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RESEARCH ARTICLE

Response of plant growth regulators and organic manure on growth attributes of cucumber (*Cucumis sativus* L.) hybrid under greenhouse conditions

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Abstract

Cucumber cultivation in the Sirmour region faces significant challenges, resulting in lower yields than in other regions. Optimizing fertiliser management is crucial to improving cucumber growth. A research trial was carried out at the Dr Khem Singh Gill Akal College of Agriculture, Eternal University, Sirmour, Himachal Pradesh, to examine the impact of organic manure and plant growth regulators (PGRs) on cucumber growth. The study included 64 treatment combinations, including the 3 organic fertilizers: vermicompost (5 t ha^{-1}), biochar (2.5 t ha^{-1}) and farmyard manure (FYM) (25 t ha^{-1}). Three PGRs, namely 2,3,5-Triiodobenzoic acid (TIBA) (10 ppm), kinetin (10 ppm), brassinosteroids (2.0 ppm) and four hybrids, namely Aviva, Adiva, Fadia and Aafreen. The results revealed that the Aviva hybrid combination with vermicompost and brassinosteroids recorded the highest values for days to 1st flowering (DF), days to 1st female flowering (DFFF), internodal length (IL), node of 1st female flower, horizontal leaf width (HLW), horizontal leaf length (HLL), vine length (VL) and number of leaves per vine (NLV). A synergistic use of Aviva hybrid, vermicompost and brassinosteroids can effectively stimulate cucumber growth. Therefore, the integration of vermicompost with a foliar spray of brassinosteroids for the Aviva hybrid is recommended to farmers in the Sirmour district to improve vegetative characters.

Keywords: brassinosteroids; cucumber; flower; organic; treatments; vermicompost

Introduction

Cucumber (*Cucumis sativus* L.), an important vegetable crop with notable biological and economic importance, is used as a model plant to investigate a number of crucial biological processes (1). Cucumbers originated in the Indo-Burma region of India. Cucumber is a common monoecious, annual, climbing vine. The root is widespread and mostly superficial. Stout, hairy, 4-angled stem that can ascend or trail with simple tendrils. The petiole is 5-15 cm long and the leaves are triangular, ovate, 7-20 cm long, with a deeply cordate base and an acuminate tip. Although andromonoecious, gynoecious and tri-monoecious types are also observed. The yellow petals measure 3-4 cm in diameter. It thrives in sandy loam soil that is high in organic matter, well-drained and with a pH range of 6.5–7.5. Due to their thermophilic nature and frost susceptibility, cucumbers thrive at temperatures above 20 °C (2). Bitterness in cucumber is due to 'cucurbitacin' (3). The fruit is consumed raw, in salads and for pickling. It is a good source of vitamins C, B1, B2, B3, B6, B9 and B12, as well as various minerals, including iron, potassium, phosphorus and calcium. Cucumber fruits contain 95 % water and are low in calories, while providing sufficient vitamins, minerals and antioxidants vital for human health (4). It has various medicinal properties, such as aiding digestion, preventing constipation and jaundice and providing a cooling effect. The essential oil present in cucumber seeds is helpful for body smoothness and brain development (5). There is a continuous demand for cucumbers due to their use in fast food, such as sandwiches and pizza (6). Additionally, its seeds have diuretic, purgative and antipyretic properties (7). Staminate and pistillate cucumber flowers are produced on separate plant branches. The female flowers have a little immature fruit at the base, while male flowers do not. The fruit stalk is significantly longer, stronger and hispid, measuring 2-5 cm. Hermaphroditic flowers, i.e., perigynous blooms, produce more spherical fruits than epigynous flowers. Staminate, pistillate and hermaphrodite flowers can be easily differentiated visually. Compared to an open condition, vegetable crop productivity can be enhanced three to five times by implementing protected cultivation (8). The greenhouse cucumber is highly sought after in both domestic and international markets due to its distinct crispness, burpless texture and excellent water-holding capacity (9–11). An essential characteristic of cucumber production is parthenocarpy, which has long been present and enhances total yield across diverse environmental conditions worldwide. Plant growth regulator (PGR) application may increase sex expression towards female flowers,

thereby increasing the number of female flowers, the number of fruits per vine and fruit weight, thereby increasing yield parameters.

Plant growth regulator are organic compounds that modify physiological processes such as plant growth, development, cell elongation and flower development (12). Compost, cow dung, farmyard manure (FYM), slurry and other bulky materials, mostly derived from farm and animal waste products, are referred to as organic manure. Sewage sludge is a highly important fertilizer amendment for soil-crop agricultural systems. Crops cultivated with organic manure are now more expensive worldwide. Organic manure produces plants free of the toxic effects of chemicals (13). Cucumber, a significant salad vegetable, generally reacted favorably to PGRs and manures. The five main phytohormones are auxin, cytokinins, gibberellins, abscisic acid and ethylene, which include over 20 distinct types of PGRs (14). But the soil is losing its fertility every day due to the long-term, careless application of synthetic fertilizer. To meet the food and other needs of the growing population, research must be directed quickly and wisely toward the efficient and prudent use of the nutrient resources already accessible. This will boost production, productivity and profitability per unit area. Combining organic manure with PGRs aims to increase crop output efficiently and sustainably while maintaining soil productivity for future generations by utilizing both natural and synthetic plant nutrient sources.

Materials and Methods

The study was conducted in March 2024 and March 2025 at the Chhapang Research Farm, Dr Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, District Sirmour, Himachal Pradesh. The experimental site was located at 30°44'20" N and 77°18'52" E, at an elevation of 921 m above mean sea level. The experimental site is located in a semi-temperate, semi-humid mid-hill agro-climatic zone of Himachal Pradesh. Four hybrids (Aviva, Adiva, Fadia and Aafreen) were sown in March during both years of the study. The pooled data across years were calculated and recorded in the paper. There were 64 treatments in the experiment, each with three replications. The experiment was carried out in a greenhouse. In the research trial four different hybrids (Aviva, Adiva, Fadia and Aafreen) were used. Three organic manures [control, vermicompost (5 t ha^{-1}), biochar (2.5 t ha^{-1}), FYM (25 t ha^{-1})] were used. In the experiment, three PGRs [control, triiodobenzoic acid (10 ppm), kinetin (10 ppm) and brassinosteroids (2.0 ppm)] were used, with control. The experiment was laid out in factorial randomized complete block design. The plot measured 1.35 × 1.20 m and the spacing was 45 × 30 cm. Five randomly chosen plants per replication were used to record data on different growth characters and growth parameters were recorded from 10 random fruits; average values were calculated.

Statistical analysis

Analysis of variance (ANOVA) was performed for each treatment combination using the general linear model (GLM). Mean values were compared using DMRT at the 0.05 significance level. All statistical analyses were performed using SPSS version 20.0.

Results and Discussion

Among the different growth characters, minimum days to 1st flowering (DF), days to 1st female flowering (DFFF), internodal length (IL) and the node of the 1st female flower (NFFF) were recorded as the lowest in the Aviva hybrid in the pooled data. Maximum horizontal leaf width (HLW), vine length (VL) and number of leaves per vine (NLV) were recorded for the Aviva hybrid in the pooled data. Maximum horizontal leaf length (HLL) was recorded in Fadia hybrid (Table 1). All growth characters were significant in the pooled data, except HLL ($p > 0.05$) (Fig. 1).

The Aviva hybrid recorded the best vegetative parameters. The data on DF and DFFF varied significantly among hybrids. The better performance of one hybrid over another in terms of earliness in flowering and maturity may be due to favourable conditions. Hybrids with genetic traits that promote early flowering, such as early maturation genes or shorter vegetative growth phases, exhibit faster initiation of flowering. Additionally, favorable environmental conditions, such as temperature, photoperiod and nutrient availability, can promote early flowering (15, 16), which may confer superior performance in terms of early initiation of flowering and early maturity. The findings were reported similarly to earlier studies (17, 18). Earliness in cucumber is reported to be a genetic character in one study (19), whereas another study reported it to be an effect of the growing environment (20). Parthenocarpic cucumber cultivars differed widely in VL, NLV, IL, HLW and HLL under protected conditions. The differences in growth parameters among cucumber hybrids could be attributed to their genetic makeup and environmental factors such as diurnal temperature variation (21) and could be explained by the protected structure's improved microclimate, leading to higher respiration and photosynthesis. This aligns with observations from earlier studies on vegetables produced in polyhouses (22, 23) and on bell peppers grown in shade net houses (24, 25). Among different growth characters, minimum DF, 1st female flowering, IL, NFFF appears and maximum HLW, VL and NLV were recorded in vermicompost in pooled values (Table 2). While maximum HLL was observed in FYM (Fig. 2), different growth contributing characters were significantly different ($p < 0.05$).

Table 1. Effect of different hybrids on growth characters of cucumber

Hybrid	DF	DFFF	IL	NFFF	HLW	HLL	VL	NLV
Aviva	33.33[a]	33.59[a]	9.86[a]	4.84[a]	23.52[a]	22.55[a]	505.17[a]	73.03[a]
Adiva	33.98[b]	35.74[b]	10.92[b]	6.31[b]	22.62[b]	20.44[a]	433.52[b]	59.09[b]
Fadia	35.03[c]	35.03[c]	11.40[c]	6.30[b]	20.58[c]	23.70[a]	370.55[c]	50.10[c]
Afreen	36.44[d]	39.78[d]	12.10[d]	8.19[c]	19.48[d]	18.18[a]	326.87[d]	44.32[d]
Std. Error	0.080	0.090	0.085	0.080	0.074	2.077	0.943	0.244
P value	<0.05	<0.05	<0.05	<0.05	<0.05	> 0.05	<0.05	<0.05

DF- Days to first flowering; DFFF- Days to first female flowering; IL- Internodal length; NFFF- Node of first female flower; HLW- Horizontal leaf width; HLL- Horizontal leaf length; VL- Vine length; NLV- Number of leaves per vine

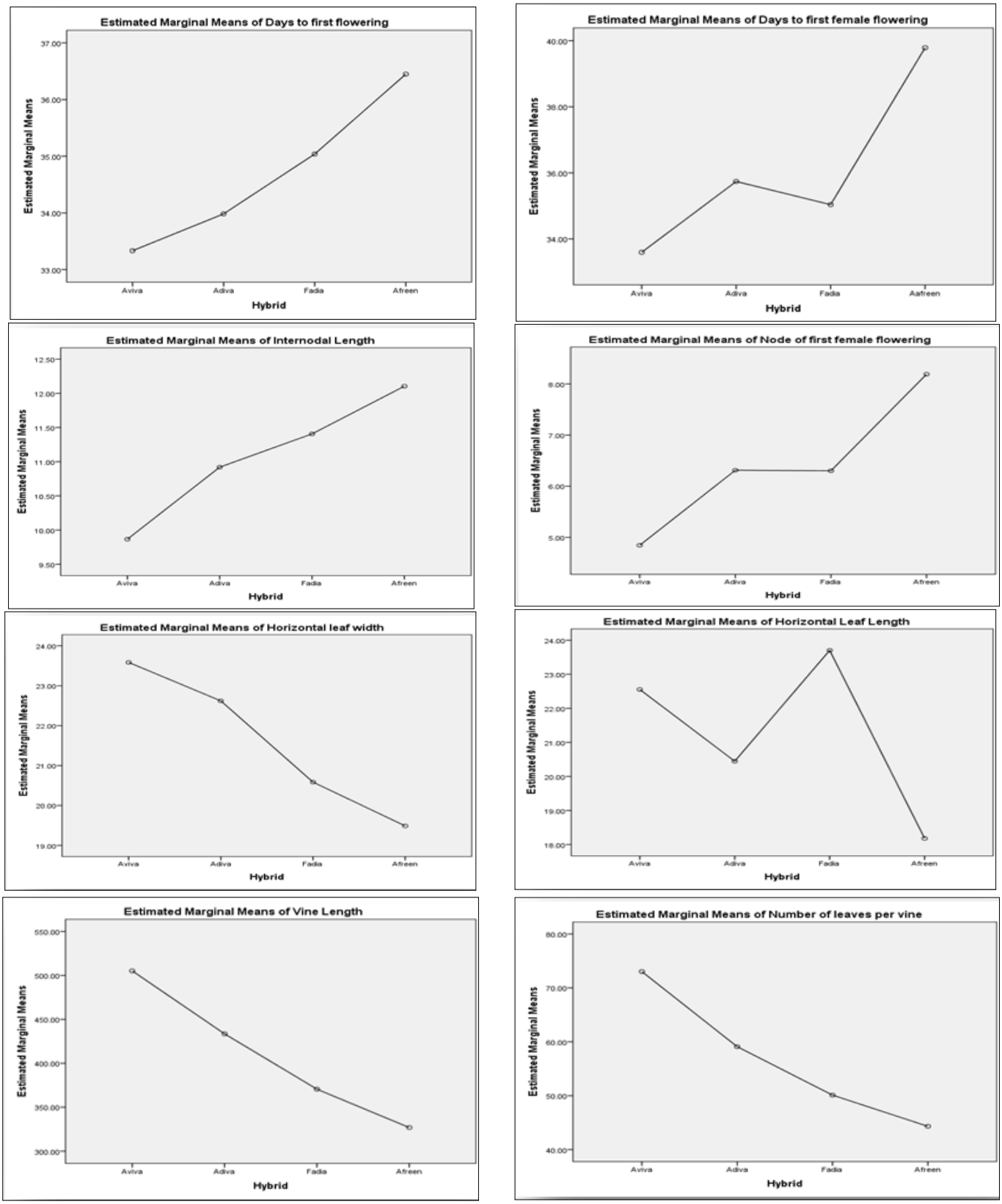

Fig. 1. Effect of different hybrids on growth characters of cucumber.

Table 2. Effect of different organic fertilizers on the growth characteristics of cucumber

Fertilizers	DF	DFFF	IL	NFFF	HLW	HLL	VL	NLV
Control	35.58[a]	38.61[a]	12.87[a]	8.60[a]	18.58[a]	17.17[a]	290.83[a]	39.30[a]
Vermicompost	33.88[b]	33.88[b]	10.00[b]	4.95[b]	23.59[b]	21.97[a-b]	476.13[b]	66.90[b]
Biochar	34.72[b]	35.88[b]	10.90[b]	6.25[c]	21.38[c]	20.54[a-b]	426.20[c]	58.69[c]
FYM	34.60[c]	35.77[c]	10.67[d]	5.82[d]	22.71[d]	25.19[b]	442.95[d]	61.65[d]
Std. Error	0.080	0.090	0.085	0.080	0.074	2.077	0.943	0.244
P value	<0.05	<0.05	<0.05	<0.05	<0.05	>0.05	<0.05	<0.05

DF- Days to first flowering; DFFF- Days to first female flowering; IL- Internodal length; NFFF- Node of first female flower; HLW- Horizontal leaf width; HLL- Horizontal leaf length; VL- Vine length; NLV- Number of leaves per vine

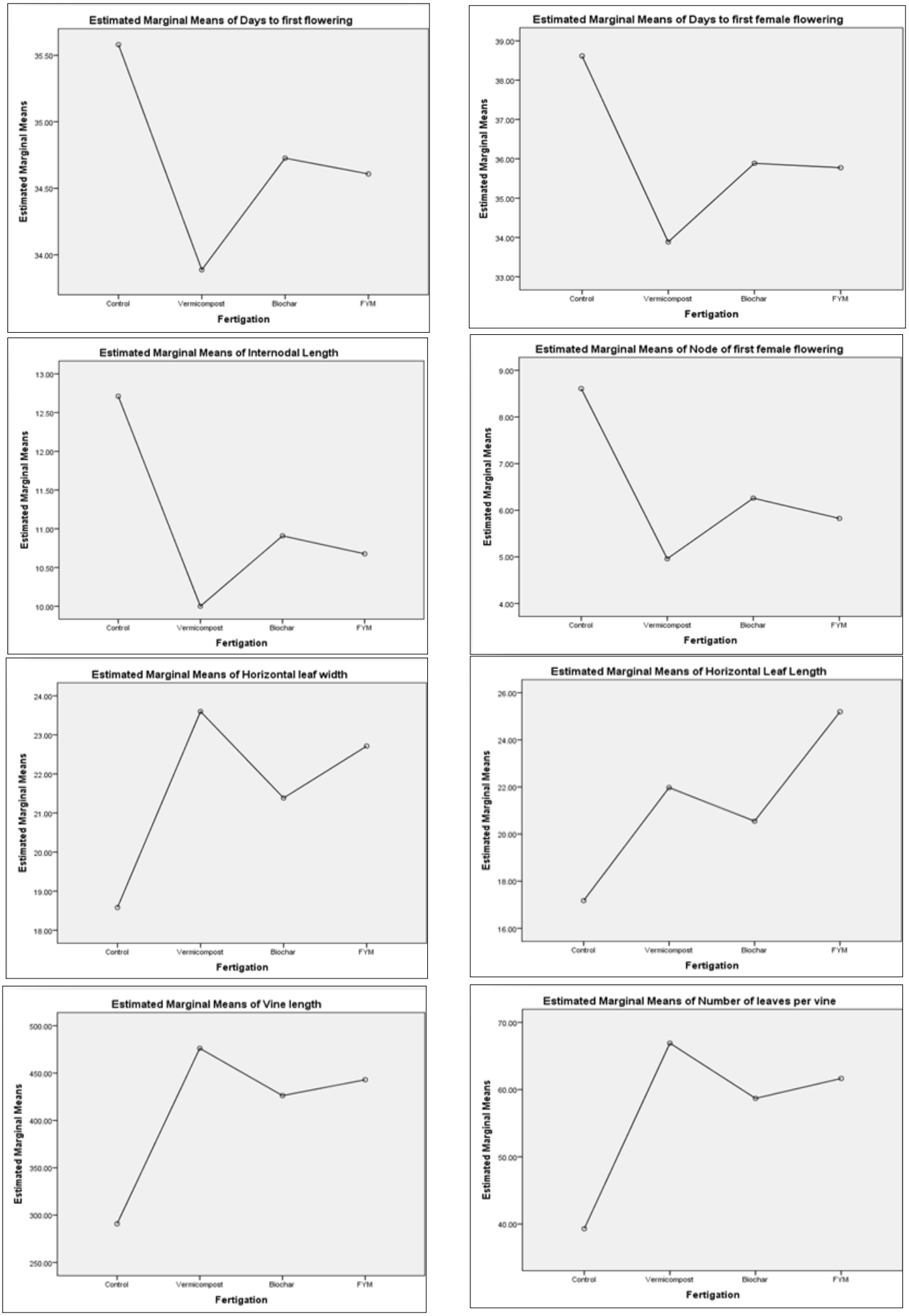

Fig. 2. Effect of different organic fertilizers on growth characters of cucumber.

This may come from enhanced root development and better soil physical characteristics, which enhance nutrient and water absorption. Vermicompost, a soil enhancer rich in nutrients, may have led to earlier flowering, including early female flowering (26, 27). Its physiochemical properties are improved by adding vermicompost (28, 29). For example, pH, cation exchange capacity and water and nutrient levels increased along with sluggish nutrient release (30, 31), which could have led to increased plant growth in treatments with vermicompost . Similar findings have been reported in cucumber (32–37). Vermicompost enhance soil structure and nutrient retention. Compared with treatments with less favourable inputs, this all-encompassing method produces robust vine development by optimizing soil health, nutrient availability and plant growth. Comparable results were reported in cucumber (38, 39).

The table clearly showed that utilising PGRs resulted in significantly improved growth characteristics, including minimum DF, DFFF, IL and NFFF were recorded in brassinosteroids, maximum HLW, VL and NLV were recorded in brassinosteroides. In comparison, maximum HLL was recorded in TIBA (Table 3). The differences in growth parameters were significant ($p < 0.05$) (Fig. 3). Cucumber plants treated with brassinosteroides were flowering early. Water may have entered the cell, causing it to expand, as the cell wall became more malleable and starch hydrolysed into sugar. Brassinosteroids may have contributed to enhanced photosynthetic activity, faster translocation and a more effective use of photosynthetic products, leading to faster cell division and longer cell length. Results agree with earlier studies on cucumber (40–42). This could be because PGRs had no effect on the opening of male cucumber flowers (43).

Additionally, it was noted that when Indole-3-acetic acid (IAA) at 100 ppm and Gibberellic acid (GA_3) at 500 ppm were applied together to cucumbers in a polyhouse, more male flowers appeared. Similarly, another study reported altered sex expression in bottle gourds due to PGRs (44). The second study found that GA_3 (< 70 ppm) during pre-flowering significantly influenced flowering and fruiting in bitter gourd (45). It is further reported that in cucumbers, NAA at 50 ppm produced more male and female flowers than NAA at 100 ppm (46). Gibberellic acid accelerates cell division and elongation to support plant growth, which leads to more primary branches as the primary vine elongates. These outcomes are consistent with previous studies (47–50).

Conclusion

The cucumber cultivated under the agro-climatic conditions of Sirmour exhibited significant variations in vegetative growth and floral parameters, indicating considerable potential for horticultural improvement. In greenhouse conditions, among the different hybrids, Aviva recorded the best results. Among the different organic manures, vermicompost recorded the highest values, while brassinosteroid, a plant growth regulator, gave the best results. Therefore, the cucumber hybrid Aviva, with vermicompost and brassinosteroid, could be an economically viable option for small and marginal farmers for cultivation in Sirmour agroclimatic conditions.

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Authors' contributions

VS conceived the study, carried out the formal analysis and investigation, and drafted the original manuscript. AS guided in the experiment and contributed to data analysis. YSB contributed to writing and editing. ASR contributed to the creation of figures and tables. MA provided materials, equipment and expertise. S contributed to editing the manuscript and to the references. R provided valuable support in recording fieldwork data. PT supported in recording data during fieldwork. MP contributed to recording data during fieldwork. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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Table 3. Effect of different plant growth regulators on growth characters of cucumber

PGR	DF	DFFF	IL	NFFF	HLW	HLL	VL	NLV
Control	35.15^{a}	36.44^{a}	11.56^{a}	6.86^{a}	21.10^{a}	19.62^{a}	380.73^{a}	52.84^{a}
TIBA	34.53^{a-b}	35.90^{a-b}	10.98^{a}	6.25^{a-b}	21.74^{b}	24.49^{a}	418.62^{b}	58.04^{b}
Kinetin	34.74^{b}	36.12^{b}	10.95^{a}	6.40^{b}	21.43^{c}	20.25^{a}	409.35^{c}	56.48^{c}
Brassinosteroides	34.36^{c}	35.69^{c}	10.79^{b}	6.12^{c}	21.98^{d}	20.51^{a}	427.40^{d}	59.17^{d}
Std. Error	0.080	0.090	0.085	0.080	0.074	2.07	0.943	0.244
P value	<0.05	<0.05	<0.05	<0.05	<0.05	>0.05	<0.05	<0.05

DF- Days to first flowering; DFFF- Days to first female flowering; IL- Internodal length; NFFF- Node of first female flower; HLW- Horizontal leaf width; HLL- Horizontal leaf length; VL- Vine length; NLV- Number of leaves per vine

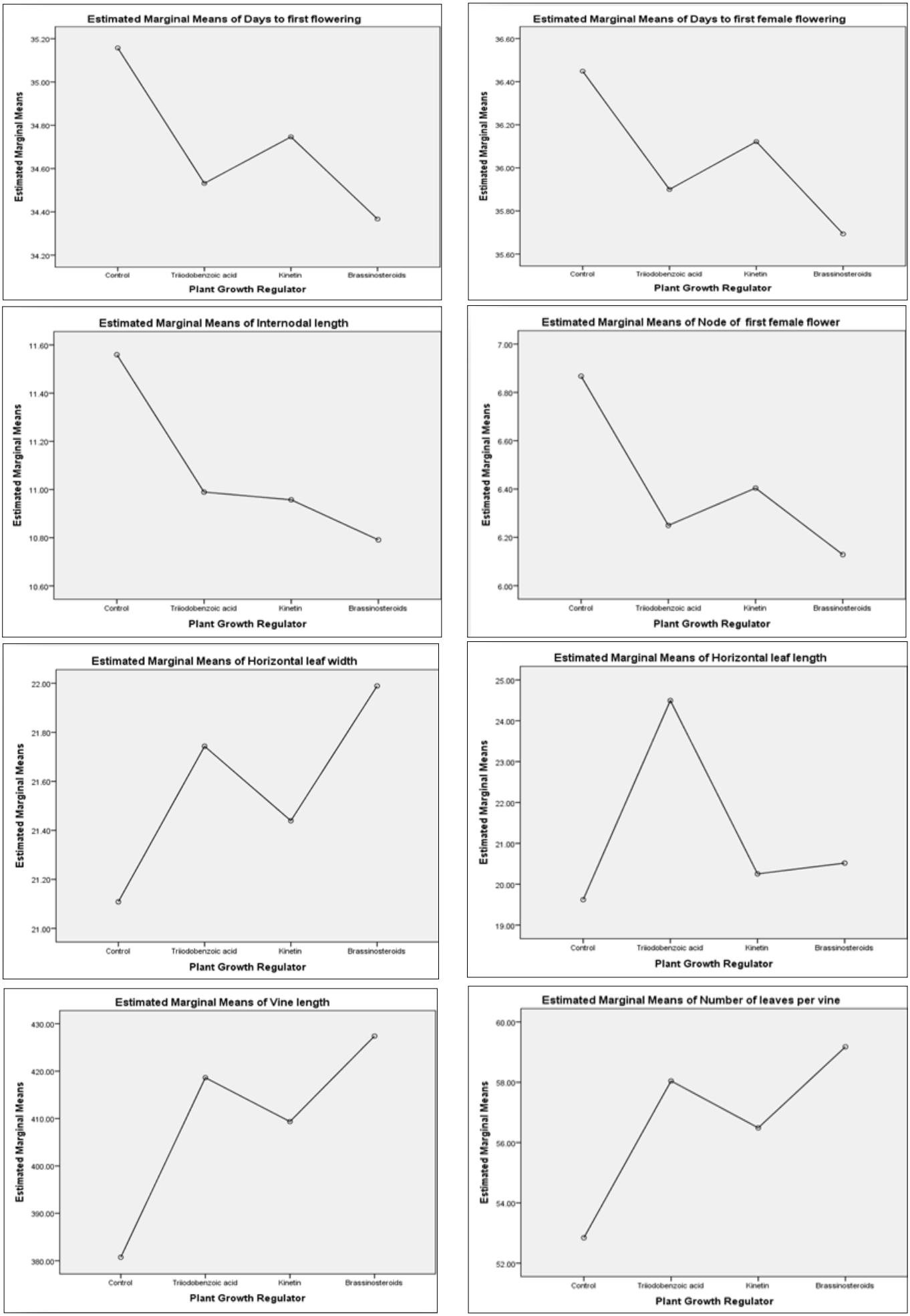

Fig. 3. Effect of different PGRs on growth characters of cucumber.

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