics for providing their valuable suggestions and guidance during the course of investigation.

Sense of obligation compels me to express my cordial thanks to **Dr. S.S. Yadav**, Professor & Head, Department of Agronomy, S.K.N. College of Agriculture, Jobner for providing assistance and necessary facilities during entire course of investigation.

I asseverate my deep sense of gratitude and sincere thanks to **Dr. R.C. Kumawat**, Dean, S.K.N. College of Agriculture, Jobner and **Dr. B.K. Sharma**, Director Education, S.K.N. Agriculture University, Jobner for providing necessary facilities and administrative help in this venture.

I feel gratified to record my cordial thanks to Dr. L.R. Yadav, Professor, Dr. O.P. Sharma, Emeritus Professor**,** Mr. B.R. Meena, Smt. Priyanka Kumawat, Assistant Proffesors, Dr. D.K. Jajoria**,** Associate Professor Department of Agronomy, Sh. S.L. Jakhar, Umed singh, Pemaram, Dana Ram, Ramnarayan and other staff members of the Departments including farm for their valuable co-operation in completing this investigation smoothly. Thanks can not be expressed in words to my seniors and cronies Hansa, Roshan, Karishma, Bhagwati, Raju, Rajbala, Sarita, Dinesh, Suresh and my Juniors Pinky, Seema, Kamal, Bharat, Nisha, Santosh, Monu, Suresh, Ramakrishana and Umashankar whose regular support and help in various ways brought this task to complete.

My vocabulary falls short to express heartiest regards to my grand parents Late **Sh. Moti Ram Yadav** and **Smt. Dhapu Devi** with most humble sense of regards I bow down my head to my respected parents **Sh. Prabhu Dayal Yadav** and **Smt. Raju Devi, My uncle – anti Sh. Amar Chand – Smt. Santosh Devi** whose blessings, inspiration, great affection and moral support led me to complete this venture. I take privilege to express my deep sense of honour to my younger sisters **Priyanka, Swarnlata** and **Kiran** and bhaiya **Dinesh, Mukesh** and **Rahul,** and bhabhi **Seema**, **Sarita**, **Madhu** and nephews **Kavya, Aarav**

It is like drop in the ocean of words to acknowledge the infinite love and sacrifice of my life partner **Mr**. **Vikash Yadav** who has been sole the source of inspiration for me to proceed ahead with my life. I am also thankful to my grand mother-in-law **Mrs. Barji Devi**, grand father-in-law **Mr. Narayan Lal**, Mother-in-law **Mrs**. **Raju Devi**, father-in-law **Mr**. **Jagdish Yadav**, Brother-in-law **Mr**.**Jitendre** for their unceasing love**.**

I extend my cordial thanks to **Mr. Suresh Yadav**, Vimal Computer's Jobner. Last but not the least, a million thanks to almighty God, who made this task and every job a success for me.

Place: Jobner

Dated: / /2018 **(Saroj Kumari Yadav)**

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

ABBREVIATIONS

%	Per cent
&	And
@	At the rate of
₹/ha	Rupees per hectare
^0C	Degree Celsius
CD	Critical difference
Cm	Centimetre
d.f.	Degree of freedom
DAS	Days after sowing
dS/m	Desi Siemens per metre
e. g.	For example
EC	Electrical conductivity
et al.	(et alibi) and else where
Fig.	Figure
g	Gram
g/ha	Gram per hectare
g/mrl	Gram per metre row length
ha	Hectare
HI	Harvest index
hrs	Hours
Hrs./day	Hours per day
i. e.	That is
K	Potassium
Kg	Kilogram
kg/ha	Kilogram per hectare
Km/hr.	Kilometer per hour
M	Metre
m^2	Square metre
Max.	Maximum
mg/g	Milligram per gram
Mg/m^3	Mega gram per cubic metre
N	Nitrogen
No.	Number
NS	Non-significant
P	Phosphorus
pH	Potential of hydrogen ion
q/ha	Quintal per hectare
RBD	Randomized block design
SEm$\pm$	Standard error of mean
Sig.	Significant
SMW	Standard meteorological week
Std.	Standard
t/ha	Tonne per hectare
USDA	United States Department of Agriculture
var.	Variety
viz.,	Namely
Zn	Zinc

Chapter-1
INTRODUCTION

Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is one of the important millet crop for arid and semi-arid climatic condition. It is world's hardiest warm season crop. It grows well in poor sandy soil due to drought escaping character and is a popular crop for drought prone areas. Pearlmillet provides staple food to the poor man in dry tracts of the country. It is nutritionally better than many cereals as it is a good source of protein having higher digestibility (12.1%), fats (5%), carbohydrates (69.4%) and minerals (2.3%). Green fodder is used either as such or is preserved as hay or silage which has proved extremely useful in dry regions.

Pearlmillet cultivation is mainly confined to the dry regions of the Southern Asia (Mainly India) and Africa (Nigeria, Niger, Mali, Tanzania, Sudan and Senegal). India is the largest producer of pearlmillet having 7.9 m ha area with an annual production of 9.18 m tonnes. The average productivity is 1298 kg/ha (Anonymous 2014-15). In India, it ranks fourth next to rice, wheat and sorghum with respect to area, however, with regard to production, it follows rice, wheat, sorghum and maize. It is mainly grown in Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana of our country. Rajasthan stands first in the country and produce 8.11 million tonnes from 4.41 m ha area with productivity of 933 kg/ha (Anonymous 2015-16). It is mainly cultivated in Jodhpur, Barmer, Jalore, Nagaur, Churu, Jaipur, Sikar, Alwar and Jhunjhunu districts. In fact, the area, production and productivity of pearlmillet, which is much below than its production potential and vary greatly with rainfall intensity and its distribution. Hence, our research effort should be diverted to remove the constraints responsible for its poor yield.

Pearlmillet growing areas in country are mostly confined to coarse texture soil suffering from the problem of poor moisture retention capacity and low soil fertility. Lack of improved cultural practices, cultivation on poor and marginal lands of low fertility and poor and delayed germination due to soil crusting are some of the major constraints responsible for its poor yield. The main problem of rainfed area is uncertainty and uneven distribution of rainfall and loss of water through runoff which lead to low and unstable productivity due to moisture stress at critical stage of crop growth. As about 85 per cent of annual rainfall is received through South-West monsoon and moisture availability on different crop growth phases is more essential because the deficiency of rain water at any critical stage may affect the plant growth and yield. Moisture stress generally results in limited total nutrient uptake and their diminished tissue concentration in crop plant. Lowered absorption of nutrients can result from interference in nutrient uptake and unloading mechanism and reduce transpirational flow (Garg, 2003). In rainfed areas, not all the rainfall received is available for the crops, but a significant part is lost as runoff, percolation and evaporation. Hence, concerned efforts are needed to develop soil moisture conservation practices to mitigate the water stress condition to increase production with minimum environment degradation. The risk factor can be minimized through *in-situ* moisture conservation, selection of suitable crop and its variety (Kumar *et al*., 2008 and Rathore *et al*., 2010). One of the common practices to reduce evaporation loss from the soil and prolonging the availability of moisture to the crop is mulching. Dust mulching decrease evaporation on the assumption that dry soil acts as a blanket and also reduce the point of contact between the soil particles due to loosening attraction between them. Mustard straw is readily available in the area where the crop is grown particularly in arid and semi-arid region. Retention of crop residue on soil also adds organic matter, which improves the quality of the seedbed and increases the water infiltration and retention capacity of the soil, fixes carbon by capturing carbon dioxide from the atmosphere and retaining it in the soil, buffers the pH of the soil and facilitates the availability of nutrients, feeds the carbon cycle of the soil, captures the rainfall and thus, increases the soil moisture content, protects the soil from being eroded and reduces the evaporation of soil moisture (Bhale and Wanjari, 2009). Application of crop residue on soil surface as a mulch reduces the loss of water through evaporation and moderate the soil profile temperature (Ram *et al.,* 2012).

Water is an important life saving natural resource for the crop. It profoundly influences photosynthesis, respiration, absorption, translocation and utilization of mineral nutrients and cell division. Due to limited availability of irrigation water in India, it is important to increase irrigation efficiency and water productivity of crop and to exploit the existing water potential by reducing the losses of water and also ensuring better living condition for crop growth. The use of soil conditioners like super absorbent polymer (hydrogel) has a great potential to exploit the existing water in soil for agricultural crops by increasing their production. Hydrogel is three-dimensional, hydrophilic polymer, loosely cross-linked networks capable of imbibing large amounts of water or biological fluids. These synthetic polymers are found in form of crystals and available under several trade names *viz.*, Super Absorbent, Pusa Hydrogel etc. are collectively called hydrogel.

The Pusa hydrogel, a semi-synthetic super absorbent polymer, developed by Indian Agriculture Research Institute (IARI). It is mixed with the soil on which the seeds are sown. The gel then absorbs water and expands 300 times its original size. It sticks to the roots of the plants and when the soil moisture falls as the temperature rises, the gel shed water to nourish the crop. Pusa hydrogel has been in use since 2012 and it is non-toxic and bio-degradable. It increases plant yield by 10-25 per cent. Due to use of Pusa hydrogel, there is 40 to 70 per cent saving of water. It works as an anti-drought mechanism and reduces the water requirement of plants. Actually, the polymer has capability to store extra water in soil that enables crops to utilize the water over an extended period of time (Kalhapure *et al.,* 2016). When polymer is mixed with the soil, it forms an amorphous gelatinous mass on hydration and is capable of absorption and desorption over long period of time, hence acts as a slow release source of water in soil. The hydrogel particles may be taken as "miniature water reservoir" in the soil and water will be removed from these reservoirs upon the root demand through osmotic pressure difference. The effect of hydrogels is affected if they are allowed to dry out and thus irrigation is important for longevity of hydrogels. Hydrogels can be applied by either mixing with the soil or by spraying. While using the spray technique, hydrogels can be mixed with micronutrients and pesticides. Use of hydrogel under rainfed condition, can better withstand drought condition without moisture stress in crop. Improvement in seed germination, crop establishment and growth will be the consequence. This will help to ensure uniform and healthy crop stand as well as achieve high crop yield. Due to the considerable volume reduction of the hydrogel as water is released to the crop, hydrogel creates within the soil, free pore volume offering additional space for air and water infiltration, storage and root growth.

The improvement of the physical soil properties like soil porosity, soil permeability and water infiltration will significantly reduce surface runoff and soil erosion, especially when soil forms semi hydrophobic crusts under compacted soil condition. The large quantities of water retained by the polymer provide extra available water to crops which facilitates better crop growth. More available water in the soil also means less frequent irrigation. The excellent water absorbency and water retention by hydrogel may prove especially practical in agriculture. It performs its wetting/drying cycles over a longer period of time, maintaining its very high water swelling and releasing capacity against soil pressure. Consequently evaporation, deep water percolation and nutrient leaching can be avoided. This product displayed a swelling potential of minimum 350 times, often exceeding 500 times its weight in pure water. Hydrogel enhances the crop productivity per unit available water and nutrients, particularly in moisture stress condition. It improves physical properties of soil, seed germination, seedling emergence rate, root growth and density that help plants to prolonged moisture stress (Ekebafe *et al.,* 2011). Hydrogel reduces the leaching of herbicide, fertilizer and requirements of irrigation for crops. It also promotes early dense flowering and tillering and delay the permanent wilting point (Mehr and Kourosh, 2008).

At present, widespread and acute deficiency of zinc is another serious problem in arid and semi-arid region (Sahrawat *et al*., 2007). The magnitude of zinc deficiency varied widely among soil types and within the various states. Coarse textured, calcareous soils of Bihar, vertisols and inceptisols of Andhra Pradesh, Tamil Nadu and Madhya Pradesh and aridisols of Haryana showed extensive deficiency of zinc resulting low crop yields. It is well known fact that zinc is now considered as fourth most important yield-limiting nutrient after, nitrogen, phosphorus and potassium (Maclean *et al.,* 2002). Increasing zinc concentration in food crops, resulting better crop production and improved human health is an important global challenge. Among the micronutrients Zn deficiency is occurring in both crops and human. Zinc deficiency reduces not only the grain yield, but also the nutritional quality of grain (Cakmak, 2008) and ultimately nutritional quality of human diet. Zn is essential for both plants and animals because it is a structural constituent and regulatory co-factor in enzymes and proteins involved in many biochemical pathways (Kabata and Pendias, 2001). Zinc plays a vital role in synthesis of chlorophyll, protein and nucleic acid and helps in the utilization of nitrogen and phosphorous by plants as it acts an activator of dehydrogenase and proteinase enzymes, directly and indirectly in synthesis of carbohydrates and protein. Zinc is constituent of tryptophan which is precursor of auxin hormone. Besides, it is associated with water uptake and water relations. Light textured soil of tract (zone-III A) are inherently deficient in zinc (0.43 ppm).

Further, availability of zinc decreases with rise in soil pH. Zinc is also required for the regulation and maintenance of the gene expression required for the tolerance of environmental stresses in plants, such as high light intensity and high temperature (Cakmak, 2002). So, moisture conservation and zinc fertilization is essential for sustained increase in the productivity of rainfed crops of India. When the supply of plant available zinc is inadequate, not only crop yields will be reduced but also the quality of crop products for use as food or feed can be expected to be sub-optimal. Zinc deficiency in the plant retards development and maturation of the panicles of grain crops (Alloway, 2004). Enhancing Zn in plant derived food is one of the way to improve human health in developing countries where and when the local population cannot afford food sources from which zinc can be taken up easily in enough quantities in the human gut.

Keeping all the above factors in view, the present investigation entitled "**Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]**" was undertaken to achieve the following objectives:

I. To study the effect of moisture conservation practices and zinc fertilization on growth, yield and quality of pearlmillet
II. To study the interactive effect between moisture conservation practices and zinc fertilization, if any
III. To evaluate the economic viability of different treatments.

Chapter-2

REVIEW OF LITERATURE

Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] is the fifth most important food grain crop after rice, wheat, maize and sorghum. As an arid and semi-arid crop, traditionally it is the component of dryland system, usually grown on the soil with depleted fertility receiving less rainfall 150-750 mm per annum. It is one of the stable food crops of quite a large population of India. India and Africa together account for 93.2 per cent of the total pearlmillet production of the world.

The available literature on the effect of moisture conservation practices and zinc fertilization on growth, yield and quality of pearlmillet has been reviewed in this chapter. Attempt has been made to cite as much literature as possible on pearlmillet but due to paucity of adequate experimental evidences, pertinent research finding involving other crops have also been include in the text, wherever felt necessary.

2.1 EFFECT OF MOISTURE CONSERVATION PRACTICES

2.2 EFFECT OF ZINC FERTILIZATION

2.1 EFFECT OF MOISTURE CONSERVATION PRACTICES

2.1.1 Effect on growth parameters

Chaudhary *et al*. (2002) in a field experiment at Jobner observed that mulching with straw and dust gave the highest dry matter accumulation and number of tillers of pearlmillet as compared to uniform row sowing, paired row sowing and kaoline spray. Poonia (2003) at Nagore (Rajasthan) reported that addition of *Tephrosia* weed mulch at 4 t/ha improve the growth parameters *viz*., plant height, dry matter accumulation and number of tillers of pearlmillet over other moisture conservation practices due to increased availability of moisture.

Conservation and availability of higher amount of moisture and nutrient during various stage of crop growth with moisture conservation practices (compartmental bounding and ridge and furrows system) resulted in better crop growth with higher amount of dry matter production and its translocation to ear in winter sorghum (Patil and Sheelavantar, 2004).

Verma *et al*. (2006) conducted a field experiment on loamy sand soil at Jobner found that *Tephrosia* and mustard straw mulch significantly increased plant height, dry matter accumulation per meter row length, total tillers per plant at 60 DAS and at harvest over control and dust mulch. Leaf area fairly gives a good idea of the photosynthetic capacity of the plant and decrease leaf area is an early response to water deficit. An increase in superabsorbent polymer concentration significantly increased the leaf area index. As the water content of the crop decrease, cell shrinks and turgor pressure subsequently concentrate solute in cell. Superabsorbent polymer increased the turgor pressure inside the cell by providing sufficient amount of water as per crop need and thus causing increase in leaf area (Yazdani *et al.,* 2007).

The highest plant height was found in ridge and furrow planted sorghum while the lowest was measured under flat bed (Kumar *et al*., 2008). Narayan *et al.* (2009) conducted a field study at Datia (MP) and reported that *in-situ* surface mulching of sunhemp (*Crotalaria juncea*) was found helpful in increasing the growth parameter of sorghum *viz*.; plant height and dry matter production under different tillage depths as compared to control.

Singh *et al*. (2012) conducted a field trials in rainfed condition of Kanpur and observed that application of organic residue mulch @ 4 t/ha in between rows after 25 days of sowing proved significantly superior to control, weeding and hoeing, ridge and furrow in terms of growth parameters (plant height, plant girth and dry matter accumulation) of sorghum. Choudhary *et al*. (2017) New Delhi find out that flat bed with 5.0 t/ha crop residue recorded significantly higher plant height, dry matter accumulation, number of ear heads, grain weight per ear head as compare to flat bed without crop residue.

2.1.2 Effect on yield attributes and yield

Jat and Gautam (2001) at Delhi also revealed that straw mulch + kaolin spray recorded higher grain yield of pearlmillet as compared to 45 cm row sowing, 30/60 cm paired row sowing, 45 cm ridge and furrow sowing, 5 t/ha straw mulch and 6% kaolin spray. In another experiment Chaudhary *et al*. (2002) at Jobner found that mulching with straw and dust gave the highest value of yield attributes and yield (grain and stover) of pearlmillet as compare to uniform row sowing.

Kumar and Gautam (2004) conducted a field experiment at New Delhi to evaluate the effect of moisture conservation and nutrient management practices on growth and yield of pearlmillet and reported that yield of pearlmillet increased significantly due to paired row planting + crop residue mulching (wheat straw at 5 t/ha) as compared to paired row planting + legume as mulch.

Tetarwal *et al*. (2006) on sandy loam soil at New Delhi revealed that moisture conservation practices of FYM @ 5 t/ha + dust mulch + straw mulch recorded significantly higher by-product yield of pearlmillet and maximum water use efficiency over rest of moisture conservation practices. Moisture conservation practices, paired row planting of pearlmillet at 30/60 cm with opening of dead furrow resulted in the highest mean grain (35.2 q/ha) and fodder (86.3 q/ha) yield as compared to spraying of 6% kaolin at flowering stage, dust mulching, spraying of 0.1% thiourea at tillering and flowering stage and removal of alternate rows at the pre-flowering stage (Rajput and Siddiqui, 2008).

Khadem *et al*. (2010) reported that application of 65 per cent cow manure and 35 per cent super absorbent (26 t/ha cow manure + 70 kg/ha super absorbent polymer) increased grain yield by 16.2 per cent as compare to control. Islam *et al*. (2011) reported that the number of grains per plant reduced marginally under low application of superabsorbent polymer whereas medium and high application, it increased by 9.3 and 16.6 per cent respectively as compare to plant without superabsorbent polymer. Dass *et al*. (2013) conducted an experiment in sandy-loamy soil at New Delhi and reported that use of Pusa hydrogel @ 5 kg/ha enhanced sorghum fodder yield by 14.5 per cent over control.

Singh *et al.* (2015) conducted field experiment at Varanasi and observed that maximum CGR (g/m^2/day), RGR (g/g/day), leaf area index were recorded with 7.5 kg hydrogel/ha, which was significantly higher than the treatments no hydrogel, 4 t mulch/ha and 2.5 kg hydrogel/ha at all stages but it was at par with 6 t mulch/ha and 5 kg hydrogel/ha at most of the growth stages among moisture conservation practices.

Jakhar *et al.* (2017) conducted a field experiment at New Delhi and revealed that maize kernel yield in ridge and furrow (RF) + crop residue (CR) 4 t/ha treatment was 10.6, 29.4 and 46.5% higher than RF + CR 2 t/ha + VAM, RF and FS (control) treatments, respectively. Whereas, in sub-plots (residual effects), Zero tillage + CR 4 t/ha recorded maximum kernel yield (3.05 t/ha) followed by ZT + CR 2 t/ha + Hydrogel (2.99 t/ha) treatment. Kanwar *et al.* (2017) conducted an field experiment at SKRAU, Bikaner to study the effect of moisture conservation practices in pearlmillet resulted that dry matter accumulation, total tillers/plant, ear head length, test weight, grain yield, stover yield and biological yield also significantly increased with the modification in surface configuration as ridge and furrow method over flat sowing, straw and dust mulch and without seed hardening.

2.1.3 Effect on nutrient concentration, uptake and quality

Application of FYM at 5 t/ha + dust mulch + straw mulch recorded significantly higher uptake of N (106.59 kg/ha) and P (41.06 kg/ha) by pearlmillet as compared to no mulch, dust mulch + straw mulch, kaolin + straw mulch (Tetarwal and Rana, 2006).

A field experiment was conducted by Sharma *et al.* (2010) at Dehradun to study the effect of *in-situ* grown live mulching with legume and they observed a significant increase in N uptake of maize due to mulching with intercropping legumes and the effect are more pronounced when mulching was done at 30 days than at 45 days. Sunhemp mulching was vastly superior to no mulching and the increase in uptake of N, P and K was 8.1, 16.1 and 10.1 per cent in maize (Singh *et al*., 2011).

Deshmukh *et al*. (2016) conducted an experiment at Maharashtra to study the effect of moisture conservation techniques and fertilizer management on yield and uptake of cotton under high density planting system and find out that the mulching with sunhemp after 30 DAS and 125% RDF (75 : 37.5 : 37.5 NPK kg/ha) + Zinc @ 2.5 kg/ha recorded higher cotton stalk, seed cotton yield and higher nutrient uptake of N, P, K, S and Zn by Cotton.

Choudhary *et al*. (2017) conducted an experiment at New Delhi and revealed that planting of pearlmillet and chickpea under the flat bed with 5.0 t/ha crop residue recorded significantly higher system productivity in term of pearlmillet equivalent yield (8.98 t/ha), water use efficiency (16.13 kg/ha-mm) and total uptake of N, P, K, Zn, Fe, Mn, Cu over flat bed without crop residue and flat bed with 2.5 t/ha crop residue.

2.1.4 Effect of moisture conservation practices on economics

Application of FYM at 5 t/ha + dust mulch + straw mulch fetched significantly higher net returns (10,051/ha) and B:C ratio (0.97) as compared to no mulch, dust mulch + straw mulch, kaolin + straw mulch (Tetarwal and Rana, 2006). Islam *et al.* (2011) opined that although the high (30 kg/ha) and very high dose (40 kg/ha) of superabsorbent polymer increased maize yield and harvest index as well as soil fertility, the high dose of 30 kg/ha of superabsorbent polymer for economic reasons was recommended. Application of superabsorbent polymer could be an effective drought mitigation strategy for field crop production and its application @ 30 kg/ha would be appropriate for maize production in arid and semiarid regions of northern China. He further reported that previously, the use of superabsorbent polymer for the amendment of agricultural soils was considered not economical. Application of superabsorbent polymer @ 15 kg/ha will cost an additional 75 USD /ha (15 kg × 5 USD), whereas, it can save initially half the fertilizer cost or 60 USD /ha (150 kg × 0.4 USD). Use of 1.75 g superabsorbent polymer per plant could be recommended for increasing per unit productivity and also net profit. Ravisankar *et al*. (2014) in a field experiment reported that application of paddy straw mulch fetched significantly higher net returns of ` 39,280/ha with B:C ratio of 1.6 from groundnut as compared to no mulch.

Choudhary *et al*. (2017) conducted an experiment at New Delhi and reported that planting of pearlmillet and chickpea under flat bed with 5.0 t/ha crop residue recorded significantly higher net returns of `25408/ha with production efficiency of `279.2/ha/day and protein content in grain during first year and B:C ratio during both the years as compared to flat bed without crop residue.

2.2 EFFECT OF ZINC FERTILIZATION

2.2.1 Effect on growth parameters

Jain *et al.* (2001) conducted a field experiment at Navgaon and studied the effects of zinc sulfate (0, 15, 30 and 45 kg/ha) applied as a soil fertilizer and as a foliar spray (0.5%) at 30 and 45 days after sowing on pearlmillet (*Pennisetum glaucum*) and reported that all treatments significantly increased plant height. Dadhich and Gupta (2003) studied the effect of Zn on pearl millet crop with zinc levels (0, 5 and 10 kg/ha) and found that the application of 10 kg Zn/ha significantly increased plant height. Application of 5 kg Zn/ha significantly enhanced plant height, dry matter accumulation and total tillers of wheat over control but remained at per with 10 kg Zn/ha (Dewal and pareek, 2004).

Dadhich and Gupta (2005) reported that application of 10 kg Zn/ha significantly increased plant height, tillers per plant, leaves per plant, stem girth, leaf area, green fodder yield and crude protein yield over the control in both the cuttings and in pooled mean.

Choudhary *et al.* (2005) conducted a field experiment to determine the effects of seven treatments of thiourea (control, seed soaking in 500 ppm and 1000 ppm, foliar spray of 500 ppm, foliar spray of 1000 ppm, seed soaking + foliar spray of 500 ppm, seed soaking - foliar spray of 1000 ppm) and three levels of zinc (0, 2.5, 5.0 kg/ha) on pearl millet (cv. HHB 67) productivity and reported that seed soaking + foliar spray of 1000 ppm thiourea and application of zinc 5.0 kg/ha produced significantly higher plant height and number of tillers and dry matter accumulation over the preceding level.

The application of increasing levels of zinc showed significant improvement in plant height of pearlmillet up to 5 kg Zn/ha and the increase in plant height of pearlmillet under 5 kg Zn/ha was 6.56 and 8.04 per cent over control in 2000 and 2001 respectively (Jakhar *et al*., 2006).

Mathukia and Khanpara (2009) observed slight improvement in root length and root dry weight of caster when it was fertilized with zinc @ 5 or 10 kg/ha. Meena and Mann (2010) carried out a field study at Tonk (Rajasthan) to find out the effect of zinc on fodder sorghum and reported that application of zinc @ 10 and 20 kg/ha were found significantly superior over control in term of higher plant height, number of leaves per plant, node per plant, dry matter production per plant and green forage yield.

Badiyala and Chopra (2011) at Palampur observed that application of $ZnSO_4$ @ 25 kg/ha to both the crop + FYM 5 t/ha to maize in maize-linseed cropping system, recorded significantly higher plant height and branches/ plant of linseed over rest of the treatments. Singh *et al.* (2016) conducted a field experiment at Backache, Mirzapur, and reported that phosphorus and zinc level significantly increase the plant height and maximum plant height

(73.83, 165.27, 167.93 and 170.33 cm) was recorded due to application of 30 kg phosphorus and 20 kg zinc/ha at 25, 50, 75 DAS and at maturity. Prasad *et al*. (2014) conducted an experiment at Mirzapur and concluded that growth parameters of pearlmillet like higher plant height, number of tillers, number of panicles, length of panicle, dry matter accumulation, were improved significantly due to application of 10 kg Zn/ha and 60 kg nitrogen/ha.

2.2.2 Effect on yield attributes and yield

Jain *et al*. (2001) conducted an experiment found that the effects of zinc sulfate (0, 15, 30 and 45 kg/ha) applied as a soil fertilizer and as a foliar spray (0.5%) at 30 and 45 days after sowing on pearlmillet, all treatments significantly increased effective tillers/row, ear length, test weight. Zinc sulfate at 45 kg/ha generated the highest values for these parameters, except net returns, which was highest (54919.4 ₹/ha) at a rate of 30 kg/ha. One or two foliar sprays of zinc sulfate were at par in increasing the seed yield.

Mali and Dashora (2003) recorded significantly higher seed yield of sorghum by 186 per cent due to application of 25 kg $ZnSO_4$/ha. Dewal and Pareek (2004) reported that application of 5 kg Zn/ha significantly enhanced effective tillers/m row length, grains/spike, test weight, grain, stover and biological yield of wheat over control but remained at per with 10 kg Zn/ha. Jain and Dahama (2005) carried out a field study at Bikaner to find out the residual effect of phosphorus and zinc on pearlmillet-wheat cropping system and found that residual effect of Zn up to 6 kg/ha significantly increase grain and stover yield of pearlmillet over control and 3 kg Zn/ha.

Chaube *et al*. (2007) at Pantnagar found that combined application of 2.5 kg Zn + 5 t FYM/ha in alternate years gave significantly higher grain and stover yield of pearlmillet as compare to other treatments. Mehta *et al*. (2008) at Jamnagar reported that application of $ZnSO_4$ @ 20 kg/ha at the time of sowing to pearlmillet crop gave higher grain yield and net returns as compare to control and 10 kg $ZnSO_4$/ha. Application of 7.5 kg Zn/ha significantly increased the number of effective tillers per meter row length, test weight and yield (grain, stover and biological) of pearlmillet over 2.5 kg Zn/ha and control (Pratap *et al*., 2008). Sammauria and Yadav (2008) at Bikaner reported that residual effect of 5.0 kg Zn/ha significantly increased effective tillers, stover and biological yield of pearlmillet. Whereas grain yield and harvest index improved significantly up to 7.5 kg Zn/ha and ear length and test weight improved up to 2.5 kg Zn/ha.

Sharma *et al*. (2008) carried out a field experiment to determine the effects of integrated nutrient management on the yield of pearl millet. Treatments include seven combinations of fertilizers and manures in main plots (60 and 30 kg/ha of N and P_2O_5, respectively (RDF); poultry manure @ 4 t/ha; poultry manure @ 2 t/ha + 50% RDF; poultry manure @ 1 t/ha + 75% RDF; farmyard manure (FYM) at 10 t/ha; FYM at 5 t/ha + 50% RDF;

and FYM at 2.5 t/ha + 75% RDF) and four levels of Zn in sub-plots (control, 2.5, 5 and 7.5 kg/ha). They reported that 7.5 kg Zn/ha significantly increased the number of effective tillers per meter row length and test weight over 2.5 kg Zn/ha and control. Ram et al. (2008) revealed that the application of 7.5 kg Zn/ha significantly increased the number of effective tillers per meter row length and test weight over 2.5 kg Zn/ha and control. The combined use of fertilizers and manures had remarkable effects on grain, stover and biological yield.

Silva *et al.* (2010) conducted an experiment in pot with six doses of zinc (0, 15, 30, 60, 120 and 360 mg dm^2), in the form of zinc sulphate. The result revealed that the use of high doses of zinc decreased dry matter production and millet growth. Zong *et al.* (2011) conducted an experiment at Agriculture University of Hebei, investigated the effects of foliar application of zinc fertilizers on yield and quality of pearlmillet (*Pennisetum glaucum*) and reported that zinc fertilization increased millet yield up to the 1.50 kg Zn/ha.

Application of $ZnSO_4$ @ 25 kg/ha + 5 t/ha FYM to maize recorded significantly higher yield attributes *viz*; number of grains per cob (445.3) and 1000 grain weight (232.3g) and grain yield of maize (4.56 t/ha) over control, recommended dose of NPK and 25 kg $ZnSO_4$/ha alone (Badiyala and Chopra, 2011). Chaudhary *et al*. (2014) in a field study at Agra observed that the residual effect of 7.5 kg Zn/ha applied to preceding greengram result into significantly higher grain and straw yield of wheat to the extent of 15.3 and 12.4 per cent over control. Prasad *et al.* (2015) at Varanasi concluded that the grain yield significantly increased by 31.47 per cent from 0 to 10 kg zinc and 47.65 per cent from 0 to 60 kg N/ha.

Katiyal *et al.* (2017) conducted an experiment of pearl millet in Uttar Pradesh found that zinc @ 7.5 kg/ha recorded highest value of grain yield (24.15 q/ha), water use efficiency (4.91 kg grain/ha mm) and B:C ratio (1.31).

2.2.3 Effect on nutrient concentration, uptake and quality

Jain and Dahama (2005) in a field experiment at Bikaner reported that the residual effect of zinc was found significant on nutrient concentration and uptake in pearlmillet, wherein, concentration and uptake of N, K and Zn were increased with increased levels of zinc, whereas, the concentration and uptake of P decrease with increasing levels. Shanmugasundaram and Savithri (2006) found a linear increase in zinc concentration in maize with increasing levels of zinc sulphate applied to the crops. The application of 5 kg Zn/ha showed perceptible improvement in protein content of pearlmillet grain and further increased in level of zinc to 10 kg/ha through increased the protein content of grain but the improvement was non-significant in both the years of study (Jakhar *et al*., 2006).

Chaube *et al*. (2007) at Pantnagar found that combined application of 2.5 kg Zn + 5 t FYM/ha to pearlmillet in alternate years have significantly higher concentration of Zn in flag leaf, apparent Zn fertilization use efficiency and its uptake by crop. Application of 20 kg

$ZnSO_4$/ha along with recommended dose of fertilizer (NPK) to maize recorded significantly higher total uptake of N, P and K as compared to recommended dose of fertilizer alone (Abrol *et al*., 2007).

Zong *et al.* (2011) conducted an experiment at Agriculture University of Hebei and reported that Zn application @ 1.5 kg/ha increased protein content by 11.13% for Jigu 20 and 10.53% for Jiyou 2 cultivars. The Zn application at all rates increased lysine acid and soluble sugar content in the grain in both cultivars. The results of this study suggest that foliar Zn application increases yield and also improves grain quality when applied at 1.50 to 2.25 kg/ha for soils with low zinc uptake.

Chauhan *et al*. (2014) from Agra (Uttar Pradesh) reported that increasing levels of zinc fertilization up to 5.0 kg Zn/ha significantly increased the protein content in grain and uptake of N and K by wheat over lower levels, however the uptake of Zn was increased significantly up to 10.0 kg Zn/ha. Paslawar and Deotalu (2015) at Maharashtra to find out that the highest gross monetary return, net monetary returns and benefit cost ratio was recorded with 125 % RDF (75 : 37.5 : 37.5 NPK kg/ha) + 2.5 Kg Zn/ha which was at par with125 % RDF (75 : 37.5 : 37.5 NPK kg/ha) which is the need of higher plant density. The highest WUE (3.02 kghamm-1) was noticed in 125 % RDF + Zn.

Deshmukh *et al*. (2016) conducted an experiment at Maharashtra to study the effect of moisture conservation techniques and fertilizer management on yield and uptake of cotton under high density planting system and find out that the mulching with sunhemp after 30 DAS and 125% RDF (75 : 37.5 : 37.5 NPK kg/ha) + Zinc @ 2.5 kg/ha recorded higher cotton stalk, seed cotton yield and higher nutrient uptake of N, P, K, S and Zn by Cotton. Choudhary *et al*. (2016) conducted an experiment at New Delhi to find out that application of 5.0 and 2.5 kg Zn/ha being at par with each other proved significantly better over control in terms of protein content and total uptake of P, B:C ratio and moisture use efficiency of chickpea. The significant improvement in quality, nutrient uptake, profitability and moisture use efficiency were observed only up to 2.5 kg Zn/ha.

Ghasal *et al*. (2017) conducted an experiment at New Delhi to find out that significant increase in macro and micro-nutrients uptake was registered due to Zn fertilization and the highest uptake of nutrients was recorded with application of 1.25 kg Zn/ha through Zn-EDTA + 0.5% foliar spray of Zn-EDTA at maximum tillering and booting stages. Thus, soil (1.25 kg Zn/ ha) + foliar (0.5%) application of Zn-EDTA was found superior with respect to macro and micro-nutrients uptake. Singh *et al*. (2017) conducted an experiment at Uttar Pradesh to study the effect of phosphorus and zinc application on nutrient content, uptake and quality of pearlmillet found that maximum N, P, K content in grain and straw recorded in 30 kg P/ha + 20 kg Zn/ha and highest zinc content in grain and straw was recorded in 10 kg P/ha + 30 kg Zn/ha.

2.2.4 Effects on Economics

Effect of zinc was found significant on economics of pearlmillet in pearlmillet-wheat cropping system, wherein, application of 9 kg Zn/ha recorded significantly higher net returns (` 9,479/ha) and B:C ratio (2.34) over control and 3 kg Zn/ha (Jain and Dahama, 2005). Jakhar *et al*. (2006) in a field study at Jobner reported that increasing levels of Zn up to 5 kg/ha significantly enhanced the net returns (₹ 11,138 and ₹ 12,277/ha) of pearlmillet during both the years of study but further increase in Zn level to 10 kg/ha could not bring any significant increase. Application of 5.0 kg Zn/ha to wheat fetched higher net returns of ₹ 70,200/ha along with B:C ratio of 2.74 than control and 2.5 kg Zn/ha (Chauhan *et al*., 2014).

Research gap

The above review suggests that pearlmillet is a very important *kharif* cereal crop of rajsthan and a lot of research work has been done on various agronomic aspects for improving productivity but still the productivity of this crop is low. Among various factor responsible for low productivity, soil moisture availability and low fertility are referred as the most limiting factors because crops are much sensitive to fertility and moisture stress. Since, there is each of information on moisture conservation practices and nutrient managment such as stover mulching, dust mulching, application of pusa hydrogel and zinc fertilization for improving productivity and profitability of pearlmillet in semi-arid condition. Hence the present investigation has been carried out to bridge this knowledge gap.

Chapter-3
MATERIALS AND METHODS

A field experiment entitled "Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]" was conducted at Agronomy farm of S.K.N. College of Agriculture, Jobner during *kharif*, 2017. The details of the procedure adopted for raising the crop and criteria used for treatment evaluation and methods adopted during the course of investigation are presented in this chapter.

3.1 Experimental field and location

The experiment was conducted at Agronomy farm of S.K.N. College of Agriculture, Jobner. Geographically, Jobner is situated 45 km west of Jaipur at 26^0 05' North latitude, 75^0 28' East longitude and at an altitude of 427 metres above mean sea level. The area falls in agro-climatic zone-IIIA (Semi-arid eastern plain zone) of Rajasthan.

3.2 Climate and weather conditions

The climate of this region is typically semi-arid, characterized by extremes of temperature during both summer and winter. The average annual rainfall of this tract varies from 300 mm to 400 mm and is mostly received during the months of July to September. During summer, temperature may go as high as 46^0C while in winter, it may fall as low as -1.5 ^{0}C. The relative humidity fluctuated between 43 to 87 per cent. There is hardly any rain during winter and summer. As the climate affects the growth, yield and quality of agricultural product, hence, climatic variables are presented in this chapter. The mean weekly weather parameters for the crop season recorded at the college meteorological observatory have been presented in table 3.1. The data revealed that *crop* season witnessed a rainfall of 147.9 mm. The mean daily maximum and minimum temperatures during the growing season of pearlmillet fluctuated between 29.4 to 36.6^0C and 15.5 to 26.2^0C, respectively. Similarly, mean daily relative humidity ranged between 37 to 81 per cent.

3.3 Cropping history of the experimental field

The cropping history of the experimental field is represented in table 3.2

Table 3.2 Cropping history of experimental field

Year	*Kharif*	*Rabi*
2013-14	**Mungbean**	**Coriander**
2014-15	**Pearlmillet**	**Mustard**
2015-16	**Mothbean**	**Fallow**
2016-17	**Clusterbean**	**Fallow**
2017-18	Pearlmillet*	**-**

* Experimental crop

3.4 Soil of the experimental field

In order to evaluate the physico-chemical properties, soil samples from 0-30 cm depth were taken from five random spots of the experimental field prior to layout and representative composite sample was prepared by mixing and processing of all soil samples together. The homogeneous composite soil sample was subjected to mechanical, physical and chemical analysis. The results of analysis along with methods used for determination are presented in table 3.3. It is apparent from data that soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon, low in available nitrogen, zinc and medium in phosphorus and potassium content.

Table 3.3: Physico-chemical properties of soil of the experimental field

S. No.	Particulars	Values	Methods used for analysis and reference
A.	**Mechanical analysis**		
(i)	Coarse sand (%)	25.4	International pipette method (Piper, 1950)
(ii)	Fine sand (%)	56.8	International pipette method (Piper, 1950)
(iii)	Silt (%)	9.6	International pipette method (Piper, 1950)
(iv)	Clay (%)	7.9	International pipette method (Piper, 1950)
(v)	Textural class	Loamy sand	International pipette method (Piper, 1950)
B.	**Physical analysis**		
(i)	Bulk density (Mg/m^3)	1.51	Method No. 38, USDA Hand Book No. 60 (Richards, 1968)
(ii)	Particle density (Mg/m^3)	2.57	Method No. 39, USDA Hand Book No. 60 (Richards, 1968)
(iii)	Total porosity (%)	41.3	Method No. 40, USDA Hand Book No. 60 (Richards, 1968)
(iv)	Field capacity (%)	12.3	Method No. 30, USDA Hand Book No. 60 (Richards, 1968)
(v)	Permanent wilting point (%)	2.46	Method No. 31, USDA Hand Book No. 60 (Richards, 1968)
C .	**Chemical composition**		
(i)	pH (1:2 soil water suspension)	8.20	Glass electrode (Jackson, 1973)
(ii)	EC (1:2 soil water suspension) at 25^0C (dS/m)	1.45	Conductivity meter (Jackson, 1973)
(iii)	Organic carbon (%)	0.24	Walkley and Black Rapid titration method (Walkley and Black, 1934)
(iv)	Available nitrogen (kg/ha)	125.7	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
(v)	Available phosphorus (kg P_2O_5/ha)	16.12	Olsen's method (Olsen *et al.,* 1954)
(vi)	Available potash (kg K_2O/ha)	151.24	Flame Photometer method (Jackson., 1967)
(vii)	Available Zinc (ppm)	0.4	Analysis of suitable aliquot of DTPA extract by AAS modle no. GBS-932. (Lindsay and norvell 1978)

3.5. Experimental details

The details of the techniques employed for the investigation on “Effect of Moisture Conservation Practices and Zinc Fertilization on Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]” during *kharif* season of 2017 are given below.

3.5.1 Experimental Treatments

The field Experiment was laid out in Factorial Randomized Block Design with three replications. Twenty treatment combinations (Table: 3.4) involving five practices of moisture conservation and four levels of zinc fertilization were included in this study. The allotment of treatments to various plots in each replication was done by referring random number. The details of the treatments are as under:

Table: 3.4 Treatment with their symbol

A.	**Moisture conservation practices**		**Symbols**
i.	Control	:	M_0
ii.	Dust mulch	:	M_1
iii.	Pusa hydrogel	:	M_2
iv.	Stover mulch	:	M_3
v.	Pusa hydrogel + stover mulch	:	M_4
B.	**Zinc application**		
I.	Control	:	Zn_0
II.	2 kg Zn/ha	:	Zn_1
III.	4 kg Zn/ha	:	Zn_2
IV.	6 kg Zn/ha	:	Zn_3

3.5.2 Design and layout of the experiment

The experiment was laid out in randomized block design and replicated three times. The treatments were randomly allocated to different plots, using random number table of Fisher and Yates (1963). The layout plan of experiment with allocation of treatments and other details are shown in fig. 3.2.

Other experimental details

(I)	Season	:	*Kharif,* 2017
(ii)	Crop	:	Pearlmillet
(iii)	Variety	:	RHB-173
(IV)	Total treatment combinations	:	5×4 = 20
(V)	Replications	:	3
(VI)	Total number of plots	:	20×3 = 60
(VII)	Experimental design	:	RBD
(VIII)	Plot size		
(A)	Gross	:	4.0 m X 3.6 m = 14.4 m^2
(B)	Net	:	3.0 m X 2.8 m = 8.4 m^2
(IX)	Spacing		
	(a) Row to Row	:	45 cm
	(b) Plant to Plant	:	10 cm
(X)	Seed rate	:	4 kg/ha
(XI)	Location	:	Agronomy Farm, S.K.N. College of Agriculture, Jobner

3.6 Salient features of the crop and variety used

3.6.1 Pearlmillet (*Pennisetum glaucum)*

Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz] is the cross pollinated crop. The inflorescence of pearlmillet is almost a cylindrical spike densely packed with the spikelets. Each spikelet consists of two glumes and two flowers, the lower flower being usually male and the upper hermaphrodite or perfect. The gynoecium is protogynous and the grains, (caryopsis) are grey, rarely yellow.

3.6.2 Varietal characteristics

RHB-173 is a medium maturing hybrid, which matures in 85-90 days. Plants are of medium tall (200cm) having long thin ear length (30 – 35 cm). Its potential yield is 30 - 33 q/ha and dry fodder yield is 68-77 q/ha. It is resistant to downy mildew and have bristles on ear heads for protection from bird damage. Variety is suitable for cultivation in arid and semi-arid regions of the state.

3.7 Treatment application

Mulching: Dust mulch was created by hoeing between the rows at 25 DAS. Stover mulch using waste mustard stover @ 5 t/ha was spread between the rows at 28 DAS.

Application of pusa hydrogel and zinc: Pusa hydrogel was applied in respective plots as band. Zinc as per treatment was applied through zinc sulphate. The weighed quantity of zinc was applied in respective plots and incorporated uniformly in whole plot.

3.8 Details of crop raising

The details of different pre and post sowing operations carried out in the experimental field is given in table 3.5 and other details are described as under.

3.8.1 Field preparation

The experimental field was thoroughly prepared by deep ploughing with tractor drawn mould board plough followed by harrowing and planking to obtain fine tilth.

3.8.2 Seed treatment

Prior to sowing, the pearl millet seeds were treated with fungicide bavistin @ 2 g/kg.

3.8.3 Fertilizer application

The recommended dose of 30 kg P_2O_5/ha through single super phosphate and 1/3 dose of nitrogen was drilled as basal 10 cm deep at the time of sowing and remaining dose of nitrogen was top dressed in 2 splits through urea.

3.8.4 Seed rate and sowing

Seeds of the pearlmillet variety, RHB-173 were sown on 06 July, 2017 in rows spaced at 45 cm apart with the help of hand operated ‘desi’ plough with ‘*kerra*’ attachment using a seed rate of 4 kg/ha.

3.8.5 Thinning and gap filling

Thinning and gap filling was done manually at 15 days after sowing to maintain the optimum plant population.

3.8.6 Weeding

Weeding was done manually at 25 DAS by uprooting of weeds with hands.

3.8.7 Irrigation

The experiment was basically planned for hyper arid and partially irrigated plain zone and under dry spell one life saving irrigation was given.

3.8.8 Plant Protection Measures

No serious diseases were observed during the course of investigation. But some spots of insect (stem borer) attack were observed. To control the borer monocrotophos 36 SL @1ml/L spray was done.

3.8.9 Harvesting

At maturity, crop was harvested from the net plot. The boarder lines were harvested separately. Each plot was harvested by sickles, tied in bundles and tagged. The tagged bundles were left for sun drying in the plots.

After complete drying to constant weight, the bundles were weighed and weight of each bundle was recorded in kg and converted to kg/ha as biological yield.

3.8.10 Threshing and winnowing

The dry weight of each bundle was recorded and then threshing was done manually by beating and trampling the ear heads of each plot separately and grains were collected in numbered bags. After winnowing, cleaned seeds were weighed to record grain yield and were converted to kg/ha.

3.9 Biometric Observations

Five plants were randomly selected and tagged permanently for easy recognition from the net plot area of studying all the individual plant characters in the present study. The details of this procedure followed for recording different observation are given below.

3.9.1 Growth parameters

3.9.1.1 Plant stand

The plant stand was counted at 20 DAS and at harvest from five randomly selected rows in each plot and the average in /ha was worked. Similarly, final plant stand was also recorded from each plot at harvest.

3.9.1.2 Plant height

Five plants were selected randomly from each plot and tagged. Height of individual plant was measured at 30, 60 DAS and at harvest from base of the plant to top of the main shoot by scale and expressed as average plant height in cm.

3.9.1.3 Dry matter accumulation

Dry matter production was recorded at 30, 60 DAS and at harvest. For this, plants from one meter row length were uprooted randomly from sample rows of each plot. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70^0 C till constant weight. The weight was recorded and expressed as average dry matter per meter row length.

3.9.1.4 Total number of tillers/plant

The tillers of five randomly selected and tagged plants of pearlmillet were counted at physiological maturity and average was worked out.

3.9.2 Yield attributes and yield

3.9.2.1 Effective tillers/plant

The effective tillers of five randomly selected and tagged plants were counted and average number of effective tillers/plant was worked out and recorded as number of effective tiller/plant.

3.9.2.2 No. of grains/ear

Five ears were taken from selected plants. After drying, these ears were threshed separately and their number of grains recorded and the average number of grains/ear was computed.

3.9.2.3 Ear head length

Five ear heads were taken randomly from selected tagged plants from each plot and their length was measured from the neck node to the tip and average was computed.

3.9.2.4 Test weight

A small seed sample was taken from the produce of each of the plot harvested and 1000-seeds were counted and weighed and recorded as test weight.

3.9.2.5 Grain yield

The total biomass harvested from each plot and ear heads separated from the lot was threshed, winnowed and dried. Thus, grain obtained were weighed separately in kg/plot and converted into grain yield in kg/ha.

3.9.2.6 Stover yield

The stover yield (kg/plot) was obtained by subtracting the grain yield from biological yield/plot. Stover yield (kg/plot) was converted in stover yield kg/ha.

3.9.2.7 Biological yield

The harvested material from each plot was thoroughly sun dried. After drying, the produce of individual plot area was weighed with the help of a balance and weight recorded in kg/plot as biological yield. Later, biological yield/plot was converted in terms of kg/ha.

3.9.2.8 Harvest index

The harvest index was worked out by dividing the grain yield (economic yield) by grain + stover yield (biological yield) obtained from plot area and multiplies by 100 to express it in per cent (Singh and Stoskopf, 1971).

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.9.3 Nutrient concentration, uptake and quality attributes

3.9.3.1 Nutrient concentration

For estimation of nitrogen, phosphorus, potassium, and zinc samples of grain and stover from each plot were taken at the time of threshing. Each dried stover sample was ground to fine powder in Willy mill for the estimation of the nutrient content. For estimating the nutrient content in grain, each sample was ground by an electric grinder.

Nitrogen: Nitrogen was estimated by digesting the samples with sulphuric acid using hydrogen peroxide to remove black colour. Estimation of nitrogen was done by colorimetric method using Nesslers reagent to develop colour

(Snell and Snell, 1949). The results so obtained were expressed as per cent nitrogen concentration.

Phosphorus: Phosphorus concentration in grain and stover was determined by Vanado-molybdo phosphate‟ yellow colour method. Digestion of samples was done by tri-acid mixture (Jackson, 1967).

Potassium: potassium concentration in grain and stover was determined by “Flame photometer”. Digestion of samples was done by tri-acid mixture (Jackson, 1973).

Zinc: Zinc concentration in grain and stover was deterimened by “ Atomic Absorption spectrophotometer” (Lindsay and norvell, 1978)

3.9.3.2 Total nutrient uptake

The total uptake of nitrogen, phosphorus and potassium was computed from N, P and K concentration in grain and stover at harvest stage using the following relationship

$$\text{Nutrient uptake (kg /ha)} = \frac{\text{Nutrient conc. in grain (\%)} \times \text{Grain yield (kg /ha)} + \text{Nutrient conc. in straw (\%)} \times \text{Straw yield (kg /ha)}}{100}$$

The total uptake of zinc in grain and stover was estimated by using following formula

$$\text{Zinc uptake (g /ha)} = \frac{\text{Zinc conc. in grain (ppm)} \times \text{Grain yield (kg /ha)} + \text{Zinc conc. in straw (ppm)} \times \text{Straw yield (kg /ha)}}{1000}$$

3.9.4 Protein content

The per cent Protein content in grain was calculated by multiplying per cent nitrogen of grain with a factors 6.25 (A.O.A.C., 1960).

3.10 Economics

The economics of any treatment is the prime important consideration before making any recommendation for its adoption to the farmers. In order to assess the effectiveness and economics of the treatments, the extra cost involved in it's application at prevailing market rates was considered. The net returns of each treatment was worked out so that the most effective and remunerative treatment could be recommended.

3.10.1 Cost of cultivation

The cost of cultivation (₹/ha) of each treatment was worked out by considering the price of inputs, charges for cultivation, labour, land and other charges.

3.10.2 Net returns

The net monetary returns (₹/ha) of each treatment were worked out by deducting the mean cost of cultivation (₹/ha) of each treatment from the gross monetary returns (₹/ha) gained from the respective treatments.

3.10.3 Benefit : Cost ratio (B:C)

The benefit: cost ratio of each treatment was calculated by dividing the gross returns with the mean cost of cultivation.

3.11 Statistical analysis

The experimental data recorded for growth, yield and other characters were subjected to statistical analysis in accordance with the "Analysis of Variance" technique suggested by (Fisher, 1950). Appropriate standard error for each of the factor was worked out. Significance of differences among treatment effects was tested by "F" test. Critical difference (CD) was worked out, wherever the difference was found significant at 5.0 or 1.0 per cent level of significance. The Analyses of Variance‟ of different components for all the parameters are given in the annexures at the end.

3.12 Correlation and regression studies

To assess the relationship, correlation and regression coefficients between grain yield of pearlmillet (Y) and the independent variables (X) such as crop dry matter accumulation, yield attributes and nutrient uptake by crop were computed using the method given by Snedecor and Cochran (1968). The regression equations were also fitted and tested for significance.

Table 3.5 Schedule of pre and post sowing operation carried out in the experimental field

S. No.	Operations	Date	Remarks
1.	Ploughing of field	15/06/2017	By tractor
2.	Planking	20/06/2017	By tractor
3.	Layout of experimental field	04/07/2017	Manually
4.	Application of recommended dose of N, P and K	05/07/2017	Manually
5.	Applicationn of zinc sulphate	06/07/2017	Manually
6.	Applicationn of pusa hydrogel	06/07/2017	Manually
5.	Sowing	06/07/2017	*Kerra* method
6	Thinning	23/07/2017	Manually
7.	Hoeing and weeding	30/07/2017	Manually
9.	Stover mulch	02/08/2017	Manually
10.	Life saving irrigation	21/08/2017	Sprinkler
11.	Dusting of monocrotophos	25/08/2017	Manually with duster
12.	Harvesting	14/10/2017	Manually
13.	Threshing	27/10/2017	Manually

Table No.3.1: Mean weekly meteorological data during crop season (*kharif,* 2017)

SMW	Duration		Temperature (⁰C)		Mean R. H (%)	Total Rainfall (mm)	Rainy days	Wind velocity (km/hr)	Evaporation (mm/day)
	From	To	Max.	Min.					
27	2-Jul	8-Jul	34.6	25.7	66	030.0	2	4.3	7.1
28	9-Jul	15-Jul	35.9	26.6	61	006.7	1	2.7	06.9
29	16-Jul	22-Jul	34.2	25.6	79	26.0	3	02.7	5.0
30	23-Jul	29-Jul	31.5	24.8	81	24.2	3	03.2	5.0
31	30-Jul	05-Aug	29.4	24.0	81	005.0	1	3.7	3.9
32	06-Aug	12-Aug	32.6	24.0	71	000	-	4.4	5.3
33	13-Aug	19-Aug	34.1	21.7	59	000	-	6.6	6.0
34	20-Aug	26-Sep	34.8	24.7	71	28.6	1	03.2	6.3
35	27-Aug	02-Sep	32.8	24.5	75	09.8	1	04.3	5.3
36	03-Sep	09-Sep	33.3	23.9	65	000	-	2.4	6.6
37	10-Sep	16-Sep	36.0	23.9	69	17.6	1	1.4	7.3
38	17-Sep	23-Sep	36.6	21.2	53	000	-	2.3	7.4
39	24-Sep	30-Sep	36.0	18.4	52	000	-	2.2	7.6
40	01-Oct	07-Oct	35.6	15.6	39	000	-	3.3	8.5
41	08-Oct	14-Oct	36.2	15.4	40	000	-	2.4	7.9

SMW = Standard Meteorology weeks

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Chapter-4

EXPERIMENTAL RESULTS

The chapter embodies the results of the present investigation entitled "Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]". The experiment was conducted in *kharif* season of 2017 at Agronomy farm of S.K.N. College of Agriculture, Jobner.

The data pertaining to various growth attributes, yield attributes, grain yield, stover yield, harvest index and economics as influenced by different moisture conservation practices and zinc fertilization along with statistical inferences are presented in tables and also illustrated graphically, wherever found necessary in this chapter. For the sake of the convenience, the entire chapter has been divided under the following heads:

4.1 EFFECT ON GROWTH ATTRIBUTES

4.2 EFFECT ON YIELD ATTRIBUTES AND YIELD

4.3 EFFECT ON NUTRIENT CONCENTRATION AND UPTAKE BY GRAIN AND STOVER

4.4 EFFECT ON ECONOMICS

4.5 CORRELATION AND REGRESSION STUDIES

4.1 Effect on growth attributes

The data on growth parameters *viz.,* plant stand, plant height, dry matter accumulation per metre row length, total number of tiller per plant at different stages of observation as affected by different treatments are presented in tables 4.1 to 4.4 (Fig. 4.1 to 4.3).

Table: 4.1 Effect of moisture conservation practices and zinc fertilization on plant stand of pearlmillet

Treatments	Plant stand/ m row length	
	20 DAS	**At harvest**
Moisture conservation practices		
Control	7.19	7.05
Dust mulch	7.28	7.12
Pusa hydrogel	7.31	7.17
Stover mulch	7.33	7.19
Pusa hydrogel + stover mulch	7.38	7.25
SEM±	0.18	0.18
CD (P=0.05)	NS	NS
Zinc levels (kg Zn/ha)		
0	7.21	7.01
2	7.26	7.17
4	7.34	7.21
6	7.37	7.23
SEM±	0.16	0.16
CD (P=0.05)	NS	NS
CV	8.53	8.54

NS = Non significant

4.1.1 Plant stand

Data presented in Table 4.1 showed that plant stand of pearlmillet remaining uninfluenced due to moisture conservation practices and zinc fertilization at 20 DAS and at harvest.

4.1.2 Plant height

The periodical plant height (cm) recorded at 30, 60 DAS and at harvest as influenced by moisture conservation practices and zinc fertilization are furnished in Table 4.2 and graphically presented in Fig. 4.1.

Moisture conservation practices: The results presented in Table 4.2 and Fig 4.1 indicated that none of the moisture conservation practices influenced the plant height significantly at 30 DAS. However, the plant height of pearlmillet recorded at 60 DAS and at harvest influenced by moisture conservation practices significantly. At 60 DAS and at harvest stages of crop growth, significantly higher plant height (149.60 and 173.74 cm) was recorded under stover mulch. Being at par with pusa hydrogel + stover mulch, application of stover mulch also increased the plant height by 8.01, 18.26 and 30.72 per cent at 60 DAS and 8.12, 18.81 and 31.15 per cent at harvest stage over pusa hydrogel, dust mulch and control, respectively. Dust mulch and pusa hydrogel also increase the plant height significantly than the control.

Zinc fertilization: The results presented in Table 4.2 and Fig. 4.1 indicated that, the zinc fertilization not influenced the plant height significantly at 30 DAS. However, the plant height of pearlmillet recorded at 60 DAS and at harvest influenced significantly through Zinc fertilization. At later stages of crop growth, increasing levels of zinc fertilization significantly increased the plant height upto 4 kg Zn/ha over preceding levels. Further increase in its level to 6 kg Zn/ha could not enhance the plant height upto the level of significance. Application of zinc at 4 kg Zn/ha increased the plant height by 9.66 and 20.96 per cent at 60 DAS and 13.72 and 24.97 per cent at harvest over 2 kg Zn/ha and control, respectively.

Interaction effect: An examination of data revealed that interaction effect of moisture conservation practices and zinc fertilization did not have significant effect on plant height at 30, 60 DAS and at harvest.

Table: 4.2 Effect of moisture conservation practices and zinc fertilization on plant height of pearlmillet

Treatments	Plant height (cm)		
	30 DAS	**60 DAS**	**At harvest**
Moisture conservation practices			
Control	29.65	114.44	132.47
Dust mulch	29.95	126.50	146.23
Pusa hydrogel	30.20	138.50	160.69
Stover mulch	31.40	149.60	173.74
Pusa hydrogel + stover mulch	31.99	154.30	179.39
SEM±	0.99	3.61	4.22
CD (P=0.05)	NS	10.32	12.08
Zinc levels (kg Zn/ha)			
0	29.49	119.75	136.54
2	30.47	132.09	149.97
4	31.06	144.85	170.64
6	31.55	149.98	176.87
SEM±	0.89	3.23	3.77
CD (P=0.05)	NS	9.23	10.80
CV	11.21	9.14	9.22

NS = Non significant

4.1.3 Dry matter accumulation

The periodical dry matter accumulation recorded at 30, 60 DAS and at harvest as influenced by moisture conservation practices and zinc fertilization are furnished in Table 4.3 and graphically presented in Fig. 4.2.

Moisture conservation practices: A critical examination of data presented in Table 4.3 and Fig 4.2 revealed that application of moisture conservation practices significantly increased the crop dry matter at 30 DAS, 60 DAS and at harvest stages over control. Significantly higher dry matter accumulation of 21.50, 129.97 and 173.05 g/m row length at 30, 60 DAS and at harvest respectively was recorded under treatment stover mulch. Being at par with pusa hydrogel + stover mulch, stover mulch improved the dry matter to the extent of 10.31, 26.32 and 42.76 at 30 DAS, 8.47, 18.92 and 30.64 at 60 DAS, 8.09, 17.31 and 27.69 per cent at harvest over pusa hydrogel, dust mulch and control, respectively. Pusa hydrogel also significantly increased the dry matter accumulation than the dust mulch and control.

Zinc fertilization: Further reference to data (Table 4.3 and Fig. 4.2) revealed that successive addition in level of zinc from 0 to 4 kg Zn/ha significantly increased the crop dry matter accumulation at 30 DAS, 60 DAS and at harvest over lower levels. The level of zinc at 4 kg Zn/ha registered dry matter production of 20.78, 126.39 and 169.23 g/m row length at 30 DAS, 60 DAS and harvest stages, respectively and thus improved it to the extent of 13.36 and 33.71 per cent at 30 DAS, 9.74 and 23.59 per cent at 60 DAS and 10.29 and 21.69 per cent at harvest stage over 2 kg Zn/ha and control, respectively. However, it showed statistical resemblance with 6 kg Zn/ha, wherein the maximum dry matter at 30 DAS, 60 DAS and at harvest was recorded. The corresponding increase due to application of 6 kg Zn/ha was 18.54, 39.83 at 30 DAS, 15.02, 29.52 at 60 DAS and 14.82, 26.70 at harvest stage over 2 kg Zn/ha and control.

Interaction effect: An examination of data revealed that interaction effect of moisture conservation practices and zinc fertilization did not have significant effect on dry matter accumulation at 30, 60 DAS and at harvest.

Table: 4.3 Effect of moisture conservation practices and zinc fertilization on dry matter accumulation of pearlmillet

Treatments	Dry matter accumulation (g/mrl)		
	30 DAS	**60 DAS**	**At harvest**
Moisture conservation practices			
Control	15.06	99.48	135.52
Dust mulch	17.02	109.29	147.51
Pusa hydrogel	19.49	119.82	160.09
Stover mulch	21.50	129.97	173.05
Pusa hydrogel + stover mulch	22.41	136.81	181.29
SEM±	0.52	3.19	4.24
CD (P=0.05)	1.49	9.14	12.13
Zinc levels (kg Zn/ha)			
0	15.54	102.26	139.06
2	18.33	115.17	153.44
4	20.78	126.39	169.28
6	21.73	132.48	176.19
SEM±	0.47	2.85	3.79
CD (P=0.05)	1.34	8.17	10.85
CV	9.47	9.28	9.21

4.1.4 Total number of tillers per plant

Results on total number of tillers per plant in pearl millet as influenced by moisture conservation practices and zinc fertilization are presented in Table 4.4 and Fig. 4.3.

Moisture conservation practices: Results given in Table 4.4 indicated that all the moisture conservation practices significantly increased the total number of tillers/ plant over control at harvest. Among the moisture conservation practices significantly, higher number of tillers/plant recorded at harvest under stover mulch over Pusa hydrogel, dust mulch and control and remained at par with pusa hydrogel + stover mulch and registered a significant increase of 9.15, 20.15 and 33.98 per cent, over pusa hydrogel, dust mulch and control respectively.

Zinc fertilization: Results presented in Table 4.4 and Fig. 4.3 revealed that application of graded levels of zinc upto 4 kg Zn/ha significantly increased the total number of tillers/plant over preceding levels. It attained 4.69 tillers/plant that were 11.93 and 32.48 per cent more than recorded under 2 kg Zn/ha and control, respectively. Further increase in level of zinc to 6 kg Zn/ha did not bring significant variation in total number of tillers/plant.

Interaction effect: Interaction effect of moisture conservation practices and zinc fertilization was found to be non-significant with respect to total number of tillers per plant at harvest.

4.2 Yield attributers and yield

Data pertaining to yield attributes and yield *viz.,* number of effective tillers/plant, number of grains/ear, length of ear, test weight, grain, stover and biological yields and harvest index are given in Table 4.4 to 4.6 and Fig. 4.4 to 4.5.

4.2.1 Number of effective tillers/plant

Results on number of effective tillers per plant in pearlmillet as influenced by moisture conservation practices and zinc fertilization are presented in Table 4.4 and Fig. 4.3.

Table: 4.4 Effect of moisture conservation practices and zinc fertilization on total tillers and effective tillers at harvest

Treatments	Total tillers/plant	Effective tillers/plant
Moisture conservation practices		
Control	3.56	2.08
Dust mulch	3.97	2.35
Pusa hydrogel	4.37	2.61
Stover mulch	4.77	2.89
Pusa hydrogel + stover mulch	4.98	3.06
SEM±	0.12	0.07
CD (P=0.05)	0.34	0.20
Zinc levels (kg Zn/ha)		
0	3.54	2.20
2	4.19	2.45
4	4.69	2.80
6	4.90	2.94
SEM±	0.10	0.06
CD (P=0.05)	0.30	0.18
CV	9.37	9.45

Moisture conservation practices: Results presented in Table 4.4 and Fig. 4.3 revealed that number of effective tillers/plant were significantly increased under treatment stover mulch with the per cent increase of 10.72, 22.97 and 38.94 over pusa hydrogel, dust mulch and control, respectively. However, application of stover mulch was remained at par to pusa hydrogel + stover mulch. Application of pusa hydrogel also significantly increased the total tillers/plant than dust mulch and control.

Zinc fertilization: Number of effective tillers/plant were significantly influenced by different levels of zinc fertilization (Table 4.4 and Fig. 4.3). Application of zinc at 4 kg Zn/ha attained 2.80 effective tillers/plant, thereby increasing them to the extent of 14.28 and 27.27 per cent over 2 kg Zn/ha and control, respectively. However, it showed statistical similarity with 6 kg Zn/ha, wherein the maximum number of 2.94 effective tillers were recorded.

Interaction effect: Interaction effect of moisture conservation practices and zinc fertilization was found to be non-significant with respect to number of effective tillers/plant at harvest.

4.2.2 Number of grains/ear

The data on number of grains/ear as influenced by different moisture conservation practices and zinc fertilization are presented in Table 4.5.

Moisture conservation practices: A perusal of data given in Table 4.5 and Fig. 4.4 revealed that all the moisture conservation practices resulted significantly higher number of grains/ear in pearlmillet than control. Significantly higher number of grains/ear (978.45) was obtained under stover mulch and increment was 11.77, 23.02 and 35.04 per cent over, pusa hydrogel, dust mulch and control, respectively and remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: Further reference of data (Table 4.5 and Fig. 4.4) showed that application of zinc at 4 and 6 kg Zn/ha recorded 942.52 and 991.46 grains/ear in pearlmillet that were found significantly superior over 2 kg Zn/ha and control. The extent of increase in grains/ear due to these two levels of zinc was 13.21 and 19.09 per cent over 2 kg Zn/ha and 23.26 and 29.66 per cent over control, respectively. However, both levels (4 kg and 6 kg Zn/ha) remained at par with each other in this respect.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on number of grains/ear.

4.2.3 Length of ear

The results on ear length (cm) as influenced by different moisture conservation practices and zinc fertilization are presented in Table 4.5 and graphically depicted in Fig. 4.5.

Moisture conservation practices: A perusal of data summarized in Table 4.5 and Fig. 4.5 showed that stover mulch significantly superior in ear length over pusa hydrogel, dust mulch and control and registered a significant increase of 8.39, 19.93 and 32.49 per cent, respectively but remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: Results presented in Table 4.5 and Fig. 4.5 revealed that application of zinc upto 4 kg/ha significantly increased the ear length over preceding levels. It attained 23.97 cm length of ear that were 9.50 and 21.92 per cent more than recorded under 2 kg/ha and control, respectively. Further increase in level of zinc to 6 kg/ha did not bring significant variation in ear length.

Interaction effect: The interaction effect of moisture conservation practices and zinc fertilization was found non significant with respect to ear length.

4.2.4 Test weight

Data on test weight of pearlmillet as influenced by different moisture conservation practices and zinc fertilization are presented in Table 4.5 and graphically depicted in Fig. 4.5.

Moisture conservation practices: The experimental results provided in Table 4.5 revealed that different moisture conservation practices exerted significant influence on test weight. Significantly, higher test weight (7.49 g) was obtained under stover mulch which was remained at par with pusa hydrogel + stover mulch. Application of stover mulch enhanced the test weight to the extent of 7.76, 17.03 and 28.25 per cent over pusa hydrogel, dust mulch and control, respectively.

Table: 4.5 Effect of moisture conservation practices and zinc fertilization on yield attributes of pearlmillet

Treatments	Number of grain/ear	Ear length (cm)	Test weight (g)
Moisture conservation practices			
Control	724.53	18.71	5.84
Dust mulch	795.30	20.67	6.40
Pusa hydrogel	875.40	22.87	6.95
Stover mulch	978.45	24.79	7.49
Pusa hydrogel + stover mulch	1040.20	25.81	7.91
SEM±	24.00	0.56	0.18
CD (P=0.05)	68.71	1.60	0.53
Zinc levels (kg Zn/ha)			
0	764.63	19.66	6.11
2	832.49	21.89	6.66
4	942.52	23.97	7.29
6	991.46	24.76	7.61
SEM±	21.47	0.50	0.16
CD (P=0.05)	61.46	1.43	0.47
CV	8.62	8.67	8.61

Zinc fertilization: Data further presented in Table 4.5 and Fig. 4.4 showed that test weight of pearlmillet seed significantly increased when the level of zinc was increased from 0 to 4 kg/ha. However, the highest test weight (7.61 g) was recorded with 6 kg Zn/ha but it was found at par with 4 kg Zn/ha.

Interaction effect: The interaction between moisture conservation practices and zinc fertilization did not show significant variation in the test weight of pearl millet.

4.2.5 Grain yield

Grain yield recorded after harvest of crop as influenced by various moisture conservation practices and zinc fertilization is presented in Table 4.6 and also graphically depicted in Fig. 4.6.

Moisture conservation practices: The results furnished in table 4.6 indicated that different moisture conservation practices had significant effect on grain yield. Significantly higher grain yield of 2511 kg/ha was recorded under stover mulch which registered a notable increase of 8.88, 18.89, and 31.81 kg/ha over pusa hydrogel, dust mulch and control respectively but remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: Data further presented in Table 4.6 and Fig. 4.6 showed that grain yield of pearlmillet increased significantly with successive increase in level of zinc upto 4 kg/ha (2470 kg/ha).The corresponding increase in terms of per cent was 9.97 and 26.40 over 2 kg Zn/ha and control. Further increase in level of zinc to 6 kg/ha produced the highest grain yield of 2486 kg/ha indicating an increase of 10.68 and 27.22 per cent over 2 kg Zn/ha and control, respectively. However, it was found statistically at par with 4 kg Zn/ha. Hence, 4 kg Zn/ha was the effective dose in terms of grain yield.

Interaction effect: The interaction between the moisture conservation practices and zinc fertilization showed non significant variation with respect to grain yield of pearlmillet.

4.2.6 Stover yield

Stover yield recorded after harvest of the pearl millet crop as influenced by moisture conservation practices and zinc fertilization are presented in Table 4.6 and also graphically depicted in Fig. 4.6.

Table: 4.6 Yield performance of pearlmillet as influced by moisture conservation practices and zinc fertilization

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Moisture conservation practices				
Control	1905	4595	6500	29.28
Dust mulch	2112	4975	7087	29.77
Pusa hydrogel	2306	5385	7691	29.96
Stover mulch	2511	5765	8276	30.31
Pusa hydrogel + stover mulch	2611	5895	8506	30.67
SEM±	60	123	184	0.65
CD (P=0.05)	173	351	525	1.85
Zinc levels (kg Zn/ha)				
0	1954	4694	6648	29.35
2	2246	5173	7419	30.23
4	2470	5675	8145	30.28
6	2486	5750	8236	30.14
SEM±	54	110	164	0.58
CD (P=0.05)	155	314	470	1.66
CV	9.01	8.01	8.02	7.47

NS = Non significant

Moisture conservation practices: The significant variation in stover yield of pearlmillet was observed due to different moisture conservation practices (Table 4.6). Stover mulch and pusa hydrogel + stover mulch increased the stover yield by 25.46 and 28.29 percent over control, respectively. However they remained at par with each other. Significantly, higher stover yield (5765 kg/ha) was obtained under stover mulch registering a significant increase of 7.05, 15.87 and 25.46 per cent over pusa hydrogel, dust mulch and control, respectively.

Zinc fertilization: Results further showed that different levels of zinc also led significant impact on stover yield of pearlmillet (Table 4.7 and Fig. 4.6). Significant response to applied zinc in terms of stover yield was observed upto 4 kg/ha (5675 kg/ha), whereas, the maximum stover yield of 5750 kg/ha was recorded at 6 kg/ha. Remaining at par with each other, these two levels of zinc fertilization enhanced the stover yield to an extent of 9.70 and 11.15 per cent over 2 kg/ha and 20.89 and 22.49 per cent over control, respectively.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on stover yield

4.2.7 Biological yield

Biological yield recorded after harvest of the pearlmillet crop as influenced by moisture conservation practices and zinc fertilization are presented in Table 4.6 and also graphically depicted in Fig. 4.6.

Moisture conservation practices: The results presented in table 4.6 indicated that different moisture conservation practices have significant effect on biological yield. Significantly higher biological yield (8276 kg/ha) was recorded under the treatment stover mulch with an increment of 7.60, 16.77 and 27.32 per cent over pusa hydrogel, dust mulch and control, respectively. However, stover mulch remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: A perusal of data (Table 4.6 and Fig. 4.5) pertaining to the effect of zinc levels on biological yield of pearlmillet revealed that every addition in level of zinc incurred significant enhancement in biological yield upto 4 kg/ha over preceding levels. It increased the biological yield in tune of 9.78 and 22.51 per cent over 2 kg Zn/ha and control, respectively. Application of zinc at 6 kg/ha also improved the biological yield to the extent of 11.01 and 23.88 per cent over 2 kg

Zn/ha and control, respectively but showed statistical similarity with 4 kg Zn/ha. Thus, 4 kg Zn/ha remained the most effective dose.

Interaction effect: The interaction between moisture conservation practices and zinc fertilization did not show significant variation in the biological yield of pearlmillet.

4.2.8 Harvest index

Data presented in Table 4.6 shows that harvest index of pearlmillet was not influenced significantly due to moisture conservation practices and zinc fertilization. However, higher and lowest harvest index was recorded under 4 kg Zn/ha and control respectively.

4.3 Nutrients concentration and total uptake by pearlmillet

Data regarding nitrogen, phosphorus, potassium and zinc concentration and uptake by grain and stover in pearlmillet at harvest are summarized in Table 4.7.

4.3.1 Nitrogen concentration in grain and stover

Moisture conservation practices: Data presented in Table 4.7 indicated that N concentration in grain and stover was significantly enhanced due to stover mulch over pusa hydrogel, dust mulch and control registering 11.26, 24.40 and 41.07 per cent more concentration of N in grain and 11.94, 27.11 and 78.57 in stover, respectively and it remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: Further examination of data presented in Table 4.7 revealed that the application of increasing levels of zinc increased the N concentration in grain and stover of pearlmillet but the significant increase was noted upto 4 kg/ha, only. This level of zinc increased the N concentration by 11.85 and 24.79 per cent in grain and 18.33 and 36.53 per cent in stover over 2 kg/ha and control, respectively. Further increase in Zn level to 6 kg/ha represented statistically similar nutrient concentration in grain and stover.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on nitrogen concentration in grain and stover of pearlmillet.

Table: 4.7 Effect of moisture conservation practices and zinc fertilization on nitrogen concentration, total uptake and protein content in grain of pearlmillet

Treatments	N concentration (%)		Total N uptake (kg/ha)	Protein content (%)
	Grain	Stover		
Moisture conservation practices				
Control	1.12	0.42	41.07	7.00
Dust mulch	1.27	0.59	56.78	7.93
Pusa hydrogel	1.42	0.67	69.57	8.87
Stover mulch	1.58	0.75	83.81	9.87
Pusa hydrogel + stover mulch	1.61	0.78	88.01	10.31
SEM±	0.04	0.02	2.13	0.23
CD (P=0.05)	0.11	0.05	6.11	0.67
Zinc levels (kg Zn/ha)				
0	1.21	0.52	48.87	7.56
2	1.35	0.60	62.40	8.44
4	1.51	0.71	78.91	9.44
6	1.56	0.75	83.30	9.75
SEM±	0.03	0.02	1.91	0.21
CD (P=0.05)	0.10	0.05	5.46	0.60
CV	9.17	10.14	10.81	9.17

4.3.2 Nitrogen uptake

Moisture conservation practices: Data presented in the Table 4.7 further reveals that application of stover mulch recorded significantly higher nitrogen uptake both in grain and stover over all treatments. Significantly higher uptake of 83.81 kg N/ha was recorded under stover mulch indicating an increase of 20.46, 47.60 and 104.06 per cent over pusa hydrogel, dust mulch and control, respectively and being at par with pusa hydrogel + stover mulch.

Zinc fertilization: Total uptake of N by crop registered profound increase due to increasing levels of zinc fertilization (Table 4.7 and Fig. 4.7). Application of zinc at 4 kg Zn/ha resulted significantly higher total nitrogen uptake of (78.91 kg N/ha) over 2 kg Zn/ha and control but remained at par with 6 kg/ha. The application of 4 kg Zn/ha improved the uptake of total N of 26.45 and 61.46 over 2 kg/ha and control, respectively.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on total nitrogen uptake of pearlmillet.

4.3.3 Protein content in grain

Moisture conservation practices: Protein content in pearlmillet grain also increased due to application of different moisture conservation practices (Table 4.7). The significantly higher protein content (9.87%) was recorded under application of stover mulch and remained at par with treatment pusa hydrogel + stover mulch. It increased the protein content by 11.27, 24.46 and 41.0 per cent over pusa hydrogel, dust mulch and control, respectively.

Zinc fertilization: Results showed that application of zinc at 4 kg Zn/ha significantly increased the protein content in grain over lower levels (Table 4.7). Application of 4 kg Zn/ha exhibited 9.43 per cent protein in grain thereby increasing it to the extent of 11.86 and 24.73 per cent over 2 kg/ha and control, respectively. Application of 6 kg Zn/ha remained at par with 4 kg Zn/ha and recorded corresponding increase of 15.65 and 28.96 per cent in protein content over 2 kg/ha and control, respectively.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on protein content of pearlmillet.

4.3.4 Phosphorus concentration in grain and stover

Moisture conservation practices: A reference to data presented in Table 4.8 indicated that P concentration in grain and stover of pearlmillet was significantly enhanced due to stover mulch over pusa hydrogel, dust mulch and control registering 8.33, 18.75 and 29.31 per cent more concentration of P in seed and 8.66, 18.96 and 31.42 per cent in stover, respectively and remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: It is further apparent from data pertaining to the effect of zinc fertilization on phosphorus concentration in grain and stover of pearlmillet was non- significant.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on phosphorus concentration in grain and stover of pearlmillet.

4.3.5 Phosphorus uptake

Moisture conservation practices: It is evident from the data presented in Table 4.8 that total phosphorus uptake in grain and stover at harvest was influenced statistically due to moisture conservation practices. The total phosphorus uptake was recorded significant due to application of stover mulch over all treatment except pusa hydrogel + stover mulch. Significantly higher total uptake of 14.12 kg P/ha was recorded under stover mulch indicating a significant increase of 17.08, 39.25 and 67.29 per cent over pusa hydrogel, dust mulch and control, respectively

Zinc fertilization: Total Phosphorus uptake was also found to be significantly improved due to zinc fertilization in pearlmillet. Application of zinc at 4 kg Zn/ha recorded total P uptake of 12.71 kg/ha that was 17.35 per cent higher than control and remained at par with 2 kg Zn/ha (Table 4.8).

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on total phosphorus uptake of pearlmillet.

Table: 4.8 Effect of moisture conservation practices and zinc fertilization on phosphorus concentration and total uptake by pearlmillet

Treatments	P concentration (%)		Total P uptake (kg/ha)
	Grain	Stover	
Moisture conservation practices			
Control	0.191	0.105	8.44
Dust mulch	0.208	0.116	10.14
Pusa hydrogel	0.228	0.127	12.06
Stover mulch	0.247	0.138	14.12
Pusa hydrogel + stover mulch	0.255	0.143	15.05
SEM±	0.006	0.003	0.33
CD (P=0.05)	0.016	0.009	0.96
Zinc levels (kg Zn/ha)			
0	0.231	0.132	10.83
2	0.229	0.129	11.95
4	0.224	0.124	12.71
6	0.219	0.118	12.36
SEM±	0.005	0.003	0.30
CD (P=0.05)	NS	NS	0.86
CV	8.635	9.009	9.70

4.3.6 Potassium concentration in grain and stover

Moisture conservation practices: A perusal of data showed that potassium concentration was enhanced significantly due to the application of stover mulch over pusa hydrogel, dust mulch and control by 8.14, 17.52 and 29.47 per cent in grain and 8.15, 27.40 and 46.16 per cent in stover, respectively (Table 4.9). However, it was remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: It is further apparent from data pertaining to the effect of zinc fertilization on potassium concentration in grain and stover of pearlmillet was non-significant.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on potassium concentration in grain and stover of pearlmillet.

4.3.7 Potassium uptake

Moisture conservation practices: Perusal of data (Table 4.9 and Fig. 4.7) showed that total K uptake was significantly enhanced due to the application of stover mulch. Application of stover mulch increased the total K uptake by 16.07, 46.43 and 81.40 per cent over pusa hydrogel, dust mulch and control, respectively. However, stover mulch was remained at par with treatment pusa hydrogel + stover mulch.

Zinc fertilization: A critical examination of the data in the Table 4.9 further shows that zinc fertilization @ 4 kg Zn/ha significantly increased total k uptake over all treatment except 6 kg Zn/ha. The magnitude of increase in total potassium uptake due to 4kg Zn/ha was to the extent of 12.04 and 38.74 per cent, over 2 kg Zn/ha and control respectively.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on total potassium uptake of pearlmillet.

Table: 4.9 Effect of moisture conservation practices and zinc fertilization on potassium concentration and total uptake by pearlmillet

Treatments	K concentration (%)		Total K uptake (kg/ha)
	Grain	Stover	
Moisture conservation practices			
Control	0.492	1.107	60.50
Dust mulch	0.542	1.270	74.95
Pusa hydrogel	0.589	1.496	94.55
Stover mulch	0.637	1.618	109.75
Pusa hydrogel + stover mulch	0.648	1.695	116.83
SEM±	0.015	0.040	2.71
CD (P=0.05)	0.043	0.113	7.75
Zinc levels (kg Zn/ha)			
0	0.536	1.297	72.32
2	0.571	1.460	89.55
4	0.594	1.486	100.34
6	0.627	1.508	103.68
SEM±	0.014	0.035	2.42
CD (P=0.05)	NS	NS	6.93
CV	9.027	9.537	10.25

4.3.8 Zinc concentration in grain and stover

Moisture conservation practices: A perusal of data showed that zinc concentration was enhanced significantly due to the application of stover mulch over pusa hydrogel, dust mulch and control by 8.05, 16.33 and 26.72 per cent in grain and 7.87, 16.72 and 27.60 per cent in stover, respectively (Table 4.10) and remained at par with pusa hydrogel + stover mulch.

Zinc fertilization: A further reference of data showed that application of zinc at 4 kg/ha significantly increased the Zn concentration in grain and stover of pearlmillet over 2 kg Zn/ha and control but it was found at par with 6 kg/ha (Table 4.11). The highest concentration in grain (37.97 ppm) and stover (26.05 ppm) were noted under 6 kg Zn/ha. Application of zinc at 4 kg Zn/ha increased the zinc concentration by 11.62 and 29.34 per cent in grain and 12.09 and 27.64 per cent in straw over 2 kg Zn/ha and control, respectively.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on zinc concentration in grain and stover of pearlmillet.

4.3.9 Zinc uptake

Moisture conservation practices: Perusal of data (Table 4.10) showed that application of stover mulch had recorded significantly higher total zinc uptake over all treatment except pusa hydrogel + stover mulch. Application of stover mulch increased the total zinc uptake by 16.32, 36.43 and 62.72 per cent over pusa hydrogel, dust mulch and control, respectively.

Zinc fertilization: A critical examination of the data in the Table 4.10 further shows that zinc fertilization @ 4 kg Zn/ha significantly increased total zinc uptake over 2 kg Zn/ha and control but remains at par with 6 kg Zn/ha. Application of zinc at 4 and 6 kg/ha increased the uptake of zinc by 22.89 and 28.71 kg/ha over 2 kg/ha and 57.77 and 65.24 kg/ha over control, respectively.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on zinc uptake of pearlmillet.

Table: 4.10 Effect of moisture conservation practices and zinc fertilization on Zinc concentration and total uptake by pearlmillet

Treatments	Zn concentration (ppm)		Zn uptake (g/ha)
	Grain	Stover	
Moisture conservation practices			
Control	29.11	19.85	148.02
Dust mulch	31.71	21.70	176.54
Pusa hydrogel	34.14	23.48	207.06
Stover mulch	36.89	25.33	240.86
Pusa hydrogel + stover mulch	37.95	26.21	255.94
SEM±	0.90	0.57	6.51
CD (P=0.05)	2.58	1.64	18.63
Zinc levels (kg Zn/ha)			
0	28.35	19.68	149.21
2	32.85	22.41	191.56
4	36.67	25.12	235.41
6	37.97	26.05	246.56
SEM±	0.81	0.51	5.82
CD (P=0.05)	2.31	1.47	16.67
CV	9.20	8.52	10.96

4.4 Economic evaluation

The regional adaptability of any agronomic practices in any crop is mainly based on the highest economic return of the treatment. Therefore, it is necessary to work out economics of different treatments for valid comparison of agronomic practices and for sound recommendation.

Sometimes, the most effective treatment may become poorer when tested on the basis of economics. The details of income, total expenses, benefit cost ratio (BCR) for the treatment combinations have been worked out and presented in Table 4.11. It is also graphically presented in Fig. 4.8.

4.4.1 Net return

Moisture conservation practices: There was an appreciable increase in net return due to moisture conservation practices as shown in Table 4.11 and Fig. 4.8. Stover mulch was found the most remunerative among all the treatments. It fetched the maximum net returns of ₹ 41117/ha thereby increasing net returns by 25.17, 33.49 and 45.37 per cent over pusa hydrogel, dust mulch and control, respectively.

Zinc fertilization: Examination of data presented in Table 4.11 and Fig. 4.8 indicated that every increase in level of zinc resulted in significantly highest net returns over preceding level upto 4 kg/ha. It fetched the net returns of ₹ 38347/ha, thereby increasing by 15.98 and 42.14 over 2 kg Zn/ha and unfertilized control. Further increase in level of zinc to 6 kg/ha recorded the highest net returns (₹ 38586/ha) indicating an increase of 16.71 and 40.02 per cent over 2 kg/ha and control, respectively. However, it was found statistically at par with 4 kg Zn/ha.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect on net returns of pearlmillet.

4.4.2 Benefit : Cost ratio

Moisture conservation practices: There was an appreciable increase in cost benefit ratio due to moisture conservation practices as shown in Table 4.11. The maximum cost benefit ratio of was recorded under treatment stover mulch (2.80) and it was followed by treatment pusa hydrogel + stover mulch (2.37). The lowest benefit cost benefit ratio of 1.24 was observed under treatment pusa hydrogel.

Table: 4.11 Effect of moisture conservation practices and zinc fertilization on net returns and B:C ratio of pearlmillet

Treatments	Net returns (₹/ha)	B:C ratio
Moisture conservation practices		
Control	28283	2.32
Dust mulch	30801	2.30
Pusa hydrogel	32847	2.24
Stover mulch	41117	2.80
Pusa hydrogel + stover mulch	38167	2.37
SEM±	724	0.03
CD (P=0.05)	2073	0.08
Zinc levels (kg Zn/ha)		
0	26978	2.14
2	33061	2.37
4	38347	2.56
6	38586	2.55
SEM±	648	0.02
CD (P=0.05)	1854	0.07
CV	7.01	6.72

Zinc fertilization: It is further evident from data presented in Table 4.11 revealed that successive addition in graded levels of zinc resulted in significantly higher B: C ratio upto 4 kg/ha over lower level. The highest B: C ratio (2.56) was recorded at 4 kg Zn/ha which was at par with 6 kg Zn/ha.

Interaction effect: An examination of data on interaction effect revealed that the interaction between moisture conservation practices and zinc fertilization did not have significant effect in B : C ratio on of pearlmillet.

4.5 CORRELATION AND REGRESSION STUDIES

To study the relationship of yield attributes and yield, simple correlation and linear regression equations were worked out between seed yield and dry matter accumulation at harvest, total tillers/plant, number of effective tillers/plant, test weight and total nitrogen, phosphorus, potassium and zinc uptake (Table 4.12).

Correlation coefficient study revealed that the yield was significantly and positively correlated with dry matter accumulation, total tiller/plant, number of effective tillers/plant, test weight, total nitrogen, phosphorus, potassium and zinc uptake. The corresponding values for correlation coefficients were 0.991, 0.992, 0.988, 0.981, 0.988, 0.990, 0.911, 0.982, 0.992 respectively. The regression equations show that with the unit increase in dry matter, total tillers/plant, effective tillers/pod, grains/ear, test weight, total nitrogen, phosphorus and potassium and zinc uptake, the corresponding grain yield increased by 15.16, 451.86, 723.13, 2.26, 353.45, 14.57, 120.22, 13.40 and 5.97, respectively.

Table 4.12 Correlation coefficients and linear regression equations showing relationship between grain yield of pearlmillet (kg/ha) and independent variables (X)

S. No.	Independent variables (X)	Correlation coefficients (r)	Regression equations ($Y=a+b_{yx}{\cdot}X$)
1	Dry matter accumulation at harvest	0.991**	$Y= -128.41+15.16\ X_1$
2.	Total tillers/plant	0.992**	$Y= 332.43+451.86\ X_2$
3.	Number of effective tillers	0.988**	$Y= 410.67+723.13\ X_3$
4.	Number of grain/ ear	0.981**	$Y= 297.30+2.26\ X_4$
5.	Test weight (g)	0.988**	$Y= -156.02+353.45\ X_5$
6.	Total N uptake(kg/ha)	0.990**	$Y= 1293.07+14.57\ X_6$
7.	Total P uptake (kg/ha)	0.911**	$Y= 851.18+120.22\ X_7$
8.	Total K uptake (kg/ha)	0.982**	$Y= 1063.34+13.40\ X_8$
9.	Total Zn uptake (g/ha)	0.992**	$Y= 1061.13+5.97\ X_9$

** Significant at 1% level of significance

Chapter-5

DISCUSSION

A brief discussion on results obtained from the present investigation entitled, “Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]” has been presented in this chapter. The results of field experiment presented in the preceding chapter have been critically discussed here. It has been attempted to establish cause and affect relationship in light of variable evidences and literature. Moisture conservation practices and zinc fertilization play a vital role in increasing production of crop.

For the sake of convenience to derive valid conclusions, the discussion has been divided under the following heads:

5.1 EFFECT OF MOISTURE CONSERVATION PRACTICES

5.2 EFFECT OF ZINC FERTILIZATION

5.3 INTERACTION EFFECT OF MOISTURE CONSERVATION PRACTICES AND ZINC FERTILIZATION

5.4 EFFECT ON ECONOMICS

5.1 EFFECT OF MOISTURE CONSERVATION PRACTICES

5.1.1 Effect on growth attributes

Results revealed (Table 4.1) that different moisture conservation practices did not show their significant influence on plant stand recorded at 20 DAS and at harvest. The data (Table 4.2 and Fig.4.1) on plant height indicated that it was non significantly influenced by different moisture conservation practices at 30 DAS, may be attributed to the slow growing habit of the crop at its initial stage of growth but significantly influenced at 60 DAS and at harvest. Significantly taller plants (149.60 and 173.74 cm at 60 DAS and at harvest, respectively) were observed under the treatment stover mulch which was at par with pusa hydrogel + stover mulch. The data presented in table 4.3 revealed that dry matter accumulation of pearlmillet per metre row length recorded at 30, 60 DAS and at harvest was found significant due to moisture conservation practices. Significantly higher dry matter accumulation of 21.50, 129.97 and 173.05 g/m row length was recorded in treatment stover mulch at 30, 60 DAS and at harvest, respectively which was at par with pusa hydrogel + stover mulch. Results given in table 4.4 indicated that all the moisture conservation practices significantly increased the total number of tillers/plant over control at harvest. Among the moisture conservation practices on average significantly higher number of tillers/plant (4.77) recorded at harvest under treatment stover mulch.

Soil moisture stress is a major limiting factor in determining the growth and yield of pearlmillet. The application of stover mulch lead to better plant growth by changing the microclimate by conserving more moisture through reducing evaporation, altering soil temperature, reduces weed flora and thus economizing the use of irrigation water. Because of this there might be increased moisture availability for longer duration, which in turn might have resulted in the better growth and development of the plants grown under the application of stover mulch. Verma (2002) recorded significantly higher values under application of organic mulches over dust mulch with respect to plant height, dry matter accumulation per metre row and total tillers per plant at 60 DAS and at harvest. The improvement in growth parameters of pearlmillet and chickpea planted under residue applied moisture management practices might be due to that residue cover helped to conserve soil moisture available through rainfall (Mulumba and Lal, 2008) and continuously provided to the needs of crops. Rapid decomposition of organic residue helped in greater availability of nutrients and suppressing weed growth, hence depletion of nutrient and moisture is checked which led to increase in growth and yield attributes and finally the grain yield. Similar findings were also reported by Kumar and Gautam (2004) in pearlmillet and Parihar *et al*., (2012) in pearlmillet - mustard.

Adequate availability of moisture to plants resulted in cell turgidity and eventually high meristematic activity, leading to more foliage development, greater photosynthetic activity and consequently higher growth and development. Moreover, applied residue as moisture management practice also enhanced the nutrient supply through decomposition of organic residue coupled with favourable moisture condition created conducive environment for plant growth and development (Dass *et al*., 2013).

Application of hydrogel influenced all growth parameters *viz.*, plant height, tillers production and dry matter accumulation at all the growth stages. It may be due to vegetative growth of plant is mainly consists of formation of somatic cells which result in growth and development of new leaves, stem and root and these meristmatic tissues have a very active protein metabolism and photosynthate transported to these site are used predominantly in the synthesis of nucleic acid and protein. Hydrogel have been reported to increase the activity of cell division, cell expansion and cell elongation, ultimately leading to an increased plant height. Similar results have been reported by Al-Harbi *et al*., (1996) in cucumber.

In the present investigation, significant increase in plant height, dry matter accumulation and number of tillers/plant were noticed due to soil application of pusa hydrogel. This increase in plant height, dry matter accumulation and number of tillers/plant was due to more retention of moisture and its longer availability to crop, where it might have helped to increase the activity of cell division, expansion and elongation, ultimately leading to increased growth attributes. Similar results have been reported by Sivalapan (2001) in soybean.

The dry matter production increased as the growth progressed and the maximum value was observed at harvest. Polymers improve water holding capacity and nutrient supplying capacity of soil which ultimately improve growth and dry matter production of plants (El-Hady *et al.,* 1981). Significantly higher dry matter production value was recorded under pusa hydrogel applied treatment over control and dust mulch at all stages of crop. This suggested that super absorbent polymer resulted in increased dry matter production, LAI, CGR, RGR and NAR and finally resulted in increased yield. Dry matter production is an indication of the overall utilization of resources and better light interception. El-Salmawi (2007) reported that increase in dry matter production was due to increase in carbohydrates, proteins, total amino acids and other biochemical and physiological parameters especially in presence of hydrogel polymer. Similarly, a significant increase in dry matter production due to hydrogel polymer was reported by Wang *et al*., (2001) in canola, Akhter *et al*., (2004) in barley and wheat and Yazdani *et al*., (2007) in soybean.

5.1.2 Effect on yield attributes and yield

The results pertaining to number of effective tillers/plant, grains/ ear, length of ear, test weight, grain, stover, & biological yields and harvest index (Tables 4.4 to 4.6) indicated that all moisture conservation practices were significantly better than control in increasing yield attributes and yield of pearlmillet. The result revealed that treatment stover mulch recorded significantly higher values of effective tillers/plant, number of grains/ear, length of ear, test weight, than control, dust mulch and pusa hydrogel but remained at par with pusa hydrogel + stover mulch.

The increased in yield attributes as result of application of mulch could be explained on the basis of highly beneficial effect of mulching on the yield contributing characters *viz.*, effective tillers/plant, number of grains/ear and test weight. Verma (2002) for increase in 1000-grain weight, grain and stover yield of pearlmillet under application of mulching. Number of grains/ear, ear length and thousand grain weights were significantly higher with mulching treatments than control (Table 4.5), because mulch being a barrier to evaporation loss and maintained more moisture in the soil, which supported large number of productive tillers and enabled them to bear more grains. Similar results have been reported by Huang *et al*. (2005) in wheat. The superiority of mulches over control could be assigned to their effectiveness in reducing the evaporation losses by creating obstacle in external evaporativity and energy supply to evaporating site by cutting of solar radiation falling on the earth surface. Higher harvest index was recorded in stover mulch (30.31%) compare to control (29.28%) (Table 4.6). Harvest index improved due to better growth and increase in grain yield which was result of improved moisture availability.

Thus, the improvement in yield attributes of pearlmillet under mulching practices could be ascribed to better availability of moisture and moderation of soil temperature which led to greater uptake of nutrients and reduced number of days taken to meet the required heat units for proper growth and development of plant and ultimately the yield attributes. The greater effectiveness of stover mulching may be due to its greater efficiency in adding nutrients in soil through decomposition of stover by suppressing weed growth, hence, depletion of nutrient and moisture is checked, thereby, making more moisture and nutrients available to crop plants. Thus, ultimately increase in plant growth leading to development in more tillers/plant and number of grains as compared to other mulch treatments.

Dust mulching also proved superior to control for number of tillers/plant and grains/ear. The favourable effect of dust mulching is due to breakdown of capillaries in the soil so that the evaporation losses were minimized. The weeds of the first flush were simultaneously removed due to dust mulching resulting in less depletion of nutrient and moisture. Thereby, making more moisture and nutrients available to crop plants.

Grain yield, stover yield and biological yield increased significantly due to mulching practices over no mulch (Table 4.6). The beneficial effect of organic mulch on grain yield might be due to favourable soil moisture regime and its better utilization in production of larger number of grains possible by reducing flower abortion, maintenance of a steady flux of assimilates during grain filling, reducing the rate of leaf senescence and maintenance of photosynthetic activity of surviving leaves and enhanced remobilization of pre anthesis assimilates to seed during grain filling. Extended period of moisture availability and lower weed incidence due to organic mulch resulted in a higher dry mattet accumulation and thereby, higher stover and biological yield. Similar finding were reported by Verma (2002) in pearlmillet and Sekhon *et al.* (2005) in soyabean.

An increase in growth and yield related attributes in the present study could be because of comparatively longer availability of water and indirectly nutrients supplied by the pusa hydrogel polymer to the plant under water stress condition, which in turn lead to better translocation of water, nutrients and photoassimilates and finally better plant development. Similar results of incorporating superabsorbent polymer into the soil on yield have been reported by Sivapalan (2006) in soybean and El-Hady *et al.* (1981) in cucumber under water stress condition. The increase in the crop yield parameters and crop yield might be due to the fact that hydrogel application increased the availability of water in root zone at early stage of crop. Hydrogels when hydrated transformed themselves into water-laden gel 'chunks' and these gel chunks acted as local water reservoirs which perhaps helped in initial establishment of crop and resulted in better crop growth. Kant *et al.,* (2008) also reported the improvement in crop parameters under water stress conditions with the application of hydrogel substrate in bean.

The increase in number of grains per ear under hydrogel applied treatment might be the result of better assimilation of carbohydrate in the ear. Hydrogel have been reported to increase the activity of cell division, cell expansion and cell elongation, ultimately leading to an increased plant height. Similar results have been reported by Sivalapan (2001) in soybean and Kumaran *et al*., (2001) in tomato. Application of hydrogel enhanced plant height, tillers/m^2, function leaves, leaf area and leaf area index indicating higher chlorophilic area improving photosynthetic efficiency of plant which in turn resulted in a higher crop yield. Crop yield is the sum total effect of the overall growth. The favourable improvements in yield attributes with above moisture management practices might be due to the favourable effect of these practices on growth through adequate supply of moisture, leading to greater nutrient uptake, efficient partitioning of metabolites and adequate accumulation and translocation of photosynthates resulted in improved yield attributes (Ramesh and Devasenapathy, 2008; Paliwal *et al*., 2011 and Tetarwal *et a*l., 2012).

5.1.3 Effect on nutrient concentration and total uptake

Stover mulching exhibited significant increase in nitrogen, phosphorus, potassium and zinc content in grain and stover as well as nitrogen, phosphorus, potassium and zinc uptake by grain and stover which was at par with pusa hydrogel + stover mulch. Tetarwal and Rana (2006) reported that application of stover mulch recorded significantly higher nutrient uptake. The improvement in nutrient content under residue applied treatments could be ascribed to favourable moisture condition in the soil maintained for relatively longer period and improvement in available nutrient status of soil through decomposition of crop residues. Thus, the favourable moisture condition and improved nutritional environment led to higher translocation and assimilation of nutrients to grain and stover (Singh and Rana, 2006 in mustard – lentil, Shiva *et al*., 2007 in sorghum, Sharma *et al*., 2010 in maize and Paliwal *et al.,* 2011in soybean - wheat).

The improvement in protein content has been observed in the present investigation, because of increased N content in grain which attributed to increased availability of nitrogen in the soil due to longer moisture availability and decomposition of crop residue. Higher nitrogen in grain is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. These results are in agreement with the findings of Meena *et al*., (2006) in chickpea and Parihar *et al.,* (2009) in pearlmillet - mustard. Since, uptake of the nutrient is the function of nutrient content and biomass production, the significant increase in content of macro and micro nutrients coupled with increased grain and stover yield under moisture management practices enhanced the total uptake of these nutrients. Sharma *et al*., (2010) in maize, Singh *et al*., (2011) in maize - wheat and Kumari and Prasad (2014) in rice also reported similar kind of findings.

Mulching improved the efficient use of water resource thus phosphorous and potassium absorption by plant directly depends on the concentration of the soil solution. It was easily absorbed and reduces the nitrogen losses to reduce evapotranspiration. Thus, mulching enhance absorption that ultimately increased uptake. Singh and Yadav (2006) also reported that incorporation of rice residue led to higher nitrogen uptake, which showed an increase of 15 and 19 percent more over rice residue removed and rice residue retained. Phosphorous and potassium absorption by plant directly depends on the concentration of the soil solution. Thus mulching enhances absorption that ultimately increased uptake.

Hydrogel had positive correlation with nitrogen and it is needed for the formation of chlorophyll, phosphorus for the synthesis of nucleic acid and similarly potassium is important for the growth and elongation probably due to its function as an osmotic regulator and may react synergistically with indole acetic acid which is responsible for growth and development and hydrogel improve their uptake. So growth and development of plants depends on proper availability of nutrients and water. Hydrogel have been reported to conserve moisture to increase the activity of cell division, cell expansion and cell elongation, ultimately leading to an increased value of growth attributes. Similar results have been reported by Al-Harbi *et al.* (1996) in cucumber, Sivalapan (2001) in soybean and Sendur Kumaran *et al.* (2001) in tomato.

5.1.4 Effect on economics

Economics is the major consideration for the farmers, while taking a decision regarding the adoption of any technology. Hence, net return and cost benefit ratio were worked out for moisture conservation practices and zinc fertilization

Pearlmillet planted under stover mulch fetched significantly higher net returns (₹ 41117) than the other treatment. Higher net returns of pearlmillet under stover mulch might be due to more returns from higher grain yield (Table 4.11) as compared to cost involved under this treatment. Similar results were obtained by Tatarwal and Rana (2006) in pearlmillet.

5.2. EFFECT OF ZINC FERTILIZATION

5.2.1 Effect on growth attributes

Zinc fertilization with 4 and 6 kg Zn/ha being at par with each other, proved significantly better over control and 2 kg Zn/ha in terms of growth parameters (plant height, dry matter accumulation and total number of tillers), (Table 4.1- 4.6). Zinc is also an essential component of enzymes responsible for assimilation of nitrogen which help in chlorophyll formation and plays an important role in nitrogen metabolism, might contribute towards increased growth and development of plant. The improvement in growth parameters with zinc fertilization were also reported by Jakhar *et al*., (2006) in pearlmillet, Badiyala and Chopra (2011) in maize - linseed, Gupta and Sahu (2012) in chickpea and Singh and Bhati (2013) lentil. The residual effect of zinc fertilization on growth of crops were also observed by Jain and Dahama (2005) in pearlmillet - wheat and Sammauria and Yadav (2008) in pearlmillet and Singh *et al.* (2013) in lentil.

5.2.2 Effect on yield attributes and yield

The considerable improvement in yield attributes *viz.,* number of effective tillers, number of grains/ear, weight of ear, length of ear and test weight were observed due to zinc fertilization. Increasing levels of zinc fertilization up to 4.0 kg Zn/ha significantly increased the number of grain, and 1,000- grain weight, grain yield (2470 kg/ha), stover yield (5675 kg/ha) and biological yield (8145 kg/ha) of pearlmillet. As discussed earlier that zinc plays an important role in nitrogen metabolism and formation of chlorophyll and carbohydrate, which maintain photosynthetic activity for longer period. Further, the increase might be owing to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting. Similar findings were also reported by Mehta *et al*., (2008) in pearlmillet, Pratap *et al*., (2008) in pearlmillet and Jyothi *et al*., in soybean (2013). Application of 6.0 kg Zn/ha remained at par with 4 kg Zn/ha and recorded higher grain, stover and biological yield of pearlmillet (Table 4.6).

Zinc plays an important role in nitrogen metabolism and formation of chlorophyll and carbohydrate, which leads to maintain photosynthetic activity for longer period and finally results in increasing the yield and yield attributes of the crop (Mehta *et al*., 2008) in pearlmillet.

5.2.3 Effect on nutrient concentration and total uptake

Data presented in table 4.7-4.10 indicated that nitrogen, phosphorus, potassium and zinc concentration in grain and stover at harvest was influenced significantly due to zinc fertilization. Protein content, N and K content in both grain and stover and total uptake of P and Zn were increased significantly up to 4.0 kg Zn/ha which was at par with 6 kg Zn/ha. The improvement in protein content by zinc fertilization ascribed to the role of Zn in nitrogen metabolism and protein synthesis. Jakhar *et al*., (2006) in pearlmillet, Yadav *et al*., (2010) in chickpea, Jyothi *et al*., (2013) in soybean, Chauhan *et a*l., (2014) in wheat and Shivay *et a*l., (2014) in chickpea were also reported similar findings.

The increase in content of nitrogen and potassium might be due to the beneficial role of Zn in increasing CEC of roots which helped in increasing absorption of nutrients from the soil. Further, the beneficial role of Zn in chlorophyll formation, regulating auxin concentration and its stimulatory effect on most of the physiological and metabolic process of plant, might have also helped to plants in absorption of greater amount of nutrients from the soil and finely translocation and assimilation into the grain and stover of the crop (Jakhar *et al*., 2006 in pearlmillet, Abrol *et al*., 2007 in maize – mustard, Singh and Bhati, 2013 in lentil).

The increased Zn content attributed to greater absorption of Zn by the crop owing to higher availability in soil due to direct addition of zinc otherwise the soil was deficit in available zinc. The increase in content of zinc was also reported by Meena *et al.* (2005) in chickpea, Chaube *et al*. (2007) in pearlmillet - wheat and Sharma and Abrol (2007) in chickpea. Application of zinc to deficient soil increased the availability of zinc in rhizosphere at a level below where the optimum requirement of crop is fulfilled. Thus, the favourable effect of zinc on photosynthesis and metabolic processes augmented the production of photosynthates and their translocation to different plant parts including grain, which ultimately increased the concentration of nutrients in the grain and stover. Similar results were also reported by Sammaria and Yadav (2008) in fenugreek and Upadhay *et a*l., (2012) in mustard.

Since, uptake of the nutrient is the function of nutrient content and biomass production, the significant increase in content of above nutrients (N, K and Zn) coupled with increased grain and stover yield under zinc applied treatments enhanced the total uptake of these nutrients (Jain and and Dahama, 2005 in wheat – pearlmillet, Jakhar *et al.*, 2006 in pearlmillet, Gupta and Sahu, 2012 in chickpea, Jyothi *et al*., 2013 in soybean and Shivay *et al*., 2014 in chickpea).

In contrast to N, K and Zn, content of P was decreased with increasing levels of zinc fertilization to pearlmillet. The decrease in phosphorus content with increasing levels of zinc might be due to the antagonistic effect of Zn and P in soils forming insoluble compounds, $Zn_3(PO_4)_2$ resulting in the low amount of P in the available pool and ultimately reduced the translocation of P from roots to the tops. Such types of findings were also reported by Sharma and Abrol (2007) in chickpea and Keram *et al*., (2012).

5.2.4 Effect on economics

Zinc fertilization treatments showed significant effect on economics of pearlmillet. Application of 4.0 kg Zn/ha to pearlmillet being at par with 6 kg Zn/ha, gave significantly higher net returns (₹ 38347) and B:C ratio (2.56) over control and 2 kg Zn/ha. Economic parameters *viz.*, gross returns, net returns and B : C ratio increased with zinc application and maximized at highest level of 4 kg Zn/ha. It might be attributed to increased grain and stover yields with zinc application. The value of increased yield was much more than the cost of zinc application which increased the net returns and B: C ratio. On the basis of result, 4 kg Zn/ha earned maximum net returns which was found 15.98 and 42.14 per cent more than the net returns obtained at 2.0 and control kg Zn/ha, respectively. These results corroborate to the findings of Jakhar *et al*., (2006) and Sharma *et al*., (2008).

5.3 INTERACTION EFFECT OF MOISTURE CONSERVATION PRACTICES AND ZINC FERTILIZATION

The interaction effect between moisture conservation practices and zinc fertilization failed to show their significant effect with respect to growth attributes, yield attributes, nutrient concentration and their uptake and economic at harvest.

Chapter-6

SUMMARY AND CONCLUSION

Results of the field experiment entitled "Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]" conducted during *kharif* season, 2017 at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) presented and discussed in the preceding chapters are summarized as under in this chapter.

The results presented and discussed in preceding chapters are summarized here under three major heads.

1. EFFECT OF MOISTURE CONSERVATION PRACTICES
2. EFFECT OF ZINC FERTILIZATION
3. INTERACTION EFFECT OF MOISTURE CONSERVATION PRACTICES AND ZINC FERTILIZATION

6.1 Effect of moisture conservation practices

6.1.1 Effect on growth attributes

1. Plant stand/ m row length of pearlmillet recorded at 20 DAS and at harvest showed non-significant difference due to moisture conservation practices.
2. Application of stover mulch significantly increased the growth characters like periodical plant height at 60 DAS and at harvest, dry matter accumulation/m row length recorded at 30, 60 DAS and at harvest and total tillers/plant of pearlmillet recorded at harvest, as compared to control, dust mulch and pusa hydrogel but remained at par with pusa hydrogel + stover mulch. Whereas at 30 DAS plant height parameters influenced non significantly.

6.1.2 Effect on yield attributes and yield

1. All yield attributes *viz.,* number of effective tillers/plant, number of grains/ear, length of ear, test weight were remarkably improved by moisture conservation practices. These values were significantly higher under

treatment stover mulch than control, dust mulch and pusa hydrogel but remained at par with pusa hydrogel + stover mulch.

2. The significantly higher grain yield (2511 kg/ha), stover yield (5765 kg/ha), test weight (7.49) and biological yield (8276 kg/ha) were recorded under the treatment stover mulch. However the improvement in grain yield was at the extent of 31.80, 18.89 and 8.89 per cent under the treatment stover mulch as compared to control, dust mulch and pusa hydrogel.
3. Harvest index were not significantly influenced by different moisture conservation practices.

6.1.3 Effect on nutrient concentration and their total uptake

1. Moisture conservation practices have significant influence on nitrogen, phosphorus, potassium and zinc concentration in plant.
2. The highest nitrogen, phosphorus, potassium and zinc in grain and stover were recorded under treatment stover mulch at harvest that was significantly higher over control, dust mulch and pusa hydrogel but remained at par with pusa hydrogel + stover mulch.

6.1.4 Effect on economics

1. The highest net return ₹ 41117 per hectare was recorded under treatment stover mulch which was significantly higher than all moisture conservation practices.
2. The maximum benefit : cost ratio of 2.80 was recorded under treatment stover mulch over all the treatments and it was followed by treatment pusa hydrogel + stover mulch with benefit cost ratio of 2.36.

6.2 Effect of zinc fertilization

6.2.1 Effect on growth attributes

1. Plant population of pearlmillet recorded at 20 DAS and at harvest showed non-significant difference due to zinc fertilization.
2. Growth parameters like periodical plant height and dry matter accumulation per meter row length recorded at 60 DAS and at harvest were significantly

influenced due to zinc fertilization, whereas at 30 DAS plant height parameters influenced non significantly. Similarly, total tillers/plant of pearlmillet recorded at harvest was significantly influenced due to zinc fertilization. The growth parameters were found significantly higher under the treatment Zn_2 (4 kg Zn/ha) than control and 2 kg Zn/ha which was at par with treatment Zn_3 (6 kg Zn/ha).

6.2.2 Effect on yield attributes and yield

1. Significantly higher number of effective tillers/plant, grains/ear, length of ear were observed under treatment Zn_2 (4 kg Zn/ha) than Zn_0 (control) and Zn_1 (2 kg Zn/ha). It was remained at par with treatment Zn_3 (6 kg Zn/ha).
2. Significantly highest grain (2470 kg/ha) stover (5675 kg/ha) and biological (8145 kg/ha) yields and test weight (7.29 g) were observed under treatment Zn_2 (4 kg Zn/ha) which was at par with treatment Zn_3 (6 kg Zn/ha).
3. Harvest index were not significantly influenced by different zinc levels.

6.2.3 Effect on nutrient concentration and total uptake

1. Zinc fertilization had significant influence on total uptake of nitrogen, phosphorus, potassium and zinc concentration at harvest.
2. The highest total N, P, K and Zn uptake at harvest recorded under treatment Z_2 (4 kg Zn/ha) which was at par with treatment Z_3 (6 kg Zn/ha).

6.2.4 Effect on economics

1. The significantly higher net returns ₹ 38347 /ha was accrued under treatment Zn_2 (4 kg Zn/ha) and it was remained at par with treatment Zn_3 (6 kg Zn/ha).
2. The treatment Zn_2 (4 kg Zn/ha) gave maximum benefit: cost ratio (2.56) which was at par with treatment Zn_3 (6 kg Zn/ha).

6.3 Interaction effect of moisture conservation practices and zinc fertilization

The combined interaction effect of moisture conservation practices and zinc fertilization failed to show their significant effect with respect to growth attributes, yield attributes, nutrient concentration and their uptake and economics.

CONCLUSION

In view of the results obtained from the present investigation, it is concluded that: -

Application of stover mulch and 4 kg Zn/ha proved to be the most superior treatment with regard to performance of pearlmillet. The use of stover mulch and 4 kg Zn/ha also fetched significantly higher net return and B : C ratio as compared to other treatments.

1. Application of stover mulch @ 5 t/ha proved to be the most suitable moisture conservation practice as it provided grain yield (2511kg/ha), net returns (₹ 41117 /ha), BCR (2.80) from pearlmillet (RHB-173) which was comparable to yield obtained under pusa hydrogel + stover mulch.
2. Application of 4 kg Zn/ha is superior to obtained significantly higher grain yield (2470 kg/ha), net return (₹ 38347/ha) and B : C ratio (2.56) of pearlmillet.

FUTURE LINE OF WORK

The following suggestions are made for future line of work on the basis of present findings.

- In order to obtain precision in research, large scale field trials should be arranged for evaluating consistency and applicability of the conclusive recommendation for farmers.
- Other new moisture conservation practices should be tested to validate present results and to compare their effectiveness in moisture conservation.

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Effect of Moisture Conservation Practices and Zinc Fertilization on Growth, Yield and Quality of Pearlmillet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz]

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ABSTRACT

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif*, 2017 on loamy sand soil. The twenty treatment combinations consisting of 5 moisture conservation practices (control, dust mulch, pusa hydrogel, stover mulch, pusa hydrogel + stover mulch) and 4 zinc fertilization levels (control, 2, 4, 6 kg/ha) were tested in randomized block design with three replications.

Results showed that the moisture conservation practices and zinc fertilization brought considerable improvement in growth, yield and quality of pearlmillet. Among moisture conservation practices stover mulch proved significantly superior to control, dust mulch, pusa hydrogel with respect to growth attributes (plant height, dry matter accumulation, total number of tillers) and remained at par with pusa hydrogel + stover mulch. The yield attributes (number of effective tillers/plant, number of grain/ear and length of ear), and grain yield (2511), stover yield (5765) and biological yields (8276) were also significantly higher under the treatment stover mulch over control, dust mulch, pusa hydrogel but remained at par with pusa hydrogel + stover mulch. The stover mulch recorded significantly higher N, P, K and Zn concentration and uptake than control, dust mulch, and pusa hydrogel. Significantly higher net returns (₹ 35352/ha) and B:C ratio (2.80) were achieved under treatment stover mulch over rest of the treatments.

Results further indicated that plant height, dry matter accumulation, total number of tillers per plant, effective tillers per plant, ear length, number of grains per ear, test weight, grain, stover and biological yield, harvest index, Zn concentration and uptake in plant, net returns and B:C ratio significantly increased with zinc fertilization @ 4 kg Zn/ha over control which remained at par with 6 kg Zn/ha. The net return and B:C ratio attained with 4 kg Zn/ha practice were ₹ 38347/ha and 2.56, respectively.

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बाजरा [*पेनीसेटम ग्लुकम* (एल.) आर. बीआर. इमेण्ड स्टन्ट्ज] की वृद्धि, उपज पर नमी संरक्षण प्रक्रियाओं एवं जिंक उर्वरीकरण का प्रभाव

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अनुक्षेपण

श्री कर्ण नरेन्द्र कृषि महाविद्यालय, जोबनेर (राजस्थान) के सस्य विज्ञान प्रक्षेप की दोमट बलुई मृदा पर खरीफ, 2017 में एक प्रयोग संपन्न किया गया। बीस उपचार संयोजन के अन्तर्गत पाूच नमी संरक्षण पद्वतियों (नियंत्रण, मृदा पलवार, पुसा हाइड्रोजेल, भूसा पलवार, पूसा हाइड्रोजेल + भूसा पलवार) तथा चार जिंक स्तर (नियंत्रण, 2, 4 एवं 6 कि.ग्रा./है.) के अभिकार्य समुच्चयों को तीन पुनरावृत्तियों के साथ यादृच्छिक भूखण्ड में संयोजित किया गया।

परिणामों ने दर्शाया कि नमी संरक्षण पद्वतियों तथा जिंक उर्वरीकरण से बाजरा की वृद्वि, उपज एवं गुणवत्ता में महतवपूर्ण सुधार हुआ। नमी संरक्षण पद्धतियों में भूसा पलवार में वृद्धि कारक (पादप ऊँचाई, शुष्क पदार्थ संचयन, कुल कल्लों की संख्या) नियंत्रण, मृदा पलवार, पूसा हाइड्रोजेल की तुलना में सार्थक रूप से ज्यादा पाये गये लेकिन यह उपचार पुसा हाइड्रोजेज + भूसा पलवार के समतुल्य पाया गया।

उपज कारक (प्रति पादप प्रभावची कल्लों की संख्या, प्रति बाली में दानों की संख्या, बाली की लम्बाई और दानों उपज (2511 किग्रा./है.) कडबी उपज (5765 कि.ग्रा./है.) एवं जैविक उपज (8276 किग्रा./है.) भी भूसा पलवार में नियंत्रण मृदा पलवार एवं पूसा हाइड्रोजेल की तुलना में सार्थक वृद्धि पाये गई लेकिन पूसा हाइड्रोजेल + भूसा पलवार के समतुल्य पाया गया। भूसा पलवार के उपयोग से दाने एवं भूसे में नाइट्रोजन, फास्फोरस व पोटेशियम की मात्रा तथा इनके उद्ग्रहण में नियंत्रण, मृदा पलवार एवं पूसा हाइड्रोजेल की तुलना में सार्थक वृद्धि हुई। सार्थक रूप से शुद्ध लाभ (₹ 35352/है.) और लाभ : लागत अनुपात (2.89) बाकी उपचारों की बजाय भूसा उपचार में प्राप्त किया गया।

परिणामों से आगे ज्ञात हुआ कि पादप ऊँचाई, शुष्क पदार्थ संचयन, प्रति पादप कुल कल्लों की संख्या,/पति पादप प्रभावी कल्लों की संख्या, बाली की लम्बाई, प्रति बाली दानों की संख्या, परीक्षण भार, उपज, कबड़ी की मात्रा, जैविक उपज, कटाई सूचकांक, पादप में जिंक की मात्रा एवं इसका उद्ग्रहण, शुद्व लाभ एवं लाभ : लागत अनुपात 4 किग्रा. जिंक/है. में कटाई सूचकांक, पादप में जिंक की मात्रा एवं इसका उद्ग्रहण, शुद्व लाभ एवं लाभ : लागत अनुपात 4 किग्रा जिंक/है. में नियंत्रण एवं 2 किग्रा जिंक प्रति हैक्टेयर की तुलना में सार्थक वृद्वि हुई जो कि 4 किग्रा/जिंक /प्रति हैं. जो कि 6 किग्रा जिंक/है. के समतुल्य था। 4 किग्रा जिंक/है. के अभ्यास के साथ लाभ ₹ 38347 प्रति है. एवं लाभ : लागत अनुपात 2.56 था।

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* कृषि स्नातकोत्तर छात्रा (सस्य विज्ञान विभाग), श्री कर्ण नरेन्द्र कृषि महाविद्यालय, जोबनेर (राजस्थान)

** कृषि मे स्नाकोत्तर उपाधि प्राप्ती की आंशिक आवश्यकता की पूर्ति के लिए वर्तमान शोधकार्य **डॉ. बी. एल. दुदवाल,** सहआचार्य, सस्य विज्ञान विभाग श्री कर्ण नरेन्द्र कृषि महाविद्यालय, जोबनेर (राजस्थान) परिसर जोबनेर में निर्देशन में प्रस्तुत किया गया।

ANNEXURE - I

Analysis of variance (MSS) for plant stand/m row length

Source of variation	d.f.	Mean sum of squares	
		20 DAS	At harvest
R	2	0.934	0.899
M	4	0.060	0.068
Zn	3	0.081	0.150
M x Zn	12	0.000	0.000
Error	38	0.387	0.373

* Significant at 5% level of significance

ANNEXURE - II

Analysis of variance (MSS) for plant height (cm)

Source of variation	d.f.	Mean sum of squares		
		30 DAS	60 DAS	At harvest
R	2	216.403	268.205	350.330
M	4	12.153	3236.834*	4504.167*
Zn	3	11.779	2756.656*	5199.195*
M x Zn	12	0.003	7.962	15.535
Error	38	11.799	156.011	213.531

* Significant at 5% level of significance

ANNEXURE – III

Analysis of variance (MSS) for dry matter accumulation

(g/m row length)

Source of variation	d.f.	Mean sum of squares		
		30 DAS	60 DAS	At harvest
R	2	4.742	195.684	357.748
M	4	112.537*	2740.536*	4132.691*
Zn	3	115.029*	2655.983*	4143.607*
M x Zn	12	0.592	8.556	11.220
Error	38	3.268	122.199	215.547

* Significant at 5% level of significance

ANNEXURE - IV

Analysis of variance (MSS) for total tillers and effective tillers/ plant

Source of variation	d.f.	Mean sum of squares	
		Tillers /plant	Effective tillers
R	2	0.253	0.088
M	4	4.021*	1.885*
Zn	3	5.491*	1.690*
M x Zn	12	0.020	0.008
Error	38	0.165	0.060

*Significant at 5% level of significance

ANNEXURE - V

Analysis of variance (MSS) for yield attributes of pearlmillet

Source of variation	d.f.	Mean sum of squares		
		Ear length/plant	No. of grain/ear	Test weight (g)
R	2	7.509	10103.276	0.674
M	4	102.077*	200051.794*	8.227*
Zn	3	78.433*	159343.582*	6.683*
M x Zn	12	0.262	681.751	0.019
Error	38	3.765	6912.167	0.406

* Significant at 5% level of significance

ANNEXURE - VI

Analysis of variance (MSS) for grain, stover, biological yield and harvest index

Source of variation	d.f.	Mean sum of squares			
		Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
R	2	75427.354	381070.793	677499.030	8.942
M	4	996126.000*	3532440.000*	8275626.000*	3.345
Zn	3	928220.000*	3621870.000*	8200050.000*	2.876
M x Zn	12	2941.185	7525.641	19820.780	0.001
Error	38	43734.196	180664.697	404206.305	5.018

* Significant at 5% level of significance

ANNEXURE - VII

Analysis of variance (MSS) for N concentration in grain and stover and total N uptake

Source of variation	d.f.	Mean sum of squares			
		N concentration (%)		Total N uptake	Protein content (%)
		Grain	Stover		
R	2	0.0207	0.0023	16.3957	0.8096
M	4	0.5704*	0.2598*	4843.7705*	22.2826*
Zn	3	0.3804*	0.1645*	3749.8902*	14.8584*
M x Zn	12	0.0018	0.0017	65.4182	0.0713
Error	38	0.0167	0.0043	54.6487	0.6511

*Significant at 5% level of significance

ANNEXURE -VIII

Analysis of variance (MSS) for P concentration in grain and stover and total P uptake

Source of variation	d.f.	Mean sum of squares		
		P concentration (%)		Total P uptake
		Grain	Stover	
R	2	0.0008	0.0001	0.8204
M	3	0.0085*	0.0029*	89.7360*
Zn	3	0.0004	0.0006	10.0279*
M x Zn	9	0.0000	0.0000	0.1069
Error	30	0.0004	0.0001	1.3467

*Significant at 5% level of significance

ANNEXURE - IX

Analysis of variance (MSS) for K concentration in grain and stover and total K uptake

Source of variation	d.f.	Mean sum of squares		
		K concentration (%)		Total K uptake (kg/ha)
		Grain	Stover	
R	2	0.0050	0.0136	36.9094
M	4	0.0526*	0.7234*	6775.0756*
Zn	3	0.0220	0.1378	2990.9983*
M x Zn	12	0.0001	0.0008	40.2424
R	2	0.0028	0.0188	87.9415

*Significant at 5% level of significance

ANNEXURE - X

Analysis of variance (MSS) for Zn concentration in grain and stover and total Zn uptake

Source of variation	d.f.	Mean sum of squares		
		Zn concentration (%)		Total Zn uptake (g/ha)
		Grain	Stover	
R	2	16.351	1.054	550.9244
M	4	159.367*	81.256*	23818.9215*
Zn	3	280.642*	123.853*	29715.0046*
M x Zn	12	0.646	0.309	279.7577
R	2	9.769	3.950	508.2894

*Significant at 5% level of significance

Annexure – XII

Cost of cultivation

A. Common cost

S. No.	Particulars	Inputs	Rate/unit (₹/ha)	Cost (₹/ha)
1.	Filed preparation			
i	Disk ploughing	Once	2000	2000
ii	Cross ploughing	Two	1000	2000
Iii	Planking	Twice	300	600
2.	Layout and preparation of seedbed	9 manday	242/	2178
3.	Uniform application of fertilizers			
	Urea	60 kg/ha	13/kg	780
	SSP	30 kg/ha	6/kg	180
5.	Seed treatment with bavistin (2 g/kg seed)	8 g/ha	126/100g	10
6.	Sowing of seeds by" *kera*' method	Bullock drawn plough	1500/ha	1500
7.	Thining, hoeing and weeding	9 manday	242/manday	2178
8.	Irrigation	One	1500/ha	1500
9.	Plant protection by monocrotophos	800 ml + 2 manday	285/500 ml	940
10.	Seed	4 kg/ha	70/kg	280
11.	Harvesting	11 manday	242/manday	2662
12.	Threshing and winnowing	10 manday	242/manday	2420
13.	Miscellaneous	-	-	1564
	Total			**20792**

B. Treatments cost (₹/ha)

A. Moisture conservation practices	Cost (₹/ha)
M_0	0
M_1	2280
M_2	5000
M_3	1500
M_4	6500
B. Zinc levels	
Control	0
2 kg Zn/ha	400
4 kg Zn/ha	760
6 kg Zn/ha	1120

C. Rate of inputs/operation

S.No.	Inputs/operation	Rates /units (₹/ha)
1	Disc ploughing	2000/ha
2	Ploughing	1000/ha
3	Labour charges	242/manday
4	Planking	300/ha
5	Cost of N through urea	13/kg
6	Cost of P_2O_5 through SSP	6/kg
7	Cost of pearlmillet seed	70/kg
8	Bavistin	126/100 g
9	Monocrotophos	285/500ml
10	Cost of stover mulch	300/t
11	Cost of pusa hydrogel	1666.67 kg/ha
12	Sale price of pearlmillet grain	1400/q
13	Sale price of pearlmillet stover	500/q

ANNEXURE – XIII

Comparative economics of various treatment combinations

Treatments combination	Common cost (₹/ha)	Treatments cost (₹/ha)	Total cost (₹/ha)	Yield (q/ha)		Value of produce (₹/ha)		Gross return (₹/ha)	Net returns (₹/ha)	B:C ratio
				Seed	Stover	Seed	Stover			
M_0Zn_0	20792	0	20792	1626.20	4052.03	22767	20260	43027	22235	2.07
M_0Zn_1	20792	400	21192	1869.21	4465.51	26169	22328	48497	27305	2.29
M_0Zn_2	20792	760	21552	2055.64	4898.86	28779	24494	53273	31721	2.47
M_0Zn_3	20792	1120	21912	2068.95	4963.60	28965	24818	53783	31871	2.45
M_1Zn_0	20792	2280	23072	1802.90	4387.12	25241	21936	47176	24104	2.04
M_1Zn_1	20792	2680	23472	2072.33	4834.81	29013	24174	53187	29715	2.27
M_1Zn_2	20792	3040	23832	2279.00	5303.99	31906	26520	58426	34594	2.45
M_1Zn_3	20792	3400	24192	2293.77	5374.08	32113	26870	58983	34791	2.44
M_2Zn_0	20792	5000	25792	1968.51	4748.67	27559	23743	51303	25511	1.99
M_2Zn_1	20792	5400	26192	2262.68	5233.25	31678	26166	57844	31652	2.21
M_2Zn_2	20792	5760	26552	2488.34	5741.10	34837	28705	63542	36990	2.39
M_2Zn_3	20792	6120	26912	2504.46	5816.97	35062	29085	64147	37235	2.38
M_3Zn_0	20792	1500	22292	2143.51	5083.77	30009	25419	55428	33136	2.49
M_3Zn_1	20792	1900	22692	2463.83	5602.54	34494	28013	62506	39814	2.75
M_3Zn_2	20792	2260	23052	2709.55	6146.23	37934	30731	68665	45613	2.98
M_3Zn_3	20792	2620	23412	2727.11	6227.46	38179	31137	69317	45905	2.96
M_4Zn_0	20792	6500	27292	2228.87	5198.41	31204	25992	57196	29904	2.10
M_4Zn_1	20792	6900	27692	2561.95	5728.88	35867	28644	64512	36820	2.33
M_4Zn_2	20792	7260	28052	2817.46	6284.83	39444	31424	70869	42817	2.53
M_4Zn_3	20792	7620	28412	2835.71	6367.88	39700	31839	71539	43127	2.52

Sale price of pearlmillet grain = ₹ 14/kg   Sale price of stover = ₹ 5/kg