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Ann PUBLISHER
Journal of Agricultural Sciences (Agrosci)
e ISSN 3074-2423
p ISSN 3032-7547

The Effect of NPK Fertilizer on Yield and Seed Quality of Jack Bean *(Canavalia ensiformis)* and Velvet Bean *(Mucuna pruriens)*

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Abstract.
Background. *Mucuna pruriens* and *Canavalia ensiformis* are two legumes that can be used as plant-based protein sources to replace soybeans. However, these plants have a lower yield compared to soybeans.
Aims. This study aims to determine the effect of NPK fertilizer doses on the yield and quality of *M. pruriens* and *C. ensiformis* seeds.
Methods. This research was conducted in Nanggela Village, Mandirancan District, Kuningan Regency, West Java, from June to November 2024. The experimental design used was a Randomized Complete Block Design (RCBD) with ten treatment combinations between jack bean and velvet bean with NPK fertilizer doses (150, 225, 300, 375, and 450 kg ha^{-1}).
Result. The research results show that the application of NPK fertilizer doses significantly affects the N, P, and protein content in jack bean and velvet bean seeds but not on the K and total fat content.
Conclusion. The weight of pods per plot and the weight of seeds per plot were significantly affected by the NPK fertilizer dosage and the species of jack bean and velvet bean.
Implementation. NPK fertiliser can be applied 150 to 450 kg ha^{-1}.

Keywords: NPK, Seed Quality, Legume, Protein

INTRODUCTION

Protein is an essential nutrient for the human body. The latest international recommendation for protein intake for adults is 0.9-1.3 kg day^{-1} or about 63-91 g day^{-1} for those weighing 70 kg (Nishimura *et al*., 2023). However, not everyone can meet their daily protein needs. The nutritional status of most people in the world is severely hindered by food insecurity (Udeh *et al.*, 2021).

Legumes are one of the sources of plant-based protein that can replace animal protein (Purwandari *et al*., 2023). The type of bean most commonly used is soybeans. Efforts to increase soybean production continue, but they have not yet been able to meet national demand. Considering that national soybean production has not yet met food needs, diversifying local types of beans becomes an alternative for the community because they have nutritional value and taste that are on par with soybeans (Winarti *et al.*, 2020).

Jack bean (*Canavalia ensiformis)* and velvet bean *(Mucuna pruriens)* are potential sources of plant-based protein. However, these two species of beans are less popular compared to mung beans and soybeans. This is because the average yield of these jack bean and velvet bean is lower compared to mung beans and soybeans. Efforts to increase yield can be done by fertilization.

Fertilization is the process of adding fertilizer to the soil to increase the nutrient content in the soil so that plants grow optimally (Nurbateun *et al*., 2017). NPK fertilizer is a compound fertilizer comprising nitrogen (N), phosphorus (P), and potassium (K). The application of NPK fertilization substantially affected plant weight (Loeman et al., 2022). In soil with low nitrogen levels, the addition of nitrogen will promote the growth of rhizobia, resulting in facilitating the growth of legume seedlings (Yin *et al*., 2018). The incorporation of phosphorus can improve root development, drought resilience, nutrient and water uptake in plants, along with disease resistance (Jin *et al*., 2015). The utilization of potassium enhances plant height, stem diameter, and potassium concentration. The treatment of potassium positively affects various strains/plants, 1000 seed weight, and seed output (Badawy *et al*., 2019).

NPK fertilizer has varying effects on the growth and yield of legumes. The application of NPK fertilizer has a significant effect on both the growth and yield of cowpea in Nigerian pastures (Nasidi *et al*., 2024). Other research results show that fertilizing with NPK 16:16:16 at a rate of 300 kg/ha on fairly fertile soil does not have a significant effect on the growth of jack bean (Soedarjo, 2021). However, there is still limited information available on the effect of fertilizers on the quality of jack bean seeds.

Information the effect of NPK fertilizer on the yield, and seed quality of jack bean and velvet bean is still limited. This research aims to determine the effect of NPK fertilizer doses on the growth, yield, and seed quality of jack bean and velvet bean.

LITERATURE REVIEW

Jack beans (*Canavalia ensiformis*) is one type of local bean that belongs to the legume group, known as jack bean, botanically, legumes belong to the Fabaceae family of Angiospermae (Popoola *et al*., 2017). Jack bean is one of the legumes that has long been known in Indonesia. jack bean can be used as an alternative to replace soybeans because its nutritional content is comparable to that of soybeans (Winarti *et al*., 2020). Jack bean has a protein content of 28.6%. Jack bean has the potential to be developed as a protein source food based on its high protein content (Paramita *et al*., 2023).

Velvet beans *(Mucuna pruriens*) belongs to the Fabaceae family (Pathania *et al*., 2020). In Indonesia, this bean is known as kacang benguk. The velvet bean can adapt and grow in P-limited soil by symbiosis with several genera of bacteria and arbuscular mycorrhizal fungi (Magadlela *et al*., 2020). Therefore, velvet beans can be used as green manure and for the rehabilitation of land deficient in N and P nutrients.

NPK fertilizer is a compound fertilizer that contains the nutrients nitrogen (N), phosphorus (P), and potassium (K) which are necessary for plant growth and development. Fertilizing using NPK efficiently can improve the quality of crop yields, soil quality, and enhance the nutrients present in the plants (Budiono *et al*., 2019).

During the metabolism process, the availability of nutrients is very important for the formation of proteins, enzymes, hormones, and carbohydrates. therefore, it will enhance the cell division process in plant tissues, which will affect the formation of buds, root growth, and leaf growth, thereby increasing the wet and dry weight of the plant's branches (Safira *et al*., 2019).

According to Ramadhan *et al*., (2022), nitrogen element in fertilizers forms a component of organic substances in seeds, including amino acids, proteins, coenzymes, chlorophyll, and various other components. Consequently, the application of nitrogen-containing fertilizers to plants will promote growth. In soil with low nitrogen levels, the addition of nitrogen will promote rhizobia development, thus enhancing legume plant growth (Yin *et al*., 2018) . Nitrogen significantly influences proteins and protoplasm, which contribute to the augmentation of plant weight. Nitrogen exists in two inorganic forms: ammonium (NH_4^+) and nitrate (NO_3^-) (Yin *et al*., 2018).

Phosphorus (P) is a crucial element for plants, providing as a structural component in organic compounds present in the plant body, including the cell nucleus, cytoplasm, cell

membrane, and reproductive structures such as flowers, stamens, stigmas, pollen grains, and ovules.(Aslamiah & Sularno, 2017).

Potassium (K) is an element that acts as a stomatal opener in plants, affecting root development and fortifying the stem, so enhancing the plant's strength and nutrition absorption capabilities.(Nora Katrin *et al*., 2021).

NPK may affect protein content since nitrogen (N) is a component of amino acids (Cahyanti *et al*., 2021). The amount of balanced and sufficient NPK in the soil will lead to optimal plant growth, including enough protein synthesis. An absence of one or more of these NPK components may disrupt protein synthesis and decrease the protein content in plant yields.

METHODS

The study was conducted at Nanggela Village, Mandirancan District, Kuningan Regency, at an altitude of 260 m above sea level, with temperatures average 26°C to 31°C, and average relative humidity of 70%. The experiment was done from June to November 2024. The tools used were hoes, measuring tapes, stakes, callipers, and writing instruments. Material used were jack bean and velvet bean seeds, and NPK Mutiara fertilizer. The research method is an experimental method with randomized complete block design (RCBD). The treatments tested were a combination of bean species (jack bean and velvet bean) with NPK fertilizer doses (150, 225, 300, 375, and 450 kg ha^{-1}). Each treatment was repeated three times so that there were 30 experimental units.

The size of the plot are 200 cm x 300 cm, with a planting spacing of 50 cm x 50 cm. Seeds are inserted into the planting holes at a rate of two seeds per hole. Fertilization occurs only once, at 14 days after planting (DAP), with a dosage according to the treatment. The beans are harvested at 120 to 150 DAP, with characterized by a change of the pods color to straw yellow or yellowish-brown hues.

The observed yield component and yield variables were number of pod per plot, pod weight per plot, seed weight per plot, weight of 100 seeds, pods per plant, and pods per plot. The seed quality variables observed were N, P, K content, and protein and lipid total. The observational data analysed by variance analysis (F-test). The post hoc test with Duncan's multiple range test at a 5%.

The method to determine total nitrogen content used trimetric analysis, phosphorus content used spectrophotometric analysis, and potassium content is determined by atomic

absorption spectroscopy (AAS). The protein content is determined through the conversion of total nitrogen, while the total fat content is assessed through gravimetric analysis.

DISCUSSION

Yield component and yield

Table 1 presents the results of the statistical analysis of the effect of NPK fertilizer dosage on the yield components and yield of jack bean and velvet bean. The combination between NPK dosages and koro species significantly affected to the number of pods per plot; the weight of pods per plot, the weight of 100 seeds, and the weight of seeds per plot. The weight of 100 seeds indicates that jack bean seeds (A to E) are considerably larger than velvet bean seeds (F to J).

Table 1. Yield Component and Yield Jack Bean and Velvet Bean with Different NPK Doses

Treat	Number of Pod per Plot		Pod Weight per Plot (g)		Weight of 100 Seeds (g)		Seed Weight per Plot (g)	
JB (150kg/Ha)	57.00	a	1628.00	ab	123.20	b	899.26	ab
JB (225kg/Ha)	265.00	b	1630.20	ab	123.97	b	923.06	ab
JB (300kg/Ha)	69.33	a	2059.16	b	123.23	b	1171.73	b
JB (375kg/Ha)	48.67	a	1393.67	ab	121.20	b	774.43	ab
JB (450kg/Ha)	51.67	a	1508.67	ab	126.50	b	846.46	ab
VB (150kg/Ha)	76.00	a	471.67	ab	73.00	a	228.23	a
VB (225kg/Ha)	33.00	a	204.33	a	76.56	a	98.86	a
VB (300kg/Ha)	51.00	a	285.33	a	69.70	a	122.26	a
VB (375kg/Ha)	67.33	a	415.67	ab	79.46	a	201.10	a
VB (450kg/Ha)	64.00	a	383.00	ab	75.46	a	178.86	a

Note:Numbers followed by the same letter in the same column are not significantly different according to the Duncan's Multiple Range Test at the 5% level. JB = Jack Bean, VB = Velvet Bean

This results different with Giawa & Harahap, (2024) which indicate that NPK fertilizer doses significantly affect the number of pod per plot. fortunately the outcomes of this study align with the conclusions of Hanafi *et al*., (2016) research showed that NPK fertilizer dose significantly affected the weight of long bean pods. In soybean cv. Grobogan, NPK fertilizer significantly affected the total number of pod and seed weight per plat (Bayyani Roswy & Sudiarso, 2022). In this study, the difference in NPK fertilizer dosage did not provide a significant difference in the yield components and results of the same species. It seems that this difference is due to the morphological differences between jack bean and velvet bean.

Arangote *et al*., (2019) Indicating that nitrogen application enhances the chemical composition of seeds without influencing seed size. Photosynthesis provides an important source during seed filling, before to this stage, the absorbed products are utilized for vegetative growth. The nutrient elements that effect seed production include phosphorus (P) and calcium (Ca), obtained from NPK fertilizer, with phosphorus specifically contributing to the development of flowers, fruits, and seeds.

Content of N, P, and K in seed

The statistical analysis results demonstrate that the NPK fertilizer dosage significantly influences the nitrogen (N) and phosphorus (P) content, whereas it does not significantly affect the potassium (K) content in the seeds of both koro bean species (Table 2). The results of the study showed that the N and P content of jack bean seeds tended to be higher than velvet bean seeds, but there was no difference in the K content of the two species.

Table 2. NPK Levels in the Seeds of Jack Bean and Velvet Bean with Different NPK Doses

Treat	N (%)	P (%)	K (%)
JB (150kg/Ha)	3.65 abc	0.15 a	1.12 a
JB (225kg/Ha)	3.59 abc	0.17 a	1.20 a
JB (300kg/Ha)	3.79 abcd	0.18 a	1.30 a
JB (375kg/Ha)	3.43 a	0.16 a	1.13 a
JB (450kg/Ha)	3.52 ab	0.18 a	1.18 a
VB (150kg/Ha)	4.12 cd	0.26 b	1.10 a
VB (225kg/Ha)	4.41 d	0.29 b	1.23 a
VB (300kg/Ha)	4.20 cd	0.28 b	1.14 a
VB (375kg/Ha)	4.11 bcd	0.27 b	1.16 a
VB (450kg/Ha)	3.95 abcd	0.26 b	1.26 a

Note: Numbers followed by the same letter in the same column are not significantly different according to the Duncan's Multiple Range Test at the 5% level. JB = Jack Bean, VB = Velvet Bean

Nitrogen, phosphorus, and potassium are macronutrients essential for plant growth; their adequate availability significantly promotes growth, particularly during the generative and vegetative stage (Bayyani Roswy & Sudiarso, 2022). Legume plants require less nitrogen from the soil, as they assimilate a significant portion of atmospheric nitrogen with the assistance of *Rhizobium* spp. The nitrogen assimilated by the plants from the NPK fertilizer will be disseminated throughout the plant, including the seeds, consequently enhancing the nitrogen concentration and protein levels in the seeds of both koro bean

species. This aligns with the research (Ramadhan et al., 2022b). Nitrogen (N), contained in NPK fertilizer, is an essential element in the organic composition of seeds, encompassing amino acids, proteins, coenzymes, chlorophyll, and other constituents. The application of nitrogen-containing fertilizers on plants can substantially increase nitrogen levels in mung bean plants.

Utilization of varying NPK doses do not have a significant effect on phosphorus content in seeds, as indicated by (Rifhat *et al*., 2023), which states that that NPK fertilizer application does not significantly affect the phosphorus content in mung bean seeds. Chekanai *et al*. (2018) pointed out that phosphorus fertilization significantly impacts only on deteriorated soil.

Protein and fat total content in seed

The statistical analysis indicated that NPK fertilizer concentrations considerably increase protein content, but total fat remains unaffected in both species (Table 3). Nitrogen is the primary element in protein synthesis; hence, an increased nitrogen content in bean seeds correlates with elevated protein levels. The protein content of jack beans tends to be lower when compared to velvet beans. Fertilization up to 300 kg/Ha tends to increase protein in jack beans but in velvet beans fertilization of more than 225 kg/Ha can reduce protein content.

Hendri et al., (2015) asserted that NPK can affect protein composition due to nitrogen (N) being a constituent of amino acids, amides, and proteins, which are essential for plant growth and protein synthesis. Tando, (2019) indicates that organic nitrogen in the soil is immediately transformed into amino acids, which subsequently synthesize functional proteins that are allocated to actively developing young cells, consequently promoting substantial vegetative growth in plants.

The phosphorus element that can be assimilated by plants increases ATP formation, consequently enhancing the rate of photosynthesis, which in turn generates ideal photosynthates, increasing an increase of protein content and seed development in both species of koro beans. This aligns with the assertion by Irwan & Nurmala, (2018), which elucidates that the quantity of pods produced is affected by the macronutrient phosphorus, which is vital to floral development. These nutrients are employed for seed maturation, protein synthesis, and the neutralization of organic acids generated during metabolism.

Table 3. Protein and Total Fat Content in Seeds of Jack Bean and Velvet Bean with Different NPK Doses

Treat	Protein (%)		Fat (%)	
JB (150kg/Ha)	22.85	abc	4.05	a
JB (225kg/Ha)	22.45	abc	3.78	a
JB (300kg/Ha)	23.68	abcd	3.21	a
JB (375kg/Ha)	21.47	a	3.40	a
JB (450kg/Ha)	22.00	ab	4.11	a
VB (150kg/Ha)	26.57	cd	3.92	a
VB (225kg/Ha)	27.58	d	3.97	a
VB (300kg/Ha)	26.35	cd	4.21	a
VB (375kg/Ha)	25.74	bcd	3.72	a
VB (450kg/Ha)	24.70	abcd	4.38	a

Note: Numbers followed by the same letter in the same column are not significantly different according to the Duncan's Multiple Range Test at the 5% level. JB = Jack Bean, VB = Velvet Bean

The protein content in jack bean seeds (22.48%) and velvet bean seeds (26.10%) higher than soybean seeds (20.8%) (Asrivananda MA *et al*., 2023) and mung bean seeds (20-25%) (Suksesty & Ikhlasiah, 2017). The average total fat content in jack bean seeds (3.84%) and velvet bean seeds (4.04%) is lower than that of soybeans (12-15%) (Asrivananda MA *et al*., 2023) but exceeds mung beans fat content (1.64 %) (Aminah dan Hersoelistyorini, 2012). This suggests that both jack bean and velvet bean may serve as an alternative source of plant-based protein to substitute soybeans.

CONCLUSION

The research shows that varying doses of NPK fertilizer have a significant effect to pod weight per plot, 100-seed weight, and seed weight per plot, nitrogen (N), phosphorus (P) content, and protein total in seed, but not on potassium (K) and total fat in both species. The utilization of NPK fertilizer doses increases the yield components and overall yield of jack bean and velvet bean. The N and total protein content in seeds were significantly affected by the combination of species and NPK fertilizer doses. This indicates that the protein content in seeds can be increased through fertilization. The relatively high protein content in jack bean and velvet bean indicates that these two species have the potential to replace soybeans as a source of vegetable protein.

ACKNOWLEDGEMENT

Gratitude is expressed to the Research Institute of Universitas Swadaya Gunung Jati which has funded this research through the University Research Grant for Fundamental Research scheme for the 2024.

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