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Influence of Crop Geometry and Mulching on Growth and Yield of Maize [*Zea mays* L.]

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Abstract
A field experiment was conducted at the Research Farm, Vivekananda Global University, Jaipur, during the Kharif season, 2025 on loamy sand soil. The experiment comprised twelve treatment combinations involving four levels of crop geometry (60 cm × 20 cm, 60 cm × 25 cm, 75 cm × 20 cm, and 75 cm × 25 cm) and three levels of mulching (No mulch, Organic mulch @ 5 t ha^{-1}, and Plastic mulch) which was laid out in a Factorial Randomized Block Design (FRBD) and replicated thrice. The results indicated that among the treatments applied, the crop geometry of 75 cm × 25 cm (G_4) recorded significantly higher growth and yield parameters viz., plant height, dry matter accumulation, number of cobs per plant, cob length, number of grains per row, number of grains per cob, seed index, grain (4641 kg ha^{-1}) and stover (9674 kg ha^{-1}) yield of maize. This was found to be at par with the application of 60 cm × 25 cm (G_2) for most yield attributes and final yields. Regarding mulching, the application of Organic mulch (M_2) recorded significantly higher growth and yield attributes, including grain yield (4086 kg ha^{-1}) and stover yield (8992 kg ha^{-1}), compared to the control. Grain yield was significantly and positively correlated with the number of grains per cob, seed index, and biological yield. Maximum net return (Rs. 96,996.6 ha^{-1}) and highest B:C ratio (2.9) were obtained with the application of 75 cm × 25 cm (G_4) geometry. In the case of mulching, while organic mulch (M_2) improved productivity, the highest B:C ratio (2.7) was recorded with the no-mulch control (M_1) due to the lower cost of cultivation. The economically optimum crop geometry for maize was found to be 75 cm × 25 cm.

Keywords: Maize, Crop Geometry, Mulching, Organic Straw, Yield Attributes

Introduction
Maize (*Zea mays* L.) refers to a class of very versatile cereal crops cultivated all over the world for many uses, providing human food, poultry feed, and high-class forage for farm animals. It is competitively globalized as the "Queen of Cereals" because of its highest maximum genetic potential yield among cereals and serves as a vital cornerstone for food security and industrial input. As a C4 plant, maize has high photosynthetic efficiency and is an important source of calories to help meet the requirements of an increasing global population. The nutritional profile of its seeds includes protein (10%), fat (4%), carbohydrates (70%), and fiber (2.3%), and it is a great source of minerals like phosphorous and magnesium. In industrial terms, maize is assuming great importance in the production of bio-fuel and the brewery industry. India is significantly involved in producing maize, with the state of Rajasthan being extremely crucial, yielding 2.11 million tonnes during the Kharif season (Anonymous, 2024). Although it has the capacity to produce large amounts of grain, low yield levels result from improper farming methods that focus on seed density and water retention. Maize is cultivated on a large scale because of its sensitivity to high levels of inputs and adaptability to different crop production systems (Reddy *et al*., 2018) [12]. The optimization of planting pattern using crop geometry forms one of the main limitations to maximizing crop yield. Correct spacing enables the minimization of inter-competition and maximization of light capture, which is highly linked to the vegetative growth and development of the maize plant. Mulching is another major management approach which helps to conserve soil moisture through reduced evaporation, temperature moderation, and weed control (Tao *et al*., 2015) [13]. Through the application of proper planting arrangements together with moisture-retaining mulch, it becomes easier to establish an optimum environment that facilitates efficient synchronization between the requirement and supply of nutrients.

Implementation of climate-resilient technologies like optimized crop geometry and organic or straw mulching presents a practical strategy to optimize the benefit-to-cost ratio. This makes it important to conduct studies of this kind in order to formulate regional recommendations.

Material and Methods

The experiment was conducted at Research farm, Vivekananda Global University, Jaipur during Kharif season 2025-26. Geographically, this place is situated at 750 47' East longitude, 260 51' North latitude and at altitude of 390 m above mean sea level in Jaipur district of Rajasthan. This region falls under Agro-climatic zone IIIa (Semi-arid eastern plain zone) of Rajasthan. The climate of this place is semi-arid characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5 ºC) and winter (4ºC). The average rainfall of this region is between 500-700 mm per annum which is mostly received during July to September. The sporadic showers in winters are also common.

There was rainfall of 494.7 mm during the crop season 2025-26. In order to evaluate the physico-chemical properties, soil samples from 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 these analyses along with methods used for determination are presented in table 3.3. It is apparent from data that the soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen and zinc, medium in phosphorus and potassium content.

Results and Discussion

Effect of Crop Geometry and Mulching on Growth Attributes

All growth attributes, viz. plant height and dry matter accumulation, were increased significantly with the application of various crop geometries and mulching practices during the year of investigation. Results showed that the sowing of maize at a crop geometry of G_4 (75 cm × 25 cm) attained the maximum plant height of 75.78, 157.56, and 199.67 cm at 40, 80 DAS, and at maturity, respectively. This treatment was found to be statistically at par with G_2 (60 cm × 25 cm) at early stages but was significantly superior over the recommended spacing G_1 (60 cm × 20 cm) and G_3 (75 cm × 20 cm) at all recorded stages. Similarly, the highest dry matter accumulation was observed with G_4 (41, 213, and 289 g plant^{-1}), which was statistically similar to G_2 and significantly superior over the rest of the treatments.

Regarding mulching, the application of M_2 (Organic mulch - straw @ 5 t ha^{-1}) recorded the maximum plant height of 67.00, 148.22, and 182.44 cm and the highest dry matter accumulation of 32, 192, and 267 g plant^{-1} at 40, 80 DAS, and at maturity, respectively. The application of M_2 was significantly superior over the no-mulch control (M_1) and plastic mulch (M_3) at all stages of observation.

Effect of Crop Geometry and Mulching on Yield Attributes

It is evident from the data that crop geometry and mulching treatments significantly affected the yield attributes of maize during the year of study. Sowing at a crop geometry of G_4 (75 cm × 25 cm) attained the maximum number of cobs per plant (2.7), cob length (20.1 cm), and grains per cob (611.6). This treatment was found to be statistically at par with G_2 (60 cm × 25 cm) for cob length and number of cobs, but it was significantly superior over the recommended spacing G_1 (60 cm × 20 cm) and G_3 (75 cm × 20 cm). Specifically, G_4 increased the number of grains per cob by 76.56% over the recommended spacing G_1. Regarding mulching, the maximum values for yield attributes were recorded with the application of M_2 (Organic mulch). This treatment produced a significantly higher number of cobs per plant (2.1), cob length (17.5 cm), and grains per cob (540.9) compared to the no-mulch control. The application of M_2 increased the number of grains per cob by 34.12% over the control M_1 and by 13.47% over plastic mulch M_3.

Effect of Crop Geometry and Mulching on Yield

The experimental results revealed that crop geometry and mulching significantly influenced the final yield. The highest grain yield (4641 kg ha^{-1}) and stover yield (9674 kg ha^{-1}) were achieved with crop geometry G_4 (75 cm × 25 cm). This treatment was statistically on par with G_2 (60 cm × 25 cm) but significantly better than G_1 and G_3. G_4 increased the grain yield by 34.79% over the recommended spacing G_1 (3443 kg ha^{-1}). In terms of mulching, M_2 (Organic mulch) recorded the maximum grain yield (4086 kg ha^{-1}) and stover yield (8992 kg ha^{-1}). This was significantly superior to both the no-mulch control and plastic mulch. M_2 increased the grain yield by 8.64% over the control M_1. Interestingly, the harvest index remained statistically at par across all mulching treatments, though it was significantly higher in G_4 and G_2 (32%) compared to G_1 and G_3 (30%).

Effect of Crop Geometry and Mulching on Economics

The maximum net returns (Rs. 96996.6 ha^{-1}) and the highest B:C ratio (2.9) were achieved with the application of G_4 (75 cm × 25 cm). This treatment was statistically equivalent to G_2 but significantly superior to the recommended spacing G_1, which yielded the lowest net returns (Rs. 58664.1 ha^{-1}). For mulching treatments, M_2 (Organic mulch) provided the maximum net returns (Rs. 78077.0 ha^{-1}). However, the highest B:C ratio (2.7) was obtained with the no-mulch control (M_1). This is attributed to the lower cost of cultivation in the control plots compared to the additional expenses incurred from purchasing and applying mulch materials. Plastic mulch (M_3) resulted in the lowest net returns and B:C ratio, likely due to the higher initial cost of the material.

Table 1: Effect of Crop Geometry and Mulching on growth attributes of Maize

Treatments	Plant height (cm)			Plant Dry matter (g Plant^{-1})		
Factor A: Crop Geometry	**40DAS**	**80DAS**	**Maturity**	**40DAS**	**80DAS**	**Maturity**
G_1: 60 cm × 20 cm (recommended spacing)	53.78	135.56	157.67	19	155	229
G_2: 60 cm × 25 cm	73.00	154.00	194.33	39	209	281

G_3: 75 cm × 20 cm	60.97	141.44	172.67	29	188	242
G_4: 75 cm × 25 cm	75.78	157.56	199.67	41	213	289
SEm±	1.62	1.62	2.73	1.17	2.56	5.87
CD (P=0.05)	4.76	4.76	8.00	3.44	7.52	17.23
Factor B: Mulching						
M_1: No mulch (control)	58.00	139.22	167.33	26	176	235
M_2: Organic mulch (straw @ 5 t ha^{-1})	67.00	148.22	182.44	32	192	267
M_3: Plastic mulch (black polyethylene, 25–30 micron)	62.44	143.56	174.89	29	184	250
SEm+	1.41	1.40	2.36	1.02	2.22	5.09
CD (P=0.05)	4.12	4.12	6.93	2.98	6.51	14.92

Table 2: Effect of Crop Geometry and Mulching on yield attributes of Maize

Treatments	**Yield attributes**				
Factor A: Crop Geometry	**Cob's/plant**	**Cob's length**	**No. of Grain rows/cob**	**No. of Grains/row**	**Grains/cob**
G_1: 60 cm × 20 cm (recommended spacing)	1.4	13.3	13.2	26.0	346.4
G_2: 60 cm × 25 cm	2.6	20.1	14.1	36.3	539.1
G_3: 75 cm × 20 cm	1.9	16.3	13.8	38.6	535.3
G_4: 75 cm × 25 cm	2.7	20.1	14.9	39.7	611.6
SEm±	0.07	0.31	0.43	1.44	24.95
CD (P=0.05)	0.20	0.92	1.25	4.24	73.16
Factor B: Mulching					
M_1: No mulch (control)	1.8	15.9	13.3	29.7	403.3
M_2: Organic mulch (straw @ 5 t ha^{-1})	2.1	17.5	14.2	37.7	540.9
M_3: Plastic mulch (black polyethylene, 25–30 micron)	1.9	16.3	13.6	33.6	476.7
SEm+	0.06	0.27	0.37	1.25	21.60
CD (P=0.05)	0.17	0.80	1.08	3.67	63.36

Table 3: Effect of Crop Geometry and Mulching on yield and economics of Maize

Treatments	**Yield**					**Economics**	
Factor A: Crop Geometry	**Grain**	**Stover**	**Biological**	**Harvest Index**	**Seed Index(g)**	**Net Return**	**B:C ratio**
G_1: 60 cm × 20 cm (recommended spacing)	3443	7864	11307	30	24.7	58664.1	2.2
G_2: 60 cm × 25 cm	4503	9410	13913	32	36.4	92594.8	2.8
G_3: 75 cm × 20 cm	3807	8797	12605	30	32.0	70322.8	2.4
G_4: 75 cm × 25 cm	4641	9674	14315	32	38.2	96996.6	2.9
SEm+	70.46	91.60	152.50	0.26	0.86	2254.87	0.04
CD (P=0.05)	206.66	268.66	447.27	0.77	2.51	6613.25	0.13
Factor B: Mulching							
M_1: No mulch (control)	3761	8347	12108	31	29.0	75677.0	2.7
M_2: Organic mulch (straw @ 5 t ha^{-1})	4086	8992	13078	31	33.4	78077.0	2.5
M_3: Plastic mulch (black polyethylene, 25–30 micron)	3906	8733	12640	31	30.7	67827.7	2.2
SEm+	61.02	79.33	132.07	0.23	0.74	1952.78	0.04
CD (P=0.05)	178.98	232.67	387.35	0.66	2.17	5727.24	0.11

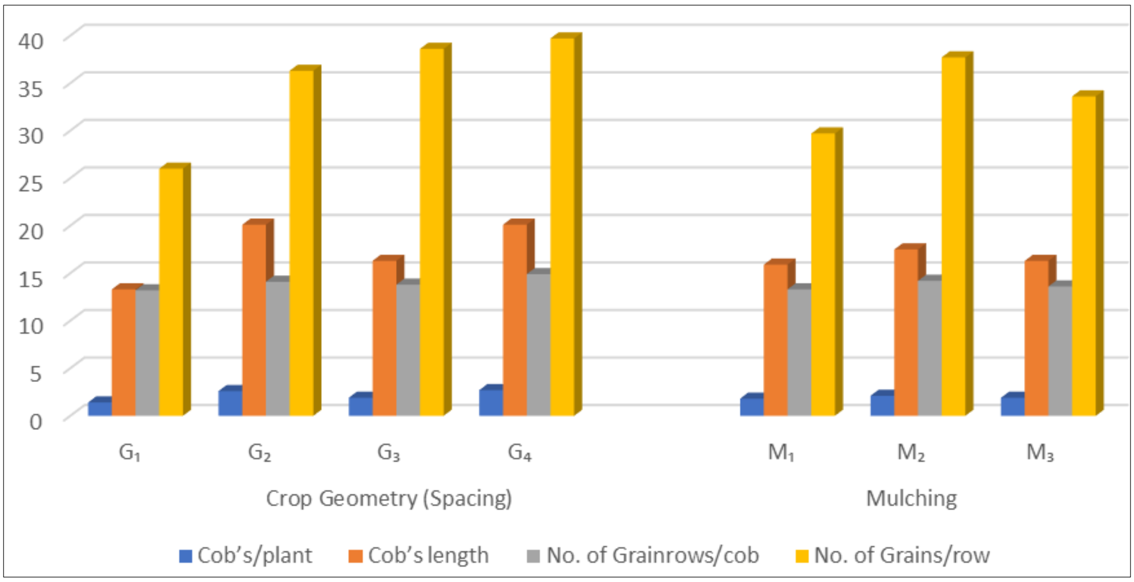

Fig 1: Effect of Crop Geometry and Mulching on yield attributes of Maize

Discussion

Growth Attributes

Growth attributes, viz., plant height and dry matter accumulation, were significantly increased with different crop geometries and mulching. Among all treatments, G_4 (75 cm × 25 cm) recorded the highest plant height and dry matter accumulation, which was at par with G_2 (60 cm × 25 cm). Higher growth parameters with G_4 might be due to wider row and plant spacing, facilitating better interception of solar radiation and reduced inter-plant competition. Beneficial effects of mulching were observed with M_2 (Organic mulch - straw @ 5 t ha⁻¹), recording maximum plant height and dry matter production. This is attributed to better soil moisture conservation and moderated soil temperature.

Yield Attributes

Yield attributing characters, viz., cobs per plant, cob length, grain rows per cob, and total grains per cob, were significantly increased. G_4 (75 cm × 25 cm) recorded the highest values for these parameters. Wider planting geometry facilitated better individual plant growth and reduced "crowding effect," consequently increasing sink capacity. Optimized spacing is an essential factor for resource availability and biological energy transformation.

M_2 (Organic mulch) recorded maximum values for all cob and grain attributes. Organic mulch maintains a cooler hydrothermal regime in the root zone, facilitating nutrient uptake during critical silking and grain-filling stages. This improved pollination and reduced kernel abortion, thereby increasing grains per row and grains per cob.

Yields

Grain yield and stover yield were significantly influenced by crop geometries. The highest grain yield (4641 kg ha^{-1}) and stover yield (9674 kg ha^{-1}) were obtained in G_4, which was superior over the recommended spacing. This is due to higher yield attributing parameters and higher sink translocation producing bolder grains. Increased yield with organic mulch (M_2) resulted from the combined effect of improved growth and yield components. Optimized spacing and moisture conservation improved the photosynthetic rate and energy transformation.

Economics

G_4 (75 cm × 25 cm) gave higher net returns (Rs. 96,996.6 ha^{-1}) and the maximum B:C ratio (2.9). This is attributed to significantly higher yields compensating for management costs. Regarding mulching, maximum net returns (Rs. 78,077.0 ha^{-1}) were found with M_2, providing better returns compared to plastic mulch. However, the maximum B:C ratio (2.7) was obtained with the no-mulch control (M_1) due to the lower cost of cultivation, as no additional expenditure was incurred on mulching materials or labor.

Conclusion

Based on one year field experimentation, it is concluded that higher yield attributes, grain yield, and better economic returns of maize can be obtained by planting the crop with 75 cm × 25 cm (G_4) crop geometry along with the application of Organic mulch (M_2). However, maximum net return (Rs. 96,996.6 ha^{-1}) and highest B: C ratio (2.9) was obtained with the application of G_4 (75 cm × 25 cm). In case of mulching, while organic mulch improved growth, yield attributes, yields and net returns but the maximum B:C ratio 2.7 was recorded with the no-mulch control (M_1) due to the lower cost of cultivation. Thus, for getting higher yields and net returns the maize crop should be sown at crop geometry of 75 cm × 25 cm along with application of straw mulch at 5t/ha at the time of owing. Above conclusions are based on single season research and its needs further confirmation by repeating the trial for at least one more season for getting more relevant and consistent results.

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