АГРОХИМИЯ, АГРОПОЧВОВЕДЕНИЕ, ЗАЩИТА И КАРАНТИН РАСТЕНИЙ/AGROCHEMISTRY, AGROSOIL SCIENCE, PLANT PROTECTION AND QUARANTINE

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THE EFFECT OF MINERAL FERTILIZERS AND GIBBERELLINS ON THE GROWTH, DEVELOPMENT AND YIELD OF BEANS (*PHASEOLUS VULGARIS L.*), GROWN IN KAPISA PROVINCE, AFGHANISTAN

Research article

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Abstract

The investigation was done at the trial location of the Faculty of Agriculture, Alberoni University in Kapisa, Afghanistan, to explore the impact of differing amounts of NPK and G on the agricultural characteristics of common bean from June to September 2022–24. The trial framework employed a randomized complete block design, with three repetitions for each state. A total of sixteen conditions, including a control, were assessed as described below. The outcome demonstrated that the application of differing rates of NPK and G, that indicated in a notable improvement in both the growth and production of beans. The tallest specimens (100.5 cm) were reached with by implementing of nitrogen at 60 kilograms per hectare, phosphorus at 60 kilograms per hectare, potassium at 30 kilograms per hectare, along with gibberellin at 300 ppm; this condition also yields the uppermost dry biomass per specimen (7.1 g). The peak number of pods per specimen (11.78) was achieved by the $N_{60}P_{60}K_{30}+GA_{200}$ condition, while the supreme seed count per specimen (64.70) was obtained with A_{11}, surpassing the other levels. And seed productivity was pointedly arising with $A_{13.}$ This clearly illustrates the advantageous role of NPK and G on the productivity of common bean. The peak seed yield (2.01 t/ha) was derived from A_{13}, which was statistically different from other treatments. In summary, the findings suggest that the mutual application of NPK and G can greatly improve the growth and yield of common bean. Importantly, treatments involving nitrogen at 60 kilograms per hectare, phosphorus at 60 kilograms per hectare, potassium at 30 kilograms per hectare, and gibberellin at various concentrations produced the most beneficial results in terms of plant height, dry biomass, pod and seed counts per specimen, 1000-seed weight, and overall seed yield.

Keywords: beans, productivity, fertilizers, doses, gibberellin.

ВЛИЯНИЕ МИНЕРАЛЬНЫХ УДОБРЕНИЙ И ГИББЕРЕЛЛИНОВ НА РОСТ, РАЗВИТИЕ И УРОЖАЙНОСТЬ ФАСОЛИ (*PHASEOLUS VULGARIS L.*), ВЫРАЩИВАЕМОЙ В ПРОВИНЦИИ КАПИСА, АФГАНИСТАН

Научная статья

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Аннотация

Исследование проводилось на испытательном полигоне сельскохозяйственного факультета Университета Альберони в Каписе, Афганистан, с целью изучения влияния различных количеств NPK и G на сельскохозяйственные характеристики фасоли обыкновенной в период с июня по сентябрь 2022–24 годов. В рамках исследования использовался рандомизированный комплексный подход с тремя повторениями для каждого состояния. В общей сложности шестнадцать состояний, включая контрольное, были оценены, как описано ниже. Результаты показали, что применение различных норм внесения NPK и G привело к заметному улучшению как роста, так и производства бобов. Самые высокие экземпляры (100,5 см) были получены при внесении азота в количестве 60 кг на гектар, фосфора в количестве 60 кг на гектар, калия в количестве 30 кг на гектар, а также гиббереллина в количестве 300 частей на миллион; при этом условии также была получена самая высокая сухая биомасса на экземпляр (7,1 г). Максимальное количество коробочек на образец (11,78) было достигнуто при использовании N60P60K30+GA200, в то время как максимальное количество семян на образец (64,70) было получено при использовании A11, что превзошло другие показатели. Кроме того, при обработке A13 значительно повышалась семенная продуктивность. Это наглядно иллюстрирует благоприятную роль NPK и G на продуктивность фасоли обыкновенной. Максимальная урожайность семян (2,01 т/га) была получена при обработке A13, которая статистически отличалась от других обработок. Таким образом, полученные результаты свидетельствуют о том, что совместное внесение NPK и G может значительно улучшить рост и урожайность фасоли обыкновенной. Важно отметить, что обработка с использованием азота в дозе 60 кг/га, фосфора в дозе 60 кг/га, калия в дозе 30 кг/га и гиббереллина в различных концентрациях дала наиболее благоприятные результаты с точки зрения высоты растений, сухой биомассы, количества стручков и семян на образец, массы 1000 семян и общего урожая семян.

Ключевые слова: фасоль, урожайность, удобрения, дозы, гиббереллин.

Introduction

The common bean (*Phaseolus vulgaris L.*) is an essential legume widely utilized for human consumption. Renowned for its great protein content, pulses serve as an excellent dietary source, offering a blend of carbohydrates, nutritional fiber, and necessary minerals, as noted by nutritionists. While the health benefits and nutritional worth of legumes are well established [1], their beneficial role in agricultural systems is frequently underestimated. pulses contribute significantly to sustainability of agriculture, particularly within intricate cropping systems. This short-duration leguminous plant hosts rhizobia, which are crucial for biological N-fixation [2], and it generally has a low carbon footprint associated to other pulses [3]. The reliance on energy-intensive nitrogen fertilizers is minimized, making pulses a key player in reducing greenhouse gas emissions. Additionally, the common bean is a nutrient-rich diet that maintains stability during post-harvest storage. In terms of regional production, Asia tops with approximately 43% of global output, followed by the Americas—North, Central, and South America (29%), and Africa (26%) [4]. Europe and Oceania give around 2% of total production. These statistics indicate that the growing in production over the past thirty years cannot solely be attributed to raised cultivation area; rather, it has yielded from advancements in bean breeding (genetics) and enhanced agronomic practices. Over the last six decades, selective breeding and genetics have significantly enhanced crop yield and quality. Investigation by Vandemark et al. (2017) [5] revealed an average annual yield growth of 12.9 kg/ha across all market classes of beans in the United States from 1909 to 2012. These yield improvements are primarily linked to the selection of plant types with enhanced disease and pest resistance. Moreover, the adoption of effective agronomic practices has maximized crop integrity [6]. These efforts have bolstered the value and potential of common bean yield, contributing positively to nutrition security. As a food crop that is typically consumed directly, common bean requires minimal processing before they reach consumers. A crucial contribution to food security and the fight against malnutrition is made by common bean [7]. It is important to highlight that more than 300 million individuals globally incorporate beans into their daily meals each year. The application of regulators (PGRs) presents a strategy for increasing yield, enhance crop quality, and managing the uptake and accumulation of essential mineral nutrients in plants. Gibberellin (G) is significant PGRs that influence crop growth and development by stimulating metabolic processes and optimizing nitrogen utilization [8]. They play a vital role in seed germination, endosperm mobilization, stem elongation, leaf expansion, reducing maturation time, and enhancing flower and fruit set, along with their composition [9]. It also helps to delay senescence, improves the growth and development of chloroplasts, and increases photosynthetic efficiency, potentially leading to higher yields [10]. The research offers valuable insights into the potential advantages of integrated nutrient management and growth promotion strategies for enhancing bean yields in Afghanistan, thereby contributing for overarching goal of improving agricultural sustainability in state.

In Afghanistan, legumes are careful the primary sources of dietary protein, with common bean (*Phaseolus vulgaris L.*), chickpeas (*Cicer arietinum*), peas (*Pisum sativum*), lentils (*Lens culinaris*), mung beans (*Vigna radiata*), and faba beans (*Vicia faba*) being commonly consumed. Due to the prevalent cultivation of various plants throughout the country, the usage of fertilizers remains minimal, effective and applicable rates take yet to be established, and outdated agricultural practices continue to be employed.

The experience objectives identify to the most effective combinations and concentrations fertilizer and phytohormone that promote optimal development and harvest of beans in the northeastern region of Afghanistan, specifically in Kapisa province.

Research methods and principles

This research was performed at the Crop Research site of Alberoni University, Kapisa, Afghanistan, from 2022 to 2024. It is located at a latitude of 35.0439 and a longitude of 69.2748, approximately 1500 m overhead marine level. The yearly precipitation is around 400 mm, with most rainfall occurring during the winter and spring periods, while summer temperatures fluctuate between 25 to 40 °C. The data on rainfall, along with maximum, minimum, and average heats due to the study period, are illustrated in Fig 1 and Fig 2.

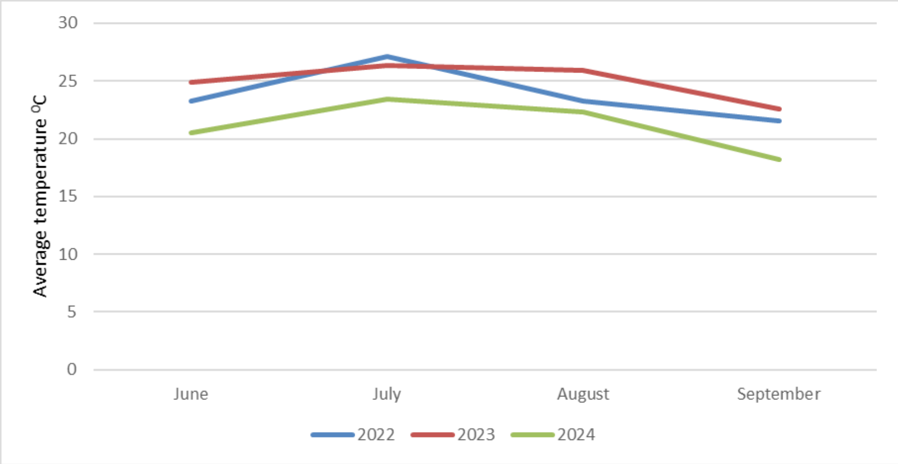

Figure 1 - Agrometeorological data when conducting experiments on the region of Alberoni University, Kapisa, Afghanistan in 2022–2024

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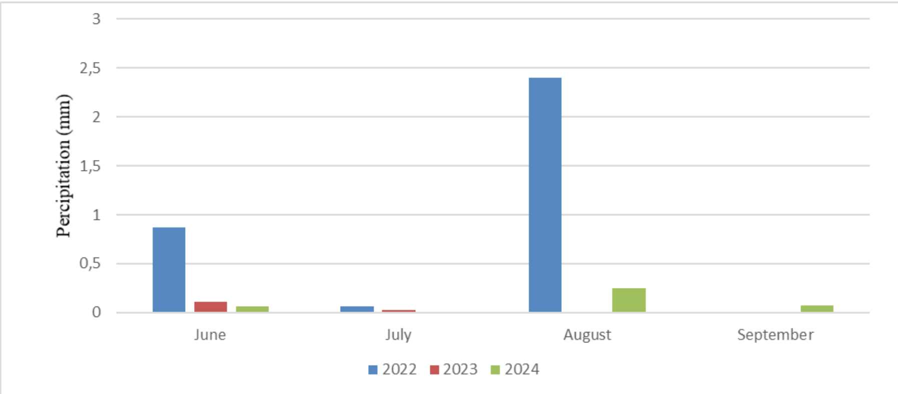

Figure 2 - Agrometeorological data when conducting experiments on the region of Alberoni University, Kapisa, Afghanistan in 2022–2024

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The agrochemical analysis of the soil was done at the Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, revealing that the soil exhibited a relatively alkaline reaction (initial pH = 8.10, post-cultivation pH = 8.52). The soil was identified as having low organic matter content, with humus levels decreasing from 1.95% to 1.75% after cultivation. Additionally, it was found to have low levels of available nitrogen, dropping from 0.10% to 0.07% following the cultivation period. The availability of phosphorus (P2O5) was also low, with values decreasing from 13.55 mg/kg to 12.32 mg/kg after cultivation. Similarly, the potassium content (K2O) was low, showing a reduction from 96.33 mg/kg to 90.5 mg/kg after the growing season, as summarized in Table 1.

Table 1 - Agrochemical characteristics of the soil of the experimental plot

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Soil properties	Value
pH before and after cultivation	8.10 and 8.52
Humus before and after cultivation (%)	1.95 and 1.75
Nitrogen before and after cultivation (%)	0.10 and 0.075
Phosphorus before and after cultivation mg/kg	13.55 and 12.32
Potassium before and after cultivation g /kg	96.33 and 90.50

The research was structured using a complete randomized block design, comprising a total of sixteen treatments, including a control, and replicated three times. The specific treatment combinations are outlined in Table 2, which details the investigational arrangement. In this seeking selected variety was Rosecoco (GPL2). Data evaluation was conducted using the OPSTATS online software for statistical analysis.

Table 2 - Scheme of field experience

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Block 1		Block 2	Block 3
A_1	Control	GA_{300}	$N_{60}P_{60}K_{30}+GA_{100}$
A_2	$N_{30}P_{20}K_{10}+GA_0$	GA_{200}	$N_{60}P_{60}K_{30}+GA_{200}$
A_3	$N_{30}P_{20}K_{10}+GA_{100}$	GA_{100}	$N_{60}P_{60}K_{30}+GA_{300}$
A_4	$N_{30}P_{20}K_{10}+GA_{200}$	$N_{60}P_{60}K_{30}+GA_{300}$	GA_{300}
A_5	$N_{30}P_{20}K_{10}+GA_{300}$	$N_{60}P_{60}K_{30}+GA_{200}$	GA_{200}
A_6	$N_{45}P_{40}K_{20}+GA_0$	$N_{60}P_{60}K_{30}+GA_{100}$	Control
A_7	$N_{45}P_{40}K_{20}+GA_{100}$	$N_{60}P_{60}K_{30}+GA_0$	GA_{100}
A_8	$N_{45}P_{40}K_{20}+GA_{200}$	$N_{45}P_{40}K_{20}+GA_{300}$	$N_{30}P_{20}K_{10}+GA_0$
A_9	$N_{45}P_{40}K_{20}+GA_{300}$	$N_{45}P_{40}K_{20}+GA_{200}$	$N_{30}P_{20}K_{10}+GA_{100}$
A_{10}	$N_{60}P_{60}K_{30}+GA_0$	$N_{45}P_{40}K_{20}+GA_{100}$	$N_{30}P_{20}K_{10}+GA_{200}$
A_{11}	$N_{60}P_{60}K_{30}+GA_{100}$	$N_{45}P_{40}K_{20}+GA_0$	$N_{30}P_{20}K_{10}+GA_{300}$
A_{12}	$N_{60}P_{60}K_{30}+GA_{200}$	$N_{30}P_{20}K_{10}+GA_{300}$	$N_{45}P_{40}K_{20}+GA_0$
A_{13}	$N_{60}P_{60}K_{30}+GA_{300}$	$N_{30}P_{20}K_{10}+GA_{200}$	$N_{45}P_{40}K_{20}+GA_{100}$
A_{14}	GA_{100}	$N_{30}P_{20}K_{10}+GA_{100}$	$N_{45}P_{40}K_{20}+GA_{200}$
A_{15}	GA_{200}	$N_{30}P_{20}K_{10}+GA_0$	$N_{45}P_{40}K_{20}+GA_{300}$
A_{16}	GA_{300}	Control	$N_{60}P_{60}K_{30}+GA_0$

Note: 2022-2024

Main results

3.1. Plant height

The analysis of plant height in relation to numerous use of NPK and G is summarized in Table 3. It shown that the common bean plants exhibited a significant increase in height due to the diverse measures of these NPK and G applied. Both NPK and G treatments had a pronounced influence on plant height when over to the control. The tallest plants, reaching a height of 100.5 cm, were achieved by application of A13. In contrast, the control exhibited the shortest plant height (68.5 cm), aligning with the observations made by Singh et al. in 2014 [11].

3.2. Dry matter plant

The data regarding the dry mass of beans affected by dissimilar levels of NPK and G are compiled in Table 3.

Table 3 - Effect NPK fertilizer and gibberellin on plant height and dry matter of beans 2022-24

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Treatments	Plant height, cm	Dry matter per plant, g
A_1	68.5	3.5
A_2	83.6	5.2
A_3	84.8	5.1
A_4	85.6	5.4
A_5	93.1	5.4
A_6	83.1	5.6
A_7	86.9	6.0
A_8	92.7	6.4
A_9	92.2	6.5
A_{10}	85.5	5.7
A_{11}	92.2	6.5
A_{12}	94.5	6.8
A_{13}	100.5	7.0
A_{14}	77.6	6.1
A_{15}	82.3	6.3
A_{16}	86.8	6.4

LSD $_{0.05}$	4.3	0.9

The dry mass of bean plants showed a significant increase when unlike levels of NPK and G were applied. The outcomes indicated that the use of these nutrients had a profound impression on the dry weight of the plants, equated to the control and other treatments. The peak dry mass reached was 7.1 grams, achieved with A13, This results statistically similar with A8, A9, A11, A12, A14, A15 and A16. In contrast, the control exhibited the lowest dry mass at 3.5 grams, corroborating findings by Meseret and Mohammed in 2014 [12].

3.3. Number of pods plant

The use of varying rates of NPK and G had a significant effect on the numeral of pods produced per plant, as illustrated in Table 4. The all-out number of pods per plant was recorded at 11.8, subsequent from the combination of A12, excepting control, A2, A6, A14 and A15 it was at par with rest treatments. Conversely, the control showed the least number of pods per plant at 6.3. It is noteworthy that fewer pods were observed on the lower branches, paralleled to the upper sections of the main stem. This observation is consistent with the findings reported by Tuarira and Moses in 2014 [13].

Table 4 - Affection of NPK and G on beans morphology and yield of seeds during 2022-24

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Treatments	Number of pods per plant	Number of seed per plant	1000 seed weigh (g)	Seed yield (t/ha)
A_1	6.3	26.4	231.7	0.9
A_2	8.5	37.9	239.2	1.1
A_3	10.9	59.2	256.7	1.3
A_4	9.7	48.8	268.3	1.2
A_5	9.8	48.9	272.0	1.2
A_6	8.1	40.7	255.6	1.1
A_7	10.9	51.5	279.0	1.4
A_8	10.4	55.2	276.1	1.5
A_9	9.3	53.4	283.5	1.3
A_{10}	9.3	47.7	269.7	1.2
A_{11}	11.7	64.7	317.0	1.7
A_{12}	11.8	64.6	291.3	1.8
A_{13}	11.6	63.8	289.2	2.0
A_{14}	8.8	44.4	264.3	1.0
A_{15}	8.9	44.9	268.9	1.0
A_{16}	10.2	51.6	272.8	1.1
LSD $_{0.05}$	2.7	12.4	20.1	0.3

3.4. Number of seed per plant

The use of NPK and G led to a notable increase in the number of seeds produced per plant, as illustrated in Table 4. The higher count of seeds per plant (64.7) was achieved with the treatment comprising A11, which was similar with A8, A9, A11 and A12. Each of the applied NPK and G treatments resulted in a major rise in seed count compared to the control. In contrast, the control recorded the lowest seed count (26.4). These results corroborate the findings of Vemulakonda, et al., 2024 [14].

3.5. 1000 seed weight

The study revealed a notable impact on the 1000 seed weight measurements. The combination treatment A_{11} resulted in the highest 1000-seed weight of 317g, except A_{12}, A_{13} better than other treatments. Conversely, the control demonstrated the lowest weight, measuring 231.7g, leading to a significant difference of 85.3g, as detailed in Table 4 and illustrated in Fig 3. These results align with the findings documented by Abdel Latif Y Idris in 2008 [15].

3.6. Seed yield

The data analysis indicates that the application of NPK fertilizers and G had a significant impact on the seed yield of beans, during the period of 2022–24, as shown in Table 4 and Fig 3. Furthermore, the maximum seed yield (2 t/ha) was noted from the A13, which was statistically obviously better than all other treatments. Conversely, the lowest seed yield (0.9 t/ha) was recorded in the control. The application of NPK, and G resulted in beneficial effects on yield and improved yield characteristics, with the most significant increases observed at higher levels of these nutrients. Similar outcomes were reported by Vemulakonda, et al., in 2024 [14].

Figure 3 - The productivities of seed yield by ton per hectare and weight of 1000 seeds counted with gram during field seasons 2022-2024

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3.7. 1000 seed weight

The research exhibited a significant effect of the data on 1000 seed weight. The treatment of N at 60 kg/ha, P at 60 kg/ha, K at 30 kg/ha + GA at 100 ppm recorded the maximum seed weight of 317g. In contrast, the control treatment showed the minimum weight of 231.7 g per 1000 seeds, resulting in a difference of 85.3g, which is the data related to 1000 seed weight inserted in Table 4 and Fig 3. These findings are consistent with the results reported by Abdel Latif Y Idris in 2008 [15].

Conclusion

It turned up significant enhancements in growth and yield through specific nutrient combinations, particularly a mixture of A13, which led to the best results. The findings point out the importance of managing nutrients and growth regulators to boost bean production, suggesting that the right combinations can enhance agricultural outputs. These results are promising for Afghan bean farmers, as they could improve crop performance and profitability. Future studies should focus on finding the best nutrient mixes for different bean varieties and soil conditions to optimize farming practices.

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Конфликт интересов

Не указан.

Conflict of Interest

None declared.

Рецензия

Все статьи проходят рецензирование. Но рецензент или автор статьи предпочли не публиковать рецензию к этой статье в открытом доступе. Рецензия может быть предоставлена компетентным органам по запросу.

Review

All articles are peer-reviewed. But the reviewer or the author of the article chose not to publish a review of this article in the public domain. The review can be provided to the competent authorities upon request.

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