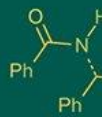
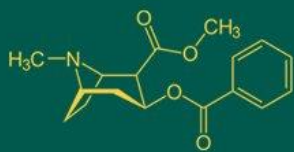


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Response of naphthalene acetic acid (NAA) and magnesium on growth and yield of sweet corn (*Zea mays* L.)

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Abstract

A field experiment was conducted during *kharif* season 2025 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences. To determine "Response of Naphthalene Acetic Acid (NAA) and Magnesium on Growth and Yield of Sweet corn (*Zea mays* L.)". The experiment was laid out in a Randomized Block Design with 10 treatments and replication thrice. The result revealed that Treatment - 5 (NAA - 40 ppm and Magnesium 25 kg/ha) recorded significantly higher Plant height (196.20 cm), Plant dry weight (151.98 g/plant), Significantly maximum number of cobs/plant (1.66), number of grain row/cob (16.83), number of grains/row (37.46), cob length (18.44 cm), cob yield (9.53 t/ha) and stover yield (19.80 t/ha) were recorded in treatment 5 (NAA - 40 ppm and Magnesium 25 kg/ha). Maximum Gross Return (3,17,450 INR/ha), Net Return (2,15,684.6 INR/ha) and Benefit:Cost Ratio (2.12) were obtained highest in the Treatment 5 (NAA- 40 ppm + Mg- 25 Kg /ha).

Keywords: NAA, magnesium, sweet corn, growth, yield and economics

Introduction

Sweet corn (*Zea mays* L.) has rapidly emerged as a highly lucrative, short-duration vegetable and cereal crop across various agrarian regions of India, notably gaining popularity in states like Delhi, Uttar Pradesh, Haryana, Maharashtra, Karnataka, and Rajasthan (Shankar *et al.*, 2013) [16]. Valued for its high sugar content, tender kernels, and robust green fodder yield, sweet corn offers exceptional economic returns per unit area for Indian smallholders. However, the production of sweet corn in modern Indian agriculture faces significant bottlenecks due to intensive multi-cropping patterns, depleting micronutrient profiles in local soils, and unpredictable abiotic stressors that frequently limit the crop from reaching its true genetic potential (Islam *et al.*, 2024) [4]. To maximize both quantitative yield attributes and qualitative economic traits, agronomic interventions using specific plant growth regulators (PGRs) and secondary macronutrients have become vital focal points in localized field research. In the contemporary agrarian economy of India, changing consumer dietary habits, accelerated industrialization of frozen and processed foods, and high domestic demand in urban centres have incentivized small and marginal farmers to rapidly adopt sweet corn cultivation. Major producing states including Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, and Haryana report significant economic returns from sweet corn production compared to conventional grain crops, primarily owing to its short growth duration (75 to 90 days) which fits seamlessly into intensive multi-cropping annual rotations (Ramanjaneyulu *et al.*, 2018) [11].

Historical records indicate that sweet corn was first cultivated by Native Americans in North America in 1779. In India, sweet corn was introduced much later as a specialty maize crop. Commercial cultivation began to expand during the 1990s and early 2000s, driven by the growth of the food processing industry, increasing urbanization, changing dietary preferences, and rising demand for fresh and processed vegetables. Today, sweet corn is cultivated in several states, including Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra, Punjab, Haryana, and Uttar Pradesh, where it serves as a high-value crop due to

its short duration (75-90 days) and better economic returns compared with many traditional cereal crops (Yadav *et al.*, 2016)^[22].

India is one of the world's leading maize-producing countries. During 2024-25, maize was cultivated on approximately 11.2 million hectares, producing about 42.3 million tonnes with an average productivity of 3.78 t/ha. Although separate official statistics for sweet corn are not available, its cultivation is expanding rapidly in states such as Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra, Punjab, Haryana, and Uttar Pradesh because of its short duration (75-90 days), high market value, and better profitability than many conventional cereal crops.

Several studies have demonstrated that balanced fertilization and improved agronomic practices significantly enhance cob yield, quality, and economic returns in sweet corn (Naik *et al.*, 2021)^[8]. Therefore, optimizing nutrient management strategies, including the use of plant growth regulators and secondary nutrients such as magnesium, is essential for improving the growth, yield, and profitability of sweet corn under Indian conditions.

Despite its excellent commercial potential, maximizing the productivity per unit area of sweet corn in India remains bounded by several crop-specific biological limitations and systemic soil nutrient degradations. Because sweet corn is harvested at the immature milk stage (typically 18 to 22 days post-silking), the crop demands highly aggressive and uninhibited early-stage vegetative growth, rapid leaf area expansion for optimum canopy light interception, and an uninterrupted source-to-sink photoassimilate translocation path. However, intensive cultivation sequences across major Indian farming belts have resulted in widespread exhaustion of critical primary, secondary, and micronutrient reserves in the soil profile. The continuous removal of nutrients without balanced replenishment has created widespread sub-surface nutrient limitations, severely weakened cellular expansion and reduced maize crop vigor (Kumar *et al.*, 2020)^[7].

To counter these nutritional deficits and maximize metabolic efficiency during the restricted crop cycle, modern Indian agronomical practices are increasingly focusing on fine-tuning crop physiology via external chemical interventions. Phytohormones and essential secondary nutrients applied as foliar sprays or targeted soil updates provide a precise, high-efficiency pathway to adjust crop ontogeny. Exogenous crop regulation aims to shift biochemical priorities away from standard baseline survival mechanisms toward upgraded structural growth, elevated chlorophyll retention, and better reproductive ear configurations.

Among these biochemical stimulants, Alpha-Naphthalene Acetic Acid (NAA) a robust synthetic auxin analog and Magnesium (Mg), an absolute structural backbone of the photosynthetic machinery, present a highly promising interactive strategy for optimizing sweet corn growth and fresh cob yield parameters (Thavaprakash *et al.*, 2019)^[20].

Naphthalene Acetic Acid (NAA) is a synthetic plant growth regulator belonging to the auxin class, which plays a multi-faceted regulatory role in plant ontogeny, morphogenetic expressions, and cellular homeostasis. When applied exogenously at crucial phenological stages such as late vegetative growth or knee-high stages NAA diffuses rapidly across the cuticle to alter internal hormonal balances. At the cellular level, NAA activates plasma membrane-bound proton pumps, leading to localized acidification of the cell

wall. This process, biochemically described by the Acid Growth Hypothesis, breaks down structural cross-links within cell wall polysaccharides, enabling internal turgor pressure to drive cell elongation and division (Singh *et al.*, 2017)^[18].

In sweet corn, this hormone-driven cellular expansion leads to visible morphological changes. Field trials conducted across varying sub-humid environments in India demonstrate that optimizing NAA application rates significantly increases structural plant height, stem thickness, and the Leaf Area Index (LAI). A larger, more active green canopy improves the crop's Net Assimilation Rate (NAR) and Crop Growth Rate (CGR), ensuring the accumulation of rich vegetative dry matter during the early growth phases. Furthermore, NAA improves the vascular development of the root network, increasing the volume of soil the plant can access and enhancing its capacity to draw mobile and immobile nutrients from the rhizosphere (Paramasivan *et al.*, 2020)^[9].

Beyond vegetative architecture, NAA alters the reproductive dynamics of sweet corn by managing metabolic source-sink pathways. Auxins establish strong physiological 'sinks' at the site of reproductive organs by upregulating the expression of sugar transporter proteins and cell wall invertase enzymes. Consequently, exogenously applied NAA helps direct mobile sucrose and carbohydrates away from standard structural reserves straight into the developing cob. In Indian sweet corn systems, this precise movement reduces the rate of tip-barrenness, minimizes premature kernel abortion, and ensures optimal grain-filling across the entire cob length. This results in uniform cob size, high single-ear weight, and superior marketable green yield (Sharma & Agarwal, 2019)^[17].

Magnesium is crucial for sweet corn production, influencing both yield and grain quality (Rani *et al.*, 2022)^[12] stated in their research that soil acidity is a major reason for low productivity in most of cultivated soils. In India, more than 45 million hectares of land is acidic and Karnataka is one among the several states where the acidic soils are spread over a large area. Out of total cultivated area of 104 lakh hectares in Karnataka, 12.3 lakh hectares of land is acidic. On most acid soils, there are several limiting factors for plant growth, including toxic levels of Al, Mn, and iron (Fe), as well as deficiencies of some essential elements, such as phosphorus (P), nitrogen (N), potassium (K), calcium (Ca), Mg, and some micronutrients such as Mo and B, low microbial activity, poor fertility, and low crop yields. To meet the demands of calcium and magnesium, as well as to create favorable conditions for better uptake of other essential nutrients, liming is an important management practice in the acid soils helping in raising the pH and base saturation of the soil and inactivation of iron, aluminium and manganese in the soil solution and minimizing phosphate fixation by iron. Simultaneously, sustaining high-density maize systems requires addressing secondary nutrient deficiencies, where Magnesium is frequently under-applied in Indian fertilizer regimens. Magnesium serves as the absolute structural center of the chlorophyll molecule, making it completely indispensable for light absorption, carbon fixation, and maintaining peak photosynthetic rates throughout the short vegetative phase of sweet corn. When external stresses or nutrient imbalances restrict Mg concentration within the leaves and roots, cellular energy

systems face oxidative stress, resulting in poor root growth and reduced nutrient absorption (Ullah *et al.*, 2022) ^[21].

Materials and method

This experiment was carried out during kharif 2025 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P), to check the Response of Naphthalene Acetic Acid (NAA) and Magnesium on Growth and Yield of Sweet corn. The experimental field soil was sandy loam with less availability of nitrogen. The experiment was laid out in randomised block design consisting of ten treatment viz T₁ (NAA-20 ppm + Mg-20 kg/ha), T₂ (NAA-20 ppm + Mg-25 kg/ha), T₃ (NAA-20 ppm + Mg-30 kg/ha), T₄ (NAA-40 ppm + Mg-20 kg/ha), T₅ (NAA-40 ppm + Mg-25 kg/ha), T₆ (NAA-40 ppm + Mg-30 kg/ha), T₇ (NAA-60 ppm + Mg-20 kg/ha), T₈ (NAA-60 ppm + Mg-25 kg/ha), T₉ (NAA-60 ppm + Mg-30 kg/ha), T₁₀ (N-P-K - 120-60-40 Kg/ha). Which were replicated thrice. 20 kg/ha seed of Sweet corn variety Sugar 75 the spacing adopted was plant to plant 45 cm and row to 15 cm according to the treatment details and the seeds were drilled at 4-5 cm depth in the net plot area 3m x 3m on 31st July 2025.

The observation on growth parameters i.e. Plant height (cm), Plant dry weight (g), were recorder whereas yield attributing parameters i.e. Number of cobs/plant, Number of grains/row, Number of grain rows/cob, Cob length, Cob yield (kg/ha), Grain yield (kg/ha) and Harvest Index (%) from the net plot area these observation were recorded. The cob and stover yield were taken for the net plot of 1m². Harvest Index(%) was calculated by using this formula (economic yield /Biological yield) x 100 and extrapolated to a per-hectare basis. The recorded data were analysed statically by ANOVA technique.

Results and discussion

Growth Parameters

Plant Height: At 80 DAS, there was significant difference among the treatments, the maximum plant height (196.20 cm) was obtained in T₅ [NAA-40 ppm + Mg-25 kg/ha]. However, T₆ [NAA-40 ppm + Mg-30 kg/ha] was statistically at par with T₅ [NAA-40 ppm + Mg-25 kg/ha].

The maximum plant height observed in T₅ [NAA- 40 ppm + Mg- 25 kg/ha] is due to the synergistic interaction between Naphthalene Acetic Acid and Magnesium. NAA stimulates crucial proton pump activity to promote rapid cell wall elongation and vertical inter nodal expansion, while the application of Magnesium ensures maximum chlorophyll core synthesis and ATP production to structurally fuel this growth. Consequently, this optimal balance of exogenous plant growth regulators and essential secondary nutrients maximizes the vegetative architecture of the sweet corn.

Similar findings regarding the positive influence of exogenous NAA applications on accelerating cell elongation and improving overall plant vegetative height were also reported by Deb and Sinha (2024) ^[3].

Plant dry weight

At 80 DAS, there was significant difference among the treatments, the maximum plant dry weight (151.98 g) was obtained in T₅ [NAA-40 ppm + Mg-25 kg/ha]. However, T₆ [NAA-40 ppm + Mg-30 kg/ha] was statistically at par with T₅ [NAA-40 ppm + Mg-25 kg/ha].

The maximum plant dry weight observed in T₅ [NAA-40 ppm + Mg-25 kg/ha] may be attributed to the synergistic

effect of Naphthalene Acetic Acid and Magnesium on cellular metabolism and photosynthetic efficiency. NAA promotes rapid cell division and elongation, resulting in enhanced vegetative growth and biomass accumulation, whereas magnesium, being the central component of chlorophyll, improves photosynthetic activity, carbohydrate synthesis and translocation of assimilates. The combined application of optimum NAA and magnesium therefore enhanced dry matter production throughout the crop growth period. Consequently, this balanced interaction between plant growth regulator and essential nutrient maximized the overall growth performance of sweet corn.

Similar findings regarding the positive influence of NAA and magnesium on dry matter accumulation and vegetative growth in maize were also reported by Rao *et al.*, (2021) and Sankaralingam and Malarvizhi (2021) ^[13, 15].

Yield Parameters

Number of cobs per plant

The statistical analysis reveals that the varying treatment combinations exerted a highly significant influence on this specific prolificacy trait. There was significant difference among the treatments, significantly higher number of cobs per plant (1.66) was recorded with the application of T₅ [NAA-40 ppm + Mg-25 kg/ha]. However, T₆ [NAA-40 ppm + Mg-30 kg/ha] was found statistically at par with T₅ [NAA-40 ppm + Mg-25 kg/ha].

Significant and maximum number of cobs/plants was observed with NAA (40 ppm), the efficient nutrient application enhanced the better root development and biomass production, resulted in increasing number of cobs per plant. Similar results were also reported by Alam and Sadat (2019) ^[1].

Number of grain row/cob

Maximum number of grain row/cob (16.83) was recorded with the application of T₅ [NAA-40 ppm + Mg-25 kg/ha]. However, T₆ [NAA 40 ppm + Mg 30 kg/ha] (15.60) and T₇ [NAA 20 ppm + Mg 20 kg/ha] (15.40) were statistically at par with T₅ [NAA-40 ppm + Mg-25kg/ha].

Application of NAA resulted in a maximum number of grain row/cob, possibly due to its effect on enhancing cell division during early spikelet initiation, while magnesium contributed to improved nutrient use efficiency during reproductive differentiation. Similar findings were also reported by Potarzycki (2011) ^[10].

Number of grains/rows

The statistical observations demonstrate that the treatment variables generated a highly distinct and significant impact on kernel retention along the row. Maximum number of grains/row (37.46) was recorded with the application of T₅ [NAA-40 ppm + Mg-25 kg/ha]. However, T₆ [NAA-40 ppm + Mg-30 kg/ha] was found statistically at par with T₅ [NAA-40 ppm + Mg-25 kg/ha].

The significant increase in grains per row could be attributed to the minimized ovule abortion mediated by NAA application. Similar findings were also reported by (Ullah *et al.*, 2022), and (Revilla *et al.*, 2021) ^[14, 21].

Cob length

There was significant difference among the treatments, significantly higher cob length (18.44 cm) was recorded with the application of T₅ [NAA - 40 ppm + Mg- 25 kg/ha].

However, T₃ [NAA-20 ppm + Mg-30 kg/ha], T₆ [NAA-40 ppm + Mg-30 kg/ha] T₈ [NAA-60 ppm + Mg-25 kg/ha] were statistically at par with T₅ [NAA - 40 ppm + Mg- 25 kg/ha].

The elongation of the cob length might be due to the cell elongation property of auxin coupled with the metabolic energy provided by magnesium. Similar findings were also reported by Khan *et al.* (2025) [6].

Cob yield (t/ha)

The statistical variance highlights that the integration of growth regulators and secondary macronutrients profoundly influenced final harvest weight. There was significant difference among the treatments, significantly higher cob yield (9.53 t/ha) was recorded with the application of T₅ [NAA-40 ppm + Mg-25 kg/ha]. However, T₆ [NAA-40 ppm + Mg-30 kg/ha] was found to be statistically at par with T₅ [NAA-40 ppm + Mg-25 kg/ha].

The maximum cob yield under optimal NAA and Mg levels might be due to the synchronized enhancement of both chlorophyll content and sink strength, optimizing the allocation of photosynthates toward economic parts. Similar findings were reported by Choudhary *et al.*, (2013) [2].

Stover yield (t/ha)

The analysis of variance reveals that the vegetative structural development responded significantly to the distinct treatment combinations. There was significant difference among the treatments, significantly higher stover yield (19.80 t/ha) was recorded with the application of T₅ [NAA-40 ppm + Mg-25 kg/ha]. However, T₆ [NAA-40 ppm

+ Mg-30 kg/ha] and T₇ [NAA-60 ppm + Mg-20 kg/ha] were statistically at par with T₅ [NAA-40 ppm + Mg-25 kg/ha]. This increase in stover yield is likely attributed to magnesium's foundational role in the central core of chlorophyll molecules coupled with auxin-induced lateral root expansion, which together accelerated vegetative dry matter accumulation. Similar observations were documented by Jeet *et al.*, (2012) [5].

Harvest Index (%)

Significantly higher numerical harvest index (33.4%) was recorded with the application of T₆ [NAA-40 ppm + Mg-30 kg/ha] and the minimum value (30.5%) was observed in Control (RDF) - [N-P-K - 120-60-40 kg/ha] and there was no significant difference between the treatments.

Conclusion

It is concluded that application of Treatment T₅ [NAA-40 ppm + Mg- 25 kg/ha] was recorded highest Cob yield, Stover yield, Gross Return, Net Return and maximum B:C Ratio in Sweet Corn.

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Competing interests

Authors have declared that no competing interests exist.

Table 1: Response of Naphthalene Acetic Acid (NAA) and Magnesium on Growth Attributes of Sweet corn.

S. No.	Treatments	Plant Height (cm)	Dry Weight (g/plant)
1	NAA 20 ppm + Mg 20 kg/ha	173.59	134.41
2	NAA 20 ppm + Mg 25 kg/ha	179.94	129.64
3	NAA 20 ppm + Mg 30 kg/ha	180.20	134.44
4	NAA 40 ppm + Mg 20 kg/ha	178.44	143.51
5	NAA 40 ppm + Mg 25 kg/ha	196.20	151.98
6	NAA 40 ppm + Mg 30 kg/ha	188.16	147.42
7	NAA 60 ppm + Mg 20 kg/ha	171.62	130.51
8	NAA 60 ppm + Mg 25 kg/ha	179.82	138.14
9	NAA 60 ppm + Mg 30 kg/ha	180.10	139.78
10	Control (N-P-K: 120-60-40 kg/ha)	168.24	125.02
	F-Test	S	S
	S.Em (±)	5.20	4.16
	CD (P = 0.05)	15.44	12.35

Table 2: Response of Naphthalene Acetic Acid (NAA) and Magnesium on Yield attributes of Sweet corn.

S. No.	Treatments	Number of Cobs/Plant	Number of Grain Rows/Cob	Number of Grains/Row	Cob Length (cm)	Cob Yield (t/ha)	Stover Yield (t/ha)	Harvest Index (%)
1	NAA 20 ppm + Mg 20 kg/ha	1.26	14.76	34.36	16.44	7.53	16.13	31.9
2	NAA 20 ppm + Mg 25 kg/ha	1.40	15.06	32.73	16.74	7.66	17.03	31.3
3	NAA 20 ppm + Mg 30 kg/ha	1.43	15.33	33.73	17.27	8.26	17.60	32.0
4	NAA 40 ppm + Mg 20 kg/ha	1.33	14.80	34.46	16.92	8.56	18.06	32.2
5	NAA 40 ppm + Mg 25 kg/ha	1.66	16.83	37.46	18.44	9.53	19.80	32.5
6	NAA 40 ppm + Mg 30 kg/ha	1.46	15.60	35.46	17.03	9.46	18.90	33.4

7	NAA 60 ppm + Mg 20 kg/ha	1.13	15.40	33.00	16.58	8.36	18.16	31.5
8	NAA 60 ppm + Mg 25 kg/ha	1.40	14.80	33.40	17.06	8.66	18.10	32.4
9	NAA 60 ppm + Mg 30 kg/ha	1.40	15.06	33.40	16.88	7.96	18.03	30.6
10	Control (N-P-K: 120-60-40 kg/ha)	1.13	15.10	32.66	16.48	6.86	15.66	30.5
	F-test	S	S	S	S	S	S	NS
	S.Em ($\pm$)	0.07	0.49	0.99	0.50	0.26	0.55	0.65
	CD (P = 0.05)	0.21	1.46	2.94	1.47	0.78	1.64	-

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