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Effect of spacing and gibberellic acid on green fodder yield attributes and economics of maize (*Zea mays* L.)

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Abstract

A field experiment was carried out during the Kharif season of 2024 at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The experimental plot's soil was sandy loam in texture, with a nearly neutral pH of 7.1, moderate organic carbon content (0.53%), low available nitrogen (165.48 kg/ha), medium levels of available phosphorus (27.52 kg/ha), and high available potassium (212.36 kg/ha). The treatments involved three levels of Gibberellic acid, three different spacings, and one control. The experiment was designed in a randomized block layout with 10 treatments, each replicated three times. The treatment with spacing of 60 x 30 cm and Gibberellic acid at 200 ppm (treatment 9) produced significantly higher plant density (8.03 plants/m²) and green fodder yield (11,024.30 kg/ha). This treatment also yielded the highest gross return (INR 88,194.00/ha), net return (INR 54,194.00/ha), and benefit-cost ratio (1.51). It can be concluded that the combination of 60 x 30 cm spacing and Gibberellic acid at 200 ppm resulted in the highest yield and most favorable benefit-cost ratio for maize.

Keywords: Gibberellic acid, plant geometry, spacing and economics

Introduction

India has the largest livestock population in the world, with approximately 520 million animals, accounting for about 15% of the global livestock population. However, the country has only 2% of the world's geographical area dedicated to fodder crops (Shah *et al.*, 2011a) [8]. Maize (*Zea mays* L.) is one of the most adaptable crops, thriving under a wide range of agro-climatic conditions. It is grown successfully across various seasons and ecosystems for different purposes. Globally, maize is often referred to as the "Queen" of cereals due to its highest genetic yield potential among cereals. It is cultivated in about 160 countries, covering nearly 150 million hectares, and grows well in diverse soil types, climates, and management practices.

In modern maize production systems, higher plant densities often lead to increased competition for limited resources, which results in greater plant-to-plant variability. India's current feed and fodder resources can only meet 47% of the country's requirements, leaving a significant deficit of 61% for green fodder and 22% for dry fodder (Shah *et al.*, 2011) [8]. There are two primary approaches to increasing fodder production: horizontal and vertical improvement. Increasing the area dedicated to fodder crops is not feasible due to the ongoing challenges of feeding the growing human population, which is increasing at more than 1% per year. Therefore, the only viable solution is to enhance fodder production vertically, by increasing the yield of fodder per unit area over time.

Gibberellic acid, a plant growth regulator, plays a crucial role in stimulating shoot apex development, primary leaf primordia, and root systems. It promotes stem growth, stimulates cell division and elongation, and aids in enzyme secretion. It also helps overcome dormancy in seeds and buds. Gibberellins can move easily in plants in both directions. Commercially, gibberellic acid is used to increase fruit size, stimulate seed germination, and enhance seed growth (Kumar *et al.*, 2012) [2, 3]. Found naturally in fungi and plants, gibberellic acid can also be synthesized commercially using microorganisms. This growth-promoting hormone has direct effects on cell elongation, germination, flowering, fruit set, and fruit development. Research has shown that gibberellic acid, when used at varying concentrations individually or in combination with other growth promoters, can significantly affect parameters such as flowering, fruiting, yield, and

quality, especially in crops like strawberries (Khunte *et al.*, 2014)^[4].

Materials and Methods

The experiments were conducted during the Kharif season of 2025 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj. This farm is situated about 5 kilometers from Prayagraj city, on the right bank of the Yamuna River along the Prayagraj-Rewa Road. Maize variety *Sugar 75* was chosen for sowing. The seeds were manually sown in rows on 2024, and were immediately covered with soil after planting. The spacing between plants and rows was based on the treatment details, and seeds were drilled at a depth of 3-4 cm. All treatments were applied following the initial soil test results and crop requirements, ensuring the appropriate nutrients were supplied for optimal crop response throughout the growing season.

Results and Discussion

1. Yield attributes

Number of plants/m²

A significant difference was observed among the treatments. The highest number of plants per square meter (14.94) was recorded in Treatment T3, which involved a spacing of 40 x 20 cm along with Gibberellic acid at 200 ppm. Treatment T2, which used a spacing of 40 x 20 cm with Gibberellic acid at 150 ppm (14.69), showed results statistically similar to Treatment T3. The lowest plant density was observed in Treatment T7, with a spacing of 60 x 30 cm and Gibberellic acid at 100 ppm, which recorded only 8.00 plants/m².

Green Fodder Maize

A significant difference was observed among the treatments for green fodder yield. The highest green fodder yield (11,024.30 kg/ha) was recorded in Treatment T9, which involved a spacing of 60 x 30 cm along with Gibberellic acid at 200 ppm. Treatment T8, with a spacing of 60 x 30 cm and Gibberellic acid at 150 ppm (10,516.02 kg/ha), showed results that were statistically similar to Treatment T9. The lowest green fodder yield was reported in Treatment T1, which used a spacing of 40 x 20 cm and Gibberellic acid at 100 ppm, yielding 9,316.41 kg/ha.

2. Economics

Gross return (INR/ha)

The highest gross return (INR 88,194.40) was observed in

Treatment T9, which involved a spacing of 60 x 30 cm along with Gibberellic acid at 200 ppm. On the other hand, the lowest gross return (INR 84,128.20) was recorded in Treatment T7, which used a spacing of 60 x 30 cm and Gibberellic acid at 150 ppm, compared to the other treatments.

Net returns (INR/ha)

The highest net return (INR 54,194.00) was recorded in Treatment T9, which involved a spacing of 60 x 30 cm with Gibberellic acid at 200 ppm. The lowest net return (INR 50,128.20) was observed in Treatment T7, with a spacing of 60 x 30 cm and Gibberellic acid at 150 ppm, compared to the other treatments.

Benefit cost ratio (B:C)

The highest benefit-cost ratio (1.51) was recorded in Treatment T9, which involved a spacing of 60 x 30 cm along with Gibberellic acid at 200 ppm. The lowest benefit-cost ratio (1.40) was observed in Treatment T8, with a spacing of 60 x 30 cm and Gibberellic acid at 150 ppm, compared to the other treatments.

Discussion

This improvement can be attributed to the fact that gibberellic acid (GA3) promotes internode extension, leaf growth, and apical dominance. According to Ravat and Makani (2015)^[7], GA3 enhances cell division, elongation, and cell wall plasticity, leading to an increase in internodal length. Additionally, the application of GA3 has been shown to stimulate axial elongation, which may be linked to the elongation of microtubules. GA3 also boosts the activity of the enzyme xyloglucan endotransglycosylase (XET), which facilitates the breaking and reforming of bonds between xyloglucan residues, thereby increasing cell wall extensibility. These mechanisms contribute to enhanced growth, particularly in terms of plant height. Furthermore, the number of branches per plant increased with GA3 application, as the hormone encourages cell division, multiplication, and enlargement. It has been reported that photosynthetic activity rises due to increased leaf growth induced by gibberellic acid, resulting in better dry matter accumulation. These findings are consistent with the earlier studies of Jatav (2007)^[1], Mukherjee and Roy (2006)^[6], and Mithra and Pathak (2005)^[5]. Overall, GA3 application leads to a significant increase in various growth attributes, especially plant height, as well as improved branch development and dry matter accumulation.

Table 1: Effect of spacing and Gibberellic acid Green fodder yield attributes of maize

S No	Treatment combinations	Number of plants/m ²	Green Fodder Maize (g)
1.	Spacing 40 x 20 cm + Gibberellic acid 100 ppm	14.72	9316.41
2.	Spacing 40 x 20 cm + Gibberellic acid 150 ppm	14.69	9383.27
3.	Spacing 40 x 20 cm + Gibberellic acid 200 ppm	14.94	9475.14
4.	Spacing 50 x 20 cm + Gibberellic acid 100 ppm	9.99	9412.70
5.	Spacing 50 x 20 cm + Gibberellic acid 150 ppm	9.94	9647.30
6.	Spacing 50 x 20 cm + Gibberellic acid 200 ppm	10.01	9751.40
7.	Spacing 60 x 30 cm + Gibberellic acid 100 ppm	8.00	9860.60
8.	Spacing 60 x 30 cm + Gibberellic acid 150 ppm	8.01	10516.02
9.	Spacing 60 x 30 cm + Gibberellic acid 200 ppm	8.03	11,024.30
10.	Control (RDF) – NPK – 120: 60: 40 kg/ha)	14.77	9969.00
	S. Em (±)	S	S
	CD (p = 0.05)	0.22	194.56

Table 1: Effect of spacing and Gibberellic acid on economics of maize

S No	Treatment combinations	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	Spacing 40 x 20 cm + Gibberellic acid 100 ppm	74,531.30	43,331.30	1.27
2.	Spacing 40 x 20 cm + Gibberellic acid 150 ppm	75,066.17	43,866.17	1.28
3.	Spacing 40 x 20 cm + Gibberellic acid 200 ppm	75,801.11	44,601.11	1.29
4.	Spacing 50 x 20 cm + Gibberellic acid 100 ppm	75,301.57	44,101.57	1.27
5.	Spacing 50 x 20 cm + Gibberellic acid 150 ppm	77,178.40	45,978.40	1.31
6.	Spacing 50 x 20 cm + Gibberellic acid 200 ppm	78,011.20	46,811.20	1.33
7.	Spacing 60 x 30 cm + Gibberellic acid 100 ppm	78,884.80	44,884.80	1.26
8.	Spacing 60 x 30 cm + Gibberellic acid 150 ppm	84,128.20	50,128.20	1.40
9.	Spacing 60 x 30 cm + Gibberellic acid 200 ppm	88,194.40	54,194.40	1.51
10.	Control (RDF) – NPK – 120: 60: 40 kg/ha	79,752.00	45,752.00	1.35

Conclusion

It can be concluded that the application of Spacing 60 x 30 cm + Gibberellic acid 200 ppm recorded higher yield attributes and economics in maize.

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