AGRONOMIC CONSTRAINTS AND PRODUCTION OF COMMON BEAN (*Phaseolus vulgaris L.*) IN THE TERRITORY OF KASONGO-LUNDA, KWANGO PROVINCE in DR Congo

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ABSTRACT

Topic Description: Common bean is a staple food in the Democratic Republic of Congo. Today, its productivity in the territory of Kasongo-Lunda is threatened by abiotic and biotic constraints, the basis of the increase in poverty and food insecurity.

Objective: The objective of this study is to identify the agronomic constraints that limit the cultivation of common beans, and to evaluate the cultivation techniques related to the decline in production in the Kasongo-Lunda territory.

Methodology and results: Twelve (12) villages in the territory of Kasongo-lunda were surveyed in February and May 2021.A survey was carried out among 331 common bean producers chosen according to the approach determined by the respondent (Snowball sampling) thus mobilizing the tools and techniques of regional agronomic diagnosis based on interview surveys, group and/or individual interviews using questionnaires and field visits. The results showed that the early and/or late return of rains, non-compliance with the fallow period, staking difficulties, lack of rotation, the producer's experience in cultivation, weeds, diseases and pests, soil infertility, degeneration of varieties, lack of supervision of producers, use of rudimentary tools, ineffective means of control limit bean cultivation. The evaluation of technical itineraries revealed that land selection, land preparation, seed selection, sowing date, number of seeds per pocket, staking, number of weeding, stage of attack of diseases and pests influence the yield of common beans in the territory of Kasongo-lunda.

Conclusion and application of the results: By accurately identifying agronomic constraints and evaluating appropriate cultivation techniques, producers were able to maximize common bean production while minimizing pest risks.

Keywords: Phaseolus vulgaris, agronomic constraints, yield, production, cropping system, technical itineraries, Kasongo-lunda.

1. INTRODUCTION

Grain legumes in the cropping system are a solution to overcome both the problems of malnutrition and low soil fertility because they can directly use mineral and atmospheric nitrogen, they are an

essential part of the agrarian system (Baudoin et *al.,* 002; IRAD, 2013; Milognon et *al.*, 2020) and their cultivation is spreading throughout the world (CIAT, 1989).

Among the legumes to meet these challenges, the common bean (*Phaseolus vulgaris L,*), deserves a place of choice because it occupies more than half of the cultivated areas and constitutes nearly 75% of the world trade in legumes intended for food. It is also an excellent source of high-quality and affordable protein, 64% complexed carbon, fiber, oligosaccharides, as well as polyphenols and isoflavones. All of these contribute to human well-being and health (Likiti et *al.,* 2021). It also plays an essential role in the diet of many populations in tropical regions, combining harmoniously with carbohydrate-rich foods, such as cereals, tubers and roots (Allen, 1996; Nyabyenda , 2005; Milognon, 2020). While recognizing not only that the consumption of legumes contributes to better management of cardiovascular disease, obesity and colorectal cancer (RAD, 2013), but also, the common bean (*P. vulgaris*) guarantees an agronomic interest resulting from its ability to establish a mutualistic symbiosis with bacteria belonging to the *Rhizobia* familyfor the use of atmospheric nitrogen as a source of nitrogen (CIAT, 2001); Charlotte, 2022).

 In the Democratic Republic of Congo, the Phaseolus bean *is* a staple food for the local population. It is grown by smallholder farmers, who frequently practice it in combination with other plants, mostly for family consumption. The nutritional benefits of the common bean in rural areas replace those of animal origin in deficit. (FAO, 2016; Ngombo, 2017; PRAUNAT, 2020; Mutekulwa, 2022).

Despite all these plastic potentialities, however, bean production is struggling to meet consumer demand in the province of Kwango in general and the territory of Kasongo-lunda in particular. Yields are rather low, around 190 to 350 Kg/ha. These levels of yields obtained are much lower than the potential yield of 550-2500 Kg/ha (I.R.A.D, 2013; Ngombo, 2017; INERA, 2018; Minagri, 2021) and those obtained in the provinces of North Kivu, South Kivu, Ituri, Central Congo, and Haut Katanga. This situation is due in particular to poor production practices and technical itineraries, combined with the early and/or late return of rains, non-compliance with the fallow period, staking difficulties, lack of rotation, soil infertility, weed pressure, the presence of diseases and pests, the degeneration of varieties, the lack of supervision of producers, the use of rudimentary tools, and ineffective means of control. Thus, the production of common beans in Kasongo-lunda, being essentially based on traditional cultivation practices, cannot compete with the large national producers.

To deal with the various constraints mentioned above, farmers must first acquire the necessary knowledge in order to control the interactions that would exist between agronomic constraints and cultural practices that affect yields, and then circumvent them (Matondo et *al.,* 2017; Mbikayi, 2018; Mutekulwa, 2022).

It is in this context that the main objective of this study is to make a sustainable contribution to the improvement of common bean production in the Kasongo-Lunda territory. Specifically, it aims to (i) Identify peasant knowledge in terms of constraints affecting production; (ii) Evaluate the cropping system practiced in terms of technical itineraries.

2. MATERIALS AND METHODS
2.1 Presentation of the study area:
The study was conducted in the Kasongo-Lunda Territory with an area of nearly 26,648 Km2, in the province of Kwango in the Democratic Republic of Congo. The geographical coordinates of the environment recorded using a GPS indicate 6°28 44.031'S and 16° 48'59 731'E. The territory

of Kasongo-lunda extends to the east the territory of Popokabaka, and forms the border with Angola along the Kwango River as far as the entrance of this river into the country where it rises. It is bordered to the east by the territories of Kahemba, Feshi, and Kenge. Its populations belong mainly to the Yaka ethnic group, which is joined by the Suku, Holo and Tchokwe in the east. Blanchart et Cie, (1945); Anonymous, (2005); FAO, (2018).

According to Köppen cited by UNECE/FAO (2008), this region has a climate that belongs to the Aw type. The average annual rainfall is more or less 1600 mm. It reaches 1700 mm in the central-eastern part of the region and 1500 mm in the southern part. The average annual daytime temperature is between 24 and 25°C. All seasons combined, the absolute maximum temperature is 38°C, the absolute minimum temperature is 12°C (Anonymous, 1999; Anonymous, 2005; CARG, 2010). The soils of Kasongo-lunda are largely dominated by the presence of sand, geologically from the Kalahari aeolian sands (Van Den Abeele and Vandenput (1956); Blanchart et Cie, 1945; Anonymous, 2021).
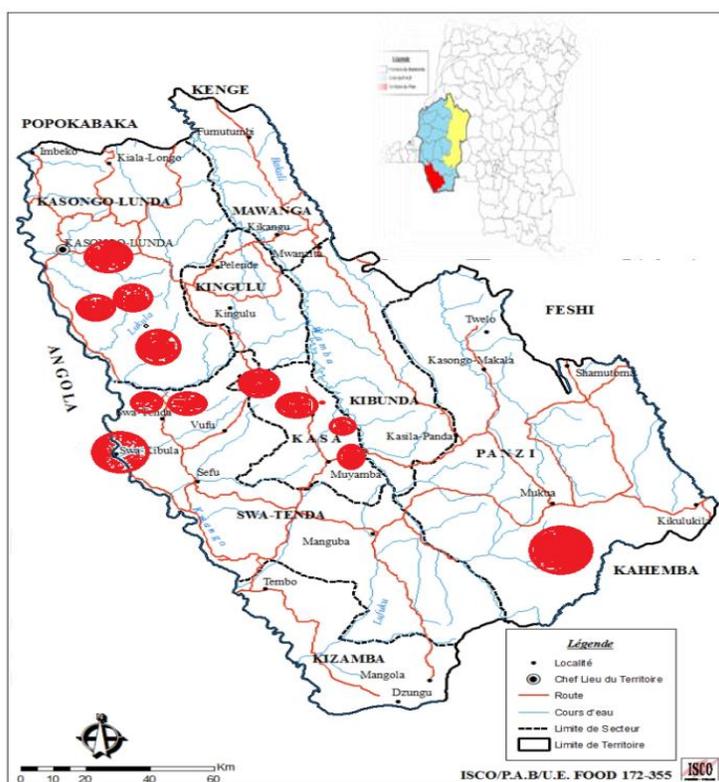

Figure 1: Geographical location of study villages in Kasongo-lunda territory

Data collection method: The study was conducted in the territory of Kasongo-lunda, using the Regional Agronomic Diagnosis (DAR) method. 12 villages including Kipanzu, N'kondo, Kingunda, Mazemba, Ngete, Mukunzi, Kingwangala, Fwangongo, Mwana-uta, Kinzamba, Swa-ibula, Kasongo-mvumbi were chosen with the participation of village chiefs, leaders according to their importance in agricultural activities. This choice also and above all took into account, thanks

to the information collected during the pre-survey, their importance in terms of the quantity of beans produced. Due to their history, these villages are pioneers in bean production. As a result, producer selection used snowball sampling. Based on their participation, a total of 331 farmers working in 12 production villages were surveyed during season B (February) and season C (May) 2021.

Table 1: Distribution of respondents by village - target

Villages	Staff	Men	%	Women	%
Kipanzu	48	22	14	26	15
Nkondo	31	14	9	17	9
Kingunda	38	17	11	21	12
Mazemba	17	8	5	9	5
Screw you	11	6	4	5	3
Kasongo-mvumbi	21	9	6	12	7
Kingwangala	53	24	16	29	16
Fwangongo	26	11	7	15	8
Mwana-uta	36	16	11	20	11
Kinzamba	15	7	5	8	4
Swa-ibula	26	12	8	14	8
Dear	09	6	4	3	2
Total	**331**	**152**	**100**	**179**	**100**

The identification criteria were set by the farmers during the exchange meeting. Producers were asked to individually list the obstacles deemed responsible for the drop in yield in their fields. For each village, this exercise took into account gender representativeness. Each group was asked to rate each constraint according to the established scale of very important (5), important (4), less important (3), unimportant (2) and not at all important (1). All the scoring averages for each presumed constraint had been calculated and presented to the farmers. The constraints presumed and listed by the peasants (Sebilotte, 1974; Landais, 1990; and Tollens ,2004).

2.3 Statistical Analysis of Data

The data collected were encoded in a database designed on Microsoft Excel and subjected to statistical tests with the SPSS (Statistical Package for Social Science version 26.0) software. Descriptive analysis (frequencies, means, minimum, maximum, standard deviations), T-test (Test Student), Tukey test and F test were used respectively to compare the means, the Tukey test was used at the 5% significance level. The F test specified the significance of the factors and the results were presented in the form of tables, figures and graphs. Multiple linear regressions were used to identify yield constraints for common beans in Kasongo-lunda. Since bean yield involves several variables, the Multiple Component analysis was used respectively to characterize the different agronomic constraints in order to highlight trends within the groups that favor the yield decline.

3. RESULTS AND DISCUSSION
3.1. Constraints on bean production
The agronomic constraints identified with producers are presented in Figure 2.
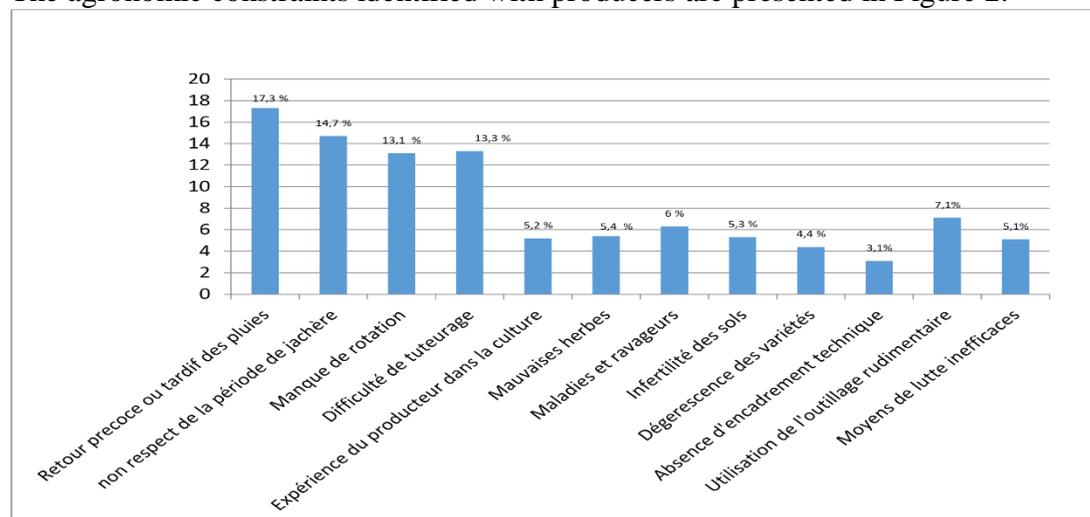

Figure 2: Farmers' perception of the constraints related to bean production

The results obtained showed the existence of twelve agronomic constraints, four of which account for 58%. These are the early and/or late return of rains, the non-respect of the fallow period, the difficulties of staking, the absence of rotation. The producer's experience in cultivation 5%, weeds 5%, diseases and pests 6%, soil infertility 5%, degeneration of varieties 4%, lack of supervision of producers 3%, use of rudimentary tools 7%, ineffective means of control 5%.

3.2 Evaluation of cropping systems adopted by farmers
3.2.1 Choice of land
The results related to the choice of land are presented in Table 2.

Table 2: Field Location, Soil Structure and Crop Rotation Operation

| Variables	Modality	Staff	%
Field Location			
	Plateau	96	29
	Lowlands marshes	16	4,8
	Lowlands	219	66,2
Soil structure			
	Clayey	28	8,31
	Clayey sand	83	24,96
	Clayey loam	220	67
The rotations practiced			
	Yes	56	16
	No	275	84

The analysis of this Table 5 indicates that 66% of bean production is carried out in the lowlands, 29% in the plateau and 4.8% is in the lowlands marshes. The results presented in Table 5 show that the type of clay loam soil is the most exploited by producers (67%), followed by sandy clay

soil (24%) and finally clay soil (8.31%) for bean production. According to Table 5, the results show that 84% do not rotate crops, but 16% return with the crop consecutively to the same plot.

3.2.2   Crop calendar of common bean in Kasongo-Lunda territory

SEASON A				SEASON B				SEASON C			
Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	June	Jul	August
███				███				███			
	███				███				███		
		███ ███				███ ███			███ ███		
		███ ███					███			███	
			███			███				███	
							███				███

Legend:Sept = September Oct = October Nov = November Dec = December Jan = January Feb = February Apr = April Jul = June Jul = July Aug = August

███ Reclamation   ███ Ploughing   ███ Seedling   ███ Weeding   ███ Staking   ███ Harvest
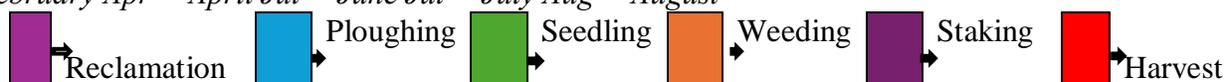
The results in Table 6 showed that the agricultural calendar in Kasongo-lunda has three seasons. Season A (September-December) is conditioned by the return of rains. Season B (January-May). In season C (May-August).

3.2.3. Cultivation method
The results in relation to cultivation and fallow are presented in Table 3.

Table 3: Cultivation method practiced

Variables	Modality	Staff	%
Cultivation method			
	Monoculture	279	84,37
	Polyculture	52	15,63
Duration of fallow period			
	0-1 years	271	82
	2-3 years	40	12
	4-5 years	17	5
	5 years later	3	1

 The results in Table 3 above show that 84% of producers practice monoculture, while 15% practice mixed cropping. Regarding the fallow period, the results in Table 6 indicate that 82% of producers report that their fallow period lasts one year, while 12% say they can leave their fields idle for two to three years, 5% keep it for four to five years and 1% keep their land for more than five years.

3.3. Evaluation of farmers' farming techniques
3.3.1 Field Opening Modes
The results of land preparation operations**, including** land clearing, felling, incineration and ploughing**,** are presented in Table 4 below.

Table 4: Clearing, incineration, felling, skidding practice

Variables	Modality	Staff	%
Field Opening Modes			
	Land clearing, incineration and ploughing	27	8,07
	Land clearing, felling, incineration and skidding	61	18,44
	Land clearing, incineration	243	73,49
Preparing the ground			
Labour			
	Yes	39	11,64
	No	292	88,36

Table 4 shows that 73% of producers clear and incinerate land to prepare their land; 18% of producers clear, fell, incinerate and clear, and 8% of producers clear, incinerate and plough. Table 4 shows that 88% of producers do not practice this operation. On the other hand, 11% of producers plough.

3.3.2. Sowing
3.3.2.1. Criteria for the selection of varieties, sowing date, sowing density and cultivated varieties
The results for variety selection criteria, sowing date, sowing density and crop varieties are shown in Table 5 below.

Table 5: Variety selection criteria, sowing date, seeding rate and cultivated varieties

Variables	Modality	Staff	%
Criteria for choosing varieties			
	Organoleptic and culinary values	89	26,88
	Seed size and colour	75	22,65
	Disease resistance	44	13,44
	Productivity	81	4,44
	Precocity	42	12,59
Sowing date			
	Before May 10	236	71,4
	From 16 to 30-Sep	24	7,1
	Before January 20	71	21,5
Sowing Density			
	1 to 2 seeds	19	5,7
	3 to 4 seeds	290	87,7
	5 to 6 seeds	22	6,6
Cultivated varieties			
	Soldiers	111	33,53
	Pages	70	21,15

	Voluble Lola	64	19,34
	Dwarf Lola	40	12,08
	Overalls	27	8,16
	PV0.14	19	5,74

Regarding the criteria for the choice of varieties by producers, organoleptic and culinary values take precedence over all criteria with 26%, followed by productivity as the second choice with 24%; This is followed by seed size and colour at 22%, and disease resistance at 13%. Table 8 shows that the sowing dates are very staggered, 71% of producers sow before May 10th, and that 7% of producers do so from September 16th to 30th, while 21% of producers sow before January 20th. In terms of seeding rate, 87% of growers adopt 3 to 4 seeds per pocket; 6% sow 5-6 seeds and 5% of growers use 1-2 seeds. Looking at the results shown in Table 8, it can be seen that in Kasongo-lunda, the local varieties KANIEKI and NKASA are the most cultivated, with 33% and 21% respectively; on the other hand, the LOLA variety is sown by 19% of producers; and the dwarf Lola variety 12%, TUTA used by 8% of producers, and finally the PV.14 variety used by 5% of producers.

3.3.2.2. Seed source

The results related to the seed source are shown in Figure 6 below.

Les résultats en rapport avec la source des semences sont montrés dans la figure 6 ci-dessous.
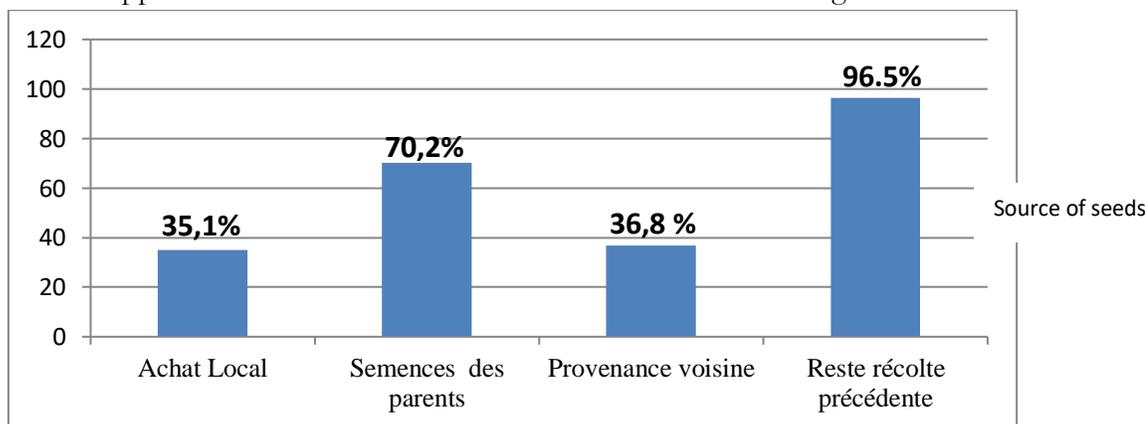

Figure 3: Source of Seed Supply

As far as the supply of seeds is concerned, Figure 6 shows that 96% come from the previous season (self-production), 70% of seeds come from parents, 36.8% come from neighbours and 35% buy locally from anyone whose quality is not controlled and most of them are already experiencing degeneration.

3.3.3 Crop Maintenance

The results of the weeding, staking, fertilisation and phytosanitary treatment operations carried out by the producers are presented in Table 6 below.

Table 6 presents the number of weedings, staking of twining beans, assessment of soil fertility practiced by farmers in Kasongo-lunda.

Variables	Modality	Staff	%
The number of weeding operations carried out			
	1 - 2 weedings	106	32
	3-4 weedings	13	4
	None	212	64
Staking of the twining bean			
	Easy Operation	43	13
	Difficult operation	288	87
Soil fertility assessment			
	High fertility	30	9
	Average fertility	126	38
	Low fertility	175	53

Table 6 shows that the number of weedings in Kasongo-lunda varies from 1 to 3 weedings. 32% of producers do 1 to 2 weedings, i.e. 4% do 3 weedings and 64% do not weed after sowing. Regarding the assessment of the staking operation, 87% of producers think that this operation is difficult, 13% say that it is rather easy. Based on the results presented in Table 6 on soil fertility assessment, 53% of producers in Kasongo-Lunda report that soil fertility is low, 38% of producers believe that their soils have average fertility, and 9% of producers believe that they work in soils with high fertility.

3.3.4. Signs of Disease

The results for the signs, diseases and pests of the common bean crop encountered are shown in Table 7.

Table 7: Symptoms of Diseases

Variables	Modality	Staff	%
Symptoms of diseases			
	Yes	236	71,43
	Not	95	28,57
Vegetative stages attacked			
	Germination	109	33,02
	Bolting	46	13,02
	Flowering	20	6,12
	Fruiting	156	47,14
Control methods used			
	Uprooting infected plants	67	20,3
	Selecting healthy seeds	68	20,8
	Traditional fumigation	75	8,7
	None	175	53

Based on the results shown in Table 7, 71% of producers report that their bean fields show unusual signs of pest attacks, indicating a significant problem with diseases and pests in the region. These attacks occur at the time of germination 33% during bolting 13% and. The flowering stages are less affected with 6% and the most affected stage are fruiting with 47%. It can be seen in Table 7 that several methods are used to control pests, such as uprooting infected plants and trapping 20.3%, selecting healthy seeds 20.8%, and traditional fumigation 8.7%. However, a significant proportion 27% do not use any means of control, indicating the lack of effective management of diseases and pests.

3.3.5. Performance
Performance results are reported in Table 8 below.

Table 8: Performance Group

Yield (kg).ha-1	Staff	Villages	Percentage
150 to 200	111	Love, Love, and God	33,5
201 to 250	102	Mukondo, Mazemba, Ngete	30,8
251 to 300	66	Swa-Ibula, Kipanzu	19,9
301 to 350	29	Kingunda, Kasongo-Mvuùbi	8,7
351 to 400	23	Kingwangala, Mwana-uta	6,9

Looking at Table 8, for producers in the Kasongo-Lunda territory, 33% obtained a yield of around 150 to 200 kg/ha, 30% from 201 to 250 kg/ha, 19% from 251 to 300 kg/ha, 8% from 301 to 350 kg/ha and 6% obtained 351 to 400 kg/ha, i.e. an average of 251 to 300 kg/ha.

3.4. Analysis of the socio-demographic characteristics of producers
The results of the analysis of the characteristics of Gender, Age Range, Educational Attainment, Marital Status, Household Size, Land Status, Producer's Side Job, Producer Association Membership, and Performance are presented in Table 12 below.

3.5. Analysis of the parameters relating to the production villages
The analysis between yield and parameters for production villages is presented in Table 9.

Table 9: Performance by village parameters.

Variables	Yield (kg/^{2}	Std. Error	T -value	P-value
Villages				
Screw you	,0223±0,027	-	-	Ref.
Mwana-uta	0,0278 ±0,063	0,0198962	2,775 **	0,005625
Kingunda	0,0270±0,080	0,0075883	6,090 ***	1.65E-09
Mazemba	0,0223±0,054	0,0058652	-0,060	0,952280
Kasongo- mvumbi	0,0248±0,400	1,861	0,063116	0,008350
Dear	0,0191±0,019	0,0093127	-3,470 ***	0,000544
Kingwangala	0,0273 ±0,060	0,0055245	9,075 ***	< 2e-16
Fwangongo	0,0195±0,007	0,0154833	-1,808	0,070912
Kondo	0,0222±0,295	0,0075232	-0,176	0,860183
Kinzamba	0,0197±0,01	0,017	-1,61	0,072
Swa-ibula	0,0232±0,02	0,0052	-0,181	0,76
Kipanzu	0,0224±0,023	0,004	-0,031	0,852

Legend:*=difference significance, **=very significant difference, ***= highly significant difference at the 0.05 thresholds; 0.01 and 0.01 and 0.001.

The results in Table 9 show that yields vary from village to village. In Mwana-uta the yield is higher than that recorded in Ngete (p=0.005625). Similarly, the yield in Kingwangala and Kingunda is significantly higher than that in Ngete (p=1.65e-09). However, the yield obtained in Mukunzi is much lower.

3.6. Cropping System Analysis
3.6.1 Bean yield analysis related to field location and cropping method.

This part concerns the yield analysis related to the location of the field and the cultivation method for the production of common beans in Kasongo-lunda.

The analysis in relation to the location of the field for the production of common beans is presented in Table 9.

Table 9: Yield as a function of field location, cropping and tilling operation.

Variable	Yield (kg/m^2)	Std. Error	T value		P-value
Field Location					
Lowland	0,0271±0,062	-	-		Réf.
Lowland marsh	0,0237±0,057	0,00404	-8,433	***	0,00
Plateau	0,0225±0,034	0,00720	-6,391	***	0,00
Cultivation method					
Monoculture	0,0252±0,061	-	-		Réf.
Polyculture	0,0245±0,058	0,0041	1,897		0,0581
Field Opening Modes					
Land clearing, incineration	0,0240±0,028	-	-		Réf
Cleared, felled, incinerated and skidded	0,0150±0,000	0,0347	-2,632	**	0,009
Land clearing, incineration and ploughing	0,0325±0,015	0,0342	2,475	**	0,013
Labour					
Yes	0,0373±0,028		-		-
Réf					
No	0,0248±0,060	0,0596	2,101	***	0,036

Legend:*=difference significance, **=very significant difference, ***= highly significant difference at the 0.05 thresholds; 0.01 and 0.01 and 0.001.

From this Table 9, lowland fields have a very high yield than those in lowland marshes and plateaus during the dry season**.** From the point of view of cultivation methods, the results show that producers who practice monoculture record a higher yield, on the other hand, producers who practice polyculture obtain a very low yield. As far as land preparation is concerned, those who do land clearing + incineration + ploughing to prepare their land obtain a statistically high yield than those who practice + land clearing + felling + incinerate + clearing. Concerning the ploughing operation, it is observed that producers who practice this operation record a higher yield on the other hand producers who do not.

3.6.2. Seeding parameters

The results of the analyses of parameters related to the sowing period, the number of seeds per pocket in relation to the yield are shown in Table 10.

Table 10: parameters related to the sowing period, the number of seeds per pocket, supply, criteria for choosing varieties and Varieties grown.

Variable/Modality	Yield (kg/m2)	Std. Error	T- value	P-value
Sowing period				
Before May 10	0,0247±0,058	-	-	Réf.
Mid-September	0,0347± 0,01	0,059543	1,687**	0,022
Mid-January	0,0255 ±0,066	0.004988	1,670	0,095
Seed per pocket				
1 to 2 seeds	0,0243±0.051	-	-	Réf.
3 to 4 seeds	0,0249±0,060	0,0084	0,598	0,550
5 to 6 seeds	0,0255±0,053	0,0047	1,967 *	0,039
Supply				
Local market	0,0244± 0,056	-	-	Réf
Previous harvest	0,0249± 0,063	0,0038	0,673	0,503
Neighbor Origin	0,0246±0,054	0,0038	0,658	0,498
Criteria for choosing varieties				
Organoleptic values	0,0191±0,021	**-**	**-**	Réf
Disease resistance	0,0244±0.053	0,0598	-0,961	0,337
Size, color seeds	0,0246±0.078	0,0087	-0,305	0,778
Productivity	0,0247±0,058	0,0043	-0,304	0,761
Earliness	0,0249±0,063	0,0083	-0,545	0,58
Cultivated varieties				
Kanieki	0,0191±0,021	-	-	Réf
Nkaasa	0,0226± 0.058	0,0562	0,961	0,690
TUTA	0,0239± 0,031	0,0073	1,855**	0,031
PV0/14	0,0232±0,058	0,0083	1,687*	0,079
Lola voluble	0,0224±0,0581	0,0057	1,666	0,633
Dwarf Lola	0,0222±0,0617	0,0043	1,394	0,628

Legend:=difference significance, **=very significant difference, ***= highly significant difference at the 0.05 thresholds; 0.01 and 0.01 and 0.001.*

Table 10 indicates that producers who sow mid-September have a significantly higher yield than those who sow in mid-January (p=0.022), while mid-January is not significantly different from Before May 10 (p=0.0952).

With regard to the number of seeds per pocket, it has been observed in Table 10 that producers who adopt 3 to 4 seeds per pocket at sowing obtain a higher yield than those who adopt to sow 1-2 seeds. In the same vein, a very low yield has been recorded among producers who adopt to sow 5 to 6 seeds.

It can be seen from Table 10 that producers who choose organoleptic and culinary values do not produce better than producers who choose productivity as criteria.

For the varieties grown in the study area, the results in Table 10 indicate that growers growing TUTA and PV.14/5 harvest better than growers growing the Dwarf Lola variety. A very low yield was recorded among the producers who grow the NKASA variety, which is nevertheless higher than that of Kanieki.

3.6.3. Crop maintenance

The results related to bean diseases and pests are presented in Table 11.

Table 11: Number of weeding, staking operation.

Variables	Yield (Kg/m2)	Std. Error	T -value	P-value
Number of weeding practices				
1 - 2 weedings	0.0232±0.017	-	-	Ref
3-4 weedings	0.0264±0.073	0,06247	1,334*	0,1841
None	0,0206±0,069	0,01881	-2,283***	0,0237
Staking				
Yes	0.0212±0.042	-	-	Ref
Not	0,0279±0,060	0,01325	4,077***	0,000

From Table 11, the results show that producers who weed three to four times have a higher yield than those who do one to two weeds. However, producers who do not weed have lower yields.

3.6.3.1. Diseases and pests of common bean.

The results related to bean diseases and pests are presented in Table 12.

Table 12: Disease Symptoms, Vegetative Stages Attacked, Control Means, Diseases, and Pests of Common Bean

Variables	Yield (Kg/m2)	Std. Error	T -value	P-value
Symptoms of diseases				
Yes 0.0232±0.042		-	-	Ref
Not	0,0286±0,060	0,01326	4,076***	0,000
Means of control				
Uprooting infected plants	0,0372±0,07	-	-	Ref
Selecting healthy seeds	0,0290±0,073	0,06237	-1,333**	0,1729
Traditional fumigation	0,0247±0,018	0,06237	1,324***	0,1859
None	0,0204±0,059	0,01891	-2,280**	0,0228
Vegetative stages attacked				
Germination	0,0247±0,592	-	-	Ref
Bolting	0,0245±0,060	0,42173	-0,078	0,9382
Flowering	0,0248±0,057	0,04322	0,346	0,9923
Fruiting	0.0174±0.074	0,04575	-1,613*	0,02

Legend:=difference significance, **=very significant difference, ***= highly significant difference at the 0.05 thresholds; 0.01 and 0.01 and 0.001.*

The results in the table above show that attacks during fruiting seem to have a significant impact on yield reduction compared to attacks during germination (p=0.02). Attacks during bolting and flowering do not appear to have a significant impact on yield.

Compared to control methods, the results indicate that uprooting allows a higher yield to be obtained compared to fumigation and other means of control.

3.7. Analysis of the interrelationships between agronomic constraints, cultivation practices and yield.

Data analysis of the interrelationships between agronomic constraints, cropping practices and yield was conducted using multiple component analysis (MCA).

This analysis summarizes information on the different associations that exist between a relatively large number of variables. The multiple component analysis (MCA) focused on 5 qualitative variables, i.e. 32 modalities.

3.7.1. Influence of varieties, cropping system, soil type on yield

The results in relation to the links between varieties, cropping system, soil type and yield are shown in Figure 4 below.
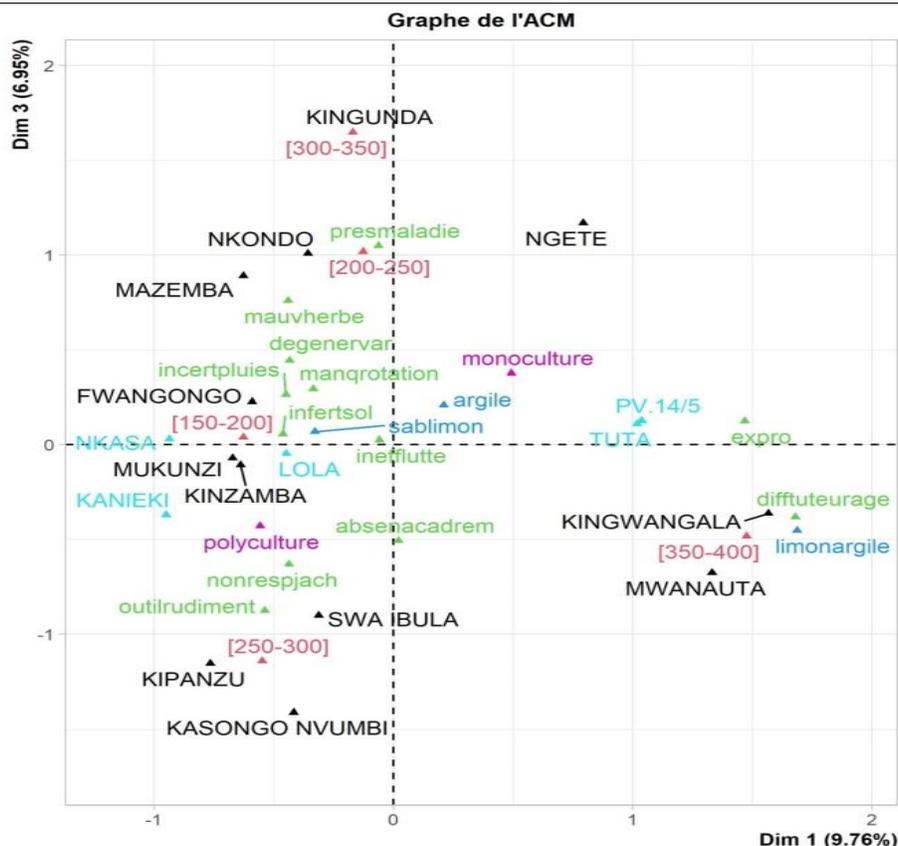
Figure 4: Correlation between varieties, cropping system, soil type on yield

Figure 4 shows that the high yield of 350 to 400 kg/h was only obtained in the villages of Kingwangala and Mwana Uta with the varieties PV.14/5 and TUTA, sown in a clayey loam soil under the constraint of difficulty of staking, monoculture as a cropping system. While in the villages of Mukunzi, Kinzamba and Fwangongo, yields are less than 150 kg to 200 kg/ha, the constraints are the non-respect of the fallow period, the use of rudimentary tools, the lack of supervision, soil infertility, the uncertainty of rainfall in sandy loamy soil and the use of the Lola, Kanieki and Nkasa varieties, the villages practice mixed farming.

3.7.2 Correlation between sowing dates, number of seeds per pocket on yield.
The results concerning the correlations of sowing dates, number of seeds per pocket on yield are presented in Figure 5 below. Figure 5 shows the correlation of varieties with respect to sowing dates (periods), number of seeds per pocket on yield.
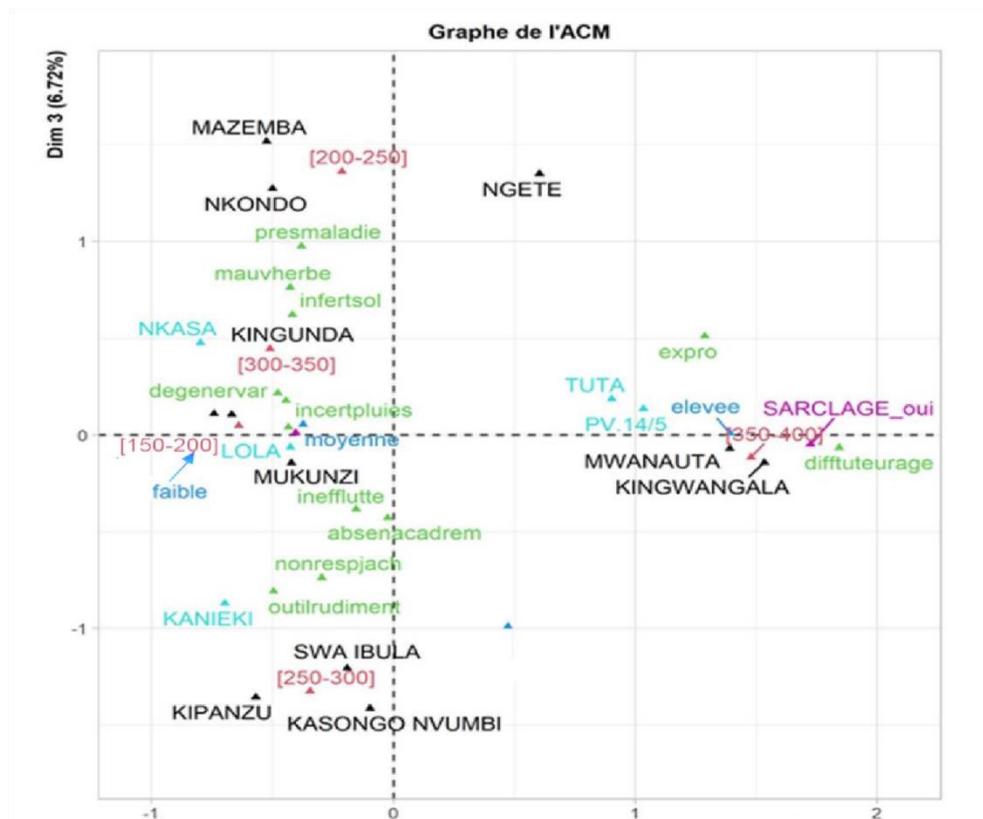
Figure 5: Correlation between sowing dates, number of seeds per pocket on yield.

According to the figure, farmers in the villages of Mukunzi and Kinzamba sow before 10 May, 5 to 6 seeds per pocket obtain a lower yield level of 150 to 200 kg/ha, In the villages of KINGWANGALA and Mwana-uta, 3 to 4 seeds per pocket are sown in mid-September, with a yield level of 350 to 400 kg/ha in season A.

3.7.3 Correlation between weeding, staking and soil fertility level on yield

The results concerning the correlations of weeding, staking and soil fertility level on yield are presented in Figure 6 below.

Figure 6: Correlation between weeding, staking and soil fertility level on yield

In view of the results in Figure 6, the multi-component analysis reveals that the villages of Mukunzi and Kinzamba have soils of low fertility and bean fields are not weeded. This leads to a yield level ranging from 150 to 200 kg/ha. The villages of KINGWANGALA and Mwana-uta have high fertility soils and weeding is practiced, which means that the yield is 350 to 400 kg/ha.

3.7.4. Correlation between diseases, stage of attacks, means of control on yield.
The results concerning the correlations of the variables presence of diseases and pests, the stages of attack and the means of control on yield.
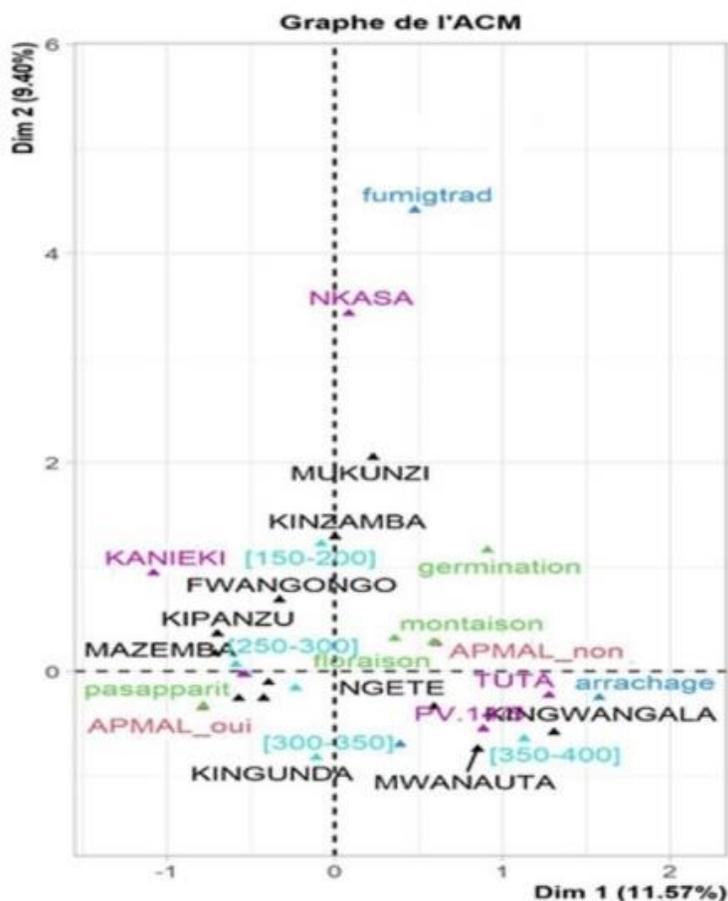
Figure 7: *Correlations of the variables presence of pests, stages of attack and means of control on yield.*

In Figure 7, uprooting plants is the most commonly used means of control in Mwana-uta, Kingwangala and Ngete. In the villages of Mukunzi, Kinzamba and Fwangongo, seed fumigation is used as a means of control. In Mazemba, Kingunda, Kipanzu, Nkondo, Swa-ibula and Kasongo-mvumbi are more involved in the selection of healthy seeds.
According to the results presented, uprooting infected plants is the best means of control, seed selection and traditional fumigation.

8. DISCUSSION OF THE RESULTS

This study identified twelve agronomic constraints on bean cultivation in the Kasongo-lunda territory by producers. The early or/late return of rains is the first constraint to production. This could be justified by the fact that the early or/late return of rains leads to the shortening of the dry

season, the decrease in the amount of rainfall and the poor distribution of rainfall during the rainy season, making the agricultural calendar complex. Contrary to the work of Missihoun et *al.,* (2017); Rujamizi et *al.,* (2017); (Kanyenga, 2000; Lukombo, 2013) who report that lack of stakes and diseases are the first constraint related to bean production.

Regarding the lack of tutors, our results are consistent with those of Missihoun et *al.,* (2017); Sebillotte , (1978) ; Wortman et *al.,* (1998) who pointed out that the leaves of early varieties die much earlier if they are not protected by a stake, resulting in lower yields. Without a stake, the yield of twining beans can decrease by up to 50% depending on the variety.

Factors such as gender, age, level of education, length of time in bean production, household size, membership in an organization, method of land acquisition, soil appreciation, type of variety, seed source, duration of fallow, weed pressure, number of weedings and adherence to the rotation have a negative influence on yield.

In terms of gender, the results show that there are more women (54.1%) who practice bean farming. Wortman *et al*., (1998); (Kinkela and Bahandi, 2019; Lufuluabo *et al*., (2021); Mudibu (2013) report the same trends. Women are the primary leaders in decisions and work in small-scale common bean production in most sub-Saharan countries. Lufuluabo et *al.,* (2021) emphasize that age, experience, level of education, and environmental conditions play an important role in agricultural production.

Regarding non-compliance with the fallow period, the lack of rotation and soil infertility, our results shown by producers do not respect the recommended duration. For Banga banga, (2018) and Mukendi et *al.,* (2019) in tropical Africa, the traditional land-use system consists of land abandonment for 5 to 7 years to restore soils.

As for the producer's experience, our results are similar to those of Baert, (1988); BAD, (2012) and Casinga et *al., (*2016) who demonstrated that through the experience of producers, early identification of signs of diseases and pests and appropriate control methods are applied correctly. These producers master cultural practices and optimize the growth and yield of bean plants.

Weeds reduce the growth and development of cultivated plants through competition. Our results are consistent with those of PABRA, (2007) and Mutekulwa (2022) who believe that invasion by *Imperata cylindrica and Brachiaria repens* depletes the soil moisture reserve and increases the possibility of severe drought in maize.

Nyabyenda, 2005; Tollens, 2004; Casinga et *al.,* (2007); INERA (2018) showed that diseases and pests are one of the main limiting factors of crop production worldwide. Some rodents (diurnal or nocturnal) attack crops at all stages of development, including planting, emergence and the stage, causing significant damage and losses to bean production. The extent of their damage to crops and therefore to bean yield is linked to the proximity of farms to the forest and the proliferation of animal species (Minagri, 2021; ITRA, 2021; ISABU, 2023).

According to local perception, the degeneration of varieties can be explained by the way seeds are acquired and stored. In fact, more than 70% of producers use seeds inherited from their parents or neighbours. This practice of transmitting seeds from parents to descendants observed among the respondents is in addition to the non-introduction of varieties adapted to the region.

In Kasongo-lunda, very little scientific information exists on bean accessions due to the lack of

technical supervision. To this is added the use of rudimentary tools. These results are in line with those of CARG, (2008) and Lufuluabo et *al.,* (2021) who indicate that the producer's experience and the lack of supervision have an impact on agricultural yield. This could indicate that experience or maturity can play a role in increasing productivity. Landais, 1990; CARG, 2010; Mbikayi, 2018; Mirindi (2024) believe that rudimentary tools cannot allow for weeding and crop management as effective as modern equipment.

9. CONCLUSION

Our study contributes to the increase in the productivity of the common bean crop. Specifically, it identified agronomic constraints and evaluated the cultural practices adopted by common bean producers in Kasongo-Lunda.

Indeed, the study conducted in the territory of Kasongo-lunda used the Regional Agronomic Diagnosis (DAR) method, which uses the approach determined by the respondent (Snowball Sampling). 12 villages were chosen with the participation of village chiefs, and leaders of agricultural activities. Overall, 331 village-based producers participated in the interview.

The results revealed the following; Among the 12 agronomic constraints responsible for the decline in yields identified by common bean producers, the early and/or late return of rains, non-compliance with the fallow period, staking difficulties, and the absence of rotation proved to be the most decisive.

Regarding the evaluation of the cultivation operations adopted by producers, 66.2% of the beans produced come from the lowlands. Clay loam soil is the most exploited by producers 67%), 84% of producers do not practice crop rotation. Land clearing + incineration. (48.15%) are the most used means for opening up the land, the most cultivated variety is Kanieki (33.33%), a variety owned by farmers. 43.02% of producers believe that soil fertility is generally average. Monoculture is more common than polyculture. 71.4% of producers sow before May 10. 71.43% of the fields were attacked by pests, which attack the crops more during the bolting period.

The yield level of bean cultivation in Kasongo-lunda remains low and varies from 350 to 400 kg/ha and obtained in the villages of Kingwangala and Mwana uta with the genetically improved PV.14/5 and TUTA varieties, on clayey loam soils but with difficulty of staking, monoculture as a cropping system. The villages of Mukunzi, Kinzamba and Fwangongo obtained lower yields (150 kg to 200 kg/ha) under the conditions of non-compliance with the fallow period, the use of rudimentary tools, lack of supervision, soil infertility, uncertainty of rainfall in sandy loamy soil and the use of unimproved varieties in a mixed farming system. The identification of agronomic constraints carried out by combining data from cropping systems and the itineraries adopted by producers made it possible to characterize the twelve villages into five groups.

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