The importance of stimulators in cultivating a non-traditional plant-indigofera Tinctoria L

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Abstract. The article depicts the duration and norms of the use of various stimulants in the cultivation of the non-traditional leguminous plant Indigofera (Indigofera tinctoria L.) and its effect on seed yield, root and stem residues, and the amount of total proteins grown in the conditions of the meadow alluvial soils of the Khorezm, the northern region of the Republic of Uzbekistan. To get a high and quality seed yield from Indigofera, it should be sown at 3 kg per hectare in the third ten days of April, and a geohumat stimulator is applied at a rate of 1.0 l/ha along with sowing, 1.6 l/ha during the period of 3–4 true leaf appearances, and 1.6 l/ha in the flowering season of the vegetation. When applied at the rate of, a higher seed yield of 18.3 t/ha was obtained compared to the control option without stimulant use, 6.8 t/ha, and 2.9 t/ha compared to the option where Uzgumi as a chosen option was used only with planting, and it is based on the fact that 1.6 t/ha of additional seed yield can be obtained compared to the option where Geohumat stimulator was used only with planting. Also, it has been scientifically justified that the amount of total proteins increased up to 12.960% in the plant leaf, 30.980% in the seed, and 6.945% in the root when the geohumat stimulator was used at acceptable rates along with planting, during the 3–4 true leaves of the growing season, and during the flowering period. It indicates that the result is 1.249, 1.47, and 1.307% more proportionally than options grown without the stimulator.

1 Introduction

Various problems arise due to the use of land for agricultural purposes in recent years; the condition of soil reclamation is deteriorating, and its productivity is decreasing year by year. Today, the expansion of the area of degraded soils causes a decrease not only in soil fertility but also in the yield of agricultural crops. That is, about 65% of the irrigated farming area of our Republic consists of soils with poor amelioration, varying degrees of deflation, erosion by wind, ravines, irrigation, and low fertility. Maintaining and increasing soil fertility remains an urgent issue today.

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It is necessary to include new grain-legume and oil crops that improve soil melioration and are resistant to salinity and drought in crop rotation systems in order to solve this problem. The list of such crops includes crotalaria, Indigofera, kenao, lupine, and others. Considering the fact that Indigofera fulfills the needs of our people in all aspects and is not fully studied from the scientific point of view, it is urgent to develop and improve the agrotechnologies of its cultivation and to introduce the results into implementation.

2 Literature review

In all the countries of the world, there was no natural indigo dye except the "Indigo" dye pigment until the 19th century. The plant Indigofera tinctoria is found in several tropical regions of the world and is more common than any other plant species from which natural dyes are obtained. Indican is the primary chemical source of the dye and is present in all plant leaves that carry indigo, producing various colours after dye processing. Each species belonging to the genus Indigofera has different characteristics and methods of obtaining dyes, but the chemical structure of all dyes is common [1-8].

When Carl Linnaeus (1701–1778) was creating a new botanical systematics of this plant species, it was named Indigofera, meaning "Indigo-bearer", and this type of plant was widely used in interregional trade. There are different views among scientists on the cultivation and distribution of the blue dye plant "Indigofera tinctoria L." Evidence suggests that India is considered a major hub of it, even though the dyeing ability of the indigenous Indigofera tinctoria plant was independently developed by people in different regions, although Indigofera tinctoria species and dye preparation methods were exchanged between countries and regions for trade purposes.

The varieties of Indigofera tinctoria show that the species spreads eastwards, mixed with the seeds of cotton, sorghum, and other plants, and spreads as a weed in Africa, Arabia, and India [3,5]. Nowadays, due to the improvement of scientific analysis methods and the growing interest in science, botanists and organic chemists are conducting a lot of research to determine the biological properties and types of dye-giving plants.

"Indigo" dye plant [6,8] Indigofera (Leguminosae) belongs to the third largest family of leguminous legumes, constitutes the genus Indigofera, and consists of almost 802 species of plants. Under favourable conditions, Indigofera tinctoria L. can grow to a height of almost 1-1.5 metres [5,7].

It is distinguished from other Indigofera tinctoria species by its fragrant leaves and flowers, which are distinctly feathery, large and long, thin, slender, straight, or oval in shape [4]. Plants belonging to the variety Indigofera are considered to be plants that grow at an altitude above the sea level of 1650 metres [3], of which about 600 species spread all over Africa, almost 200 species in Asia, about 80 species in America, and 60 species in Australia [8].

Since Indigofera is a leguminous plant, it enriches the soil with nitrogen and is a convenient predecessor plant in crop rotation. After extracting the dye, the stems and leaves are composted and incorporated into the soil before ploughing [8]. The stem is used as firewood for tank boilers (heating pots) in indigo factories in India.

The indicators of the dynamics of the reduction of salts in the soil were chlorine ion - 0.037%; SO4 -0.0028%; dry residue by 0.01%; and Ph0.07, which was observed to decrease while investigating the effect of the Indigofera plant on soil salinity in improving the productivity of degraded soils in the soil-climatic conditions of the Khorezm region [1]. In the traditional medicine system, indigofera has healing properties; it is used for constipation, liver diseases, gout, and heart diseases. The Vietnamese use it to treat various skin diseases, while in India it is used to treat kidney diseases [3]. As it can be seen from the analysis of the literature, due to the lack of information in the literature on the agrotechnics of cultivation of the non-traditional leguminous crop indigofera, which is grown for only dye and hay in our region, the scope of scientific research works is not enough on the solution of these issues concerning the different soil-climatic conditions of our republic, fertilizer and water standards, the period and standards of using bio-stimulants with it, and obviously the theme is in need of investigation. Therefore, the solution to the above-mentioned problems was the basis for conducting the current scientific studies.

3 Research methods

State variety testing of agricultural crops *(Methodology of the State Variety Testing of Agricultural Crops) and* "Methods of Conducting Field d Experiments." The amount of total proteins in the stem, leaf, root, and seed of Indigofera was determined by the Keldal method, and the chemical element analysis of the leaf, root, and seed was done by the inductively coupled plasma mass spectroscopy method on the ISP-MS (Nexion 2000) device in laboratory conditions. Productivity indicators were mathematically processed in the dispersion analysis method based on the manual *"Field experiment methodology (Field* experiment methodology) by B.A.Dospehov.

Field experiments have been held in the conditions of alluvial soils in the meadow of the Khorezm region and studied the effect of biostimulants on the growth and development, biochemical composition, formation of buds, and productivity of indigofera. It was conducted according to the experimental system presented in Table 1.

Table 1. Experimental system.

Options	Name of biostimulants	Along with planting, l/ha	In the period of 3-4 pine leaves, l/ha	During ploughing, l/ha
Option 1	Control	-	-	-
Option 2	An example	0.4	-	-
Option 3	An example	0.4	0.3	0.4
Option 4	Geogumat	1.0	-	-
Option 5	Geogumat	1.0	1.6	1.6
Option 6	Fertilife	7.0	-	-
Option 7	Fertilife	7.0	0.4	0.5

In the experiment, Uzgumi bio-stimulant was taken as ethanol, and local Geo-gumat and imported Ferti-life bio-stimulants from abroad were used in the recommended norms while sowing, during the periods of 3–4 cypress and flowering.

4 Results and discussion

Seed and biomass can be obtained from the Indigofera plant. Harvesting of Indigofera biomass is also considered important, and its duration is determined depending on the condition of the crop in the field. If the harvesting period is wrongly determined, the grown biomass can be wasted; if it is delayed, on the contrary, the produced leaf biomass can die; that is, the leaves can turn yellow and fall off. That is why the period for collecting leaves should be determined correctly.

The purpose of the experiments was to obtain seeds from indigofera for saving seeds. If indigofera is grown for seeds, it is necessary to delay its harvesting for up to 15–20 days. During this period, most of the seed pods ripen, and the colour of the seed pods turns dark brown. In order to obtain plant seeds, it is advisable to harvest when the pods turn an average of 70–80% dark brown. In this process, the plant stalks are washed and dried, and

 https://doi.org/10.1051/bioconf/202413001003

the defoliated and seed pods left on the stem are crushed, separated, cleaned, and stored dry in airtight containers. The leaves are placed in separate bags and prepared for dyeing.

According to the data obtained on the seed yield of indigofera in the conditions of meadow alluvial soils of Khorezm region, it was found that it was 11.5-18.3 ts/ha when different stimulants were used at different rates.

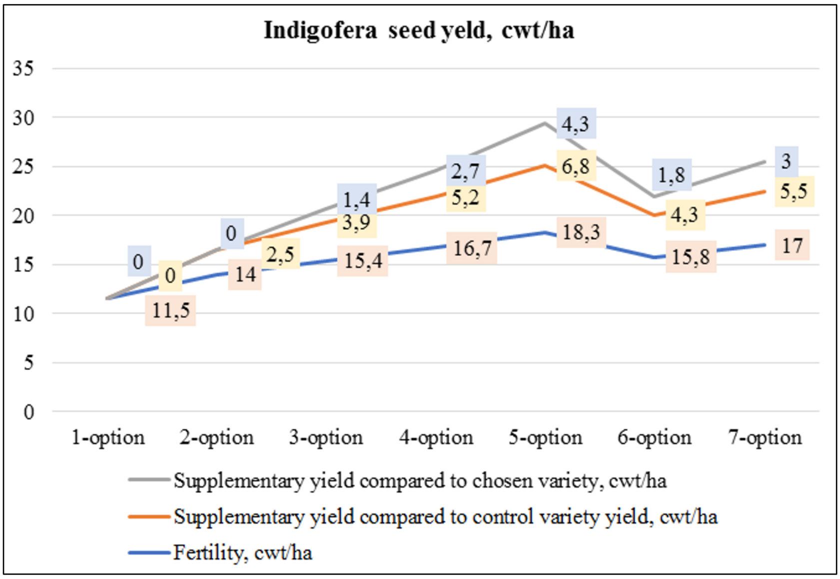

Fig. 1. Effects of stimulants on Indigofera seed yield.

The highest result is obtained in option 5 when a geohumat stimulator is used together with planting and during the plant growth period when (3–4)true leaves appear and during flowering period. It was 18.3 ts/ha. According to the obtained results, the seed yield in the control variant without the use of the stimulant was 11.5 t/ha, and when the Uzgumi stimulator was used as ethanol only with planting of 0.4 l/ha, the seed yield was 14.0 t/ha compared to the control option of 2.5 t/ha, and an additional crop was obtained. With planting Uzgumi stimulator - 0.4; when 3-4 leaves are released - 0.3; when applied at the rate of -0.4 l/ha during the tillering period, 15.4 t/ha Uzgumi yield was obtained; 3.9 t/ha additional grain yield was obtained compared to the control option; and 1.4 t/ha additional grain yield compared to the option when Uzgumi was used only with sowing (Figure 1).

In the cultivation of Indigofera, when the local geohumat stimulator was used at a rate of 1.0 l per hectare with planting, the yield was 16.7 t/ha. With planting at 1.0, when 3–4 leaves were released and in the period of flowering, when applied at a rate of 1.6 l/ha, a high yield of 18.3 t/ha of crop was obtained. From this option, compared to the control option, 6.8 t/ha, compared to the option where Uzgumi was used only with planting as a chosen option, 4.3 t/ha, with Uzgumi planting -0.4; when 3-4 leaves are released -0.3; during the flowering period, 2.9 t/ha more seed yield was obtained compared to the option used at the rate of -0.4 l/ha and 1.6 t/ha more seed yield was obtained compared to the option where the Geogumat stimulator was used only with planting.

Fertilife stimulator imported from abroad was also used in the experiment, and when Fertilife was applied only at planting, an additional yield of 4.3 t/ha was obtained compared to the control. Fertilife stimulator with planting: 7.0; when it produces 3–4 leaves: 0.4; in the flowering phase, when applied at the rate of 0.5 l/ha, an additional yield of 5.5 t/ha was obtained compared to the control variant, while the seed yield was 1.3 t/ha less than option 5, which was used with a high-yielding Geogumat stimulator. So, the application of the local Geogumat stimulator in the cultivation of seed crops from indigofera in the following amounts while planting: 1.0 and 3–4 true leaves (1.6); in the stage of flowering at a rate of 1.6 l per hectare, this creates a basis for obtaining a high grain yield from the plant in the conditions of the meadow alluvial soils of the Khorezm region.

Indigofera, along with other leguminous crops, serves to maintain and increase soil fertility through root nodule bacteria and root and shoot residues. According to the information obtained from the literature, in the conditions of typical grey soils in the Tashkent region, when indigofera was planted as the main crop, up to 20–80 nodular bacteria were formed in one plant.

Indigofera root and stem residues were studied in the experiment, and it was found that 2.92–5.11 t/ha of roots and 1.72-2.37 t/ha of stem residues were collected. The best result is obtained when planting indigofera where Geohumat stimulator was used, and during the growing season of the plant, 3–4 cinnabar and during flowering cycles, 5.11 t/ha of roots and 2.37 t/ha of shoot residues were formed in the option (diagram 2).

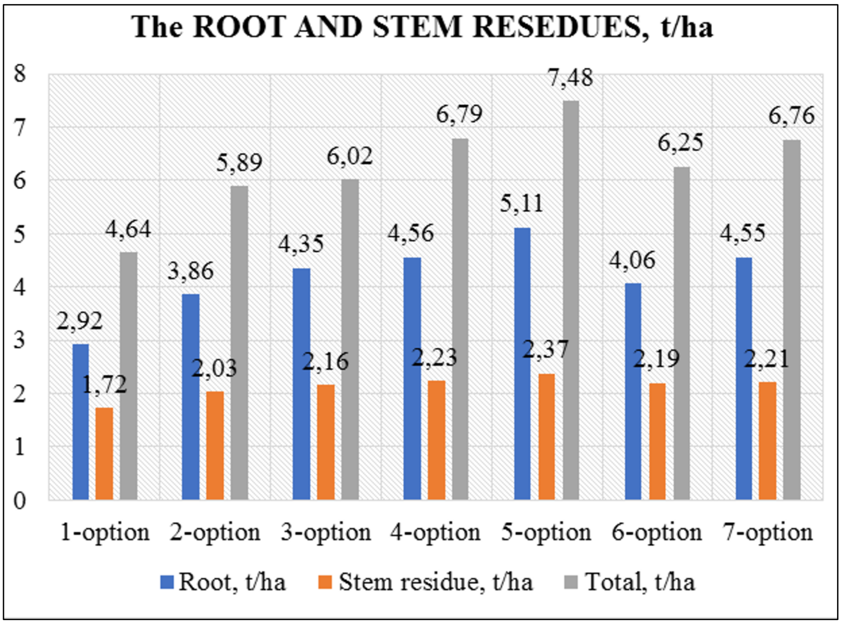

Fig. 2. Effect of stimulators on the amount of root and stem residues of Indigofera, t/ha

In this option, the amount of root and stem residues formed is 7.48 tonnes per hectare, which is 2.84 t/ha more than the control option without stimulants; Geohumat stimulator 0.69 t/ha from the option used only with planting; and more than 0.72-1.46 t/ha of root and stem residues were formed from the options using Uzgumi and Fertilife stimulants.

Therefore, the growth and development of indigofera when treated with a Geohumat stimulator at the time of planting (1.0 l/ha) and during the 3-4 leaf (1.6 l/ha) appearance and flowering (1.6 l/ha) periods of plant development is fast, and as a result of the perfect development of its root system, a high amount of organic residues (roots and stems) is formed. As a result, the perfect atmosphere is created to maintain and increase soil fertility.

To assess the importance of any new crop in the national economy, it is first important to study its chemical composition. Therefore, in our scientific research, the amount of total proteins and macro- and microelements in the indigofera plant was determined.

The amount of total protein was determined by the Keldal method. According to the results of the analysis, the amount of total proteins in the plant leaf is 11,711–12,960%, in the seed 29,673–30,980%, and in the root 5,475–6,945%.

Changes in the amount of total proteins in plant body parts can be influenced by air temperature, planting time, rate, and other factors, including bacterial fertilisers, i.e., stimulants. That's why it is important to study the effect of duration, amount, and norms of stimulants on the *total amount of proteins in indigofera leaf, root, and seed.*

Table 2. Effects of stimulants on the amount of total protein in plant organs

Options	Plant organs			Difference from control		
	Per leaf, %	At the root, %	in the seed %	Per leaf, %	At the root, %	In seed, %
Option 1	11.711	5.475	29,673	-	-	-
Option 2	12.111	6.055	30.103	+0.4	+0.58	+0.43
Option 3	12.712	6.465	30,675	+1.001	+0.99	+1.002
Option 4	12.637	6.578	30,723	+0.926	+1.103	+1.05
Option 5	12,960	6.945	30,980	+1.249	+1.47	+1.307
Option 6	12.467	6.263	30,523	+0.756	+0.788	+0.85
Option 7	12,830	6.765	30,875	+1.119	+1.29	+1.202

When the amount of total proteins in the Indigofera leaf was determined, it was 11.711–12.960% according to the options, and the effect of the stimulants was observed. A high result was found in option 5, which used geohumat stimulant along with planting, and in the appearance of 3-4 true leaves and tillering periods (12.960%). The amount of total proteins detected in this variant was 1.249% higher than the control variant and 0.849–0.13% higher than the variants treated with other stimulants.

Also, the amount of total proteins in the indigofera root was 5.475–6.745% according to variants, and the highest value was 6.945% in variant 5. The total amount of indigofera root in this variant was 1.47% higher than that of the non-stimulated control variant. The seed of leguminous crops differs from other crops in terms of nutritional value. Because the level of protein digestibility is high in the composition, the amount of seed protein varies according to the plant variety, growing soil, weather conditions, applied fertilisers, and agrotechnological measures [8].

When the total protein content of Indigofera seeds was determined in the option used with Geohumat stimulator while planting and in 3–4 true leaf appearance and flowering periods, their amount was 29,673–30,980%, which was higher than other options. That is, the amount of total proteins in this option was 30.980%, which was 1.307% more than the non-stimulant option and 0.257% more than the option with geohumat-only planting (Table 2). So, to increase the amount of total proteins in indigofera leaf, root, and seed, along with planting Geohumat stimulator at 1.0 per hectare and 1.6 during the period of 3-4 true leaf appearance, application of 1.6 l standards during the growing season creates a basis for obtaining a high-calorie crop from the plant.

5 Conclusion

As a conclusion, it should be noted that in order to obtain a high and quality seed yield from the non-traditional leguminous plant indigofera in the conditions of the meadow alluvial soils of the northern region of the Khorezm region of our republic, it should be planted at a rate of 3 kg per hectare in the third ten days of April. It is recommended to apply Geogumat stimulator at a rate of 1.0 l/ha along with sowing at a rate of 1.6 l/ha on the 3^{rd} and 4^{th} days of the growing season during the leafing period and 1.6 l/ha during the flowering period.

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