

**FORMATION OF ROOT NODULE BACTERIA IN CHICKPEA
VARIETIES SOWN AT DIFFERENT DATES UNDER THE FOOTHILL
RAINFED CONDITIONS OF THE KASHKADARYA REGION**

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Abstract. *This article presents the results of a 2020 field study on the formation of root nodules in local chickpea (*Cicer arietinum* L.) varieties cultivated under the foothill rainfed conditions of the Kashkadarya region. The experiment was conducted using three chickpea varieties: Obod (standard variety), Malxotra, and Jahongir. The effect of three sowing dates (1 February, 15 February, and 1 March) on root nodule formation was investigated.*

The study demonstrated that the formation of root nodules varied depending on both the variety and the sowing date. The obtained results provide a scientific basis for selecting promising chickpea varieties and determining the optimum sowing dates for rainfed foothill areas of the Kashkadarya region, thereby contributing to improved biological nitrogen fixation and sustainable chickpea production.

Keywords: *chickpea (*Cicer arietinum* L.), root nodules, nodule-forming bacteria, sowing date, rainfed conditions, foothill areas, Obod, Malxotra, Jahongir.*

Introduction. Chickpea (*Cicer arietinum* L.) is one of the world's major grain legume crops and serves as an important source of dietary protein for human nutrition. In addition, root nodule bacteria (*Rhizobium ciceri*) establish a symbiotic relationship with chickpea roots, enabling the fixation of atmospheric nitrogen and improving soil fertility (Mironova, 2017). Therefore, chickpea is valued not only as a food crop but also as an important legume that enriches the soil with biologically fixed nitrogen (Safarov, 2020).

The formation of root nodules is significantly influenced by agronomic factors, including sowing date, planting pattern, and the biological characteristics of

the variety. Early sowing promotes root system development and stimulates nodule formation (Kumar et al., 2016). In contrast, delayed sowing may reduce the number of nodules because of increased soil temperature and insufficient soil moisture (Ponomarenko, 2018).

The foothill rainfed areas of the Kashkadarya region are characterized by an arid climate. Under such conditions, determining the optimum sowing date is essential for maximizing the biological potential of chickpea varieties. Therefore, the present study evaluated root nodule formation in three chickpea varieties—Obod, Malxotra, and Jahongir—sown at three different planting dates.

Geographical Location and Soil–Climatic Conditions of the Experimental Site

The field experiment was conducted in the Kamashi District of the Kashkadarya Region, which is located in the central part of the region. Therefore, its soil and climatic conditions are generally representative of the regional average. Nevertheless, variations in precipitation, air temperature, and the occurrence of hot, dry winds (garmisel) considerably influence crop growth, development, and productivity. These effects are particularly pronounced under rainfed conditions. Consequently, the experimental results varied substantially from year to year.

The experimental site is situated in the foothill rainfed zone of the Kashkadarya Region and is characterized by light sierozem (light gray) soils. These soils occupy approximately 548.0 thousand hectares within the region and are widely distributed along the Kashkadarya River as well as across the plains and foothill areas. The parent materials consist mainly of loess, deluvial, and proluvial deposits.

The soils are characterized by a low humus content (0.8–1.4%), high carbonate content, and predominantly medium- to light-textured loamy composition. In addition, the contents of available phosphorus and exchangeable potassium are relatively low. The experimental field is located at an altitude of 500–750 m above sea level, approximately 150–200 m higher than the surrounding plains, and is therefore free from soil salinity.

Since the experimental area is located under rainfed farming conditions, agricultural practices did not cause substantial changes in soil structure. However, continuous cultivation under these conditions gradually increases biomass accumulation within the plough layer, thereby improving agricultural productivity. The increase in soil organic matter enhances the soil's water-physical properties and contributes to better soil quality. Light sierozem soils have been studied only to a limited extent, and most previous investigations have primarily focused on their geographical characteristics.

Materials and Methods. Field experiments were conducted under the foothill rainfed soil and climatic conditions of the Kashkadarya Region, Uzbekistan. The experiment consisted of 27 treatment combinations arranged in three replications. The row spacing in the experimental field was 60 cm. The study was carried out over a three-year period using a short-rotation barley–chickpea cropping system.

Three chickpea varieties included in the State Register of Agricultural Crop Varieties of the Republic of Uzbekistan—Obod, Malxotra, and Jahongir—were used in the experiment. All agronomic practices were performed in accordance with the research program of the dissertation and the recommended experimental methodologies.

Results and Discussion. According to the results obtained in 2020, the number of root nodules formed in local chickpea varieties differed considerably depending on the sowing date. Nodule development at each growth stage was influenced by both varietal characteristics and sowing time, directly affecting biological nitrogen fixation and subsequent plant growth.

For the 1 February sowing date, the Obod (standard) variety produced 14.5 nodules per plant at the branching stage, 20.1 at the flowering stage, and 17.9 at the pod formation stage, with an average of 17.5 nodules per plant.

Under the same sowing date, the Malxotra variety formed 19.6, 25.7, and 23.5 nodules per plant at the branching, flowering, and pod formation stages, respectively, with an average of 22.9 nodules per plant. Although this variety

produced a greater number of nodules than the standard, the recorded differences relative to the reference values were -5.1 , -5.6 , -5.6 , and -5.43 nodules, respectively.

The Jahongir variety sown on 1 February formed 15.4 nodules per plant ($+0.9$) at the branching stage, 18.3 ($+1.8$) at the flowering stage, and 15.7 ($+2.2$) at the pod formation stage, resulting in an average of 15.9 nodules per plant ($+1.63$). The average value exceeded that of the Obod variety by 0.9 nodules per plant.

For the 15 February sowing date, the Obod variety formed 11.5, 15.4, and 13.9 nodules per plant at the branching, flowering, and pod formation stages, respectively, with an average of 13.6 nodules per plant.

The Malxotra variety produced 15.6 (-4.1), 20.7 (-5.3), and 17.7 (-3.8) nodules per plant at the corresponding growth stages, with an average of 18.0 nodules per plant (-4.40). These findings indicate that the Malxotra variety maintained relatively high nodule formation even when sown on 15 February, although negative differences compared with the reference values were observed.

The Jahongir variety sown on 15 February formed 10.4 nodules per plant ($+1.1$) at the branching stage, 14.5 ($+0.9$) at the flowering stage, and 12.6 ($+1.3$) at the pod formation stage, with an average of 12.5 nodules per plant ($+1.10$).

Table 1. Effect of Sowing Dates on the Number of Root Nodules in Local Chickpea Varieties (2020)

Chickpea variety	Planting pattern	Number of root nodules per plant (1 nodules/plant)							
		Branching stage	Difference from the standard	Flowering stage	Difference from the standard	Pod formation stage	Difference from the standard	Average	Difference from the standard

			varie ty		varie ty		varie ty		varie ty
1 February									
Obod (St)	60x9-1	14,5		20,1		17,9		17,5	
Malxotra	60x9-1	19,6	-5,1	25,7	-5,6	23,5	-5,6	22,9	-5,43
Jahongir	60x9-1	+0,9	18,3	+1,8	15,7	+2,2	15,9	+1,63	+0,9
15 February									
Obod (St)	60x9-1	11,5		15,4		13,9		13,6	
Malxotra	60x9-1	15,6	-4,1	20,7	-5,3	17,7	-3,8	18,0	-4,40
Jahongir	60x9-1	10,4	+1,1	14,5	+0,9	12,6	+1,3	12,5	+1,10
1 March									
Obod (St)	60x9-1	11,8		16,7		14,6		14,4	
Malxotra	60x9-1	15,3	-3,5	19,5	-2,8	17,1	-2,5	17,3	-2,93
Jahongir	60x9-1	10,3	+1,5	14,6	+2,1	12,1	+2,5	12,3	+2,03

For the 1 March sowing date, the Obod variety formed 11.8 nodules per plant at the branching stage, 16.7 at the flowering stage, and 14.6 at the pod formation stage, with an average of 14.4 nodules per plant. These values indicate a noticeable decline compared with the results obtained from the February sowings.

The Malxotra variety produced 15.3 nodules per plant (−3.5) at the branching stage, 19.5 (−2.8) at the flowering stage, and 17.1 (−2.5) at the pod formation stage, with an average of 17.3 nodules per plant (−2.93). These results demonstrate that the

Malxotra variety maintained a high capacity for root nodule formation even when sown on 1 March.

The Jahongir variety formed 10.3 nodules per plant (+1.5) at the branching stage, 14.6 (+2.1) at the flowering stage, and 12.1 (+2.5) at the pod formation stage, with an average of 12.3 nodules per plant (+2.03). These findings indicate that Jahongir outperformed the Obod variety and maintained relatively stable symbiotic activity even under late sowing conditions.

Overall, the sowing date had a pronounced effect on the number of root nodules. The highest values were recorded for the 1 February sowing, whereas nodule formation declined under the 15 February sowing and decreased further when sowing was delayed until 1 March.

Among the tested varieties, Malxotra consistently exhibited the highest nodulation capacity across all sowing dates. The number of root nodules ranged from 19.6 to 15.3 nodules per plant at the branching stage, 25.7 to 19.5 at the flowering stage, and 23.5 to 17.1 at the pod formation stage. These results indicate the high symbiotic efficiency and nitrogen-fixing potential of the Malxotra variety under the foothill rainfed conditions of the Kashkadarya Region.

The Jahongir variety also performed better than the standard Obod variety at all sowing dates. Its superiority ranged from +0.9 to +1.5 nodules per plant at the branching stage, +0.9 to +2.1 at the flowering stage, and +1.3 to +2.5 at the pod formation stage, demonstrating its stable ability to form root nodules under different sowing periods.

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