Effect test of Industrial Organic Manure on the Physical Growth and Yield Performance of Bean in Bugesera District Environment

Case of Earth Boost fertilizer on Colta variety

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Abstract

The study was designed to test the Earth Boost effect on physical growth and yield performance of bean. Four fertilizer compositions were thus compared to the control (untreated) in Completely Randomized Block experimental design with 6 replications; where Earth Boost was compared to the traditional organic manure (cow dung) on the one hand, and between the combinations of each with the *diammonium phosphate,* DAP. The observations and data collected focused mainly on the height, stem girth, the number of leaves and the yield of bean plants as well as their respective analysis of variance allowing assessing the effect of treatments on the physical growth and yield. The results overall showed the efficiency of EB on the growth in height, leaf and stem girth development as well as on yield. Therefore, the additional yield performance obtained by its use or in substitution of traditional organic manure constitutes economic reasons for introduction of this new factor into the system of production.

Key words: Organic manure, Earth boost, Colta bean variety, Bean fertilization

I. INTRODUCTION

A widespread view holds that mineral fertilizers are harmful to the environment, plants and humans while those of organic origin are not. This view is often expressed in political fora on promoting the greater use of fertilizers in Africa. In the current context of agricultural land in Rwanda (acidic soils and stripped by erosion), organic fertilization has been indeed proved to be the first limiting factor for agricultural production and the use of mineral fertilizers without organic matter being a genuine economic waste. Overall, the benefits of organic agriculture are expected to be environmental, social and economic. For a living and fertile soil, organic agriculture is a system for crops, livestock and fish farming that emphasizes environmental protection and the use of natural farming techniques. It is concerned not only with the end-product, but with the entire system used to produce and deliver the agricultural product. To this end, the entire farm cycle, from production and processing, to handling and delivery, excludes the use of artificial products such as genetically modified organisms (GMOs) and certain external agricultural inputs such as pesticides, veterinary drugs, additives and fertilizers (FAO, 2007). Organic farmers rely instead on natural farming methods and modern scientific ecological knowledge in order to maximize the long-term health and productivity of the ecosystem, enhance the quality of the products and protect the environment. Proponents of organic methods believe that it is a more sustainable and less damaging approach to agriculture.

Organic agriculture became visible on a wider scale in the 1960s, when farmers and consumers became concerned that the amount of chemicals used in crop and animal production could have negative consequences for human health and the environment. Since then, it has developed into a more cohesive and organized movement and it is now the fastest growing food sector globally (Willer and Youssefi, 2007 and Heckman, 2006). However, there is a lack of sufficient of organic matter of animal and plant origin for the fertilization of the land under crops. Hence, the use of industrial origin organic fertilizers is an alternative. This article attempts to analyze the effect of industrial organic fertilizers on the physical plant growth and crop yield.

1.1. Environmental benefits of organic agriculture

The basic frame is that the soil is a complex and a non-renewable resource.

The positive impact of organic farming on the environment is directly related to the specific practices of this mode of production, based in particular on the non-use of synthetic chemical products, recycling of organic matter, crop diversity and pest biological control by focusing throughout the chain on respectful and environmentally processes of the ecosystem.

The soil is a living and multi-functional environment, housing a variety of bacteria, micro-fungi, insects, earthworms, etc. Its importance has been amplified awareness in the late 90s. Once viewed primarily as an economic resource, the soil is now recognized for its environmental functions of water retention, sewage pollution, natural habitat, etc. It is a nonrenewable resource, preserving the often irreversible damage, given its major role in the regulation of major natural balances. The preservation of the soil life is the basis of its long-term fertility and ensuring sustainable food production. Since 2001, the United States of America and the European Union began discussions for a soil protection strategy, in particular by establishing a state of land degradation monitoring plan (FAO, 2003). Physical, chemical or biological, the consequences of damage to the resource of soil and its potential are all important:

(i) Physical degradation appears by phenomena of soil sealing (loss fertility, in organic life), compaction (compaction of the upper layers) and erosion (matter loss, particle entrainment by water, wind ...). The consequences are losses of soil purifying functions, a change in the hydraulics of the soil and increased pollution of watercourses. Moreover, the physical degradation involves agricultural land losses and declines productivity;

(ii) Chemical degradation is visible through the acidification (decrease in pH), being able to be of industrial or agricultural origin, or otherwise salinization (increase in pH). This degradation leads to surface water pollution, soil sterilization, and risks to human health due to the toxicity of soil and outgoing products;

(iii) Biological degradation is characterized by the presence of pesticide residues and / or losses in organic matter. The consequences are a loss of biodiversity with decreased populations of insects, bacteria, micro-soil fungi, an accentuation of chemical damage (contamination by pesticides) and physical (loss effects of organic matter), increased flow of greenhouse gases (carbon destocking). Organic farming carries demonstrated positive impacts on the structure and fertility of the soil mainly characterized by higher levels of organic matter and intense soil biological activity.

The whole of the studies shows that the organic matter content in cultivated soils are higher in the event of biological practices. This is explained by organic fertilization practices (livestock manure, straw, compost, green manure crops) and diversified rotations. The biological activity of the soil is also more developed. The soil organisms (for example, earthworms, fungi, surface insects) are more diversified, with more intense biological activity.

Thus, the results of monitoring studies of soil characteristics cultivated in agro-biological mode and conventional mode, conducted over 21 years by the FIBL (Research Institute for Organic Farming) in Europe show that "organic" soils are:

(i) 20 to 30% of microbial biomass in addition, with an upper respiratory and enzymatic activity;
(ii) 30 to 40% of earthworms in addition, factors of soil stability, natural laborers of the earth;
(iii) 90% of spiders and more and a large diversity of species;
(iv) 40% of mycorrhizal root colonization and more, with all the consequent benefits for plant nutrition and plant protection.

The richness in organic matter improves soil physical characteristics: increased structural stability, better porosity, higher water retention capabilities. Thus, FIBL studies show that organic soils contain 30% more stable aggregates.

The best water holding capacity of soils cultivated in organic mode allows a better crop resistance to drought (like in Bugesera District area). Thus, American studies on corn and tomato crops in conditions of high water stress, have shown that higher yields were obtained by organic production methods. This is particularly important against the chronic lack of water in recent years found in many regions (Clark et al., 1999).

According to the French Ministry of Ecology (2005), the organic matter naturally protects the soil from erosion. Furthermore, regardless of the physical characteristics of the soil, the presence of intermediate crops organically produced, covering the ground is an effective protection factor throughout the year. Thus, a trial in the US revealed that soil erosion on cultivated land according to organic production is 25% lower than soil erosion on cultivated land in conventional mode (Lotter, 2003).

The organic farming is suitable for clean water and preserved aquatic ecosystems. Agricultural activities and other human activities have an impact on the quality of water, be it surface water, groundwater or of the littoral. These impacts are diverse: siltation of rivers, eutrophication, pollution by dissolved substances such as chemical fertilizers and pesticides of synthesis or biogenic salts. In their paper, Benoit et al. (2003) said particularly harmful agricultural practices to water quality are:

(i) Intensive use of chemical fertilizers and synthetic pesticides, whose residues can be found in the waters, disrupting the operation of the aquatic flora and fauna and contaminate groundwater aquifers;

(ii) Excessive intake of synthetic chemical fertilizers and veterinary products which lead to excess nitrates in the soil and leaching into groundwater;

Land management has a significant impact on the environment. Conventional agriculture prioritizes high yields and does little to harmoniously interact with and preserve its immediate environment. These practices can result in widespread environmental degradation, commonly resulting in soil erosion, water, soil and air pollution, biodiversity loss, and desertification. They also contribute to global warming and agriculture sector today accounts for more than thirteen percent of global anthropogenic greenhouse gas emissions according to the Intergovernmental Panel on Climate Change (2007). Conversely, organic agriculture uses an individualized approach to land management that emphasizes preservation of a land's natural ecosystem, while consuming less energy and reducing the risks of pollution common to conventional agriculture. Organic agriculture, therefore, seeks to offer a responsible alternative to conventional practices in the face of ever-growing concerns over climate change and environmental degradation.

The environmental benefits of organic agriculture can also extend to climate change. The International Panel on Climate Change has strongly advocated the adoption of sustainable cropping systems such as those used on organic farms to reduce carbon emissions. Organic methods are indeed expected to result in lower emissions with carbon emission between 48 to 66% lower than on conventional farms.

1.2. Economic benefits of organic agriculture

Organic agriculture has seen tremendous economic growth in the last decade. This has been mainly demand-driven, as consumers have become increasingly concerned with the safety of conventionally-grown foods and the ethical downfalls of industrial agriculture. Farmers, in turn, have realized that consumers are willing to pay a premium for organically-grown foods (FAO and WHO, 1999). As a result according to IFOAM (2005) and WTO (1999), organic farmers must carefully plan how best to enter such markets and obtain certifications that will be recognized where they wish to sell their products. Governments have also contributed to this growth, by subsidizing conversions to organic farming, as they have recognized that organic farming can help them achieve environmental, food security, and rural development goals.

Today, organic agriculture is the fastest growing food sector in the world in both land use and market size, although this fact is tempered by the fact that it was virtually non-existent until very recently (CTA et al., 2008). That being said, growth rates in organic food sales have been in the range of 20–25 percent for the last ten years. Organic methods can be used to produce foods and plants as well as nontraditional agricultural products. Consumers buy organic products because they expect a certain standard of production that is environmentally-friendly and free of any artificial inputs. Organic certification ensures those standards are met and is essential for consumer-trust and expansion of the organic market (Kessie, 2000).

II. MATERIALS AND METHODS

2.1. Experimental design

Four different treatments were compared with the control (untreated) for this experimental research work which was led out in a Completely Randomized Block Design (CRBD) with six replications. The agricultural experimentation usually calls upon this kind of experimental design. The treatments are applied to groups of homogeneous units called complete replications or blocks. They are moreover randomly distributed in each block, this distribution differing from one distribution to another (Jolicoeur, 1991).

According to Dagnelie (2003), this experimental design presents as advantages: (i) to be more effective than the entirely random design. The elimination of the differences between the blocks, variability source, contributes to reduce the experimental error; (ii) There can be any number of treatments and replications provided that the heterogeneity of these last is very low. It is possible to repeat more than one once a treatment in a block; (iii) the statistical analysis is rather simple. It is possible to omit with the need one or more treatments or one or more blocks, without modifying for as much the method of analysis. The omission of certain observations requires only one minor correction of this method.

The study was carried out during the 2014 rainfall season B (March-May 2014). Each plot of treatment was established at 3m x 3m dimension after 15 days of land preparation.

The experiment was conducted in the derived savannah of Bugesera District, Rilima Sector with mean annual rainfall of 800-950 mm and annual temperature of about 29.4^{o}C and relative humidity of about 62% during dry season and about 88% during rainy season according to the Rwanda Meteorology Agency (2015). The variety of bean seed used was Colta which was obtained from the local market. The germination and humidity tests were conducted to ascertain that the seeds were viable at more than 95%.

2.2. Land preparation and plantation

The soil was cleared, ploughed and tilled before sowing and marked into 6 blocks and 5 elementary plots each of 3m x 3m (9m^2) were made in each block, making a total of 30 elementary plots. The distance between blocs and between elementary plots was of 0.80 m. Two bean grains were planted per hole at the depth of 3 cm with a spacing of 30 cm x 20 cm.

After the bean seeds were sown every care given to plants (including maintenance, watering during hydrous stress days, weeding and ridging and aphids control) was realized over the entire extent of the trial to complete the same day finally to ensure the homogeneity in plant development conditions.

2.3. Treatments under study

The choice of the treatments to be compared was in connection with the aim of the study and respected a certain agricultural logic. All compared to the witness without any treatment, the test will also try to show the difference between the organic manure traditionally used and earth boost (industrial organic manure), on the one hand, and between their application each one in combination with the *diammonium phosphate*, DAP, on the other hand.

Thus in this experimental work on Colta bean variety, the treatments applied are as follows:

(i) T_0: Control without any treatment

(ii) T_1: TOM, traditional organic manure (cow dung completely mineralized) with a dose of 20 tons/ha.

(iii) T_2: EB, Earth Boost with a dose of 50 kg/ha.

(iv) T_3 : TOM (20 tons/ha) + DAP (100 kg/ha)

(v) T_4 : EB (50 kg/ha) + DAP (100 kg/ha)

2.4. Data collection and analysis

Primarily observations focused on the physical growth of the bean plants: the seed emergence rate (appreciated 14 days after sowing), the vigor of the plants (height and stem girth) three, five, seven and nine weeks after plantation, the number of pods and the harvest output.

For each parameter of observation, the data were collected per treatment and per block the same day on all the extent of the trial finally to ensure the homogeneity of the collected data. Observations were carefully carried out at the appropriate time and the related data reflected in tables for statistical analysis purpose.

The collected data were analyzed using ANOVA. Comparisons were made between treated and untreated plots for the different fertilizers incidence on bean plants growth and yield. Differences were tested using the Least Significant Difference (LSD) test at various significance levels ($p\leq 0.05$; $p\leq 0.01$ and $p\leq 0.001$).

III. RESULTS AND DISCUSSIONS

3.1. Effect of treatments (fertilizers) on the seed emergence rate

The data relating to the bean seed germination has been collected 14 days after sowing and the effect of different fertilizers (treatments) on the seed emergence was analyzed using ANOVA. The calculated germination rates (%) by treatment and by replication are given in the table 1 after an angular transformation (The data related to the germination rates in percentages have been subjected to an angular transformation for a normal distribution according to the trigonometric relation, $y = 2arcsin\sqrt{x/n}$, before the analysis (table 1).

Table 1. Angular transformation of the seed emergence rate

Treatments	Replications						Average
	I	II	III	IV	V	VI	
T0	2.74	2.76	3.02	2.57	3.11	3.05	2.88
T1	2.86	2.72	2.72	2.76	3.14	3.02	2.87
T2	2.99	3.14	2.76	3.14	2.76	2.82	2.94
T3	3.07	3.08	2.76	2.99	3.09	2.98	3.00
T4	3.20	3.27	2.63	3.28	2.92	2.87	3.03

Source: Primary data from experimental trial

The statistical analysis results (ANOVA) summarized in the table 2 has not shown any statistically significant difference between blocks at the lowest significance level α = 0.05 [F_{obs} =0.86 ≤ $F_{(0.05)}$=2.71]; this proves that the experimentation was started from a relatively homogeneous land and was led under similar conditions in all replications.

Table 2. Summary of the variance analysis of the seed emergence rate

Source of variation	DF	SS	MS	F_{obs}	$F_{th(0.05)}$	$F_{th(0.01)}$	$F_{th(0.001)}$	Conclusion
Blocs	(r-1) = 5	0.1709	0.03	**0.86**	**2.710**	**4.1**	**6.46**	NS *
Treatments	(v-1) = 4	0.1164	0.03	**0.73**	**2.860**	**4.43**	**7.09**	NS
Error	(r-1)(v-1) = 20	0.8000	0.04					
Total	Rv-1 = 29	1.08						

*: Differences statistically Non Significant

At α = 0.05 significance level, the results also did not reveal any statistically significant difference between treatments. The lack of statistically significant differences between treatments, even at the lowest level, [F_{obs} = 0.73 < $F_{(0.05)}$ = 2.86], shows that the fertilizers used as treatments do not have any effect on the germination rate.

3.2. Effect of treatments on the physical growth performance of beans' plants

The observations and data collected at three, five, seven and nine weeks after plantation (WAP) on the plants' height, stem girth and the number of leaves as well as their respective analysis of variance allowed to assess the effect of treatments on the physical growth of bean plants.

3.2.1. Effect of the treatments on the height of bean plants.

The analysis of data on the height growth of bean plants at different observation dates has always revealed real and statistically very highly significant differences at α = 0.001 level. The calculation of the least significant difference (LSD) at various levels of significance, according to the *Student t-test* ,($LSD = t_\alpha ES_m \sqrt{2} = t_\alpha \frac{ET}{\sqrt{r}} \sqrt{2} = t_\alpha \frac{\sqrt{CMR}}{\sqrt{r}} \sqrt{2} = t_\alpha \frac{\sqrt{2CMR}}{\sqrt{r}}$) at each observation date, allowed the separation of the means into homogeneous groups (Table 3).

Table 3. Summary of the ANOVAs and means' separation into homogenous groups at different dates of observation on the height of bean plants

Treatments	Means of beans' height (cm) per treatment			
	3WAP	5WAP	7WAP	9WAP
T0	12.28 a	26.15 a	68.73 a	119.83 a
T1	13.91 b	32.18 b	88.33 b	130.67 b
T2	16.03 c	37.97 c	106.55 c	142.67 c
T3	16.16 c	39.08 c	111.83 d	143.17 c
T4	17.76 d	44.54 d	124.67 e	147.63 c
LSD(0.05)	0.49	1.43	2.21	7.00
LSD(0.01)	0.72	2.10	3.24	10.23
LSD(0.001)	1.01 ***	2.94 ***	4.54 ***	14.35 ***

* Significant at 5% alpha level (significant)
* Significant at 1% alpha level (highly significant)
*** Significant at 1‰ alpha level (very highly significant)

According to the results of analysis of variance and means' separation into homogeneous groups (summarized in table 3), the 4 fertilizer compositions were positively and significantly distinguished with the control (untreated) at α = 0.001 significance level. Furthermore it should be noted the significant and positively stronger effect of Earth Boost (T2) compared to the traditional organic manure (T1) on the one hand, and between their associations with the *diammonium phosphate*, DAP, on the other hand.

In addition, the lack of real and meaningful difference between Earth Boost (T2) and TOM associated with DAP (T3) leads to confirm the important effect of EB on the physical development of the plants. In view of these results, the Earth Boost effect (T2) is greater than that of the traditional organic manure (T1) in all cases: each used alone or in combination with the DAP.

3.2.2. The Effect of the Treatments on the Mean Number of Bean Leaves.

Similarly the number of leaves of bean plants was collected at the various dates of observation and was subjected to ANOVA which every time revealed the existence of real and statistically very highly significant differences between treatments at α = 0.001 level. Furthermore according to the *Student t-test*, the least significant difference, LSD, was calculated at different levels, means grouped into homogenous groups and the same conclusions as in the previous case seem to be emerging with the crowning of Earth Boost in combination with DAP (table4).

Table 4. Summary of the ANOVAs and means' separation into homogenous groups at different dates of observation on the number of leaves of bean plants

Treatments	Means of leaves' numbers per treatment			
	3WAP	5WAP	7WAP	9WAP
T0	3.83 a	5.83 a	8.67 a	12.33 a
T1	8.83 b	10.83 b	13.67 b	17.33 b
T2	11.33 c	13.33 c	17.00 c	21.33 c
T3	12.33 c	14.33 c	17.17 c	21.83 c
T4	16.33 d	20.33 d	24.67 d	29.50 d
LSD(0.05)	1.14*	1.25*	1.55*	1.38*
LSD(0.01)	1.67**	1.83**	2.26**	2.02**
LSD(0.001)	2.34***	2.57***	3.17***	2.83***

* Significant at 5% alpha level (significant)
* Significant at 1% alpha level (highly significant)

*** Significant at 1‰ alpha level (very highly significant)

In terms of leaf development, it is still important to note the lack of real and significant differences between EB (T2) and the TOM-DAP Association (T3); which once again reveals the significant impact of EB on physical growth of bean plants. This positive effect of ET (T2) on leaf plant development will result in increasing the photosynthetic surface; which will be reflected positively in principle on the yield performance.

3.2.3. The Effect of the Treatments on the Mean Stem Girth of bean

With regard to the girth of the bean stem development, the same conclusions are drawn as in the previous two cases. Data carefully collected and subjected to the analysis of variance are indeed resulted in the following findings:

(i) Coronation of EB in combination with DAP or T4;

(ii) Absence of real and significant differences between EB applied alone and TOM in combination with DAP (T3); which proves once more the effectiveness of the industrial EB organic fertilizer on the physical plant.

Table 5. Summary of the ANOVAs and means' separation into homogenous groups at different dates of observation on the stem girth of bean plants

Treatments	Means (mm)			
	3WAP	5WAP	7WAP	9WAP
T0	3.83 a	5.83 a	8.67 a	12.33 a
T1	8.83 b	10.83 b	13.67 b	17.33 b
T2	11.33 c	13.33 c	17.00 c	21.33 c
T3	12.33 c	14.33 c	17.17 c	21.83 c
T4	16.33 d	20.33 d	24.67 d	29.50 d
LSD(0.05)	1.14*	1.25*	1.55*	1.38*

LSD(0.01)	1.67**	1.83**	2.26**	2.02**
LSD(0.001)	2.34***	2.57***	3.17***	2.83***

* Significant at 5% alpha level (significant)
* Significant at 1% alpha level (highly significant)
*** Significant at 1‰ alpha level (very highly significant)

3.3. Effect of treatments on the yield performance

The performance of treatments on agricultural output was apprehended by collecting data on the mean numbers of bean pods two weeks before harvest and weighing this one for the yield (kg / ha) performance analysis.

3.3.1. Effect of treatments on bean pods development

The pods were carefully counted by treatment and by blocks and the data were subjected to analysis of variance (table 5). This, as in the previous cases, has continued to reveal real differences and statistically very highly significant at α = 0.001 level: [F_{obs} = 210.04 > $F_{0.001}$ = 7.09].

Table 6. Summary of the variance analysis of the mean numbers of bean pods

Source of variation	DF	SS	MS	F_{obs}	$F_{th(0.05)}$	$F_{th(0.01)}$	$F_{th(0.001)}$
Blocs	(r-1) =5	4.84	0.97	0.62	2.71	4.1	6.46 NS
Treatments	(v-1)=4	1317.63	329.41	210.04	2.86	4.43	7.09 ***
Error	(r-1)(v-1)=20	31.37	1.57				
Total	(rv-1)=29	1353.84					

In view of these very significant differences, a *Student t-test* was performed to proceed to the separation of means into homogeneous groups using the least significant difference calculated at various significance levels: α = 0.5; α = 0.01 and α = 0.001 (table 7).

Table 7- Results of means' separation into homogeneous groups

Treatments	Means	Homogeneous groups		
		LSD(0.05)=1.25	LSD(0.01)=1.83	LSD(0.001)=2.57
T0	14.25	a	a	a
T1	18.67	b	b	b
T2	25.17	c	c	c

T3	27.33	d	D	c
T4	33.17	e	e	d

This separation of the means into homogeneous groups also highlighted a marked and positive demarcation of Earth Boost (T3) applied alone compared to Traditional Organic Manure also applied alone (T2), on the one hand, and both combined with DAP, on the other hand. From the standpoint of pod development and unlike in previous cases, real differences appeared between T2 (Earth Boost) and T3 (TOM + DAP) where the latter was more effective than the first, which differences however disappear α = 0.001 significance level.

3.3.2. Effect of treatments on the yield performance

The ANOVA of the data relating to the outputs after having revealed real and very highly significant differences between the means [Fobs = 293.10 > F0.001 = 7.09], the separation of the averages at various levels of significance also highlights the superiority of Earth Boost compared to other treatments (tables 8 and 9).

Table 8. Summary of the variance analysis of the bean yield

Source of variation	DF	SS	MS	F_{obs}	$F_{th(0.05)}$	$F_{th(0.01)}$	$F_{th(0.001)}$
Blocs	(r-1) =5	62131	12426	**1.84**	**2.710**	**4.1**	**6.46 NS**
treatments	(v-1)=4	7313112	1828278	**270.61**	**2.860**	**4.43**	**7.09 *****
Error	(r-1)(v-1)=20	135121	6756				
Total	(rv-1)=29	7510365					

Table 9. Results of means' separation into homogeneous groups

Treatments	**Means**	**Homogeneous groups**		
		$LSD_{(0.05)}$= 82.10	**$LSD_{(0.01)}$=120.06**	**$LSD_{(0.001)}$=168.47**
T0	1756.67	a	a	a
T1	2365.00	b	b	b
T2	2754.83	c	c	c

T3	2842.50	d	c	c
T4	3208.83	e	d	d

In terms of yield performance, the results in Table 9 show that the means are separated into 5 groups completely different at the significance level α = 5%. However, for α = 1% and α = 1 ‰, T2 and T3 return in the same group; reflecting the absence of real differences between the two. The same results show the greater effect of Earth Boost applied alone or in combination with DAP than other fertilizer compositions.

IV. CONCLUSION AND RECOMMENDATIONS

This study aimed to test the performance Earth Boost (industrial organic fertilizer) compared with traditional organic manure used. Within that framework, 4 treatments were compared to the control (untreated) in a completely randomized blocks experimental design with five (5) treatments and six (6) replications. The observations relating to the height, stem girth and the number of leaves of bean plants as well yield were carried out, the data collected and subjected to the analysis of the variance.

The results obtained show that the use of Earth Boost (industrial organic manure) improves the chemical and physical properties of the soil, thereby increasing the physical growth and yield of bean plants. The results show that its application highly increases plant height, number of bean leaves (therefore increasing of photosynthetic area), stem girth (increasing the resistance to pours), number of bean pods and yield at harvest.

The differences in output between T2 (Earth Boost) and T1 (Traditional organic Manure), on the one hand, and between T4 (Earth Boost + DAP) and T3 (Traditional Organic Manure + DAP), on the other hand, being respectively of 389.83 kg/ha and 366.33 kg/ha, can economically justify the use of Earth Boost whose extra cost rises to approximately 60,000 francs Rwandan.

The positive effect of Earth Boost on the physical growth of bean plants is probably due to its capacity of increasing the organic matter and improving nutrient retention in the root zone; aerating compacted soils and improving their structure with its humic acid and thus water, nutrients and roots can penetrate the soil more easily; coating by its humic acid the sand particules in light sandy and increasing the cation exchange (CEC) and the ability of the soil to retain nutrients and water. Nutrients, in particular nitrate are not leached out to the groundwater but together with the water retained in soil, so that they remain available for the plants and retaining water in dry sols.

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