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EFFECT OF MOISTURE CONSERVATION PRACTICES AND NANO FERTILIZER LEVELS ON GROWTH AND YIELD OF HYBRID MAIZE (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted at Soil Conservation and Water Management Farm, Chandra Shekhar Azad University of Agriculture and Technology Kanpur, during 2024 and 2025 to evaluate the effect of moisture conservation practices and fertility management involving nano fertilizers on the growth and yield of maize (*Zea mays* L.). The experiment was laid out in a split-plot design with four moisture conservation practices in the main plots: conventional tillage (M_1), minimum tillage (M_2), organic crop residue @ 4 t ha^{-1} (M_3), and hydrogel @ 5 kg ha^{-1} (M_4). Seven fertility levels comprising different combinations of recommended fertilizer dose (RDF) and foliar application of nano urea and nano zinc were assigned to subplots. The treatments included control (100% RDF), 50% RDF with two sprays of nano fertilizers at various concentrations (3, 4, and 5 ml l^{-1}), and 75% RDF with one spray of nano fertilizers at similar concentrations. The results indicated that moisture conservation practices significantly influenced the growth and yield of hybrid maize. Among the moisture conservation treatments, Hydrogel @ 5 kg ha^{-1} (M_4) recorded the highest plant height (215.70 cm), dry matter accumulation (318.34 g $plant^{-1}$), 1000-grain weight (267.75 g), grain yield (43.07 q ha^{-1}), stover yield (81.98 q ha^{-1}) and harvest index (34.36%), whereas the lowest values were recorded under Minimum tillage (M_2).Similarly, among fertility levels, 75% RDF + one spray each of nano urea and nano zinc @ 5 ml l^{-1} (F_7) produced the highest plant height (216.31 cm), dry matter accumulation (320.14 g $plant^{-1}$), 1000-grain weight (268.12 g), grain yield (44.12 q ha^{-1}), stover yield (83.67 q ha^{-1}) and harvest index (34.49%). The lowest values for all growth and yield parameters were observed under the Control treatment (F_1: RDF 120:60:40).

***Keywords*:** crop residue, Hybrid maize, hydrogel, grain yield, stover yield and harvest index, nano urea, nano zinc.

Introduction

The third-most important cereal crop in the world after rice and wheat is maize (*Zea mays* L.). Belonging to the grass family Gramineae (2n = 20), maize is often referred to as a "miracle crop" and the "queen of grains" due to its remarkable productivity (Ikramullah *et al*., 2011). Maize demonstrates efficient utilization of solar radiation compared to other cereals. Maize can be cultivated at an altitude of up to 3300 meters above sea level, spanning from 500 N to 400 S latitude, in temperate, sub-tropical and tropical regions worldwide. It thrives in various soil types, ranging from sandy loam to clay loam, with medium-textured soil having pH values between 6.5 and 7.5 considered most suitable for successful cultivation. Maize plants are monoecious and protandrous and the shedding of pollen is accelerated during hot and dry weather conditions. This versatile crop serves as a valuable resource for both food and non-food products, such as adhesive, vegetable oil, sweeteners, beverages, alcohol and bioethanol. Apart from expanding its industrial applications, enhancing maize productivity and improving its quality through agronomic methods are crucial in combating hunger and malnutrition. As far as maize adaptability to diverse soil types and climates, there is significant potential to increase current yields and create ample room for growth.

Achieving optimal maize production relies on the availability of essential macronutrients (such as N, P, K, Ca, Mg and S) and micronutrients (including Zn, B, Cu, Mn, Mo, Ni and Fe). While micronutrients are required in smaller quantities, they play an equally significant role in promoting plant growth and development (Alloway, 2004), as well as enhancing yield and quality (Bolach *et al*., 2008). Among these essential micronutrients, zinc holds vital importance for the growth and development of both crops and humans, as well as animals.

Nanotechnology is progressing from its initial experimental stage to becoming operational and practical, resulting in greater recognition and utilization of this technology in the agricultural sector (Baruah and Dutta, 2009). As a result, the controlled release of nutrients through the use of nano fertilizers emerges as a valuable strategy for advancing sustainable agriculture and nurturing a sustainable ecosystem (Cui *et al*., 2010).

Zinc plays a critical role in various metabolic reactions in plants, serving as an essential component of numerous enzymes. It contributes significantly to plant disease resistance, photosynthesis, cell wall integrity, protein synthesis, pollen formation (Gurmani *et al*., 2012) and enhances the activity of antioxidant enzymes and chlorophyll levels in plant tissues (Sbartai *et al*., 2011). Insufficient zinc levels not only hinder plant growth and yield but also have a significant impact on human health. More than 3 billion people worldwide suffer from iron and zinc deficiencies, particularly in regions where the population heavily relies on a limited diet based on cereal crops (Hafeez, 2013).

Following nitrogen (N), phosphorus (P) and potassium (K), zinc (Zn) is currently regarded as the fourth most significant nutrient that limits production in India. There is a significant yield loss due to Zn deficiency in 50 % of the soils used to grow maize in India alone (Singh, 2010). Zinc is a crucial component in the generation of biomass (Kaya and Higgs, 2002). In terms of micronutrient deficiencies, Zn and manganese (Mn) deficiency make plants more vulnerable to drought stress (Khan *et al*., 2003). Currently, there are only two acknowledged primary ways to address zinc deficiency. Although spraying inorganic salts on foliage has been demonstrated to be advantageous, the consequences are sometimes patchy since zinc only partially penetrates leaves. Throughout the period of canopy development, frequent treatments are also necessary. Example of using artificial chelates to remediate soil plants can also absorb and use Zn - EDTA, although this depends on the soil properties, mainly its pH and whether it has been limed or not. For a respectable amount of time, zinc deposition is prevented by zinc chelates based on EDDHA, which are stable in soil.

Globally, it is grown on 205.9 million hectares of land, producing 1236.8 million tonnes of grain with an average yield of 58.8 q/ha (FAO 2023). Global consumption of maize has grown at a compound annual growth rate (CAGR) of 2.3% over a period of 10 years increasing from 988.6 million MT in 2013 to 1236.8 million MT in 2023. Global exports grew at a decadal CAGR (2013-2023) of 5.1%, increasing from 122.8 million MT in 2013 to 202.1 million MT in 2023. The global consumption pattern of maize is: feed- 61%, food and industry - 22%. It has attained a position of industrial crop globally as 83% of its production used in feed, starch and bio-fuel industries (FICCI 2024).

India holds 4^{th} rank in terms of area and 7^{th} in terms of production of maize. In 2022-23, the maize production in India (28 m MT) has increased 16 times since 1950- 51 *i.e*. 1.73 m MT. Further, the average productivity of maize has also increased to 2965 kg/ha *i.e*. 5.42 times from 547 kg/ha (4). In India the predominant maize growing states which accounts for more than 80% of the total production are Andhra Pradesh (20.9), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%) and Himachal Pradesh (4.4%) (5). In India, 85% of maize is produced in the *Kharif* season and rest in other seasons).

Materials and Methods

Experimental Site and Soil Characteristics

The field experiment was conducted during the *kharif* season of 2024-2025.The experimentation was done at the Soil Conservation & Water Management Farm of the Chandra Shekhar Azad University of Agriculture & Technology located in Kanpur district is situated in the sub-tropical region of Uttar Pradesh in part of Gangetic alluvium, lying between the river Ganga and Yamuna. It covers 115 km from North to South and 105 km from East to West. It lies between 25^0 26' and 26^0 58' North latitude and 79^0 31' and 80^0 34' East longitude. The elevation of the farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur is approximately 125.9 meters above Mean Sea Level. The average rainfall of the district is about 800 mm. The major portion of rainfall is received during the monsoon season from the first week of July to the last week of September.

Experimental Design and Treatments

The experiment will be conducted using a Split Plot Design with three replications. Although the full experiment has factors like moisture conservation practice and fertility levels, this research conducted in 2024. A total of seven fertility levels treatments were studied:(A) Moisture Conservation practices - 4 (Main plot), M_1- Conventional tillage (two harrowing), M_2 - Minimum tillage (one cross ploughing), M_3 -Organic crop residue @ 4 tons per ha, M_4 -Hydrogel @ 5 kg/ha (B) Fertility Levels - 7 (Sub plot) F_1 - Control (RDF 120:60:40), F_2-50% RDF+ 2 spray each of nano urea and nano zinc @ 3ml/ltr each (35, 50 DAS), F_3-50% RDF+ 2 spray each of nano urea and nano zinc @ 4ml/ltr each (35, 50 DAS), F4-50% RDF+ 2 spray each of nano urea and nano zinc @ 5ml/ltr each (35 ,50 DAS), F_5 -75% RDF+ 1spray each of nano urea and nano zinc @ 3ml/ltr each (35 DAS), F6- 75% RDF+ 1spray each of nano urea and nano zinc @ 4ml/ltr each (35 DAS), F_7 -75% RDF+ 1spray each of nano urea and nano zinc @ 5ml/ltr each (35 DAS).

The dose of nitrogenous, phosphoric, and potassic fertilizer recommended for Maize was 120:60:40 kg/ha of N, P_2O_5, K_2O. A 1/3rd of the nitrogenous doses, along with the total phosphoric and potassic doses, were applied as a basal application, while the rest of the nitrogenous doses were applied in equal proportions during the tasseling and silking stages.

Observations recorded

The technique of representative sampling was adopted for recording the observation on various morphological characters in carrot. At every observation 5 plants from each net plots were selected at random were tagged properly to record the change in the morphological characters at different successive stages of growth. The first recording of observations was done 30 days after sowing and subsequent readings were taken after 30 days interval.

Plant height (cm)

The height of the plant was measured from the ground level to the tip of the leaves with the help of meter scale and their mean were calculating and expressed in cm.

Number of leaves plant^{-1}

The total number of leaves were counted from the tagged three plants than average per plant was worked out.

Dry matter accumulation (g)

Total dry matter production in leaf, stem and cob was recorded at 30 DAS and at harvest. Samples were dried at 65 ± 2 °C to attain constant weight and average dry weight was calculated and expressed in grams per plant.

1000-grain weight (g)

For 1000-grain weight sample of grains were taken from the produce of each plot. 1000-grain were counted and weighed on electronic balance.

Grain yield (q ha^{-1})

The yield of grain per plot was recorded in kilogram after threshing and finally converted in qha^{-1} for all the treatments.

Stover yield (q ha^{-1})

The yield of stover per plot was recorded in finally converted in q ha^{-1} for all the treatments.

Harvest Index (%)

Harvest index was calculated by the following formula.

$$HI\ (\%) = \frac{Grain\ Yield\ (q/ha)}{Biological\ yield\ (q/ha)}\ X\ 100$$

Result and Discussion

The data pertaining to evaluate the effect of moisture conservation practices and fertility management involving nano fertilizers on the growth and yield of maize (*Zea mays* L.).The result for growth and yield of maize (*Zea mays* L.) showed significant different for various treatment applied soil application of M_4- hydrogel 5 kg ha^{-1}. In general, plant height increased with the advancement of crop age up to the harvest. It is evident from the results obtained during both years that the plant height recorded at 30 DAS and at maturity was influenced significantly due to different moisture conservation practices during both years as well as pooled basis. The plant height was slightly higher at different growth stages in the second year of the field experimentation. At 30,60, 90 DAS and maturity stages, significantly higher plant height was recorded with the application of M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3 - Organic crop residue @ 4 tons ha^{-1} than the rest of the moisture conservation practices during both the years and pooled basis. The lowest plant height was noticed with treatment M_2- Minimum tillage (one cross ploughing) at all the stages during the study of both years and on a pooled basis. At maturity stages, the highest values were 214.70 cm and 213.64 cm in the year 2024 and 216.70 cm and215.64 cm in the year 2025, respectively. The lowest values were 201.35 and 203.35 cm recorded with the treatment M_2- Minimum tillage (one cross ploughing) in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum plant heigh (cm) was found in M_4- Hydrogel @ 5 kg ha^{-1} (215.70) followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} (214.64) and the lowest plant height was noticed with treatment M_2- Minimum tillage (one cross ploughing) (202.35 cm). Similar findings were also recorded by Song *et al.* (2000), Kayode and Ademiluyi (2004), Wasaya *et al.,* (2012)

Different fertility levels significantly influenced the plant height of maize at all stages during both the years and on a pooled basis. At 30 DAS and maturity stages, significantly higher plant height was recorded with the application of treatment of F_7 -75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each than the rest of the others fertility levels during both the years and pooled basis. The lowest plant height was noticed with treatment F_1 - Control (RDF120:60:40) at all the stages during the study of both years and on a pooled basis. At maturity stages, the highest values were 215.31 cm and 214.34 cm in the year 2024 and 217.31 cm and 216.34 cm in the year 2025, respectively. The lowest values 189.16 cm and 191.16 cm were recorded with treatment F_1- Control (120:60:40) in the years 2024 and 2025, respectively. On the pooled (two-year) basis, the maximum plant height (216.31 cm) was found in F_7 -75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each (215.34 cm) and the lowest plant height was noticed with F_1 - Control (RDF120:60:40) (190.16 cm). These results are in close conformity with the findings of Uma *et al*., 2019), Bala *et al*. (2019) Satdev *et al*. (2020), (Ajithkumar *et al*., (2021), Rajesh *et al*. (2021), Renu *et al*. (2023).

In general, the number of leaves plant^{-1} increased with the advancement of crop age up to harvest. It is evident from the results obtained during both years that the number of leaves plant^{-1}recorded at 30 DAS and at maturity stages was influenced significantly due to different moisture conservation practices during both years as well as a pooled basis. At 30, 60, 90 DAS and maturity stages, a significantly higher number of leaves plant^{-1} was recorded with treatment of M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} than the rest of the moisture conservation practices during both the years and pooled basis. The lowest number of leaves plant^{-1}was noticed with treatment M_2- Minimum tillage (one cross ploughing) at all the stages during the study of both years and on a pooled basis. At the maturity stages, the highest values were 14.58 and 14.15 in the year 2024 and 14.71 and 114.44 in the year 2025, respectively. The lowest values were 13.25 and 13.46 recorded with the treatment M_2- Minimum tillage (one cross ploughing) in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum number of leaves plant^{-1}(14.65) was found in M_4- Hydrogel @ 5 kg ha^{-1} followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1}(14.29) and the lowest number of leaves plant^{-1}was noticed with treatment M_2- Minimum tillage (one cross ploughing) (13.46). A similar result has also been reported by Aikins *et al.* (2012), Memon *et al.* (2013)

It is clear that fertility levels significantly influenced with respect to the number of leaves plant^{-1}of maize at all stages during both the years as well as pooled basis. At 30 DAS and maturity stages, significantly higher number of leaves plant^{-1} was recorded with treatment of F_7-75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each than the rest of the others fertility levels during both the years and pooled basis. The lowest number of leaves plant^{-1}was noticed with treatment F_1 - Control (RDF 120:60:40) at all stages during both the years and on a pooled basis. At the maturity stages, the highest values were 14.70 and 14.30 in the year of in the year of 2024 and 15.60 and 14.55 in the year of 2025, respectively. The lowest values 12.25 and 12.45 were recorded with treatment F_1 - Control (RDF120:60:40) in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum number of leaves plant^{-1} (15.15) was found in F_7 -75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each (14.42) and the lowest number of leaves plant^{-1} was noticed with F_1-Control (RDF120:60:40) (12.35). The results were in line with the observations by Uma *et al.* (2019), Deepak Sathyan (2022), Mahesh *et al.* (2022)

It is obvious that the dry matter accumulation plant^{-1} increased with the advancement of crop age up to harvest. It is evident from the results obtained during both years that the dry matter accumulation recorded at 30 DAS and at the maturity stage was influenced significantly due to different of moisture conservation practices during both years as well as a pooled basis. At the 30, 60, 90 DAS and maturity stages, a significantly higher dry matter accumulation was recorded with treatment of M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} than the rest of the moisture conservation practices during both the years and pooled basis. The lowest dry matter accumulation was noticed with treatment M_2 - Minimum tillage (one cross ploughing) at all the stages during the study of both years and on a pooled basis. At maturity stages, the highest values were 317.45 g and 304.84 g in the year 2024 and 319.24 g and 306.53 g in the year 2025, respectively. The lowest values were 291.87g and 293.61 g recorded with the treatment M_2- Minimum tillage (one cross ploughing) in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum dry matter accumulation $plant^{-1}$(318.34 g) was found in M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} (305.67 g) and the lowest dry matter accumulation was noticed with treatment M_2- Minimum tillage (one cross ploughing) (292.74 g). The dry matter production is the result of better plant growth as reported by Kumar and Angadi (2016), Shinoto *et al.* (2019)

Different fertility levels significantly influenced with respect to dry matter accumulation of maize at all stages during both the years as well as a pooled basis. At 30 DAS and maturity stages, a significantly higher dry matter accumulation $plant^{-1}$was recorded with treatment of F_7 -75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each than the rest of the others fertility levels during both the years and pooled basis. The lowest dry matter accumulation $plant^{-1}$ was noticed with treatment F_1-Control (RDF120:60:40) at all stages during both the years and on a pooled basis. At the maturity stages, the highest values were 319.21 g and 315.33 g in the year of in the year of 2024 and 321.08 g and 317.20 g in the year of 2025, respectively. The lowest values 232.97 g and 233.99 g were recorded with treatment F_1- Control (RDF 120:60:40) in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum dry matter accumulation $plant^{-1}$ (320.14) was found in F_7 -75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each(316.27 g) and the lowest dry matter accumulation $plant^{-1}$was noticed with F_1 - Control (RDF120:60:40) (233.48 g). The results were in line with the observations by Manikandan and Subramanian (2016), Bala *et al*. (2019), Sannathimmappa *et al*. (2023).

It is further evident from the results obtained during both years that 1000 grain weight recorded was influenced significantly due to different moisture conservation practices during both years as well as pooled basis. Significantly higher 1000 grain weight were recorded with treatment M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} than the rest of the moisture conservation practices during both the years and pooled basis. The lowest 1000 grain weight was noticed with treatment M_2- Minimum tillage (one cross ploughing) during the study of both years and on a pooled basis. The highest values were 266.75 g and 261.09 g in the year 2024 and 268.75 g and 263.66 g in the year 2025, respectively. The lowest values were recorded with the treatment 249.72 g and 252.58 g in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum 1000 grain weight (267.75 g) was found in M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3 - Organic crop residue @ 4 tons ha^{-1} (262.37 g) and the lowest 1000 grain weight was recorded with treatment M_2 - Minimum tillage (one cross ploughing) (251.15 g).

Different fertility levels significantly influenced with 1000 grain weight during both the years as well as a pooled basis. Significantly, higher 1000 grain weight were recorded with treatment of F_7 -75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each than the rest of the others fertility levels during both the years and pooled basis. The lowest value was noticed with treatment F_1 - Control (RDF120:60:40) during both years and on a pooled basis. The highest values were 267.17 g and 263.31 g in the year of 2024 and 269.07g and 265.32 g in the year of 2025, respectively. The lowest values 232.26 g and 234.26 g were recorded with treatment F_1 - Control (RDF 120:60:40) in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum 1000 grain weight (268.12 g) was found in in F_7 -75% RDF +1 spray each of nano urea and nano zinc of @ 5ml/litr each followed by treatment F_6 -75% RDF +1 spray each of nano urea and nano zinc of @ 4ml/litr each (264.31 g) and the lowest 1000 grain weight was noticed with F_1- Control (RDF 120:60:40) (233.26 g).

It is further evident from the results obtained during both years that grain yield was significantly influenced due to different moisture conservation practices during both years as well as on pooled basis. Significantly higher grain yield was recorded with treatment M_4- Hydrogel @ 5 kg ha^{-1} which was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} than the rest of the moisture conservation practices during both the years and pooled basis. The lowest grain yield was noticed with treatment M_2- Minimum tillage (one cross ploughing) during the study of both years and on a pooled basis. The highest values were 42.04 q ha^{-1} and 40.01 q ha^{-1} in the year 2024 and 44.10 q ha^{-1} and 42.09 q ha^{-1} in the year 2025, respectively. The lowest values were recorded with the treatment 36.51 q ha^{-1} and 38.39 q ha^{-1} in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum grain yield (43.07 q ha^{-1}) was found in M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} (41.05 q ha^{-1}) and the lowest grain yield was recorded with treatment M_2- Minimum tillage (one cross ploughing) (37.45 q ha^{-1}). Reported by Chaudhary *et al.,* (1985), found in their research that the yield and yield components were significantly increased by the application of increase in proper supply soil moisture.

Different fertility levels significantly influenced with grain yield during both the years as well as a pooled basis. Significantly, higher grain yield was recorded with treatment F_7 - 75% RDF + 1 spray each of nano urea and nano zinc @ 5 ml/ltr which was followed by treatment F_6- 75% RDF + 1 spray each of nano urea and nano zinc @ 4 ml/ltr than the rest of the fertility levels during both the years and pooled basis. The lowest grain yield was noticed with treatment F_1- Control (RDF 120:60:40) during both years and on a pooled basis. The highest values were 43.07 q ha^{-1} and 42.41 q ha^{-1} in the year 2024 and 45.15 q ha^{-1} and 44.47 q ha^{-1} in the year 2025, respectively. The lowest values were recorded with the treatment 31.17 q ha^{-1} and 33.25 q ha^{-1} in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum grain yield (44.12 q ha^{-1}) was found in F_7 - 75% RDF + 1 spray each of nano urea and nano zinc @ 5 ml/ltr was followed by F_6- 75% RDF + 1 spray each of nano urea and nano zinc @ 4 ml/ltr (43.44 q ha^{-1}) and the lowest grain yield was recorded with treatment F_1- Control (RDF 120:60:40) (32.21 q ha^{-1}). These findings agree with findings of Vijay (2022), Nandy *et al.* (2023), Ninama *et al.* (2023), Pathak *et al.* (2024), Vasanth *et al.* (2024).

It is further evident from the results obtained during both years that stover yield was significantly influenced due to different moisture conservation practices during both years as well as on pooled basis. Significantly higher stover yield was recorded with treatment M_4- Hydrogel @ 5 kg ha^{-1} which was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} than the rest of the moisture conservation practices during both the years and pooled basis. The lowest stover yield was noticed with treatment M_2- Minimum tillage (one cross ploughing) during the study of both years and on a pooled basis. The highest values were 80.42 q ha^{-1} and 78.37 q ha^{-1} in the year 2024 and 83.54 q ha^{-1} and 81.60 q ha^{-1} in the year 2025, respectively. The lowest values were recorded with the treatment 74.85 q ha^{-1} and 77.98 q ha^{-1} in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum stover yield (81.98 q ha^{-1}) was found in M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} (79.98 q ha^{-1}) and the lowest stover yield was recorded with treatment M_2- Minimum tillage (one cross ploughing) (76.41 q ha^{-1}). A similar finding result by Materechera and Mloza-Banda (1997)

Different fertility levels significantly influenced with stover yield during both the years as well as a pooled basis. Significantly higher grain yield was recorded with treatment F_7 -75% RDF + 1 spray each of nano urea and nano zinc @ 5 ml/ltr which was followed by treatment F_6 - 75% RDF + 1 spray each of nano urea and nano zinc @ 4 ml/ltr than the rest of the fertility levels during both the years and pooled basis. The lowest stover yield was noticed with treatment F_1- Control (RDF 120:60:40) during both years and on a pooled basis. The highest values were 82.14 q ha^{-1} and 81.51 q ha^{-1} in the year 2024 and 85.21 q ha^{-1} and 84.57 q ha^{-1} in the year 2025, respectively. The lowest values were recorded with the treatment 65.60 q ha^{-1} and 69.65 q ha^{-1} in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum stover yield (83.67 q ha^{-1}) was found in F_7 - 75% RDF + 1 spray each of nano urea and nano zinc @ 5 ml/ltr was followed by treatment F_6 - 75% RDF + 1 spray each of nano urea and nano zinc @ 4 ml/ltr (83.04 q ha^{-1}) and the lowest stover yield was recorded with treatment F_1- Control (RDF 120:60:40) (67.63 q ha^{-1}). These findings agree with findings of Pathak *et al.* (2024), Vasanth *et al.* (2024).

It is further evident from the results obtained during both years that harvest index was significantly influenced due to different moisture conservation practices during both years as well as on pooled basis. Significantly higher harvest index was recorded with treatment M_4- Hydrogel @ 5 kg ha^{-1} which was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} than the rest of the moisture conservation practices during both the years and pooled basis. The lowest harvest index was noticed with treatment M_2- Minimum tillage (one cross ploughing) during the study of both years and on a pooled basis. The highest values were 34.25% and 33.74% in the year 2024 and 34.47% and 33.97% in the year 2025, respectively. The lowest values were recorded with the treatment 32.76% and 32.96% in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum harvest index (34.36%) was found in M_4- Hydrogel @ 5 kg ha^{-1} was followed by treatment M_3- Organic crop residue @ 4 tons ha^{-1} (33.85%) and the lowest harvest index was recorded with treatment M_2- Minimum tillage (one cross ploughing) (32.86). These results are in complete agreement with those obtained by Mugendi *et al.* (2019)

Different fertility levels significantly influenced with during both the years as well as a pooled basis. Significantly higher harvest index was recorded with treatment F_7 -75% RDF + 1 spray each of nano urea and nano zinc @ 5 ml/ltr which was followed by treatment F_6 -75% RDF + 1 spray each of nano urea and nano zinc @ 4 ml/ltr than the rest of the fertility levels during both the years and pooled basis. The lowest harvest index was noticed with treatment F_1-Control (RDF 120:60:40) during the study of both years and on a pooled basis. The highest values were 34.37% and 34.20% in the year 2024 and 34.61% and 34.60% in the year 2025, respectively. The lowest values were recorded with the treatment 32.20% and 32.31% in the years 2024 and 2025, respectively. On the pooled two-year basis, the maximum harvest index (34.49%) was found in F_7- 75% RDF + 1 spray each of nano urea and nano zinc @ 5 ml/ltr was followed by treatment F_6 -75% RDF + 1 spray each of nano urea and nano zinc @ 4 ml/ltr(34.40%) and the lowest harvest index was recorded with treatment F_1- Control (RDF 120:60:40) (32.25%). Reported by Farnia and Omidi (2015), Rawi *et al.* (2021).

Conclusion

The result concluded that the application of Hydrogel @ 5 kg ha^{-1} coupled with 75% RDF along with one foliar spray each of nano urea and nano zinc @ 5 ml l^{-1} was the most effective treatment for improving growth and yield of hybrid maize under moisture stress conditions.

Table 1: Effect of moisture conservation practices and fertility levels on plant height at (30 DAS and at harvest stage) of hybrid maize

Treatments	Plant height (cm)					
	30 DAS			At harvest		
	2024	2025	Pooled	2024	2025	Pooled
(A)Moisture Conservation Practices (Main plot)						
M_1- Conventional tillage (two harrowing)	61.89	63.09	62.49	207.90	209.90	208.90
M_2- Minimum tillage (one cross ploughing)	59.17	60.29	59.73	201.35	203.35	202.35
M_3- Organic crop residue @4 tons ha^{-1}	63.39	64.66	64.03	213.64	215.64	214.64
M_4- Hydrogel @ 5kg ha^{-1}	65.05	66.23	65.64	214.70	216.70	215.70
SE (d)	1.14	1.16	1.15	3.91	3.94	3.92
CD at 5%	2.85	2.91	2.88	9.75	9.84	9.80
(B) Fertility levels (sub plot)						
F_1- Control (RDF 120:60:40)	60.88	61.92	61.40	189.16	191.16	190.16
F_2 -50% RDF +2 spray each of nano urea and nano zinc @3ml/ltr each (35, 50 DAS)	59.87	61.03	60.45	210.08	212.08	211.08
F_3- 50% RDF +2 spray each of nano urea and nano zinc @4ml/ltr each (35, 50 DAS)	61.00	62.17	61.58	211.13	213.13	212.13
F_4- 50% RDF +2 spray each of nano urea and nano zinc @5ml/ltr each (35, 50 DAS)	61.98	63.15	62.56	212.36	214.36	213.36
F_5 - 75% RDF +1 spray each of nano urea and nano zinc @3ml/ltr each (35 DAS)	63.06	64.24	63.65	213.42	215.42	214.42
F_6 - 75% RDF +1 spray each of nano urea and nano zinc @4ml/ltr each (35 DAS)	64.07	65.48	64.77	214.34	216.34	215.34
F_7 -75% RDF +1 spray each of nano urea and nano zinc @5ml/ltr each (35 DAS)	65.79	66.96	66.37	215.31	217.31	216.31
SE(d)	1.07	1.09	1.08	3.60	3.63	3.62
CD at 5%	2.17	2.21	2.19	7.26	7.33	7.30

Table 2: Effect of moisture conservation practices and fertility levels on No. of leaves $plant^{-1}$ (30 DAS and at harvest stage) of hybrid maize

Treatments	No. of leaves $plant^{-1}$					
	30 DAS			At harvest		
	2024	2025	Pooled	2024	2025	Pooled
(A)Moisture Conservation Practices (Main plot)						
M_1- Conventional tillage (two harrowing)	7.14	7.24	7.19	13.70	14.05	13.87
M_2- Minimum tillage (one cross ploughing)	6.87	6.97	6.92	13.25	13.67	13.46
M_3- Organic crop residue @4 tons ha^{-1}	7.20	7.31	7.25	14.15	14.44	14.29
M_4- Hydrogel @ 5kg ha^{-1}	7.38	7.47	7.43	14.58	14.71	14.65
SE (d)	0.12	0.13	0.13	0.26	0.26	0.26
CD at 5%	0.32	0.32	0.32	0.65	0.66	0.66

(B) Fertility levels (sub plot)						
F_1- Control (RDF 120:60:40)	7.05	7.15	7.10	12.25	12.45	12.35
F_2 - 50% RDF +2 spray each of nano urea and nano zinc @3ml/ltr each (35, 50 DAS)	6.85	6.95	6.90	13.90	14.11	13.99
F_3- 50% RDF +2 spray each of nano urea and nano zinc @4ml/ltr each (35, 50 DAS)	6.95	7.05	7.00	14	14.21	14.09
F_4- 50% RDF +2 spray each of nano urea and nano zinc @5ml/ltr each (35, 50 DAS)	7.07	7.17	7.12	14.10	14.30	14.20
F_5 - 75% RDF +1 spray each of nano urea and nano zinc @3ml/ltr each (35 DAS)	7.22	7.32	7.27	14.20	14.35	14.27
F_6 - 75% RDF +1 spray each of nano urea and nano zinc @4ml/ltr each (35 DAS)	7.32	7.42	7.37	14.30	14.55	14.42
F_7 - 75% RDF +1 spray each of nano urea and nano zinc @5ml/ltr each (35 DAS)	7.57	7.67	7.62	14.70	15.60	15.15
SE(d)	0.12	0.12	0.12	0.24	0.24	0.24
CD at 5%	0.25	0.25	0.25	0.48	0.49	0.48

Table 3: Effect of moisture conservation practices and fertility levels on dry matter Accumulation (30 DAS and at harvest) of hybrid maize

Treatments	Dry matter Accumulation (g plant^{-1})					
	30 DAS			At harvest		
	2024	2025	Pooled	2024	2025	Pooled
(A)Moisture Conservation Practices (Main plot)						
M_1- Conventional tillage (two harrowing)	13.37	14.19	13.98	296.24	297.99	297.11
M_2- Minimum tillage (one cross ploughing)	12.80	13.01	12.91	291.87	293.61	292.74
M_3- Organic crop residue @4 tons ha^{-1}	14.03	14.27	14.15	304.82	306.53	305.67
M_4- Hydrogel @ 5kg ha^{-1}	14.41	14.90	14.66	317.45	319.24	318.34
SE (d)	0.25	0.26	0.25	5.78	5.81	5.80
CD at 5%	0.63	0.65	0.64	14.43	14.51	14.47
(B) Fertility levels (sub plot)						
F_1- Control (RDF 120:60:40)	13.52	13.62	13.57	232.97	233.99	233.48
F_2 - 50% RDF +2 spray each of nano urea and nano zinc @3ml/ltr each (35, 50 DAS)	13.07	13.50	13.28	311.04	312.91	311.98
F_3- 50% RDF +2 spray each of nano urea and nano zinc @4ml/ltr each (35, 50 DAS)	13.32	13.72	13.52	312.30	314.17	313.23
F_4- 50% RDF +2 spray each of nano urea and nano zinc @5ml/ltr each (35, 50 DAS)	13.47	13.85	13.66	313.13	315	314.06
F_5 - 75% RDF +1 spray each of nano urea and nano zinc @3ml/ltr each (35 DAS)	13.60	13.95	13.77	314.17	316.05	315.11
F_6 - 75% RDF +1 spray each of nano urea and nano zinc @4ml/ltr each (35 DAS)	14.20	14.47	14.33	315.33	317.20	316.27
F_7 - 75% RDF +1 spray each of nano urea and nano zinc @5ml/ltr each (35 DAS)	15.07	15.57	15.32	319.21	321.08	320.14
SE(d)	0.23	0.24	0.24	5.20	5.24	5.22
CD at 5%	0.47	0.49	0.48	10.50	10.56	10.53

Table 4: Effect of moisture conservation practices and fertility levels on 1000 grain weight (g) of hybrid maize

Treatments	1000 grain weight (g)		
	2024	2025	Pooled
(A)Moisture Conservation Practices (Main plot)			
M_1- Conventional tillage (two harrowing)	253.97	254.49	254.23
M_2- Minimum tillage (one cross ploughing)	249.72	252.58	251.15
M_3- Organic crop residue @4 tons ha^{-1}	261.09	263.66	262.37
M_4- Hydrogel @ 5kg ha^{-1}	266.75	268.75	267.75
SE (d)	4.79	4.83	4.81
CD at 5%	11.96	12.05	12.01
(B) Fertility levels (sub plot)			
F_1- Control (RDF 120:60:40)	232.26	234.26	233.26
F_2 - 50% RDF +2 spray each of nano urea and nano zinc @3ml/ltr each (35, 50 DAS)	259.07	261.07	260.07
F_3- 50% RDF +2 spray each of nano urea and nano zinc @4ml/ltr each (35, 50 DAS)	260.07	262.08	261.07
F_4- 50% RDF +2 spray each of nano urea and nano zinc @5ml/ltr each (35, 50 DAS)	261.13	263.14	262.13
F_5 - 75% RDF +1 spray each of nano urea and nano zinc @3ml/ltr each (35 DAS)	262.17	264.17	263.17
F_6 - 75% RDF +1 spray each of nano urea and nano zinc @4ml/ltr each (35 DAS)	263.31	265.32	264.31
F_7 - 75% RDF +1 spray each of nano urea and nano zinc @5ml/ltr each (35 DAS)	267.17	269.07	268.12
SE(d)	4.45	4.47	4.46
CD at 5%	8.97	9.03	9.00

Table 5: Effect of moisture conservation practices and fertility levels on yield (q ha^{-1}) and Harvest Index (%) of hybrid maize

Treatments	Grain Yield (q ha^{-1})			Stover Yield (q ha^{-1})			Harvest Index (%)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
(A)Moisture Conservation Practices (Main plot)									
M$_1$- Conventional tillage (two harrowing)	38.61	40.61	39.61	77.03	80.31	78.67	33.34	33.94	33.64
M$_2$- Minimum tillage (one cross ploughing)	36.51	38.39	37.45	74.85	77.98	76.41	32.76	32.96	32.86
M$_3$- Organic crop residue @4 tons ha^{-1}	40.01	42.09	41.05	78.37	81.60	79.98	33.74	33.97	33.85
M$_4$- Hydrogel @ 5kg ha^{-1}	42.04	44.10	43.07	80.42	83.54	81.98	34.25	34.47	34.36
SE (d)	0.75	0.79	0.77	1.45	1.51	1.48	0.60	0.63	0.61
CD at 5%	1.88	1.97	1.93	3.63	3.76	3.70	N/A	N/A	N/A
(B) Fertility levels (sub plot)									
F$_1$- Control (RDF 120:60:40)	31.17	33.25	32.21	65.60	69.65	67.63	32.20	32.31	32.25
F$_2$ -50% RDF +2 spray each of nano urea and nano zinc @3ml/ltr each (35,50 DAS)	38.01	39.91	38.96	76.97	79.92	78.44	33.03	33.31	33.17
F$_3$- 50% RDF +2 spray each of nano urea and nano zinc @4ml/ltr each (35,50 DAS)	38.99	40.85	39.92	77.87	80.88	79.38	33.34	33.76	33.55
F$_4$- 50% RDF +2 spray each of nano urea and nano zinc @5ml/ltr each (35,50 DAS)	40.00	41.98	40.99	79.20	82.29	80.74	33.54	33.96	33.75
F$_5$ - 75% RDF +1 spray each of nano urea and nano zinc @3ml/ltr each (35 DAS)	41.40	43.45	42.43	80.38	83.49	81.94	33.97	34.28	34.12
F$_6$ - 75% RDF +1 spray each of nano urea and nano zinc @4ml/ltr each (35 DAS)	42.41	44.47	43.44	81.51	84.57	83.04	34.20	34.60	34.40
F$_7$ - 75% RDF +1 spray each of nano urea and nano zinc @5ml/ltr each (35 DAS)	43.07	45.15	44.12	82.14	85.21	83.67	34.37	34.61	34.49
SE(d)	0.67	0.70	0.69	1.33	1.39	1.36	0.58	0.56	0.57
CD at 5%	1.35	1.42	1.39	2.69	2.81	2.75	1.17	1.14	1.15

Plant height (cm)

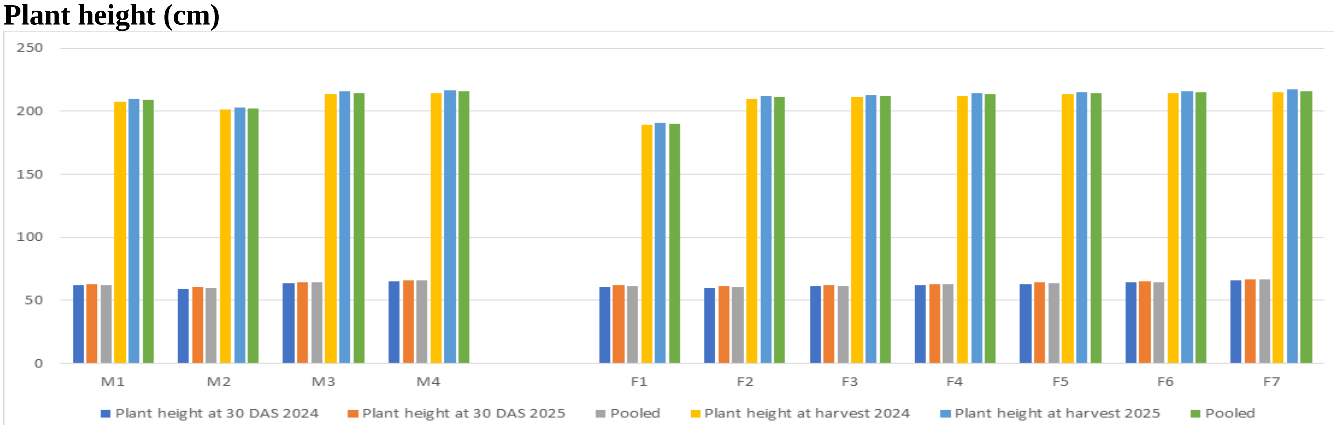

Fig. 1 : Effect of moisture conservation practices and fertility levels on plant height at (30 DAS and at harvest stage) of hybrid maize.

No. of leaves/plant

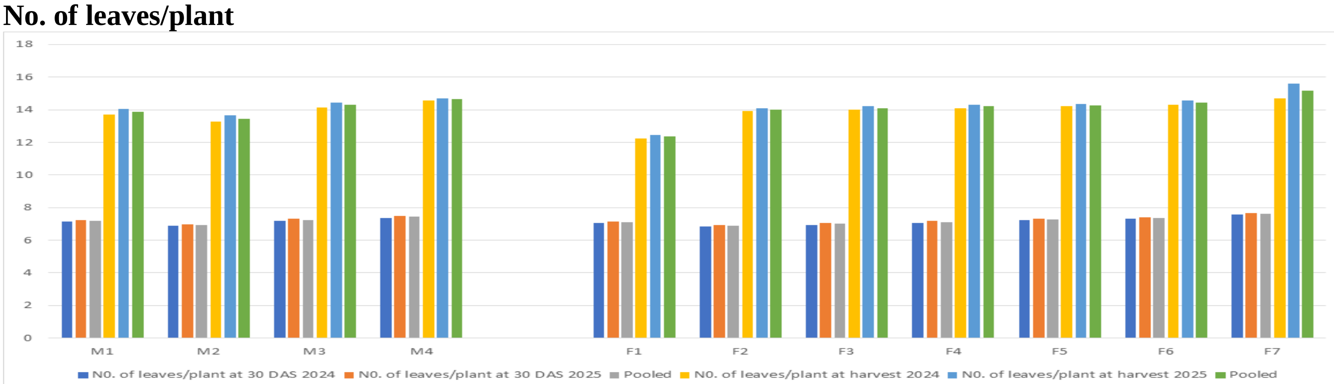

Fig. 2 : Effect of moisture conservation practices and fertility levels on No. of leaves plant^{-1} (30 DAS and at harvest stage) of hybrid maize

Dry matter accumulation (g)

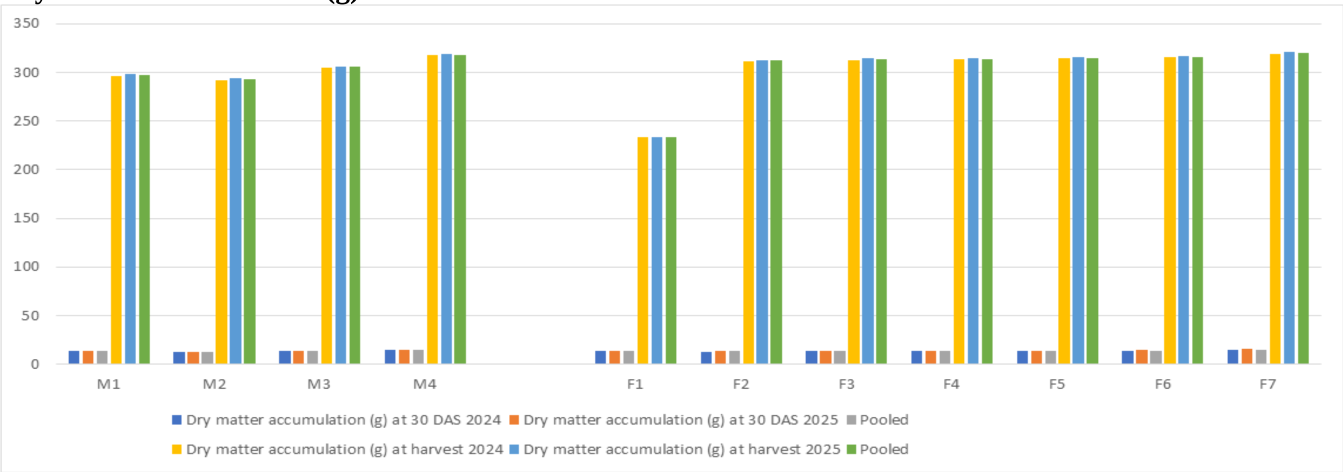

Fig. 3 : Effect of moisture conservation practices and fertility levels on dry matter Accumulation (30 DAS and at harvest) of hybrid maize

1000-grain weight (g)

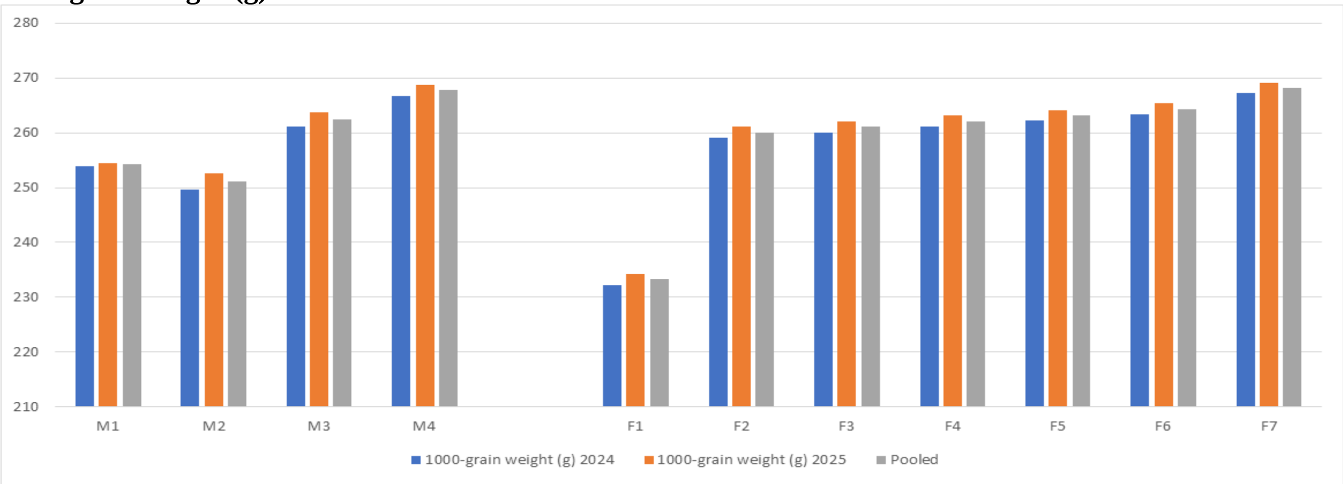

Fig. 4 : Effect of moisture conservation practices and fertility levels on 1000 grain weight (g) of hybrid maize

Yield (q/ha) and Harvest Index (%)

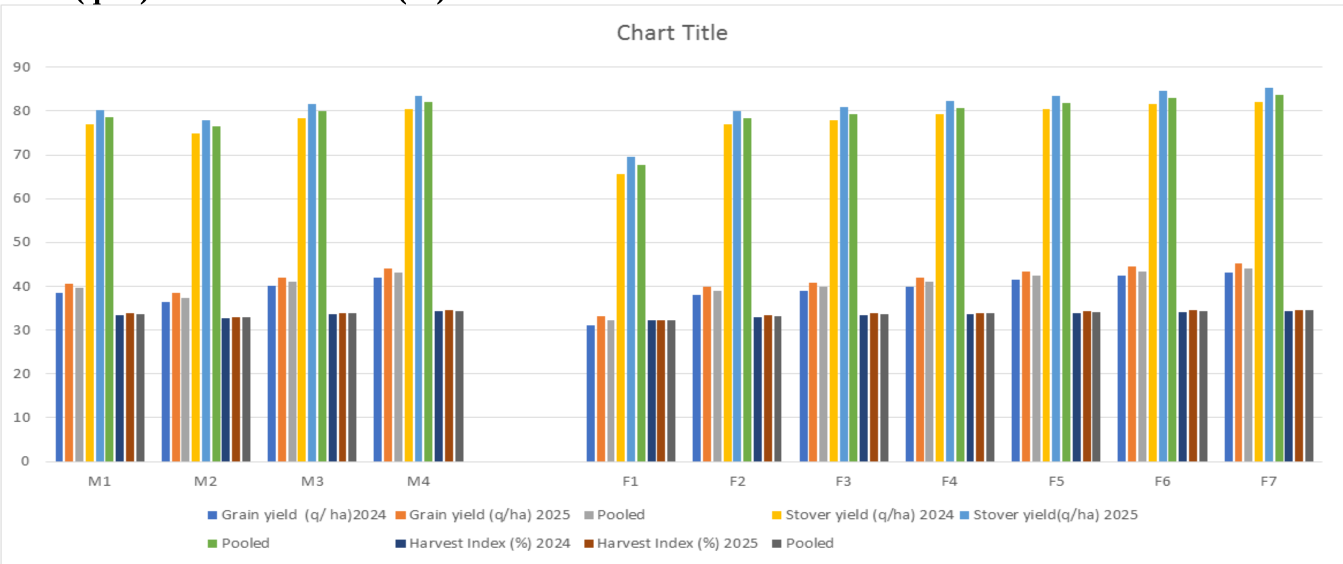

Fig. 5 : Effect of moisture conservation practices and fertility levels on yield (q ha^{-1}) and Harvest Index (%) of hybrid maize

References

Aikins, S. H. M., Afuakwa, J. J., & Owusu-Akuoko, O. (2012). Effect of four different tillage practices on maize performance under rain-fed conditions. *Agriculture and Biology Journal of North America*, ***3***(1), 25–30.

Ajithkumar, K., Kumar, Y., Savitha, A. S., Ajayakumar, M., Narayanaswamy, C., & Bhat, S. N. (2021). Effect of IFFCO nanofertilizer on growth, grain yield and managing turcicum leaf blight disease in maize. *International Journal of Plant and Soil Science*, ***33***(16), 19–28.

Alloway, B. J. (2008). *Zinc in soils and crop nutrition*. International Zinc Association. (Original work published 2004)

Bala, R., Kalia, A., & Dhaliwal, S. S. (2019). Evaluation of efficacy of ZnO nanoparticles as remedial zinc nano fertilizer for rice. *Journal of Soil Science and Plant Nutrition*, ***19***, 379–389.

Baruah, S., & Dutta, J. (2009). Nanotechnology applications in sensing and pollution degradation in agriculture. *Environmental Chemistry Letters*, ***7***, 191–204.

Bolach, Q. B., Chachar, Q. I., & Tareen, M. N. (2008). Effect of foliar application of macro and micro nutrients on production of green chilies (*Capsicum annuum* L.). *Journal of Agricultural Technology*, ***4***(2), 177–184.

Choudhary, P., Singh, D., Kaushik, M. K., Sharma, S. S., Jain, H. K., Saharan, V., & Chouhan, D. (2022). Production, productivity and quality of maize (*Zea mays* L.) as affected by foliar application of zinc-based nano-fertilizer and different fertility levels. *Journal of Pharmaceutical Innovation*, ***11***(2), 1878–1882.

Cui, H. X., Sun, C. J., Liu, Q., Jiang, J., & Gu, W. (2010). Applications of nanotechnology in agrochemical formulation: Perspectives, challenges and strategies. In *Proceedings of the International Conference on Nanoagriculture*. Sao Pedro, Brazil.

Deepak Sathyan. (2022). Effect of nano nutrients on pea growth and yield (*Pisum sativum* L.). *Journal of Pharmaceutical Innovation*, ***11***(9), 1895–1898.

FAOSTAT. (2023). *Food and Agriculture Organization of the United Nations*. https://www.fao.org/faostat/

Federation of Indian Chambers of Commerce & Industry. (2024). *The Indian maize sector: Trends, challenges & imperatives for sustainable growth*. https://www.ficci.in/study_details/24008

Farnia, A., & Omidi, M. M. (2015). Effect of nano-zinc chelate and nano-biofertilizer on yield and yield components of maize (*Zea mays* L.) under water stress condition. *Indian Journal of Natural Sciences*, ***5***(29), 4614–4624.

Gurmani, A. R., Khan, S. U., Andaleep, R., Waseem, K., & Khan, A. (2012). Soil application of zinc improves growth and yield of tomato. *International Journal of Agriculture and Biology*, ***14***(1).

Hafeez, B. (2013). Role of zinc in plant nutrition: A review. *American Journal of Experimental Agriculture*, ***3***(2), 374–391.

Ikramullah, Hussain, I., Noor, M., Kausar, M., Shah, N., Khalil, H., Noor, M., & Shah, M. (2011). Heterotic effects for yield and protein content in white quality protein maize. *Sarhad Journal of Agriculture*, ***27***(3).

Kaya, C., & Higgs, D. (2002). Response of tomato (*Lycopersicon esculentum*) culture at low zinc. *Scientia Horticulturae*, ***93***, 53–64.

Kayode, J., & Ademiluyi, B. (2004). Effect of tillage methods on weed control and maize performance in southwestern Nigeria. *Journal of Sustainable Agriculture*, ***23***(3), 39–45.

Khan, H. R., McDonald, G. K., & Rengel, Z. (2003). Zinc fertilization improves water use efficiency, grain yield and seed Zn content in chickpea. *Plant and Soil*, ***249***, 389–400.

Kumar, B. R. M., & Angadi, S. S. (2016). Influence of tillage, mulching and weed management practices on growth, yield and economics of maize. *Journal of Farm Sciences*, ***29***(2), 194–199.

Mahesh, R. H., Dayal, A., Nasakar, J., & Sharan, E. A. (2022). Effect of particle size and concentration of zinc oxide nanoparticles on growth, yield and yield attributing traits of maize (*Zea mays* L.). *International Journal of Novel Research and Development*, ***7***.

Manikandan, A., & Subramanian, K. S. (2016). Evaluation of zeolite-based nitrogen nano-fertilizers on maize growth, yield and quality on Inceptisol and Alfisols. *International Journal of Plant and Soil Science*, ***9***(4), 1–9.

Materechera, S. A., & Mloza-Banda, H. R. (1997). Soil penetration resistance, root growth and yield of maize as influenced by tillage system on ridges in Malawi. *Soil and Tillage Research*, ***41***(1–2), 13–24.

Memon, S. Q., Mirjat, M. S., Mughal, A. Q., & Amjad, N. (2013). Effect of conventional and non-conventional tillage practices on maize production. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Science*, ***29***(2), 155–163.

Nandy, P., Das, S. K., & Tarafdar, J. C. (2023). Effect of integrated nutrient management and foliar spray of zinc in nanoform on rice crop nutrition, productivity and soil chemical and biological properties in Inceptisols. *Journal of Soil Science and Plant Nutrition*, ***23***(1), 540–555.

Ninama, J., Debbarma, V., Bhakher, R., & Meena, R. K. (2023). Response of zinc and nano urea on growth and yield of maize (*Zea mays* L.). *International Journal of Environment and Climate Change*, ***13***(9), 1046–1052.

Pathak, S., Mehera, B., Kumar, P., & Amitayush, I. (2024). Effect of nano urea and zinc on growth and yield of kharif maize. *International Journal of Plant & Soil Science*, ***36***(8), 632–638.

Rajesh, H., Yadahalli, G. S., Chittapur, B. M., Halepyati, A. S., & Hiregoudar, S. (2021). Growth, yield and economics of sweet corn (*Zea mays* L. Saccarata) as influenced by foliar sprays of nano fertilisers. *Journal of Farm Sciences*, ***34***(4), 381–385.

Rawi, A. S. M., Shachai, N. F., & Cheyed, S. H. (2024). Effect of spraying dates with concentrations of nano-zinc on some maize growth traits, yield quality traits and field emergence. In *IOP Conference Series: Earth and Environmental Science*, ***1371***(5), Article 052017. IOP Publishing.

Sannathimmappa, H. G., Patil, M., Channagouda, R. F., & Patil, C. (2023). Effect of nano nitrogen and nano zinc nutrition on growth and yield of irrigated maize in southern transition zone of Karnataka. *Journal of Pharmaceutical Innovation*, ***12***(1), 1706–1709.

Satdev, V. J., Chavda, B. N., & Saini, L. K. (2020). Effect of nano ZnO on growth and yield of sweet corn under South Gujarat condition. *International Journal of Conservation Science*, ***8***(1), 63–65.

Sbartai, H., Djebar, M. R., Rouabhi, R., Sbartai, I., & Berrebbah, H. (2011). Antioxidative response in tomato plants (*Lycopersicon esculentum* L.) roots and leaves to zinc. *American-Eurasian Journal of Toxicological Sciences*, ***3***(1), 41–46.

Shinoto, Y., Matsunami, T., Otani, R., & Maruyama, S. (2019). Growth and yield of maize using two tillage systems in crop rotation of paddy fields. *Plant Production Science*, ***22***(1), 58–67.

Singh, M. V. (2010). Micronutrient nutritional problems in soils of India and improvement for human and animal health. *Indian Journal of Fertilisers*, ***5***(4), 11–56.

Uma, V., Jayadeva, H. M., Rehaman, H. A., Kadalli, G. G., & Umashankar, N. (2019). Influence of nano zinc oxide on yield and economics of maize (*Zea mays* L.). *Mysore Journal of Agricultural Sciences*, ***53***(4), 44–48.

Vasanth, P., Sivakumar, K., Jeyajothi, R., & Chandrasekaran, P. (2024). Foliar spray of urea and nano-urea on the growth and yield of maize (*Zea mays* L.).

Vijay, F. V. (2022). Effect of zinc oxide nanoparticles (ZnONPs) on yield attributes and yield of hybrid maize (*Zea mays* L.). *Journal of Pharmaceutical Innovation*, ***11***(8), 225–228.

Wasaya, A., Tahir, M., Tanveer, A., & Yaseen, M. (2012). Response of maize to tillage and nitrogen management. *The Journal of Animal & Plant Sciences*, ***22***(2), 452–456.