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Effect of *Sesbania sesban* L. as a Green Manure on Yield of Rainfed-lowland Rice

Lihou CHIN[1*]; Sophoanrith RO[2]; Siranet ROEURN[2]; Hong CHEANG[2] ; Phiny CHIV[1] and Vanchey ROS[1]

[1] Faculty of Agriculture, Svay Rieng University of Agriculture, Cambodia
[2] Faculty of Agricultural Science, Royal University of Agriculture, Cambodia
*Corresponding; Lihou CHIN[1]

Abstract:- Rice (Oryza sativa L.) is the most important grain crop for more than half of the world's population especially in Asia. Nitrogen (N) plays a crucial role in rice production. The incorporation of the cover crop as a pre-rice crop is the potential to improve the nitrogen used by rice crops. The experiment was conducted on the clay loam of Svay Rieng Province Cambodia in 2022 during the rice cropping season. The trial was designed using Spit-Plot design, with 4 levels of nitrogen (N) as main-plot and Cover Crop (CC) as a sub-plot. The CC was either the absence of CC or the use of incorporated Sesbania sesban L. (30 kg ha^{-1}) as a pre-rice crop. The application rate of nitrogen was 0, 35, 70 and 105 kg ha^{-1}, respectively. Direct-seeded rice (DSR) was 100 Kg ha^{-1}. The size of each plot was 16 m^2 (4 m×4 m). The experiment was conducted in 3 replicates. An analysis of variance (ANOVA) on Plants Height revealed a significant difference at 1% ($P < 0.01$) effect of nitrogen level. N35 had the greatest average height (82.95 cm) and N0 was the shortest plant height (77.15 cm). Additionally, a significant difference at 1% ($P < 0.01$) of planting (CC). CC1 was the tallest plant height (81.75 cm), while CC0 was the shortest plant height (78.49 cm). However, the interaction between N level and CC was not statistically significant ($P > 0.05$) on Plant height. An analysis of variance (ANOVA) on Grain yield showed a significant difference at 1% ($P < 0.01$) N70 had the highest average yield (4.92 tons/ha) and N0 had the lowest yield averaging (3.53 tons/ha). Planting (CC) was a significant difference at 1% ($P < 0.01$). CC1 had the highest average yield (4.60 tons/ha), while CC0 had the lowest average yield (4.13 tons/ha). the interaction between N level and CC was not statistically significant ($P > 0.05$) The results suggested that among 4 levels of nitrogen, The application of any rates of fertilizers increased the grain yield compared to non-N application. The grain yield was even higher with the incorporation of CC as a pre-rice crop.

Keywords:- *Sesbania sesban, Nitrogen and Rice.*

I. INTRODUCTION

There are sixty percent of the world's rice consumption occurs in Southeast Asia. Rice is a food grain that is consumed worldwide. It supplies a substantial amount of energy and protein to the world's population. Due to population increase, it is predicted that the world's rice demand would reach 765 million tonnes by 2030. India produced 99.24 million tonnes of rice in 2018, more than the previous year. In addition to being a staple grain, rice provides important elements such carbs, vitamins, and minerals. It has antioxidant-rich phenolic chemicals that can help fend off diabetes and cardiovascular disease. A lot of alcoholic beverages, like sake and Huangjiu, are made from rice (Sanusi et al., 2021). Lowland rice that is rainfed is grown in regions with limited water supplies and depends on rainfall for irrigation. Several studies cover different facets of lowland rice farming that is rainfed. In Nigeria's rainfed lowland ecosystem, Alagbo et al. emphasize the significance of creating efficient weed management plans for rice production that is sustainable (Alfassassi et al. 20230).

A crucial component for the growth and development of rice is nitrogen. Although applying nitrogen fertilizer in excess might result in low production efficiency and environmental degradation, it can also improve rice yield. Thus, increasing nitrogen use efficiency (NUE) is essential to agriculture's sustainability. Several agronomic techniques, including split nitrogen fertilizer delivery, nitrification inhibitor usage, balanced fertilization, and slow-release nitrogen fertilizers, can improve rice NUE. These methods can enhance rice yield and quality while preserving the equilibrium of nitrogen metabolism. Furthermore, new developments in N efficiency-related genes may boost NUE even more and enable the development of novel cultivars with higher nitrogen tolerance (Sangita et al. 2023).

Egyptian river hemp, or Sesbania sesban (L.) Merr., is a well-known plant that grows throughout Egypt, the remainder of Africa, and Asia. This little tree or fast-growing shrub is widely used in traditional medicine, soil conservation, erosion control, and fodder production (Shimaa et al., 2023). There are various advantages of sesbania sesban for the soil. It can enhance plant growth, the microecology of saline-alkaline rhizosphere soil, and the soil's physicochemical and nutritional qualities (Yin et al., 2023). Additionally, by competing with soil cadmium and lowering

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the transport of Cd from roots to grains, Sesbania sesban can lower the buildup of Cd in crop grains (Bin et al., 2024).

II. MATERIALS AND METHODS

A. Experimental Location

The experiment was conducted in Prasat Village, Pouthi Reach Commune, Svay Chrum District, Svay Rieng Province Cambodia in 2022 during the rice cropping season.

B. The Properties of Soil

The soil type of the experimental plot was clay loam. The soil parameters before the experiment were as follows: 0.95 g kg–1 total nitrogen (N), 6.93 mg kg–1 available phosphorus (P), 0.207 mg kg–1 available potassium (K), 0.86% organic matter content (OM), and pH of 4.56.

C. Experimental Design

The experiment was arranged in a Split Plot design, with 4 levels of nitrogen (N) as main-plot factor and Cover Crop (CC) as a sub-plot. The application rate of N was 0, 35, 70 and 105 kg ha–1, respectively. Direct-seeded rice (DSR) was 100 Kg ha-1. The size of each plot was 16 m2 (4 m×4 m). The experiment was conducted in 3 replicates. In all treatments, N was 40%, 30% and 30% at early tilling stage, at seedling stage at panicle initiation stage at seedling stage respectively. For all treatments, phosphorus (30 kg ha–1 as single superphosphate) and potassium (30 kg ha–1 as KCl) were applied at early tilling stage as basal fertilizer.

D. Statistical Analysis

All data collected were typed into Excel to calculate the mean after each experiment, and the data were analyzed in ANOVA tables at specific rates of 5% and 1% and compared with LSD using Statistix 8 software.

III. RESULTS AND DISCUSSION

➢ *Plant Height, Leave Length and Leave Width*

An analysis of variance (ANOVA) on Plant height revealed a significant effect of nitrogen (N) level (P < 0.01). Plants grown with the highest N level (N35) had the greatest average height (82.95 cm). The lowest N level (N0) resulted in the shortest plants (77.15 cm), representing a mean difference exceeding 1% compared to N35. Additionally, a significant effect of planting configuration (CC) was observed (P < 0.01). The CC1 configuration yielded the tallest plants on average (81.75 cm), while the CC0 configuration produced the shortest plants (78.49 cm). However, the interaction between N level and planting configuration was not statistically significant (P > 0.05), suggesting these factors independently affected plant height.

In the study conducted by Rezaul Karim et al., it was observed that the plant height of long-grain rice increased with higher levels of nitrogen application. Similarly, Nargis Sultana et al. found that the highest plant height at harvest was obtained with a nitrogen level of 75 kg N ha-1 (Yin et al., 2023).

An analysis of variance (ANOVA) on leaf length at 81 days old revealed a significant effect of nitrogen (N) level (P < 0.01). Plants grown with the highest N level (N70) had the longest leaves on average (25.51 cm). Conversely, the lowest N level (N105) resulted in the shortest leaves (23.35 cm), representing a mean difference exceeding 1% compared to N35. A significant effect of planting configuration (CC) was also observed (P < 0.01). The CC1 configuration yielded plants with the longest leaves on average (25.20 cm), while the CC0 configuration produced plants with the shortest leaves (23.70 cm). However, the interaction between N level and planting configuration was not statistically significant (P > 0.05), suggesting these factors independently affected rice leaf length.

An analysis of variance (ANOVA) on leaf width at 81 days old revealed no significant effect of nitrogen (N) level (P > 0.05). Although N70 exhibited the greatest average leaf width (1.11 cm), this difference was not statistically significant compared to other N levels. However, a significant effect of planting configuration (CC) was observed (P < 0.05). Plants grown in the CC1 configuration had the widest leaves on average (1.11 cm), while those in the CC0 configuration had the narrowest leaves (1.05 cm). It's important to note that the seemingly similar values for N70 and CC1 leaf width likely represent coincidental results due to the lack of a significant difference at the N level. The interaction between N level and planting configuration was again not statistically significant (P > 0.05), suggesting these factors independently affected rice leaf width.

Table 1: Plant Height, Leaf Length and Leaf Width

Treatment	Plant Height (cm)	Leave Length (cm)	Leave Width (cm)
N 0	77.15 c	23.467 b	1.0567 a
N 35	82.95 a	25.467 a	1.0833 a
N 70	81.18 ab	25.517 a	1.11 a
N 105	79.20 bc	23.350 b	1.09 a
CC0	78.49 b	23.700 a	1.0533 b
CC1	81.75 a	25.200 a	1.1167 a
CV	2.35	6.57	4.32
N	** (P=0.007<0.01)	** (P=0.004<0.01)	ns (P=0.371>0.05)
CC	** (P=0.002<0.01)	ns (P=0.051>0.05)	* (P=0.010<0.05)
CC X N	ns (P=0.500>0.05)	ns (P=0.845>0.05)	ns (P=0.410>0.05)

Note N: levels of nitrogen
CC0: Not Grow of Sesbania Seban
CC1: Grow of Sesbania sesban
ns: not significantly different (p>0.05), * significantly different 5% (p<0.05) and ** significantly different 1% (p<0.01).

➢ *Growth Rate*

An analysis of variance (ANOVA) on growth rate showed significant effects of nitrogen (N) level and planting configuration (CC) on rice growth rate (P < 0.05). The combination C1N1 exhibited the highest growth rate, averaging 226.67 g/week. Conversely, the C0N0 combination resulted in the lowest growth rate, averaging 115.22 g/week.

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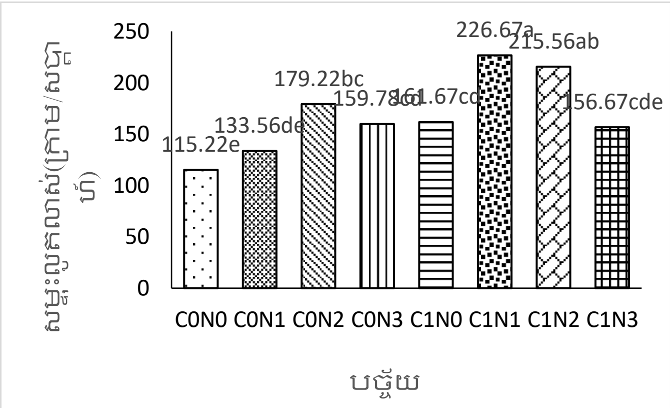

Fig 1: Grow Rate

Note: - An analysis of variance (ANOVA) on growth rate showed a significant difference at 5% (P = 0.039 < 0.05).

- The coefficient of variation (CV) was 13.52%.
- An analysis using least significant difference (LSD) at a 5% level did not detect any significant differences in meaning among consonant suffixes.

➢ *Days of Flowering, Panicle Length and Grain Yield*

An analysis of variance (ANOVA) on days of flowering found no significant effect of nitrogen level (N) (P > 0.05). Although N0 plants flowered earliest at an average of 69.33 days, this difference wasn't statistically significant compared to other N levels. However, planting configuration (CC) significantly impacted days to days of flowering (P < 0.05). Plants grown in the CC0 configuration flowered the latest on average (68.58 days), while those in the CC1 configuration flowered the earliest (67.83 days).

An analysis of variance (ANOVA) on panicle length found no significant effect of nitrogen (N) level on panicle length (P > 0.05). While N35 produced the longest panicle on average (23.30 cm), this difference wasn't statistically significant compared to other N levels. However, planting configuration (CC) significantly impacted panicle length (P < 0.05). Plants grown in the CC1 configuration had the longest panicle on average (23.40 cm), while those in the CC0 configuration had the shortest panicle (22.62 cm). There seems to be a typo with "27.40 cm" as the shortest length for CC0 planting. It should likely be a lower value, closer to 22.62 cm.

An analysis of variance (ANOVA) on grain yield revealed a significant effect of nitrogen (N) level (P < 0.01). Plants grown with the highest N level (N70) produced the greatest yield, averaging 4.92 tons/ha. Conversely, the lowest N level (N0) resulted in the lowest yield, averaging 3.53 tons/ha. This difference represents a statistically significant mean difference exceeding 1%. Planting configuration (CC) also significantly impacted yield (P < 0.01). The CC1 configuration yielded the highest average yield (4.60 tons/ha), while the CC0 configuration produced the lowest average yield (4.13 tons/ha). Again, this difference was statistically significant (P < 0.01).

Table 2: Days of Flowering, Panicle Length and Grain Yield

Treatment	Days of flowering (Days)	Panicle Length (cm)	Grain Yield (T/ha)
N 0	69.333 a	22.983 ab	3.538 b
N 35	67.667 a	23.3 a	4.596 a
N 70	67.167 a	23.167 a	4.929 a
N 105	68.667 a	22.6 b	4.413 a
CC0	68.583 a	22.625 b	4.137 b
CC1	67.833 b	23.400 a	4.6 a
CV	0.85	3.38	5.96
N	ns (P=0.438>0.05)	ns (P=0.083>0.05)	** (P=0.005<0.01)
CC	* (P= 0.013<0.05)	* (P=0.040<0.05)	** (P=0.002<0.01)
CC X N	ns (P= 0.297>0.05)	ns (P=0.671>0.05)	ns (P= 0.165 >0.05)

Note N: levels of nitrogen
CC0: Not Grow of Sesbania Seban
CC1: Grow of Sesbania sesban
ns: not significantly different (p>0.05), * significantly different 5% (p<0.05) and ** significantly different 1% (p<0.01).

➢ *Grains Per Panicle, Filled Grain Per Panicle and Panicles Number Per M^2*

An analysis of variance (ANOVA) on the total number of grains per panicle revealed no significant effect of nitrogen (N) level (P > 0.05). Although N35 produced the highest average number of grains (95.60), N0 produced the lowest average number of grains (76.39). Similarly, planting configuration (CC) did not significantly impact the total number of grains (P > 0.05). On average, CC1 panicles contained the most grains (92.77), while CC0 panicles contained the fewest (83.72). However, this difference wasn't statistically significant. Importantly, the interaction between N level and planting configuration was not statistically significant (P > 0.05), suggesting these factors independently affected the total number of grains per panicle.

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An analysis of variance (ANOVA) on filled grain revealed no significant effect of nitrogen (N) level (P > 0.05). While N35 produced the highest average filled grain (73.70), this difference wasn't statistically significant compared to other N levels. However, planting configuration (CC) significantly impacted the total number of grains (P < 0.05). filled grain in the CC1 configuration had the most filled grains on average (69.24), while those in the CC0 configuration had the lowest (62.52). This difference represents a statistically significant mean difference exceeding 5%. Importantly, the interaction between N level and planting CC was not statistically significant (P > 0.05), suggesting these factors independently affected the total number of filled grains per panicle.

An analysis of variance (ANOVA) on panicle numbers revealed a significant effect of nitrogen (N) levels (P < 0.05). The panicle numbers grown with the highest N level (N70) had the highest average panicle numbers (26.51). Conversely, panicle numbers from plants grown with the lowest N level (N0) had the lowest average panicle numbers (16.97). Planting configuration (CC), however, did not significantly impact the panicle numbers (P > 0.05). On average, panicles grown in the CC1 configuration contained the most panicle numbers (23.52), while those in the CC0 configuration contained the fewest (21.19). However, this difference was not statistically significant. Importantly, the interaction between N level and planting configuration was not statistically significant (P > 0.05), suggesting these factors independently affected the panicle number.

Table 3: Grains per Panicle, Filled Grain per Panicle and Panicle Number per m^2

Treatment	Grains (Grains/Panicle)	Filled Grain (Grains/Panicle)	Panicles Number (Panicle/M^2)
N 0	76.394 b	59.42 a	425.58 b
N 35	95.6 a	73.7 a	513.42 a
N 70	94.991 a	68.474 a	511.63 a
N 105	86 ab	61.95 a	499.88 ab
CC0	83.722 a	62.527 b	493.27 a
CC1	92.770 a	69.245 a	481.98 a
CV	10.94	10.16	9.05
N	ns (P= 0.091>0.05)	ns (P=0.219>0.05)	ns (P=0.098>0.05)
CC	ns (P= 0.051>0.05)	* (P= 0.039<0.05)	ns (P=0.548>0.05)
CC X N	ns (P= 0.360>0.05)	ns (P= 0.667>0.05)	ns (P=0.494>0.05)

Note N: levels of nitrogen
CC0: Not Grow of Sesbania Seban
CC1: Grow of Sesbania sesban
ns: not significantly different (p>0.05), * significantly different 5% (p<0.05) and ** significantly different 1% (p<0.01).

➢ *Straw Yield*

An analysis of variance (ANOVA) on straw weight revealed a significant effect of both nitrogen (N) level and planting configuration (CC) (P < 0.05). The C1N3 combination resulted in the highest average straw weight, at 14.70 tons/ha. Conversely, the C0N0 combination produced the lowest average straw weight, at 7.70 tons/ha.

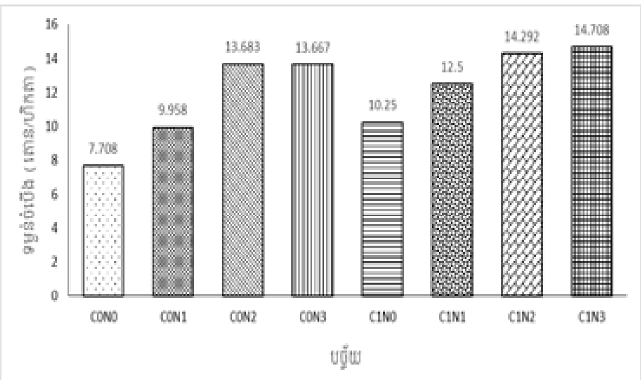

Fig 1: Straw Yield

Note: - An analysis of variance (ANOVA) on growth rate showed a significant difference at 5% (P = 0.016 < 0.05).

- The coefficient of variation (CV) was 4.06%.
- An analysis using least significant difference (LSD) at a 5% level did not detect any significant differences in meaning among consonant suffixes.

➢ *Stem Nitrogen Seed Nitrogen and Soil Nitrogen*

An analysis of variance (ANOVA) on nitrogen in rice stem showed no significant difference (P> 0.05) with nitrogen (N) level, with N105 having the highest nitrogen content of 0.90% and N0 nitrogen in rice being the lowest at 0.68%, but there was no significant difference (P> 0.05) in CC cultivation, with CC1 having the highest nitrogen in rice at 0.83% and the suffix CC0 having the lowest nitrogen content in rice plants at 0.72%. The interactions between N and CC were not significantly different (P> 0.05).

An analysis of variance (ANOVA) on nitrogen in grain showed no significant difference (P> 0.05) with nitrogen (N) level, with N105 having the highest nitrogen content at 1.61% and N0. Nitrogen in grains was the lowest at 1.20%, but there was no significant difference (P> 0.05) in CC cultivation, with the suffix CC1 having the highest nitrogen in grains at 1.45% and the suffix CC0 having the lowest nitrogen content of the grain at 1.38%. The interactions between N and CC were not significantly different (P> 0.05).

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An analysis of variance (ANOVA) on soil nitrogen showed no significant difference (P> 0.05) with nitrogen (N) level, with N0 having the highest nitrogen content at 0.15% and N35 with nitrogen. The lowest soil content was 0.12%, but there was no significant difference (P> 0.05) in CC cultivation, with the suffix CC0 having the highest nitrogen content in the soil at 0.14% and the suffix CC1 containing nitrogen. In the smallest land, it is 0.12%. The interactions between N and CC were not significantly different (P> 0.05).

Table 5: Stem Nitrogen Seed Nitrogen and Soil Nitrogen

Treatment	Stem Nitrogen	Seed Nitrogen	Soil Nitrogen
N 0	0.682 c	1.207 c	0.153 a
N 35	0.750 ab	1.272 ab	0.122 a
N 70	0.778 ab	1.588 ab	0.127 a
N 105	0.905 a	1.615 a	0.130 a
CC0	0.728 a	1.384 a	0.143 a
CC1	0.830 a	1.457 a	0.123 a
CV	3.52	9.05	5.96
N	ns (P= 0.097>0.05)	ns (P=0.055>0.05)	ns (P=0.372>0.05)
CC	ns (P= 0.065>0.05)	ns (P=0.454>0.05)	ns (P=0.198>0.05)
CC X N	ns (P= 0.981<0.05)	ns (P=0.482>0.05)	ns (P=0.810>0.05)

Note N: levels of nitrogen
CC0: Not Grow of Sesbania Seban
CC1: Grow of Sesbania sesban
ns: not significantly different (p>0.05), * significantly different 5% (p<0.05) and ** significantly different 1% (p<0.01).

IV. CONCLUSION

The results of the experiment could be concluded that the Plant height revealed a significant effect of nitrogen (N). Plants grown with the highest (N35) had the greatest average height (82.95 cm). The lowest (N0) resulted in the shortest plants (77.15 cm). Additionally, a significant effect of planting configuration (CC). The CC1 configuration yielded the tallest plants on average (81.75 cm), while the CC0 configuration produced the shortest plants (78.49 cm). However, the interaction between N level and planting configuration was significant. Grain yield revealed a significant effect on nitrogen (N) levels. Plants grown with the highest (N70) produced the greatest yield, averaging 4.92 tons/ha. Conversely, the lowest N level (N0) resulted in the lowest yield, averaging 3.53 tons/ha. This difference represents a statistically significant mean difference. Planting configuration (CC) also significantly impacted yield. The CC1 configuration yielded the highest average yield (4.60 tons/ha), while the CC0 configuration produced the lowest average yield (4.13 tons/ha). Again, this difference was statistically significant.

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