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Influence of growth promoters on seed quality in relation to positional polymorphism in sesamum (*sesamum indicum* L.)

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Abstract

India being the world's largest producer of sesamum, struggles with low yields due to rainfed farming and underdeveloped practices. Sesamum, valued for its high-quality oil and adaptability holds significant potential for productivity improvement. The use of growth promoters plays a crucial role in enhancing crop productivity and quality by influencing key physiological processes in plants. This study evaluated the impact of growth promoters on seed quality and positional polymorphism of sesamum Cv. GKVK S-1 using an FCRD design with foliar sprays of different growth promoter such as NAA, ascorbic acid, IAA and benzyl adenine. Positional polymorphism studies revealed that irrespective of treatments, seeds from bottom position exhibited superior quality traits compared to top and middle. Among interactions, NAA @ 100 ppm and bottom position seeds exhibited highest thousand seed weight (4.23 g), seed germination (94.0%) and seedling vigour indices 1 and 11 (984 and 434 respectively). The study concluded that applying NAA at 100 ppm significantly improved the growth, seed yield and quality of sesamum cv. GKVK S-1. Seeds from the bottom position, particularly with NAA treatment exhibited superior seed quality highlighting the effectiveness of growth promoters.

Keywords: Growth promoters, fruit position, seed germination, seed quality

Introduction

Oilseeds have long been an integral part of India's agricultural economy, serving as one of the primary sources of vegetable oils for both domestic consumption and export. Ranking second in demand after cereals, oilseeds contribute significantly to the agricultural sector, supporting millions of farmers and acting as a critical part of India's overall food security. In the early 1990s, India's 'Yellow Revolution' briefly propelled the country towards self-sufficiency in oilseeds production (Anon, 2022 a). This marked a period of substantial growth in the production of oilseeds, helping India reduce its dependence on imported vegetable oils. However, since that time, India has faced challenges in sustaining such progress. Despite being the fourth-largest oilseed producer globally, behind the USA, Brazil and China, India remains one of the largest importers of vegetable oils largely due to relatively low domestic productivity. Oilseeds in India can be classified into two main types: edible oilseeds such as groundnut, rapeseed, soybean, sunflower, sesamum, safflower and niger, and non-edible oilseeds such as castor and linseed. Both categories serve important functions, with edible oils being a staple in Indian households and non-edible oils having industrial applications. Among the many oilseeds cultivated in India, sesamum holds a special place due to its high-quality edible oil and its ancient history of cultivation. Belonging to the family Pedaliaceae, sesamum is one of the oldest oilseed crops known to humanity. In recent times India, China, Myanmar and Sudan are the major producers of sesamum. India, in particular, holds the distinction of being the world's largest producer of sesamum, with an output of approximately 8.66 lakh tonnes grown on 19.47 lakh hectares of land. This accounts for roughly one-third of the world's sesamum production. However, despite India's dominant role in sesamum cultivation the country's average yield of sesamum

is low at 413 kg/ha, lags behind other nations such as China (535 kg/ha). Factors such as climatic variability, dependent on rainfed agriculture and underdeveloped farming practices contribute to this gap in productivity (Angel *et al.*, 2022) [5]. Sesamum is highly adaptable and grows to a height of 0.5 to 2.5 meters, depending on the environmental conditions. It has opposite lanceolate leaves that are 4-14 cm long and its flowers are tubular in shape which can be white, purple or blue. The seeds are cream-white and hulled, with a flattened, pear-shaped appearance, measuring 3-4 mm long. The fruit known as a capsule, is typically 2-8 cm long and 0.5-2 cm wide. When mature the capsule dries and splits open to release the seeds.

From a nutritional standpoint, sesamum seeds are a rich source of edible oil, containing 45-50 % oil. The oil is high in unsaturated fatty acids, particularly oleic and linoleic acids, which are beneficial for heart health. Sesamum seeds also provide a good source of fiber, which helps to reduce cholesterol and triglyceride that helps in reducing risk of heart disease. In addition to these benefits sesamum seeds are rich in protein (20%) and carbohydrates (14.2%) (Angel *et al.*, 2022) [5]. Sesamum oil is naturally resistant to rancidity due to the presence of antioxidants like sesamin, sesamol and sesamol. Furthermore, sesamum seeds are a valuable source of vitamins (E, A, B1, B2) and minerals such as calcium and phosphorus. After oil extraction, the residual sesamum meal contains 35-50 % protein and is particularly rich in the essential amino acids, tryptophan and methionine. The seed coat, which contains about 1.3 % calcium, is also an important source of minerals for human and animal nutrition (Mostashari and Mousavi, 2024) [10]. Plant growth promoters are complex chemicals applied in minute quantities, can significantly influence plant growth and metabolism. Unlike fertilizers and pesticides, which are often used in larger quantities, growth promoters act at much lower concentrations and have a more targeted effect on specific physiological processes. Some of the benefits of growth promoters' application include prolonging photosynthesis, reducing respiration and enhancing the partitioning of photo-assimilates. These regulators also optimize the uptake of minerals and stimulate nitrogen metabolism, all of which contribute to better plant growth, higher yields, and improved seed quality. Plant growth promoters are also known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates, aiding in positional polymorphism studies.

Materials and methods

Seeds of sesamum variety GKVK S-1 were collected from AICRP on oil seed scheme and the field experiment was conducted by using FCRD design during *khari*, 2023 at ZARS, University of Agricultural Sciences, GKVK, Bangalore. Different growth promoters listed below were used as a foliar application at flower initiation stage (45 DAS), capsule formation stage (60 DAS) and only ascorbic acid was sprayed at 75 DAS (as it is antioxidant and delays senescence) then observations on quality parameters were recorded. Treatments were used as mentioned as T₁: Control, T₂: Benzyl adenine @ 25 ppm, T₃: Benzyl adenine @ 50 ppm, T₄: NAA @ 75 ppm, T₅: NAA @ 100 ppm, T₆: Ascorbic acid @ 75 ppm, T₇: Ascorbic acid @ 100 ppm, T₈: IAA @ 75 ppm and T₉: IAA @ 100 ppm. Positional polymorphism is a common phenomenon in plants. In this

study, seeds from three different positions (top, middle and bottom) were harvested to examine the effect of growth promoters on the seed quality at these different positions.

Observations were recorded

1000 seed weight (g)

Seed samples that were harvested separately from three different positions (top, middle and bottom) of plant was taken randomly and was put to seed counter for counting thousand seeds. The weight of thousand seed was recorded and expressed in grams.

Seed germination (%)

Seed samples that were harvested separately from three different positions (top, middle and bottom) of plant for which germination test was conducted in the laboratory by using top of paper method as per ISTA rules (Anon., 2021). Hundred seeds in four replications were placed on top of paper in petri plate. Then kept under room conditions (requires alternating temperature regimes of 20 to 30°C). The germinated seedlings were evaluated on the third and sixth day and seed germination % was expressed based on normal seedlings present in test.

Seed germination % =	$\frac{\text{Number of normal seedlings germinated}}{\text{Total number of seeds used for the test}} \times 100$
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Mean seedling length (cm)

From the germination test, ten normal seedlings were selected randomly from each treatment at three different positions (top, middle and bottom) on the day of final count. The shoot length was measured and expressed in centimetres.

Mean seedling dry weight (mg)

Ten normal seedlings were selected randomly from each treatment at three different positions (top, middle and bottom) on the day of final count and kept in butter paper. Later, dried in a hot-air oven maintained at 70± 2°C for 24 hours. Then, seedlings were removed and allowed to cool in a desiccator for 30 minutes before weighing in an electronic balance. The average weight was calculated and expressed as seedling dry weight in mg per 10 seedlings.

Seedling vigour index-I

The seedling vigour index-I was computed by multiplying seed germination percentage and seedling length (cm) at different positions (top, middle and bottom) and expressed as a whole number (Abdul-Baki and Anderson, 1973) [1].

Seedling vigour index-I = Seed germination (%) x [Root length + Shoot length] (cm)

Seedling vigour index-II

The seedling vigour index-II was computed by multiplying seed germination percentage and seedling dry weight (mg) at different positions (top, middle and bottom) and expressed as a whole number (Abdul-Baki and Anderson, 1973) [1].

Seedling vigour index-II = Seed germination (%) x Seedling dry weight (mg)

Result and Discussion

This study was conducted to evaluate whether the properties of growth promoters such as enhancing the plant's physiological efficiency by prolonging photosynthesis, improving the partitioning of photo-assimilates, increasing ion uptake and stimulating nitrogen metabolism (Angel *et al.*, 2022) [5] could overcome the effects of positional polymorphism. The aim was to achieve uniform seed quality across different capsule positions (top, middle, and bottom). However, this objective was not fulfilled, as the growth promoters applied at these concentrations were not effective to uniformize seed quality across the various capsule positions.

1000 seed weight (g)

The results on the thousand seed weight as influenced by foliar application of growth promoters in relation to positional polymorphism are presented in Table 1. Significant difference was observed for thousand seed

weight by the foliar application of growth promoters across different treatments. The data showed that the application of NAA at 100 ppm (T₅) resulted in higher (4.02 g) thousand seed weight followed by NAA at 75 ppm (T₄) with (3.91 g). In contrast, the control (T₁) recorded the lowest (3.07 g). This indicated that the application of NAA enhanced thousand seed weight. Thousand seed weight across the capsule position revealed significant variation. Seeds from the bottom position capsule (P₃) had the highest (3.74 g) thousand seed weight followed by middle position (P₂) with (3.59 g). Whereas lowest (3.38 g) was found at top position (P₁).

The interaction between the treatment and capsule position was statistically significant, with highest (4.23 g) thousand seed weight was found in NAA at 100 ppm in the bottom position (T₅P₃) followed by NAA at 75 ppm at the bottom position (T₄P₃) with (4.18 g). In contrast the lowest (2.98 g) was observed in control at top position (T₁P₁).

Table 1: Effect of growth promoters on 1000 seed weight (g) in relation to positional polymorphism of sesamum

Treatments (B)	Seed germination (%)			
	Capsule position (A)			
	Top (P ₁)	Middle (P ₂)	Bottom (P ₃)	Mean (B)
T ₁ : Control	78.0	83.0	85.0	83.0
T ₂ : Benzyl adenine @ 25 ppm	80.0	85.0	87.0	85.0
T ₃ : Benzyl adenine @ 50 ppm	81.0	86.0	88.0	86.0
T ₄ : NAA @ 75 ppm	88.0	90.0	92.0	90.0
T ₅ : NAA @ 100 ppm	89.0	91.0	94.0	91.0
T ₆ : Ascorbic acid @ 75 ppm	85.0	87.0	89.0	87.0
T ₇ : Ascorbic acid @ 100 ppm	83.0	86.0	90.0	88.0
T ₈ : IAA @ 75 ppm	86.0	89.0	91.0	88.0
T ₉ : IAA @ 100 ppm	87.0	90.0	92.0	89.0
Mean (A)	84.0	88.0	90.0	87.0
	S. Em. ±		CD (p=0.05)	CV (%)
T (AxB)	14.96		4.69	3.23
A	4.75		1.56	
B	6.51		2.71	

Cv. GKVK S-1

Table 2: Effect of growth promoters on seed germination (%) in relation to positional polymorphism of sesamum cv. GKVK S-1

Treatments (B)	1000 seed weight (g)			
	Capsule Position (A)			
	Top (P ₁)	Middle (P ₂)	Bottom (P ₃)	Mean (B)
T ₁ : Control	2.98	3.02	3.19	3.07
T ₂ : Benzyl adenine @ 25 ppm	3.16	3.29	3.38	3.28
T ₃ : Benzyl adenine @ 50 ppm	3.37	3.49	3.61	3.49
T ₄ : NAA @ 75 ppm	3.58	3.97	4.18	3.91
T ₅ : NAA @ 100 ppm	3.68	4.17	4.23	4.02
T ₆ : Ascorbic acid @ 75 ppm	3.38	3.51	3.65	3.51
T ₇ : Ascorbic acid @ 100 ppm	3.39	3.55	3.72	3.56
T ₈ : IAA @ 75 ppm	3.42	3.61	3.79	3.60
T ₉ : IAA @ 100 ppm	3.44	3.72	3.96	3.70
Mean (A)	3.38	3.59	3.74	3.57
	S. Em±		CD (p=0.05)	CV (%)
T (AxB)	0.57		0.19	3.36
A	0.19		0.06	
B	0.36		0.12	

NAA: Naphthaleneacetic acid **IAA:** Indole acetic acid

The foliar application of NAA effectively increased the thousand seed weight in sesamum, with positional variation in the capsules further amplifying this effect. The increase in thousand seed weight due to treatment could be attributed due to enhanced nutrient translocation and hormonal regulation. With respect to positional variation, plant architecture plays a significant role in assimilate partitioning among the plant parts. Flower position within an inflorescence and the inflorescence's position within the

overall plant architecture are important factors affecting this variation. The number of reproductive structures depending on available resources also influences the allocation of assimilates between flowers or fruits on different branches. Since reproductive structures are first formed at the base and proceed toward the top (racemose), pollination is delayed at the top, leading to lower availability of assimilates in top seeds, causing an increase in seed weight at the bottom, Valdes and Ehrlen (2024) [18]. Similar results were observed in soybean (Illipronti *et al.*, 2000) [9], where seed position on

the plant contributed to variation in seed quality, and in coriander (Amjad *et al.*, 2005) ^[4].

Seed germination (%)

The results on the seed germination percentage as influenced by foliar application of growth promoters in relation to positional polymorphism are presented in Table 2. Seed germination percentage differed significantly due to the foliar application of growth promoters. NAA at 100 ppm (T₅) resulted in highest (91.0 %) seed germination followed by NAA at 75 ppm (T₄) with 90 per cent. Conversely, the control (T₁) was recorded the lowest (83.0 %). This indicated that the application of NAA enhanced seed germination percentage. Seed germination percentage across the capsule position exhibited significant variation. Seeds from the bottom position capsule (P₃) showed the highest (90 %) seed germination percentage followed by middle position (P₂) with 88 per cent. Whereas, the lowest (84 %) was found at top position (P₁).

The interaction between treatment and seed position was also found significant, with highest (94 %) seed germination was found in NAA at 100 ppm in bottom position (T₅P₃) followed by NAA at 75 ppm at bottom position (T₄P₃) with 92.0 per cent. In contrast, the lowest (78.0 %) was found in control at top position (T₁P₁). The increased seed germination percentage of seeds located at the bottom of plant compared to those in the middle and top can be

attributed to several key factors. Bottom seeds are generally more mature and have better access to nutrients and moisture, being closer to the soil. This often results in higher seed quality. Furthermore, the plant's resource allocation favours lower seeds, allowing them to benefit from nutrient reserves. This overall improves seed germination (%) of bottom seeds. These results were consistent in soybean (Prasad *et al.*, 2010) ^[13] and in maize (Adebisi *et al.*, 2013) ^[3].

Mean seedling length (cm)

The results on the mean seedling length as influenced by foliar application of growth promoters in relation to positional polymorphism are presented in Table 3. Significant difference was found for mean seedling length by the foliar application of growth promoters across different treatments. Results showed that the application of NAA at 100 ppm (T₅) resulted in highest (10.28 cm) mean seedling length followed by NAA at 75 ppm (T₄) with 9.89 cm while, the control (T₁) was recorded the lowest (8.05 cm). There was a significant variation in mean seedling length across the capsule position. Seeds from the bottom position capsule (P₃) showed the highest (9.39 cm) mean seedling length followed by middle position (P₂) with 9.24 cm. Whereas lowest (9.09 cm) was found in top position (P₁).

Table 3: Effect of growth promoters on seedling length (cm) in relation to positional polymorphism of sesamum cv. GKVK S-1

Treatments (B)	Seedling length (cm)			
	Capsule Position (A)			
	Top (P ₁)	Middle (P ₂)	Bottom (P ₃)	Mean (B)
T ₁ : Control	7.66	8.13	8.35	8.05
T ₂ : Benzyl adenine @ 25 ppm	8.08	8.35	8.54	8.32
T ₃ : Benzyl adenine @ 50 ppm	8.53	8.99	8.92	8.81
T ₄ : NAA @ 75 ppm	9.84	9.84	10.00	9.89
T ₅ : NAA @ 100 ppm	10.13	10.25	10.48	10.28
T ₆ : Ascorbic acid @ 75 ppm	9.14	9.06	9.22	9.14
T ₇ : Ascorbic acid @ 100 ppm	9.26	9.17	9.36	9.26
T ₈ : IAA @ 75 ppm	9.44	9.50	9.68	9.54
T ₉ : IAA @ 100 ppm	9.73	9.86	9.96	9.85
Mean (A)	9.09	9.24	9.39	9.24
	S. Em±		CD (p=0.05)	CV (%)
T (AxB)	1.92		0.64	4.26
A	0.63		0.21	
B	1.22		0.37	

NAA: Naphthaleneacetic acid IAA: Indole acetic acid

The interaction between treatment and seed position was found significant for mean seedling length. The highest (10.48 cm) mean seedling length was found in NAA at 100 ppm in the bottom position (T₅P₃) followed by NAA at 75 ppm in the bottom position (T₄P₃) with 10.00 cm. In contrast lowest (7.66 cm) was found in control in top position (T₁P₁).

Mean seedling dry weight (mg)

The results on the mean seedling dry weight as influenced by foliar application of growth promoters in relation to positional polymorphism are presented in Table 4. Significant difference was found for mean seedling dry weight by the foliar application of growth promoters across different treatments. Results showed that application of NAA at 100 ppm (T₅) resulted in highest (4.14 mg) mean seedling dry weight followed by NAA at 75 ppm (T₄) with

3.99 mg, while the control (T₁) recorded the lowest (3.14 mg). Significant variation was observed in mean seedling dry weight across the capsule positions. Seeds from the bottom position capsule (P₃) showed the highest (4.05 mg) mean seedling dry weight followed by middle position (P₂) with 3.57 mg. Whereas, the lowest (3.42 mg) was found in top position (P₁). The interaction between treatment and seed position was found significant for mean seedling dry weight with highest (4.62 mg) mean seedling dry weight was found in NAA at 100 ppm in the bottom position (T₅P₃) followed by NAA at 75 ppm in the bottom position (T₄P₃) with 4.42 mg. In contrast, the lowest (2.78 mg) was found in control at top position (T₁P₁). These results were consistent in Okra (Pruthivishree *et al.*, 2025a, Pruthivishree *et al.*, 2025b) ^[14, 15], VS Mor *et al.*, in sorghum and in maize (Adebisi *et al.*, 2013) ^[3].

Table 4: Effect of growth promoters on seedling dry weight (mg) in relation to positional polymorphism of sesamum cv. GKV S-1

Treatments (B)	Seedling dry weight (mg)			
	Capsule Position (A)			
	Top (P ₁)	Middle (P ₂)	Bottom (P ₃)	Mean (B)
T ₁ : Control	2.78	3.10	3.56	3.14
T ₂ : Benzyl adenine @ 25 ppm	2.96	2.98	3.84	3.26
T ₃ : Benzyl adenine @ 50 ppm	3.24	3.56	3.87	3.56
T ₄ : NAA @ 75 ppm	3.87	3.71	4.42	3.99
T ₅ : NAA @ 100 ppm	3.93	3.87	4.62	4.14
T ₆ : Ascorbic acid @ 75 ppm	3.25	3.51	3.83	3.53
T ₇ : Ascorbic acid @ 100 ppm	3.39	3.63	4.07	3.69
T ₈ : IAA @ 75 ppm	3.54	3.78	4.16	3.83
T ₉ : IAA @ 100 ppm	3.86	3.97	4.05	3.96
Mean (A)	3.42	3.57	4.05	3.68
	S. Em. ±		CD (p=0.05)	CV (%)
T (AxB)	0.89		0.29	4.76
A	0.28		0.09	
B	0.51		0.17	

NAA: Naphthalene acetic acid IAA: Indole acetic acid

Seedling vigour index-I

The results on the mean seedling vigour index-I as influenced by foliar application of growth promoters in relation to positional polymorphism are presented in Table 5.

Table 5: Effect of growth promoters on seedling vigour index-I in relation to positional polymorphism of sesamum GKV S-1

Treatments (B)	Seedling vigour index-I			
	Capsule Position (A)			
	Top (P ₁)	Middle (P ₂)	Bottom (P ₃)	Mean (B)
T ₁ : Control	620	674	710	668
T ₂ : Benzyl adenine @ 25 ppm	669	677	743	696
T ₃ : Benzyl adenine @ 50 ppm	714	772	785	757
T ₄ : NAA @ 75 ppm	865	886	915	888
T ₅ : NAA @ 100 ppm	901	932	984	939
T ₆ : Ascorbic acid @ 75 ppm	776	788	827	797
T ₇ : Ascorbic acid @ 100 ppm	796	815	842	818
T ₈ : IAA @ 75 ppm	812	846	882	847
T ₉ : IAA @ 100 ppm	846	887	918	884
Mean (A)	778	808	845	810
	S. Em. ±	CD (p=0.05)		CV (%)
T (AxB)	179.69	59.53		4.48
A	59.65	19.84		
B	103.15	34.37		

NAA: Naphthalene acetic acid IAA: Indole acetic acid

Significant difference was observed for seedling vigour index-I by the foliar application of growth promoters. The data showed that the application of NAA at 100 ppm (T₅) resulted in maximum (939) seedling vigour index-I followed by NAA at 75 ppm (T₄) with 888. In contrast, the control (T₁) recorded the minimum (668). Seedling vigour index-I across the capsule position revealed significant variation. Seeds from the bottom position capsule (P₃) had the highest (845) seedling vigour index-I followed by middle position (P₂) with 808. Whereas lowest (846) was found in top position (P₁). The interaction between treatment and seed position was statistically significant, with highest (984) seedling vigour index-I was found in NAA at 100 ppm in the bottom position (T₅P₃) followed by NAA at 75 ppm in the bottom position (T₄P₃) with 915. In contrast lowest (620) was observed in control in top position (T₁P₁).

Seedling vigour index- II

The results on the mean seedling vigour index-II as influenced by foliar application of growth promoters in relation to positional polymorphism are presented in Table 6. Significant difference was observed for seedling vigour index- II by the foliar application of growth promoters across different treatments. It was observed that the application of NAA at 100 ppm (T₅) resulted in higher (378) seedling vigour index- II followed by NAA at 75 ppm (T₄) with 306. Whereas, control (T₁) recorded the lowest (258). This indicated that the application of NAA enhanced seedling vigour index- II. Seedling vigour index- II across the capsule position exhibited significant variation. Seeds from the bottom position capsule (P₃) showed the highest (364) seedling vigour index- II followed by middle position (P₂) with 313. Whereas lowest (293) was found in top position (P₁).

Table 6: Effect of growth promoters on seedling vigour index-II in relation to positional polymorphism of sesamum cv. GKVK S-1

Treatments (B)	Seedling vigour index-II			
	Capsule Position (A)			
	Top (P ₁)	Middle (P ₂)	Bottom (P ₃)	Mean (B)
T ₁ : Control	224	252	299	258
T ₂ : Benzyl adenine @ 25 ppm	245	257	334	279
T ₃ : Benzyl adenine @ 50 ppm	272	306	340	306
T ₄ : NAA @ 75 ppm	340	333	405	359
T ₅ : NAA @ 100 ppm	349	352	434	378
T ₆ : Ascorbic acid @ 75 ppm	276	309	343	309
T ₇ : Ascorbic acid @ 100 ppm	291	323	367	327
T ₈ : IAA @ 75 ppm	304	336	372	337
T ₉ : IAA @ 100 ppm	336	350	379	355
Mean (A)	293	313	364	323
	S. Em. ±	CD (P=0.05)		CV (%)
T (AxB)	75.96	25.29		4.77
A	26.26	8.43		
B	41.25	14.26		

NAA: Naphthalene acetic acid **IAA:** Indole acetic acid

The interaction between treatment and seed position was also found significant, with highest (434) seedling vigour index-II recorded in NAA at 100 ppm in the bottom position (T₅P₃) followed by NAA at 75 ppm in the bottom position (T₄P₃) with 405. In contrast lowest (224) was found in control in top position (T₁P₁). The results demonstrate that the application of growth promoters, particularly NAA at 100 ppm, significantly improved seedling vigour index-I and II compared to untreated seeds (control). The improvement in seedling vigour index with NAA application could be attributed to its role in nutrient mobilization and overall plant vigour during early seedling development. Additionally, the positive response of seeds from the bottom capsule position can be linked to the physiological maturity of seeds in this position, where nutrient accumulation and development are more advanced (Abubakar *et al.*, 2023) [2]. Similar results followed in lupin (Natalia (2020), Bhuker A, *et al.*, 2023 [11, 8] in green gram and in okra (Oladiran and Ibrahim, 2011) [12].

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