



DETERMINATION OF PROTEIN CONTENT IN MUNG BEAN YIELD UNDER THE CONDITIONS OF FERGANA REGION

Mirzayeva Mutabar Azamovna

Candidate of Agricultural Sciences, Associate Professor,
Fergana State University, Fergana, Uzbekistan

Teshaboyev Nodirbek Ikromjonovich

PhD in Agricultural Sciences,
Fergana State University, Fergana, Uzbekistan

Abstract

The article presents data on the influence of sowing dates and rates on yield and biologically valuable traits in the conditions of typical gray soils of the Fergana region. In the conditions of typical gray soils of the Fergana region, when mung beans were sown as a repeated crop in the third decade of June at a rate of 14 kg per hectare, the bulk density of the soil in the arable and sub-arable layers decreased by 0.03 g/cm³ compared to the variants planted at a rate of 10 kg per hectare, and soil porosity increased by 1.0-1.2%. It was also observed that with an increase in the sowing rate, the content of nitrate nitrogen increased.

Keywords: Typical gray soil, repeated cropping, mung bean, planting date and criteria, root and shoot residues, agrophysical properties of soil, protein.

Introduction

In the Republic, autumn cereals are cultivated annually on more than one million hectares of irrigated land. After the harvest of winter wheat from these areas, opportunities arise for growing secondary (repeated) crops. Taking this into account, firstly, cultivating leguminous grain, cereal, and vegetable crops as secondary crops on fields vacated after winter wheat can significantly contribute



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to strengthening food security in the country and meeting the population's daily food needs. Secondly, in areas where soil fertility is declining, the cultivation of secondary crops also creates conditions for enriching the soil with organic matter. If the secondary crop is a leguminous plant, the nitrogen-fixing bacteria (*Azotobacter*) living in symbiosis with the root system enrich each hectare of land with 100 to 300 kg of nitrogen that is easily absorbable by plants by fixing atmospheric nitrogen. Leguminous grain crops are considered good precursors for cotton, wheat, rice, hemp, and vegetable crops.

According to scientific observations conducted in various soil and climatic conditions of the Republic, agro-technologies have been developed for the cultivation and care of more than 50 crop species as secondary crops after the harvest of cereal grains. These crops not only increase soil fertility but also serve as valuable fodder for livestock. As a result of this practice, the economic performance of farms improves, additional income is generated, and soil fertility is preserved.

Literature Review

Scientific studies have shown that in short-term crop rotation systems, the cultivation of repeated leguminous grain and cover crops leads not only to the restoration and improvement of soil fertility due to the accumulation of organic residues in the soil, but also to enhanced water retention, improved water-physical properties, and increased diversity of soil microflora, all contributing to positive changes in soil quality.

Globally, leguminous grain crops are cultivated on approximately **135 million hectares** of land. Among these crops, **mung bean** ranks **second** in terms of cultivation area worldwide—after **soybean**, which occupies nearly **74 million hectares** globally—followed by **chickpeas**, with about **10 million hectares**. In **Uzbekistan**, mung bean is grown annually as a secondary (repeated) crop on more than **18–25 thousand hectares**. Uzbekistan plays a significant role in the global mung bean export market, exporting up to **67 thousand tons** of mung bean per year [1].



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Mung bean seeds are rich in **amino acids** and essential minerals such as **magnesium, calcium, sulfur, sodium, iron, manganese, copper, boron, cobalt, nickel, iodine, and phosphorus salts**. On average, **60–80 centners of hay** or **240–300 centners of green mass** are obtained per hectare.

The **digestible protein** content in mung bean green mass is **two to three times higher** than that of maize leaves and stalks. Silage prepared by mixing **maize with mung bean** is notable for its **high nutritional quality**.

Mung bean occupies one of the leading positions as a **forage crop**. On average, **mung bean hay contains about 15% protein**. When grown as a **green manure (siderate) crop** on stubble fields, it can produce **200–250 centners per hectare** of green biomass [2].

In the scientific research conducted by **M.V. Donskaya** and **S.V. Bobkov**, observations of **82 varieties and breeding lines** of mung bean revealed that **warmer weather during the growing season accelerated grain filling** in most samples [3]. However, in some samples, it was observed that **high temperatures had little to no significant effect** on the **protein content** of the grain. According to the dissertation work by **I.G. Aukina**, in the **chestnut soils of the Volga region (Saratov)**, mineral fertilization of mung bean **increased protein content from 23.6% to 29.4%** and **oil content from 4.87% to 6.57%**, although **starch content decreased** as a result [4]. Observations also revealed a **strong correlation** between **mung bean yield** and the **soil content of nitrate nitrogen and mobile phosphorus**. In experiments by **A.P. Dolmatov** and **D.A. Kupriyanov** in the **Pre-Urals region of Orenburg**, it was found that **differentiated application of mineral fertilizers (N₂₀ + N₁₅P₁₅K₁₅ in autumn)** resulted in a **yield of 10.5 centners**, while **split application (N₂₅ + N₁₅P₁₅K₁₅ in autumn)** led to a **protein content of 24.7%** in the grain [5].



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Methodology

The research was conducted using a combination of field observations and laboratory analyses based on established methodological guidelines. The following standardized protocols were employed: **Methods of Agrochemical Analysis of Soils and Plants** (1973, Tashkent) [6], which provided procedures for assessing soil nutrient composition and plant biochemical properties. **Methods of Agrophysical Research** (1973, Tashkent) [7], outlining techniques for evaluating soil physical properties and their effects on crop growth.

Methods of Soil Microbiology and Biochemistry (Moscow, 1991) [8], detailing procedures for analyzing soil microbial activity and biochemical processes critical for nutrient cycling. **Methods for Conducting Field Experiments** (Uzbek Research Institute of Plant Industry, Tashkent, 2007) [9], which guided the design, implementation, and statistical analysis of field trials.

Study Area and Conditions

The experimental site was located in the Fergana region, situated in the northeastern part of the Republic. The climate is characterized by a long, hot summer and a short, cold winter, with high humidity primarily observed during the spring season.

The annual sum of temperatures ranges between **4900–5000 °C**, of which **2500–2900 °C** are considered effective temperatures for crop growth. The frost-free period lasts **213–233 days**, with the first autumn frost occurring between **October 14 and November 2**. The last spring frost occurs between **March 16 and March 25**, and stable air temperatures above **+10 °C** begin from **March 21**. Precipitation during the growing season varies between **40 and 140 mm**, while outside the growing season it ranges from **100 to 380 mm**. Evaporation during the growing period reaches **1110–1580 mm**, and outside this period it is **394–402 mm**, often leading to water deficiency.

The spring of 2023 was characterized by heavy rainfall and low temperatures, the summer was notably hot, and autumn experienced cooler temperatures.



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In 2024, spring remained rainy with low temperatures, summer was relatively cooler with reduced heat activity, and autumn was comparatively cool, although October was relatively warm. In the experiment, mung bean varieties “Durdona”, “Qahrabo”, and “Marjon” were sown as secondary crops.

Discussion of Research Results

The bulk density of the experimental field soils was measured at 1.32 g/cm³ in the arable layer (0–30 cm) and increased to 1.37 g/cm³ in the sub-arable layer (30–50 cm), indicating progressive compaction with depth.

According to the experimental results obtained under typical gray soils of the Fergana region, the initial soil porosity in fields with repeated mung bean cultivation was 49.2% in the 0–30 cm layer and 47.3% in the 30–50 cm layer. When mung bean was grown as a secondary crop, delayed planting dates and increased seeding rates led to a decrease in crude protein content in the grain. Specifically, when mung bean was sown early (June 30) at seeding rates of 10–14 kg/ha, the crude protein content in the grain ranged between 21.5% and 22.6%, with differences among variants decreasing to 0.8–1.1%. In contrast, mung bean sown later (around July 10) at the same seeding rates produced grain with crude protein content ranging from 19.8% to 20.6%, representing a decrease of 1.6–2.6% compared to the early sowing.

At the end of the growing season, soil porosity measured by seeding rates on June 30 was 46.7–48.1% in the 0–30 cm soil layer and 46.1–47.3% in the 30–50 cm layer. The highest porosity (48.1%) in the 0–30 cm layer was observed in the variant with a seeding rate of 14 kg/ha.

This indicates that increasing seeding rates improved soil porosity by approximately 1–1.2%. The humus content in the experimental field soil was 0.799% and 0.701% in the 0–30 cm and 30–50 cm layers, respectively. Total nitrogen content was 0.125% in the upper layer and 0.081% in the lower layer, while phosphorus content was 0.281% and 0.296%, respectively.



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The available nutrient forms were measured as follows: nitrate nitrogen at 8.15 mg/kg (0–30 cm) and 3.79 mg/kg (30–50 cm); available phosphorus at 17.09 mg/kg and 16.01 mg/kg; and exchangeable potassium at 215 mg/kg and 209 mg/kg. These results indicate that the soils were very poorly supplied with nitrate nitrogen but had low levels of available phosphorus and exchangeable potassium. Indeed, when the agro-physical, water, and water-physical properties of the soil are within optimal ranges, the activity of microorganisms in the soil intensifies, resulting in improved soil fertility. An increase in soil fertility positively affects the yield quantity and quality of agricultural crops. In particular, it enhances the quantity and quality of protein, starch, cellulose, oils, and other organic compounds in the crop. Therefore, studying the impact of sowing rates and timing of mung bean planted as a catch crop on yield quantity and quality is an important scientific and practical issue.

Among leguminous grain crops, mung bean (*Phaseolus aureus*) belongs to the legume family and is an annual leguminous crop, a type of bean. Its main varieties include those originating from India, China, and Iran. The homeland of mung bean is Southwest Asia, where it has been cultivated since 4,000 to 3,000 BC. Currently, mung bean is grown in Central Asia, India, Pakistan, Afghanistan, Iran, China, Japan, and many other countries. Its taproot penetrates the soil up to 1.5 meters and forms nitrogen-fixing nodules. The stem length varies from 20 to 100 cm, growing upright or climbing, with broad and large leaves. The flowers are bisexual, papilionaceous, arranged in groups of 3 to 12 in leaf axils, and range in color from yellow to yellow-green.

The fruit is a slender, cylindrical pod 6–18 cm long, containing 6 to 15 seeds. Seeds are yellow, green, or black, with a thousand-seed weight ranging from 40 to 80 grams. Mung bean is a thermophilic plant; its seeds germinate within 5–7 days at 12–15 °C. The plant is sensitive to frost, with seedlings dying at -1 to -2 °C. Mung bean is moisture-demanding; to ensure seed germination, it requires water equal to the seed weight, especially during pod filling.



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It develops well in shaded areas and fertile meadow soils. It is primarily self-pollinating. In Uzbekistan, mung bean sown in spring matures in 85–95 days, while sowing at the end of summer matures in 60–65 days. Approximately 75–80% of the pods are harvested when ripe. The grain contains 24–28% protein, 46–50% starch, 2–4% oil, and vitamins. Mung bean is widely used in food, easily digestible, and its flour is used for pasta production. Its green biomass serves as nutritious fodder in animal husbandry, and stems can be used for silage. Under irrigated conditions, yields range from 10 to 16 centners per hectare, and from 8 to 12 centners per hectare when grown as a catch crop. Scientific research by M. Xoliqov [10] demonstrated that early sowing (third decade of June), narrow row spacing (45 cm), and increased plant density (550,000 plants/ha) in mung bean catch crops shorten the maturation period by 6–7 days, increase yield by 17.6–19.2%, increase the number of nodules on roots to 7.0–9.7 per plant, and their weight to 2.0–3.8 g. Additionally, increased irrigation frequency positively influenced nodule formation and yield accumulation. Mung bean grain stands out in terms of nutritional value due to the digestibility of its crude protein, averaging 86%. The crude protein content varies depending on the crop variety, growing conditions, climate, fertilization, and agronomic practices. Notably, mung bean grown as a catch crop tends to have higher crude protein content in the grain. Moreover, higher air temperatures may contribute to an increase in crude protein content in mung bean grains. The effects of sowing dates and seeding rates on crude protein content in mung bean grains have been confirmed by various studies. Similar findings were reported by Kh.Kh. Saydaminova et al. [11], who observed that when mung bean varieties were cultivated under soil drought conditions, the stress effects varied depending on the biological characteristics of the varieties. Specifically, in some varieties, the protein content decreased insignificantly, while the oil content increased markedly; in others, the opposite trend was observed. Therefore, investigating the influence of sowing dates and seeding rates on the crude protein content of mung bean grains grown as a catch crop following winter wheat is of particular importance. In this study, the effect



of sowing dates and seeding rates on the crude protein content of mung bean grains cultivated as a catch crop after winter wheat is presented in Table 1.

The research results indicate that when mung bean was sown early (June 30) at seeding rates of 10–14 kg/ha, the crude protein content in the grain ranged between 21.5% and 22.6%, with differences among variants reducing to 0.8–1.1%. In contrast, when mung bean was sown later, at the beginning of July (July 10) with the same seeding rates, the crude protein content ranged from 19.8% to 20.6%, showing a decrease of 1.6–2.6% compared to early sowing.



Table 1. Crude protein content in mung bean grains grown as a successive crop after winter wheat at different planting dates and seeding rates.

Options	Planting Dates	Varieties of Mush bean	Seeding Rates, kg	Crude protein content, %	Difference relative to seeding rate + -	Difference relative to planting date + -
1-option	30.06	“Durdona”	10	22,6	-	
2-option			12	21,8	-0,8	
3-option			14	21,5	-1,1	
4-option		“Qahrabo”	10	20,6	-	
5-option			12	20,3	-0,3	
6-option			14	19,7	-0,9	
7-option		“Marjon”	10	21,5	-	
8-option			12	21,0	-0,5	
9-option			14	20,2	-1,3	
10-option	10.07	“Durdona”	10	20,6	-	-2,0
11-option			12	20,2	-0,4	-1,6



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12-option	15.07	"Qahrabo"	14	19,8	-0,6	-1,7	
13-option			10	19,7	-	-0,9	
14-option			12	18,9	-0,8	-1,4	
15-option			14	18,2	-1,5	-1,5	
16-option		"Marjon"	10	18,6	-	-2,9	
17-option			12	18,2	-0,4	-2,8	
18-option			14	17,8	-1,8	-2,4	
19-option		"Durdona"	10	20,3	-	-2,3	
20-option			12	20,2	-0,1	-1,6	
21-option			14	20,8	+0,5	-0,7	
22-option			"Qahrabo"	10	19,2	-	-1,4
23-option				12	18,9	-0,3	-1,4
24-option				14	18,8	-0,4	-0,9
25-option		"Marjon"	10	20,3	-	-1,2	
26-option	12		18,2	-2,1	-2,8		
27-option	14		18,8	-1,5	-1,4		

	Durdona			Qahrabo			Marjon		
10	22,6	20,6	20,3	20,6	19,7	19,2	21,5	18,6	20,3
12	21,8	20,2	20,2	20,3	18,7	18,9	21	18,2	18,2
14	21,5	19,8	20,8	19,7	18,2	18,8	20,2	17,8	18,8
r	-0,97	-1	0,78	-0,98	-0,98	-0,96	-0,99	-1	-0,69
r		0,97	-0,59		0,93	0,89		0,99	0,59
r			-0,78			1,00			0,69

When mung bean was sown in the second decade of July (July 15) at seeding rates of 10–14 kg/ha, the crude protein content in the grain ranged from 20.2% to 20.8%, representing a decrease of 0.7–2.3% compared to the early sowing variants. The same patterns were observed in the "Qahrabo" and "Marjon" mung bean varieties. The crude protein content in the grain varied depending on the sowing dates and seeding rates, ranging from 19.7% to 20.6% in the "Qahrabo" variety and from 18.2% to 21.5% in the "Marjon" variety. Research conducted by V.G. Klimenko also noted that sowing leguminous grain crops at later than optimal dates significantly reduces the crude protein content in the grain.



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Klimenko attributed this decline primarily to insufficient air temperature and light, which hinder the full progression of photosynthesis in the plant [12].

Analysis of the data revealed that increasing seeding rates and delaying sowing dates consistently decreased the protein content in the grain, regardless of the variety. Correlation analysis demonstrated a moderate ($r = -0.69$) to strong negative correlation ($r = -0.78$; -0.99) between seeding rate and protein content. An exception was observed in only one case, where the protein content in the grain of the “Durдона” variety sown in the second decade of July showed a strong positive correlation with the sowing date. Overall, the analysis indicated that delaying sowing dates led to a reduction in the protein content of mung bean grain. The protein content was positively correlated with sowing dates, showing moderate ($r = 0.59$; 0.69) to strong ($r = 0.89$; 0.99) positive correlations. In conclusion, when mung bean is grown as a catch crop, delaying sowing dates and increasing seeding rates leads to a decrease in the crude protein content of the grain.

Conclusions

1. Under the conditions of typical gray soils in the Fergana region, sowing mung bean as a catch crop at a seeding rate of 14 kg/ha at the end of June resulted in a slight reduction of bulk density by 0.03 g/cm³ in both the arable and sub-arable soil layers, compared to lower seeding rates, and contributed to an increase in soil porosity by 1.0–1.2%.
2. Experimental findings indicate that, under the same soil conditions, the nitrate nitrogen content in the soil at the end of the growing season increased with higher mung bean seeding rates. Specifically, at a seeding rate of 10 kg/ha, nitrate nitrogen content measured 6.92 mg/kg, whereas increasing the seeding rate by 4 kg/ha raised the nitrate nitrogen content to 10.82 mg/kg, an increase of 3.9 mg/kg.
3. Delayed sowing dates and increased seeding rates for mung bean cultivated as a catch crop adversely affected the crude protein content in the grain. Early sowing (June 30) at seeding rates of 10–14 kg/ha resulted in crude protein content ranging from 21.5% to 22.6%, with differences between variants narrowing to



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0.8–1.1%. Conversely, sowing at the beginning of July (around July 10) under similar seeding rates led to a reduction in crude protein content to 19.8%–20.6%, representing a decrease of 1.6–2.6% compared to early sowing.

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