

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(6): 1248-1253
www.biochemjournal.com
Received: 21-03-2026
Accepted: 23-04-2026

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Effect of weed management and growth hormones on growth, yield and economics of black wheat (*Triticum aestivum* L.) in the North East plain Zone

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6So.8806>

Abstract

A field experiment was conducted during the *rabi* season of 2025-26 at the Agricultural Research Farm, Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj (Uttar Pradesh), to evaluate the effect of weed management practices and plant growth hormones on the growth, yield and economics of black wheat (variety NABI-MG). The experiment was laid out in a Randomized Block Design with twelve treatment combinations of four weed management practices (Metribuzin @ 175 g a.i. ha⁻¹, Metsulfuron-methyl @ 4 g a.i. ha⁻¹, Pendimethalin 30% EC and hand weeding) and three growth regulators (IBA, GA₃ and amino acid), replicated three times. Among all the treatments, T₁₁ (Hand weeding + GA₃) recorded the maximum plant height (106.54 cm), leaf area index (3.45 at harvest), dry matter accumulation (24.50 g plant⁻¹), number of tillers (336.25 m⁻²), number of ears (361.85 m⁻²), seeds per plant (44.83), ear length (9.67 cm), seed yield (45.60 q ha⁻¹), straw yield (51.00 q ha⁻¹), biological yield (94.30 q ha⁻¹) and harvest index (48.36%). The same treatment also gave the highest gross return (₹2,65,792 ha⁻¹), net return (₹2,02,499 ha⁻¹) and benefit-cost ratio (3.20). The lowest values for growth, yield and profitability were recorded under T₁ (Metribuzin @ 175 g a.i. ha⁻¹ + IBA). It is concluded that the combination of hand weeding with foliar application of GA₃ is the most productive and remunerative practice for black wheat cultivation under the agro-climatic conditions of the North East Plain Zone.

Keywords: Black wheat, weed management, growth regulators, GA₃, hand weeding, yield, economics, benefit-cost ratio

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most widely cultivated cereal crops and forms the backbone of food security in India, where it is grown over about 30 million hectares with an annual production of nearly 110 million tonnes. In recent years, attention has shifted from quantity to quality of food, and pigmented wheat varieties such as black wheat have gained importance because of their high anthocyanin and phenolic content. These compounds possess strong antioxidant properties, and black wheat additionally offers a comparatively lower glycemic index and higher fibre content, making it a promising functional food. Despite these advantages, the cultivation of black wheat is still limited, mainly due to the lack of region-specific agronomic recommendations.

Among the various constraints in wheat production, weed infestation is a major factor that can reduce grain yield by 30-50% through competition for nutrients, moisture, light and space, the loss being most severe during early crop growth. Chemical control using herbicides such as metribuzin, metsulfuron-methyl and pendimethalin is popular because it is effective and less labour-intensive, although excessive reliance on a single herbicide can encourage resistant weeds and affect soil health. Hence integrated approaches combining chemical and manual methods are advocated.

Plant growth regulators (PGRs) influence growth and development even at low concentrations. Gibberellic acid (GA₃) promotes cell elongation, leaf expansion and photosynthesis; indole-3-butyric acid (IBA) stimulates root development; and amino acids act as biostimulants supporting nitrogen metabolism. Combining effective weed management with judicious use of PGRs may therefore produce better results than either practice alone,

particularly for black wheat where information is scarce. Keeping these points in view, the present investigation was undertaken with the following objectives: (i) to study the effect of weed management and growth hormones on the growth and yield of black wheat; and (ii) to work out the economics of the different treatment combinations.

2. Materials and Methods

The field experiment was carried out during the *rabi* season of 2025-26 at the Agricultural Research Farm, Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj (U.P.), situated at 25°13' N latitude and 81°46' E longitude at an altitude of about 98 m above mean sea level. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction (pH 8.25), low in organic carbon (0.42%) and available nitrogen (181.60 kg ha⁻¹), medium in available phosphorus (16.50 kg ha⁻¹) and available potassium (230.47 kg ha⁻¹).

The experiment was laid out in a Randomized Block Design (RBD) with twelve treatment combinations replicated three times, giving a total of 36 plots, each of 9 m² (3 m × 3 m). The black wheat variety NABI-MG was sown manually at a spacing of 20 cm × 3 cm using a seed rate of 100 kg ha⁻¹. Metribuzin @ 175 g a.i. ha⁻¹ and metsulfuron-methyl @ 4 g a.i. ha⁻¹ were applied as post-emergence herbicides, pendimethalin 30% EC was applied as a pre-emergence herbicide immediately after sowing, and hand weeding was carried out at 30 and 60 DAS. The growth regulators (IBA, GA₃ and amino acid) were applied as foliar sprays at the recommended concentrations using a knapsack sprayer. The treatment combinations were T₁-T₁₂ as shown in Table 1.

Observations on plant height, leaf area index (LAI), dry matter accumulation, root length and number of tillers were recorded at 30, 60 and 90 DAS and at harvest. Yield attributes (number of ears m⁻², number of seeds plant⁻¹, ear length and test weight), seed yield, straw yield, biological yield and harvest index were recorded at harvest. Economics of treatments was worked out in terms of cost of cultivation, gross return, net return and benefit-cost (B:C) ratio. The data were statistically analysed by the analysis of variance technique for RBD, and treatment means were compared using the critical difference (CD) at 5% level of significance.

Table 1: Treatment combinations of weed management and growth hormones.

Treatment	Details
T ₁	Metribuzin @ 175 g a.i. ha ⁻¹ + IBA
T ₂	Metribuzin @ 175 g a.i. ha ⁻¹ + GA ₃
T ₃	Metribuzin @ 175 g a.i. ha ⁻¹ + Amino acid
T ₄	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + IBA
T ₅	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + GA ₃
T ₆	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + Amino acid
T ₇	Pendimethalin 30% EC + Amino acid
T ₈	Pendimethalin 30% EC + IBA
T ₉	Pendimethalin 30% EC + GA ₃
T ₁₀	Hand weeding + IBA
T ₁₁	Hand weeding + GA ₃
T ₁₂	Hand weeding + Amino acid

3. Results and Discussion

3.1 Growth parameters

All growth parameters increased progressively with the advancement of crop age. Plant height, dry matter accumulation and number of tillers reached their maximum at harvest, whereas LAI peaked at 90 DAS and declined slightly thereafter due to senescence of the lower leaves. Differences among treatments were non-significant at 30 DAS but became significant at 60 DAS and at harvest.

At harvest, the maximum plant height (106.54 cm), leaf area index (3.45), dry matter accumulation (24.50 g plant⁻¹) and number of tillers (336.25 m⁻²) were recorded under T₁₁ (Hand weeding + GA₃), which remained statistically at par with T₉ (Pendimethalin + GA₃), T₁₀ (Hand weeding + IBA) and T₁₂ (Hand weeding + Amino acid). The superior performance of T₁₁ may be attributed to effective weed control through hand weeding, which maintained a weed-free environment and reduced crop-weed competition, together with the role of GA₃ in promoting cell division, cell elongation, chlorophyll synthesis and translocation of assimilates. In contrast, the maximum root length (115.34 cm) was recorded under T₁₀ (Hand weeding + IBA), reflecting the specific role of IBA in stimulating root initiation and proliferation. The lowest values of most growth parameters were observed under T₁ (Metribuzin + IBA), owing to comparatively less effective weed suppression and lower stimulatory effect on shoot growth.

Table 2: Effect of weed management and growth hormones on growth parameters of black wheat at harvest.

T. No.	Treatment	Plant height (cm)	LAI	Dry matter (g plant ⁻¹)	Root length (cm)	Tillers (m ⁻²)
T ₁	Metribuzin @ 175 g a.i. ha ⁻¹ + IBA	95.14	2.88	17.96	111.84	255.34
T ₂	Metribuzin @ 175 g a.i. ha ⁻¹ + GA ₃	98.42	2.97	22.61	96.55	273.98
T ₃	Metribuzin @ 175 g a.i. ha ⁻¹ + Amino acid	97.77	3.24	21.25	102.64	263.64
T ₄	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + IBA	97.8	3.33	21.98	112.8	276.25
T ₅	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + GA ₃	104.58	3.11	22.84	98.26	300.16
T ₆	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + Amino acid	99.55	3.08	21.99	103.84	297.34
T ₇	Pendimethalin 30% EC + Amino acid	103.84	3.39	22.98	105.68	311.58
T ₈	Pendimethalin 30% EC + IBA	98.64	3.27	22.85	113.64	310.64
T ₉	Pendimethalin 30% EC + GA ₃	104.59	3.14	23.23	99.48	323.86
T ₁₀	Hand weeding + IBA	103.51	3.37	23.88	115.34	325.67
T ₁₁	Hand weeding + GA ₃	106.54	3.45	24.5	100.82	336.25
T ₁₂	Hand weeding + Amino acid	104.45	3.41	23.94	109.4	330.58
F-test		S	S	S	S	S
SEm (±)		2.45	0.122	0.863	3.645	10.156
CD (P = 0.05)		7.18	0.359	2.53	10.691	29.786

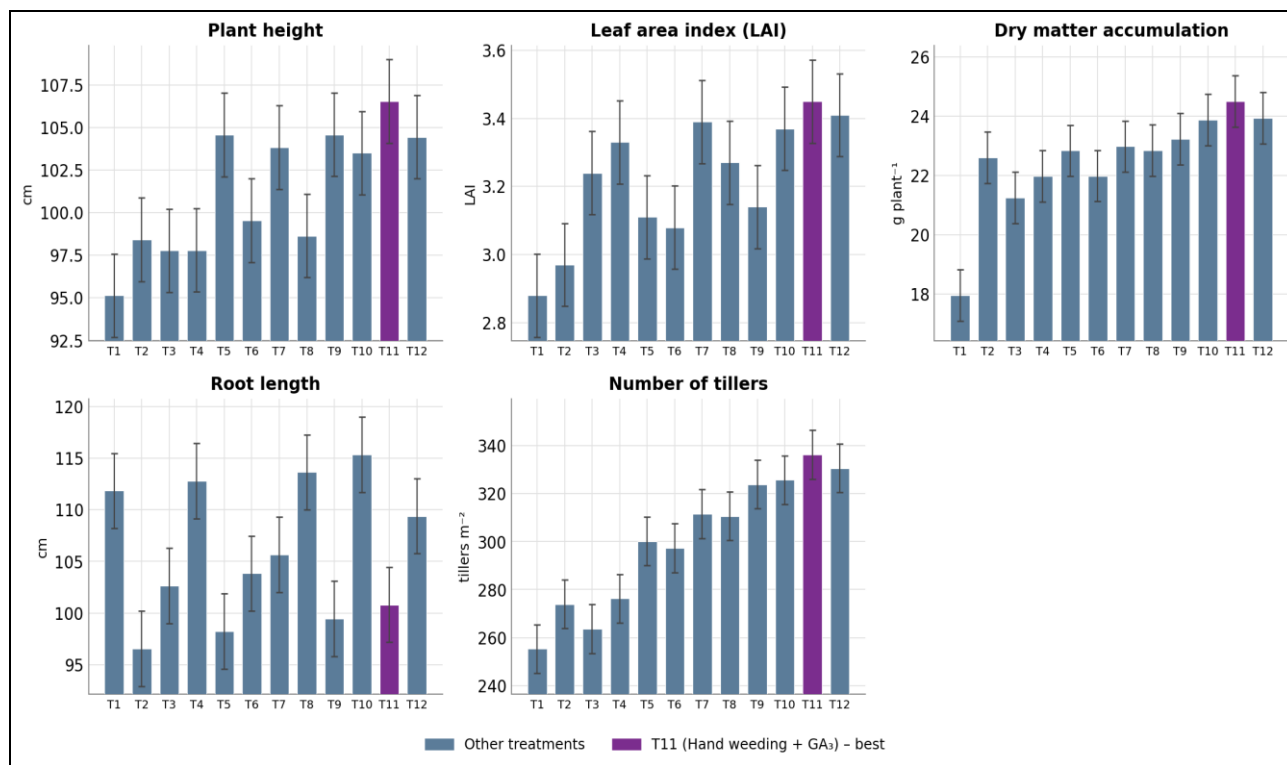


Fig 1: Effect of weed management and growth hormones on growth parameters of black wheat at harvest (bars = treatment means; whiskers = SEM $\pm$; T₁₁ highlighted).

3.2 Yield attributes

The yield attributes were significantly influenced by the treatments, except test weight, which differed only numerically. The maximum number of ears (361.85 m⁻²), number of seeds per plant (44.83), ear length (9.67 cm) and test weight (36.89 g) were recorded under T₁₁ (Hand weeding + GA₃), closely followed by T₁₂ (Hand weeding +

Amino acid), T₁₀ (Hand weeding + IBA) and T₉ (Pendimethalin + GA₃). The improvement in yield attributes under T₁₁ is the result of better weed control and the favourable effect of GA₃ on photosynthesis and assimilate translocation from source to sink during the reproductive phase. The minimum values were recorded under T₁ (Metribuzin + IBA).

Table 3: Effect of weed management and growth hormones on yield attributes of black wheat.

T. No.	Treatment	Ears (m ⁻²)	Seeds plant ⁻¹	Ear length (cm)	Test weight (g)
T ₁	Metribuzin @ 175 g a.i. ha ⁻¹ + IBA	234.88	28.64	7.45	35.3
T ₂	Metribuzin @ 175 g a.i. ha ⁻¹ + GA ₃	266.37	33.67	8.76	35.34
T ₃	Metribuzin @ 175 g a.i. ha ⁻¹ + Amino acid	264.88	34.28	8.43	35.67
T ₄	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + IBA	267.81	37.94	8.92	35.81
T ₅	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + GA ₃	269.89	39.81	9.44	35.69
T ₆	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + Amino acid	269.15	38.72	9.14	35.82
T ₇	Pendimethalin 30% EC + Amino acid	271.84	41.06	9.34	36.12
T ₈	Pendimethalin 30% EC + IBA	271.56	40.34	9.18	36.34
T ₉	Pendimethalin 30% EC + GA ₃	272.62	41.62	9.53	36.85
T ₁₀	Hand weeding + IBA	274.97	42.73	9.37	35.83
T ₁₁	Hand weeding + GA ₃	361.85	44.83	9.67	36.89
T ₁₂	Hand weeding + Amino acid	276.43	43.28	9.47	36.51
F-test		S	S	S	NS
SEm ($\pm$)		11.228	1.376	0.402	1.365
CD (P = 0.05)		32.931	4.037	1.181	NS

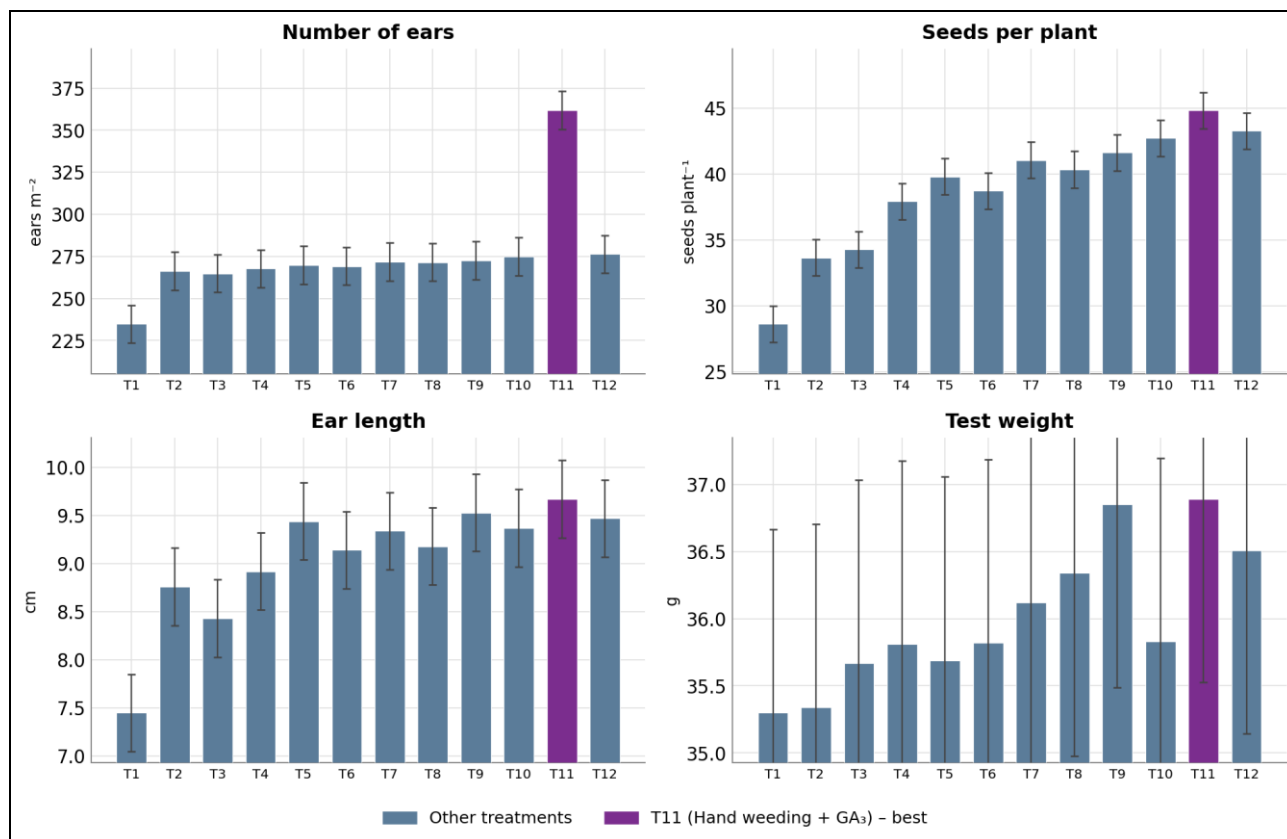


Fig 2: Effect of weed management and growth hormones on yield attributes of black wheat (bars = treatment means; whiskers = SEM $\pm$; T₁₁ highlighted).

3.3 Yield and harvest index

Seed yield, straw yield, biological yield and harvest index varied significantly among the treatments. The maximum seed yield (45.60 q ha⁻¹), straw yield (51.00 q ha⁻¹), biological yield (94.30 q ha⁻¹) and harvest index (48.36%) were recorded under T₁₁ (Hand weeding + GA₃), followed by T₁₂ (Hand weeding + Amino acid), T₁₀ (Hand weeding + IBA) and T₉ (Pendimethalin + GA₃). The higher seed yield

under T₁₁ is a cumulative outcome of more ears per unit area, more seeds per plant, longer ears and better test weight, while the higher harvest index indicates more efficient partitioning of photosynthates towards the economic yield. The lowest seed yield (24.60 q ha⁻¹) and harvest index (22.75%) were recorded under T₁ (Metribuzin + IBA), reflecting poor growth and inefficient resource utilization.

Table 4: Effect of weed management and growth hormones on yield and harvest index of black wheat.

T. No.	Treatment	Seed yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
T ₁	Metribuzin @ 175 g a.i. ha ⁻¹ + IBA	24.6	36	46.6	22.75
T ₂	Metribuzin @ 175 g a.i. ha ⁻¹ + GA ₃	28.9	39.3	68.2	41.27
T ₃	Metribuzin @ 175 g a.i. ha ⁻¹ + Amino acid	26.8	38.6	58.4	33.9
T ₄	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + IBA	29.8	41.7	72.2	42.42
T ₅	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + GA ₃	31.6	42.9	74.5	45.87
T ₆	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + Amino acid	30.8	42.4	77.8	42.38
T ₇	Pendimethalin 30% EC + Amino acid	38.3	45.2	83.5	42.55
T ₈	Pendimethalin 30% EC + IBA	33.1	44.7	72.5	42.48
T ₉	Pendimethalin 30% EC + GA ₃	40.9	47.6	88.5	46.21
T ₁₀	Hand weeding + IBA	42.3	48.7	91.6	45.57
T ₁₁	Hand weeding + GA ₃	45.6	51	94.3	48.36
T ₁₂	Hand weeding + Amino acid	42.7	49.3	93.7	46.18
F-test		S	S	S	S
SEm ($\pm$)		1.477	1.746	2.548	1.472
CD (P = 0.05)		4.332	5.122	7.472	4.317

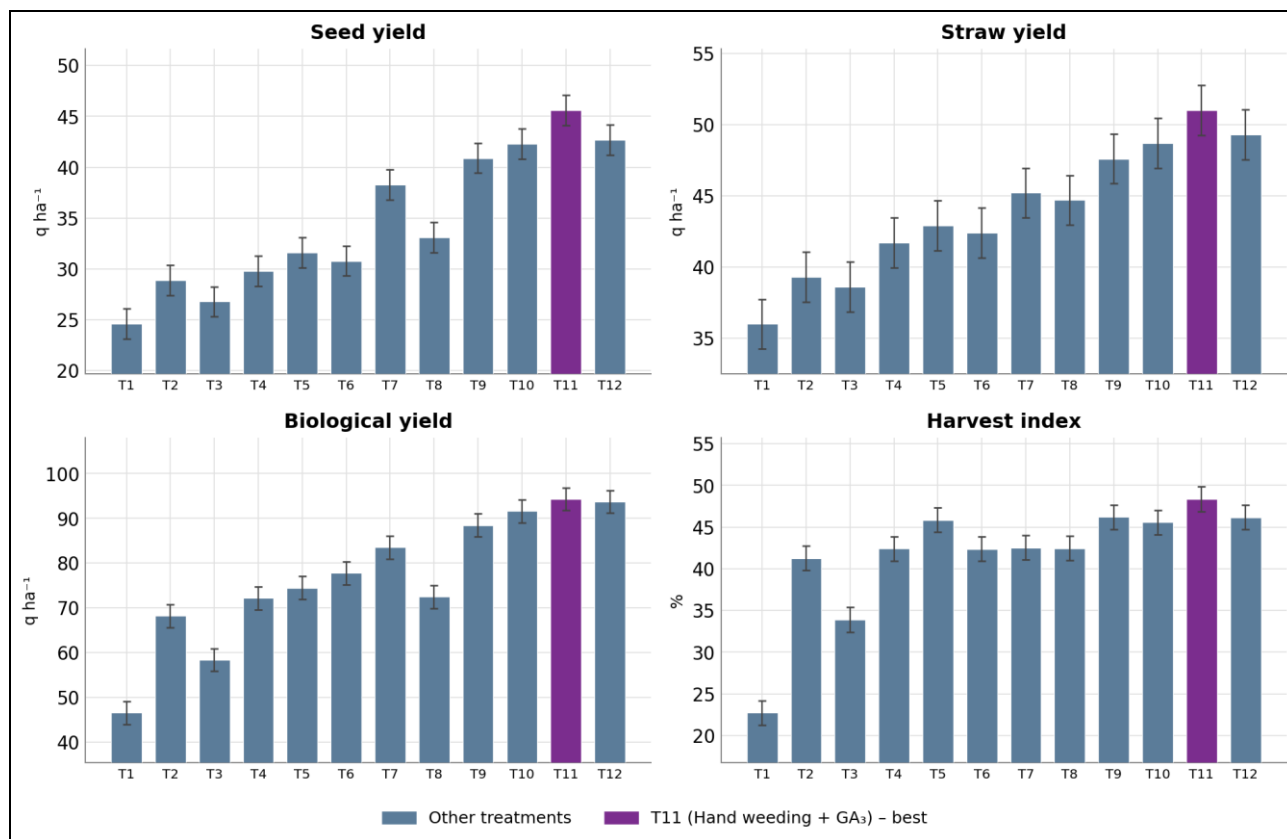


Fig 3: Effect of weed management and growth hormones on yield and harvest index of black wheat (bars = treatment means; whiskers = SEM $\pm$; T₁₁ highlighted).

3.4 Economics of treatments

The cost of cultivation ranged from ₹51,448 ha⁻¹ (T₁) to ₹66,545 ha⁻¹ (T₄), depending on the herbicide used, the growth regulator applied and labour requirement for hand weeding. The maximum gross return (₹2,65,792 ha⁻¹) and net return (₹2,02,499 ha⁻¹) were obtained under T₁₁ (Hand weeding + GA₃), owing to its superior seed and straw yields.

The benefit-cost ratio was highest under T₁₁ (3.20), followed by T₁₂ (3.08), T₁₀ (3.07) and T₉ (3.03), and lowest under T₁ (2.06). The high B:C ratio under T₁₁ indicates that every rupee invested generated the greatest return, confirming that hand weeding combined with GA₃ is the most remunerative practice for black wheat under the agro-climatic conditions of Prayagraj.

Table 5: Effect of weed management and growth hormones on the economics of black wheat cultivation.

T. No.	Treatment	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	B:C ratio
T ₁	Metribuzin @ 175 g a.i. ha ⁻¹ + IBA	51,448	1,57,528	1,06,080	2.06
T ₂	Metribuzin @ 175 g a.i. ha ⁻¹ + GA ₃	64,945	2,41,154	1,76,209	2.71
T ₃	Metribuzin @ 175 g a.i. ha ⁻¹ + Amino acid	58,442	2,09,383	1,50,941	2.58
T ₄	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + IBA	66,545	2,50,222	1,83,677	2.76
T ₅	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + GA ₃	61,693	2,40,702	1,79,009	2.9
T ₆	Metsulfuron-methyl @ 4 g a.i. ha ⁻¹ + Amino acid	63,442	2,44,546	1,81,104	2.85
T ₇	Pendimethalin 30% EC + Amino acid	60,190	2,39,219	1,79,029	2.97
T ₈	Pendimethalin 30% EC + IBA	61,545	2,40,239	1,78,694	2.9
T ₉	Pendimethalin 30% EC + GA ₃	56,545	2,28,032	1,71,487	3.03
T ₁₀	Hand weeding + IBA	60,042	2,44,152	1,84,110	3.07
T ₁₁	Hand weeding + GA ₃	63,293	2,65,792	2,02,499	3.2
T ₁₂	Hand weeding + Amino acid	58,293	2,37,751	1,79,458	3.08

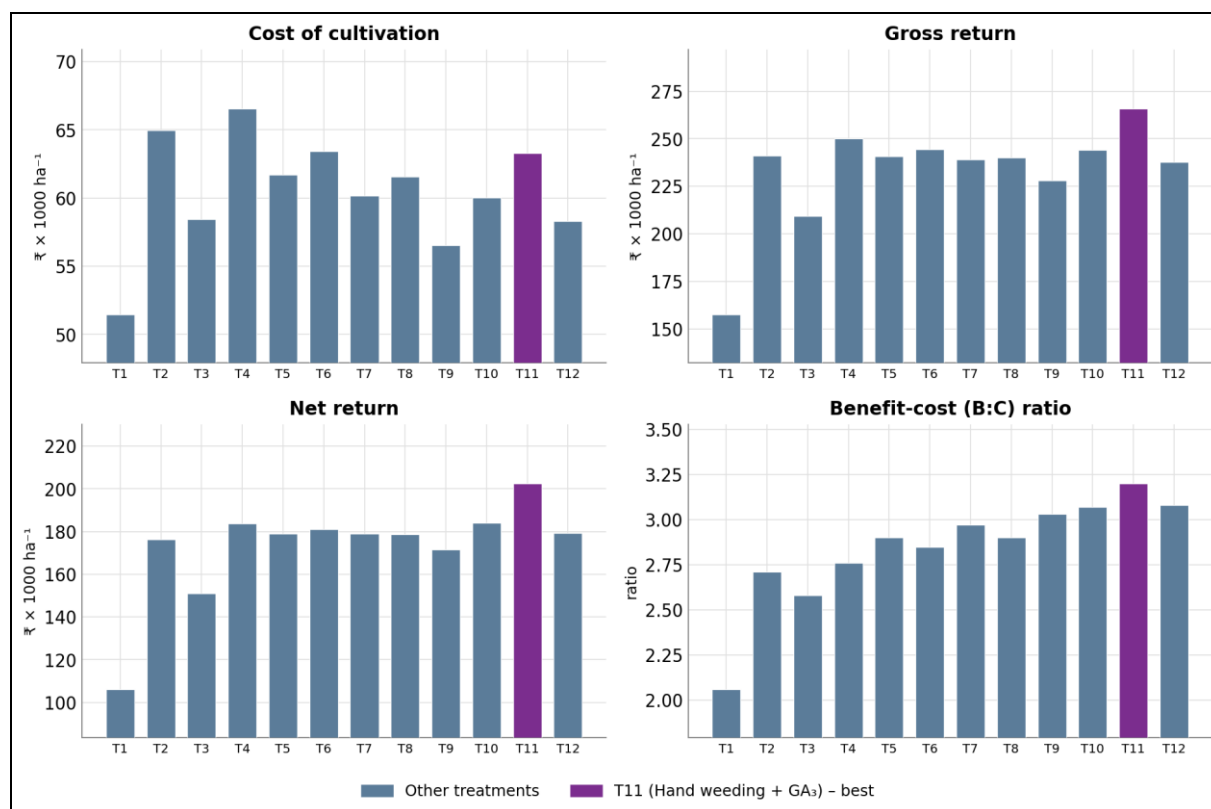


Fig 4: Effect of weed management and growth hormones on the economics of black wheat cultivation (values in ₹ × 1000 ha⁻¹ for cost and returns; T₁₁ highlighted).

4. Conclusion

On the basis of one season of experimentation, it is concluded that the combination of hand weeding with foliar application of gibberellic acid, T₁₁ (Hand weeding + GA₃), proved to be the most effective treatment for black wheat, producing the highest growth, yield attributes, seed yield (45.60 q ha⁻¹), biological yield, harvest index and profitability (net return ₹2,02,499 ha⁻¹; B:C ratio 3.20). Therefore, T₁₁ may be recommended for achieving higher productivity and profitability of black wheat under the agro-climatic conditions of the North East Plain Zone. As the conclusions are drawn from a single year's data, the study should be repeated for at least one more season, and with additional combinations and concentrations of growth regulators, to confirm the findings.

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