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Effect of different sowing times and plant growth regulators on growth, yield and quality of cowpea

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Abstract

The present investigation was conducted during kharif 2025 at the Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The study was undertaken to determine the influence of sowing time and plant growth regulators on vegetative growth, flowering behaviour, green-pod yield and quality of cowpea, and to identify a suitable treatment combination for higher productivity as well as early harvesting. The experiment was laid out in a factorial randomized block design with three replications. The treatments consisted of three sowing times: second week of June (S_1), fourth week of June (S_2) and second week of July (S_3); and four regulator treatments: water spray (G_0), brassinolide at 2 ppm (G_1), GA_3 at 15 ppm (G_2), and brassinolide at 2 ppm + GA_3 at 15 ppm (G_3). Thus, twelve treatment combinations were evaluated using cowpea variety PDKV-Rutuja. The fourth week of June sowing (S_2) was superior for most growth and yield attributes, recording maximum plant height at 60 DAS (65.92 cm), branches plant⁻¹ (6.34), leaf area (122.00 cm²), flowers cluster⁻¹ (3.93), green pods plant⁻¹ (27.41) and green-pod yield (193.34 g plant⁻¹, 5.80 kg plot⁻¹ and 71.67 q ha⁻¹). GA_3 at 15 ppm was most effective for plant height (79.04 cm at 60 DAS), whereas combined brassinolide + GA_3 (G_3) was superior for branches (8.02 plant⁻¹), leaf area (136.77 cm²), flowers cluster⁻¹ (4.77), green pods plant⁻¹ (29.26), green-pod yield (227.04 g plant⁻¹, 6.81 kg plot⁻¹ and 84.13 q ha⁻¹), pod length (26.32 cm), pod width (5.54 mm) and chlorophyll index (56.71 SPAD). The interaction S_2G_3 recorded the highest green-pod yield of 237.62 g plant⁻¹, 7.12 kg plot⁻¹ and 87.88 q ha⁻¹. In contrast, S_1G_1 was best for earliness, attaining 50 percent flowering in 48 days and completing the last harvest in 96 days. Hence, S_2G_3 may be recommended for maximum green-pod productivity and improved quality under Akola conditions, while S_1G_1 may be preferred for early market harvest.

Keywords: Cowpea, sowing time, brassinolide, GA_3 , green pod yield, quality

Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is an important vegetable legume valued for its tender green pods, dry seeds and fodder. Its green pods contribute protein, minerals and vitamins to the diet (Chakraborti, 1986) ^[1], while its association with Rhizobium improves soil nitrogen status (Summerfield *et al.*, 1977) ^[9]. In Maharashtra, vegetable cowpea is commonly grown during kharif, when the timing of sowing determines the crop's exposure to rainfall, temperature and humidity during vegetative and reproductive phases.

Sowing date is therefore a key management decision. An appropriate sowing window can promote canopy development, flowering and pod formation, whereas delayed sowing may expose the crop to less favourable conditions. Previous work has shown that cowpea growth and yield respond to sowing time (Sutar *et al.*, 2014; Coulibaly *et al.*, 2023) ^[10, 2]. Plant growth regulators can further modify crop performance. GA_3 promotes cell elongation and vegetative growth (Emongor, 2007) ^[3], while brassinolide may improve photosynthetic efficiency and stress tolerance (Zhang *et al.*, 2008) ^[12]. The use of brassinolides helps maintain metabolic function and cellular stability, thereby extending plant lifespan and improving overall stress adaptation (Hayat *et al.*, 2010) ^[4]. Studies by Mukhtar and Singh (2006) ^[7] demonstrated that GA_3 positively influenced flowering, pod development, and overall yield in cowpea. Similarly, Selvakumar (2014) ^[8] reported higher pod yields with PGR application during the pre-flowering stage.

The present study assessed the individual and interactive effects of sowing time and these regulators on growth, yield and quality of cowpea.

The response of vegetable cowpea to plant growth regulators is expected to depend upon the prevailing environment at the time of application. A sowing date that provides favourable moisture, temperature and radiation may allow the crop to make better use of growth-regulator-mediated changes in canopy development, flower production and assimilate distribution. Thus, the combined study of sowing time and growth regulators is important for identifying a treatment that is productive as well as practically useful to growers.

Materials and Methods

The investigation was carried out during kharif 2025 at the Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experimental soil was medium black, moderately fertile and approximately neutral in reaction (pH 6.5-7.0). Cowpea variety PDKV-Rutuja was sown on flat beds at 60 × 45 cm spacing after Rhizobium seed treatment. Farmyard manure at 25 t ha⁻¹ and 25:75:60 kg N:P:K ha⁻¹ were applied as per the experimental protocol.

The treatments comprised three sowing times: S₁, second week of June; S₂, fourth week of June; and S₃, second week of July. The regulator treatments were G₀, water spray; G₁, brassinolide at 2 ppm; G₂, GA₃ at 15 ppm; and G₃, brassinolide at 2 ppm + GA₃ at 15 ppm. The 12 treatment combinations were arranged in a factorial randomized block design with three replications. Foliar sprays were applied at 20, 30 and 45 days after sowing. Data on growth, flowering, green-pod yield and quality were recorded and analysed using analysis of variance; standard error of mean and critical difference at 5% were used for treatment comparisons.

Results and Discussion

Growth attributes

The data presented in Table 1 show that sowing time and plant growth regulator application appreciably influenced the vegetative development of cowpea. The effects were more evident at the later stages of crop growth. Among the sowing times, S₂ (fourth week of June) recorded the maximum plant height at 60 DAS (65.92 cm), followed by S₁ (64.23 cm), whereas S₃ recorded the lowest height (58.78 cm). The better performance of S₂ may be due to a more favourable growing environment during the active vegetative and reproductive phases, which enabled the crop to develop a stronger canopy.

Among the growth regulator treatments, GA₃ at 15 ppm (G₂) resulted in the maximum plant height of 79.04 cm at 60 DAS. The interaction S₂G₂ recorded the maximum plant height (80.40 cm). This increase in height may be attributed to the known role of GA₃ in promoting cell elongation and internodal growth. Similar enhancement of vegetative growth with GA₃ application in cowpea was reported by Emongor (2007) [3]. Although increased plant height is desirable up to an optimum level, the results also show that the treatment giving the tallest plants was not necessarily the treatment producing the highest yield.

Branch number and leaf area showed a different pattern. The combined application of brassinolide and GA₃ (G₃) produced the maximum number of branches (8.02 plant⁻¹ at 60 DAS) and leaf area (136.77 cm²). The interaction S₂G₃ was superior for both attributes, recording 8.47 branches plant⁻¹ and 139.63 cm² leaf area. A better branched plant

with a larger assimilatory surface can support greater flower production and pod development. The combined treatment therefore appears to have improved crop architecture more effectively than either regulator applied alone.

Table 1: Effect of sowing time and plant growth regulators on major growth attributes of cowpea

Treatment	Plant height at 60 DAS (cm)	Branches at 60 DAS	Leaf area (cm ²)
S ₁ : 2nd week of June	64.23	6.07	120.66
S ₂ : 4th week of June	65.92	6.34	122.00
S ₃ : 2nd week of July	58.78	5.64	117.31
G ₀ : Water spray	46.71	4.49	101.26
G ₁ : Brassinolide 2 ppm	56.66	5.24	111.14
G ₂ : GA ₃ 15 ppm	79.04	6.32	130.79
G ₃ : Brassinolide 2 ppm + GA ₃ 15 ppm	69.49	8.02	136.77
S ₁ G ₀	46.30	4.73	100.32
S ₁ G ₁	59.80	5.20	111.77
S ₁ G ₂	78.90	6.23	132.70
S ₁ G ₃	71.90	8.13	137.84
S ₂ G ₀	52.00	4.50	103.25
S ₂ G ₁	56.50	5.60	112.12
S ₂ G ₂	80.40	6.80	133.00
S ₂ G ₃	74.80	8.47	139.63
S ₃ G ₀	41.83	4.24	100.20
S ₃ G ₁	53.67	4.93	109.53
S ₃ G ₂	77.83	5.93	126.67
S ₃ G ₃	61.77	7.46	132.85
F-test	Sig	Sig	Sig
SE(m)±	1.90	0.13	0.92
CD at 5%	5.57	0.38	2.69

Plant height

The data on plant height revealed significant differences among sowing times at all recorded stages. At 60 DAS, S₂ recorded the maximum plant height of 65.92 cm, followed by S₁ (64.23 cm), while S₃ recorded the minimum height of 58.78 cm. Among the plant growth regulator treatments, G₂ (GA₃ at 15 ppm) recorded the maximum height of 79.04 cm, whereas the control recorded 46.71 cm. The interaction effect was significant, and S₂G₂ recorded the tallest plants (80.40 cm). The increased height under GA₃ may be due to enhanced cell division and cell elongation, which promote internodal extension and vegetative growth. These findings are in agreement with Emongor (2007) [3], who reported improved vegetative growth of cowpea with GA₃ application.

Number of branches per plant

The number of branches per plant was significantly influenced at 60 DAS. S₂ recorded the maximum number of branches (6.34), followed by S₁ (6.07), whereas S₃ recorded the minimum value (5.64). The combined application of brassinolide and GA₃ (G₃) was superior among the growth regulator treatments, recording 8.02 branches plant⁻¹, compared with 4.49 branches plant⁻¹ in the control. The maximum number of branches (8.47) was observed in S₂G₃. The improvement in branching may be due to better plant vigour and stimulation of lateral bud development under the combined treatment. Increased branching provides more productive sites for flower and pod formation and may therefore contribute to the higher yield recorded under this treatment.

Leaf area

Leaf area was significantly affected by both sowing time and growth regulator treatments. The maximum leaf area among sowing dates was recorded with S₂ (122.00 cm²), while S₃ recorded the minimum value (117.31 cm²). Among the regulators, G₃ produced the maximum leaf area of 136.77 cm², followed by G₂ (130.79 cm²); the control recorded 101.26 cm². The interaction S₂G₃ recorded the highest leaf area (139.63 cm²). This greater leaf area probably enhanced photosynthetic surface and assimilate production, thereby supporting flowering and green-pod development. The response also indicates that the combined regulator treatment was more effective in maintaining an adequate canopy than individual application.

Flowering and harvesting behaviour

Sowing time and growth regulator treatments significantly influenced flowering behaviour and crop duration (Table 2). The earliest 50% flowering among sowing times was obtained with S₁ (51.00 days), followed by S₂ (59.00 days) and S₃ (62.50 days). Among the regulators, brassinolide at 2 ppm (G₁) was most effective for earliness, requiring 55.00 days for 50% flowering. The S₁G₁ combination was the

earliest of all the treatment combinations and attained 50% flowering in 48.00 days. This response suggests that early June sowing, supplemented with brassinolide, helped the crop make a quicker transition to the reproductive phase.

The number of flowers per cluster was maximum under S₂ (3.93) among sowing times and under G₃ (4.77) among growth regulator treatments. The S₂G₃ interaction produced 4.83 flowers cluster⁻¹. The improvement in flower production under the combined regulator treatment may be associated with better canopy development and a more favourable balance between vegetative growth and reproductive sink formation. In practical terms, the treatment that was earliest was not the same as the treatment that produced the most flowers; this distinction is relevant when selecting a treatment for either early market supply or maximum pod yield.

The duration to the last harvest followed a clear trend. S₁ completed harvesting earlier (98.25 days) than S₂ and S₃. S₁G₁ recorded the shortest duration to last harvest (96.00 days), whereas the later sowing treatments generally required a longer period. Therefore, S₁G₁ may be preferred by growers who seek an early harvest, even though its final yield was lower than the best-yielding S₂G₃ treatment.

Table 2: Effect of sowing time and plant growth regulators on flowering and harvest duration

Treatment	50% flowering (days)	Flowers cluster ⁻¹	Last harvest (days)
S ₁ : 2nd week of June	51.00	3.76	98.25
S ₂ : 4th week of June	59.00	3.93	103.50
S ₃ : 2nd week of July	62.50	3.57	107.50
G ₀ : Water spray	58.67	2.63	102.67
G ₁ : Brassinolide 2 ppm	55.00	3.47	101.67
G ₂ : GA ₃ 15 ppm	58.33	4.15	103.67
G ₃ : Brassinolide 2 ppm + GA ₃ 15 ppm	58.00	4.77	104.33
S ₁ G ₀	52.00	2.60	99.00
S ₁ G ₁	48.00	3.50	96.00
S ₁ G ₂	50.00	4.17	97.00
S ₁ G ₃	54.00	4.77	101.00
S ₂ G ₀	60.00	2.90	103.00
S ₂ G ₁	56.00	3.70	102.00
S ₂ G ₂	62.00	4.30	105.00
S ₂ G ₃	58.00	4.83	104.00
S ₃ G ₀	64.00	2.40	106.00
S ₃ G ₁	61.00	3.20	107.00
S ₃ G ₂	63.00	3.97	109.00
S ₃ G ₃	62.00	4.71	108.00
F-test	Sig	Sig	Sig
SE(m)±	1.08	0.06	0.87
CD at 5%	3.17	0.17	2.55

Days to 50 percent flowering

The results showed that days required for 50 percent flowering were significantly influenced by sowing time and growth regulator application. S₁ required the minimum number of days (51.00) for 50 percent flowering, followed by S₂ (59.00 days), whereas S₃ required 62.50 days. Among growth regulators, G₁ (brassinolide at 2 ppm) was the earliest treatment, requiring 55.00 days, compared with 58.67 days under water spray. The earliest flowering was recorded in S₁G₁ (48.00 days). This early flowering may be associated with favourable conditions under early June sowing and the physiological effect of brassinolide in promoting a timely transition from vegetative to reproductive development.

Number of flowers per cluster

The number of flowers per cluster differed significantly among treatments. S₂ produced the maximum number of flowers per cluster (3.93), while S₃ produced the minimum (3.57). G₃ was superior among the growth regulator treatments and recorded 4.77 flowers per cluster, as against 2.63 in the control. The interaction S₂G₃ recorded the maximum value of 4.83 flowers per cluster. The higher flower production under this interaction may be due to improved branching, leaf area and physiological activity, resulting in greater availability of assimilates for reproductive growth. This enhanced floral potential was reflected subsequently in the greater number of green pods per plant.

Days required to last harvest

The duration to last harvest was significantly influenced by sowing time and growth regulator treatments. S_1 completed the last harvest earliest, at 98.25 days, compared with 103.50 days under S_2 and 107.50 days under S_3 . The earliest completion of harvest was recorded with S_1G_1 (96.00 days). Although G_1 had a smaller numerical effect on the main treatment mean, its combination with S_1 was particularly effective for earliness. The result shows that growers aiming for an early market window may use second-week-of-June sowing together with brassinolide at 2 ppm.

Green-pod yield and yield attributes

The results in Table 3 demonstrate that green-pod number and yield were significantly influenced by sowing time, growth regulator application and their interaction. The fourth week of June sowing (S_2) produced the maximum number of green pods plant⁻¹ (27.41), green-pod yield plant⁻¹ (193.34 g), green-pod yield plot⁻¹ (5.80 kg) and yield ha⁻¹ (71.67 q). These values were greater than those observed under S_1 and S_3 . The superiority of S_2 may be attributed to the more favourable crop environment during

flowering and pod development, allowing greater retention and development of green pods.

Growth regulator application markedly improved yield. G_3 recorded 29.26 green pods plant⁻¹, 227.04 g yield plant⁻¹, 6.81 kg yield plot⁻¹ and 84.13 q ha⁻¹. In comparison, the water-spray control recorded 23.86 pods plant⁻¹, 149.99 g yield plant⁻¹, 4.50 kg plot⁻¹ and 55.63 q ha⁻¹. Thus, the combined regulator treatment increased green-pod yield by 51.4% over the control on a hectare basis. The response may be explained by complementary effects of brassinolide and GA_3 on canopy development, flower production, pod set and movement of assimilates to developing pods.

The S_2G_3 interaction was distinctly superior, recording 29.40 green pods plant⁻¹, 237.62 g yield plant⁻¹, 7.12 kg plot⁻¹ and 87.88 q ha⁻¹. This interaction combined the most favourable sowing time for productivity with the regulator treatment that promoted the strongest branching, leaf area and flower production. The present result agrees with reports that GA_3 can improve growth and yield components in cowpea (Emongor, 2007; Mshelmbula *et al.*, 2021) [3, 6], while the addition of brassinolide appears to have strengthened the overall response under the present field conditions.

Table 3: Effect of sowing time and plant growth regulators on green-pod yield of cowpea

Treatment	Pods plant ⁻¹	Yield plant ⁻¹ (g)	Yield plot ⁻¹ (kg)	Yield ha ⁻¹ (q)
S_1 : 2nd week of June	26.75	185.25	5.56	68.68
S_2 : 4th week of June	27.41	193.34	5.80	71.67
S_3 : 2nd week of July	26.47	177.91	5.33	66.00
G_0 : Water spray	23.86	149.99	4.50	55.63
G_1 : Brassinolide 2 ppm	26.59	172.91	5.18	64.24
G_2 : GA_3 15 ppm	27.80	192.07	5.76	71.12
G_3 : Brassinolide 2 ppm + GA_3 15 ppm	29.26	227.04	6.81	84.13
S_1G_0	23.20	146.23	4.39	54.19
S_1G_1	26.60	172.97	5.19	64.03
S_1G_2	27.80	191.89	5.76	71.06
S_1G_3	29.20	229.91	6.92	85.43
S_2G_0	24.75	157.26	4.71	58.49
S_2G_1	27.00	178.27	5.34	65.96
S_2G_2	28.20	200.21	6.02	74.33
S_2G_3	29.40	237.62	7.12	87.88
S_3G_0	23.63	146.48	4.39	54.19
S_3G_1	26.17	167.48	5.02	62.73
S_3G_2	27.40	184.11	5.52	67.98
S_3G_3	28.67	213.58	6.40	79.09
F-test	Sig	Sig	Sig	Sig
SE(m)±	0.20	1.81	0.07	0.98
CD at 5%	0.59	5.32	0.21	2.86

Number of green pods per plant

The number of green pods per plant was significantly affected by both factors and their interaction. Among sowing times, S_2 recorded the highest number of pods (27.41 plant⁻¹), whereas S_3 recorded 26.47 pods plant⁻¹. G_3 recorded the maximum number of pods (29.26 plant⁻¹), followed by G_2 (27.80), while the control produced 23.86 pods plant⁻¹. The S_2G_3 combination was superior and recorded 29.40 green pods plant⁻¹. The increased pod number under G_3 can be attributed to its positive effect on branching, flower production and retention of developing pods.

Green-pod yield per plant

Green-pod yield per plant was significantly influenced by sowing time, growth regulators and their interaction. S_2

recorded the maximum yield of 193.34 g plant⁻¹, followed by S_1 (185.25 g plant⁻¹), whereas S_3 recorded 177.91 g plant⁻¹. G_3 recorded the highest yield among the regulators (227.04 g plant⁻¹), compared with 149.99 g plant⁻¹ in the control. The maximum yield per plant was recorded in S_2G_3 (237.62 g). This increase was associated with the combined improvement in pod number and vegetative growth, which likely promoted stronger source-to-sink movement of photosynthates toward the developing green pods.

Green-pod yield per plot

The green-pod yield per plot followed the same trend as yield per plant. S_2 produced the maximum plot yield of 5.80 kg, whereas S_3 recorded 5.33 kg. G_3 was superior among growth regulator treatments and recorded 6.81 kg plot⁻¹; the corresponding value under control was 4.50 kg. The

interaction S_2G_3 recorded the maximum plot yield of 7.12 kg. This result demonstrates that the favourable response observed at the plant level was maintained at the plot level and indicates the practical production advantage of this treatment combination.

Green-pod yield per hectare

The data on green-pod yield per hectare revealed a significant response to both sowing time and growth regulators. S_2 recorded the maximum yield of 71.67 q ha⁻¹ among sowing times, while S_3 recorded the lowest value (66.00 q ha⁻¹). G_3 recorded 84.13 q ha⁻¹, which was substantially greater than the control (55.63 q ha⁻¹). The highest hectare yield was obtained from S_2G_3 (87.88 q ha⁻¹), followed by S_1G_3 (85.43 q ha⁻¹). The results establish the fourth week of June as the most suitable sowing period for productivity and brassinolide at 2 ppm + GA₃ at 15 ppm as the most promising regulator treatment under the conditions of the present investigation.

Green-Pod Quality

The quality characteristics of green pods are presented in Table 4. S_1 produced the longest pods among sowing times (25.23 cm), whereas G_3 produced the maximum pod length (26.32 cm), pod width (5.54 mm) and chlorophyll index (56.71 SPAD). The longest green pods were obtained with the S_1G_3 interaction (26.80 cm). The effect of sowing time and the interaction on pod width was non-significant; however, the regulator treatments differed significantly. Similarly, chlorophyll index was not significantly altered by sowing time, but was significantly higher under G_3 than under the control.

The quality response supports the yield results: the combined brassinolide and GA₃ treatment not only increased pod number and yield but also improved pod size and leaf chlorophyll status. This is important for vegetable cowpea because tender, well-developed and visually acceptable pods contribute directly to market value. Under the conditions of this experiment, G_3 therefore offered a broad advantage across growth, yield and quality characteristics.

Table 4: Effect of sowing time and plant growth regulators on green-pod quality

Treatment	Pod length (cm)	Pod width (mm)	Chlorophyll index (SPAD)
S_1 : 2nd week of June	25.23	4.77	52.95
S_2 : 4th week of June	24.57	4.81	53.18
S_3 : 2nd week of July	24.09	4.69	52.48
G_0 : Water spray	21.91	4.02	49.74
G_1 : Brassinolide 2 ppm	24.67	4.14	51.61
G_2 : GA ₃ 15 ppm	25.62	5.32	53.43
G_3 : Brassinolide 2 ppm + GA ₃ 15 ppm	26.32	5.54	56.71
S_1G_0	23.60	---	---
S_1G_1	24.73	-	-
S_1G_2	25.80	-	-
S_1G_3	26.80	-	-
S_2G_0	21.67	-	-
S_2G_1	24.67	-	-
S_2G_2	25.67	-	-
S_2G_3	26.27	-	-
S_3G_0	20.47	-	-
S_3G_1	24.60	-	-
S_3G_2	25.40	-	-
S_3G_3	25.90	-	-
F-test	Sig	NS	NS
SE(m)±	0.42	0.08	1.15
CD at 5%	1.24	-	-

Green-pod length

Green-pod length was significantly influenced by sowing time, growth regulators and their interaction. S_1 recorded the maximum pod length among sowing dates (25.23 cm), whereas S_3 recorded 24.09 cm. Among regulator treatments, G_3 produced the longest pods (26.32 cm), followed by G_2 (25.62 cm), while the control recorded 21.91 cm. The interaction S_1G_3 produced the maximum pod length of 26.80 cm. The longer pods under the combined treatment may be due to improved cell expansion and better assimilate availability during pod development.

Green-pod width

The effect of sowing time on green-pod width was non-significant, although S_2 recorded the highest numerical value of 4.81 mm. In contrast, growth regulator treatments differed significantly. G_3 recorded the maximum pod width (5.54 mm), followed by G_2 (5.32 mm), whereas the control

recorded 4.02 mm. The interaction effect was non-significant. The response indicates that regulator application, particularly the combined brassinolide and GA₃ treatment, contributed to better pod development and marketable pod size irrespective of the sowing date.

Chlorophyll index

The chlorophyll index was not significantly influenced by sowing time or by its interaction with growth regulator treatment. However, the effect of growth regulators was significant. G_3 recorded the highest chlorophyll index of 56.71 SPAD, followed by G_2 (53.43 SPAD), while the control recorded 49.74 SPAD. The higher chlorophyll index under the combined treatment suggests improved leaf physiological status and may partly explain the superior growth and yield observed under G_3 . Better chlorophyll retention can support photosynthetic activity and sustained supply of assimilates for green-pod production.

Benefit: Cost ratio

The economic analysis presented in Table 5 showed that the benefit (B) ratio varied considerably among the sowing dates and plant growth regulator treatments. The highest B ratio (3.73) was obtained with S₂G₃, comprising sowing in the fourth week of June followed by foliar application of brassinolide @ 2 ppm + GA₃ @ 15 ppm. The next best treatment was S₁G₃, involving sowing in the second week of

June with the same plant growth regulator combination, which recorded a B ratio of 3.57. In contrast, the lowest B ratio (2.26) was observed under S₃G₀, where cowpea was sown during the second week of July without plant growth regulator application. Overall, sowing in the fourth week of June along with brassinolide @ 2 ppm + GA₃ @ 15 ppm proved to be the most economically viable treatment.

Table 5: Economics of different sowing times and plant growth regulators on yield (kg ha⁻¹) of Cowpea

Treatment combinations	Yield (q ha ⁻¹)	Gross returns (Rs ha ⁻¹)	Cost of cultivation (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)	B:C Ratio
S ₁ G ₀	54.19	136550	58170	78380	2.34
S ₁ G ₁	64.03	162650	58650	104000	2.77
S ₁ G ₂	71.06	177250	58590	118660	3.02
S ₁ G ₃	85.43	211500	59090	152410	3.57
S ₂ G ₀	58.49	153700	58170	95530	2.64
S ₂ G ₁	65.96	166800	58650	108150	2.84
S ₂ G ₂	74.33	185400	58590	126810	3.16
S ₂ G ₃	87.88	220675	59090	161585	3.73
S ₃ G ₀	54.19	131800	58170	73630	2.26
S ₃ G ₁	62.73	161725	58650	103075	2.75
S ₃ G ₂	67.98	170025	58590	111435	2.90
S ₃ G ₃	79.09	192150	59090	133060	3.50

Conclusion

The study demonstrated that sowing time and plant growth regulator application significantly influenced the growth, earliness, yield, and quality of vegetable cowpea. Sowing during the 4th week of June was most favourable for overall crop performance. The combined foliar application of brassinolide @ 2 ppm + GA₃ @ 15 ppm produced superior growth and yield attributes, with S₂G₃ (4th week of June sowing + brassinolide @ 2 ppm + GA₃ @ 15 ppm) emerging as the most effective treatment combination. However, for attaining early flowering and early completion of harvest, S₁G₁ (second week of June sowing + brassinolide @ 2 ppm) was more suitable. An important observation of the study was that the combined application of brassinolide @ 2 ppm + GA₃ @ 15 ppm showed a beneficial effect even under delayed sowing conditions. Under the 2nd week of June sowing, the combined application of brassinolide @ 2 ppm + GA₃ @ 15 ppm maintained the yield at a level that was statistically comparable with the superior treatment involving 4th week of June sowing + brassinolide @ 2 ppm + GA₃ @ 15 ppm. This indicates that the combined application of these growth regulators may have the potential to partially alleviate the adverse effects associated with delayed sowing.

although, under the conditions of this study, sowing vegetable cowpea during the 4th week of June with brassinolide @ 2 ppm + GA₃ @ 15 ppm can be suggested for improved productivity and quality.

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