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Research Article

Growth analysis and parametric budgeting of different exogenous phytohormones on direct sown finger millet (*Eleusine coracana L.)* under irrigated conditions

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Abstract
Finger millet (*Eleusine coracana* L.) is an important cereal crop known for its nutritional value and adaptability to diverse environmental conditions. In recent years, there has been growing interest in exploring the potential of plant growth regulators (PGR) to enhance crop productivity and quality. The present investigation aimed to evaluate the effect of plant growth regulators on direct sown finger millet variety Co (Ra) 14 in 2022-23. The experiment was laid out in randomized complete block design consisting of ten treatments *viz.*, T_1 (100% RDF - Control), T_2 (100% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm), T_3 (100% RDF + Foliar spraying of Gibberellic acid @10 ppm), T_4 (100% RDF + Foliar spraying of Salicylic acid @100 ppm), T_5 (50% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm), T_6 (50% RDF + Foliar spraying of Gibberellic acid @10 ppm), T_7 (50% RDF + Foliar spraying of Salicylic acid @100 ppm), T_8 (Foliar spraying of Brassinosteroid @ 0.5 ppm), T_9 (Foliar spraying of Gibberellic acid @10 ppm), T_{10} (Foliar spraying of Salicylic acid @100 ppm). The experiment result showed that the application of 100% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm (T_2) significantly enhanced growth and physiological parameters like plant height (134.1 cm), SPAD value (28.61), soluble protein (11.25%), relative water content (50.2%) and lower proline content (0.15 μ moles g^{-1}). The same treatment combination recorded higher grain yield (4791 Kg ha^{-1}), straw yield (5950 Kg ha^{-1}), per day productivity (44.6 Kg ha^{-1}) and partial productivity (82.9 Kg ha^{-1}) and BEP (126.88%)of finger millet.

Keywords: Finger millet, Growth parameters, Plant growth regulators, Physiological characters, Yield economics

INTRODUCTION

Food demand will rise in direct proportion to global population growth. Today, cereals account for nearly 50% of the calories consumed worldwide. Millets are known as one of the most important cereal grains. In India, the total area under finger millet cultivation is 12.11 lakh ha with an average yield and production of 1401 kg ha^{-1} and 16.96 lakh tonnes (AICRP, 2020 - 2021 http://www.aicpmip.res.in/aboutus.html.). All the millets are three to five times higher in their nutritional content when compared to the nutritional content of widely used rice and wheat. Finger millet (*Eleusine coracana*) is one of the oldest indigenous domesticated tropical cereals. It is a highly productive crop that can thrive under a variety of harsh environmental conditions. Globally, finger millet production ranks sixth among cereals, contributing about 12% of total millet production (Mundada *et al.*, 2020). Plant growth regulators (PGR), called bio-stimulants, act inside plant cells to stimulate specific enzymes and help to regulate plant metabolism. They are normally active at very low concentrations in plants. Brassinosteriod (BRs) regulate different developmental processes in plants, such as seed germination, cell elongation, photomorphogenesis and xylem differentiation (Zhang *et al*., 2014; Wei and Li, 2016). Recently, the use of BRs in improving crop productivity under stress conditions gained considerable attention (Liu *et al*., 2017). Salicylic Acid (SA) belongs to the group of plant phenolics is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plants such as growth, photosynthesis, nitrate metabolism, ethylene production, heat production and flowering (Hayat *et al.,* 2010). Gibberellic acid is important in seed germination, endosperm mobilization, stem elongation, leaf expansion, shortening maturation time, and boosting flower and fruit set and composition. Prabha *et al*. (2016) reported that the foliar application of plant growth regulators (PGRs) and nutrients twice at 50 and 70 days after sowing gave better yield and economic returns. In view of these, a field experiment was conducted to study the effect of plant growth regulators on direct sown finger millet (*Eleusine coracana L.) under irrigated conditions.*

MATERIALS AND METHODS

Experimental site

The field experiment was conducted during the *Rabi* season of 2021-2022 at the south farm in Karunya Institute of Technology and Science, Coimbatore. The experimental site is geographically located in the western agro-climatic zone of Tamil Nadu at 10^0 56'N latitude and 76^0 44'E longitude at an elevation of 474 m above mean sea level. The standard methods were used for the characteristics of the soil. The soil of the experimental plot was sandy clay loam in texture with neutral soil pH (5.36) (Jackson, 1973), Medium organic carbon (1.03 %) (Walkley and Black, 1934), Low available N (289 kg ha^{-1}) (Subbiah and Asija, 1956), Medium available P (115 kg ha^{-1}) (Olsen *et al*., 1954) and high available K (437 kg ha^{-1}) (Stanford and English, 1949).

Treatment details

The experiment was laid out in randomized block design with three replications, comprising ten treatments *viz.,* T_1 (100% RDF - Control), T_2 (100% RDF + Foliar spray (FS) of Brassinosteroid @ 0.5 ppm), T_3 (100% RDF + Foliar spray (FS) of Gibberellic acid (GA_3) @10 ppm), T_4 (100% RDF + Foliar spray (FS) of Salicylic acid (SA) @100 ppm), T_5 (50% RDF + Foliar spray (FS) of Brassinosteroid (BRs) @ 0.5 ppm), T_6 (50% RDF + Foliar spray (FS) of Gibberellic acid @10 ppm), T_7 (50% RDF + Foliar spray (FS) of Salicylic acid @100 ppm), T_8 (Foliar spray (FS) of Brassinosteroid @0.5 ppm), T_9 (Foliar spray (FS) of Gibberellic acid @ 10 ppm), T_{10} (Foliar spray (FS) of Salicylic acid @ 100 ppm). The CO (Ra) 14 variety of finger millet was used as the test variety. The parameters *viz.,* plant height, relative water content, SPAD value, proline, grain protein, grain yield, straw yield, per day productivity, partial factor productivity, gross returns, net returns, and benefit-cost ratio were also recorded with the standard process of observation. The observed data were statistically analyzed by ANOVA with 5% significance (Gomez and Gomez, 1984).

Relative water content

Relative water content was estimated following the procedure of Barr and Weatherly (1962).

$$\text{RWC (\%)} = \frac{\text{Fresh weight-dry weight}}{\text{Turgid weight-Dry weight}} \times 100 \qquad \text{Eq. 1}$$

SPAD value

The chlorophyll content of leaves was recorded using the chlorophyll meter (SPAD – 502, chlorophyll meter) as described by Peng *et al*. (1993).

Proline content

The proline content was estimated at the vegetative and reproductive stages according to the standard method described by Bates *et al.* (1973).

$$\mu \text{ moles proline } g^{-1} \text{fr. wt.} = \frac{(\mu\text{g proline/ml x ml toluene x 5})}{(115.5\mu\text{g}/\mu\text{mole x g sample })} \qquad \text{Eq.2}$$

Grain protein content

After harvest, finger millet grain protein content was estimated by using Lowry method and result was expressed in percentage (Lowry *et al*., 1951)

Per day grain productivity

The grain productivity was estimated by using Triveni *et al*. (2018) method and experessed in kg ha^{-1}

$$\text{Per day productivity} = \frac{\text{Grain yield per hectare (Kg)}}{\text{Crop duration (days)}} \qquad \text{Eq. 3}$$

Partial factor productivity

Partial factor productivity indicates grain yield obtained per nutrients applied and it was calculated as per the method suggested by Dobermann (2007) by using the following formula and expressed as kg ha^{-1}.

$$\text{PFP} = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Total nutrients applied (kg ha}^{-1})} \qquad \text{Eq. 4}$$

Benefit-cost ratio

The benefit-cost ratio was calculated by using Smith (1963) method.

$$\text{Benefit- cost ratio} = \frac{\text{Gross retiurns (₹ ha}^{-1})}{\text{Total cost of cultivation (₹ ha}^{-1})} \qquad \text{Eq. 5}$$

Statistical analysis

The data collected on various characters studied during the experiment were subjected to statistical analysis in randomized block design (Gomez and Gomez, 1984). The treatments differences that were non-significant at 5 % were denoted as NS.

RESULTS AND DISCUSSION

Plant Height

The data on the plant height of finger millet as influenced by the nutrients and plant growth regulators at various growth stages are presented in Table 1. Among different treatments compared, 100% RDF + Brassinosteriod @ 0.5ppm (T_2) registered the highest plant height of 43.4 cm, 73 cm and 134.1 cm at 45, 60 DAS and at harvest. There were no significant differences in plant height at 45 DAS. At 60 DAS, application of 100% RDF + FS of Brassinosteroid @ 0.5ppm (T_2) gave the highest plant height of 73 cm, which was followed by 100% RDF + FS of Gibberellic acid @10 ppm (T_3). It was probably due to the enhanced availability of nutrients along with PGR, which resulted in more leaf area, enhanced photo assimilates, and increased plant height. The increase in plant height by brassinosteriod might be attributed to its synergistic interaction with available endogenous auxin. It could be observed in terms of cell wall plasticity and cell elongation in proso millet were reported by Mollasadeghi et al. (2011). Sengupta *et al*. (2015) reported that Brassinosteriod-induced plant promotion was associated with enhanced levels of nucleic acids, soluble protein and carbohydrates. The lowest plant height was recorded in control (T_1) at 45, 60 DAS and at harvest stages (37.2, 42.5 and 93.6 cm), respectively.

Relative Water content

Nutrient levels and plant growth regulators showed a higher RWC in 100% RDF + FS of Brassinosteroid @ 0.5ppm (T_2) (88.6, 82.6 and 50.2 %) at all three stages of observations was presented in Fig. 1. It was statistically identical with 100% RDF + FS of Gibberellic acid

Table 1. Effect of different exogenous phytohormones on plant height (cm) of direct sown finger millet

Plant height (cm)			
Treatment	**45 DAS**	**60 DAS**	**Harvest**
T_1 – 100% RDF (Control)	37.2	42.5	93.6
T_2 - 100% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	43.4	73.0	134.1
T_3 - 100% RDF + Foliar spraying of Gibberellic acid @10 ppm	35.3	61.7	113.7
T_4 - 100% RDF + Foliar spraying of Salicylic acid @100 ppm	41.9	58.8	110.8
T_5 - 50% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	36.7	58.0	110.0
T_6 - 50% RDF + Foliar spraying of Gibberellic acid @10 ppm	34.0	55.5	109.1
T_7 - 50% RDF + Foliar spraying of Salicylic acid @100 ppm	43.8	54.9	106.9
T_8 - Foliar spraying of Brassinosteroid @0.5 ppm	40.6	51.8	103.8
T_9 - Foliar spraying of Gibberellic acid @10 ppm	40.6	51.3	103.3
T_{10} - Foliar spraying of Salicylic acid @100 ppm	40.3	49.1	101.1
Sed	3.97	5.28	9.53
CD (P=0.05%)	NS	11.18	20.18

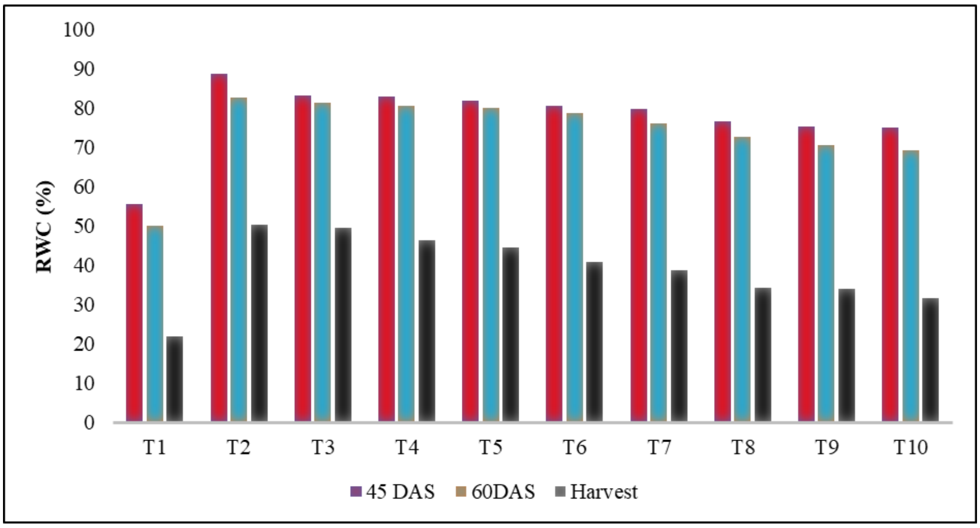

Fig. 1. *Effect of different exogenous phytohormones on relative water content of direct sown finger millet; T_1 - Control, T_2 - 100% RDF + FS of BRs @ 0.5 ppm, T_3 -100% RDF + FS of GA_3 @10 ppm, T_4 - 100% RDF + FS of SA @100 ppm, T_5 - 50% RDF + FS of BRs @ 0.5 ppm, T_6 - 50% RDF + FS of GA_3 @10 ppm), T_7 - 50% RDF + FS of SA @100 ppm, T_8 – FS of BRs @ 0.5 ppm, T_9 - FS of GA_3 @ 10 ppm, T_{10} - FS of SA @ 100 ppm.*

@ 10 ppm (T_3) (49.6 %) and 100% RDF + foliar spray of Salicylic acid @100 ppm (T_4) (46.2 %). This might be due to the PGR regulating the stomatal openings and reducing transpiration loss under drought conditions, enabling the plants to maintain turgor pressure and photosynthesis under water deficit conditions. The brassinosteriod decreased the transpirational losses that induced the stomatal closure and ameliorated the drought stress in maize as reported by Suresh *et al*. (2018). Further, Desoky *et al*. (2021) reported that applying brassinosteroid may reduce water loss and ameliorate drought stress by improving plant water content.

SPAD value

Different nutrient levels and plant growth regulators influenced the chlorophyll content at all crop growth stages (Fig. 2). The treatment of 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) recorded higher SPAD values at all three stages (42.08, 34.64 and 28.61). It was on par with 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) with values of (37.91 and 33.42) at 45 and 60 DAS. At harvest 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) and 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) showed a higher SPAD value of 28.61. The high chlorophyll content noticed with the application of PGR was attributed to the protection of chlorophyll molecules from photo-oxidation and increased chlorophyll synthesis given by (Ramesh *et al*., 2015). The SPAD value in the plants treated with salicylic acid was increased, which may be another reason for the increase in photosynthesis reported by Mohanabharathi *et al*. (2019). The lowest value was noticed in control (T_1) (27.46, 24.52, 15.83) at all three observations.

Proline content

Exogenous application of plant growth regulators under drought conditions significantly increased the proline content at all three stages, as shown in Fig. 2. Among all the treatments, The minimum value was recorded in 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) (0.15 µ moles g^{-1}). The best treatment was 100% RDF + FS of Gibberellic acid @10 ppm (T_3) obtained 0.21 µ moles g^{-1}. The maximum value was recorded in Control (T_1) with the value of 0.98 µ moles $g^{-1,}$ which was statistically on par with Foliar spraying of Salicylic acid @100 ppm (T_{10}) and FS of Gibberellic acid @10 ppm (T_9). Similar results were also reported by Ullah *et al*. (2012), stating that foliar application of salicylic acid increased the accumulation of osmolytes like soluble protein and proline to maintain relative water content under drought conditions. The application of brassinosteriod was found to induce the expression of proline biosynthetic in stomata, which contributed to the observed decrease in proline content in finger millet, were reported by Farjam *et al*. (2013).

Grain Protein

The grain protein content was influenced by all the treatments at three stages of observation (Table 2). Application of 100% RDF + FS of Brassinosteroid @ 0.5ppm (T_2) caused maximum protein content at 45, 60 DAS and at harvest recorded 5.9, 9.4 and 11.24 %, which was statistically on par with 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) (5.64, 9.11 and 10.81 %) and 100% RDF + FS of Salicylic acid @ 100 ppm (T_4) (5.31, 8.69, 10.02 %). The increased grain protein content in soybean was due to brassinosteriod, which leads to an increase in enzyme activity during tissue growth, as Kumar *et al.* (2018) reported. Similarly brassinoteriod affects the transcription and translocation, thereby influencing the enzyme and grain protein reported by Khan *et al*. (2018) in chickpea. The lowest protein content was recorded in control (T_1) at all three stages of observation (2.8, 4.9 and 6.25 %).

Grain and straw yield

Spraying of foliar nutrients and growth regulators significantly influenced grain yield, is presented in Table 3. The plots receiving 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) produced a higher grain and straw yield of 4791 and 5950 kg ha^{-1} followed by 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) (4450 and 5768 kg ha^{-1}) which was statistically on par with 100% RDF + FS of Salicylic acid @100 ppm (T_4) (4422 and 5712 kg ha^{-1}). This might be due to the enhancement of growth attributing characters like LAI, CGR, RGR, and NAR which paves the way for increasing grain yield. Dawood *et al*. (2012) observed that the increase in yield by PGRs was due to the effect of physiological and bio-

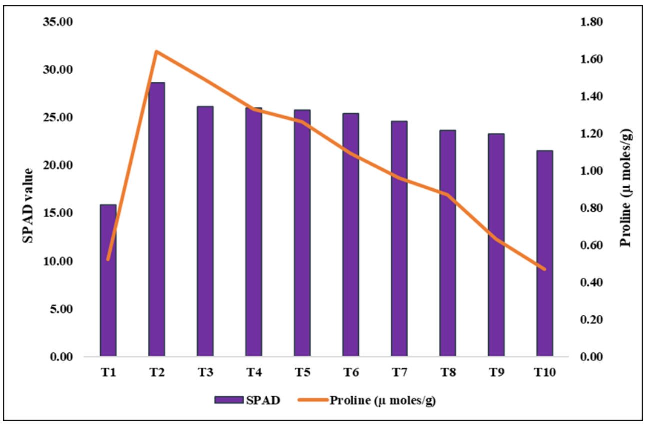

Fig. 2. *Effect of different exongenous phytohormones on SPAD value and proline content of direct sown finger millet; T_1 - Control, T_2 - 100% RDF + FS of BRs @ 0.5 ppm, T_3 -100% RDF + FS of GA_3 @10 ppm, T_4 - 100% RDF + FS of SA @100 ppm, T_5 - 50% RDF + FS of BRs @ 0.5 ppm, T_6 - 50% RDF + FS of GA_3 @10 ppm), T_7 - 50% RDF + FS of SA @100 ppm, T_8 – FS of BRs @ 0.5 ppm, T_9 - FS of GA_3 @ 10 ppm, T_{10} - FS of SA @ 100 ppm.*

Table 2. Effect of different exogenous phytohormones on grain protein (%) of direct sown finger millet

Grain protein Content (%)			
Treatment	**45 DAS**	**60 DAS**	**Harvest**
T_1 – 100% RDF (Control)	2.81	4.92	6.25
T_2 - 100% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	5.93	9.42	11.25
T_3 - 100% RDF + Foliar spraying of Gibberellic acid @10 ppm	5.64	9.11	10.81
T_4 - 100% RDF + Foliar spraying of Salicylic acid @100 ppm	5.31	8.69	10.02
T_5 - 50% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	4.81	8.36	7.71
T_6 - 50% RDF + Foliar spraying of Gibberellic acid @10 ppm	4.55	7.94	7.5
T_7 - 50% RDF + Foliar spraying of Salicylic acid @100 ppm	4.21	7.43	7.38
T_8 - Foliar spraying of Brassinosteroid @0.5 ppm	3.90	6.42	7.29
T_9 - Foliar spraying of Gibberellic acid @10 ppm	3.41	6.22	6.67
T_{10} - Foliar spraying of Salicylic acid @100 ppm	3.14	5.53	6.38
Sed	0.432	0.72	0.83
CD (P=0.05%)	0.915	1.53	1.76

Table 3. Effect of different exogenous phytohormones on grain and straw yield (kg ha^{-1}) of direct sown finger millet

Treatment	**Grain Yield (kg ha^{-1})**	**Straw Yield (kg ha^{-1})**
T_1 – 100% RDF (Control)	3871	4568
T_2 - 100% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	4491	5840
T_3 - 100% RDF + Foliar spraying of Gibberellic acid @10 ppm	4450	5768
T_4 - 100% RDF + Foliar spraying of Salicylic acid @100 ppm	4422	5712
T_5 - 50% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	4298	5473
T_6 - 50% RDF + Foliar spraying of Gibberellic acid @10 ppm	4273	5264
T_7 - 50% RDF + Foliar spraying of Salicylic acid @100 ppm	4243	5101
T_8 - Foliar spraying of Brassinosteroid @0.5 ppm	3991	4844
T_9 - Foliar spraying of Gibberellic acid @10 ppm	3974	4798
T_{10} - Foliar spraying of Salicylic acid @100 ppm	3945	4662
Sed	80.28	82.99
CD (P=0.05%)	169.9	175.7

chemical processes that led to amelioration in vegetative growth, active assimilation and translocation from source to sink. Hence, Brassinosteriod and salicylic acid can ameliorate the drought by active translocation and partitioning efficiency from source. Application of brassinosteriod induced an increase in the translocation of photoassimilates towards an increase in grain and straw yield in finger millet were reported by Mohanabharathi *et al*. (2019). The lowest grain yield was recorded in control (T_1) with values of 3871 and 4468 kg ha^{-1}.

Per day productivity

The effect of plant growth regulators on per day productivity is presented in Table 4. Per day productivity was significantly higher in 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) recorded 44.6 Kg $ha^{-1,}$ which was followed by 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) (38.4 kg ha^{-1}). It was statistically comparable with 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) (38.4 kg ha^{-1}) and 100% RDF + FS of Salicylic acid @100 ppm (T_4) (38.0 kg ha^{-1}). Similar results of increased productivity per day in pearl millet was due to increased dose of NPK fertilizers, medium duration variety and higher yield were reported by Triveni *et al*. (2017); Mesfin and Zemach (2015). The present study observed the lowest per day productivity in control (T_1) with 29.6 kg ha^{-1} in finger millet.

Partial factor productivity

The effect of plant growth regulators on partial factor productivity is presented in Table 4. Partial factor productivity was found maximum with the application of 100% RDF + foliar spray of Brassinosteroid @ 0.5ppm (T_2) (82.9 Kg ha^{-1}) which was statistically on par with 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) and 100% RDF + FS of Salicylic acid @100 ppm (T_4) which registered the values of 80.4 and 79.5 kg ha^{-1}. The higher partial productivity might be due to higher nutrient uptake and more utilization of indigenous nutrients in pearl millet given by Patra *et al*. (2012). The lowest value was recorded at 57.9 kg ha^{-1} in control (T_1) in finger millet.

Economics

The data presented in Table 5 shows that the cost of cultivation incurred for different treatment combinations varied from ₹ 55,011 ha^{-1} to ₹ 67,022 ha^{-1} during the experiment. Among different treatments compared, the application of 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) recorded higher gross return (₹ 1,30,670 ha^{-1}), net return (₹ 69,647 ha^{-1}) and B:C ratio (2.1). The

Table 4. Effect of different exogenous phytohormones on per day productivity (kg ha^{-1}) and partial factor productivity (kg ha^{-1}) of direct sown finger millet

Treatment	PDP (kg ha^{-1})	PFP (kg ha^{-1})
T_1 – 100% RDF (Control)	29.6	60.2
T_2 - 100% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	44.6	82.9
T_3 - 100% RDF + Foliar spraying of Gibberellic acid @10 ppm	38.4	80.4
T_4 - 100% RDF + Foliar spraying of Salicylic acid @100 ppm	37.0	79.5
T_5 - 50% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	38.0	72.7
T_6 - 50% RDF + Foliar spraying of Gibberellic acid @10 ppm	37.5	69.8
T_7 - 50% RDF + Foliar spraying of Salicylic acid @100 ppm	36.6	66.3
T_8 - Foliar spraying of Brassinosteroid @0.5 ppm	34.1	64.4
T_9 - Foliar spraying of Gibberellic acid @10 ppm	33.7	62.2
T_{10} - Foliar spraying of Salicylic acid @100 ppm	33.7	61.9
Sed	6.25	6.86
CD (P=0.05%)	2.96	14.53

Table 5. Effect of different exogenous phytohormones on economics of direct sown finger millet

Treatments	Cost of cultivations	Gross return	Net return	Agronomic B.C ratio	Economic B.C ratio
T_1 - 100% RDF (Control)	60572	78323	17751	0.3	1.3
T_2 - 100% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	61023	130670	69647	1.1	2.1
T_3 - 100% RDF + Foliar spraying of Gibberellic acid @10 ppm	67022	127442	60420	0.9	1.9
T_4 - 100% RDF + Foliar spraying of Salicylic acid @100 ppm	62222	124192	61970	1.0	2.0
T_5 - 50% RDF + Foliar spraying of Brassinosteroid @ 0.5 ppm	58467	123910	65443	1.1	2.1
T_6 - 50% RDF + Foliar spraying of Gibberellic acid @10 ppm	64466	122588	58122	0.9	1.9
T_7 - 50% RDF + Foliar spraying of Salicylic acid @100 ppm	59666	117003	57337	1.0	2.0
T_8 - Foliar spraying of Brassinosteroid @0.5 ppm	55011	114460	59449	1.1	2.1
T_9 - Foliar spraying of Gibberellic acid @10 ppm	61010	105895	44885	0.7	1.7
T_{10} - Foliar spraying of Salicylic acid @100 ppm	56210	85229	29019	0.5	1.5

*Data not statistically analysed

next higher net return was observed in 100% RDF + foliar spray of Brassinosteriod @0.5 ppm (T_3) with values of ₹65,443 with a B:C ratio of 2.1. The highest gross return was recorded in 100% RDF + FS of Gibberellic acid @ 10 ppm (T_3) (₹1,27,442). The maximum Net return, gross return and B: C ratio in mungbean were observed by Revathi *et al*. (2018). Suresh *et al*. (2018) also reported that foliar application of nutrients and PGR increased the net return, gross return and B: C ratio in pearl millet. The lowest gross and net return values were found in control (T_1), which recorded ₹78,323 and ₹17,751 with B:C ratio of 1.3.

Parametric budgeting and Sensitivity analysis

Economic evaluation involves various parameters, *viz*., resource budgeting, material analysis and parametric budgeting, which are the most appropriate for this type of system evaluation (Gonzales and Van Deer Veen, 1989). Makowski *et al*. (2006) studied the parametric budgeting for modelling of crops in dynamic crop varieties. The effect of plant growth regulators on parametric budgeting of the present study is presented in Table 6 and Fig. 3. The highest Return above variable cost (RAVC) was registered for 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) about ₹68527 ha^{-1}. Return above labour cost (RLC), 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) recorded higher RLC of ₹3.48 ha^{-1}. The percentage increase over BEP was higher in 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) of 126.88%. Across all the studied different plant growth regulators, the percentage increase in yield above (BEP) was consistently positive and greater than zero.

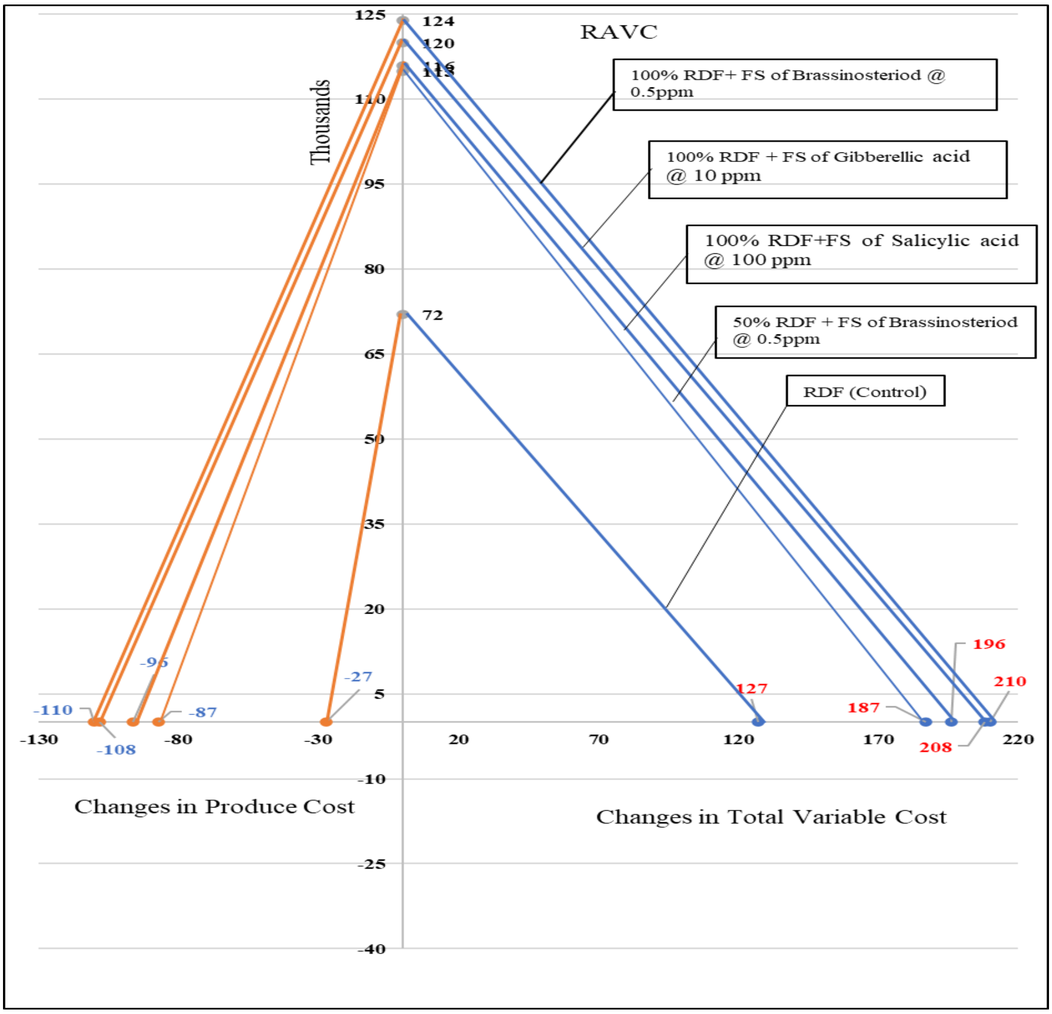

Fig. 3. *Effect of different exogenous phytohormones on sensitivity analysis of direct sown finger millet; T_1 - Control, T_2 - 100% RDF + FS of BRs @ 0.5 ppm, T_3 -100% RDF + FS of GA_3 @10 ppm, T_4 - 100% RDF + FS of SA @100 ppm, T_5 - 50% RDF + FS of BRs @ 0.5 ppm.*

Table 6. Effect of different exogenous phytohormones on parametric budgeting of direct sown finger millet

Treat-ments	GY 1	GR 2	MC 3	LC 4	ICC 5	TVC 6 (3+4+5)	RAVC 7 (2-6)	RMC 8 (2-4/3)	RLC 9 (2-3/4)	MBCR 10 (2/6)	BEP 11	% increase over BEP
T_1	3871	78323	32012	27870	1796	61678	16645	1.58	1.66	1.27	1550	149.79
T_2	4491	130670	32013	28320	1810	62143	68527	3.20	3.48	2.10	1980	126.87
T_3	4450	127442	38012	28320	1990	68322	59120	2.61	3.16	1.87	2135	108.45
T_4	4422	124192	33212	28320	1846	63378	60814	2.89	3.21	1.96	2011	119.93
T_5	4298	123910	29456	28320	1733	59509	64400	3.25	3.34	2.08	1913	124.62
T_6	4273	122588	35456	28320	1913	65689	56898	2.66	3.08	1.87	2069	106.56
T_7	4243	117003	30656	28320	1769	60745	56258	2.89	3.05	1.93	1944	118.21
T_8	3991	114460	26900.9	27420	1630	55951	58509	3.24	3.19	2.05	1824	118.80
T_9	3974	105895	32900	27420	1810	62130	43765	2.39	2.66	1.70	1979	100.78
T_{10}	3945	85229	28100	27420	1666	57186	28043	2.06	2.08	1.49	1855	112.66

*Data not statistically analysed; GY – Grain yield, GR – Gross return, MC – Material cost, LC – Labour cost, ICC – Interset on capital cost at 10%, TVC – Total Variable cost, RAVC – Return above variable cost, RMC – Return to material cost, RLC – Return to labour cost, MBCR – Marginal benefit cost ratio & BEP – Break even point

This observation suggests that the proposed plant growth regulators were more financially advantageous compared to control (T_1). Houshyar *et al.* (2015) also reported that foliar application of PGR in maize significantly increased return above variable cost and above labour cost with a 105% increase of BEP over control. Similar findings were reported by Mousavi *et al.* (2019) in canola and Taheri *et al.*(2017) in rice cultivars. Notably, 100% RDF + FS of Brassinosteroid @ 0.5 ppm exhibited the highest increase in yield above the BEP, demonstrating that it generated profits exceeding those of the control (T_1) without requiring any alterations in the cultivation costs. The lowest RAVC was recorded for control (T_1) at ₹16645 ha^{-1}.

Conclusion

The study revealed that the application of different plant growth regulators (Brassinosteriod, Salicylic acid and Gibberellic acid) significantly improved finger millet growth and yield. The combined effect of nutrients with PGR was more effective in increasing growth and physiological parameters along with the yield of finger millet. Application of 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) registered significantly higher plant height, RWC, SPAD value, proline and grain protein content at 45, 60 DAS and at harvest stages. It also increased grain yield, straw yield and economics of finger millet. Hence it was concluded that the application of 100% RDF + FS of Brassinosteroid @ 0.5 ppm (T_2) in CO 14 finger millet variety had a remarkable effect in increasing its productivity with a higher benefit-cost ratio under irrigated conditions.

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Conflict of interest

The authors declare that they have no conflict of interest.

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