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Research Paper

Difficulties in producing common beans (*Phaseolus vulgaris* L.) in the A season in the lowland region of Kisangani in the Democratic Republic of Congo.

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Abstract: *The aim of this study was to determine the best sowing period for beans in season A in Kisangani, for increasing production and contributing to food self-sufficiency. The HM21-7 biofortified bean variety supplied by CIAT-Harvest Plus/Bukavu was tested at three staggered sowing times: March 15, April 15 and May 15, 2021, in a randomized complete block design with 3 replications and 3 treatments each, to assess agronomic performance. The results showed that the performance of the variety studied depended on the sowing period. However, sowing at May 15 induced more vigorous growth than other periods. Also, the overall seed production obtained in season A (133.1 Kg/ha) is unattractive and far lower than in higher altitude regions. From this study, we can note that there is no better agronomic performance when sowing is carried out in season A in the Kisangani region, hence our hypothesis that sown on May 15, the bean crop would benefit from a good growing period coinciding with the end of the short rainy season and would give a better production is rejected.*
Key words: *Biofortified beans, sowing dates, production, performance, Kisangani.*

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I. Introduction

The seeds of the common bean (Phaseolus vulgaris L.), like those of other pulses, are prized for their very high protein content (20-26%). Beans are an essential food crop in Central and Southern Africa, where populations are generally poor (Raemaerkers, 2001). According to FAOSTAT (2016), in 2014 the Democratic Republic of Congo (DRC) produced 119900 tonnes of dry beans on an area of 196650 ha, with a low average yield of 610 Kg/ha. This low yield may be consecutive to low soil fertility. However, yield losses of food grain legumes are around 25% and depend on several factors including low soil fertility, the use of low-yielding varieties, diseases, insect pests and climatic disturbance (Casinga et al. 2016; FAOSTAT, 2016; Kanyenga et al. 1989).

To further emphasize the importance of beans in the diet of the Democratic Republic of Congo, the Centre International d'Agriculture Tropicale (CIAT) HarvestPlus/Bukavu has invested in bean improvement in Bukavu, DRC, through the development of biofortified varieties (Beart, 1995; CGIAR, 2013). These biofortified bean varieties offer high yields of seed beans rich in protein, Iron and Zinc for the benefit of infants and pregnant women (Casinga et al. 2016; HarvestPlus DRC, 2023).

Indeed, biofortification improves the nutritional value of staple food crops, enabling the population to obtain sufficient micronutrients directly from their usual foods (CGIAR et al. 2013; Darch et al. 2023). In Tshopo Province in general, and in the city of Kisangani in particular, beans have been a frequent meal for many households for many years. However, the beans consumed in Kisangani are mainly imported from neighbouring provinces, notably Ituri and Grand Kivu (Messiaen, 1975).

Previously a crop not recommended in Kisangani, a low-lying region with unfavourable ecological conditions, bean growing is increasingly attracting growers in the Kisangani region keen to break away from dependence on supplies from eastern DRC. Previous adaptation work has shown a strong chance of success in season B, provided that a better sowing period is chosen to ensure good pod filling during the rainy season (Monde and Songbo, 2002). With this in mind, the present work was initiated to determine the best sowing period for A-season bean cultivation in Kisangani.

II. Materials and methods

2.1. Study environment

The trial was conducted in Malimba (Figure 1), a locality located at kilometre point (PK 31) on the Buta road, Alibuku axis on the outskirts of Kisangani. The geographical coordinates of the experimental site are 025°15'41.7" Longitude East; 00°42'48.7 Latitude North with an average altitude of 404m.

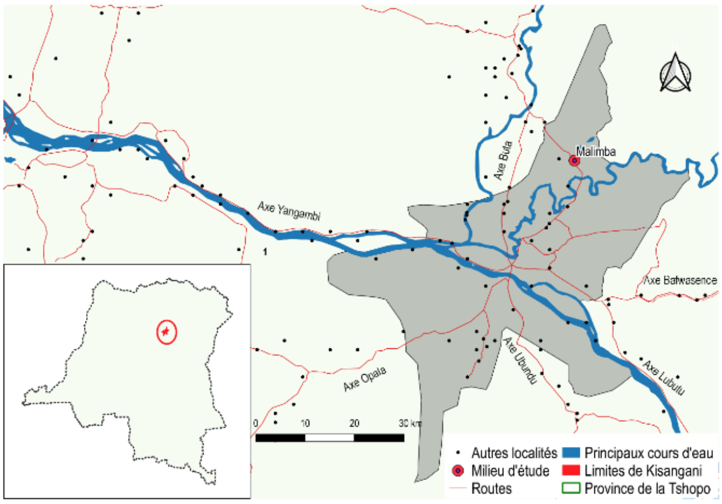

Figure 1: Study environment (Malimba, a locality located at PK 31 route Buta, axis Alibuku in the
Source: (Likiti et al, 2021)

Malimba is located in the Tshopo Province in the Kisangani region of the Democratic Republic of Congo. It enjoys a continental equatorial climate belonging to class Af of Koppen's classification (Alongo, 2015). Like the Kisangani region, Malimba experiences fairly high temperatures with little perceptible variation. Average daily temperatures range from 23.5°C to 25.3°C. Average rainfall is high throughout the year, but its distribution is not stable: 1728.4 mm (minimum 1417.5 mm and maximum 1975 mm), interrupted by two short dry seasons characterized by a drop in rainfall: from December to February and from June to August, respectively, corresponding to two short seasons of low rainfall (Nyakabwa, 1992). On the other hand, the two rainy periods are from September to November and March to May. Average rainfall in the driest month is around 60 mm. Relative humidity varies between 80 and 90% (Dhed'a, 2011).

Table 1: Rainfall and temperature recorded during our experiment.

Month	Precipitation (mm)		Temperature (°C)		
	Quantity (mm)	Nbr	Max	Mean	Min
March	556,6	8	32	26	21
April	393,4	11	32	26	21
May	268,8	5	33	20	19
June	250	6	28	26	24
July	245	7	32	20,5	20,1
August	358	10	27	25	23

(Source: Mini-station installed on 2021 experimental site)

The greatest amount of precipitation was recorded in March. April recorded 11 days of rain, with more than two dry weeks. On the other hand, the maximum temperature was recorded in May.

2.2 Materials

Biofortified beans, particularly the HM 21-7 variety, were used as experimental material. This bean comes from CIAT-Harvest Plus/Bukavu and has the following characteristics: The HM 21-7 biofortified bean variety was bred by INERA Mulungu, and has a Nain type I b growth habit. It flowers on the 38th day and reaches maturity 80 days after sowing, with red seeds streaked with white (Figure 2).

Figure 2 : Variété HM 21-7 utilisée comme matériel expérimental (Photo Diko, 2022)

2.3 Methods

2.3.1. Experimental set-up

The experimental set-up used was that of a Latin square with 3 replicates, each comprising 3 treatments. The 3 treatments were the three different bean sowing dates tested in season A, namely : T1 sowing on March 15, T2 sowing on April 15 and T3 sowing on May 15, 2022. The experimental field area was 13m x 15m, i.e. 195m2. The dimensions of the experimental plots were 3m x 3m or 9m2. They were separated from each other by 1m aisles, while the blocks were separated from each other by 1.5m aisles. Figure 3 illustrates the experimental set-up used.

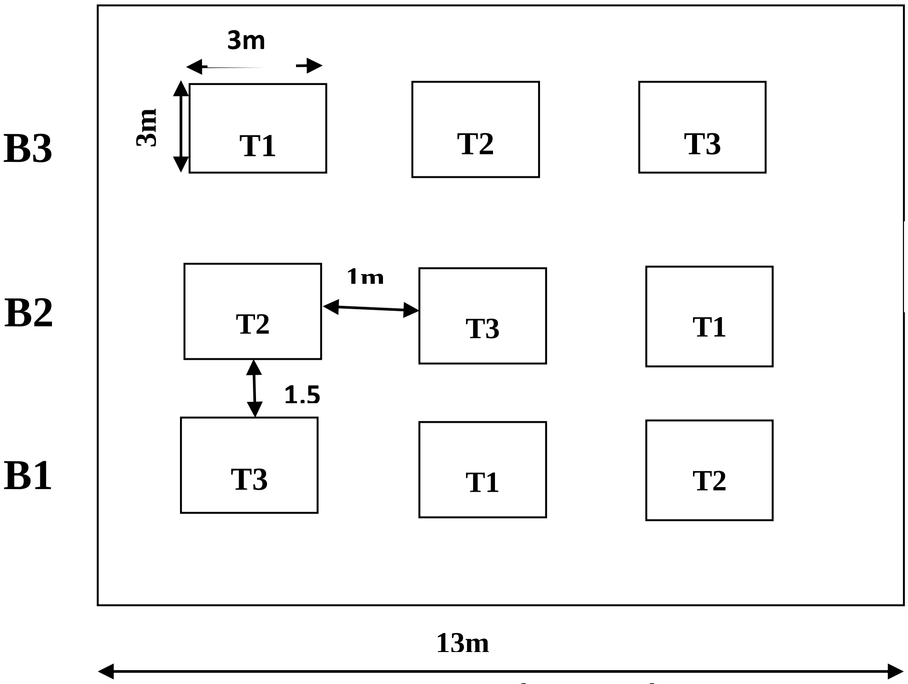

Figure 3. Experimental set-up used.

Legend: T1: sowing on 15/03/2021; T2: sowing on 15/04/2021; T3: sowing on 15/05/2021.

2.3.2. Conduct of the experiment

Sowing was carried out at 40 cm x 40 cm spacing, with 2 seeds per plot. The soil was not amended in any way. Maintenance work began two weeks after sowing and continued until the end of the experiment, as necessary. This included replanting of voids, weeding to leave 2 plants per bunch, manual weeding and weeding. Harvesting was carried out before pod dehiscence, in a staggered fashion, as the treatments reached physiological maturity at different dates. The harvested pods were dried for four days before threshing.

Observations were made on vegetative, production and phytosanitary parameters. Observations on vegetative parameters were made at emergence and flowering, and covered :

The emergence rate, which refers to the number of emerged seeds out of the total sown. It is determined by the following formula

Emergence rate = (Number of seeds emerged)/(Total number of seeds sown) x 100 (1)

Diameter at the collar was measured with a caliper on the stem about 1cm above the ground.

Plant height measured from the plant collar to the last bud on the main stem using a metric tape.

Leaf area measured with a lath. It was determined from a leaf located in the 4th position from top to bottom, using the relationship SF=L x l x FC (2).
The leaf area correction factor was determined gravimetrically according to Kanyenga 2016. Calculations showed that the HM21-7 variety used had a corrective factor of 0.65.
Where: SF = Leaf area
L= length
l= width
CF = Corrective factor 0.65.
Post-harvest production observations were made on the following parameters:
Weight of 100 seeds by weighing on an electronic scale;
Yield by extrapolation of plot production per hectare.
Disease incidence data were assessed at the start of flowering using the following formula:
Incidence x 100 (3)
As for severity, a standard evaluation scale ranging from 1 to 9 was used (Van Schoonhoven & Pastor-Corrales, 1987).
Where
1, 2 and 3: Resistance: no visible symptoms, or very slight symptoms, covering around 2% of the leaf or pod surface;
4, 5 and 6: Tolerance: Visible and striking symptoms, resulting only in limited economic damage, covering around 5 to 10% of the leaf or pod surface, damage may also be observed on the stem and branches.
7, 8 and 9: Susceptibility: severe to very severe symptoms, covering around 25% or more of the leaf, stem, branch or pod surface, causing severe yield losses or plant death.

2.3.4. Data processing and analysis

The data processed and presented were obtained by averaging across the three blocks. Microsoft Excel 2007 was used to enter and perform a descriptive statistical analysis of the data. The mean values obtained were compared after analysis of variance (ANOVA) using Tukey's test in order to identify differences in the performance of the varieties studied at the 5% threshold.

III. RESULTS

Growth parameters

Figures 4, 5, 6 and 7 show results relating to vegetative parameters (emergence rate, crown diameter, plant height and leaf area) measured during field trials.

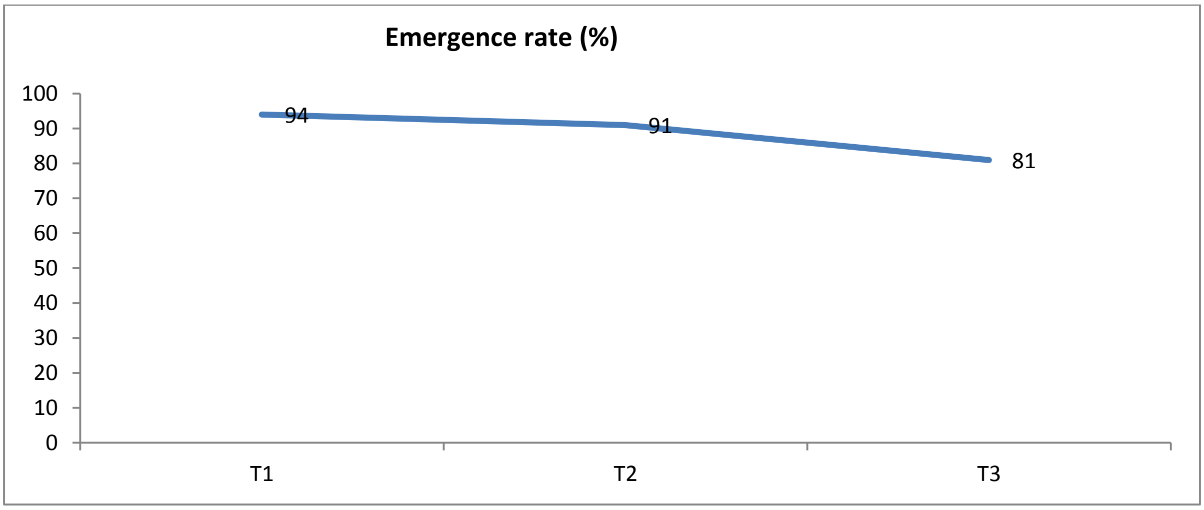

Figure 4: Emergence rates for the different sowing dates studied (in %)

Figure 4 shows that emergence rates ranged from 81% to 94%. This may be due to the higher quality seed used. Of these 3 sowing periods, the sowing carried out on March 15 had the highest recovery rate (94%), while the sowing carried out on May 15 was lower (81%) than the other treatments. This trend from March 15 to May 15 shows the decrease in emergence rate as a function of storage time, expressing the loss of germination capacity in Kisangani.

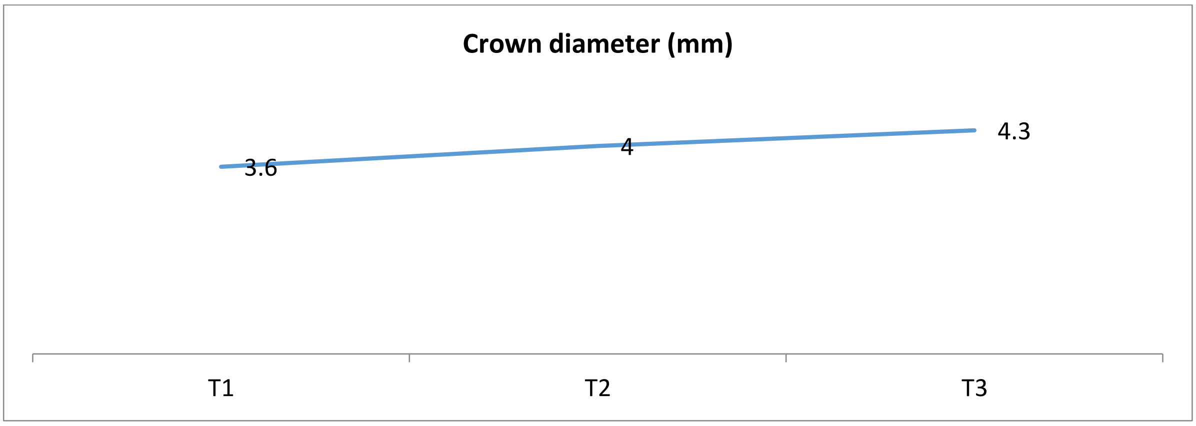

Figure 5. Neck diameter of three bean sowing dates tested in Kisangani (in millimetres)

In terms of collar diameter, the May 15 planting had a larger collar diameter (4.3 mm), followed by the April 15 planting (4 mm), with the March 15 planting having a smaller collar diameter (3.6 mm) than the others.

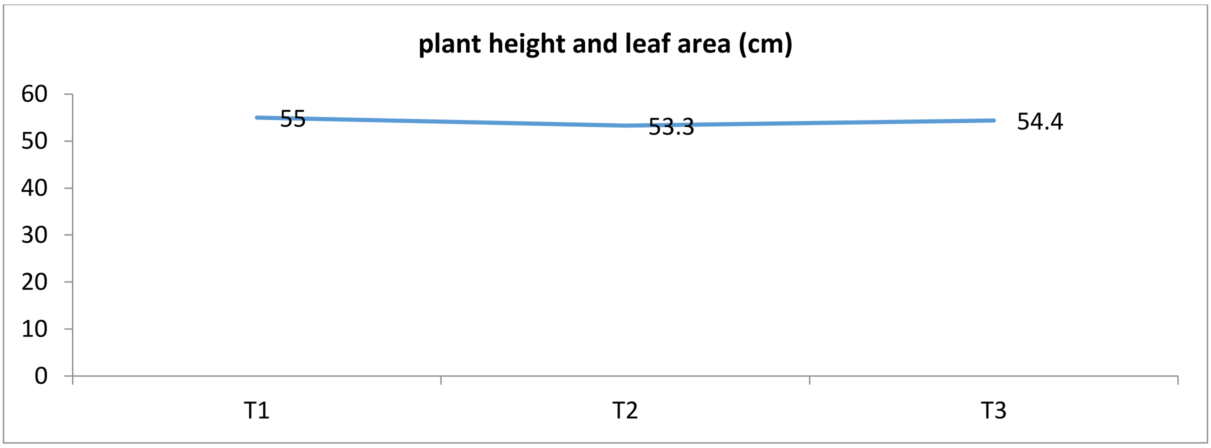

Figure 6. Average plant height for three sowing dates (in centimetres)

Plant heights were similar between treatments. This similarity can be explained by their genetic characteristics, as well as by the fact that the treatments tested did not show different growth habit proportions (all were voluble).

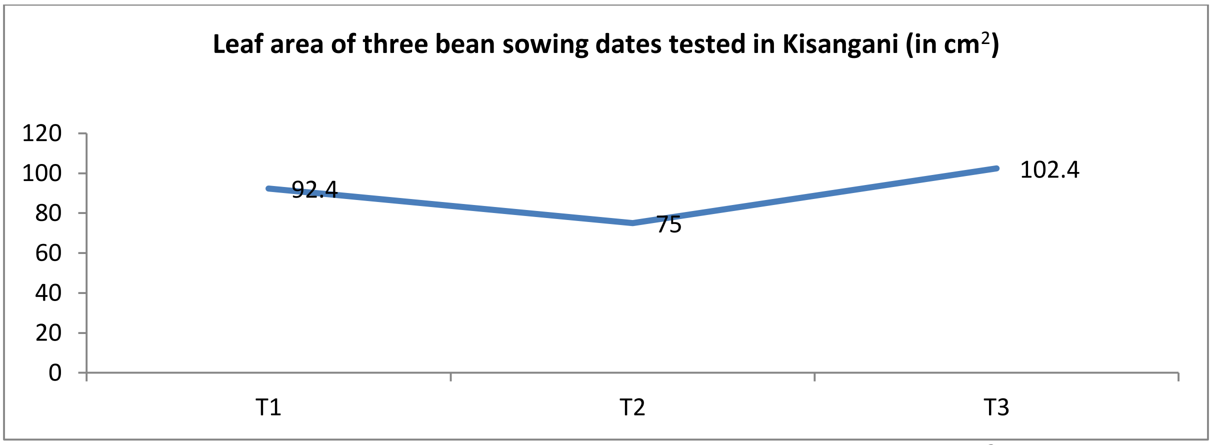

Figure 7. Leaf area of three bean sowing dates tested in Kisangani (in cm^2)

In terms of leaf area, the May 15 sowing date had a large leaf area (102.4 cm^2), followed by the March 15 sowing date (92.4 cm2), with the April 15 sowing date being smaller (75 cm^2) than the others.
At the 95% confidence level, the P-values obtained are above the 0.05 error threshold. Analysis of variance on vegetative parameters did not reveal any significant differences between the different treatments studied, despite the slight numerical differences recorded.

Production parameters

Figure 8 shows the results for production parameters (100g weight and plot production).

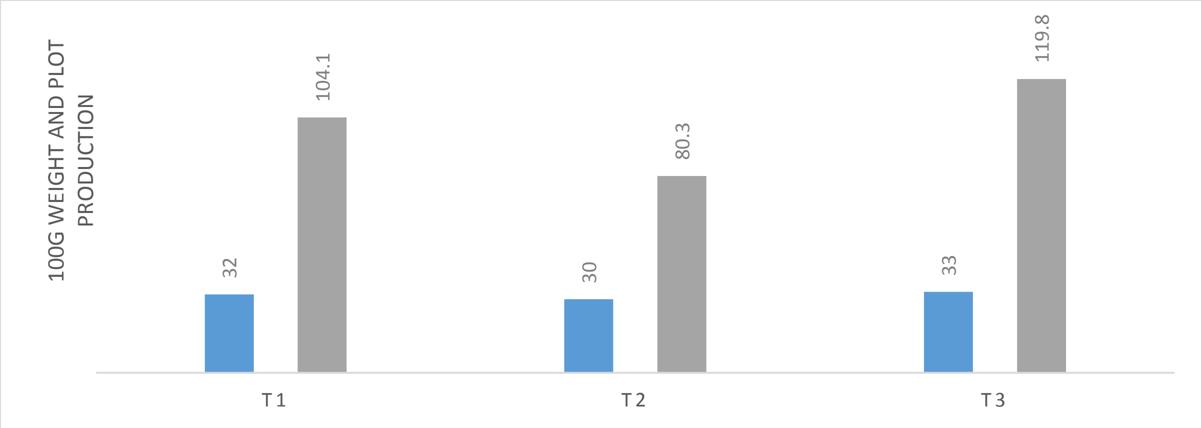

Figure 8. Results in relation to production (100g weight in g and plot production in g).

Comparison of variety averages by analysis of variance shows that there are significant differences between the 3 periods tested in terms of 100-seed weight and plot production. This confirms the behavior observed in the expression of vegetative parameters. It is worth noting that the May 15 sowing period produced the highest yields of all, at 109.8 kg/ha and 54.1 kg/ha respectively.

Phytosanitary parameters

Figure 9 below shows the incidence and severity of diseases observed during our experiment.

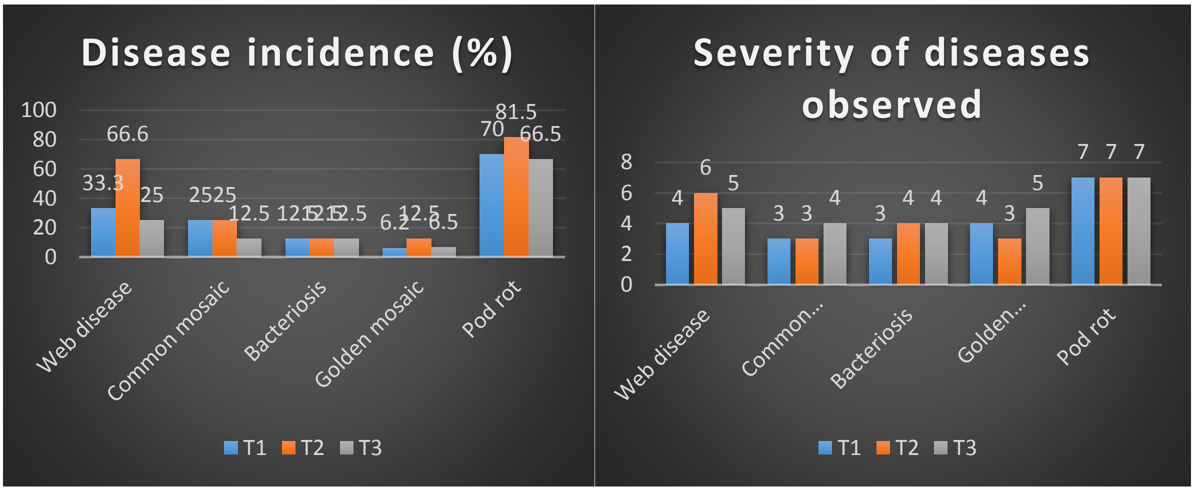

Figure 9. Incidence and severity of observed diseases

Figure 9 above shows the presence of the following five diseases in the Kisangani region: web disease, common mosaic, golden mosaic, bacterial blight and pod rot. The 3 treatments proved tolerant to these diseases in crop season A, with the exception of pod rot, where the recorded incidence was higher, ranging from 66.5% to 81.5%, and the severity at level 7. This resulted in a yield loss of around 90%. This pod rot attack is thought to be due to excessive rainfall (245 to 556.6 mm) during the sowing period in crop season A, which favored the development of bean pathogens. Above all, excessive rainfall during flowering and fruiting in this season also contributed to low bean yields.

IV. Discussion

Emergence rates recorded for all treatments applied were high, with an average of 81%. These rates remain higher than those recorded at high altitude in Bukavu by Casinga et al. (2016), which ranged from 36 to 70%. These results are thought to be due to the quality of the seeds. During this study, one type of vegetative habit (voluble) was observed among the bean plants tested. This shows that this trait is fixed for this variety.

The main diseases causing serious damage to the bean crop are: bean anthracnose, sclerotinia, white mould, rust, seed rot, damping-off, bean golden mosaic and angular leaf spot (Tu, 1997). Trial results revealed the presence of the following diseases in the Kisangani region: web disease, common mosaic, golden mosaic, bacterial blight and pod rot.

In the adaptive trial of five biofortified bean varieties in season B, Likiti (2021) recorded an incidence of pod rot ranging from 4.4% to 19.3%. Current results confirm that the bean tested was significantly attacked, as the highest incidence of pod rot recorded was 81.5% and the severity level 7 for season A.

As for seed yield, the results obtained show a very poor agronomic performance of the treatments studied under trial conditions in season A. All the sowing periods tested showed very low yields of 89.2 to 133.1 Kg/ha, which are below the CIAT average (800 to 1200 Kg/ha) and those recorded in a trial to determine the best sowing date for common beans in season B in Kisangani by Likiti in 2021 (1000 Kg/ha). Crop yield is the result of a more or less favorable interaction between the environmental milieu (climate, soil, biological environment) and the plant's genetic potential (Cassel et al., 2000). Under Kisangani conditions, the high rainfall recorded could have been the triggering factor for several pathologies that led to the poor agronomic performance of the biofortified bean variety tested. As a result, the three different sowing periods tested produced significantly lower yields than the unfertilized bean yield of 500 kg/ha (Caburet et al., 2009).

V. **Conclusion**

The aim of the study was to determine the best A-season sowing period for good agronomic performance of biofortified beans in the Kisangani region. Three sowing dates were tested in a Latin square layout, namely March 15, April 15 and May 15, 2021. The results showed that the performance of the variety studied depended on the sowing date. The results highlighted the presence of several diseases in the Kisangani region. This confirms that the common bean variety tested was significantly attacked, as the highest incidence of pod rot recorded was 81.5% and the severity at level 7 for season A. The overall production obtained during this season (110Kg/ha) is unattractive and is far lower than that obtained in highland regions and in previous work carried out on the same Malimba site, due to the prevalence of pod rot. From this study, we can see that excess rainfall favors the development of pathogens that prevent vegetative performance from achieving high yields in season A in the Kisangani region. The greatest difficulty in cultivation remains the climatic conditions that favor excessive development of common bean pathogens in the Kisangani region. In view of the results, this study should be extended to the various CIAT-Harvest Plus bio-fortified varieties to identify those that will be resistant to the region's pathogens.

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