Journal of Medicinal and Industrial Plant Sciences (2025) 3 (3): 25- 36
ISSN: 2959 – 121X
DOI: https://doi.org/10.32894/MEDIP.25.3.3.3

Effect of gibberellin acid and pinching timing on photosynthetic pigments in fenugreek (*Trigonella foenum-graecum* L.) under two agro climatic conditions

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ABSTRACT
This study aimed to assess how various pinching schedules and gibberellin (GA) treatments affect carotenoid and chlorophyll levels in fenugreek at two different sites, Ankawa (AK) and Grdarash (GR), along with evaluating pigment absorption properties. The experiment was conducted in both locations using four pinching treatments: no pinching (P0), pinching once at 30 days after sowing (DAS) (P1), at 45 DAS (P2), and twice at 30 and 45 DAS (P3). Gibberellin was applied at 25, 45, and 65 DAS in concentrations of 100, 200, and 300 ppm (G1, G2, and G3), in addition to a control with no application (G0). Key findings revealed that gibberellin levels and pinching at 45 DAS (P2) significantly affected absorbance at 665 nm in AK ($P < 0.05$), while absorbance at 649 nm was notably influenced by gibberellin concentrations in GR. Additionally, gibberellin treatments in AK significantly enhanced absorbance at 470 nm. Interaction analysis highlighted that double pinching (P3) combined with all gibberellin levels had a highly significant effect on chlorophyll concentration at GR ($P < 0.01$). Furthermore, pinching treatments notably impacted carotenoid content at GR, and gibberellin levels also influenced chlorophyll amounts in AK. Overall, the results indicate that careful timing of gibberellin applications and pinching can effectively enhance carotenoid and chlorophyll content and improve pigment absorption in fenugreek. This approach has the potential to boost photosynthetic efficiency and enhance the yield of medicinal plants across varied environmental conditions.
KEYWORDS: Chlorophyll, Carotenoids, pinching, Gibberellin.

Received: 27/06/2025; **Accepted**: 15/07/2025; **Available online:** 30/09/2025

تأثير حمض الجبريلين وتوقيت التقليم على الأصباغ التمثيلية الضوئية في الحلبة (*Trigonella foenum-graecum L*) تحت ظروف مناخية زراعية مختلفة

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الملخص
هدفت هذه الدراسة إلى تقييم كيفية تأثير جداول التقليم المختلفة ومعاملات الجبريلين **(GA)** على مستويات الكاروتينات والكلوروفيل في نبات الحلبة في موقعين مختلفين، وهما عنكاوا **(AK)** وگردارش**(GR)** ، بالإضافة إلى دراسة خصائص امتصاص الأصباغ. أُجريَت التجربة في كلا الموقعين باستخدام أربع معاملات تقليم: بدون تقليم**(P0)** ، تقليم مرة واحدة بعد 30 يومًا من الزراعة**(P1)** **(DAS)** ، تقليم بعد 45 يومًا من الزراعة**(P2)** ، وتقليم مرتين عند 30 و45 يومًا من الزراعة **(P3).** تم تطبيق الجبريلين في أيام 25 و45 و65 بعد الزراعة بتركيزات 100 و200 و300 جزء في المليون**(G1)** ، **G2**، و**(G3**، بالإضافة إلى معاملة ضابطة بدون تطبيق **(G0).** أظهرت النتائج الرئيسية أن مستويات الجبريلين والتقليم عند 45 يومًا بعد الزراعة **(P2)** أثرت بشكل كبير على الامتصاصية عند 665 نانومتر في موقع عنكاوا**($P < 0.05$)** ، في حين تأثرت الامتصاصية عند 649 نانومتر بشكل ملحوظ بتركيزات الجبريلين في موقع گردارش. بالإضافة إلى ذلك، عززت معاملات الجبريلين في عنكاوا الامتصاصية عند 470 نانومتر بشكل كبير. أظهر تحليل التداخلات أن التقليم المزدوج **(P3)** بجميع مستويات الجبريلين أدى إلى تأثير معنوي عالي في تركيز الكلوروفيل في گردارش **($P < 0.01$).** كما أثرت معاملات التقليم بشكل ملحوظ على محتوى الكاروتينات في**GR** ، وأثرت مستويات الجبريلين أيضًا على كمية الكلوروفيل في **AK.** تشير النتائج عمومًا إلى أن التوقيت الدقيق لتطبيقات الجبريلين والتقليم يمكن أن يعزز بشكل فعال من محتوى الكاروتينات والكلوروفيل ويحسن من امتصاص الأصباغ في نبات الحلبة. وتمتلك هذه الطريقة إمكانات واعدة في تعزيز كفاءة التمثيل الضوئي وزيادة إنتاجية النباتات الطبية في ظل ظروف بيئية متنوعة.
الكلمات المفتاحية: الكلوروفيل، الكاروتينات، التقليم، جيبريلين.

INTRODUCTION

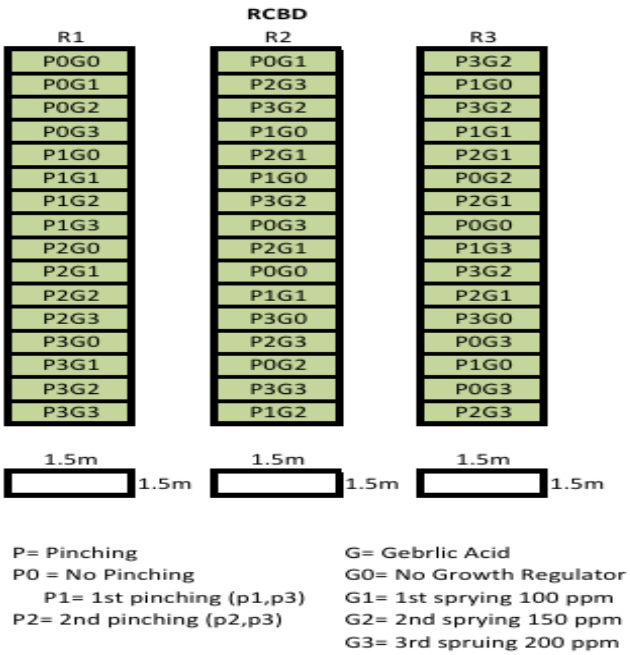
Trigonella foenum-graecum L. or so-called fenugreek is a useful medicinal and culinary herb that has gained popularity with regard to its health and nutritional properties. Hypoglycemic and anti-inflammatory effects as well as antioxidant properties have been long used via the fenugreek, which is a rich source of the bioactive compound's flavonoids, saponins, and essential oils (Kumar et al., 2023). Some agronomic measures like growth regulator applications and pinch may play a significant role in plant growth, secondary metabolite production, and overall production of fenugreek. Photo-morphology Horticultural practices such as pinching can alter the structure of plants, promote branching, and potentially stimulate biosynthesis of secondary metabolites by altering the source-sink relationship of plants (Khorshidian et al., 2023). On the same note, gibberellins (GA) create its share of the effect to a range of physiological activities, which include pigmentation synthesis, leaf growth, and internode growth (Shahzad et al., 2024). The application of chlorophyll as a non-destructive method to the in vivo study of the physiological behavior of fenugreek in response to salinity was done by Bagheri et al. using the instrument, a non-destructive chlorophyll content meter, the CCM-200 Plus. The analysis has also indicated that there is a sharp fall in chlorophyll concentration with rise in salinity highlighting the adverse effect of salt stress on photosynthetic performance. The authors came to the conclusion that chlorophyll sensing in real-time may be an early indicator in diagnostic use in salinity influenced agricultural systems and an important input indicator in stress response management (Bagheri, Akbari & Ebrahimzadeh, 2021).Other studies carried out a detailed spectrophotometric study in attempt to determine the baseline values of chlorophyll with respect to fenugreek; following the step and technique applied by Arnon. Different positions of leaves were extracted into acetone and determined as the amounts of chlorophyll a and b in terms of absorbancies at 645 and 663 nm. The experiment observed that the mature upper leaves had a greater content of pigments as opposed to younger or aging leaves, showing that there was occurrence of developmental differences in photosynthetic capacity. This study supported the usefulness of solvent-based spectrophotometry in the study of physiology of fenugreek (Kumar, Meena & Yadav, 2018). Patil et al. conducted their literature review in which they compared the levels of chlorophyll present in the leaves and stems of the fenugreek plants. Spectrophotometry was applied in the analysis of pigments that demonstrated a remarkable amount of chlorophyll in the leaves. This strengthens nutritional and medicinal significance of fenugreek foliage, especially serving functional food use. The paper also reminds about the anatomical specificity of pigment distribution in the herbaceous plants (Patil et al., 2022). Khan and Sharma were concerned with time dynamic of change in chlorophyll with various stages of development of fenugreek. By applying the usual acetone extraction and spectrophotometric measurement, they found that there was gradual increase in the levels of chlorophyll throughout the vegetative stage until flowering. These results indicate that the harvest scheduling could be

synthesized using a chlorophyll profiling that is tightly related to the bio mass quality and nutritional value (Khan & Sharma, 2019).

However, not much is said about the combination of pinching and GA treatment to influence the colour profiles and the overall phytochemical concentrations of fenugreek. The three pinching schedules investigated in this study were no pinching (P0), one pinching at 30 DAS (P1), one pinching at 45 DAS (P2) and two pinching at 30 and 45 DAS (P3). Such schedules were crossed with gibberellin treatments (G0: no GA, G1: 100 ppm GA, G2: 200 ppm GA and G3: 300 ppm GA). The GA sprays were applied thrice at 25, 45, and 65 DAS in two different agroclimatic locations and namely Ankawa (AK) and Grdarasha (GR). This experiment aims at demystifying how such agronomic procedures influence the chlorophyll and carotenoids levels together with pigment absorption of fenugreek plant to various wavelengths (Dar et al., 2014). Learn more about these relationships and it may maximize the production of fenugreek as both food and medicine.

MATERIALS AND METHOD

- The experiment, which was conducted at two locations (AK and GR), employed four pinching treatments: no pinching (P0), pinching once at 30 days after sowing (DAS) (P1), at 45 DAS (P2), and twice at 30 and 45 DAS (P3).
- Gibberellin is applied at 25, 45, and 65 DAS at concentrations of 100, 150, and 200 ppm (G1, G2, and G3), as well as no application (G0).
- RCBD details : see the Diagram below :



RESULT AND DISCUSSION

- Gibberellin levels and pinching at 45 DAS (P2) had a substantial impact on absorbance at 665 nm at AK ($P < 0.05$).
- Absorbance at 649 nm was significantly impacted by gibberellin concentrations at GR. In AK, gibberellin treatments significantly raised absorbance at 470 nm.
- Analysis of interactions showed:

Double pinching (P3) and all gibberellin levels interacted in a substantially significant way for chlorophyll concentration at GR ($P < 0.01$).

- At GR, pinching treatments had a major impact on carotenoid content. Gibberellin levels at AK also had an impact on the amount of chlorophyll.

The majority of results were non-significant except any other specified in the table with letters of significance. Table (1) and Figure (1) exhibit the effect of pinching (A1-A4) and gibberellin (B1-B4) through 665 nm absorbance that relates to the quantity of chlorophyll an in fenugreek leaves. Treatment A4B4 in Ankawa was the one with highest absorbance (0.79) indicating that Chlorophyll a synthesis can be enhanced by late pinching with high dose of gibberellin. The chlorophyll a of Grdarasha peaked (0.915) in A1B2 which means that, chlorophyll a could also be also enhanced by early pinching with moderate amounts of gibberellin depending on the place. The late pinching and the increased level of gibberellin increases the values of chlorophyll a is also corroborated by the pooled results which indicated that A4 (0.627) had the highest average value of absorbance in pinching levels and B4 (0.6215) in gibberellin levels. All these patterns are graphically verified in Figure (1) to indicate that gibberell tin and pinching at the correct time can have tremendous effect of normal absorption in chlorophyll an at 665 nm.

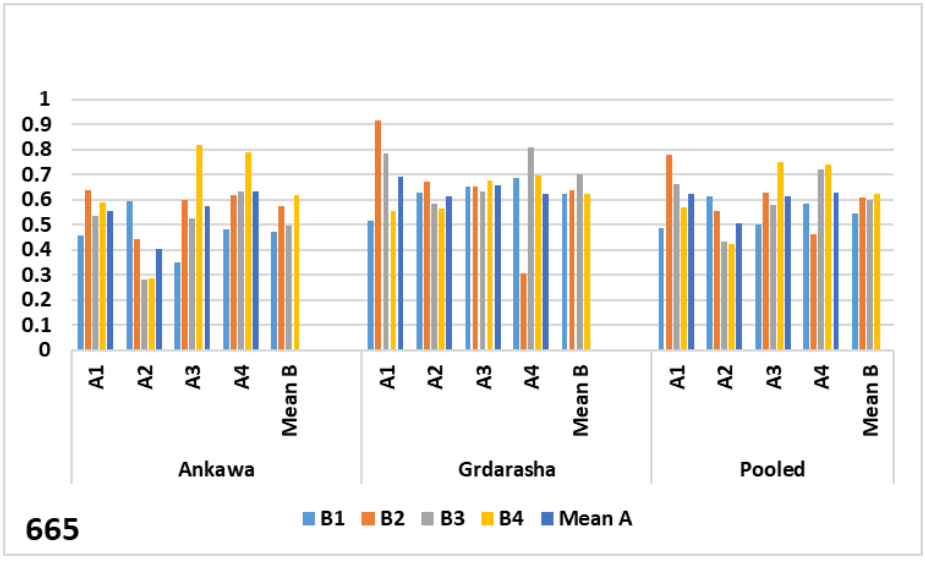


Figure (1) Effect of 4 levels of each of pinching (A) and Gibberellin (B) on 665µ absorbance in fenugreek grown at two locations.

Table 1. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on 665µ absorbance in fenugreek grown at two locations.

		B1	B2	B3	B4	Mean A
	A1	0.456a	0.64a	0.536a	0.587ab	0.555a
	A2	0.596a	0.442a	0.282a	0.285b	0.401b
Ankawa	**A3**	0.35a	0.598a	0.525a	0.817a	0.573a
	A4	0.481a	0.62a	0.632a	0.79a	0.631a
	Mean B	0.471a	0.575a	0.494a	0.62a	
		B1	B2	B3	B4	Mean A
	A1	0.517a	0.915a	0.784a	0.554a	0.693a
	A2	0.628a	0.672ab	0.582a	0.565a	0.612a
Grdarasha	**A3**	0.654a	0.654ab	0.632a	0.679a	0.655a
	A4	0.685a	0.306b	0.807a	0.695a	0.623a
	Mean B	0.621a	0.637a	0.701a	0.623a	

Footnote: Means labeled with different alphabetic letters differ significantly at $p \leq 0.01$.

Table (2) and Figure (2) present the results of the impact of pinching (A1-A4) and gibberellin (B1-B4) on the absorbance of the fenugreek at 649 nm reflecting the presence of chlorophyll b. The treatment with the highest value (0.527) was A3B1 in Ankawa and this means that low gibberellin concentration and gentle pinching can enhance chlorophyll b. Treatment A4B4 entailed Grdarasha exhibiting maximum absorbance of 0.468 implying that pinching lately with higher gibberellin predisposes into pigmentation in diverse environmental conditions. Effectiveness of delayed pinching and high gibberellin application was demonstrated by the pooled data which indicated that, in all respects, the A4 had the highest average (0.309) and B4 had a significant effect (0.3085) also. These patterns are evident with the help of the Figure (2) which indicates that specific combinations of pinching and gibberellins significantly enhance the absorbance of chlorophyll b at 649 nm.

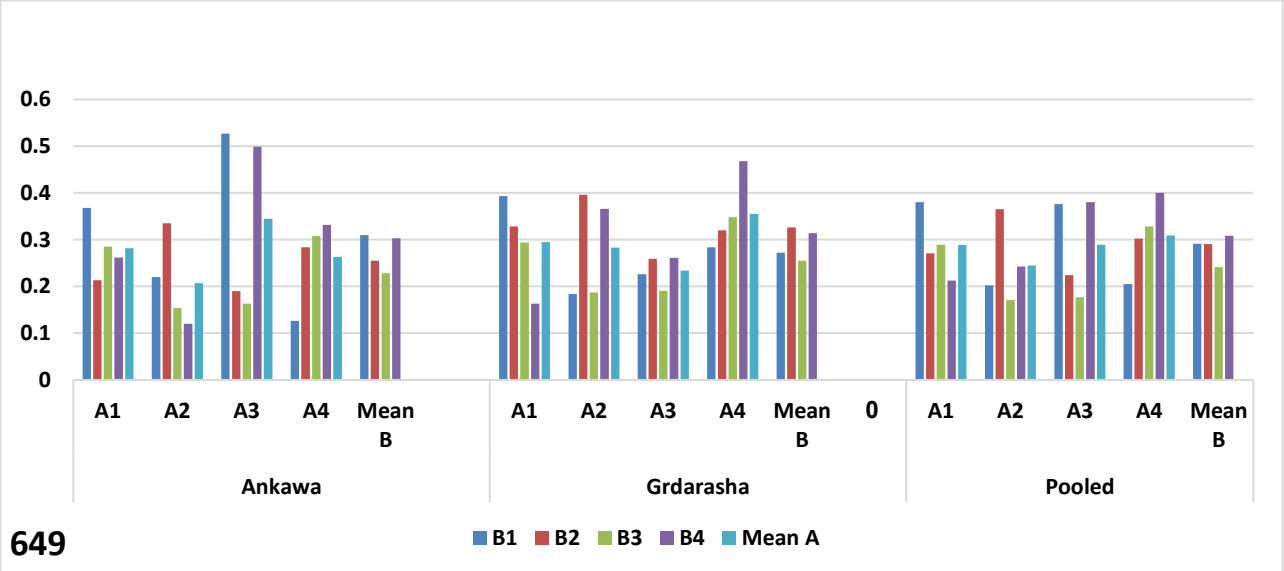


Figure 2. Effect of 4 levels of each of pinching (A) and Gibberellin (B) 649µ absorbance in fenugreek grown at two locations .

Table 2. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on 649µ absorbance in fenugreek grown at two locations.

		B1	B2	B3	B4	Mean A
	A1	0.368a	0.213a	0.285a	0.262a	0.282a
	A2	0.22a	0.335a	0.154a	0.12a	0.207a
Ankawa	**A3**	0.527a	0.19a	0.163a	0.499a	0.345a
	A4	0.126a	0.284a	0.308a	0.332a	0.263a
	Mean B	0.31a	0.255a	0.228a	0.303a	
		B1	B2	B3	B4	Mean A
	A1	0.393a	0.328a	0.294a	0.163a	0.295a
	A2	0.184a	0.396a	0.187a	0.366a	0.283a
Grdarasha	**A3**	0.226a	0.259a	0.191a	0.261a	0.234a
	A4	0.284a	0.32a	0.348a	0.468a	0.355a
	Mean B	0.272a	0.326a	0.255a	0.314a	
	0	B1	B2	B3	B4	Mean A
	A1	0.3805a	0.2705a	0.2895a	0.2125a	0.2885a
	A2	0.202a	0.3655a	0.1705a	0.243a	0.245a
Pooled	**A3**	0.3765a	0.2245a	0.177a	0.38a	0.2895a
	A4	0.205a	0.302a	0.328a	0.4a	0.309a
	Mean B	0.291a	0.2905a	0.2415a	0.3085a	

Footnote: Means labeled with different alphabetic letters differ significantly at $p \leq 0.01$.

Table (3) and Figure (3) depict the effects of the pinching (A1-A4) and gibberellin treatments (B1-B4) on absorbance by fenugreek at 470 nm as a parameter of carotenoid concentration. The highest level of absorbance in Ankawa was recorded under treatment A4B4 (1.165), proving how effective more gibberellin concentration and late pinching was on the build-up of pigments. Also, Grdarasha recorded a significant responsiveness under A4B4 (1.355), revealing that the mixture of the treatment enhances carotenoid-related absorbance in diverse environments. The pooled data concept supports this trend whereby A4 has a maximum combined mean (1.017) and B3 and B4 keep on increasing an absorbance level. Figure (3) illustrates a further treatment of the data because advance pinching and increased gibberellin application resulted in major increase of 470 nm absorbance in the fenugreek leaves.

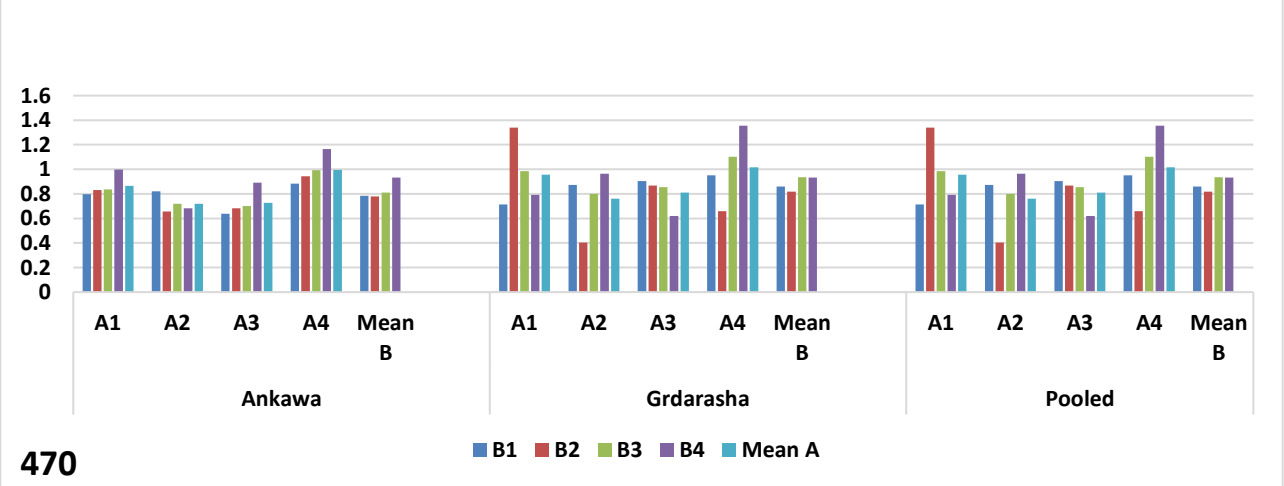


Figure (3) Effect of 4 levels of each of pinching (A) and Gibberellin (B) on 470µ absorbance in fenugreek grown at two locations .

Table 3. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on 470µ absorbance in fenugreek grown at two locations .

		B1	B2	B3	B4	Mean A
	A1	0.797a	0.832a	0.835a	0.998a	0.866ab
	A2	0.821a	0.657a	0.718a	0.683a	0.720b
Ankawa	**A3**	0.638a	0.682a	0.701a	0.891a	0.728b
	A4	0.884a	0.944a	0.992a	1.165a	0.996a
	Mean B	0.785a	0.779a	0.811a	0.934a	
		B1	B2	B3	B4	Mean A
	A1	0.713a	1.339a	0.986a	0.792b	0.957a
	A2	0.872a	0.404b	0.799a	0.965ab	0.76a
Grdarasha	**A3**	0.903a	0.868ab	0.854a	0.619b	0.811a
	A4	0.951a	0.659b	1.103a	1.355a	1.017a
	Mean B	0.86a	0.817a	0.935a	0.933a	
	0	B1	B2	B3	B4	Mean A
	A1	0.847a	0.531a	0.759a	0.824a	0.912ab
	A2	0.771a	0.775a	0.778a	0.755a	0.740b
Pooled	**A3**	0.918a	0.802a	1.048a	1.260a	0.770b
	A4	0.823a	0.798a	0.873a	0.934a	1.007a
	Mean B	0.847a	0.531a	0.759a	0.824a	

Footnote: Means labeled with different alphabetic letters differ significantly at $p \leq 0.01$.

Effects of the pinching (A1- A4) and gibberellin concentrations (B1 to B4) on the quantity of chlorophyll an in fenugreek cultivated at two pleasant areas namely Ankawa and Grdarasha are demonstrated in Table (4) and Figure (4). The maximum chlorophyll a content was in treatment A4B4 (8.831) in Ankawa which implies that high gibberellin and late pinching is better in the synthesis of chlorophyll. A1B2 (10.516) and A4B3 (8.975) stood out in particular as successes, and generally Grdarasha consistently showed larger values, showing that the environment had a significant impact in this location. Pooled data was able to depict the positive interaction between these treatments and indicated that A4 and A3 sustained higher concentration of chlorophyll a, more so in the presence of B3 and B4. Such findings are also captured graphically on Figure (4) where chlorophyll a increment can be observed with the best pinching gibberellin mix especially after later pinching treatments.

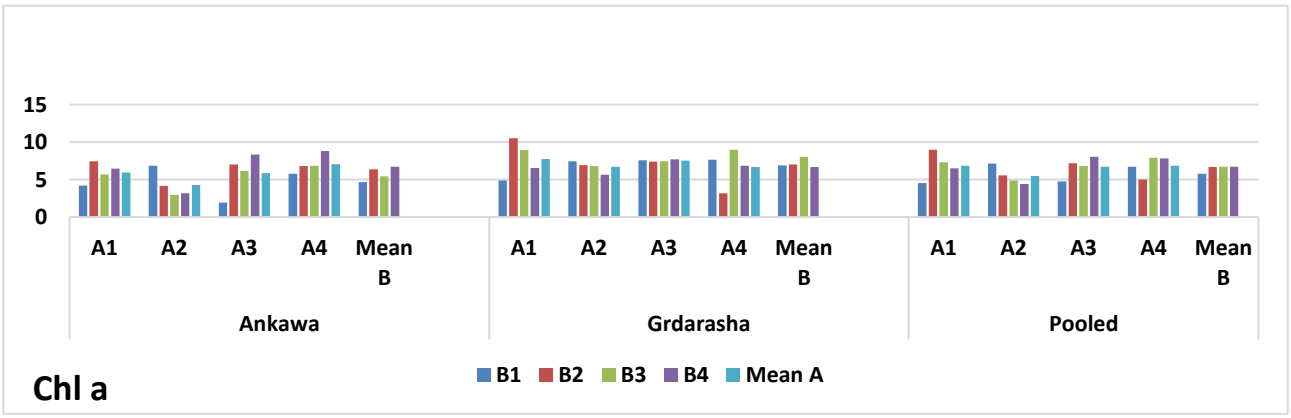


Figure 4. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of Chlorophyl a at two locations

Table 4. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of Chlorophyl a at two locations.

		B1	B2	B3	B4	Mean A
	A1	4.18a	7.442	5.684	6.481ab	5.947
	A2	6.827a	4.171	2.968	3.185b	4.288
Ankawa	**A3**	1.939a	7.005a	6.171a	8.331ab	5.862a
	A4	5.766a	6.808a	6.841a	8.831a	7.061a
	Mean B	4.678a	6.356a	5.416a	6.707a	
		B1	B2	B3	B4	Mean A
	A1	4.872a	10.516a	8.953a	6.555a	7.724a
	A2	7.437a	6.927ab	6.803a	5.655a	6.706a
Grdarasha	**A3**	7.569a	7.392ab	7.452a	7.714a	7.532a
	A4	7.678a	3.169b	8.975a	6.856a	6.67a
	Mean B	6.889a	7.001a	8.046a	6.695a	
	0	B1	B2	B3	B4	Mean A
	A1	4.526a	8.979a	7.3185a	6.518a	6.8355a
	A2	7.132a	5.549a	4.8855a	4.42a	5.497a
Pooled	**A3**	4.754a	7.1985a	6.8115a	8.0225a	6.697a
	A4	6.722a	4.9885a	7.908a	7.8435a	6.8655a
	Mean B	5.7835a	6.6785a	6.731a	6.701a	

Footnote: Means labeled with different alphabetic letters differ significantly at $p \leq 0.01$.

Table (5) and Figure (5) analyze the impact of change in gibberellin treatments (B1-B4) and pinching levels (A1-A4) on quantity of chlorophyll b in Ankawa and Grdarasha fenugreek. Conversely, Grdarasha expressed maximum chlorophyll b in A4 under B4 (7.194) indicating the positive impact of late pinching and high gibberellin treatment in such an atmosphere. • Ankawa: The maximum value of chlorophyll b (11.706) was obtained in case of treatment A3 under B1, which is the treatment that returned a good response towards early pinching and low levels of gibberellin. Based on the combined data, there was a high tendency of A4 generating the highest levels of mean chlorophyll b implying that it was constant in the two locations. Graphically, these findings can be illustrated in the basic representation of the figure 5 showing the fact that the period of pinching and gibberellin content significantly determined the rate of chlorophyll b production in fenugreek.

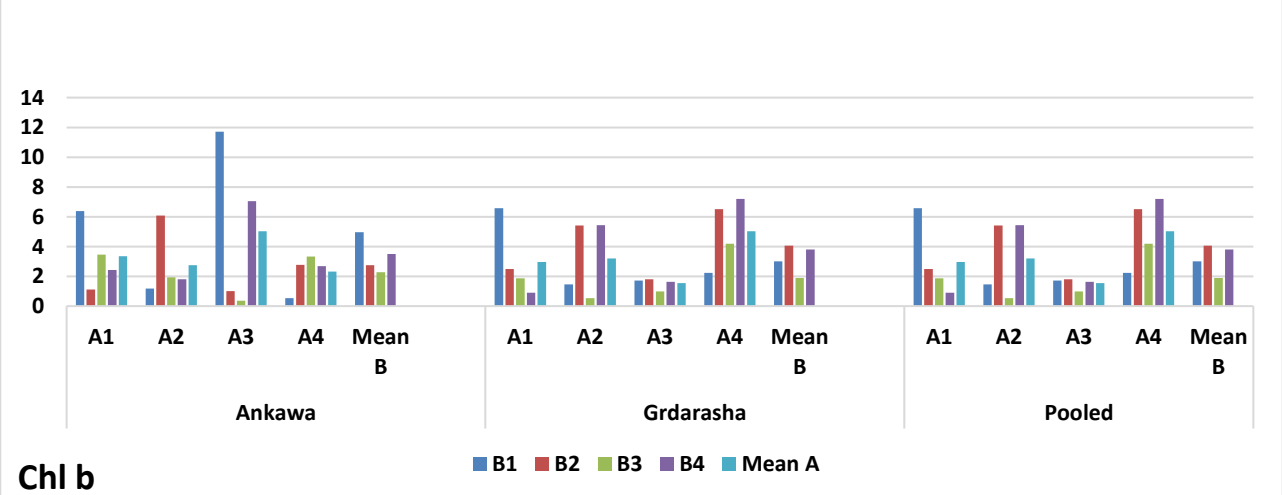


Figure 5. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of Chlorophyl b at two locations

Table 5. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of Chlorophyl b at two locations.

		B1	B2	B3	B4	Mean A
	A1	6.385a	1.118a	3.456a	2.429a	3.347a
	A2	1.183a	6.083a	1.934a	1.802a	2.75a
Ankawa	**A3**	11.706a	1.005ab	0.357b	7.042ab	5.028a
	A4	0.537a	2.765a	3.319a	2.692a	2.328a
	Mean B	4.953a	2.743a	2.267a	3.491a	
		B1	B2	B3	B4	Mean A
	A1	6.579a	2.496a	1.87a	0.896a	2.96a
	A2	1.462a	5.403a	0.523a	5.44a	3.207a
Grdarasha	**A3**	1.718a	1.803a	0.988a	1.639a	1.537a
	A4	2.228a	6.506a	4.192a	7.194a	5.03a
	Mean B	2.997a	4.052a	1.893a	3.792a	
	0	B1	B2	B3	B4	Mean A
	A1	6.579a	2.496a	1.87a	0.896a	2.96a
	A2	1.462a	5.403a	0.523a	5.44a	3.207a
Pooled	**A3**	1.718a	1.803a	0.988a	1.639a	1.537a
	A4	2.228a	6.506a	4.192a	7.194a	5.03a
	Mean B	2.997a	4.052a	1.893a	3.792a	

Footnote: Means labeled with different alphabetic letters differ significantly at $p \leq 0.01$.

Table (6) and Figure (6) display the effects of carotenoid content of fenugreek at two sites-Ankawa and Grdarasha under the treatment of the different levels of pinch and gibberellin treatments which are (A1-A4) and (B1-B4). As the results showed, throughout the course of treatments, A2 recorded the lowest values, yet A4 and B4 in Ankawa ticked upwards slightly on carotenoid figures. A2 remained the least effective, but Grdarasha varied more actually, as the highest carotenoid content was shown by A1 under B2. The pooled data showed that the presence of carotenoid was comparatively increased in A4 with B3 or B4 which shows that there is a moderate advantage of increased gibberellin doses and delayed pinching. These findings are corroborated graphically by Figure (6), where the critical influence of the combination of the location and treatment in enhancing carotenoid in fenugreek is outlined.

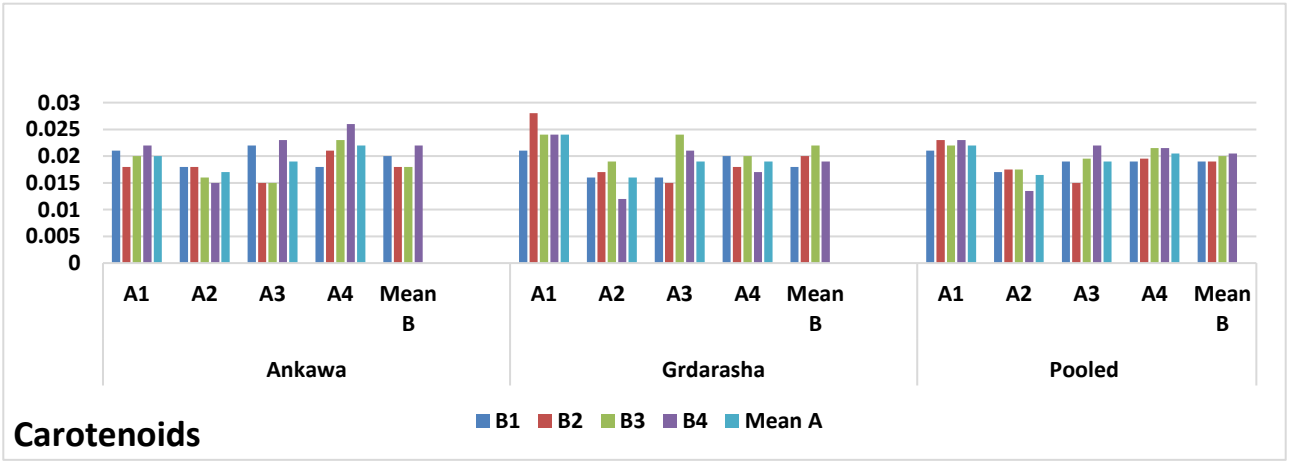


Figure 6. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of carotenoids in fenugreek grown at two locations

Table 6. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of carotenoids in fenugreek grown at two locations

		B1	B2	B3	B4	Mean A
	A1	0.021a	0.018a	0.02a	0.022a	0.02a
	A2	0.018a	0.018a	0.016a	0.015a	0.017a
Ankawa	**A3**	0.022a	0.015a	0.015a	0.023a	0.019a
	A4	0.018a	0.021a	0.023a	0.026a	0.022a
	Mean B	0.02a	0.018a	0.018a	0.022a	
		B1	B2	B3	B4	Mean A
	A1	0.021a	0.028a	0.024a	0.024ab	0.024a
	A2	0.016a	0.017b	0.019a	0.012b	0.016a
Grdarasha	**A3**	0.016a	0.015ab	0.024a	0.021ab	0.019a
	A4	0.02a	0.018ab	0.02a	0.017b	0.019a
	Mean B	0.018a	0.02a	0.022a	0.019a	
	0	B1	B2	B3	B4	Mean A
	A1	0.021a	0.023a	0.022a	0.023a	0.022a
	A2	0.017a	0.0175a	0.0175a	0.0135a	0.0165a
Pooled	**A3**	0.019a	0.015a	0.0195a	0.022a	0.019a
	A4	0.019a	0.0195a	0.0215a	0.0215a	0.0205a
	Mean B	0.019a	0.019a	0.02a	0.0205a	

Footnote: Means labeled with different alphabetic letters differ significantly at $p \leq 0.01$.

Table (7) and Figure (7) describe the effect of different pinching procedures (A1 A4) and gibberellin concentrations (B1 B4) on the net chlorophyll content of the leaves of the fenugreek plant in two distinct locations namely, Ankawa and Grdarasha. In either location, treatment A4 generally was the best in terms of optimal chlorophyll content especially when combined with B4 which shows synergetic effect of higher doses of the gibberellin and late pinching of the plants. Throughout treatments, chlorophyll level in Grdarasha was higher as compared to that of Ankawa implying that soil or environmental factors might have contributed. Based on the result of the combination, it is found that A4 and B4 were increasing the level of chlorophyll steadily indicating the measures as successful treatment of the physiology of the fenugreek leaves. Figure (7) supports the findings In the table visually, and it indicates how important pinching and gibberellin are in influencing the total chlorophyll accumulated in fenugreek.

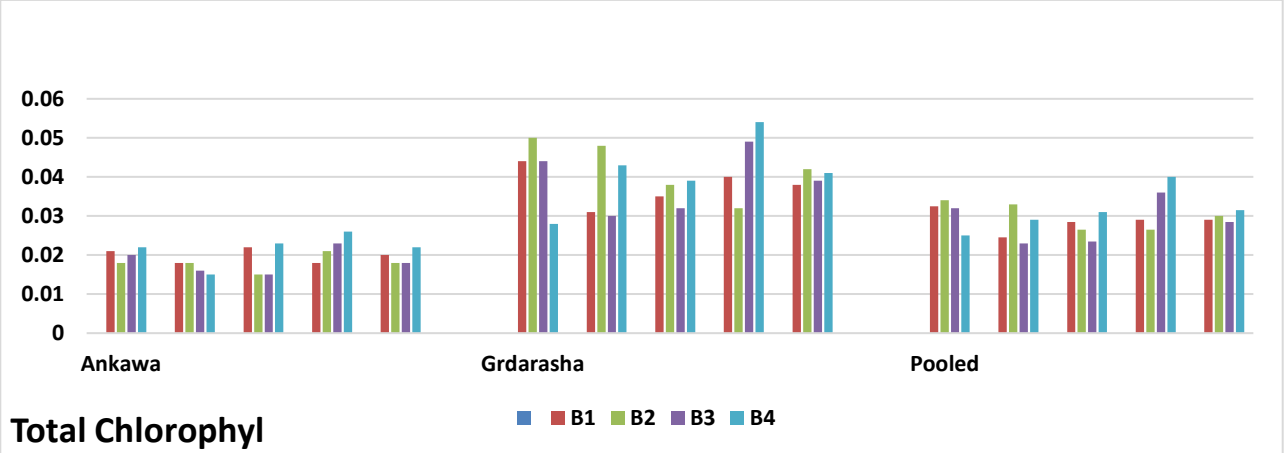


Figure 7. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of total chlorophylls in fenugreek grown at two locations

Table 7. Effect of 4 levels of each of pinching (A) and Gibberellin (B) on presence of total chlorophylls in fenugreek grown at two locations

		B1	B2	B3	B4	Mean A
	A1	0.021a	0.018a	0.02a	0.022a	0.02a
	A2	0.018a	0.018a	0.016a	0.015a	0.017a
Ankawa	**A3**	0.022a	0.015a	0.015a	0.023a	0.019a
	A4	0.018a	0.021a	0.023a	0.026a	0.022a
	Mean B	0.02a	0.018a	0.018a	0.022a	
		B1	B2	B3	B4	Mean A
	A1	0.021a	0.028a	0.024a	0.024ab	0.024a
	A2	0.016a	0.017b	0.019a	0.012b	0.016a
Grdarasha	**A3**	0.016a	0.015ab	0.024a	0.021ab	0.019a
	A4	0.02a	0.018ab	0.02a	0.017b	0.019a
	Mean B	0.018a	0.02a	0.022a	0.019a	
	0	B1	B2	B3	B4	Mean A
	A1	0.021a	0.023a	0.022a	0.023a	0.022a
	A2	0.017a	0.0175a	0.0175a	0.0135a	0.0165a
Pooled	**A3**	0.019a	0.015a	0.0195a	0.022a	0.019a
	A4	0.019a	0.0195a	0.0215a	0.0215a	0.0205a
	Mean B	0.019a	0.019a	0.02a	0.0205a	

Footnote: Means labeled with different alphabetic letters differ significantly at $p \leq 0.01$.

CONCLUSION

The experiment's findings showed that the presence of chlorophyll and carotenoids in fenugreek at two different places, as well as pigment absorption, were strongly impacted by both pinching regimens and gibberellin treatments. Notably, 150 ppm and 200 ppm gibberellin treatments, as well as pinching at 45 DAS and twice at 30 and 45 DAS, improved the accumulation of carotenoid and chlorophyll, especially in the Grdarasha site. These results imply that fenugreek's photosynthetic pigment content can be enhanced by a combination of prompt pinching and suitable gibberellin concentrations, providing a possible method for increasing its nutritional and therapeutic value.

In addition, the results showed that by carefully regulating gibberellin treatments and pinching timings, fenugreek's levels of carotenoid and chlorophyll may be increased and pigment absorption improved. This technique may boost photosynthetic efficiency and boost the output of medicinal plants under different growth conditions. This research recommends choosing a healthy, disease-resistant type suitable for your area, planting during the cooler part of the growing season for best results, use well-drained, fertile soil. Prepare the land well and add natural compost or manure, and Sowing Method: Plant in straight rows with enough space between plants. Soak seeds in water before sowing to help them sprout better finally Irrigation: so water after planting, then as needed depending on the weather. Avoid overwatering and ensure good drainage. In order to improve cultivation

techniques, future research should examine the effects of these treatments on secondary metabolites and total plant productivity.

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