



Research Article

# Investigating the Influence of Fertilizer Application Rates on Soybean Yield Across Diverse Locations

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## Abstract

This study investigated the impact of varying fertilizer application rates on soybean yield and agronomic characteristics in three distinct locations within Lao PDR (Laos People's Democratic Republic-Lao PDR): the Rice and Cash Crop Research Center (RCCRC), the Faculty of Agriculture Nabong Campus (National University of Laos, NUoL), and the Faculty of Agriculture and Environment Nongpheu Campus (Savannakhet University, SKU). The field experiment was conducted during the 2022 growing season (August to December) using a randomized complete block design (RCBD) with three replications. Five fertilizer treatments were applied to a total of 15 experimental units, encompassing varying combinations and rates of organic and inorganic fertilizers. Agronomic traits, including plant height, number of branches, pods per plant, individual plant weight, 100-seed weight, and grain yield, were measured at maturity. Data analysis was performed using Statistix 10.0 software with a significance level of 95% ( $P < 0.05$ ). Significant differences ( $P < 0.01$ ) were observed among the fertilizer treatments for the number of branches, pods per plant, individual plant weight, and ultimately, grain yield. However, plant height and 100-seed weight were not significantly affected by the different fertilizer applications ( $P > 0.05$ ). The highest grain yields were achieved with the application of organic fertilizer at a rate of 2,000 kg/ha (2.48 t/ha) and a combination of organic fertilizer at 1,000 kg/ha with inorganic fertilizer at 100 kg/ha (2.57 t/ha). Conversely, the control treatment, which received no fertilizer, resulted in the lowest grain yield. These results highlight the importance of fertilizer management strategies in optimizing soybean production in Lao PDR. Further research is needed to assess the long-term effects of these fertilizer regimes on soil health and environmental sustainability.

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## Keywords

Soybean, Chemical, Organic, Fertilizer

## 1. Introduction

Soybean (*Glycine max* (L.) Merr.) is a globally significant legume crop, providing essential protein, oil, and fiber for human and animal consumption. In Laos, soybeans are a crucial component of the agricultural sector and contribute to both domestic food security and export markets. However, soybean production in Laos faces challenges, including declining cultivation areas and the need to increase yields to meet growing demand.

Fertilizer management plays a critical role in enhancing soybean productivity. Organic fertilizers, such as compost and manure, can improve soil health and nutrient availability, while inorganic fertilizers provide a concentrated source of essential nutrients like nitrogen, phosphorus, and potassium. The combined use of organic and inorganic fertilizers has been shown to have synergistic effects on soybean yield and quality.

Hasan had reported the impact of different fertilizer regimes on soybean production. For instance, found that the combined application of organic and inorganic fertilizers significantly increased soybean yield in saline agro-ecosystems in Bangladesh [1]. Similarly, Abbas reported that integrated nutrient management strategies, incorporating both organic and inorganic fertilizers, enhanced soybean productivity in Egypt [2].

In addition to fertilizer management, other factors influencing soybean yield include soil conditions, planting practices, and pest and disease control. Site-specific fertilizer recommendations, considering soil type, climate, and other environmental factors, are crucial for optimizing soybean production.

This study aims to investigate the influence of varying fertilizer application rates on soybean yield and agronomic characteristics in three diverse locations within Lao PDR. The findings will contribute to the development of sustainable and effective fertilizer management strategies for soybean production in Laos and other similar agricultural contexts.

## 2. Materials and Methods

### Experimental Design and Treatments

The field experiment was conducted during the 2022 growing season (August - December) at three locations in Laos: Rice and Cash Crop Research Center (RCCRC), Na-

tional Agriculture and Forestry Research Institute (NAFRI), Vientiane Capital, Lao PDR. Faculty of Agriculture Nabong Campus (NUoL), National University of Laos, Vientiane Capital, Lao PDR. Faculty of Agriculture and Environment Nongpheu Campus (SKU), Savannakhet University, Savannakhet Province, Lao PDR.

A randomized complete block design (RCBD) with three replicates was employed at each location. Five fertilizer treatments (T) were implemented:

T1: Control (no fertilizer)

T2: Chemical fertilizer (NPK 15:15:15) at 300 kg/ha

T3: Chemical fertilizer (NPK 15:15:15) at 200 kg/ha

T4: Combined fertilizer (NPK 15:15:15) at 100 kg/ha + Organic fertilizer at 1,000 kg/ha

T5: Organic fertilizer at 2,000 kg/ha

Each experimental unit was a 4 m x 4 m plot. Sowing distance within plots was 20 cm between plants and 40 cm between rows. Three to five seeds were drilled per hole at a depth of 5-8 cm. After 5-7 days, seedlings were thinned to three plants per hole. This planting design and management were consistent across all three locations.

### Plant Material

Napok 1 soybean variety, derived from a cross between DT 12 and SJ 5 in 2008 at RCCRC, was used in the experiment. This newly developed variety exhibits adaptability to diverse environments and is suitable for various soil types. The selection of Napok 1 aimed to evaluate its potential for high yield under different fertilizer regimes.

### Data Collection

The following agronomic data were collected at maturity from five representative plants per plot:

Plant height (cm)

Number of branches per plant

Number of pods per plant

Individual plant weight (g)

100-seed weight (g)

Grain yield was obtained from the entire plot and converted to t/ha.

### Data Analysis

Data were initially summarized using Microsoft Excel. Statistical analysis was performed using Statistix 10.0 soft-

ware. Analysis of variance (ANOVA) was conducted to assess the main effects of fertilizer treatments on all measured variables. The least significant difference (LSD) test (Fisher's LSD) was used for mean comparisons between treatments and blocks at a 95% confidence level ( $P < 0.05$ ).

### 3. Results

At the Rice and cash Crops Research Center, National Agriculture and Forestry Research Institute can be summarized as follows: the results of the experiment show that the composition in term of number of branches per plant, number of pods per plant, weight per plant and yield there is a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ), for composition of plants height and 100 seeds weight were no statistical difference (not significant)  $P > 0.05$ . Organic fertilizer (2,000 kg/ha) gave a maximum yield of 3.15 t/ha while the control yielded only 2.46 ton per hectare (Table 1).

Faculty of Agriculture Nabong campus, National University of Laos can be summarized as follows: the results of the experiment show that the composition in term of number of branches per plant, number of pods per plant, weight per plant and yield there is a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ). for composition of plants height and 100 seeds weight were no statistical difference (not significant)  $P > 0.05$ . In all of the experiments, the yield was the lowest compared to the experiments at the Rice and cash Crops Research Center and Faculty of Agriculture and Environment

Nongpheu campus, Savanhnakhet University, Because the soil condition is quite sandy and there are outbreaks of diseases and insects. The experimental chemical fertilizer + organic fertilizer (100 kg/ha + 1,000 kg/ha) obtained the highest yield at (1.97 t/ha) while the control (no fertilizer) yielded the lowest at 1.36 t/ha (Table 2).

Faculty of Agriculture and Environment Nongpheu cam pas, Savanhnakhet University, the results of the experiment show that the composition in term of plants height, number of branches per plant, number of pods per plant, weight per plant and yield there is a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ). Organic fertilizer (2,000 kg/ha) and chemical fertilizer + Organic fertilizer (100 kg/ha + 1,000 kg/ha) were the highest yielders with yields 3.74 t/ha and 3.84 t/ha respectively, while the control (no fertilizer) yielded the lowest yield of 2.15 t/ha (Table 3).

Results of all 3 zone: From summarizing and analyzing the results, the results can be explained as follows: Composition of number of branches per plant, number of pods per plant, weight per plant and yield there are a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ). but, plant height and 100 seeds weight there are no statistical difference (not significant). Among the 5 treatments: Organic fertilizer (2,000 kg/ha) and chemical fertilizer + organic fertilizer (100 kg/ha + 1,000 kg/ha) gave the highest yield of 2.48 and 2.57 t/ha, respectively, while the control yielded the lowest (Table 4).

**Table 1.** Yield and composition of yield at Rice and cash Crops Research Center, National Agriculture and Forestry Research Institute.

Treatment	Plant height (cm)	Number of branches per plant	Number of pods per plant	Weight per plant (g)	100 Seeds weight (g)	Yield (t/ha)
T1	72.26 ab	4.10 b	117.67 b	27.02 b	13.10 a	2.46 c
T2	74.23 ab	4.46 b	118.07 b	26.59 b	13.13 a	2.69 bc
T3	79.73 a	4.40 b	117.53 b	26.62 b	13.70 a	3.05 ab
T4	73.93 ab	5.26 a	144.67 a	34.72 a	13.96 a	3.09 ab
T5	68.13 b	4.13 b	110.13 b	26.12 b	13.76 a	3.15 a
P-Value	NS	**	**	**	NS	**
CV	7.24	7.67	6.48	5.27	7.48	8.12

NS = no statistical difference (not significant).

\*\* = there is a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ).

\* = there is a statistical difference at the confidence level greater than 95% ( $P < 0.05$ ).

abc = in the same row with the same letters there is no statistical difference.

**Table 2.** Yield and composition of yield at Faculty of Agriculture Nabong campus, National University of Laos.

Treatment	Plant height (cm)	Number of branches per plant	Number of pods per plant	Weight per plant (g)	100 Seeds weight (g)	Yield (t/ha)
T1	26.66 a	1.86 d	19.66 d	3.29 d	12.93 a	1.36 e
T2	30.86 a	3.36 a	37.06 a	7.44 a	13.26 a	1.69 b
T3	31.00 a	3.40 a	36.80 a	6.41 b	12.73 a	1.64 c
T4	30.40 a	2.76 b	33.53 b	6.28 b	12.76 a	1.97 a
T5	29.26 a	2.46 c	27.80 c	4.93 c	13.20 a	1.54 d
P-Value	NS	**	**	**	NS	**
CV	8.67	3.66	5.15	3.99	5.68	3.59

NS = no statistical difference (not significant).

\*\* = there is a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ).

\* = there is a statistical difference at the confidence level greater than 95% ( $P < 0.05$ ).

abc = in the same row with the same letters there is no statistical difference.

**Table 3.** Yield and composition of yield at Faculty of Agriculture and Environment Nongpheu cam pus, Savanhnakhet University.

Treatment	Plant height (cm)	Number of branches per plant	Number of pods per plant	Weight per plant (g)	Yield (t/ha)
T1	62.88 c	7.66 c	49.96 b	16.52 c	2.15 d
T2	68.64 b	9.88 b	52.49 b	21.84 b	2.45 c
T3	70.99 b	10.32 ab	56.20 b	23.26 ab	2.96 b
T4	73.69 ab	11.12 ab	94.11 a	23.74 a	3.65 a
T5	76.73 a	11.30 a	96.17 a	24.37 a	3.74 a
P-Value	**	**	**	**	**
CV	3.88	7.01	9.08	3.83	3.82

NS = no statistical difference (not significant).

\*\* = there is a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ).

\* = there is a statistical difference at the confidence level greater than 95% ( $P < 0.05$ ).

abc = in the same row with the same letters there is no statistical difference.

**Table 4.** Results of all 3 zone.

Treatment	Plant height (cm)	Number of branches per plant	Number of pods per plant	Weight per plant (g)	100 Seeds weight (g)	Yield (t/ha)
T1	53.94 a	4.58 b	62.43 c	15.61 c	12.96 a	1.66 c
T2	57.91 a	5.91 a	69.21 bc	18.62 b	13.34 a	1.95 b
T3	60.57 a	6.04 a	70.17 bc	18.76 b	12.19 a	2.22 ab
T4	59.34 a	6.38 a	90.77 a	21.59 a	13.47 a	2.57 a

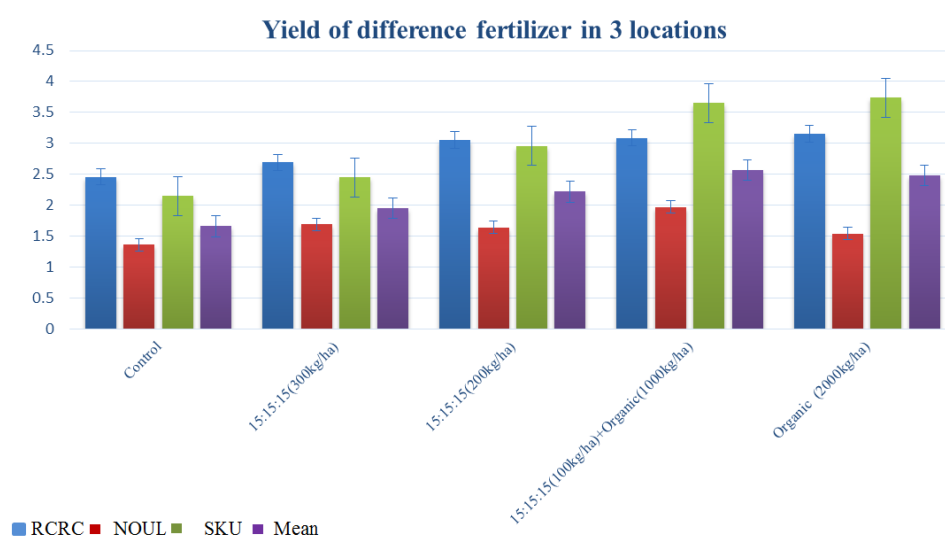
Treatment	Plant height (cm)	Number of branches per plant	Number of pods per plant	Weight per plant (g)	100 Seeds weight (g)	Yield (t/ha)
T5	58.04 a	5.97 a	78.03 b	18.47 b	12.38 a	2.48 a
P-Value	NS	**	**	**	NS	**
CV	6.64	8.16	7.09	3.86	8.65	9.89

NS = no statistical difference (not significant).

\*\* = there is a statistical difference at the confidence level greater than 99% ( $P < 0.01$ ).

\* = there is a statistical difference at the confidence level greater than 95% ( $P < 0.05$ ).

abc = in the same row with the same letters there is no statistical difference.



**Figure 1.** Graph showing the yield of different fertilizer in 3 zone.

## 4. Discussion

This study examined the impact of various fertilizer regimes on soybean yield and growth characteristics in Lao PDR. Results demonstrated that the application of organic fertilizer at a rate of 2,000 kg/ha and a combined application of organic (1,000 kg/ha) and inorganic (100 kg/ha) fertilizers yielded the highest grain production, with 2.48 t/ha and 2.57 t/ha, respectively. In contrast, the control group, which received no fertilizer, exhibited the lowest yield. This outcome is consistent with existing literature that highlights the beneficial effects of organic fertilizers, both independently and in combination with inorganic fertilizers, on soybean growth and yield across diverse cultivation areas [3, 5-9, 11, 12, 14, 15].

The study's findings underscore the complexity of fertilizer management in soybean production. Beyond fertilizer type and application rate, the specific nutritional needs of the

crop must be considered. Providing essential macronutrients, such as nitrogen, phosphorus, and potassium, and micronutrients like zinc, iron, and manganese, is crucial for optimizing yield [4, 10, 13, 16]. This can be achieved through soil testing and analysis to determine nutrient deficiencies and tailor fertilizer applications accordingly.

While strategic fertilizer application can significantly enhance soybean yield, an over-reliance on inorganic fertilizers may prove counterproductive. Excessive use of inorganic fertilizers can disrupt soil microbial communities, reduce organic matter content, and contribute to environmental pollution through nutrient runoff. Therefore, a balanced fertilization strategy incorporating both organic and inorganic sources is advocated to promote both robust yields and long-term soil health [12, 13]. Organic fertilizers, such as compost and manure, can improve soil structure, water-holding capacity, and nutrient availability, contributing to a more sustainable production system.

In addition to fertilizer management, the study emphasizes the importance of other agronomic practices in maximizing

soybean yield. These include appropriate site selection, planting date, weed control, and pest management. Furthermore, the integration of rhizobium inoculants can enhance nitrogen fixation in soybean, reducing the need for nitrogen-based fertilizers and further promoting sustainable production practices [8, 9]. The influence of fertilizer regimes on soybean production extends beyond fertile soil conditions, impacting yields across a range of ecosystems and environmental conditions [5, 7, 11-14]. This highlights the need for site-specific fertilizer recommendations that consider soil type, climate, and other environmental factors. Future research should focus on developing integrated nutrient management strategies that optimize soybean productivity while minimizing environmental impacts. This may involve exploring the use of cover crops, crop rotation, and precision agriculture techniques to enhance nutrient use efficiency and promote sustainable soybean production systems.

## 5. Conclusions

From all the experiments, it can be concluded that: Among the 5 treatments, it has been shown that: organic fertilizer (2,000 kg/ha) and scientific fertilizer + organic fertilizer (100 kg/ha + 1,000 kg/ha) give the highest yield of 2.48 and 2.57 t/ha respectively; while the controller gives the lowest output. So; in the soybean production process regardless of whether it is implemented in different environments, production areas and ecosystems, if you want to produce soybeans with a high yield, every time you plant, you need to add fertilizer, but you must add it in the right proportion, according to the period and correctly according to the correct technique-method of applying fertilizer, so that the production of soybeans every time will get a high yield.

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## Author Contributions

**Nelamith Bounbandit:** Data curation, Writing – original draft

**Siviengkhek Phommalaht:** Formal Analysis, Project administration, Supervision, Validation, Writing – review & editing

## Conflicts of Interest

The authors declare no conflicts of interest.

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