







Research Article

Effect of Mycorrhizal Fungus, *Gliricidia sepium* and *Azadirachta indica* Oil on Growth and Yield Parameters of Two Tomato Varieties in Foubot, Cameroon

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Abstract

Tomato (*Lycopersicon esculentum*. L) is one of the most important fruit vegetables for human consumption. However, its cultivation is confronted with the use of chemicals that are toxic, expensive and cause enormous damage to the environment. Hence the search for environmentally friendly alternatives to improve yields in poor soils. Thus, the use of mycorrhizal fungus, *Gliricidia sepium* and neem oil (*Azadirachta indica*) on the growth and production of tomato in this work could constitute a draft solution. On a plot of 492m², consisting of 126 ridges in two blocks, the hybrid RAJA F1 and standard RIO POWER GRANDE tomato varieties consisting of seven treatments each were grown in the dry and rainy seasons of the year 2024 at IRAD Foubot in Cameroon. An ANOVA of the results obtained was carried out using R.4.2.2 software and Excel 2019 and the Tukey test was used to compare the means of the treatments. At 12 weeks after transplantation in the field, the T2 and T3 treatments fertilized with mycorrhizal fungus respectively presented significantly greater stem heights, number of leaves and leaf areas at $P < 0.05$ than the other treatments. The number of terminal buds, flowers, fruits and yield per hectare was significantly higher for the T2 and T3 treatments compared to the other treatments while the T6 and T7 treatments fertilized with *Gliricidia sepium* had significantly higher fruit weights of 10 fruits than the other treatments. The mycorrhizal fungus, *Gliricidia sepium* and neem oil represent alternatives that can practically replace the fertilization of tomatoes with chemical fertilizers.

Keywords

Azadirachta indica, *Gliricidia sepium*, Growth, Mycorrhizal Fungus, Tomato, Yield

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1. Introduction

Globally, and particularly in developing countries, there is a need to produce twice as much food as in 2020 in order to feed the three billion additional people expected to exist by 2030 in order to ensure global food security [1]. From a nutritional standpoint, vegetable consumption is very important for the proper functioning of the body. Vegetables, whether traditional or indigenous, represent potential in terms of nutritional quality and are therefore highly recommended from a dietary standpoint [2]. In 2020, tomato was the most widely grown crop on the globe with an annual production of 186.82 million tonnes on an area of 5.051.983 hectares across the planet and precisely in more than 170 countries under various conditions and through different technical itineraries on approximately 5.2 million hectares of land, for a yield of approximately 172 million tonnes [3, 4]. In Cameroon, approximately 1.068.495 tonnes of tomatoes are produced annually on 93.76 hectares for a yield of 11.4 tonnes per hectare for the country's five agro-ecological zones. Tomato represents the second most widely grown market garden crop in terms of area across the planet, just behind the potato, and in terms of production for processing, it occupies first place [5]. Tomato is the most cultivated fruit vegetable in Cameroon and in all five agro-ecological zones of the country [2]. Tomato cultivation provides food production that provides income to smallholders and commercial farmers to help them cope with famine and malnutrition in the population [6]. The production of this foodstuff is now faced with many constraints such as the use of chemical fertilizers and synthetic chemical pesticides to produce easily and quickly, which unfortunately cause soil degradation by destroying microfauna and macrofauna. These chemicals also migrate to circulating and groundwater and therefore constitute a source of pollution for the environment and risk to human health worldwide [7, 8]. To date, the environmental issues facing global agriculture are calling into question conventional production models; hence the need for agricultural research to propose alternatives aimed at reducing or even eliminating these synthetic products [9]. To therefore meet the challenges related to respect for the environment and human health, scientists, in collaboration with farmers, are exploring new avenues for production with low levels of chemical inputs. It therefore appears appropriate to find natural alternatives to the environment, with sustainable

environmental, social and economic characteristics that can ensure more appropriate growth and production of cultivated plants and more specifically of tomatoes. The use of mycorrhizal fungus, *Gliricidia sepium* and neem oil (*Azadirachta indica*) in the process of soil fertilization and plant treatment is part of the search for natural methods of growth and improvement of tomato yield in order to contribute to the search for global food security.

2. Materials and Methods

2.1. Study Site

The trial was conducted in the city of Foumbot, more precisely at the IRAD Station of Foumbot, the main city of the Foumbot Sub-division. This Sub-division is located in the West region and more precisely in the Noun Division, between 5° 20' and 5° 35' North latitude, then at 10° 30' and 10° 45' East longitude (Figure 1). It covers an area of 579 km². Foumbot is located in agro-ecological zone III of the Western Highlands of the five that exist in Cameroon. This zone has an area of 31192 km² with a rainfall ranging from 1500 to 2000 mm/year and a period of 180 days. Its soils are very fertile and suitable for agricultural activities, young on steep slopes, leached in old plateaus, horizon B of illuviation in closed depressions, plateaus enriched with volcanic materials. The main crops consist of cocoa, coffee, corn, dry beans, potatoes and market gardening [10]. Foumbot is under the influence of the equatorial climate of the Cameroonian high-altitude type. This climate is under the influence of two air masses, namely the harmattan and the monsoon, which blow the region all year round. Generally speaking, from mid-November to mid-March, the hot and dry winds carried to the South by the Saharan anticyclone push the ITCZ back to 4° North latitude and plunge the entire region into the dry season accompanied by high temperatures. In addition, the sheltered position of the Foumbot region, located on the eastern slope of the Cameroonian ridge and below the Kovu cliff (Mifi Division) in West Cameroon, explains the low rainfall compared to Bafoussam located at 1430 m altitude which receives 2010 mm of average annual precipitation [10].

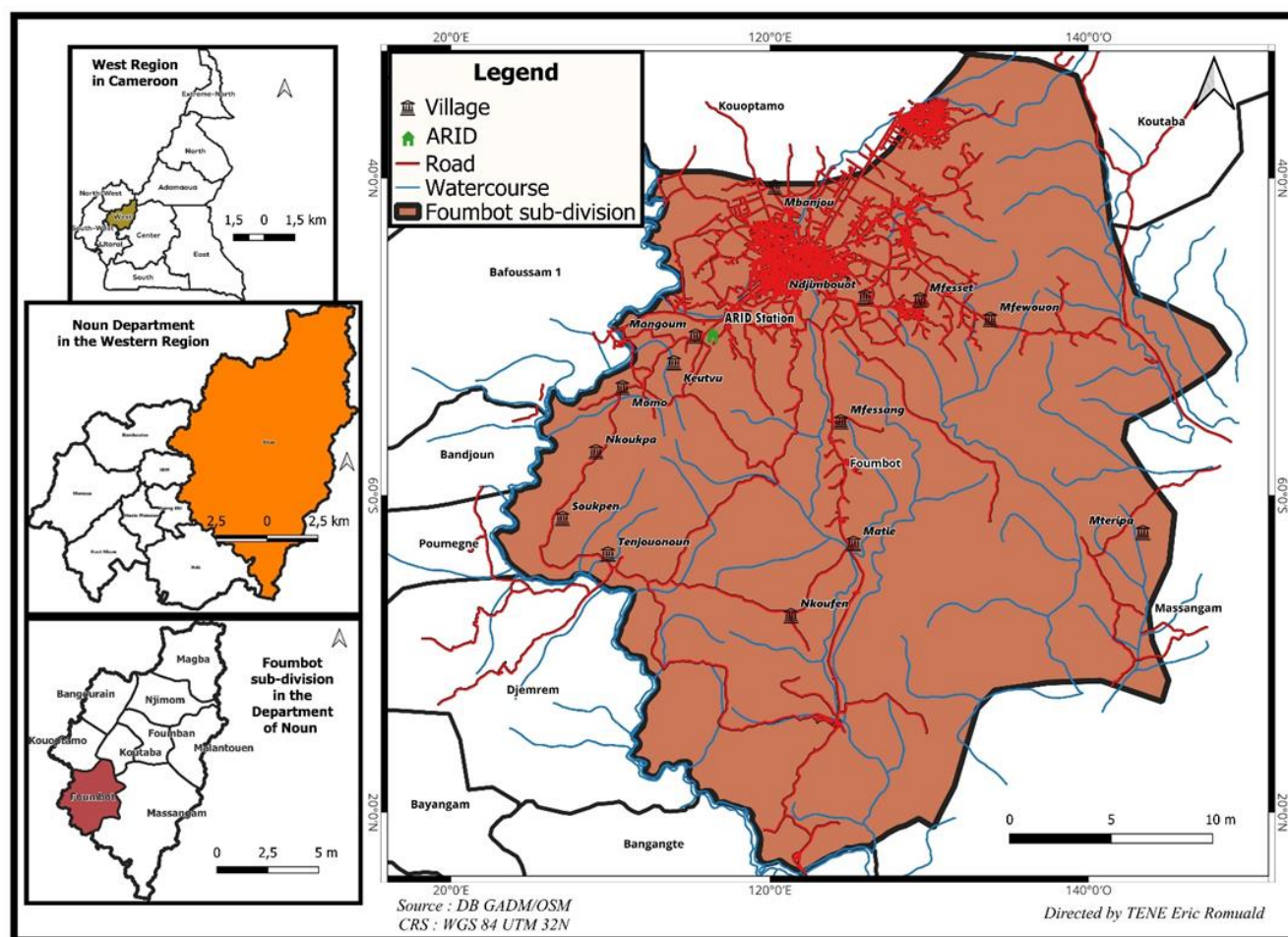


Figure 1. Location map of the Foubot Sub-division.

2.2. Material

2.2.1. Biological Material

(i). Plant Material

In this study, the plant material consisted of seeds of two varieties of tomato (*Lycopersicon esculentum*. L) including a standard or composite variety of tomato RIO POWER GRANDE partially improved and a more improved one called Hybrid RAJA F1 purchased in a local market. In this work, fresh leguminous plants of *Gliricidia sepium*, and Chinese bamboo (*Bambusa vulgaris*) were harvested within the IRAD Station of Foubot.

(ii). Animal Biological Material

The *Rhizophagus irregularis* and *Rhizophagus intraradices* strains of the mycorrhizal fungus were purchased from the Microbiology Laboratory of the Department of Plant Biology and Physiology of the Faculty of Sciences of the University of Ngaoundéré and Yaoundé I in Cameroon respectively.

2.2.2. Chemical Production Material

The chemicals purchased consisted of compound fertilizer (NPK: 20-10-10), Urea, PLANTINE B 80 WP fungicide, and insecticides: K-OPTIMAL, CIGOGNE, AMMONIUM SULFATE, CAIMENT B, CORAGEN.

2.3. Methods

2.3.1. Nursery

(i). Experimental Nursery Design

The nursery for each growing season was made on a plot of 4.9 m x 4.7 m, or 23.03 m² consisting of 14 ridges arranged parallel in two rows of 7 ridges for each of the two tomato varieties tested. The two rows were separated by a space of 0.5 m and each ridge was 2m x 0.5 m and then in the rows, the gap between neighboring ridges was 0.2 m with 0.1 m left at the ends of each ridge. Figure 2 below shows the design following the order of treatments by tomato variety (RIO GRANDE and RAJA F1 varieties).



Figure 2. Young plants of the different treatments of the two varieties of tomatoes produced in the nursery ready for transplantation in the field.

(ii). Treatments of Young Seedlings in the Nursery

The fourteen beds of the nursery were divided into two blocks of each seven ridges corresponding to each variety. These seven ridges of each variety corresponded to the seven treatments also adopted in the field after transplantation of the young seedlings where growth and development were followed up to the fruiting stage.

2.3.2. Experimental Field Design

The experiments for each growing season (dry season and rainy season) were conducted on a plot of 492 m², consisting of 126 ridges in two blocks of 63 ridges of 4.7 m x 0.5 m each with a spacing of 0.2 m between the ridges for the two varieties. Each block consisted of three sub-blocks of 21 ridges each in an open environment with a completely randomized block design of 7 treatments repeated three times in each sub-block. Each ridge/treatment consisted of 10 plants, or 630 plants per variety giving a total of 1260 plants for the two varieties per growing season. A one-meter peripheral path was traced around the plot to facilitate circulation and data collection.

(i). Treatments

The experiment consisted of 7 treatments as shown in Table 1 below.

Table 1. Treatments.

Treatments Traitements	Treatment components
T1	UNF + UNT
T2	MF + PC

Treatments Traitements	Treatment components
T3	MF + NT
T4	20+10+10+U
T5	20+10+10+U
T6	Gs + PC
T7	Gs + NT

Legend: UNF (Unfertilized); UNT (Untreated); MF: Mycorrhizal Fungus; PC: Preventive Chemical Treatment based on PLANTINE B 80 WP, K-OPTIMAL, CIGOGNE, CAIMENT B, CORAGEN; NT (Natural Preventive Treatment based on neem oil); 20-10-10 (Fertilizer composed of nitrogen, phosphorus and potassium in the proportions 20-10-10); U (Urea); Gs: *Gliricidia sepium*.

(ii). Trial

After 35 days from the date of sowing in the nursery, the seedlings ready to be transplanted were obtained and the most physically vigorous were selected and transplanted into the fields. The ridges were made in such a way as to allow excess water to flow freely following heavy rains and on the other hand, arrangements were made to keep as much irrigation water on site as possible during periods of no rain. During the dry season, water was brought into the plot from the neighboring backwater and from a supply channel, which allowed the water to circulate continuously in all the furrows throughout this campaign. This was done for about a month of no rains during the rainy season. The ridges were made in such a way as to allow excess water to flow freely following heavy rains. Treatments T2 and T3 were fertilized with Mycorrhizal Mushrooms: a mixture of *Rhizophagus irregularis* and *Rhizophagus intraradices* strains, at a rate of 50 g per line and then 60 g per pocket at the time of transplantation.

The plants in treatments T4 and T5 were chemically fertilized in the same way as in the nursery: 75 g of NPK (20-10-10) and 5 g of urea, applied per pocket at the start just after transplanting and then every 2 weeks.

Treatments T6 and T7 were each fertilized with *Gliricidia sepium* manure from the nursery at a rate of one liter of the latter diluted in 10 liters of water and applied by ridges every 7 days.

Pest and disease control was carried out as in the nursery: Treatments T2, T4 and T6 were chemically treated as a preventative measure, using the fungicide PLANTINE B 80 WP at a quantity of 20 mL (about a teaspoon) and the systemic insecticide K-OPTIMAL at a frequency of 2 times per week. This insecticide was thus applied as a preventative measure in a quantity of 10 mL in the 16-litre sprayer and similarly for the same quantities of CIGOGNE which were introduced into a sprayer for an application frequency corresponding to an application every 4 days to keep insects and whitefly away.

Treatments T3, T5 and T7 were also naturally treated as a preventative measure using 2 mL of neem oil introduced into the sprayer and applied to the plants concerned from transplanting and then every two weeks until the end of production.

As soon as the first fruits appeared, treatments T2, T4 and T6 were chemically treated per plant using a spoonful of CORAGEN insecticide applied twice a week to combat the tomato leaf miner (*Tuta absoluta*), nicknamed Boko Haram by producers. Twenty milliliters of the mixture consisting of ½ liter of K-OPTIMAL and ½ liter of CIGOGNE were introduced into a 16-liter sprayer and applied every 4 days against caterpillars. Treatments T3, T5 and T7 were also treated naturally using 2 mL of neem oil introduced into the sprayer and applied to the plants during production. At the end of the work thus carried out, the desired parameters were determined.

Growth parameters were recorded respectively at two weeks after transplanting (2WAT) which was the first period (P1), five and half weeks after transplanting (5.5WAT) or second period (P2) and 12 weeks after transplanting (2WAT) or third period (P3). Stem heights were measured using the tape measure, the number of leaves counted and the leaf areas (S) calculated according to the formula of Kumar et al. (2002) [11], by measuring the length (L) and width (l) of the leaves with the ruler.: $S = L \times l \times 0.80 \times N \times 0.662$.

N = total number of leaves of the plant according to Murray (1960) [12]. The production parameters considered from the start of production were: the number of terminal buds produced per plant counted every week, the number of flowers produced per plant counted every week, the number of fruits reaching maturity per plant counted every week, the weight of 10 fruits produced per plant measured using the scale, the fruit yield in quintal per hectare, calculated by extrapolation at the

end of production.

2.4. Data Analysis

A variance analysis (ANOVA) was performed using R.4.2.2 software and Excel, version 2016, which allowed the Tukey test to be performed, comparing a multiple of means in a single step at the probability threshold of $P < 0.05$.

3. Results

3.1. Growth Parameters

3.1.1. Number of Leaves

The number of leaves of the Standard RIO POWER GRANDE and RAJA F1 hybrid varieties was evaluated in the field at different periods after transplanting the young shoots like all other growth parameters, during each growing season (dry season and rainy season). Thus, the first period of evaluation of the number of leaves of the plants took place at two weeks after transplanting the young shoots (2WAT), the second period at five and a half weeks after transplanting (5.5 WAT) and the third period at twelve weeks after transplanting (12 WAT).

(i). Dry Season

a) Standard RIO POWER GRANDE variety

At the end of periods P1, P2 and P3, the results show that the number of leaves in the Standard RIO POWER GRANDE variety gradually evolves from period P1 to period P3 in all treatments. However, this evolution differs significantly from one treatment to another. In period P3, the number of leaves is significantly higher in treatments fertilized with mycorrhizal fungus: T2 ($32 \pm 1b$) and T3 ($31.66 \pm 1.5b$). These treatments T2 and T3 are respectively chemically and naturally treated against diseases and pests during their growth. The unfertilized and untreated T1 treatment ($18.33 \pm 0.57a$) and the T6 treatment ($19 \pm 1a$) fertilized with *Gliricidia sepium* and chemically treated against diseases and pests have the least significantly high leaf numbers compared to the other treatments. The T4 treatment ($21 \pm 1a$) fertilized and chemically treated against diseases and pests, the T5 treatment ($21.33 \pm 0.57a$) chemically fertilized and naturally treated and the T7 treatment ($21.33 \pm 3.05a$) fertilized with *Gliricidia sepium* and naturally treated have significant leaf numbers although these numbers are not significantly different from the control treatment (T1) and the T6 treatment (Table 2).

Table 2. Number of leaves per plant of Standard and Hybrid plants grown during the dry and rainy seasons.

Seasons	Varieties	Periods	Sig.	T1	T2	T3	T4	T5	T6	T7
Dry season	Standard	P1: 2 WAT	0		7.66±0.57 ^b	7.66±0.57 ^b	5.66±0.57 ^a	5.66±0.57 ^a	5±0 ^a	5.66±0.57 ^a
		P2: 5.5 WAT	0	10.66±0.57 ^a	15.33±2.08 ^b	15.33±1.5 ^b	11.33±0.57 ^a	11.66±0.57 ^a	10.66±0.57 ^a	11.33±0.57 ^a
		P3: 12 WAT	0	18.33±0.57 ^a	32±1 ^b	31.66±1.5 ^b	21±1 ^a	21.33±0.57 ^a	19±1 ^a	21.33±3.05 ^a
	Hybrid	P1: 2 WAT	0	5.66±0.57 ^a	8.66±0.57 ^b	9±0 ^b	6.33±0.57 ^a	7±1 ^a	6.33±0.57 ^a	6.33±0.57 ^a
		P2: 5.5 WAT	0.001	12±0 ^a	15±2.6 ^{ab}	17.66±0.57 ^b	12.66±0.57 ^a	13±1 ^a	14.33±1.52 ^{ab}	12±1 ^a
		P3: 12WAT	0	22±1 ^a	34.66±0.57 ^b	35.33±0.57 ^b	22.66±0.57 ^a	24.66±1.52 ^a	25.33±2.08 ^a	23±1 ^a
Rainy season	Standard	P1: 2WAT	0	4.66±0.57 ^a	7.66±0.57 ^{bc}	7±1 ^b	5±0 ^a	5±0 ^a	5.33±0.57 ^a	5.66±0.57 ^{ab}
		P2: 5.5WAT	0	10.66±0.57 ^a	15.66±1.52 ^b	14.63±1.15 ^b	11±0 ^a	11.33±0.57 ^a	11±1 ^a	12.66±0.57 ^a
		P3: 12WAT	0	18.66±0.57 ^a	33.33±0.57 ^b	32±1 ^b	20.33±0.57 ^a	20.33±0.57 ^a	20.33±1.52 ^b	20.33±0.57 ^a
	Hybrid	P1: 2WAT	0	5.66±0.57 ^a	9±0 ^b	8.66±0.57 ^b	6.66±0.57 ^a	7±1 ^a	6.33±0.57 ^a	6.66±0.57 ^a
		P2: 5.5WAT	0.001	11.66±0.57 ^a	15.36±2.08 ^b	15.42±2.08 ^b	12±0 ^a	12.66±1.15 ^{ab}	11.66±0.57 ^a	11.33±0.57 ^a
		P3: 12WAT	0	21.66±0.57 ^a	35.66±1.52 ^b	36±1 ^b	23±1 ^a	23.33±1.52 ^a	23±1 ^a	22.33±0 ^a

P1: first period after sowing; P2: second period after sowing; P3: third period after sowing

- Presentation of the results in the form: means±standard deviations

- The means which have the same letter for the same indicator, reflect the absence of significant difference between them according to the Turkey test at the probability threshold $P < 0.05$

b) Hybrid RAJA F1 variety

At the end of periods P1, P2 and P3, the results of the number of leaves in the Hybrid RAJA F1 variety also show an evolution of the number of leaves from period P1 to period P3 in all treatments. This evolution differs significantly in most treatments. At period P3, the number of leaves observed in treatments T2 (34.66±0.57b) and T3 (35.33±0.57b) fertilized with mycorrhizal fungus, differs significantly from the rest of the treatments. These treatments T2 and T3 are respectively chemically and naturally treated against diseases and pests during their growth. Treatment T1 (22±1a) unfertilized and untreated, treatment T4 (22.66±0.57a) fertilized and chemically treated against diseases and pests and treatment T7 (23±1a) fertilized with *Gliricidia sepium* and treated naturally have the lowest leaf numbers compared to the rest of the treatments. Treatment T5 (24.66±1.52a) chemically fertilized and treated naturally and treatment T6 (25.33±2.08a) fertilized with *Gliricidia sepium* and then chemically treated, have significant leaf numbers although these numbers are not significantly different from treatments T1, T4 and T7 (Table 2).

(ii). Rainy Season

a) Standard RIO POWER GRANDE variety

The outcome of the first period P1 resulted in significant disparities in all treatments. These results also showed that the number of leaves changed from period 1 to period 3 in all treatments in the rainy season for the Standard RIO POWER GRANDE variety. At the end of period 3, it appears that treatments T2 (33.33±0.57b) and T3 (32±1b) fertilized with

mycorrhizal fungus differ significantly from the rest of the treatments. These treatments T2 and T3 treated respectively chemically and naturally against diseases and pests during their growth have the most significantly high values compared to the other treatments. Treatment T1 (18.66±0.57a) unfertilized and untreated has the lowest value compared to the other treatments. Treatments T4 (20.33±0.57a) fertilized and chemically treated, T5 (20.33±0.57a) chemically fertilized and naturally treated, T6 (20.33±1.52b) fertilized with *Gliricidia sepium* and chemically treated and T7 (20.33±0.57a) fertilized with *Gliricidia sepium* and naturally treated have significant leaf numbers although these numbers are not significantly different from the control treatment T1 (Table 2).

b) Hybrid RAJA F1 variety

At the end of period P1, the results do not show significant differences in most of the treatments studied, except for treatments T2 (9±0b) and T3 (8.66±0.57b). However, an evolution of the leaf numbers is observed from period P1 to period P3. At the end of this period P3, the results show that treatments T2 (35.66±1.52b) and T3 (36±1b) fertilized with mycorrhizal fungus, differ significantly from the rest of the treatments. These treatments T2 and T3 also have the highest number of leaves compared to the other treatments. Treatment T1 (21.66±0.57a) unfertilized and untreated has the lowest number of leaves compared to the other treatments. Treatments T4, T5, T6 and T7, although having high numbers of leaves, are not significantly different from the results of the control T1 (Table 2).

3.1.2. Stem Height

(i). Dry Season

Standard RIO POWER GRANDE variety

The end of periods P1, P2 and P3 showed that the stem height of the Standard RIO POWER GRANDE variety in the dry season gradually increased from period P1 to period P3. However, the values of this increase differ from one treatment to another. At period P3, the results show in this variety that the lowest values are observed in the control treatment T1 ($85 \pm 0.29a$), the treatment T4 ($88.63 \pm 0.77 a$) chemically fer-

tilized and naturally treated and the treatment T6 ($87.23 \pm 0.25 a$) fertilized with *Gliricidia sepium* and chemically treated while the treatment T5 ($114.16 \pm 1.25c$) chemically fertilized and naturally treated against diseases and pests, has the most significantly high value at the threshold of $P < 0.05$. Treatments T2 ($105 \pm 0.5b$) fertilized with mycorrhizal fungus and chemically treated, T3 ($107.83 \pm 0.76b$) fertilized with mycorrhizal fungus and naturally treated and T7 ($107.66 \pm 4.04b$) fertilized with *Gliricidia sepium* and naturally treated against diseases and pests, although presenting average values, did not have significant differences (Table 3).

Table 3. Stem height of Standard and Hybrid plants grown during the dry and rainy seasons.

Seasons	Varieties	Periods	Sig.	T1	T2	T3	T4	T5	T6	T7
Dry season	Standard	P1: 2WAT	0	9 ± 0.4^a	13.75 ± 0.66^c	19.1 ± 0.36^d	12.03 ± 0.45^b	21.7 ± 0.6^c	10.1 ± 0.36^a	15.06 ± 0.8^c
		P2: 5.5WAT	0	23 ± 1^a	29.06 ± 0.6^d	33.36 ± 0.55^f	24.58 ± 0.52^{ab}	36.43 ± 0.51^g	22.03 ± 0.15^{ac}	31.16 ± 0.66^e
		P3: 12WAT	0	85 ± 0.29^a	105 ± 0.5^b	107.83 ± 0.76^b	88.63 ± 0.77^a	114.16 ± 1.25^c	87.23 ± 0.25^a	107.66 ± 4.04^b
	Hybrid	P1: 2WAT	0	13.36 ± 0.55^a	12.46 ± 0.5^a	16.93 ± 0.3^b	20.16 ± 0.15^c	21.9 ± 0.45^d	22.93 ± 0.4^d	19.2 ± 0.3^c
		P2: 5.5WAT	0.001	25.13 ± 0.15^c	21.33 ± 0.15^a	27.1 ± 0.6^d	35.23 ± 0.32^f	37.16 ± 0.2^g	22.93 ± 0.4^b	33.26 ± 0.23^e
		P3: 12WAT	0	94.16 ± 0.76^b	88.5 ± 0.5^a	96.83 ± 0.28^c	115.8 ± 0.34^e	120.43 ± 0.51^f	128 ± 1^g	111.16 ± 0.76^d
Rainy season	Standard	P1: 2WAT	0	10.56 ± 0.51^a	22.5 ± 0.62^e	19.96 ± 0.25^d	15.26 ± 0.3^b	17.5 ± 0.5^c	15.6 ± 1.12^b	15.06 ± 0.2^b
		P2: 5.5WAT	0	24.3 ± 0.65^a	35.26 ± 0.64^{cd}	33.33 ± 0.15^{bcd}	32.26 ± 0.37^{bc}	31.83 ± 0.66^{bc}	33.5 ± 0.5^{bcd}	34.13 ± 2.2^{bcd}
		P3: 12WAT	0	87.9 ± 0.17^a	115.03 ± 0.25^d	114.06 ± 1^{cd}	107.96 ± 1.05^b	109.5 ± 0.5^b	113.06 ± 0.9^c	114.1 ± 0.1^{cd}
	Hybrid	P1: 2WAT	0	12.36 ± 0.32^a	23.73 ± 0.64^c	20.06 ± 0.9^{bc}	20.5 ± 1.32^{bc}	22.46 ± 0.5^c	19 ± 0.5^b	22 ± 1^c
		P2: 5.5WAT	0.001	22 ± 0.39^a	44.93 ± 1.1^d	35.76 ± 0.8^b	34.93 ± 1.79^b	39.96 ± 0.15^c	36 ± 1^b	36.06 ± 0.9^b
		P3: 12WAT	0	90.16 ± 0.76^a	133.13 ± 0.41^f	117.56 ± 1.25^d	115.76 ± 0.68^{cd}	122.43 ± 0.51^e	112.4 ± 0.52^b	115.23 ± 0.68^c

P1: first period after sowing; P2: second period after sowing; P3: third period after sowing

- Presentation of the results in the form: means \pm standard deviations

- The means which have the same letter for the same indicator, reflect the absence of significant difference between them according to the Turkey test at the probability threshold $P < 0.05$

Values in Cm

b) Hybrid RAJA F1 variety

The evolution of the size of the plants recorded for the hybrid RAJA F1 variety was also observed by treatment from period P1 to period P3. The analysis of these results shows that this evolution of the height of the stems varies significantly from one treatment to another at the threshold $P < 0.05$. The third period P3 is distinguished by the highest values. The results show that treatment T6 ($128 \pm 1g$) fertilized with *Gliricidia sepium* and chemically treated has the most significantly higher height compared to the other treatments. Treatment T5 ($120.43 \pm 0.51f$) chemically fertilized and naturally treated follows directly and differs significantly from the remaining treatments. The treatments, T4 ($35.23 \pm 0.32e$) fertilized and chemically treated, T7 ($111.16 \pm 0.76 d$) fertilized *Gliricidia sepium* and naturally treated, T3 ($96.83 \pm 0.28c$) fertilized with mycorrhizal fungus and naturally treated, T1 ($94.16 \pm 0.76b$)

unfertilized and untreated and T2 ($88.5 \pm 0.5a$) fertilized with mycorrhizal fungus and chemically treated, have significantly different sizes in decreasing order (Table 3).

(ii). Rainy Season

a) Standard RIO POWER GRANDE variety

The evolution of stem height from period P1 to P3 through P2 in the rainy season in the standard RIO POWER GRANDE variety experienced continuous growth in all treatments. Period P3 shows that treatment T2 ($115.03 \pm 0.25d$) fertilized with mycorrhizal fungus and chemically treated has the most significantly higher height compared to the other treatments. The heights that immediately followed were those of treatments T3 (114.06 ± 1^{cd}) fertilized with mycorrhizal fungus and naturally treated and T7 (114.1 ± 0.1^{cd}) fertilized with

Gliricidia sepium and naturally treated. Treatments T6 (113.06±0.9c) fertilized with *Gliricidia sepium* and chemically treated, T4 (107.96±1.05b) fertilized and chemically treated, and T5 (109.5±0.5b) chemically fertilized and naturally treated followed significantly in decreasing order. The control treatment T1 (87.9±0.17a) unfertilized and untreated had the lowest pruning height value (Table 3).

b) Hybrid RAJA F1 variety

Once the P1, P2 and P3 periods have reached the end of the rainy season respectively and for the case of the hybrid RAJA F1 variety, the results showed that the height of the stems gradually evolves from the P1 period to the P3 period. However, this evolution differs significantly from one treatment to another. The most significantly higher height compared to the other treatments was observed in treatment T2 (133.13±0.41f) fertilized with mycorrhizian fungus and chemically treated at the threshold $P < 0.05$. Of the six remaining treatments, treatment T5 (122.43±0.51e), chemically fertilized and naturally treated, followed directly. The third most significantly higher height was observed in treatment T3 (117.56±1.25d), fertilized with mycorrhizian fungus and naturally treated. Treatment T4 (115.76±0.68cd) fertilized and chemically treated was then distinguished from the four remaining treatments by superiority in height at the threshold of $P < 0.05$. Treatments T7 (115.23±0.68c) fertilized with *Gliricidia sepium* and naturally treated T6 (112.4±0.52b) fertilized with *Gliricidia sepium* and

chemically treated and T1 (90.16±0.76a) unfertilized and untreated show stem size values in decreasing order and significantly different (Table 3).

3.1.3. Leaf Areas

(i). Dry Season

a) Standard RIO POWER GRANDE variety

From period P1 to period P3 in all treatments, the results obtained showed a progressive increase in leaf areas for the Standard RIO POWER GRANDE variety. This evolution nevertheless differs significantly in general from one treatment to another. At period P3, the leaf area is significantly higher in treatments T2 (287.66±3.21 c) fertilized with mycorrhizian fungus and chemically treated and T3 (290.66±2.08 c) fertilized with mycorrhizian fungus and naturally treated and T7 (284.66±8.38 c) fertilized with *Gliricidia sepium* and naturally treated. Treatment T1 (165±5a) unfertilized and untreated and treatment T4 (162.33±2.08 a) fertilized and chemically treated against diseases and pests have the smallest leaf areas compared to the other treatments. Treatments T6 (281.66±1.52bc) fertilized with *Gliricidia sepium* and chemically treated and T5 (273±3b) chemically fertilized and naturally treated have in decreasing order each obtained a larger leaf area than the control treatment (Table 4).

Table 4. Leaf areas of Standard and Hybrid plants grown during the dry and rainy seasons.

Seasons	Varieties	Periods	Sig.	T1	T2	T3	T4	T5	T6	T7
Dry season	Standard	P1: 2WAT	0	60.66±2.51 ^a	112.33±1.52 ^a	150.66±2.08 ^a	79.33±2.08 ^a	118±1 ^b	120±1 ^b	118±1.73 ^b
		P2: 5.5WAT	0	151±1 ^a	282±1 ^d	281.33±0.57 ^d	152±1.73 ^a	266±1 ^b	271.33±2.08 ^c	264±1 ^b
		P3: 12WAT	0	165±5 ^a	287.66±3.21 ^c	290.66±2.08 ^c	162.33±2.08 ^a	273±3 ^b	281.66±1.52 ^{bc}	284.66±8.38 ^c
	Hybrid	P1: 2WAT	0	63.33±0.57 ^a	154.16±0.76 ^c	122±1 ^b	150±1 ^d	122±1 ^b	125±1 ^c	122±1 ^b
		P2: 5.5WAT	0	154±1 ^a	324±1 ^c	323.33±0.57 ^c	319±1 ^b	316.33±1.15 ^b	318±2 ^b	324±1 ^c
		P3: 12WAT	0.03	165.33±5.03 ^a	327.33±1.52 ^b	334.33±7.37 ^b	228±168.87 ^{ab}	320.33±4.5 ^{ab}	325±1 ^b	327.66±0.57 ^b
Rainy season	Standard	P1: 2WAT	0	121.33±1.52 ^b	121.33±1.52 ^b	126±1 ^c	116.5±0.5 ^a	118.83±0.76 ^{ab}	121.33±0.57 ^b	117.96±1 ^a
		P2: 5.5WAT	0	272.66±1.52 ^a	335.83±1.04 ^c	384.32±4.35 ^d	271.33±1.52 ^a	273.66±0.57 ^a	284±1 ^b	281.33±1.52 ^b
		P3: 12WAT	0	288.33±3.05 ^a	349±1 ^c	397.66±1.52 ^d	290.33±2.51 ^a	291.33±1.52 ^a	301±1 ^b	304.33±6.65 ^b
	Hybrid	P1: 2WAT	0	71.66±2.08 ^a	157.66±0.57 ^b	300±13.22 ^d	155.66±2.08 ^b	157.66±1.52 ^b	156±1 ^b	254.66±5.03 ^c
		P2: 5.5WAT	0	154±1 ^a	359.5±1.32 ^{cd}	413.36±2.12 ^e	328±1 ^{cd}	292±35.51 ^b	328.5±0.86 ^{cd}	324.6±2.08 ^{bc}
		P3: 12WAT	0	201.33±1.52 ^a	399.33±2.08 ^d	451.66±1.52 ^e	350.66±30.02 ^c	314±1 ^b	368±1 ^c	380±2.64 ^c

P1: first period after sowing; P2: second period after sowing; P3: third period after sowing

- Presentation of the results in the form: means ± standard deviations

- The means which have the same letter for the same indicator, reflect the absence of significant difference between them according to the Turkey test at the probability threshold $P < 0.05$

Values in Cm^2

b) Hybrid RAJA F1 variety

At the end of periods P1, P2 and P3, the results of the leaf

areas in the hybrid RAJA F1 variety also show an increase in leaf area from period P1 to period P3 in all treatments. This increase differs significantly in the majority of treatments. At period P3, the leaf areas observed in treatments T2 ($327.33 \pm 1.52b$) fertilized with mycorrhizal fungus and chemically treated and T3 ($334.33 \pm 7.37b$) fertilized with mycorrhizal fungus and naturally treated and then T6 ($325 \pm 1b$) fertilized with *Gliricidia sepium* and chemically treated and T7 ($327.66 \pm 0.57b$) fertilized with *Gliricidia sepium* and naturally treated differ significantly from the rest of the treatments. Treatment T1 ($165.33 \pm 5.03a$) unfertilized and untreated against diseases and pests obtained the most significantly low leaf area compared to the rest of the treatments. Treatments T4 ($228 \pm 168.87ab$) chemically fertilized and chemically treated and T5 ($320.33 \pm 4.5ab$) chemically fertilized and naturally treated against diseases and pests had significantly larger leaf areas compared to control treatment T1 which had the most significantly lower leaf area. (Table 4).

(ii). Rainy Season

a) Standard RIO POWER GRANDE variety

The results of the leaf areas of the periods P1, P2 and P3 in the hybrid RAJA F1 variety also show a progressive evolution of the values from the period P1 to the period P3 in all the treatments. At the end of the period P3, it appears that the treatment T3 ($397.66 \pm 1.52d$) fertilized with mycorrhizal fungus and treated naturally, has the most significantly higher value compared to the other treatments. The treatments T1 ($288.33 \pm 3.05a$) unfertilized and untreated against diseases and pests, T4 ($290.33 \pm 2.51a$) fertilized and chemically treated against diseases and pests, and T5 ($291.33 \pm 1.52a$) chemically fertilized and treated naturally against diseases and pests, have the lowest values compared to the other treatments. Treatment T2 ($349 \pm 1c$) fertilized with mycorrhizal fungus and chemically treated follows directly with a leaf area significantly higher than those of the rest of the treatments. Treatments T6 ($301 \pm 1b$) fertilized with *Gliricidia sepium*, and chemically treated and T7 ($304.33 \pm 6.65b$) fertilized with *Gliricidia sepium*, and naturally treated against diseases and pests have leaf areas directly and significantly higher than that of the unfertilized and untreated control treatment (Table 4).

b) Hybrid RAJA F1 variety

The results of the leaf area of the plants were recorded in the hybrid RAJA F1 variety from the period P1 to P3. However, a continuous evolution of the leaf areas is observed from P1 to P3. At the end of the P3 period, the results show that treatment T3 ($451.66 \pm 1.52e$) fertilized with mycorrhizal fungus and naturally treated against diseases and pests, has the most significantly higher value compared to the rest of the treatments. Treatment T1 ($201.33 \pm 1.52a$) unfertilized and untreated has the most significantly lower leaf area compared to the other treatments. Treatment T2 ($399.33 \pm 2.08d$) fertilized with mycorrhizal fungus and naturally treated against diseases and pests has the second most significantly larger leaf area. Treatments T4 ($350.66 \pm 30.02c$) fertilized and

chemically treated, T6 ($368 \pm 1c$) fertilized with *Gliricidia sepium* and chemically treated and T7 ($380 \pm 2.64c$) fertilized with *Gliricidia sepium* and naturally treated also have the most significantly high leaf areas. Treatment T5 ($314 \pm 1b$) chemically fertilized and naturally treated against diseases and pests has the value most significantly close to that of the leaf area of the control treatment T1 (Table 4).

3.2. Production Parameters

Five production parameters were recorded during the dry season and the rainy season for both varieties. The production parameters are as follows: the number of terminal buds, the number of flowers, the number of fruits, the weight of 10 fruits in grams and finally the yield in quintal per hectare.

3.2.1. Standard RIO Power Grande Variety

(i). Dry season

The analysis of the results on the number of terminal buds shows that all treatments had a positive influence on production. This production is significantly higher at the threshold of $P < 0.05$ in plants of treatment T2 ($32.33 \pm 4.93b$), fertilized with mycorrhizal fungus and treated with chemicals and treatment T3 ($30 \pm 3.6b$), fertilized with mycorrhizal fungus and treated naturally. As for the number of flowers produced, the analyses show that the most significantly high results are also obtained in treatments T2 ($28 \pm 1b$) and T3 ($28.66 \pm 3.21b$). The analysis of fruiting also shows that the number of fruits produced is significantly higher in treatments T2 ($25.33 \pm 1.52b$) and T3 ($26.33 \pm 2.88b$). Regarding the weight of 10 fruits, the most significantly high results are rather obtained in treatments T4 ($45.33 \pm 1.52b$) chemically fertilized and treated with chemicals, T5 ($44.66 \pm 1.15b$) chemically fertilized and naturally treated, T6 ($48 \pm 1b$) naturally fertilized and chemically treated and T7 ($48 \pm 1b$) naturally fertilized and naturally treated. Regarding yield per hectare (in quintal per hectare), the most significantly high values were obtained for treatments T2 ($0.39 \pm 0c$) and T3 ($0.38 \pm 0.02c$). These values are directly followed by those obtained for treatments T7 ($0.26 \pm 0.01b$), T6 ($0.26 \pm 0.01b$), T5 ($0.24 \pm 0.01b$) and T4 ($0.22 \pm 0.03b$). The control treatment T1 ($0.15 \pm 0a$) which received neither fertilization nor treatment, had the most significantly low value (Figure 3)

(ii). Rainy season

In the rainy season, a decrease in production in all treatments, of the standard RIO POWER GRANDE variety was observed without this necessarily being at the same fervor, from the number of flower buds to the number of fruits produced, including flowers. The number of terminal buds obtained in the rainy season having the most significantly high value at the threshold of $P < 0.05$ is also observed in treatments T2 ($28.66 \pm 3.21b$) and T3 ($28.33 \pm 1.52b$) while the most significantly low value is obtained in treatment T1 ($16 \pm 2a$) neither fertilized nor treated. The analysis of the number of flowers produced also shows that the most significantly high values are

obtained in treatments T2 ($28 \pm 3.6b$) and T3 ($27.33 \pm 1.52b$). Similar results are also obtained during the analysis of the number of fruits produced per plant. Thus, the most significantly high values are obtained in treatments T2 ($25.33 \pm 3.78b$) and T3 ($24.66 \pm 1.15b$). As for the analysis of the results of 10 fruits produced per plant, the most significantly high values are rather obtained in treatments T6 ($47.33 \pm 0.57c$), T7 ($47 \pm 1c$), T5 ($45.33 \pm 0.57c$), and T4 ($45 \pm 1c$) while the most significantly low values are obtained respectively in treatments T3

($38.33 \pm 0.57b$), T2 ($37 \pm 1ab$) and T1 ($35 \pm 1a$) at the probability threshold of $P < 0.05$. In terms of yield, the analysis of the results shows that the most significantly high values are observed in treatments T7 ($0.27 \pm 0.02c$), T6 ($0.26 \pm 0.01c$), T5 ($0.25 \pm 0.01c$) and T4 ($0.24 \pm 0.01c$). These values are significantly followed by those of treatments T2 ($0.37 \pm 0.04b$) and T3 ($0.37 \pm 0.02b$). The most significantly low production is obtained in treatment T1 ($0.15 \pm 0.01a$) neither fertilized nor treated at the probability threshold $P < 0.05$ (Figure 4).

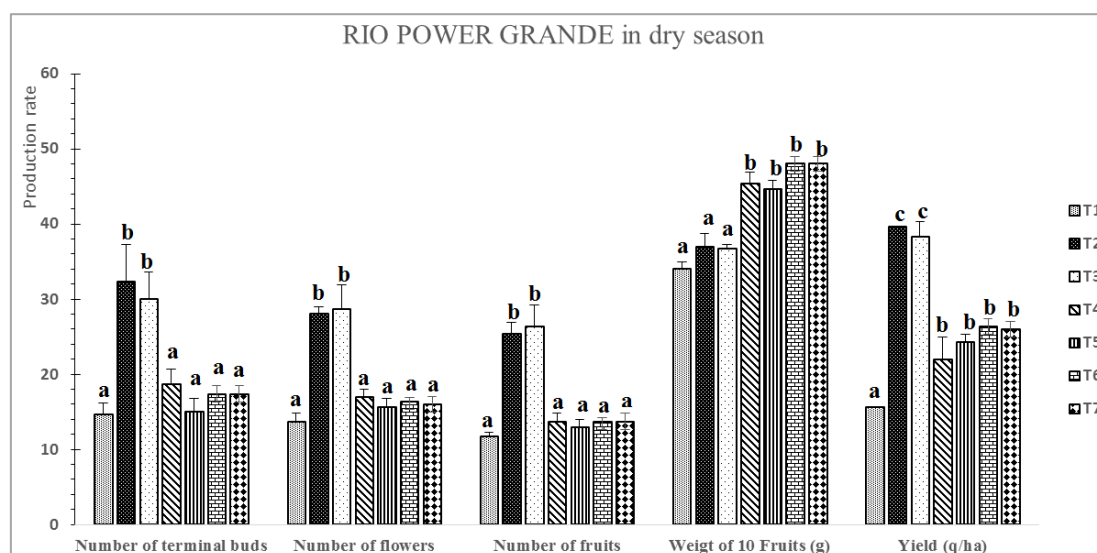


Figure 3. Different production parameters of the Standard RIO POWER GRANDE variety in the dry season.

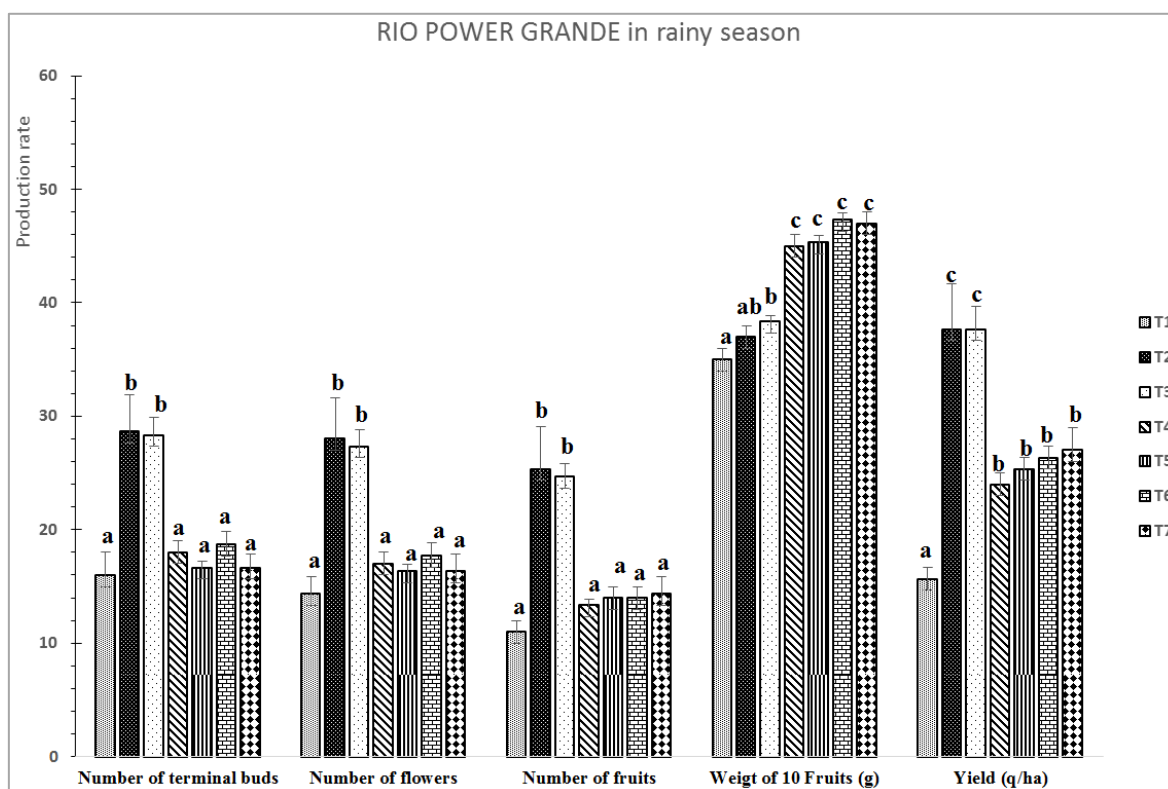


Figure 4. Different production parameters of the Standard RIO POWER GRANDE variety in the rainy season.

3.2.2. Hybrid RAJA F1 Variety

(i). Dry season

In the hybrid RAJA F1 variety, the analyses show at the end of the dry season that the results vary according to the treatments regardless of the production parameter studied. Thus, the analysis of the results shows that the number of terminal buds is significantly higher in the chemically fertilized treatments T2 (34 ± 1 b) and T3 (33.33 ± 2.51 b) at the threshold of $P < 0.05$. These two treatments T2 and T3 are respectively chemically and naturally treated against diseases and pests during their growth. The unfertilized and untreated treatment T1 (16 ± 1 a) has the lowest number of terminal buds as well as the treatments T4 (17 ± 1 a), T5 (17 ± 1 a), T6 (17 ± 1.73 a), and T7 (17.33 ± 0.57 a). The same treatments T2 (33 ± 1 b) and T3 (32.66 ± 2.51 b) also have the most significantly high number of flowers while the most significantly low number of flowers is observed in treatments T1 (15.33 ± 0.57 a), T4 (17 ± 1 a), T5 (17 ± 1 a), T6 (17 ± 1.73 a), and T7 (17.33 ± 0.57 a). This is also

the case regarding the number of fruits per plant where the most significantly high number is observed in treatments T2 (30.66 ± 1.15 b) and T3 (31 ± 1.73 b) and the most significantly low number of buds in treatments T1 (13 ± 1 a), T4 (15 ± 1 a), T5 (16 ± 1 a), T6 (15.66 ± 2.08 a), and T7 (16 ± 1 a). As for the weight of 10 fruits, the most significantly high number is rather observed in treatments T4 (50.66 ± 0.57 c), T5 (51 ± 1 c), T6 (54 ± 1 d), and T7 (53.66 ± 1.52 d) followed directly by treatments T2 (38.66 ± 0.57 b) and T3 (39.33 ± 0.57 b). The most significantly low weight of 10 fruits is observed in treatment T1 (35.33 ± 0.57 a) neither fertilized nor treated. Regarding yield, the most significantly high yield is observed in treatments T2 (0.46 ± 0.0 c) and T3 (0.48 ± 0.01 c) and then in treatments T4 (0.3 ± 0 b), T5 (0.32 ± 0.01 b), T6 (0.34 ± 0.04 b), and T7 (0.35 ± 0.05 b) at the threshold of $P < 0.05$. The most significantly low yield observed in the control treatment T1 (0.18 ± 0.01 a) neither fertilized nor treated (Figure 5).

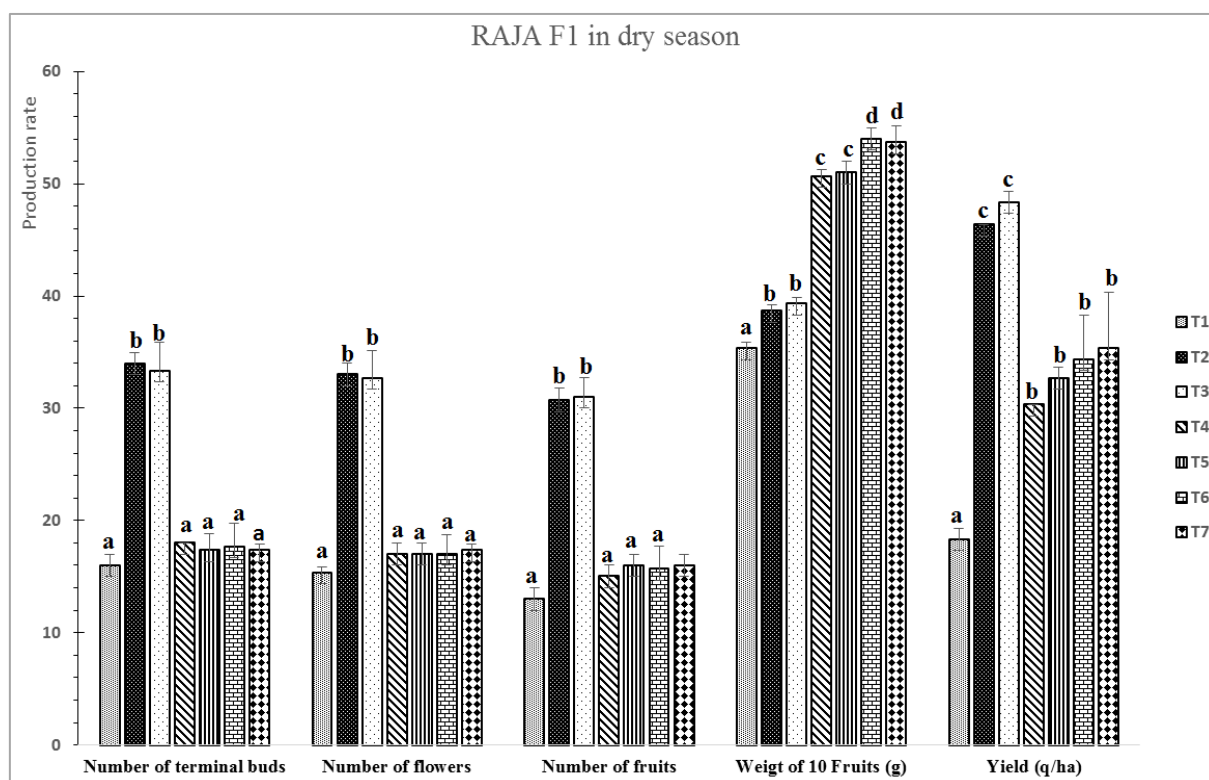


Figure 5. Different production parameters of the RAJA F1 hybrid variety in the dry season.

(ii). Rainy season

The analyses in the hybrid RAJA F1 variety also show at the end of the rainy season that the results vary according to the treatments regardless of the production parameter studied. Thus, the number of terminal buds is also significantly higher in treatments T2 (32.33 ± 4.93 b) and T3 (33.66 ± 1.52 b) chemically fertilized at the threshold of $P < 0.05$. These treatments T2 and T3 are respectively chemically and naturally treated

against diseases and pests during their growth. The most significantly low number of terminal buds was observed in treatments T1 (17.66 ± 2.3 a), T4 (17.33 ± 2.08 a), T5 (19.33 ± 1.52 a), T6 (19.33 ± 0.57 a), and T7 (19.33 ± 0.57 a). Concerning the case of number of flowers produced per plant, it also emerges that the most significantly high number of flowers is also observed in treatments T2 (34.33 ± 1.52) and T3 (33 ± 1 b) while the most significantly low number of flowers is

observed in treatments T1 ($16.66 \pm 1.52a$), T4 ($17.33 \pm 2.08a$), T5 ($19 \pm 1.73a$), T6 ($18.66 \pm 0.57a$) and T7 ($18.33 \pm 0.57a$). As for the number of fruits produced per plant, the most significantly high number is also observed in treatments T2 ($31.66 \pm 2.08b$) and T3 ($30.33 \pm 1.52b$) while the most significantly low number of flowers produced is also observed in treatments T1 ($13.66 \pm 0.57a$), T4 ($15.33 \pm 1.15a$), T5 ($16.33 \pm 1.52a$), T6 ($15.66 \pm 1.15a$), and T7 ($16.33 \pm 0.57a$). However, the weight of 10 fruits is significantly higher in treatments T4 ($52.66 \pm 0.57c$), T5 ($52.33 \pm 0.57c$), T6

($54.33 \pm 0.57d$), and T7 ($54.66 \pm 0.57d$) followed directly by that of treatments T2 ($39 \pm 1b$) and T3 ($39.66 \pm 0.57b$). The weight of 10 fruits is however significantly low in treatment T1 ($37 \pm 0a$) neither fertilized nor treated at the threshold of $P < 0.05$. Returning to the yield, it is significantly higher in treatments T2 ($0.49 \pm 0.03c$) and T3 ($0.47 \pm 0.02c$) followed directly by treatments T4 ($0.32 \pm 0.01b$), T5 ($0.34 \pm 0.02b$), T6 ($0.35 \pm 0.03b$), and T7 ($0.35 \pm 0b$). The most significantly low yield is observed in treatment T1 ($0.2 \pm 0.01a$) neither fertilized nor treated (Figure 6).

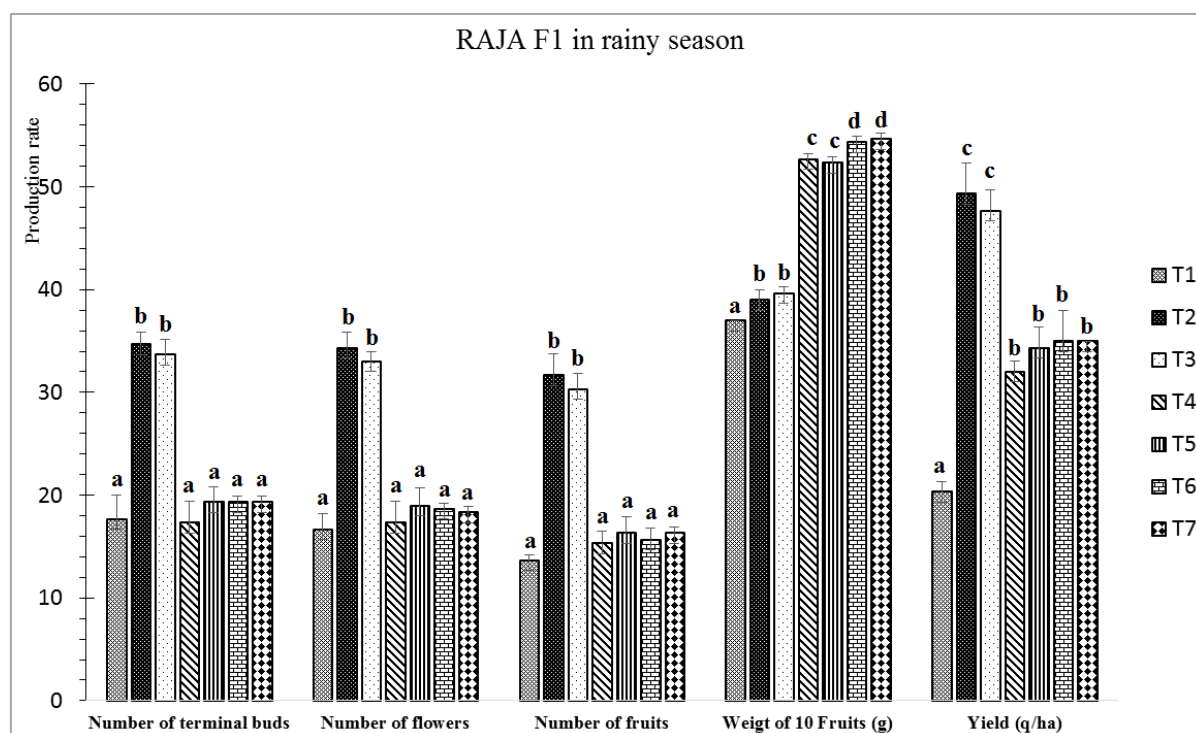


Figure 6. Different production parameters of the RAJA F1 hybrid variety in the rainy season.

4. Discussion

4.1. Growth Parameters

The effects of the mycorrhizal fungus and local plant extracts on tomato growth parameters were evaluated at different periods after transplanting the young shoots. The end of the P3 periods was characterized by growth in all treatments carried out regardless of the parameter studied in both varieties. The control treatment T1, neither fertilized nor treated, always had lower growth than the other treatments regardless of the parameter studied during the two growing seasons. However, the growth evolving continuously although it is significantly low, observed in treatment T1 during the two growing seasons, testifies to the existence of fertilizing elements, pre-existing in the soil of the study site exploited in the two growing seasons. These results corroborate those ob-

tained by Baldé et al. (2024) [13] who studied the effect of *Casuarina equisetifolia* L. compost on the growth of African eggplant (*Solanum aethiopicum* L.) in the Niayes area of Senegal.

Treatments T2 and T3 fertilized with mycorrhizal fungus had significantly higher performances in growth factors than all other treatments, during both campaigns and for each of the two tomato varieties tested. Treatments T6 and T7 fertilized with *Gliricidia sepium* manure and those of treatments T4 and T5 chemically fertilized were in turn significantly higher for these growth parameters than the unfertilized control treatment. The mycorrhizal fungus therefore certainly produced more fertilizing elements, water and conditions favorable to the growth of tomato plants than the other types of fertilizer input. Indeed, the mycorrhizal fungus, once applied, enters into symbiosis with the roots of the plants, providing minerals to the plants and receiving in return carbon products of photosynthesis. Mycorrhizal fungi are therefore

biofertilizers capable of improving the growth of cultivated plants by boosting the absorption of fertilizing elements at soil level through the roots [14]. Mycorrhizian fungi are capable of spreading inside the soil and facilitating the creation of a mechanism that makes the activity of taking up nutrients and water from the soil by plant roots more effective. This fungus also promotes plant resistance to pests and diseases, regulating their growth by means of phytohormones. These results are similar to those obtained by Kouamé (2020) [15] on the effects of biofertilizers based on *Azolla caroliniana*, another soil and compost microorganism on tomato crops (*Solanum lycopersicum* L.) in the Center-West of Côte d'Ivoire. In this work, he specifically evaluated two growth parameters for which he obtained more favorable results for natural treatments compared to chemical treatment and control treatment.

The significant results of tomato plants amended with *Gliricidia sepium* manure would also be justified by their fertilizing qualities and especially by their high nitrogen content recognized in these leguminous plants. Leguminous plants very often have a lot of nitrogen because, apart from the nitrogen they take from the soil by means of their roots like all other plants, they generally achieve the symbiotic relationship with rhizobium bacteria which allows them to also obtain atmospheric nitrogen from the air. The mycorrhizal fungus *Gliricidia sepium* also positively affects microbial biomass, respiration activity and spore density in the soil [16]. Slurries, on the other hand, usually provide more benefits to cultivated plants than other forms of organic fertilizer inputs because slurries are products that have already undergone a certain level of degradation and therefore have fertilizing elements in free form that can be immediately assimilated by plants in a growing and producing situation. In addition, this decomposition of slurries is a generally continuous process even when they are applied in the field, because they always continue to degrade to provide more beneficial fertilizing elements to plants. Slurries are products that have generally undergone a fermentation phase, which makes them increasingly healthy and therefore incapable of holding infectious elements, or at least holding them up to a certain dose, which preserves plants in growing conditions against infections when these slurries are used. Slurry, an organic product, would therefore protect crops better than the same organic products that have not been transformed into slurry. During the fermentation of *Gliricidia sepium* leaves into manure, bacteria would decompose coumarin into dicoumarin, making the final product a good rodenticide as well. In addition, *Gliricidia sepium* has secondary metabolites that would compromise the germination phase of weed seeds [17]. The present results are similar to those obtained by Chairul et al. (2024) [18] who in their work on the effect of liquid organic fertilizer from *Gliricidia sepium* on the vegetative growth of lettuce in Indonesia found that a dose of 20% of this natural fertilizer allowed for the greatest growth in size and leaf area of lettuce.

All the growth parameters of this study showed for the vast majority of treatments per season, a superiority of the per-

formances of the hybrid RAJA F1 variety over that of the Standard RIO POWER GRANDE. This would be due to the greater genetic improvement that the seeds of the hybrid variety would have undergone at the time of their selection, compared to those of the standard variety. The seeds of the hybrid variety would have had genes more appropriate for growth compared to those of the standard variety. The work of Iddrisu et al. (2024) [19] on the effect of the variety and spacing of plants on the growth of peanuts, also reflects that the different varieties of seeds do not generally grow in the same way. The growth of plant species and varieties grow differently depending on pedoclimatic and genetic factors. For each of the Standard RIO POWER GRANDE and hybrid RAJA F1 varieties, the rainy season recorded higher results for the majority of treatments compared to the results obtained in the dry season, with the exception of the leaf number parameter which had a higher result in the dry season for the hybrid RAJA F1 variety. The experimental design adopted in the dry season allowing irrigation from the surrounding backwater certainly did not allow for water conditions and other environmental conditions that could ensure growth as normal as that usually obtained in the rainy season.

4.2. Production Parameters

Treatments T2 and T3 of this study, fertilized with mycorrhizal fungus, regularly obtained the numbers of terminal buds, flowers, fruits and a significantly higher yield than the unfertilized control treatment T1. This result is certainly due to the fact that the mycorrhizal fungus would promote productivity more by the fact that it directly provides the roots of plants in the soil with water and essential minerals for their nutrition. The mycorrhizal fungus has the ability to spread inside the soil, promoting a network that will improve the absorption of nutrients and the conservation of water in order to make it more available to the roots and therefore ensure this productivity obtained. These results are similar to those obtained by Subaedah et al. (2024) [20] who studied soybean production in a situation of fertilization by mycorrhizal fungus powder in four different ecosystems in Indonesia. The chemically fertilized T4 and T5 treatments and the *Gliricidia sepium* slurry fertilized T6 and T7 treatments had superiority over the T1 treatment for these agronomic parameters at the probability threshold: $P < 0.05$. The *Gliricidia sepium* slurry fertilized treatments were, however, higher but not significantly for these four production parameters compared to the chemically fertilized treatments. *Gliricidia sepium* is a leguminous plant sufficiently rich in nitrogen and other nutrients and its state applied in the form of slurry makes it more suitable for natural fertilization and a certain level of productivity. These results are in line with those of Doumbia et al. (2020) [21] who worked respectively on tomato production in Bangladesh and on cotton, corn and sorghum crops in Mali. The weight of 10 fruits regularly obtained higher values for the T6 and T7 treatments fertilized with *Gliricidia sepium*

manure. Indeed, for the standard RIO POWER GRANDE variety during the two production campaigns, these T6 and T7 treatments and those of T4 and T5 chemically fertilized, significantly dominated the other treatments but with a non-significant superiority of T6 and T7 respectively over T4 and T5. The hybrid RAJA F1 variety rather recorded a significant superiority of T6 and T7 over the other treatments during the two growing campaigns, the T1 treatment having had the most significantly low weights. The T4 and T5 treatments had significantly the highest values compared to the T2 and T3 treatments. These observations made allow us to say about the weight of 10 fruits that it is the T6 and T7 treatments fertilized with *Gliricidia sepium* manure which had the greatest weights for the two tomato varieties during the two production seasons. *Gliricidia sepium* manure produced fruits in significantly higher numbers and weights compared to those obtained with other treatments. These results are explained once again by the great richness in nitrogen that the plants of this tree or shrub of the legume family show. They acquire nitrogen not only by absorption from the soil, but also through the symbiotic relationship with rhizobium bacteria from which these plants appropriate atmospheric nitrogen from the air and have small quantities of other fertilizing elements. The application of this legume plant in the form of manure easily provides fertilizing elements directly usable by the cultivated plant. In addition, the continuous decomposition process in the soil provides more of these fertilizing elements to the plant. The micro and macrofauna in the presence of manure are also revived, facilitating the assimilation of available organic and mineral fertilizers. These results obtained with *Gliricidia sepium* are similar to those of Simo et al. (2024) [22] concerning the study of the production of tomato variety NUNHEM'S under the effect of local plants at the IRAD of Foubot in Cameroon. They had obtained among other things, a significant superiority of the weight of 30 fruits following fertilization based on the leguminous plant *Acacia muricata* and that of *Gliricidia sepium*. Within the two varieties, the agronomic results did not really vary from one season to another. This is certainly due to the continuous irrigation in the dry season and during the month of absence of rains of the rainy season as already mentioned above even if they did not allow identical behavior of the growth parameters during the two campaigns. These irrigations would have provided sufficient quantities and provisions so that the production of the two seasons does not really differ. These results are contradictory to those of Rahman et al. (2017) [23] from testing the production potential of six varieties of eggplant (*Solanum melongena* L.) seeds in yield and quality between summer and winter seasons in Bangladesh. These results are also contrary to those by Vázquez et al. (2024) [24] who studied the Effects of deficient irrigation on the yield of celery crops.

From one season to another, the production results were slightly more favourable for the hybrid RAJA F1 variety compared to the standard RIO POWER GRANDE. The na-

ture of the hybrid seed, which was more genetically improved than the standard seed from the start, as mentioned in the cases of growth parameters, would justify this aspect of the results. These results corroborate to some extent with those of Felföldi et al. (2022) [25] obtained in high tunnels in Romania from 12 tomato genotypes.

The weight of 10 fruits for treatments T2 and T3 fertilized with mycorrhizian fungus was significantly lower than those for treatments T4 and T5 chemically fertilized and T6 and T7 fertilized with *Gliricidia sepium*. This could be justified by the doses of mycorrhizian fungus applied, which would have been insufficient to allow for larger and heavier tomato fruits. These results contradict the work obtained by Franczuk et al. (2023) [26] who used mycorrhizal fungi to improve pepper production.

5. Conclusion

The study conducted as part of this work aimed to test the effect of the mycorrhizal fungus, *Gliricidia sepium* and neem oil on the growth and production parameters of the hybrid tomato RAJA F1 and standard RIO POWER GRANDE varieties. The mycorrhizal fungus proved to be the most effective in growth and production parameters for both seasons apart from the weight of 10 fruits which on the other hand was significantly higher with the application of *Gliricidia sepium*. The unfertilized treatments, in almost all the results, presented the lowest results during the two crop seasons. Whether the treatment product was chemical or based on neem oil, significant differences were not observed in most treatments during the two crop seasons. The results obtained both in terms of growth parameters and production using fertilizers such as mycorrhizal fungus, *Gliricidia sepium* and neem oil as a treatment product, can be used to replace chemical fertilization and chemical treatment in tomato production.

Abbreviations

IITA	International Institute of Tropical Agriculture
IRAD	Research Institute for Agricultural Development

Author Contributions

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Conflicts of Interest

The authors declare no conflicts of interest.

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