



## **Influence of Accessions and Organic Amendment Associated With a Biofertilizer on Fungal Diseases, Plant Biomass and Yield of Common Beans**

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### **Abstract**

A trial was conducted at the experimental farm of the Institute of Agricultural Research for Development (IARD) Dschang on the use of amendments with bio fertilizers or not against fungal diseases on bean. The 1987 CIAT scale was used to assess disease severity, the biomass and the yield. Three major fungal diseases were recorded in the field, namely angular leaf spot (ALS), floury leaf spot (FLS) and rust. Accession Mancha 3 (9 - 74%) and RWR 3194 (0 - 24%) gave the highest and the lowest disease severity, respectively for the ALS and Rust. The three accessions were more tolerant to Rust than other diseases. The highest fresh biomass (767 g) was obtained in the interaction RWR 3194 x Poultry manure x Biofertilizer, while RWR 3194 x Compost interaction gave the highest number of nodules (204) followed by RWR 3194 x Biofertilizer x Compost interaction (147). Yield was highest in RWR 3194 x NPK 12-6-20 interaction (3.20 t.ha<sup>-1</sup>). The highest fresh biomass weight was obtained from the treatment combining accession RWR 3194, bio fertilizer and poultry manure (767g.plant<sup>-1</sup>). The study shows that the use of RWR 3194 accession combined with Compost (15 t.ha<sup>-1</sup>) or Poultry manure (5 t.ha<sup>-1</sup>) and Biofertilizer could be used to improve beans production and in a sustainable soil management program based on their tolerance to diseases and productivity.

**Keywords:** *Biofertilizer, Common bean, Fungal diseases, Organic fertilizer, Yield.*

### **Introduction**

Pesticides have become a serious public health issue, and a source of environmental contamination (Silva and Canellas, 2022). One of the major risks of single use of mineral fertilizers is soil acidification, so pure or organo-mineral manure could be an alternative for producers (Abbas, *et al.*, 2014). The use of organic materials is an important strategy to reduce synthetic agrochemicals, improve soil conditions and increase nutrient uptake by plants. A study carried out by Chellemi and Lazarovits, (2002) showed that organic fertilizers could provide multiple benefits for Florida vegetable production

systems including improving fertility, increasing soil microbial populations, and reducing the incidence of soilborne diseases. A comprehensive meta-analysis of recent scientific literature (2010-2021) on the use of organic matter as a method for pest and disease control was conducted using data reduction techniques, such as the main component analysis. This study showed that in general, all reported organic matter showed strong inhibition of pests and diseases, with a control effectiveness close to 75% for fungal diseases and 67% for pest control. Anqi Sun, *et al.*, (2022) showed that structural equation

modelling revealed that long-term organic fertilization regimes contributed to the suppression of plant pathogens and fungi primarily by modulating bacterial and protistane communities' residents. In addition, some beneficial bacteria could cause changes in the rhizosphere and plants, resulting in improved plant development, growth and productivity, as well as inhibition of the development of plant diseases (Glick, 2012). Among these beneficial microorganisms, Rhizobium is a group of bacteria that can establish a symbiotic relationship with legumes and play an important role in maintaining soil fertility (Herridge, et al., 2008). Rhizobia, in general, have been widely exploited for their ability to bind nitrogen, but many species of Rhizobium are also known to promote legume yield by suppressing the growth of pathogenic fungi (Mabrouk and Belhadj, 2010). Mechanisms involved in plant disease biocontrol include competition for infection sites and nutrients, activation of induced systemic resistance, and production of substances such as growth hormones, antibiotics, enzymes, siderophores, hydrogen cyanide and exo-polysaccharides (Kebede, 2021). Rhizobia use a single mechanism or combination of these mechanisms to suppress plant disease at once (Mabrouk and Belhadj, 2010). Several Rhizobium strains have been reported to cause disease resistance, while also promoting increased crop yields and biomass. In addition, Rhizobia was found to induce

systemic resistance to immunize plants, which a valuable process is resulting to foliar and viral diseases (Volpiano, et al., 2020). Thus, the main objective of this work was to find environmentally friendly alternatives in the fight against fungal diseases of common bean by using organic manure associated or not with a bio fertilizer.

## Materials and Methods

### Description of Study Area and Site

The trial was conducted on the experimental plot of the Institute of Agricultural Research for Development (IARD), and the Plant Pathology Laboratory of the Faculty of Agronomy and Agricultural Sciences (FAAS) at the University of Dschang. The site is located in the agro-ecological zone of the highlands of western Cameroon. The climate is of equatorial type monsoon with mountain facies determined by altitude which average is 1400 m. It is characterized by two seasons: a rainy season that goes from mid-March to mid-November and a dry season from mid-November to mid-March. Annual precipitation is around 2000 mm. Relative humidity is generally above 60%. Dschang receives an average annual exposure of 2000 hours (IRAD, 2019). The soil type at the experimental site is sandy loamy with a pH of 6.1 (Sanyang, et al., 2019). The plant material of the study consisted of three common bean accessions: RWR 3194, Feb 192, Mancha 3. The composition of the biofertilizer is shown in Table 1.

**Table 1:** Composition of the biofertilizer used in the trial

| Composition               | Concentration CFU/g |
|---------------------------|---------------------|
| <i>Bradyrhizobium</i> sp. | $2.2 \times 10^2$   |
| <i>Bacillus</i> sp.       | $5.6 \times 10^2$   |
| <i>Pseudomonas</i> sp.    | $5.6 \times 10^2$   |
| <i>Azobacter</i> sp.      | $1.3 \times 10^2$   |
| <i>Aspergillus</i> sp.    | $1.0 \times 10^2$   |
| <i>Rhizobium</i> sp.      | $4.2 \times 10^2$   |

CFU/g: colony forming units per gram

The quantitative data were assessed using the following variables: disease severity and incidence, plant biomass and yield. Data were collected from ten plants selected on a zig-zag model on the two median lines of each plot.

Symptoms of fungal diseases were observed on the leaves. The incidence and severity of diseases were collected from 10 plants in the two central lines of the experimental unit. These symptoms were best observed between

the 8th and 10th week after sowing. Disease incidence (DI) was obtained as followed:  $DI = (\text{number of infected plants} / \text{total number of plants considered}) \times 100$ . The severity scale developed by Allen, *et al.* (1996) was used to calculate the intensity of disease symptoms. Observation of diseases was made by a visual evaluation of symptoms on the leaf surface and the plant disease severity was done by evaluating the degree of infection through visual assessment of the symptoms on plant leaves. The numbers 1, 3, 5, 7, 9 were used to score the severity of fungal diseases (Rezende, *et al.*, 2014).

In order to identify the pathogens, a microscopic observation was done. The leaves with symptoms of different fungal diseases were collected, cut into pieces of about 3mm<sup>2</sup> in the edge of the necrosis, and then sterilized with sodium hypochlorite at 3% for 3 minutes to eliminate possible opportunist's microorganisms. Then, triple rinsing with distilled water for 5, 10 and 15 minutes respectively to remove the disinfectant residue. The pieces of leaves were then wrung out with hydrophilic paper to remove excess water and placed in equally spaced Petri dishes, and the whole was incubated at 23°C.

Identification of pathogens was done using two methods:

- Scotch method: a segment of transparent scotch was carefully placed on the area of the leaf with symptoms containing developed spores of rust and placed on a slide containing a drop of methylene blue dye. It was then observed using a compound light microscope at a magnification of 400x.

- Slide method: for angular leaf spot and floury leaf spot, the leaves exhibiting the symptoms were cultured in beans leaves dextrose agar (BLDA) and potato dextrose agar (PDA) media respectively. Then, a drop of methylene blue was carefully dropped on the slides containing a small fragment of the fungus mycelium and observed under the compound light microscope at a magnification of 400x.

### Field experimentation

The experimental design was a split-plot with two factors, the main factor being the bean accession with three modalities: RWR 3194, Feb 192, Mancha 3 and, the secondary factor which is the type of fertilizer with seven modalities: Poultry manure (P), Compost (C), Biofertilizer (Bio), Poultry manure + Bio fertilizer (P+Bio), Compost + Bio fertilizer (C+Bio), negative control (T-) and Positive control or chemical fertilizer (NPK 12-6-20) (T+).

Land preparation consisted of weeding, ploughing and materialization of units. The spreading of manure and compost were done immediately after ploughing. The sowing took place on March 31, 2023 and was done in line with 25 cm spacing and 50 cm spacing at a rate of 3 seeds per stand then followed by thinning to obtain 2 plants per stand. The poultry manure and compost were incorporated into the soil at a depth of about 5 cm, at doses of 5 t.ha<sup>-1</sup> and 15 t.ha<sup>-1</sup> respectively (according to the local council instruction), 2 kg and 6 kg per experimental unit, two weeks before sowing. The chemical fertilizer (NPK 12-6-20), was applied at a dosage of 300 kg.ha<sup>-1</sup> one month after sowing.

Insects present in the experimental plot including caterpillars, aphids were controlled with an insecticide (active ingredients: lambda-cyhalothrine (15g/L) and acetamipride (20g/L)) at a concentration of 40 mL/sprayer of 15L and treatments were applied weekly. Weeding were regular and manual.

### Application of the biofertilizer

Seeds were coated with the biofertilizer substrate (for biofertilizer treatments) for a dosage of 10 g/kg of seed, then stirred until the mixture adhered evenly to the seeds, according to the manufacturer's instructions. After their treatment, seeds were immediately sown into the holes and covered with soil.

### Plant biomass evaluation and Harvest

Destructive plant sampling was conducted at 50% flowering stage for the evaluation of plant biomass and nodules (Asafor *et al.*, 2022).

Harvest was done 80 days after sowing (DAS) for Mancha 3, and 90 DAS for Feb 192 and RWR 3491, when the pods were dry. The seeds extracted from the pods were dried in an oven at 65°C until a constant mass was obtained to determine the dry mass.

Yield was calculated according to the following formula (Soltner, 2005):  $Yield = (M_{gr} / NP) \times 10000 / D$

Where: Yield = yield in kg/ha,  $M_{gr}$  = seed mass in kg, NP = number of harvested plants and D = density (number of plants per hectare).

Disease and biomass variables and yield data were submitted to analysis of variance (ANOVA) using R software version 4.0 and the means separation was done using the

Duncan test (1955) at the probability threshold of 0.05.

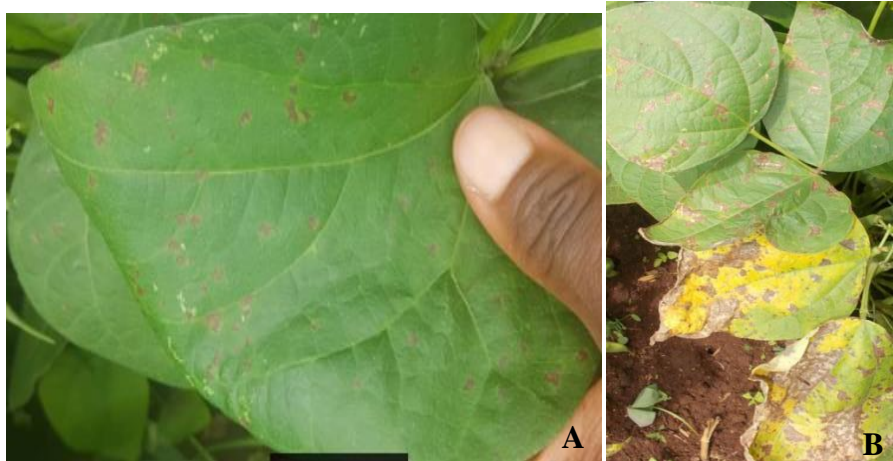
## Results

### Description of symptoms of Fungal Diseases of Common Beans Diagnosed in the Field

On the basis of their symptoms and microscopic observations, three fungal diseases of common beans were identified on the three beans accessions studied: Angular leaf spot (ALS), Floury leaf spot (FLS) and, Rust.

#### Angular Leaf Spot

ALS appears as angular spot on bean leaves. These spots are bounded by the veins. Symptoms first appear on the primary leaves and become lighter towards the end of flowering (Figure 1).



**Figure 1:** Floury Leaf Spot symptoms on bean leaves:  
A-Early stage B-Matured or late stage

In the laboratory, the fungus *Pseudocercospora griseola* isolated on infected leaves was responsible to ALS.

#### Floury Leaf Spot

This disease appears as white spot on the lower side of bean leaves. As the disease

progresses, chlorosis becomes visible on the upper side of the leaves (Figure 2) and enlarges, before the leaf eventually dries out.



Figure 2: Symptoms of Floury Leaf Spot on leaves: Upper (A) and lower (B) side.

In the laboratory conditions, inoculation of *Mycovellosiella phaseoli* isolated from infected leaves developed the disease

### Rust

The rust symptoms appeared as a brown stick needle point surrounded by a yellow halo on the leaves (Figure 3).



Figure 3: Rust symptoms on both side of bean's leaves. Upper (A) side and lower (B) side

### Effect of accession on fungal diseases of the common bean

#### 1. Severity

Statistical analyses showed significant differences between bean accessions for the fungal diseases. For ALS, Mancha 3 gave the highest percentage of attack (74.28%), while RWR 3194 gave the lowest percentage (24.52%). Concerning FLS, accessions RWR 3194 and Mancha 3 showed a level of

sensitivity comparable to that of the accession Feb 192. Mancha 3 was the most rust-sensitive accession with a percentage of 9.52%, while RWR 3194 and Feb 192 had statistically similar and lower percentages than Mancha 3 (0 and 0.48% respectively). Mancha 3 was found to have the highest severity for the three identified fungal diseases (Table 2).

**Table 2:** Severity (%) of Angular leaf spot, Flourey leaf spot and Rust on common bean accessions.

| Bean accessions | ALS                     | FLS                      | Rust                   |
|-----------------|-------------------------|--------------------------|------------------------|
| RWR 3194        | 24.52±4.88 <sup>c</sup> | 45.23±10.45 <sup>a</sup> | 0.00±0.00 <sup>b</sup> |
| Feb 192         | 47.86±7.84 <sup>b</sup> | 28.09±14.16 <sup>b</sup> | 0.48±3.43 <sup>b</sup> |
| Mancha 3        | 74.28±4.18 <sup>a</sup> | 46.43±9.45 <sup>a</sup>  | 9.52±0.12 <sup>a</sup> |

The means affected by the same letter in the column are not significantly different at the 5% probability threshold; ALS = Angular leaf spot and FLS= Flourey leaf spot.

## 2. Incidence

With respect to incidence, we did not observe any significant difference between accessions for ALS, but significant differences were noted between accessions for FLS: Feb 192 gave the lowest incidence (89.52%) while RWR 3194 and Mancha 3 gave statistically similar percentages (100 and 99.04% respectively). Significant differences were also observed between bean accessions with regard to rust: Mancha 3 gave the highest percentage (38.09%) whereas Feb 192 and RWR 3194 which had statistically similar percentages showed a lower level of

sensitivity. Overall, the accession Mancha 3 was found to have the highest incidence for the three identified fungal diseases (Table 3).

### Effect of the Accession on Common Bean Yield

A very highly significant (at the probability threshold  $p < 0.05$ ) effect of bean accession on yield was observed. Accessions RWR 3194 and Mancha 3 yielded similar and higher yields than those obtained with Feb 192. This gives good prospects for unpopularized or local high yielding accessions that could be popularized to improve the productivity of common bean in the study area (Table 3).

**Table 3:** Incidence of Angular leaf spot, Flourey leaf spot and Rust and yield of common bean accessions.

| Bean Varieties | ALS                     | FLS                      | Rust                     | Yield (t.ha <sup>-1</sup> ) |
|----------------|-------------------------|--------------------------|--------------------------|-----------------------------|
| RWR 3194       | 97.14±9.56 <sup>a</sup> | 100±0.00 <sup>a</sup>    | 0.00±0.00 <sup>b</sup>   | 2.80±0.49 <sup>a</sup>      |
| Feb 192        | 100±0.00 <sup>a</sup>   | 89.52±14.99 <sup>b</sup> | 1.90±6.01 <sup>b</sup>   | 2.34±0.47 <sup>b</sup>      |
| Mancha 3       | 100±0.00 <sup>a</sup>   | 99.05±4.36 <sup>a</sup>  | 38.09±31.56 <sup>a</sup> | 2.81±0.46 <sup>a</sup>      |

<sup>a,b</sup>Means affected by the same letter in the column are not significantly different at the 5% probability threshold; ALS = Angular leaf spot and FLS= Flourey leaf spot.

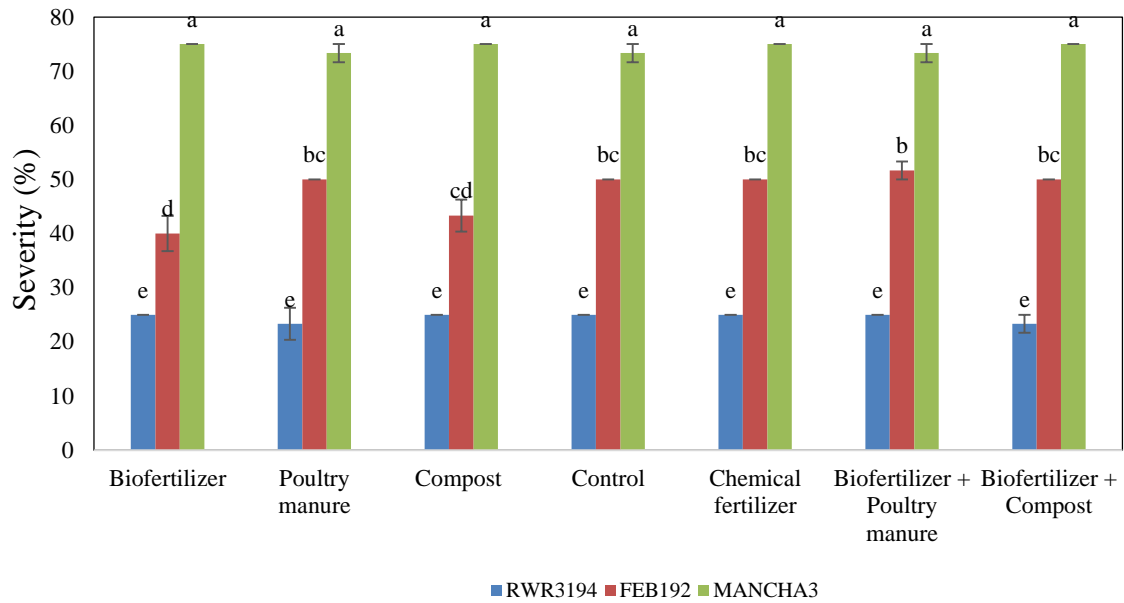
### Effect of Amendment Supplemented with a Biofertilizer or notf on Fungal Diseases

Analysis of variance at the significance level  $p < 0.05$  showed no significant difference between amendment and bio fertilizers on the disease variables (ALS, FLS and rust) of common bean, for both severity and incidence.

### Interactions between Accessions and Amendment Supplemented with a Biofertilizer or not on Fungal Diseases and Yield

#### 1. Disease severity

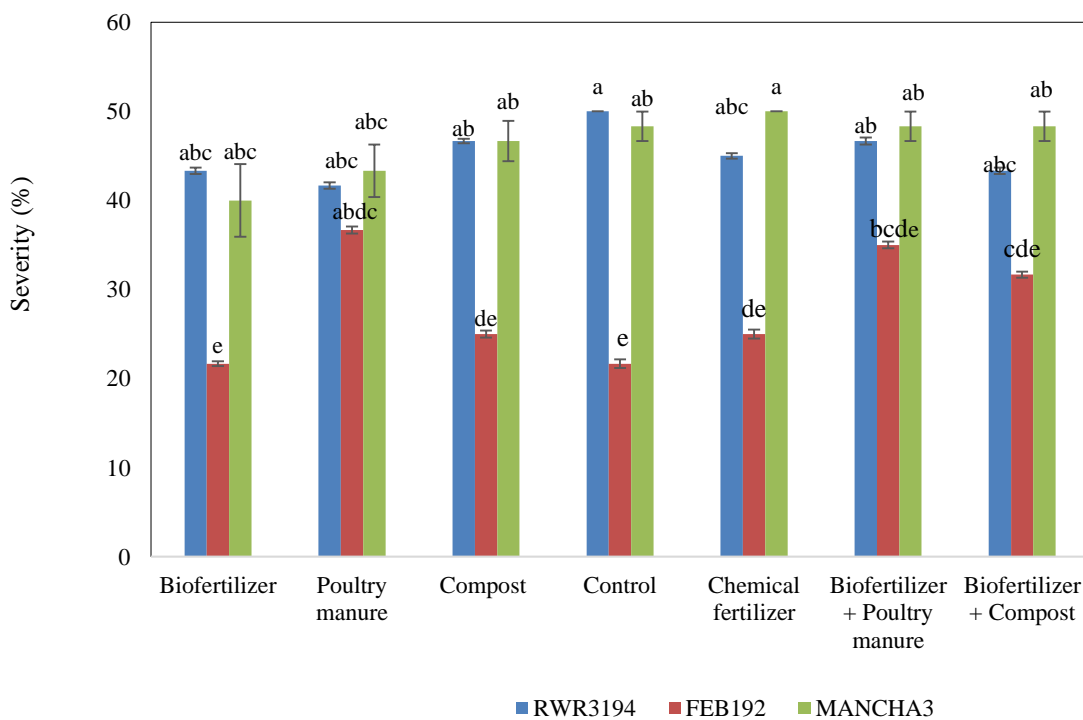
The interaction between accessions and amendments supplemented with the bio fertilizer or not showed significant differences for angular leaf spot, flourey leaf spot and rust. For angular leaf spot, Mancha 3 showed the highest severity (70%), followed by Feb 192 (50%) and RWR 3194 with the lowest severity (25%). This result showed that RWR 3194 would be the most resistant accession to angular leaf spot and Mancha 3 the most sensitive to the same disease, regardless of the type of amendment (Figure 4). This resistance was mostly related to accession rather than the type of fertilizer.



**Figure 4:** Angular leaf spot severity (%) by variety and type of amendment.

For the FLS, accessions RWR 3194 and Mancha 3 generally showed an intermediate severity (40 to 50%), while accession Feb 192 showed the lowest severity (25%), regardless

of the type of amendment associated or not with biofertilizer. This disease was present in all treatments, as well as ALS (Figure 5).



**Figure 5:** Floury leaf spot severity by accession and type of amendment.

Rust was present only on accession Mancha 3 and with a severity ranging between 5% and 15% on average, Regardless of whether or not biofertilizer-supplemented amendment is

used, except for biofertilizer-supplemented poultry manure treatment combined with the Feb 192 variety where rust was observed (Figure 6).

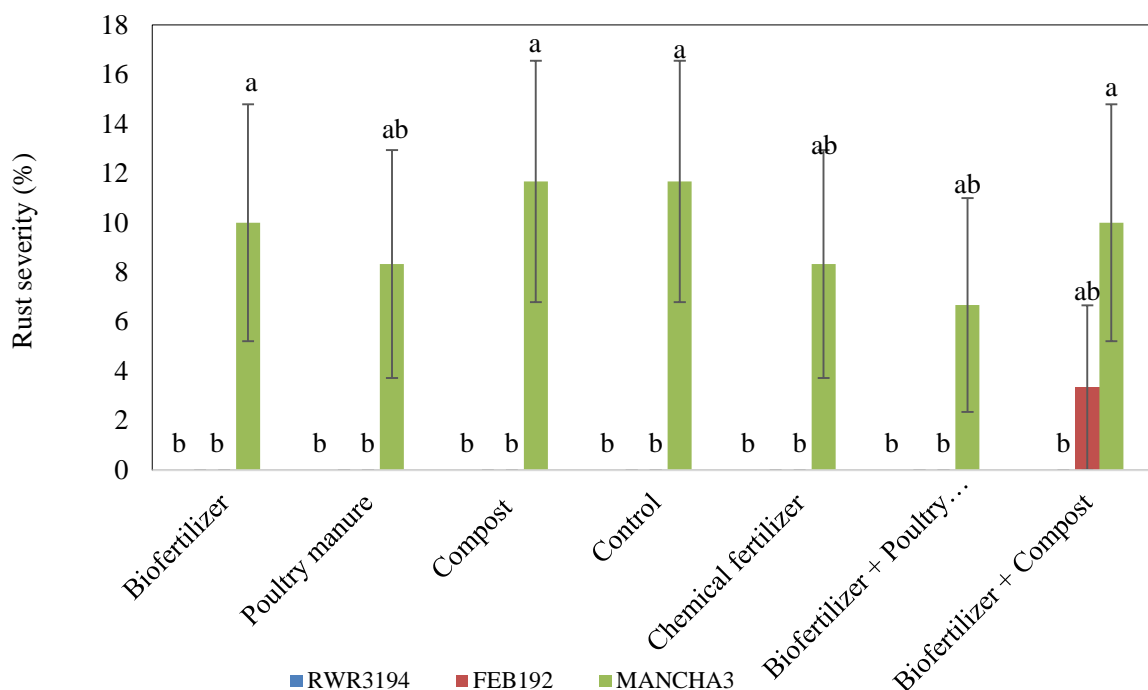


Figure 6: Rust severity (%) by variety and type of soil amendment.

## 2. Incidence

Statistical analysis did not show a significant difference between the different treatments for ALS, but highly significant differences were noted for FLS and rust. In general, accessions RWR 3194 and Mancha 3 had the

highest percentages (with 100% incidence) for FLS compared to Feb 192. For rust, accessions RWR 3194 and Feb 192 were not affected by this disease, unlike Mancha 3 (Table 4).

Table 4: Effect of the interaction between bean accessions and amendment supplemented with biofertilizer or not on fungal disease incidence.

| Treatment      | ALS (%)                  | FLS (%)                    | Rust (%)                  |
|----------------|--------------------------|----------------------------|---------------------------|
| RWR 3194*Bio   | 100±0.00 <sup>a</sup>    | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| RWR 3194*P     | 86.67±23.09 <sup>a</sup> | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| RWR 3194*C     | 100±0.00 <sup>a</sup>    | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| RWR 3194*T-    | 100±0.00 <sup>a</sup>    | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| RWR 3194*T+    | 100±0.00 <sup>a</sup>    | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| RWR 3194*Bio+P | 100±0.00 <sup>a</sup>    | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| RWR 3194*Bio+C | 93.33±11.55 <sup>a</sup> | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| Feb 192*Bio    | 100±0.00 <sup>a</sup>    | 86.67±23.09 <sup>abc</sup> | 0.00±0.00 <sup>b</sup>    |
| Feb 192*P      | 100±0.00 <sup>a</sup>    | 100±0.00 <sup>a</sup>      | 0.00±0.00 <sup>b</sup>    |
| Feb 192*C      | 100±0.00 <sup>a</sup>    | 86.67±11.55 <sup>abc</sup> | 0.00±0.00 <sup>b</sup>    |
| Feb 192*T-     | 100±0.00 <sup>a</sup>    | 73.33±11.55 <sup>c</sup>   | 0.00±0.00 <sup>b</sup>    |
| Feb 192*T+     | 100±0.00 <sup>a</sup>    | 80.00±20.00 <sup>bc</sup>  | 0.00±0.00 <sup>b</sup>    |
| Feb 192*Bio+P  | 100±0.00 <sup>a</sup>    | 100.00±0.00 <sup>a</sup>   | 0.00±0.00 <sup>b</sup>    |
| Feb 192*Bio+C  | 100±0.00 <sup>a</sup>    | 100.00±0.00 <sup>a</sup>   | 13.33±11.55 <sup>ab</sup> |
| Mancha 3*Bio   | 100±0.00 <sup>a</sup>    | 93.33±11.54 <sup>ab</sup>  | 40.00±34.64 <sup>ab</sup> |

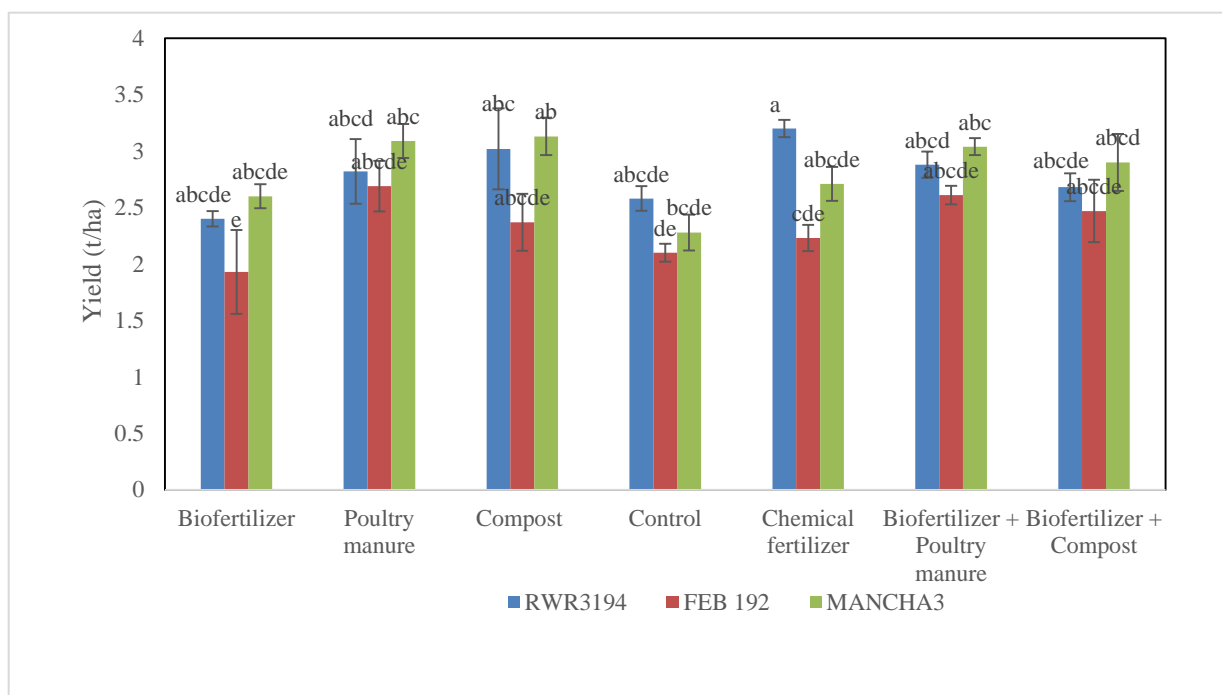
|                |                       |                       |                           |
|----------------|-----------------------|-----------------------|---------------------------|
| Mancha 3*F     | 100±0.00 <sup>a</sup> | 100±0.00 <sup>a</sup> | 33.33±11.55 <sup>ab</sup> |
| Mancha 3*C     | 100±0.00 <sup>a</sup> | 100±0.00 <sup>a</sup> | 46.67±46.18 <sup>a</sup>  |
| Mancha 3*T-    | 100±0.00 <sup>a</sup> | 100±0.00 <sup>a</sup> | 46.67±23.09 <sup>a</sup>  |
| Mancha 3*T+    | 100±0.00 <sup>a</sup> | 100±0.00 <sup>a</sup> | 33.33±41.63 <sup>ab</sup> |
| Mancha 3*Bio+P | 100±0.00 <sup>a</sup> | 100±0.00 <sup>a</sup> | 26.67±46.18 <sup>ab</sup> |
| Mancha 3*Bio+C | 100±0.00 <sup>a</sup> | 100±0.00 <sup>a</sup> | 40.00±40.00 <sup>ab</sup> |

<sup>a,b,c</sup>Means affected by the same letter in the column are not significantly different at the 5% probability threshold. Bio: Biofertilizer; C: Compost; P: Poultry manure; T-: Control; T+: Chemical fertilizer (NPK: 12-6-20); Bio+C: Biofertilizer + Compost; Bio+P: Biofertilizer +Poultry manure

**Interactions between Accessions and Amendments, Supplemented with Biofertilizer or not on the Yield of Common Bean**

Significant differences were found between the different treatments for the yield variable of common bean. The highest average yield was obtained with RWR 3194 associated with positive control (3.20 t.ha<sup>-1</sup>), followed by Mancha 3 associated with compost (3.13 t.ha<sup>-1</sup>). The lowest average yield was obtained with the Feb 192 associated with the

biofertilizer (1.93 t.ha<sup>-1</sup>) (Figure 7). In general, for all the treatments, Feb 192 accession which has already been disseminated in the study area, gave the lowest performance compared to the others which were recently introduced in the sutudy area. This implies that in terms of yield, new bean accessions such as RWR 3194 and Mancha 3 can be recommended to farmers, eventhough other selection criteria such as the palatability test will be required to confirm this choice.



**Figure 7:** Yields of bean’s accessions and type of amendments.

**Biomass of the arial and ground parts of the plants and Nodulation of Beans According to Treatments**

Significant difference (p<0.05) were noted in the number of nodules and fresh biomass of

the plants for different treatments. However, there were no significant difference of the dry biomass. The highest fresh biomass weight was obtained from the treatment combining accession RWR 3194, bio fertilizer

and poultry manure (767g.plant<sup>-1</sup>) while the lowest was obtained with Feb 192 combined with the bio fertilizer and the control (353.00 and 375.67 g.plant<sup>-1</sup> respectively). The treatment combining compost and bean accession RWR 3194 produced the highest number of nodules, while the chemical fertilizer was the lowest among all treatments.

This would be explained by the negative effect of chemicals on soil microorganisms that destroy them. However, treatments with the biofertilizer did not produce the highest number of nodules (Table 5). This could be explained by an incompatibility of the strains used with the bean accessions in the trial.

**Table 5:** Influence of the interaction between bean accessions and organic amendments, supplemented with a biofertilizer or not on the biomass and number of nodules of the bean.

| Treatments     | Fresh biomass of the plants (g.plant <sup>-1</sup> ) | Number of nodules           | Dry biomass of the plants (g.plant <sup>-1</sup> ) |
|----------------|--|-----------------------------|--|
| RWR 3194*Bio   | 507.00±131.39 <sup>cdefg</sup>                       | 87.00±4.00 <sup>bcd</sup>   | 98.00±21.52 <sup>a</sup>                           |
| RWR 3194*P     | 764.33±96.72 <sup>ab</sup>                           | 64.00±20.00 <sup>cdef</sup> | 156.33±9.29 <sup>a</sup>                           |
| RWR 3194*C     | 615.00±96.66 <sup>abcd</sup>                         | 204.33±58.19 <sup>a</sup>   | 132.67±13.43 <sup>a</sup>                          |
| RWR 3194*T-    | 409.67±176.96 <sup>efg</sup>                         | 84.00±35.76 <sup>bcde</sup> | 98.00±44.03 <sup>a</sup>                           |
| RWR 3194*T+    | 587.00±97.22 <sup>abcde</sup>                        | 10.33±11.84 <sup>f</sup>    | 117.00±7.00 <sup>a</sup>                           |
| RWR 3194*Bio+P | 767.33±74.38 <sup>a</sup>                            | 58.33±9.29 <sup>cdef</sup>  | 159.00±4.58 <sup>a</sup>                           |
| RWR 3194*Bio+C | 624.67±143.20 <sup>abc</sup>                         | 147.00±115.64 <sup>ab</sup> | 128.00±13.11 <sup>a</sup>                          |
| Feb 192*Bio    | 353.00±80.13 <sup>g</sup>                            | 40.00±27.51 <sup>cdef</sup> | 89.67±22.28 <sup>a</sup>                           |
| Feb 192*P      | 577.00±111.00 <sup>bcde</sup>                        | 46.00±34.07 <sup>cdef</sup> | 123.67±12.50 <sup>a</sup>                          |
| Feb 192*C      | 547.33±86.96 <sup>cdef</sup>                         | 106.00±97.50 <sup>bc</sup>  | 121.33±22.00 <sup>a</sup>                          |
| Feb 192*T-     | 375.67±130.59 <sup>fg</sup>                          | 54.00±49.69 <sup>cdef</sup> | 86.33±30.24 <sup>a</sup>                           |
| Feb 192*T+     | 471.33±168.63 <sup>cdefg</sup>                       | 13.67±10.50 <sup>ef</sup>   | 108.67±25.70 <sup>a</sup>                          |
| Feb 192*Bio+P  | 504.67±106.61 <sup>cdefg</sup>                       | 74.00±44.19 <sup>cdef</sup> | 119.00±30.51 <sup>a</sup>                          |
| Feb 192*Bio+C  | 525.67±112.27 <sup>cdefg</sup>                       | 66.00±24.27 <sup>cdef</sup> | 121.00±27.51 <sup>a</sup>                          |
| Mancha 3*Bio   | 558.33±75.25 <sup>cdef</sup>                         | 31.33±4.51 <sup>def</sup>   | 139.67±18.77 <sup>a</sup>                          |
| Mancha 3*F     | 433.00±25.16 <sup>defg</sup>                         | 32.67±22.03 <sup>def</sup>  | 106.00±17.52 <sup>a</sup>                          |
| Mancha 3*C     | 463.00±189.93 <sup>cdefg</sup>                       | 41.00±33.45 <sup>cdef</sup> | 113.33±50.89 <sup>a</sup>                          |
| Mancha 3*T-    | 433.33±171.99 <sup>defg</sup>                        | 68.67±25.00 <sup>cdef</sup> | 117.33±52.27 <sup>a</sup>                          |
| Mancha 3*T+    | 402.00±49.12 <sup>efg</sup>                          | 18.33±17.56 <sup>def</sup>  | 106.67±14.22 <sup>a</sup>                          |
| Mancha 3*Bio+P | 532.67±15.18 <sup>cdefg</sup>                        | 70.33±33.31 <sup>cdef</sup> | 130.33±14.64 <sup>a</sup>                          |
| Mancha 3*Bio+C | 525±68 <sup>cdefg</sup>                              | 53.33±35.95 <sup>cdef</sup> | 131±6.51 <sup>a</sup>                              |

<sup>a,b,c</sup> Means affected by the same letter in the column are not significantly different according to Tukey test at the 5%. Bio: Biofertilizer; C: compost; P: Poultry manure; T-: Control; T+: Chemical fertilizer; Bio+C: Biofertilizer + compost; Bio+P: Biofertilizer +Poultry manure.

## Discussion

Results showed that treatment with poultry manure induced the best performance for bean biomass. Likewise, Farhad, (2009) demonstrated that the weight of biomass increases with the dose of poultry manure. This result corroborates the findings of Yoldas, *et al.* (2019) who applied poultry manure and observed a significantly improved yield, bulb weight, bulb height, number of shoot points as compared to the control. Almaz, *et al.* (2017) demonstrated that it is recommended to replace 50% of inorganic

fertilizers with poultry manure in order to reduce the use of chemical fertilizers without reducing crop yields, and also this combination gave the highest monetary advantage in a system of intercropping over the application of organic manure alone. These results are also similar to those obtained by Hussein *et al.* (2016) who in a study found that poultry manure and NPK fertilizer increased the yield of common bean, however they mostly recommended poultry manure because of its lower cost. Concerning fungi diseases, results of the effect of organic

fertilizer associated or not with bio fertilizers are different from those obtained by Silvia and Canellas, (2022) who found that in general, the organic matter inhibited fungal diseases by 75%. This difference could be explained by the source of the organic matter, since the source they had studied was most often lombricompost. This means that not all organic matter inhibit disease and pests. This result also confirms an earlier study in which the RWR 3194 accession was among the most resistant to ALS out of a total of 32 tested genotypes (Kouam, et al., 2023). For treatments that received the biofertilizer, we did not notice its significant effect to inhibit or suppress fungal diseases compared with treatments that did not receive it. This may be due to the presence of endogenous Rhizobium strains that have also formed nodules in other treatments. An increase in the inoculum concentration of Rhizobium could substantially cause a reduction in the fungal population (Mabrouk and Belhadj, 2010).

It was also found that the average number of nodules in the chemical fertilizer positive control was lowest for all bean growth. This would be explained by the negative effect of chemicals on soil microorganisms that destroy them. However, treatments with the biofertilizer did not produce the highest number of nodules. This result is similar to that obtained by Asafor, et al., (2022) who, after using Rhizobium strains on groundnut found that the number of nodules, and the efficiency of nodules showed no significant difference with the value in the negative control.

### Conclusion

It was found that soil amendment associated or not with bio fertilizer did not have any effect on fungal diseases (ALS, FLS and Rust) of common bean both for severity and incidence. However, the highest average yield was obtained with the RWR 3194 accession associated with positive control (3.20 t.ha<sup>-1</sup>), followed by Mancha 3 associated with compost (3.13 t.ha<sup>-1</sup>). The lowest average yield was obtained with the variety Feb 192 associated with the bio fertilizer (1.93 t.ha<sup>-1</sup>).

Finally, RWR 3194 could be the most resistant accession to ALS and Mancha 3 the most sensitive to the same disease, regardless of the type of amendment.

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