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# Effect of Different Establishment Methods and Soil Moisture Conservation Practices on Growth Attributes of Spring Maize

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**ABSTRACT: Maize cultivation during the spring season is a lucrative proposition for the farmers However, high moisture demand of spring maize exerts considerable pressure on more no. of irrigation Thus, a two year field experiment was conducted during spring season of year 2019-21 and 2020-21 at GBPUAT, Pantnagar, Uttarakhand, to study the influence of establishment methods (flat bed and furrow sowing) and different soil moisture conservation practices (Rice straw mulching, plastic mulching, earthing and mulching+ earthing) on growth attributes of spring maize. Experimental results revealed that plant height, stem girth and number of green leaves/plant of spring maize were recorded highest in furrow sowing, which were significantly higher than flat bed sowing method during 60 DAS and at maturity stage of crop. The mean increase in plant height between growth periods of 45 to 60 DAS was 48.7 %, 45.6% and 60 DAS to till maturity 29.2%, 28.8% in 2019-20 and 2020-21 respectively, in furrow sowing. During growth period of 45 to 60 DAS the mean increase in stem girth was 13.78%, 15.5% and between 60 DAS to maturity it showed a declination of 7.2%, 9.71% in both the year, respectively. The mean increase in no. of leaves per plant during 60 DAS to at harvest was 5.3%, 7.75% in furrow sowing and 5.6%, 7.2% in flat sowing in 2019-20 and 2020-21. Amongst the different moisture conservation practices, plant height, stem girth and number of green leaves per plant was significantly at par from each other but statistically significant value was recorded over no mulch treatment. The CGR, RGR and AGR of both the years were at par among different moisture conservation practices under furrow sowing and flat sowing methods at 60 DAS and crop maturity stage. Adoption of moisture conservation practices significantly influence the growth attributes of maize at all growth stages, it might be due to the favorable microclimate created by application of mulch and better availability of moisture during entire crop growth period, better root activity and better nutrients uptake contributes overall plant growth.**

**Keywords:** Maize, Flat, Furrow, Plastic Mulch, CGR, RGR, AGR etc.

## INTRODUCTION

Globally, maize is known as the queen of cereals because it has the highest yield potential among the cereal crops. It is most important versatile crop cultivated for multiple purpose uses such as, food, feed, fodder, ethanol production etc. Maize is generally grown in all the three seasons and several environmental, cultural and genetic factors influence maize yield and quality Kumari *et al.* (2017). Spring season cultivation is advantageous due to less insect, pests, disease infestation and unintrrupted availability sunshine hours. However, the major constraints during spring season include high temperature and limited water supply.

Several studies have indicated that inclusion of moisture management practices, *viz*., mulching with different material, earthing and different crop establishment methods like furrow sowing could enhance crop productivity in a profitable and sustainable manner Sonpure *et al.* (2015). Furrow sowing can help to mitigate the severe water limitations by facilitating application of irrigation water directly to the root zone and reducing evaporation losses. Mulching is a desirable management practice for soil water conservation as it manages soil temperature and soil moisture as well as improves crop yield and water use efficiency. Mulching with crop residues or synthetic material are suitable practices in regulating soil temperature, retaining water, reducing nitrate leaching, controlling weeds (Datta *et al.*, 2017) improving soil physical properties and nitrogen balance (Dass and Bhattacharyya 2017) as it is grown during evaporative high demand period. Since, the water requirement of the maize is quite high, therefore one cannot afford to allow unproductive loss of soil water through the process of evaporation. Planting maize on ridges has

been known to produce high yield and water productivity, but under stress condition the performance has not been found to par with flat or furrow sowing. Also, the water loss occurs at a rapid pace from the top of the ridges, making root zone moisture deficit. During such high ET period, the planting of maize in furrows has been found quite effective, as reported by many researchers. Wadile *et al.* (2017) concluded that furrow sowing method recorded significantly higher green cob yield (24.5 t $ha^{-1}$) which might be due to persistent availability of soil moisture in furrow sowing method. Since in furrow sowing, the irrigation is directly applied to plant root zone, hence ensures maximum availability of water to the plants. In Ethiopia while studying the integrated effect of mulching and furrow methods of sowing on maize, Meskelu *et al.* (2018), found that application plastic mulch produced the highest values of yield attributes followed by straw mulching. One of the potential options to support the maize crop in terms of better anchoring and moisture supply could be the earthing process. In comparison to flat sowing, earthing would be of great help in furrow sowing, as the nitrogen will be covered by the soil.

## MATERIALS AND METHODS

*A. Site of Experiment*

The field experiment was conducted at N. E. Borlaug crop research centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand) during spring season in the year of 2019-20 and 2020-21. This region falls under sub-humid, sub-tropical climate with hot and dry summer and severe cold winters. May is the hottest, while January is the coldest month of the year. The area receives a mean annual rainfall of 1433 mm of which 75-80% is received in between June and September.

*B. Soil characteristics*

The soil of *Tarai* region is alluvial in origin and developed from calcareous, medium to moderately coarse textured materials under predominant influence of tall vegetation and moderate to well drain conditions. The soil samples were collected from 0-15 cm soil depth for chemical analysis. The experimental plot had silt loam soil texture with 7.1 pH (Jackson, 1973), (0.73%) organic carbon Walkley and Blake (1934), EC (0.32 dS/m), (170 kg/ha) available N Subbiah and Asija (1956), (22 kg/ha) available phosphorus Olsen *et al.* (1954) and 1 N $NH_4OAC$ extractable K (270 kg/ ha) values in the soil were estimated Jackson (1973).

*C. Experimental design*

This experiment was laid out in factorial randomized complete block design (RCBD) with 10 treatments consisting of two different crop establishment methods *viz*., flat bed method and furrow sowing method as well as moisture conservation practices *viz*., control, straw mulch, plastic mulch, earthing and mulching + earthing with three replications. Spring maize (variety, pioneer-1844) was sown with seed rate of 20 kg $ha^{-1}$ during month of February in both the year 2019-20 and 2020-21 of experiment. The crop was fertilized with a dose of 150:60:40 kg $ha^{-1}$ N, $P_2O_5$ and $K_2O$. One third dose of nitrogen and entire phosphorus and potassium was applied as basal and remaining nitrogen was top dressed in two equal splits at knee height and at tasseling stages, respectively. Irrigation was given by flooding method as per need to maintain soil moisture for crop growth. For proper weed management, pre- emergence application of Atrazin @ 1 kg a.i. $ha^{-1}$ in 400 liters of water applied one day after sowing of the crop. To manage pest and disease problem recommended chemical with recommended dose was applied as and when required. Both plastic mulch and rice straw mulch was applied at completion of plant emergence (20-25 DAS). In case of furrow sowing, the mulches were applied on ridge only. Earthing operation was done at knee height stage. In case of straw mulching + earthing treatment, mulch applied along the crop row and covered gently during the process of earthing.

## RESULTS AND DISCUSSION

Yield potential of any crop can be exploited only when proper agronomic management practices are followed to improve crop establishment, growth, development, yield and yield attributes. Crop establishment practices and moisture conservation practices affects growth and development of a crop. Climatic and edaphic factor like temperature, available soil moisture, nutrient etc. decide the pace of metabolic activities of plant which directly or indirectly affect crop performance particularly summer condition.

*A. Plant Height*

Plant height is a reliable indicator of growth of the plant particularly in maize crops, which represents the infrastructure development for other growth attributes such as number of leaves, stem girth, leaf length and leaf area over a period of time. The analysis of the data presented in Table 1 showed that plant height of maize at 45 DAS, 60 DAS and at harvest influenced significantly by different establishment method. The plant height increased with the advancement of crop age till 60 DAS sharply and decreases gradually thereafter. The mean increase in plant height between growth periods of 45 to 60 DAS was 48.7 %, 45.6% and 60 DAS to till maturity 29.2%, 28.8% higher respectively, in furrow sowing during both the years of study. Furrow planting produced significantly taller plants as compared to flat one, the same results has also been observed by Babu *et al.* (2020); Halli and Angadi (2017); Kanakdurga *et al.* (2012).

**Table 1: Effect of different establishment methods and soil moisture conservation practices on plant height of maize crop at different growth stages.**

| Treatment | Plant height (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 45 DAS | | 60 DAS | | At Harvest | |
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| **Establishment method** | | | | | | |
| Flat sowing | 105.5 | 110.3 | 155.9 | 161.2 | 203.3 | 206.9 |
| Furrow sowing | 111.9 | 116.7 | 166.4 | 170.0 | 215.1 | 219.1 |
| **S.Em.±** | 1.69 | 1.74 | 2.51 | 2.46 | 2.91 | 2.87 |
| **CD at 5%** | 5.03 | 5.17 | 7.46 | 7.31 | 8.65 | 8.53 |
| **Moisture conservation practice** | | | | | | |
| Control | 103.3 | 107.1 | 150.0 | 154.9 | 196.7 | 199.5 |
| Rice straw mulch | 109.4 | 113.8 | 162.1 | 166.8 | 209.9 | 214.3 |
| Plastic mulch | 112.2 | 117.4 | 169.8 | 174.0 | 219.0 | 221.5 |
| Earthing | 109.9 | 115.4 | 163.9 | 167.7 | 212.7 | 216.8 |
| Straw mulching + Earthing | 108.7 | 113.7 | 160.1 | 164.6 | 207.4 | 213.1 |
| **S.Em.±** | 2.68 | 2.75 | 3.97 | 3.89 | 4.60 | 4.54 |
| **CD at 5%** | NS | NS | 11.80 | 11.56 | 13.67 | 13.49 |

Among different moisture conservation practices, the plant height was affected significantly at 60 DAS and at harvest stage over control treatment. The higher value of plant height was recorded in plastic mulch treatment followed by earthing, which was statistically at par from plastic mulch. These findings are in agreement with reports of Meskelu *et al.* (2018); Zhang *et al.* (2017); Singh *et al.* (2016). Adoption of moisture conservation practices significantly influence the plant height of maize crop at all growth stages. Mulch application curtails the evaporation losses of water thus make higher availability of soil moisture for later use of crop. Besides this, it moderates the soil temperature in root zone resulting in better root activity which contributes to overall plant growth.

*B. Stem girth*

The data regarding plant stem girth at different stages during 2019-20 and 2020-21 as recorded in the experiment are presented in Table 2. The stem girth was recorded at mid of the second inter-node from the base of the stem. The stem girth of maize increased with the advancement of crop age up to 60 DAS and then after decreased gradually till maturity. At all the stages of stem girth measurement furrow sowing produce significantly thicker stem over flat bed sowing method. During growth period of 45 to 60 DAS the mean increase in stem girth was 13.78%, 15.5% and between 60 DAS to crop maturity period, it showed a declination of 7.2%, 9.71% in 2019-20 and 2020-21, respectively in furrow sowing method. Datta *et al.* (2020) at Pantnagar reported that, furrow method of sowing resulted in an increase in stem girth to the tune of 3.6% at 60 DAS, which was significantly higher as compared to flat sowing method.

Due to moisture conservation practices, the stem girth was affected significantly at 60 DAS and at harvest stage. At these stages mulched treatments, produce significant changes on stem girth of maize over control treatment. Among the moisture conservation practices, stem girth at different stages significantly at par to each other but the higher thickness of stem was observed in application of plastic mulch. These results are in close conformity with the findings of Dawar *et al*. (2023); Datta *et al.* (2020).

**Table 2: Effect of different establishment methods and soil moisture conservation practices on stem girth of maize crop at different growth stages.**

| Treatment | Stem girth (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 45 DAS | | 60 DAS | | At Harvest | |
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| **Establishment method** | | | | | | |
| Flat sowing | 7.69 | 7.93 | 8.71 | 9.24 | 8.17 | 8.34 |
| Furrow sowing | 8.05 | 8.28 | 9.15 | 9.57 | 8.49 | 8.64 |
| **S.Em.±** | 0.12 | 0.12 | 0.10 | 0.11 | 0.10 | 0.09 |
| **CD at 5%** | 0.35 | 0.35 | 0.31 | 0.33 | 0.30 | 0.26 |
| **Moisture conservation practice** | | | | | | |
| Control | 7.64 | 7.87 | 8.47 | 8.85 | 7.94 | 8.11 |
| Rice straw mulch | 7.91 | 8.13 | 8.95 | 9.47 | 8.34 | 8.54 |
| Plastic mulch | 8.02 | 8.28 | 9.29 | 9.74 | 8.72 | 8.77 |
| Earthing | 7.89 | 8.14 | 9.00 | 9.53 | 8.39 | 8.58 |
| Straw mulching + Earthing | 7.86 | 8.10 | 8.95 | 9.43 | 8.27 | 8.47 |
| **S.Em.±** | 0.19 | 0.19 | 0.16 | 0.18 | 0.16 | 0.14 |
| **CD at 5%** | NS | NS | 0.49 | 0.52 | 0.47 | 0.41 |

The decrease in stem girth at later phase of crop growth can be attributed to detaching of leaf sheath from the stem due to senescence, which otherwise contributed to stem girth at early stages of crop growth as it remain intact with stem during that period. It may further be supported by the fact that the stem cells towards the maturity loose the turgidity and consequently the stem thickness is reduced.

*C. Number of green leaves per plant*

Number of green leaves per plant is an important symbol of plant growth and development which determines the capacity of plant to trap solar energy for photosynthesis and other metabolic activities and further to prepare photosynthetic product for the plant. Though, number of leaves is genetically controlled but it might be distinctly modified by good agronomic management. The observations with respect to the number of green leaves per plant, are presented in Table 3, indicated that there was no significant effect of crop establishment on number of green leaves per plant of maize at 45 DAS in both year but at 60 DAS and at harvest furrow sowing produces significantly higher no. of green leaves per plant over flat bed sowing. The mean increase in no. of green leaves per plant between 60 DAS to at harvest was 5.3%, 7.75% in furrow sowing and 5.6% 7.2% in flat sowing in both the year respectively.

The data revealed that among moisture practices, no. of green leaves per plant of maize attained the significantly higher under plastic mulch compared to no mulch application and at par with earthing and rice straw mulch at 60 DAS and maturity stage of spring maize during both the years. These findings are in agreement with reports of Singh *et al.* (2022); Singh *et al.* (2016). Further, increase in no. of green leaves per plant of maize might be due to the favorable microclimatic conditions created by application of mulch and better availability of moisture during entire crop growth period, better nutrients uptake contributes overall plant growth.

*D. Crop Growth Rate (CGR)*

Crop growth rate is the dry matter production in per unit time and per unit area. Data pertaining to crop growth rate as calculated at different growth period *viz*., (0-45 DAS), (45- 60 DAS) and (60- at maturity) have been presented in Table 4. It is evident from the data that establishment method had significantly affected on crop growth rate at initial growth period. Higher value of CGR was observed in furrow sowing method, the value of CGR increased with the advancement of crop age till 60 DAS sharply and decreases gradually thereafter till maturity during both years of investigation.

**Table 3: Effect of different establishment methods and soil moisture conservation practices on number of green leaves per plant of maize crop at different growth stages.**

| Treatment | Number of green leaves per plant | | | | | |
|---|---|---|---|---|---|---|
| | 45 DAS | | 60 DAS | | At Harvest | |
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| **Establishment method** | | | | | | |
| Flat sowing | 8.5 | 8.7 | 10.7 | 11.1 | 11.3 | 11.9 |
| Furrow sowing | 8.8 | 9.0 | 11.3 | 11.6 | 11.9 | 12.5 |
| **S.Em.±** | 0.13 | 0.13 | 0.16 | 0.15 | 0.16 | 0.16 |
| **CD at 5%** | NS | NS | 0.49 | 0.45 | 0.47 | 0.48 |
| **Moisture conservation practice** | | | | | | |
| Control | 8.3 | 8.5 | 10.4 | 10.7 | 11.0 | 11.4 |
| Rice straw mulch | 8.7 | 8.9 | 11.1 | 11.4 | 11.7 | 12.3 |
| Plastic mulch | 9.0 | 9.2 | 11.7 | 11.9 | 12.2 | 12.6 |
| Earthing | 8.8 | 8.9 | 11.1 | 11.5 | 11.8 | 12.4 |
| Straw mulching + Earthing | 8.6 | 8.8 | 10.9 | 11.4 | 11.6 | 12.2 |
| **S.Em.±** | 0.21 | 0.20 | 0.26 | 0.24 | 0.25 | 0.26 |
| **CD at 5%** | NS | NS | 0.77 | 0.71 | 0.75 | 0.77 |

**Table 4: Effect of different establishment methods and soil moisture conservation practices on crop growth rate of maize crop at different growth stages.**

| Treatment | CGR (g $m^{-2}$ $day^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | (0-45) DAS | | (45-60) DAS | | (60-Harvest) | |
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| **Establishment method** | | | | | | |
| Flat sowing | 5.78 | 6.26 | 26.36 | 26.95 | 13.14 | 13.47 |
| Furrow sowing | 6.43 | 6.83 | 27.73 | 28.75 | 14.14 | 14.40 |
| **S.Em.±** | 0.16 | 0.18 | 1.24 | 1.17 | 0.53 | 0.63 |
| **CD at 5%** | 0.47 | 0.53 | NS | NS | NS | NS |
| **Moisture conservation practice** | | | | | | |
| Control | 5.48 | 5.79 | 24.21 | 25.27 | 11.64 | 12.61 |
| Rice straw mulch | 6.16 | 6.66 | 27.26 | 27.78 | 13.89 | 14.02 |
| Plastic mulch | 6.61 | 7.04 | 29.49 | 30.54 | 14.90 | 14.87 |
| Earthing | 6.24 | 6.72 | 27.53 | 28.12 | 14.31 | 14.30 |
| Straw mulching + Earthing | 6.05 | 6.50 | 26.72 | 27.54 | 13.46 | 13.86 |
| **S.Em.±** | 0.25 | 0.28 | 1.97 | 1.85 | 0.84 | 0.99 |
| **CD at 5%** | NS | NS | NS | NS | NS | NS |

The extent of increase CGR in furrow sowing method at 0-45 DAS period was 10.34% and 7.93% higher over flat bed sowing during in 2019-20 and 2020-21. In later phase of crop growth after 45 DAS, the CGR of spring maize had not significantly affected by crop establishment method, but the higher value of CGR was calculated in furrow sowing over flat bed sowing method.

In case of moisture conservation practices, the plastic mulch had observed higher value of CGR in growth stages as compared to remaining treatments, but all the moisture conservation practices are statistically at par to each other at all the successive growth interval during both years of investigation. The extent of increase in application of plastic mulch from (0-45 DAS) to (45-60 DAS) was 3.46 and 3.35 times more during in 2019-20 and 2020-21. Positive effect of moisture conservation practices on CGR of maize crop has also been reported by Awal and Khan (2000).

*E. Relative Growth Rate (RGR)*

The rate of accumulation of new dry mass per unit of existing dry mass per unit time, is a major determinant of plant competitiveness. RGR is an indirect measurement of the rate of resource acquisition over already synthesized biomass. It is evident from the data that (Table 5) different establishment method and different moisture conservation practices had a no significant effect on relative growth rate by the crop at all the successive crop growth interval during both years of investigation.

However, higher relative growth rate was calculated in between 45-60 DAS growth period and with the advancement of crop growth the value of RGR declined gradually in all moisture conservation practices and establishment methods. The data revealed that the RGR of crop attained the higher value during active crop growing stage i.e. 45- 60 DAS. At this growth stage, crops are in their log phase of growth and development and higher rate of biomass produced and synthesized per unit time. Non significant effect of moisture conservation practices also reports by Awal and Khan (2000).

*F. Absolute Growth Rate (AGR)*

Absolute growth rate is the function of amount of growing material present and is influenced by the environment. It gives Absolute values of growth between two intervals. A critical examination of data presented on Table 6 revealed that during both the years of experiment, Absolute growth rate of maize at 0-45 DAS growth period was found significant, while it was grown in furrow sowing.

**Table 5: Effect of different establishment methods and soil moisture conservation practices on relative growth rate of maize crop at different growth stages.**

| Treatment | RGR (g g$^{-1}$ day$^{-1}$) | | | |
|---|---|---|---|---|
| | (45-60) DAS | | (60-Harvest) | |
| | 2020 | 2021 | 2020 | 2021 |
| **Establishment method** | | | | |
| Flat sowing | 61.6 | 59.4 | 13.5 | 13.3 |
| Furrow sowing | 59.5 | 58.6 | 13.5 | 13.2 |
| **S.Em.±** | 2.6 | 2.4 | 0.5 | 0.6 |
| **CD at 5%** | NS | NS | NS | NS |
| **Moisture conservation practice** | | | | |
| Control | 60.6 | 60.0 | 13.0 | 13.4 |
| Rice straw mulch | 60.5 | 58.2 | 13.6 | 13.3 |
| Plastic mulch | 60.8 | 59.6 | 13.6 | 13.1 |
| Earthing | 60.5 | 58.4 | 13.8 | 13.4 |
| Straw mulching + Earthing | 60.5 | 58.9 | 13.5 | 13.3 |
| **S.Em.±** | 4.2 | 3.8 | 0.8 | 0.9 |
| **CD at 5%** | NS | NS | NS | NS |

**Table 6: Effect of different establishment methods and soil moisture conservation practices on absolute growth rate of maize crop at different growth stages.**

| Treatment | AGR (cm day$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | (0-45) DAS | | (45-60) DAS | | (60-Harvest) | |
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| **Establishment method** | | | | | | |
| Flat sowing | 2.34 | 2.45 | 3.36 | 3.40 | 0.86 | 0.83 |
| Furrow sowing | 2.49 | 2.59 | 3.64 | 3.56 | 0.88 | 0.89 |
| **S.Em.±** | 0.04 | 0.04 | 0.23 | 0.22 | 0.07 | 0.07 |
| **CD at 5%** | 0.11 | 0.11 | NS | NS | NS | NS |
| **Moisture conservation practice** | | | | | | |
| Control | 2.29 | 2.38 | 3.12 | 3.19 | 0.85 | 0.81 |
| Rice straw mulch | 2.43 | 2.53 | 3.51 | 3.53 | 0.87 | 0.86 |
| Plastic mulch | 2.49 | 2.61 | 3.84 | 3.78 | 0.90 | 0.86 |
| Earthing | 2.44 | 2.57 | 3.60 | 3.49 | 0.89 | 0.89 |
| Straw mulching + Earthing | 2.41 | 2.53 | 3.43 | 3.39 | 0.86 | 0.88 |
| **S.Em.±** | 0.06 | 0.06 | 0.36 | 0.35 | 0.12 | 0.12 |
| **CD at 5%** | NS | NS | NS | NS | NS | NS |

The extent of increase AGR in furrow sowing method at 0-45 DAS period was 8.69% and 4.0% higher over flat bed sowing, respectively during in 2019-20 and 2020-21. In the advancement of crop growth the AGR of spring maize was statistically at par with flat bed sowing of crop establishment method in both the year of experiment. Initially AGR was increases with crop growth up to 60 DAS and then it shows decreasing trends till crop maturity. Among different moisture conservation practices at different growth stages of crop development there was no significant difference in absolute growth rate, but the higher value of AGR was observed in application of plastic mulch treatment in the 2019-20 and 2020-21 cropping seasons. Since plant height of spring maize increased with the advancement of crop age till 60 DAS sharply and gradually thereafter decreases till maturity similar trends of AGR was observed because it was derived from observations which was recorded for plant height.

## CONCLUSIONS

Our study demonstrated that the growing of spring maize crops in the tarai region of Uttarakhand, furrow sowing method should be adopted for better crop establishment, as it recorded significantly higher plants growth attributes *viz*., plant height, stem girth, no. of green leaves per plant, yield, productivity and quality of spring maize. Application of plastic mulch was found to be a viable option, where labour scarcity for earthing and non availability of straw mulch, to conserve available soil moisture and achieve higher productivity of spring maize.

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