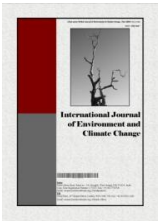

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Evaluation of Interactive Effects of Row Arrangement, Plant Geometry and Mulching on Yield of Early Maturity Maize Hybrid under Traditional Rainfed Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. Authors GM and ER conceived and designed the project, authors KS, DS, GU and BM supervised the study and wrote the paper. Author GM checked and corrected the final draft. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study the grain yield performance of early maturity maize hybrid under rainfed conditions in relation to row arrangement, plant geometry and mulching.
Place of Study: A field experiment was conducted at Agricultural research station, Karimnagar during *kharif* 2011-12.
Methodology: The experiment was carried out in red sandy loam soils, in a split- split plot design with main plots as row arrangement (2) i.) Equal rows at 67cm ii). Paired row at 84: 50cm (Between and within paired rows), Sub plots as plant geometry (3) i.) with 40000 Plants/ha (intra row spacing of 37 cm) ii.) with 50000 Plants /ha (intra spacing of 30cm) iii.) with 60000 Plants/ha (intra row spacing of 25cm) and Sub- sub plots as mulching treatments (2) i.) without mulching ii.) with surface mulch @ 5 t/ha. The results indicated that there is no significant difference in grain

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yield of early maturity maize hybrid, when the crop is grown in equal row spacing of 67cm (5148 kg/ha) or paired row spacing of 84:50cm (4962 kg/ha). The grain yield of maize crop with 60000 Plants /ha (*i.e.,* 25 cm intra row spacing) recorded higher grain yield of 5339 kg/ha followed by maize crop with 50000 Plant /ha (*i.e.,* 30 cm intra row spacing) with 5097 kg/ha grain yield and 4729 kg/ha with 40000 Plant/ha (*i.e.,* 37 cm intra row spacing). When crop rows were mulched with grass and dried weed material @ 5t/ha significantly increased the maize grain yield (5724 kg/ha) by 23 % than compared to the crop kept without mulch (4386 kg/ha). Consequently, the maize crop with surface mulching resulted in higher net returns (Rs.31770/ha) and benefit cost ratio of 1.7 over no mulching. While, the interaction for all parameters was non significant.

Results: It can be concluded that farmers can either follow equal row spacing or paired row spacing based on situation, as there is no significant difference in terms of yield by either method. Mulching of inter row of maize crop under rainfed conditions has resulted in 23% increased yield than that of crop kept without mulch.

Keywords: Early; maize hybrid; mulching; plant density; plant geometry; row arrangement.

1. INTRODUCTION

Maize (*Zea mays L.)* is an important cereal food crop of the world with highest production and productivity compared to other cereal crops. It is the most versatile crop with respect to its adoptability and is valued as food, fodder, feed and industrial raw material. It is grown in diverse environmental conditions as the crop has tremendous genetic variability which enables it to thrive in tropical, subtropical and temperate climates. In India, it is being estimated that maize demand will continue to increase in view of increasing demand in poultry and livestock sectors in the country and growing populations and changing food habits.

In the country, maize is cultivated in an area of 90.3 lakh hectares with production of 277.15 thousand tons and productivity of 3070Kg/ha which contributed to 9% of the Indian food basket. In Telangana state, Maize occupied an area of 5.54 lakh hectares with production of 25.6 lakh tons and productivity of 4.6t/ha [1]. With the growing demand, enhancement of maize yield in the coming years across all the growing locations in India is a big challenge particularly in the era of climate change [2].

Maize is grown throughout the year in India. It is predominantly and traditionally a Kharif crop. More than 75% of the maize is grown under rainfed conditions which are much higher than rainfed area under rice and wheat [3]. In Karimnagar district of Telangana state, maize is one of the important crop after paddy and cotton, occupies an area of around 60,000 hectares during kharif. During this season, the crop is mostly grown under rainfed conditions and is often subjected to vagaries of monsoon. The low yields of maize in kharif could be attributed to the genotype selection inadequate plant stand, discrepancies in fertilizer application due to lack of moisture availability, dry spells or high moisture conditions due to high rainfall with cloudy weather. The agronomic manipulation i.e., the plant distribution in the field, plant geometry, mulching in crop management plays important role to mitigate the ill effects of monsoon by way of harvesting maximum solar radiation, effective utilization of soil resources and retention of moisture. Any maize hybrid grown with suitable agronomic management can only increase the yield. In this context, to harness the full yield potential of early maturity maize hybrid through agronomic intervention, an experiment was conducted to assess the interactive effects of row arrangement, plant geometry and residue level (mulching) on yield of early maturity maize hybrid under rainfed conditions.

2. MATERIALS AND METHODS

The field experiment under AICRP on Maize improvement project was conducted at ARS, Karimnagar, Telangana state ($18^0$26'N and $79^0$5'E) during Kharif, 2011. The climate of the area is semi-arid. The soil of experimental site is red sandy loam with pH 7.09, EC 0.26 $dS^{-1}m$, organic carbon 0.71%, available N 176 Kg/ha, available P_2O_5 37Kg/ha and available K_2O 392 Kg/ha.

The experiment was conducted in a split – split plot design with two main plots as row arrangement 1. Equal row spacing of 67 cm^2. Paired row spacing of 84: 50 cm (84 cm between pairs and 50 cm within pair), with three sub plots as plant geometry 1) 40000 pl/ha (with intra row spacing of 37 cm), 2) 50000 pl/ha (intra row

spacing of 30 cm) 3) 60000 pl/ha (intra row spacing of 25 cm) and two sub-sub plots as residue levels as 1) clean field. 2) 5 t/ha of surface residue mulching and replicated thrice. The total precipitation of 575.4 mm was received during kharif from June to September, 2011.

The early maturity maize hybrid 'Double' was sown in 8 rows of 5 m length (27 m^2) sub–sub plot size as per the treatment by dibbling 2 seeds/hill, finally the plants were thinned to single plant/hill to have the desired plant population. Intercultivations was carried out twice with bullock drawn guntaka and earthing up done. The fertilizer N @150 Kg/ha was applied in 3 equal splits as basal, knee high and tasseling stage, Phosphorus @60 Kg/ha applied as basal and potassium @60 Kg/ha was applied in 2 splits as basal and tasseling stage along with N application. Preemergence herbicide Atrazine was applied after sowing. Data on yield and yield attributes were recorded.

Five plants from each treatment plot were labeled randomly to record the observations of plant growth and yield attributes from the selected plants. The economic returns were compared by calculating the Net returns and benefit cost ratio for row arrangement, plant geometry and mulching treatments. The sale price of maize grain for calculation of returns is taken as Rs.13.50/Kg. The data relating to yield and yield attributes and economics were analysed as per the procedure of analysis of variance and significance by F test at 5% probability [4].

3. RESULTS AND DISCUSSION

3.1 Effect of Row Arrangement

In red sandy loam soils of Karimnagar under rainfed conditions it is observed that there is no significant difference in grain yield of early maturity maize hybrid, when crop is grown in equal row spacing of 67 cm (5148 kg/ha) or paired row spacing of 84:50 cm (4962 kg/ha). In terms of cob yield also there is no significant difference in maize crop with respect to crop grown in equal row spacing of 67 cm (6266 kg/ha) or paired row spacing of 84:50 cm (6102 kg/ha). Yield attributes like cob length, kernel numbers per row and green weight per cob were also found to be non-significant with different row arrangement (Table 1). Similar results were reported by [5] Abuzar et al who attributed the reason to availability of better resources under both the row arrangements. The Net returns and B:C ratio also found to be non significant with respect to row arrangement (Table 2). The non-significant difference in grain and cob yield in row arrangement of equal row spacing of 67 cm or paired row spacing of 84:50 cm can be attributed to similar competition as plant population under both the row arrangements is same. Further the yield is rather a complex product of number of its yield attributing traits and accordingly non significant difference in yield attributes *i.e.* cob length, kernel number and grain weight per cob might have resulted in non-significant yield with respect to row arrangement. Further, confirming this result, Mariana Robles [6] has also reported that twin rows never yielded significantly more than single rows at any plant density.

3.2 Effect of Plant Geometry

Among different plant geometry treatments under rainfed conditions, the grain yield of early maturity maize hybrid with 60000 plants per hectare (25 cm intra row spacing) recorded higher grain yield of 5339 kg/ha followed by maize crop with 50000 plants per hectare (5097 Kg/ha) (30 cm intra row spacing) and 4729 kg/ha with 40000 plants per hectare (37 cm intra row spacing). Similarly, the cob yield of maize also recorded higher (6524 Kg/ha) with 60000 plants/ha (25 cm intra row spacing) and was inturn followed by 50000 plants/ha (30 cm intra row spacing) (6223 Kg/ha) and maize crop with 40000 plants/ha (37 cm intra row spacing) (5795 Kg/ha). The non significant difference in grain and cob yield at different plant densities may be attributed to the performance of early maturity maize hybrid in terms of its potentiality as grain yield is a function of integrated effects of genetic makeup of cultivars and growing conditions on the yield components of a crop and is the end result of many complex morphological and physiological processes occurring during the growth and development of a crop [7].

The cob length (18.6 cm) recorded significantly higher at wider intra row spacing of 37 cm(40000 plants/ha) and 30 cm 50000 plants/ha) (18.6 cm) and decreased at intra row spacing of 25 cm (60000 plants/ha) (18.2 cm) (Table 1). The kernel no/row resulted higher at plant geometry of 50000 plants/ha (intra row spacing of 30 cm) (39.8) and was found to be on par with 40000 plants/ha (intra row spacing of 37 cm) (39.6) and 60000 plants/ha with intra row spacing of 25 cm (38.2). The grain weight/cob also did not vary with different plant geometry. The wider plant

Table 1. Effect of row arrangement, plant geometry and mulch on productivity of early maturity maize under rainfed conditions

	Cob yield (kg/ha)	Grain yield (kg/ha)	Cob length (cm)	Kernel no./row	Grain weight/cob
A. Row Arrangements					
Equal row at 67 cm	6266	5148	18.5	40.5	158.8
Paired row at 84: 50 cm	6102	4962	18.4	37.9	135.1
SEd	682	575	0.6	2.1	13.0
CD (0.05)	NS	NS	NS	NS	NS
B. Plant geometry					
40000 plants/ha (plant spacing 37 cm)	5795	4729	18.6	39.6	154.1
50000 plants/ha (plant spacing 30 cm)	6233	5097	18.6	39.8	145.2
60000 plants/ha (plant spacing 25 cm)	6524	5339	18.2	38.2	141.6
SEd	478	404	0.6	1.3	8.9
CD (0.05)	NS	NS	NS	NS	NS
C. Residue level					
Clean field	5504	4386	18.3	37.3	142.3
5t/ha of surface residue mulch	6864	5724	18.6	39.1	149.5
SEd	424	389	0.9	0.7	3.5
CD (0.05)	922	846	0.28	1.6	7.1
Interaction (Row arrangements x Residue level)					
SEd	316	267	0.7	1.5	10.3
CD (0.05)	NS	NS	NS	NS	NS

Table 2. Effect of row arrangement, plant geometry and mulch on economics of early maturity maize under rainfed conditions

	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C Ratio
A. Row Arrangements			
Equal row at 67 cm	69504	24369	1.6
Paired row at 84: 50 cm	66986	21101	1.5
SEd	4538	4538	0.1
CD (0.05)	NS	NS	NS
B. Plant geometry			
40000 plants/ha (plant spacing 37 cm)	63840	18705	1.4
50000 plants/ha (plant spacing 30 cm)	68816	23306	1.5
60000 plants/ha (plant spacing 25 cm)	72079	26194	1.6
SEd	2904	2904	0.1
CD (0.05)	NS	NS	NS
C. Residue level			
Clean field	77280	31770	1.7
5t/ha of surface residue mulch	59209	13699	1.3
SEd	1804	1804	0.1
CD (0.05)	5557	5556	0.2
Interaction (Row arrangements x plant geometry or Row arrangement X Residue level or Row arrangements x plant geometry X Residue level)			
CD (0.05)	NS	NS	NS

spacing with intra row spacing of 37 cm (40000 plants/ha) recorded higher grain weight/cob (154.1 g) followed by intra row spacing of 30 cm (50000 plants/ha) (145.2 g) and decreased at intra row spacing of 25 cm i.e., 60000 plants/ha (141.6 g). This could be attributed to lower plant population in wider spacing which must have received sufficient space, moisture, nutrients and this inturn might have led to more production of photosynthates per unit area and might have proved beneficial for growth and development of maize crop as compared to closer spacing [8]. But increased values of yield attributes i.e., cob length, kernel no/row and grain weight/cob at wider intra row spacing could not compensate the yield in wider spacing than compared to closer spacing i.e., less intra row spacing (higher population) as yield attributes result high on single plant basis but they do not compensate to yield per unit area basis. The net returns and B:C ratio also did not differ significantly at different plant densities (Table 2). Similar results were also obtained by Sahoo [9].

3.3 Effect of Mulching (Residue Level)

Local knowledge about the type and suitability of soils for crop production helps farmers to reduce environmental risks and minimize crop failures and thus enhance the livelihoods. Among mulching (Residue level) treatments, when maize crop rows were mulched with crop residues (grass and dried weed material) @ 5t/ha, significantly increased the maize grain yield (5724 kg/ha) by 23% than compared to the crop kept without mulch (4386 kg/ha). The maize cob yield also resulted significantly higher with application of 5t/ha of surface residue mulch (6864 kg/ha) than compared to no mulch (5504 kg/ha). The increased maize cob and grain yield may be attributed to higher cob length (186 cm), Kernel number per row (39.1) and grain weight per cob (149.5 g) in surface mulching with residues than compared to crop kept without mulching. This might be attributed to the beneficial effect of mulching particularly under rainfed conditions by way of increased availability of soil moisture, reduced evaporation losses and soil temperature. [10] Sharma et al also reported that the maximum soil moisture content, infiltration rate and grain yield of maize and wheat recorded in mulching practices over no mulch treatment. Ratan Lal, 1974 [11] stated that increase in grain yield by mulching was attributed primarily to a decrease in soil temperature and partly due to improved soil moisture regime. [12] Li et al, 2013 was also of the view that mulching increases the water retention capacity of the soil by reducing the evaporation losses and maintains optimum and uniform temperature over no mulch. Consequently the maize crop with surface mulching resulted in higher net returns (Rs.31770/ha) than compared to the crop without mulching (Rs.13699/ha). The Benefit cost ratio also was to be higher with mulching (1.7) over no mulching (1.3) (Table 2).

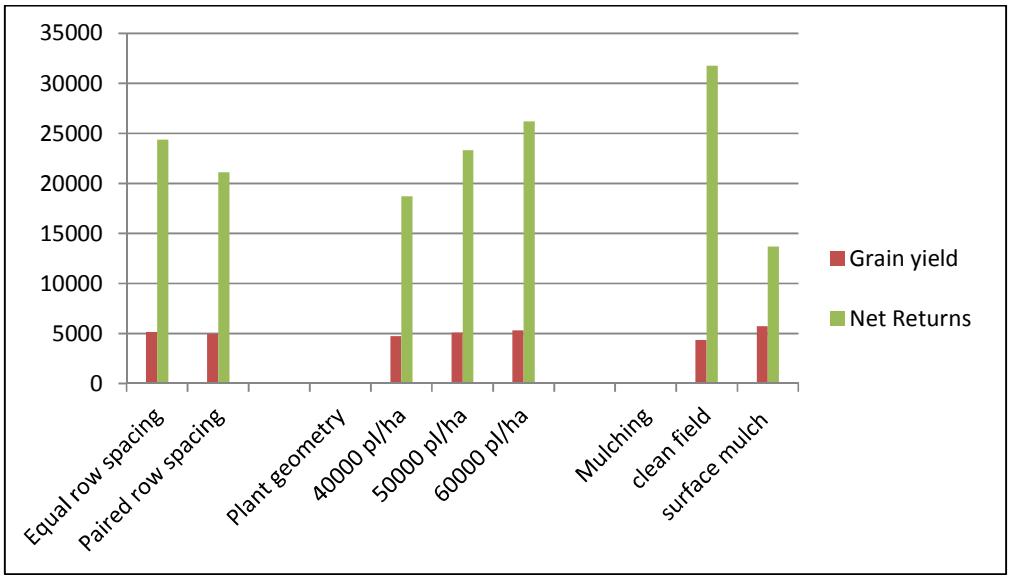

Fig. 1. Effect of row arrangement, plant geometry and mulch on productivity and economics of early maturity maize under rainfed conditions

4. CONCLUSION

The experiment can be concluded that row arrangement i.e., equal row spacing or paired row method can be followed based on crop growing situation i.e., whether the crop is taken up under drip or not as there is no significant difference in terms of yield. When drip method or intercrops were taken up than paired row method can be adopted, on other situations, equal row spacing can be choosen. Among the plant geometry, the intra spacing of 25 cm can be adopted as yield and yield attributes recorded higher at this spacing. Mulching with surface crop residue @ 5t/ha under rainfed conditions has resulted in 23% increased grain yield of early maturity maize hybrid than that of crop kept without mulch. Consequently, the maize crop with surface mulching resulted in higher net returns (Rs.31770/ha) and benefit cost ratio of 1.7 over no mulching.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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