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Performance Evaluation of Two Soybean Varieties (*Glycine max* (L.) Merr.) for Growth and Yield on Frontland Clay Soil in La Grange, Region 3, Guyana

Devwattie Dass, Karamchand Bramdeo, Jagnarine Singh

National Agriculture Research and Extension Institute, Mon Repos, East Coast Demerara, Georgetown, Guyana
Email: davydass2016@yahoo.com

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Abstract

Soybean (*Glycine max* (L.) Merr.) is the most important protein crop globally as it offers a high-quality protein source for animal feed, particularly for poultry, swine, and aquaculture, with its cultivation area in Guyana on the increase. To investigate soybean growth and yield performance of two soybean varieties (Tracaja and FT3282) grown on Frontland clay soil, with the goal of reducing reliance on expensive imported feed ingredients and enhancing local agricultural productivity, a field study was conducted in 2024 using sprinkler irrigation system. A complete randomized block design with four replications was used for the two treatments (Tracaja and FT3282). The results show that the studied soybean growth parameter (plant height) and the yield components (pods per plant, seeds per pod, seeds per plant, mass of seeds per plant and 1000-seed weight) were greater for variety FT3282. The variety FT3282 also showed significantly greater yield ($P < 0.05$) 4.7 t/ha, while Tracaja yielded ($P < 0.05$) 3.2 t/ha, both at 14% moisture content. These harvested soybeans seeds are intended for use as seed material and animal feed, and farmers aim to increase soybean production to meet these demands.

Keywords

Soybean, Varieties, Tracaja, FT3282, Yield Performance, Seed Material

1. Introduction

Soybean (*Glycine max* (L.) Merr.) is a valuable legume that is widely grown due to its high protein and oil content, making it an important crop in global agriculture. It is a significant producer of animal feed, edible oil, and other industrial items [1] [2]. Soybean production has gained popularity in Guyana due to its potential to diversify local agriculture and reduce dependency on imported protein sources [3]. As demand for soybean in the stock feed industry rises, enhancing soybean yield and growth under various environmental conditions is crucial for increasing productivity in regions with varying soil types and temperatures.

Soybean cultivation success is determined by a number of factors, including genetic variety, soil quality, and weather [4]. Varietal selection of this crop is critical in growth and yield performance, especially in areas with specific soil types, such as the clay soils of La Grange in Region 3, Guyana. Clay soils, which are usually associated with poor drainage, excessive compaction, and high nutrient retention, present both challenges and opportunity for crop growth [5]. The ability of different soybean varieties to thrive in these conditions has yet to be thoroughly examined in Guyana, highlighting the need of region-specific research in developing high-yielding varieties appropriate for local soils.

Recent studies on soybean growth in tropical environment show that soil texture and structure have a significant impact on root development, water retention, and nutrient uptake [6] [7]. Understanding how different soybean varieties respond to these variables is crucial for developing effective crop management strategies and increasing output in Guyana's distinct agricultural environment. While many soybean cultivars have shown tolerance to clay soils in other parts of the world, insufficient research has been conducted to determine their effectiveness in Guyana's particular environment.

This study was conducted to assess the growth and yield performance of two varieties of soybean (*Glycine max* (L.) Merr.) grown in La Grange West Bank, Region 3. The study aims to determine the best variety for cultivation in this region by examining key parameters such as plant height, pods per plant, and overall output. The findings of this study will serve to inform future agricultural practices and support the sustainable development of Guyana's soybean sector.

2. Research Objective

The primary objective of this research was to assess the growth and yield performance of two varieties of soybean (*Glycine max* (L.) Merr.) grown in La Grange West Bank, Region 3

3. Methodology

The field trial was conducted on a 120 square meter size plot in La Grange, Region 3, Guyana, during the 2024. This area has a tropical climate with distinct wet and dry seasons, similar to the rest of region 3, Guyana [8]. During the experimental period, the average temperature ranged from 29˚C to 31˚C, while the average low was around 24˚C. The average relative humidity was 74.2%, while the total monthly rainfall was 19.59 mm.

The soil at the study site is classified as Frontland clay, a common soil type in the region known for its fertility and structure [9]. Prior to planting, preliminary soil testing findings showed a reasonable level of fertility, with a pH range of 6.2 which is appropriate for soybean growth, 198 kg ha^{-1} of N, 29 kg ha^{-1} of P, and 297 kg ha^{-1} of K, as well as a moderate quantity of organic matter of 3.5%.

Two soybean (*Glycine max* (L.) Merr.) varieties were chosen for this investigation because of their high protein content, making them appropriate for use in animal feed. The two soybean cultivars under study, FT3282 and Tracaja, were developed by Embrapa (Brazilian Agricultural Research Corporation). The FT3282 and Tracaja varieties are the results of Embrapa's intensive breeding efforts to increase soybean resilience and yield in Brazil's diverse climates. Seeds of both varieties were sourced from farmers in the Rupununi Savannah, Region 9, where they thrive under natural native growing conditions. The performance of the two soybean varieties was assessed using a randomized complete block design (RCBD), with four replications for each treatment. All of the treatments were distributed at random within each block. This was to make it possible to account for block variability, RCBD is perfect.

Every block received two treatments, which were randomized within the block, and each treatment was shown once. Before planting, the plot was prepared to a depth of 15 cm to create a good seedbed. Each treatment was planted using 50 cm row spacing and 5 cm intra-row spacing. Soybean seeds were sown, at a depth of 3cm and weeds were carefully removed to reduce competition for nutrients and water. Fertilization was done in three split applications to meet the nutritional requirements for optimal soybean growth. At planting, 140 kg/ha of Triple Super Phosphate (TSP) was used to supply phosphorus. Three weeks after planting, 140 kg/ha of urea (46% nitrogen) and 140 kg/ha of TSP were used to meet nitrogen and phosphorus requirements. Seven weeks after planting, 140 kg/ha of 12:12:17:2 NPK compound fertilizer was applied to ensure a balanced supply of macronutrients. The crop was irrigated using sprinkler irrigation system to maintain adequate soil moisture levels, particularly during periods of drought [10]. Plant data were recorded at four-week intervals, beginning four weeks after planting. Data was gathered from a randomly selected sample of 10 plants from each block. The height from the base of the soybean to the tip of the leaf or top of the inflorescence was measured with a tape measure to determine plant height [11] [12].

Insect pest control was implemented when needed with a broad-spectrum insecticide based on visual field evaluations. Both soybean varieties were harvested, upon reaching physiological maturity. The plants were manually harvested, and the pods were separated. The seeds were then threshed, cleaned, and weighed at a uniform moisture content of 14% for yield evaluation. The Moisture content of the harvested seeds was then tested with a moisture meter. The grain yield was calculated by recording the total weight and expressing in tons/ha. The total weight of the gathered seeds was recorded and expressed as tons per hectare.

All statistical analyses were carried out using IBM SPSS Statistics 26 and a graph was plotted using Microsoft Excel 2016. Data from growth and yield parameters were analyzed using one-way ANOVA with a significance threshold of $P < 0.05$. One-way ANOVA was adapted to analyze the RCBD data by treating both treatment and block effects. The reason for the choice of this statistical analysis was because one-way ANOVA accounts for variation between blocks and compares the means of several groups, which can be applied to Randomized Complete Block Design (RCBD) data and also taking into account the variance within blocks as a possible source of error, one-way ANOVA can be performed to ascertain whether there are significant differences between treatment means.

4. Results

Table 1. Evaluation of growth and yield parameters. Data are shown as mean ± SD. Different lowercase letters within the rows indicate significant difference at $P < 0.05$.

Varieties	Plant Height at Maturity (cm)	Number of pods per plant	Number of seeds per pod	Number of seeds per plant	Weight of seeds per plant (g)	Weight of 1000 seeds (g)	Average Yield (t/ha)
Tracaja	85.43 ± 2.20b	226.7 ± 3.04b	2.1 ± 0.31b	603.66 ± 3.22b	88.96 ± 1.69b	123.56 ± 1.38b	3.20 ± 0.49b
FT3282	89.25 ± 2.55a	284.7 ± 3.19a	3.2 ± 0.40a	858.1 ± 8.08a	118.28 ± 7.48a	134.70 ± 2.08a	4.70 ± 0.17a

The two varieties, Tracaja and FT3282, were evaluated on different growth and yield parameters. There were significant variances between the varieties in all parameters evaluated.

FT3282 had a significantly higher plant height at maturity (89.25 cm) than Tracaja (85.43 cm), which was statistically significant ($p < 0.05$) (see **Table 1**). FT3282 had significantly more pods per plant (284.7) than Tracaja (226.7), with a p-value less than 0.05. The number of seeds per pod also significantly higher in FT3282 (3.2) compared to Tracaja (2.1).

FT3282 had considerably more seeds per plant (858.1) than Tracaja (603.66), indicating higher reproductive output ($p < 0.05$). FT3282 had higher seed weight per plant (118.28 g) than Tracaja (88.96 g) ($p < 0.05$). FT3282 had a larger weight per 1000 seeds (134.70 g) than Tracaja (123.56 g) ($p < 0.05$). FT3282 had a substantially higher average yield of 4.70 t/ha than Tracaja (3.20 t/ha), demonstrating superior productivity in the given growing conditions ($p < 0.05$).

Figure 1 shows the average grain yield performance of two (2) soybean varieties. Means are represented by bars, with error bars of ± SD. Lowercase letters indicate a significant difference at $P < 0.05$. FT3282 produced an average yield of 4.70 tons per hectare, which was much higher than Tracaja's average yield of 3.20 tons per hectare. The graph shows the average yield for each variety, with error bars denoting the standard deviation (± SD). Statistical analysis showed a significant difference between the two varieties ($p < 0.05$), indicated by different lowercase letters above the bars. FT3282 outperformed Tracaja in terms of yield, indicating higher productivity under the specified growth conditions. Agronomic characteristics and environmental compatibility may make the FT3282 soybean variety more suitable for growing in Guyana, especially considering the climate and soil similarities between Guyana's primary agricultural regions and the sections of Brazil where FT3282 was produced.

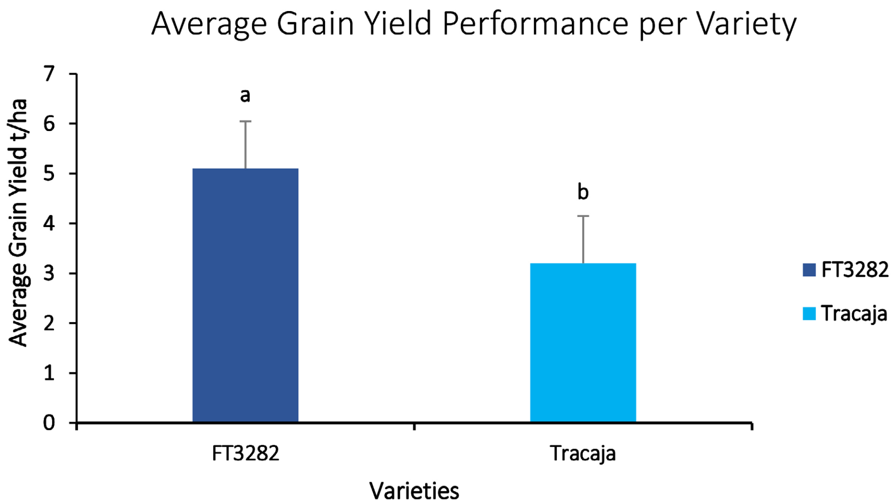

Figure 1. Illustrates the average grain yield performance of two soybean cultivars, Tracaja and FT3282.

5. Discussion

Plant Height at Maturity

The FT3282 variety had a much larger maturity height (89.25 ± 2.55 cm) than Tracaja (85.43 ± 2.20 cm). The taller height of FT3282 implies that it may have an advantage in terms of light interception and canopy coverage, potentially leading to improved photosynthetic efficiency, which is critical for maximum output. In this soybean trial, the observed yield difference between FT3282 and Tracajá attributed to light interception. FT3282, with a greater plant height (89.25 cm vs. 85.43 cm), likely captured more solar radiation due to its taller canopy, potentially allowing for greater photosynthetic activity and biomass accumulation. This enhanced light interception could have contributed to its higher yield compared to the slightly shorter Tracajá. Previous research has indicated that taller plants can lead to increased dry matter accumulation and seed production, although this is not always true dependent on environmental variables [13] [14].

Number of Pods per Plant

FT3282 produced considerably more pods per plant (284.7 ± 3.19 pods) than Tracaja (226.7 ± 3.04 pods). This data implies that FT3282 has a higher potential for reproductive output. The number of pods per plant is an important component of yield since each pod contains seeds that contribute directly to overall yield [15] [16]. A larger pod number in FT3282 indicates improved reproductive success and maybe higher production capacity.

Number of Seeds per Pod and Number of Seeds per Plant

FT3282 produced more seeds per pod (3.2 ± 0.40) compared to Tracaja (2.1 ± 0.31). This difference indicates that FT3282 converts its blooms more efficiently into viable seeds. FT3282 produced more seeds per plant (858.1 ± 8.08) compared to Tracaja (603.66 ± 3.22). The number of seeds per plant is an important element in determining yield, and a higher seed count is often correlated with increased production, assuming that other factors like nutrient availability and insect resistance are maximized [17] [18].

Weight of Seeds per Plant and Weight of 1000 Seeds

FT3282 surpassed Tracaja in terms of seed weight per plant (118.28 ± 7.48 g vs. 88.96 ± 1.69 g) and 1000 seed weight (134.70 ± 2.08 g vs. 123.56 ± 1.38 g). The increased seed size in FT3282 may indicate a higher genetic potential for seed growth. Larger seeds are frequently connected with higher quality, and they can improve the plant's ability to establish itself and generate resistant seedlings under ideal conditions [19] [20]. However, while larger seeds frequently contribute to higher quality, they may not always be useful in resource-constrained situations, where smaller seeds may have a stronger establishing potential. Beyond genetic potential, a number of environmental and agronomic factors can contribute to variations in seed size and weight between the soybean types Tracajá and FT3282. The availability of nutrients is important; different types may have varying levels of nutrient uptake and utilization efficiency, particularly for essential elements like potassium, phosphorus, and nitrogen.

Further explaining the performance disparities between Tracajá and FT3282, is the fact that heat and water stress during the reproductive and seed filling periods can drastically impair seed development, with various varieties reacting differently depending on their stress tolerance.

Average Yield (t/ha)

FT3282 produced a substantially higher average yield (4.70 ± 0.17 t/ha) than Tracaja (3.20 ± 0.49 t/ha). This yield difference is consistent with the previously reported growth and yield parameters, such as the increased number of pods, seeds per pod, and seed weight in FT3282. Higher yield potential in FT3282 can be due to its improved reproductive capability and seed size, which directly contribute to increased total biomass and seed production. Several studies have shown that yield is a multifactorial feature, with pod number, seed size, and seed number being important components of soybean yield potential [21] [22].

The findings of this study show a considerable variation in average grain yield between the two soybean varieties, FT3282 and Tracaja. An average yield for FT3282 was 4.70 tons/ha, which was much greater than the 3.20 tons/ha recorded with Tracaja (**Figure 1**). The statistical analysis revealed a substantial difference between the two types, as seen by the distinct lowercase letters indicating the means in **Figure 1**, with a p-value less than 0.05.

These findings are consistent with prior research that found higher yields in newer, high-performance soybean varieties than in older or traditional types [23], discovered that newer soybean varieties, including those with superior genetic features for disease resistance and agronomic attributes, outperform older varieties in terms of production under ideal growing conditions. Similarly, [24], found that recent breeding efforts have resulted in significant yield improvements for varieties with superior resilience to environmental challenges, such as FT3282, which is expected to benefit from these advances.

FT3282 enhanced performance can be due to a variety of variables, including increased pod fullness, seed size, and resistance to biotic and abiotic stressors. According to [25], modern soybean varieties are frequently bred for features that improve both yield potential and resilience to environmental difficulties like drought and pests, which could explain FT3282 better productivity. Furthermore, the higher production observed in FT3282 may indicate improved nutrient uptake efficiency, as demonstrated by [26] [27], who found that newer varieties are more efficient in utilizing soil nutrients than traditional varieties.

Tracaja, the older variety, produced a lower yield. This result is consistent with that of [17], who found that older soybean varieties have lower yield potential due to inefficient resource utilization and lower tolerance to environmental challenges. Tracaja may also be more sensitive to some pests or illnesses that newer varieties, such as FT3282, are better equipped to handle as a result of disease resistance breeding. For example, [28] stated that genetic breakthroughs in soybean cultivars have resulted in improved insect resistance, which adds to higher yields. While the yield difference between the two varieties in this study is significant, it is critical to examine the unique environmental and agronomic circumstances under which these varieties were evaluated. Soil fertility, water availability, and climatic conditions could all have a substantial impact on yield. While increased yield is a valuable attribute of FT3282, yield improvements must translate into tangible economic benefits, which depend on a broader set of variables including the cost of seed, input requirements such as fertilizers, pesticides and labor can significantly affect profitability. Furthermore, market prices and demand for the varieties grown are favorable to ensure an economic advantage one over the other. A holistic analysis will provide a more realistic picture for farmers and stakeholders, supporting better informed decisions regarding adoption.

Future research should investigate how these parameters interact with the genetic traits of the varieties to have a better understanding of the determinants of yield performance. Also, to accurately assess the benefits of switching to FT3282, it is essential to evaluate not just its agronomic performance but also the full economic analysis.

6. Conclusion

In conclusion, the soybean variety FT3282 surpassed Tracaja in terms of growth and yield, with taller plants, a greater number of pods, more seeds per pod, more seed weight per plant, and much higher average yield. These findings suggest that FT3282 may be a more productive choice under similar growing conditions. To properly appreciate its potential, future study should focus on determining the growth and yield parameter of these features across different environmental conditions, as well as finding the genetic elements that contribute to observed performance differences. Furthermore, enhancing critical agronomic measures including planting density, soil fertility, and irrigation could help both varieties achieve their full output potential and also a full economic analysis.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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