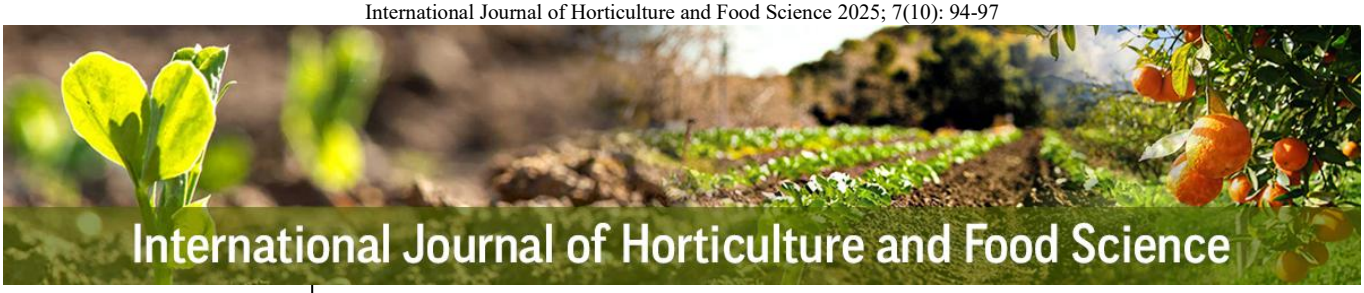

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Effect of mulching and bio-regulators on growth and flowering of gaillardia (*Gaillardia pulchella*)

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Abstract
A field experiment was carried out at the Crop Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan, during *summer season* 2024-25, employing a Factorial Randomized Block Design with twenty-one treatments and three replications. The experiment included different mulching materials paddy straw, black polythene, and control as well as bio-regulators at varying concentrations of GA_3 and NAA (Control, 100, 150, 200 ppm). The findings demonstrated that the highest growth and yield parameters were consistently observed under paddy straw mulch and GA_3@200ppm treatments, which produced the tallest plants (79.33 cm), greatest plant spread (61.42 cm), most branches (25.89), and earliest flowering (56.55) were also recorded in these treatments. These results suggest that paddy straw mulch and GA_3 at 200 ppm are highly effective for enhancing growth, flowering, yield, and quality attributes of gaillardia under sandy loamy soil conditions in Rajasthan, making them recommended practices for maximizing ornamental floriculture production in the region.

Keywords: Gaillardia, mulching, bio stimulants, yield attributes, growth, yield, rabi

1. Introduction
The genus Gaillardia, popularly known as blanket flower, comprises both annual and perennial herbaceous plants belonging to the family Asteraceae, and is indigenous to the American continents. Among the various species, *Gaillardia pulchella* is the most extensively grown ornamental type due to its bright, attractive blooms and exceptional adaptability to diverse agro-climatic environments.

Botanically, Gaillardia plants are characterized by upright, well-branched stems reaching heights of about 40-80 cm, and alternately arranged leaves that are often basal, lanceolate, or pinnatifid in shape, and sometimes covered with fine hairs or glandular structures (Chandarsekhar, 2024) [3]. This striking floral arrangement not only enhances the ornamental value of the plant but also ensures an extended flowering period from late spring through autumn, making Gaillardia a favoured species for ornamental gardening and landscape beautification (Native Plant Trust, 2025) [9].

In India, the commercial importance of Gaillardia has increased significantly, particularly in states promoting large-scale floriculture**.** Reports from Chhattisgarh reveal that the crop covers an area of about 184 hectares**,** producing approximately 1,108 metric tonnes annually, with an average productivity of 6.02 MT/ha. Similarly, in the Akola district of Maharashtra, economic assessments have shown average yields of around 30,000 kg/ha and a benefit-cost ratio of 2.16, emphasizing its profitability and suitability for small and marginal farmers (Yadu *et al.,* 2020) [13]. In Rajasthan, Gaillardia has gained recognition for its tolerance to semi-arid conditions, and it is frequently included in varietal trials and evaluation studies aimed at promoting crop diversification and ensuring year-round flower production in the region. The positive effects of mulching are not limited to improved plant growth and yield but also encompass enhanced flower quality, increased stem length, and extended vase life all of which are vital attributes for the commercial success of ornamental crops such as Gaillardia. Findings from recent multi-location experiments indicate that black polythene mulch effectively stabilizes soil conditions, thereby prolonging the growing season and producing larger, more vibrant flowers that fetch higher prices in the market.

Consequently, mulching is considered a recommended agronomic practice, as it not only contributes to maximizing productivity but also strengthens the market competitiveness and environmental adaptability of Gaillardia under diverse climatic conditions (Kaur *et al.,* 2023) [4].

The use of Naphthalene Acetic Acid (NAA) in Gaillardia has been shown to significantly promote stem elongation, leaf expansion, and early, uniform flowering**,** as evidenced by recent field research. These effects contribute to a higher number of blooms with improved uniformity**,** a desirable trait in commercial floriculture where consistent flower size and synchronized blooming are essential for bulk harvesting and marketing**.** When applied before the flowering stage**,** NAA enhances root growth and shoot development**,** leading to stronger and more resilient plants capable of maintaining high productivity even under less favourable growing conditions (Maurya, 2020) [8].

In the case of Gaillardia, experimental findings reveal that GA_3 at 100 ppm results in the tallest plants, maximum number of lateral shoots, and the widest canopy, all of which are strongly associated with a notable rise in flower number and flower size. Apart from promoting vegetative growth, GA_3 also accelerates flowering, ensures greater bloom uniformity, and significantly boosts the overall flower yield, thereby improving both the quantity and market value of the crop (Khan and Devi, 2018) [5].

2. Materials and Methods

A field experiment was carried out at the Crop Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan, during *summer season* 2024-25, employing a Factorial Randomized Block Design with twenty-one treatments and three replications. The experiment included different mulching materials paddy straw, black polythene, and control as well as bio-regulators at varying concentrations of GA_3 and NAA (Control, 100, 150, 200 ppm) T_1 (Black polythene mulch + NAA @ 100 ppm), T_2 (Black polythene mulch + NAA @ 150 ppm), T_3 (Black polythene mulch + NAA @ 200 ppm), T_4 (Black polythene mulch + GA_3 @ 100 ppm) T5 (Black polythene mulch + GA_3 @ 150 ppm), T6 (Black polythene mulch + GA_3 @ 200 ppm), T7 (Black polythene mulch + Control), T8 (Paddy straw mulch + NAA @ 100 ppm), T9 (Paddy straw mulch + NAA @ 150 ppm), T10 (Paddy straw mulch + NAA @ 200 ppm), T11 (Paddy straw mulch + GA_3 @ 100 ppm), T12 (Paddy straw mulch + GA_3 @ 150 ppm) T13 (Paddy straw mulch + GA_3 @ 200 ppm), T14 (Paddy straw mulch + Control), T15 (Control + NAA @ 100 ppm), T16 (Control + NAA @ 150 ppm), T17 (Control + NAA @ 200 ppm), T18 (Control + GA_3 @ 100 ppm) T19 (Control + GA_3 @ 150 ppm), T20 (Control + GA_3 @ 200 ppm) and T21 (Control). The study was arranged in a Factorial Randomized Block Design (FRBD) with three replications. Data were recorded on various growth parameters, including plant height, plant spread (measured in centimetres from the ground level to the top), number of branches per plant and days to flowerings (counted after flower bud emergence).

3. Results and Discussion

3.1 Plant height (cm)

Result pertaining to the plant height (cm) is presented in Table1 shows the effect of mulching and bio stimulants significantly increased plant spread over control.

At 30, 60 and 90 days after sowing, the highest plant height among mulching treatments was recorded in Treatment Paddy straw mulch (17.76cm, 50.52cm and 79.33cm), which was significantly at par with Treatment Black polythene mulch (16.22cm), while the lowest height was observed in the Control (14.82cm, 37.12cm and 55.47cm). For bio-regulators, the tallest plants were observed in Treatment GA_3@200ppm (18.11cm, 51.59cm and 78.54cm), followed by Treatment GA_3@150ppm (17.57cm) and Treatment GA_3@100ppm (17.03cm), all significantly higher than NAA treatments and the Control (15.23cm, 37.55cm and 53.48cm), which showed the least plant height. The increase in plant height of *Gaillardia* under mulching and bio-regulator treatments corresponds with outcomes reported in recent agronomic investigations. The maximum plant height achieved with paddy straw mulch and black polythene mulch at 90 DAS supports the view that organic mulches help conserve soil moisture and enhance nutrient availability, thereby stimulating vegetative growth (Ramadhani *et al.,* 2024) [11]. Likewise, foliar application of GA_3 at 200 ppm markedly improved plant height by stimulating cell elongation and division, which is consistent with the established function of gibberellins as promoters of plant growth (Yadu *et al.,* 2025) [14]. Similar observations were made by Kumar *et al*. (2019) [7], who reported that the combined use of mulching and GA_3 significantly increased biomass production and plant height in ornamental species.

3.2 Plant spread (cm)

Result pertaining to the plant spread is presented in Table 1 shows the effect of mulching and bio stimulants significantly increased plant spread over control.

At 30, 60 and 90 days after sowing, the highest plant spread among mulching treatments was recorded in Treatment Paddy straw mulch (16.88cm, 35.02cm and 61.42cm), which was significantly at par with treatment black polythene mulch (15.72 cm), while the lowest spread was observed in the Control (13.79cm, 28.88cm and 42.25 cm). For bio-regulators, the greatest plant spread was seen in Treatment GA_3@200ppm (16.63cm, 34.52cm and 60.45cm), These were all significantly superior to NAA treatments, with the minimum recorded in the Control (13.25cm, 27.34cm and 40.11cm). Regarding plant spread, the findings indicate that both mulching and GA_3 application significantly enhanced the canopy width of *Gaillardia*, a vital trait for maximizing the photosynthetic surface area and overall productivity. The widest plant spread observed under paddy straw mulch implies that organic mulches contribute to an improved soil microenvironment and nutrient recycling, which promote lateral vegetative expansion (Kazemi and Jozay, 2020) [6]. Similarly, GA_3 application stimulated horizontal growth by promoting cell elongation, a phenomenon also reported in several ornamental species (Singh *et al.,* 2020) [12]. The notable differences compared with untreated controls highlight the importance of such treatments in achieving greater spatial growth, resulting in superior flower yield and quality. Overall, these observations confirm the complementary role of mulching and growth regulators in enhancing plant architecture in Gaillardia.

3.3 Number of branches per plant

Result pertaining to the number of branches/plants is presented in Table 2 shows the effect of mulching and bio stimulants significantly increased number of branches/plants

over control.

At 30, 60 and 90 days after sowing, the highest number of branches among mulching treatments was recorded in Treatment Paddy straw mulch (organic) (13.98, 22.43 and 25.89 number of branches), which was significantly at par with treatment black polythene mulch (12.27 number of branches/plant), while the lowest number was observed in the Control (10.91, 17.88 and 21.67 number of branches). For bio-regulators, the greatest number of branches was seen in Treatment GA_3@200ppm (13.69, 21.98 and 25.57 number of branches), closely followed by Treatment GA_3@150ppm (13.32 branches) and Treatment GA_3@100ppm (12.88 branches). These were all significantly superior to NAA treatments, with the minimum recorded in the Control (10.66, 17.17 and 21.33 number of branches). The increase in the number of branches per plant under mulching and bio-regulator treatments highlights enhanced vegetative growth as a positive response to both cultural and physiological practices. Among the treatments, paddy straw mulch produced the maximum branching, which may be attributed to its gradual nutrient release and improvement of soil organic matter, creating favourable conditions for sustained shoot development (Patel *et al.,* 2022) [10]. Similarly, foliar application of GA_3 at 200 ppm resulted in the highest number of branches, consistent with its established role in stimulating axillary bud emergence and reducing apical dominance in flowering plants (Bordoloi and Saikia, 2022) [2]. Increased branching directly contributes to a greater number of potential flowering sites and, consequently, higher yield potential. These observations are in line with the findings of Arha *et al.* (2021) [1].

3.4 Days to initiation of flowering

Result pertaining to the days to initiation of flowering is presented in Table 2 shows the effect of mulching and bio stimulants significantly increased days to initiation of flowering over control.

For days to initiation of flowering, the earliest flowering was recorded in the Paddy straw mulch (organic) treatment (56.55 days), closely followed by Black polythene mulch (60.12 days), both of which were significantly earlier than the Control (71.43 days). Among bio-regulators, the minimum days to initiation of flowering was observed in GA_3@200ppm (56.14 days), followed by GA_3@150ppm (58.45 days) and GA_3@100ppm (59.68 days). These GA_3 treatments were all markedly earlier than those of NAA or the Control (71.01 days), indicating a pronounced effect of GA_3 in hastening flower initiation. The minimum days to flower initiation under both mulching and bio-regulator treatments demonstrates the efficiency of these practices in accelerating reproductive development in *Gaillardia*. The earliest flowering recorded with paddy straw mulch and GA_3 at 200 ppm aligns with previous findings. According to Singh *et al.* (2020) [12], higher concentrations of GA_3 promote early flowering by stimulating cell expansion and facilitating the movement of assimilates toward developing floral buds. Likewise, organic mulches help maintain optimal soil temperature and moisture around the root zone, creating favorable conditions that hasten floral initiation.

4. Conclusion

The study demonstrates that paddy straw mulch and GA_3@200 ppm significantly enhance growth, flowering, yield, and flower quality in gaillardia compared to control. At 90 DAS, these treatments produced the greatest plant height, spread, and number of branches. They also hastened flowering initiation, increased flower yield per plant and hectare, and improved flower size, stalk length, and shelf life. Overall, combining paddy straw mulch with GA_3@200 ppm is an effective approach to maximize gaillardia productivity and quality.

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Table 1: Effect of mulching and bio-regulators on plant height (cm) and plant spread (cm) of gaillardia

Treatments	Plant height (cm)			Plant spread (cm)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Mulching treatments						
Black polythene mulch	16.86	47.75	73.49	15.71	32.97	57.88
Paddy straw mulch (organic)	17.76	50.52	79.33	16.88	35.02	61.42
Control	14.82	37.12	55.47	13.79	28.88	42.25
SEm±	0.49	0.29	0.09	0.39	0.27	0.19
CD	0.98	3.37	3.81	1.06	1.61	1.94
Bio-regulators						
NAA@100ppm	15.65	40.33	63.77	14.97	30.97	51.77
NAA@150ppm	16	42.74	67.3	15.53	32.48	53.03
NAA@200ppm	16.15	45.77	70.58	15.83	32.89	55.42
GA3@100ppm	17.03	48.62	75.11	15.99	33.84	57.29
GA3@150ppm	17.19	49.31	77.23	16.02	33.99	58.88
GA3@200ppm	18.11	51.59	78.54	16.63	34.52	60.45
Control	15.23	37.55	53.48	13.25	27.34	40.11
SEm±	0.51	0.67	3.71	0.69	0.71	0.92
CD	1.06	2.38	2.31	0.65	1.43	1.69

Table 2: Effect of mulching and bio-regulators on plant spread (cm) and Days to initiation of flowering of gaillardia

Treatments	Number of branches			Days to initiation of flowering
	30 DAS	60 DAS	90 DAS	
Mulching treatments				
Black polythene mulch	12.28	21.1	23.36	60.12
Paddy straw mulch (organic)	13.98	22.43	25.89	56.55
Control	10.91	17.88	21.67	71.43
SEm±	0.34	0.48	0.25	0.82
CD	0.56	1.12	2.42	2.69
Bio-regulators				
NAA@100ppm	11.35	19.57	22.69	67.71
NAA@150ppm	11.97	19.92	22.92	65.55
NAA@200ppm	12.71	21.28	23.9	62.36
GA3@100ppm	12.99	21.48	24.13	58.68
GA3@150ppm	13.36	21.89	24.94	57.45
GA3@200ppm	13.69	21.98	25.57	56.14
Control	10.66	17.17	21.33	71.01
SEm±	0.42	0.74	0.56	1.16
CD	0.65	0.78	1.51	3.10

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