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Comparative study of the yield of some varieties of biofortified common beans installed in the eco-climatic conditions of Fungurume, Katanga and Kitanda. R.D. Congo

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Abstract: Four varieties of fortified organic twine beans from the National Institute for Agricultural Research and Research (INERA) Mulungu through the Harvest plus project were installed in three different environments to compare their yield. To achieve this, the trials were conducted in Lualaba and Haut-Katanga / DRC: Fungurume in Lualaba, Katanga and Kitanda in Haut-Katanga following a complete randomized block device consisting of four varieties of fortified organic twined bean and a local variety. Agronomic parameters such as germination rate, number of knots, final height of the plant, number of pods per plant, number of seeds per pod, weight of 100 seeds and yield in t / ha observed were collected and submitted to ANOVA.The results show that the four varieties have different behavior depending on the sites. Although the yield is low for this season, the Katanga site shows good bean behavior than the other two sites: Fungurume and Kitanda. In addition, Cuarentino and M211 varieties gave high yields.

Keywords: genotype x environment interaction, Bio fortification, yield; common bean, Phaseolus vulgaris L.

Introduction

Access to a healthy diet is a fundamental right of every human being on this planet. Yet one billion people, mostly in developing countries, go to bed hungry every day (Khush G, 2010). In the past 40 years, agricultural research for developing countries has been focused on increasing cereal production. Recently, there has been a shift: now, agriculture must not only produce more calories to reduce hunger, but also produce nutrient-rich foods to reduce hidden hunger (Kennedy et al., 2003) . Mason and Garcia (1993); Welche et al (1997); WHO (1999); World Bank (1994) and Kashat et al., 2019 have claimed that three billion people suffer the insidious repercussions of micronutrient deficiencies, also known as "hidden famine", and the number is increasing because they do not have access to more nutritious foods because of poverty.The daily diet of poor people consists mainly of basic necessities, such as white-grain maize, rice and cassava, which are low in micronutrients (Kashat et al., 2019). However, the consequences of micronutrient malnutrition can be disastrous (Harvest Plus, 2015). Nearly two-thirds of all child deaths are associated with nutritional deficiencies, especially micronutrient deficiencies (Caballero, 2002). Failure to consume one of these nutrients will result in adverse metabolic disorders that lead to illness, poor health, weakened development of children, and a high economic cost to society (Brancas and Ferrari, 2002, Grantham et al. 1999, Ramakrishna et al., 1999).Food security and household incomes in Sub-Saharan Africa have declined significantly over the past two decades, leading to increased poverty and malnutrition, especially among poor smallholders and urban poor (Kimani al., 2001). The WHO report (2000) on global health identified iodine, iron, vitamin A and zinc deficiencies as among the most important health risk factors worldwide. World populations suffer from micronutrient deficiencies, mostly caused by a lack of food intake of vitamins and minerals. The fight against micronutrient malnutrition is therefore a precondition for any prospect of rapid and appropriate national development (WHO, 2011).Despite its immense agricultural potential, the Democratic Republic of Congo is one of the poorest countries in the world, where food insecurity and malnutrition continue to be acute (Huart et al., 2007; Lutete, 2007).). WHO (2016) confirms that six million children in DR Congo suffer from malnutrition (also called hidden hay). The Democratic Republic of Congo (DRC), and in particular the province of Lualaba and Upper Katanga, are no exception. Despite copper and cobalt deposits blanketed in these two provinces, poverty, food insecurity and malnutrition are more severe in these provinces than in many other provinces of the country. The UN agencies FAO and WHO (2011) have stipulated that policy and program responses consist of nutrition-based strategies such as food diversification and fortification and finally supplementation. These approaches should be considered complementary, their relative importance varying according to local conditions and the specific distribution of needs in the target population.Of the three options for increasing micronutrient intakes, supplement programs are often the ones that provide the fastest improvement in micronutrient status of individuals or target groups. Fortification of foods tends to have a less immediate effect but a much broader and more lasting impact. As for food diversification, if it is generally considered the most desirable option and whose results are the most sustainable, it is the one whose implementation requires the most time. In fact, common bean is the world's largest food legume, and is widely consumed in Africa where it can be an extremely productive crop.Now the technique of bio fortification by the selection work conducted by Harvest Plus, led to the release of the first generation of beans rich in iron, cassava, cassava and sweet potato rich in vitamin A precisely in Rwanda, DRC, Uganda, in Nigeria and Zambia (Haskell, 2012). Food fortified with micronutrients can help stem the scourge that threatens Congolese people (Harvest Plus, 2012). The lack of micronutrients in daily diets is a serious risk to human health. As a result, life expectancy is only decreasing and children and pregnant women are victims; especially those from very poor families and even more in the countryside.It is with a view to finding effective solutions through the fortification of micronutrient fortified organic products (Fe, Zn and vitamin A) in Lualaba and Haut-Katanga, that this work was initiated with a view to comparing the yield of fortified organic twined beans installed in three different environments: Katanga, Kitanda and Fungurume. This work pursues as specific objectives, determined the (the) best variety (s) of fortified organic twined bean which will give the best yield in these three environments. In the course of this research, the hypotheses are that: (1) the fortified organic twined bean varieties do not have the same behavior in their introduction medium, (2) the environment influences on the behavior of organic voluble varieties fortified and (3) the yield efficiency of fortified organic twined varieties would depend on the locality.

Material and methods

This study was conducted in the Lualaba and Upper Katanga region. These regions belong to the climatic type Cw6 of the Köppen classification (FAO, 2005). This type defines warm temperate rainy climates where the average temperature of the coldest month is between + 18 ° C and -3 ° C and the total rainfall of the driest month is equal to or less than the total rainfall during the rainiest month. Our study area has only one growing season per year (FAO, 2009, Munyemba, 2010). For all these regions, the city of Lubumbashi is located in a rainy tropical climate of the type CW6 of the Koppen classification characterized by the succession of two seasons during the year: the rainy season and the dry season. The rainy season starts in the second half of October and ends in the first half of April. The dry season identifies two periods: one cold (May to August) and the other warm (September to mid-October) (Mpundu, 2010, Shutcha, 2010). The average annual temperature is 20°C.Relative humidity changes with rainfall and reaches the point at the end of the dry season, while the highest value is the monthly water level, estimated at an average of 66%. According to Robert (1956), the greater Katanga is a geographical region which differs in its relatively high altitude and relatively low elevation zones that occur in the north-west and north of the province of Greater Katanga. In our study area, Schmitz (1971) reports that the surroundings of Lubumbashi form a plateau scarcely excavated by rivers and from which rise some mountains that can exceed 1450 m of altitude, but there are altitudes exceeding some 1500 m at the Zambian border, not far from Sakania. The lowest points are at 1160, 1165 and 1175 m, depending on the valleys. In the Likasi region, to the southwest, the peaks exceed 1600 m.Based on various works carried out in the field of description and classification of soils in Katanga, since the INEAC so far, the soils of the greater Katanga are very diversified by their nature. Lubumbashi and its surroundings belong to the group of ferralitic soils (Kasongo et *al*., 2013). The natural vegetation of the city of Lubumbashi and its surroundings is a miombo forest. This is the result of evolution conditioned by anthropogenic activities while Kolwezi and its surroundings have rocky outcrops belonging to the Precambrian crystalline bedrock (gneiss, granite and shale) and sediments (mostly sandy) of the Pleistocene. These soils are not rich despite the luxuriance of the vegetation that is attributed to a high richness in humus. This is because the humus is quickly destroyed (Anonymous, 2005). As for the vegetation of Kolwezi, this one is in full regression. However, the vegetation of our experimental site is composed by Titonia diversifolia, Impera tacylindrica, Acacia. The tests were installed in 3 sites, namely Fungurume in Lualaba, Katanga with Mangombo and Kitanda in Upper Katanga. The geographical characteristics of these three sites are presented in Table 1.

Table 1: Geographical feature of experimental sites.

Sites	Altitude	Latitude South	Longitude East
Fungurume	1210m	10°34’ 08,5’’	26°19’ 49,2’’
Katanga	1173m	11° 06’33,4’’	27°07’18.7’’
Kitanda	1167m	11°27’12,3’’	27°44’27,4’’

Table 2: Rainfall data (mm) of Fungurume, Katanga and Kitanda sites from February 2015 to June 2015.

Month	Katanga	Kitanda	Fungurume
February	200,5	415,7	162
March	307,6	180,95	46
April	85,1	77,3	0,0
May	0,3	0,0	0,0
June	0,0	0,0	0,0
Total	593,5	673,95	208

Sources: Mangombo Station, Loano and Kwatebala 2015.

The fungurume site

Located in the province of Lualaba and 195 km from Lubumbashi. It is characterized by sandy-clay soil on the north-east side; this part is entirely favorable to agriculture. The remaining part consists of rocky soil located on hills and mountains rich in natural mineral resources. The average temperature is 20 ° C, with low values (below 18 ° C) in the dry season and higher values (25 ° C) in the rainy season (Placet, 1975). The recolonization flora of the experimental site was dominated by grassy savannah and the woodland savanna dominated by Andropogon, Bidens pilosa, Aframomum, Imperata cylindrica and Thitonia diversifolia species. The soil that supported our test has always been used for maize cultivation (SADRI et al., 2015). Rainfall data during the growing season are shown in Table (2). This table shows that the rainfall conditions prevailing during the trial were generally unsatisfactory for normal bean development.

The Katanga site

Located 95 km from the city of Lubumbashi on the Likasi axis, the Katanga site is near the farm Mangombo farm. It is characterized by Acrisols, formed on very heavy clay alluvium and fluvial alluvium. Here we find a flora dominated by: Imperata cylindrica, Andropogon spp, Hypparhenia spp and Albizzia spp which is the most abundant shrub species of this environment. The previous crop was the corn crop. Rainfall data during the cropping season are shown in Table (2). This table shows that the rainfall conditions prevailing during the test were generally satisfactory for normal bean development.

The Kitanda site

Located 50 km from Lubumbashi on the Kasenga road. In general, the soils of Lubumbashi are of the ferralitic type, deeply altered, characterized in particular by the abundance of sesquioxides of iron and alumina and clay materials with low exchange capacity (kaolinite). The flora of the experimental site is dominated by: Imperata cylindrica, Andropogon spp, Hypparhenia spp and albizzia spp and other trees of the genus Brachystegia, Julbernadia and Isoberligna of the clear forest which constitute the most abundant shrub species. The previous crop was the bean crop. The climate data of this site does not differ from Lubumbashi and are included in the table (2). This table shows that the rainfall conditions prevailing during the trial were generally satisfactory for normal bean development.

Materials

The biological materials used in the trials are the four varieties of fortified organic beans from INERA Mulungu through the Arvest plus project (Cuarentino, Namulenga, M211 and Codmlu) and a local variety. These fortified organic varieties have been improved to increase the micronutrient content and then be a source of these nutrients needed to fight malnutrition. Given their need in poor countries, these varieties were chosen to compare their yield to that of the local variety in all three environments. NPK 10-20-10 was applied to sowing as a basal fertilizer at a rate of 4 g per pouch, or 200 kg per hectare and a fertilizer equivalent of 20 kg N, 40 kg P_2O_5 and 20 kg N K_2O per hectare.

Methods

The experiment was conducted according to a complete randomized block device consisting of five varieties repeated 3 times. In total, each site had a block of 15 plots according to the number of varieties and as many times of repetition where the varieties were arranged in a random manner. The block had a total area of 1102 m2 that is 58m long and 19m wide. The plot area was 10m x 5m or 50m2 and the spacings between plots were 2m. The number of lines per parcel was 20 lines and the spacing between the lines was 20 cm. while the gap between the pockets was 20 cm and each plot had 500 pockets. Indeed, the spacings between the lines and on the line were 20 cm x 20 cm.

The tests were conducted in the field. Land preparation consisted of plowing followed by harrowing. These two operations were carried out using tractor with disc plows for plowing and a harrow for harrowing. After these operations the block was delimited by means of decametre and materialized by the stakes based on bamboo stalk. Similarly, the different parcels and their distances. In addition, the pockets were delimited through the ropes where we had already reported the spacings between the lines and on the line. The pockets were made from the hoe at the time of sowing. It should be noted that plowing and harrowing were carried out one week before sowing and this was done from January 28th to February 2nd in the Katanga site; February 10th to 13th in the Kitanda site and in the Fungurume site, from February 21st to 25th, 2015. The sowing dates for the different sites are: February 5th for the Katanga site, February 17th for Kitanda and February 28th for Fungurume.

Sowing was carried out at three sites, Katanga, Kitanda and Fungurume respectively as of 5 / February / 2015, 17 / February / 2015 and 28 / February / 2015 due to two seeds per pocket at a depth of 5 cm, ie a seeding density of 200,000 plants / ha. To promote the development of roots in the soil and to remove bad ones in the field, hoeing and weeding were respectively carried out. Hoeing occurred at two weeks of sowing while weeding was done when the weeds were observed in the field. At 15 days after sowing, the staking was carried out as it was twining bean to allow the good fixation of plants. The harvests were carried out by site following the dates hereafter the 01/07/0215 in Katanga, the 17/07/2015 in Fungurume and the 27/06/2015 in Kitanda. They were based on the maturity of pods, they were done by tearing the plant by hand at the collar. On the other hand, the harvest was made variety by variety according to the plots.During the experimental period, observations were made on: The emergence rate at 10 days after sowing (%), the size of the plants at harvest (cm), the number of nodes and internodes of the plants at harvest, the number of pods per plant, number of seeds per pod, weight of 100 seeds and yield per hectare. Data on the different parameters collected were subjected to one-way analysis of variance (ANOVA) for the determination of means, with the post-hoc ppds test for the separation of means in case of significant difference between the means of treatments.

Results

The vegetative performance of fortified and local bi-volubile bean varieties.

Table (3) shows that the vegetative parameters of five varieties selected for our study in the three chosen sites Katanga, Kitanda and Fungurume gave results which vary respectively between 53.6 and 66.3% for the survey rate. ; 182.6 and 202.3% for the final height and 20 and 23% for the number of nodes. The comparison of means by variance analysis (ANOVA, α = 0.05) showed that all five varieties were not influenced by the environment regardless of the site.

Table 3: Averages of the vegetative parameters of five (5) common bean varieties across the set of environments.

Variety	Raised rate (%)	Final height (cm)	Number of nodes
Locale	53,6 ± 11,2a	186,5 ± 5,89a	20 ± 0,31a
Cuarentino	66,3 ± 23,9a	189,7 ± 35,7a	23 ± 3,22a
Namulenga	55,0 ± 24,1a	193,4 ± 50,8a	22 ± 2,46a
M211	62,1 ± 16,1a	182,6 ± 37,9a	20 ± 2,70a
Codmlu	55,3± 20,8a	202,3 ± 49,1a	22 ± 3,37a
p =0,05	0,604	0,856	0,149

Performance of new varieties bean biofortified on production parameters.

For the set of production parameters, it is apparent from Table 4 above that the treatment of effect on the production parameters irrespective of the site except for the weight of 100 seeds where, the statistical analyzes showed highly differences. significant by the local variety that had the lowest weight of 100graines (11.7gr), the other varieties behaved well up to reach weight of 100 seeds of the order of 35.2 gr for the variety Codmlu . The yield, meanwhile, did not show any significant differences, statistically it was found that all the varieties behaved well and gave superior yield compared to the local variety, despite the fact that this yield itself is low in relation to the yield generally obtained.

Table 4: Averages of the production parameters of five (5) common bean varieties in the three environments.

Varieties	Pod /plant	Seed /pod	Weight100 (gr)	Yield (kg/ha)
Locale	8 ± 0,17a	5 ± 0,26a	11,7 ± 0,45c	240 ± 0,015b
Cuarentino	7 ± 3,97a	5 ± 1,54a	28,1 ± 3,82b	477 ± 0,393a
Namulenga	7 ± 4,16a	4 ± 1,36a	27,2 ± 4,05b	295 ± 0,131b
M211	8 ± 3,94a	5 ± 1,15a	24,2 ± 3,32b	498 ± 0,288a
Codmlu	7 ± 3,77a	5 ± 1,14a	35,2 ± 5,66a	328 ± 0,111ab
p =0,05	0,81	0,478	0,000	0,086

Effect of vegetative parameters of bean varieties according to sites.

It can be seen from Table 5 that the differences are highly significant for vegetative parameters irrespective of the site. We note that for both Katanga and Kitanda sites, the emergence rate was 66.75%. On the other hand, the Fungurume site reveals a low rate with an average of less than 50% for all varieties. The highest plant height was observed in the Fungurume and Katanga sites. These last two have an average height of 206cm while the site Kitanda, gave him the smallest heights (160,7 cm). The Katanga site showed the highest number of nodes compared to the other two sites (Fungurume and Kitanda), ie 23 nodes against 20.

Table 5: Averages of vegetative parameters of five (5) varieties of common bean according to each site.

SITES	Raised rate (%)	Final height (cm)	Number of nodes
Fungurume	41,9 ± 12,4b	192,9 ± 26,8a	21 ± 2,23b
Katanga	71,4 ± 13,5a	219,1 ± 34,0a	23 ± 2,98a
Kitanda	62,1 ± 19,4a	160,7 ± 29,3b	20 ± 1,82b
p 0,05	0,000	0,000	0,001

Effect of yield parameters of bean varieties according to each site.

From Table (6) it can be seen from this table that the difference in the number of pods per plant and seed per pod is highly significant compared to sites. The largest number of pods per plant (10) was observed in the Fungurume site and the smallest (4) in the Kitanda site. While it is the Katanga site that has had the largest number of seeds per pod (6) and the smallest (4) in the Kitanda site. Significant differences were observed in yield against the weight of 100 seeds was not influenced by the medium.

Table 6: Average production parameters of five (5) common bean varieties per site.

SITES	Pod /plant	Seed /pod	Weight 100 (gr)	Yield (kg/ha)
Fungurume	10 ± 2,37a	5 ± 0,74a	21,5 ± 11,4a	348 ± 0,15ab
Katanga	9 ± 1,61a	6 ± 0,75a	23,7 ± 13,0a	491 ± 0,30a
Kitanda	4 ± 2,96b	4 ± 1,28b	24,3 ± 12,9a	263 ± 0,20b
p 0,05	0,000	0,000	0,815	0,031

Effect of the environment on the performance of common beans

Table (7) shows, after statistical analysis, that there are significant effects of vegetative behaviors depending on the varieties with respect to each site ($P < 0.05$); Except for the final height of plants ($P > 0.05$). The highest emergence rate was observed in the Katanga (Cuarentino, Namulenga and M211) and Kitanda (Cuarentino) sites. On the other hand Cuarentino, Namulenga and Codmlu presented the lowest rates of emergence and this in the Fungurume site. In addition, the highest number of nodes was observed in the Fungurume (Namulenga) and Katanga (Cuarentino and Codmlu) sites. The low number of nodes was observed in the Fungurume (Codmlu) and Kitanda (Namulenga and M211) sites. Finally, the site effects on the final height of plants are not significant compared to varieties.

Table 7: Averages of the vegetative parameters of each variety per site.

SITES	Varieties	Raised rate (%)	Final height (cm)	Number of nodes
FUNGURUME	Locale	53,6 ± 12,9b	186,5± 6,81a	20 ± 0,36ab
	Cuarentino	37,8 ± 11,3c	182,9± 18,3a	21 ± 2,02ab
	Namulenga	37,7 ± 4,77c	225,1± 42,6a	24 ± 1,67a
	M211	45,3± 11,5bc	185,8± 14,5a	20 ± 1,86ab
	Codmlu	34,9 ± 16,7c	184,2± 26,0a	19 ± 1,56b
KATANGA	Locale	53,6 ± 12,9b	186,5± 6,81a	20 ± 0,36ab
	Cuarentino	78,8 ± 2,36a	229,1± 18,0a	26 ± 4,05a
	Namulenga	84,8 ± 4,25a	215 ± 36,6a	22 ± 2,06ab
	M211	72,6 ± 9,57a	211,4± 34,2a	23 ± 1,05ab
	Codmlu	67,3± 12,2ab	253,9± 39,7a	26 ± 2,60a
KITANDA	Locale	53,6 ± 12,9b	186,5± 6,81a	20 ± 0,36ab
	Cuarentino	82,5 ± 17,5a	157,3± 22,1a	22 ± 1,51ab
	Namulenga	42,5± 16,5bc	140,3± 27,2a	19 ± 0,86b
	M211	68,4± 12,7ab	150,6± 39,8a	18 ± 2,08b
	Codmlu	63,8± 18,9ab	169,1± 35,6a	21 ± 1,60ab
Effects Sites*Varieties	p=0,05	0,011	0,0687	0,0108

Table (8) allows us to see statistical analyzes of different production parameters per site. This shows that the difference is significant for the number of pods per plant, for the number of seeds per pod and for the yield per hectare, except for the weight of 100 seeds which was not influenced by the middle.

Table 8: Average yields measured for each common bean variety by site.

Sites	Varieties	Pod /plant	Seed /pod	Weight 100 gr	Yield (kg/ha)
FUNGURUME	Locale	8 ± 0,20ab	5 ± 0,30ab	11,7 ± 0,52b	240 ± 0,01bc
	Cuarentino	9 ± 3,93ab	4 ± 0,50ab	32,6 ± 1,52a	187 ± 0,004c
	Namulenga	12 ± 2,48a	6 ± 0,86a	23,6 ± 2,31ab	312 ± 0,04b
	M211	11 ± 1,15a	6 ± 0,32a	22 ± 5,29ab	590 ± 0,11ab
	Codmlu	9 ± 2,12ab	5 ± 0,55ab	28,3 ± 1,15a	413± 0,037ab
KATANGA	Locale	8 ± 0,20ab	5 ± 0,30ab	11,7 ± 0,52a	240 ± 0,01bc
	Cuarentino	8 ± 1,99ab	7 ± 0,11a	25,0 ± 1,37ab	797 ± 0,42a
	Namulenga	8 ± 0,75ab	5 ± 0,37ab	26,7 ± 1,33ab	395 ± 0,14b
	M211	10 ± 2,74a	6 ± 0,20a	25,6 ± 1,74ab	752 ± 0,15a
	Codmlu	10 ± 0,55a	5 ± 0,40ab	39,9 ± 2,01a	270 ± 0,083bc
KITANDA	Locale	8 ± 0,20ab	5 ± 0,30ab	11,7 ± 0,52b	240 ± 0,01bc
	Cuarentino	2 ± 0,23c	4 ± 1,35ab	26,6 ± 2,38ab	44 ± 0,39d
	Namulenga	3 ± 0,20c	3 ± 1,15c	31,3 ± 3,67a	176 ± 0,10c
	M211	5 ± 4,63bc	5 ± 1,80ab	25,2 ± 1,08ab	153 ± 0,077c
	Codmlu	2 ± 0,49c	3 ± 0,98c	37,4 ± 3,38a	300 ± 0,157b
Effects Sites*Variétés	P=0,05	0,0162	0,013	4,84 e-06	0,021949

Discussions

The results obtained from the vegetative parameters and yield analyzes show that there are no significant differences between the varieties, except for the weight of 100 seeds depending on the varieties. For the latter, the Codmlu variety gave the highest weight that all the others and the weakest was observed on the local variety (control). Although not significant by variety, the yield averages obtained with the introduced varieties were higher than those obtained with the local variety. These varieties in introduction although being new, the results of observed parameters showed that they adapt a little well in the agroecological conditions of aforementioned media compared to the local variety (control).Several studies (Carolina, 2005.) have shown that beans adapt easily to different environments. It has also been shown that this crop has a high ecological plasticity due to its high genetic variability (Kanyenga 2012). Indeed, the results relating to varietal behavior provide information on the adaptation of these new varieties in our study environments. As it has been shown that there are no significant effects between the different varieties in relation to the local variety, the ideal would be to repeat these same tests over time to determine the actual factors of both adaptation. as variability in agronomic behavior. This has been proven by Kanyenga, (2012) and Agropolis, (2001) that genome expression of plant material is a major consequence of the environment throughout the planet. Environmental constraints related to climate and soil quality are the main factors limiting crop production worldwide. A wide variety of tolerances to these constraints exists between species and varieties. In most cases, each individual has a variety of variants of their genetic programs. Faced with each type of constraint, the plant is able to select, in this set, alternative genetic programs whose expression allows a better adaptation to the new conditions. This ability to use environmental cues to drive genome expression is a specialty of the plant world, known as phenotypic plasticity (Agropolis, 2001).The results of the ANOVA on the vegetative behaviors of varieties according to the sites suggest that the varieties show a different behavior according to the sites. Katanga was the best on all vegetative parameters, while Fungurume was better only for height of plants at harvest, but weak for other parameters. Similarly the Kitanda site has been better for germination rate, but has low mean plant heights and number of nodes. In addition, the number of pods per plant, number of seeds per pod, and yield were influenced by the sites. Only the weights of 100graines did not show a significant site effect between their average. These results show that the number of pods and the number of seeds were high in the Fungurume and Katanga sites; and, weak in the Kitanda site. However, the highest yield was observed in the Katanga site and low in the Kitanda site. Among the many abiotic environmental factors that can reduce potential production, four main factors have been identified as limiting in the usual growing environments according to Connors et al. 1992 and Connors et al. 1997: temperature, radiation, water and nitrogen from the soil. For the present study, these factors explain the different variety behaviors according to the sites. Each environment being particular for its edapho-climatic conditions, the latter can influence positively or negatively on the genotype which in turn expresses different phenotypes according to the varieties and sites (Kanyenga, 2012). Based on these, the Katanga site proved to be a better environment for the set of parameters than the two (2) others.This is confirmed on the one hand by the results of the study conducted by Kasongo (2008) which shows that the agricultural sites lying in the plain of the Lufira Valley are full of good edaphic conditions and on the other hand, the date of semi (5 / February) and rainfall recorded during the trial period in the Katanga site (Table 2) confirm these remarks to the detriment of two other sites which are, Fungurume and Kitanda, which recorded low rainfall and planting had place respectively as of 17 / February and 28 / February this year. Constraints, such as water deficit or mineral deficiencies, mainly affect the development and growth of organs and the level of photosynthetic activity (Pierre et al., 2008). It was observed a month of March with almost no rain during the test at both sites. This water deficit would explain the low genotypic expressions of crops such as yield reduction. Several studies (Laure et al., 2010), show a positive correlation between water deficits and the decline in the expression of crop production potential, these deficits have consequences on the culture water stress, which plays to the detriment development and growth of the plant thus inducing the reduction of the crop yield. The lack of water is one of the main environmental factors that can limit the growth and productivity of plants, because photosynthesis can only be realized at the cost of considerable water losses (300 to 500 liters of water for one year). gram of carbon) (Laure et al., 2010).

Conclusion

The purpose of this work was to compare the yield of four common bean varieties (Phaseolus vulgaris L.) in three different environments to determine their levels of adaptability. To achieve this, the trials were conducted at Fungurume, Katanga and Kitanda following a complete randomized block design consisting of four (4) varieties of fortified organic common bean and a local variety (control).The vegetative and production parameters observed were subjected to statistical analyzes which allowed us to draw conclusions that Cuarentino and M211 varieties gave high yields and can be pre-vulgarized in their study environments. As for the sites, Katanga proved to be better for the production of these varieties because of the higher yield for all varieties compared to the other two sites. To overcome the different constraints encountered throughout our study, we suggest that this investigation can be resumed taking into account the contribution of organic or mineral amendments, and by changing the sowing dates in order to improve the growing conditions. and the yield of these varieties.

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