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Selection of F_1 Sweetpotato Hybrids for Fresh Root Yield in Butembo Area, Eastern Democratic Republic of the Congo

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Abstract – **Sweet potato (*Ipomoea batatas* L. Lam) is the second most important root and tuber crop in the Democratic Republic of the Congo (DRC) after cassava. However, its root yields in the country are among the lowest in the world due to several production limiting factors among which the lack of improved varieties with high yield potential and resistance to biotic and abiotic factors. Cultivar development through plant breeding is the most cost-effective to overcome this problem as no additional investment is required from farmers. This study aimed at selecting promising sweet potato hybrids for root yield potential among sixty F_1 hybrids from a polycross mating involving the variety Elengi as the female parent. Field experiment was conducted in Butembo area, eastern DRC, at the Catholic University of Graben Field Station using a randomized complete block design with three replications. Data were collected on total number of roots per plant, number and weight of marketable roots per plant, fresh root yield, fresh biomass weight per ha and harvest index. These data were thereafter subjected to the analysis of variance using GenStat 15th edition software package. Results showed significant differences among genotypes for all observed traits ($P<0.05$). The genotype Elengi, one of the check varieties, provided the highest root yield (23.50 t ha^{-1}). Best yielding F_1 hybrids were SPH23 (21.87 t ha^{-1}) and SPH48 (21.02 t ha^{-1}). Among yield related parameters, the weight of marketable roots per ha was the most strongly correlated with fresh root yield ($r = 0.96$*) and could be, therefore, adopted by breeders as an indirect selection criterion for fresh root yield in sweet potato breeding programmes. Best ten percent among F_1 sweet potato hybrids including SPH23, SPH48, SPH27, SPH12, SPH44 and SPH52 were selected and recommended for further testing in a multi-site evaluation for stability analysis across major agro-ecological conditions of eastern DRC.**

Keywords – **Agronomic Performance, Ipomoea Batatas, North-Kivu and Polycross Mating.**

I. Introduction

Sweet potato (*Ipomoea batatas* L. Lam) belongs to the Convolvulaceae or morning glory family. It is the only economically important species from the *Ipomoea* genus (Woolfe, 1992; Mandal, 2006). Its role as a cash crop is significantly increasing worldwide due to its high root yield potential and ability to grow under a wider range of environments (Chiona, 2009; Wang et al., 2011; Gurmu, 2015). Among the major starchy staple crops, sweet potato has the highest rate of calorie production per unit area and time (Woolfe, 1992; Thattappilly and Loebestein, 2009; Rukundo et al., 2015). Orange-fleshed sweet potato varieties are rich, low priced and sustainable source of vitamin A in the form of beta-carotene (Low et al., 2009). Vitamin A is known to play an important role in metabolic functions, eyesight, regular growth and development, and immune system (Stathers et al., 2013; Low et al., 2017; Gurmu et al., 2017; Mbusa et al., 2018a). These are recommended to pregnant and lactating mothers as well as adults for a good health, and early embryonic development of all mammals.

Sweet potato has become, after cassava, an important root and tuber crop in Democratic Republic of the Congo (DRC), where 411,257 tonnes were harvested from 82,108 ha in 2017 (FAO, 2019). This crop plays a major role in food and income security in DRC where it is widely exploited on small plots by most smallholder farmers. Over 40% of that DRC production is from North- and South-Kivu provinces in the eastern part of the country. Tuberous roots and sweet potato leaves, called ''Matembele'' in the region, are highly valued by populations of the Kivu region (Phemba, 2008). Its importance increased over the last two decades mainly due to the occurrence of cassava mosaic disease and Maize Lethal Necrosis Disease, which severely devastated these two staple crops (Mbusa, 2017).

Despite its high potential for food and income security, African fresh root yield, which is approximately 7 t ha^{-1} (Stathers et al., 2013; Stathers et al., 2015), remains very low compared to the world mean yield (12.01 t ha^{-1}) and to crop potential yields recorded in developed countries like United States of America (25.08 t ha^{-1}) and Chine (21.35 t ha^{-1}) (FAO, 2019). A similar scenario is observed in DRC; where the fresh root yield varies between 4 and 7 t ha^{-1} with an overall mean of approximately 5 t ha^{-1} (Phemba, 2008; FAO, 2019). This may be due to lack of improved plant materials with high yield potential and resistance to biotic and abiotic factors, poor cultural management, and non-consistent sweet potato breeding program in the region. These issues should, therefore, be addressed to increase the fresh root yield in eastern DRC. This study is a part of a breeding programme laid by the Agricultural and Veterinary Research Center of Graben (CERAVEG) of the Catholic University of Graben (UCG, Butembo) focusing on the development of high yielding sweet potato varieties adapted to Nord-Kivu agro-ecological conditions, in eastern DRC. The specific objective of this study was to select elite F_1 sweet potato hybrids for fresh root yield and other agronomic traits in Butembo area conditions.

II. Material and Methods

A. *Experimental Site*

The field experiment was conducted at the Agricultural and Veterinary Research Center of Graben (CERAVEG) Field Station of the Catholic University of Graben. CERAVEG Field Station is located in Butembo City (between coordinates 0°05' and 0°10'N and 29°17' and 29°18'E, at an elevation 1700 m above the sea level). Butembo has a humid subtropical climate influenced by mountains. The station receives a binomial rainfall with the short rain season occurring from March to May and long rain season from August to November (Vyakuno, 2006). The average annual rainfall varies between 1200 and 1500 mm while the average annual temperature is 18°C (Vikanza, 2011). The soil is well drained, darkish to dark red in color and clay ferralitic soil type. Table 1 presents data on weather conditions during the experimental period.

Table 1. Weather conditions of Butembo during the experimental period.

Years	2017	2018			
Months	December	January	February	March	April
Maximum Temperature (°C)	24.07	23.80	25.57	24.16	23.64
Minimum Temperature (°C)	14.23	13.90	14.22	14.58	14.90
Mean Temperature (°C)	19.15	18.85	19.90	19.37	19.27
Relative Humidity (%)	87.16	89.45	87.57	87.09	88.94
Rainfall (mm)	41.00	111.60	278.50	516.90	547.00

Years	2017	2018			
Months	December	January	February	March	April
Days of rain	5	6	12	19	18

Source: ITAV Meteorological Station (2018).

B. *Plant Materials*

Sixty-four sweet potato genotypes among which 60 F_1 sweet potato hybrids (SPH) and four check varieties were used in this field experiment. F_1 sweet potato hybrids were from a bulked seed from an open-pollinated polycross nursery of 30 parents grown at CERAVEG Field Station of the UCG in Butembo in 2016 involving the sweet potato variety Elengi as a female parent. The four checks included Elengi (a bred clone released by the National Institute for Agronomic Research and Studies, INERA Mulungu in 1994), Nairobi (an introduced clone by local traders in 1995), and Anonym and CEMDL (landraces).

C. *Experimental Design*

The field trial was conducted at the CERAVEG Field Station during the period of December 2017 to April 2018. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each replication was made of 64 plots corresponding to 64 test genotypes used as treatments. Genotypes were planted on a ridge of 1 m of diameter with three plants per ridge ranged in a triangular mode at spacing of 0.3 m within the ridge and 1 m between ridges. The ridge corresponding to a plot size had 0.785 m^2 as surface. The genotypes were irrigated and weeded by hand when necessary. Table 2 presents major characteristics of parental lines involved in F1 sweet potato hybrids development.

Table 2. Characteristics of parental sweet potato lines used in the polycross mating design to develop F_1 sweet potato hybrids evaluated in this study.

Names	Origin	Maturity (Days)	Yield (t ha^{-1})	Flesh color	References
Naspot1	NaCRRI/Uganda	120	29.0	Cream	Mwanga et al., 2003
Naspot8	NaCRRI/Uganda	115	20.0	Orange	Kapinga et al., 2010
Naspot10	NaCRRI/Uganda	115	16.0	Orange	Kapinga et al., 2010
Naspot11	NaCRRI/Uganda	115	26.5	Orange	Mwanga et al., 2011
Naspot12	NaCRRI/Uganda	115	24.0	Orange	Kapinga et al., 2010
Naspot13	NaCRRI/Uganda	115	38.0	Orange	Kapinga et al., 2010
Dimbuka	Landrace/Uganda	125	25.0	Cream	Mwanga et al., 2009
NKA38L/OP/	Bred clone/Uganda	-	-	-	-
Naspot7	NaCRRI/Uganda	115	20.4	Orange	Mwanga et al., 2009
M950384/OP/	Bred clone/Uganda	-	-	-	-
CEMDL	Landrace/DRC	150	10.0-20.0	Cream	-
Clone1	UCG/DRC	-	-	Cream	-
Mughuma	Landrace/DRC	-	-	-	-
Kanyamatsitsi	Landrace/DRC	-	-	-	-
Kikoma	Landrace/DRC	-	-	-	-
Nyakosoro	Landrace/DRC	-	-	-	-
Mbaiteka	Landrace/DRC	-	-	Cream	-

Kamutima	Landrace/DRC	-	-	-	-
Anonym	Landrace/DRC	150	12.5	Cream	-
Mayaya	Landrace/DRC	-	-	Yellow	-
Kinya Beni	Landrace/DRC	-	-	White	-
Vander Wall	FAO	135	15.0-25.0	Orange	SENASEM, 2009
Irene	Mozambique	120	19.6	Orange	Kapinga et al., 2010
Kenspot4	Kenya	120	17.1	Orange	Kapinga et al., 2010
Mugande	Landrace/Uganda	125	25.0-40.0	Cream	SENASEM, 2009
Ntakubura	FAO	-	-	Yellow	-
Nterera bana	FAO	-	-	-	-
Kenspot5	KEPHIS/Kenya	125	14.8	Orange	Kapinga et al., 2010
Elengi	INERA/DRC	120	30.0-50.0	Yellow	SENASEM, 2009
Clone*2*	UCG/DRC	-	-	Cream	-

Note: UCG = Catholic University of Graben; SENASEM = Service National des Semences; NaCRRI = National Crop Resources Research Institute; KEPHIS = Kenya Plant Health Inspectorate Service.

D. *Data Collection*

Fresh roots were harvested 150 days after planting using hand hoe. Data were collected on all the plants on the ridge. Yield and yield related components were measured as follows: total number of roots per plant (NT) obtained by a total count of roots per plant, number and weight of marketable roots per plant (NMR and MRW) was determined by counting and weighting individual tuberous roots from a plant and then, those weighing between 100 and 500 grams were considered as marketable. Fresh root yield (FRY) was measured in kilograms by bulking harvested roots from each plot using a weighing balance. Recorded weight per plot was thereafter extrapolated to tonnes per hectare. Fresh biomass weight (FBW) was measured in kilograms as the harvested roots together with fresh cut vines per plot and was extrapolated to tonnes per hectare. Harvest index (HI) was estimated as the ratio of the fresh root yield to fresh biomass weight and expressed in percentage.

First filiation sweet potato hybrids were selected following Grunerberg et al. (2009) method which suggested a selection intensity of 10%. Selection was exclusively based on fresh root yield.

E. *Data Analysis*

Data for total number of roots per plant (NT), number and weight of marketable roots per plant (NMR and MRW), fresh root yield (FRY), fresh biomass weight (FBW) and harvest index (HI) were subjected to the analysis of variance using GenStat 15th edition software (VSN International, 2012). Means were separated with the Fisher's protected least significant differences (LSD) test at 5% significance level. Pearson's correlation coefficient analysis was performed to determine the association between the traits.

III. Results

A. *Analysis of the Variance*

Table 3 presents mean squares of fresh root yield and yield related components of sixty-four sweet potato genotypes evaluated in Butembo agro-ecological conditions. Analysis of variance showed significant differences among sweet potato genotypes for fresh root yield and all other agronomic parameters ($P < 0.05$).

Table 3. Mean Squares for Root Yield and Yield Components among Sixty-Four Sweet potato Genotypes under Butembo Agro-Ecological Conditions.

Source of variation	d.f.	NT	NMR	WMR	FRY	FBW	HI
Replications	2	43.79	1.27	2.05	8.44	1160.40	1240.10
Genotypes	63	24.02*	6.11*	111.44*	132.26*	273.80*	1609.40*
Residual	126	11.98	1.71	29.17	37.91	168.50	488.50
Total	191						

Note: ^{ns} and * = not and significant difference at P ≤ 0.05; d.f = degree of freedom; NT = total number of roots per plant; NMR = number of marketable roots per plant; WMR = weight of marketable roots per plant; FRY = fresh root yield (t ha^{-1}); FBW = fresh biomass weight (t ha^{-1}) and HI = harvest index (%).

B. *Agronomic Performance of F_1 Hybrid Sweet potato lines in Butembo Agro-ecological Conditions*

Results on means for all yield parameters are presented in Table 4. The F_1 sweet potato hybrids SPH23 and SPH44 recorded the highest total number of roots per plant (10.70). Another breeding line with high number of roots per plant was SPH28 which yielded 10.30 storage roots. However, genotypes SPH18, SPH22, SPH03 and SPH34 did not bear any storage roots. The highest numbers of marketable roots per plant were recorded on the check variety Elengi (5.00) and breeding lines such as SPH27 (4.70), SPH23 (4.0) and SPH48 (4.00). Genotypes SPH18, SPH22, SPH03 and SPH34 did not bear any marketable roots. Regarding the marketable root weight, the check variety Elengi recorded the highest marketable root weight of 21.66 t ha^{-1} followed by the sweet potato hybrids SPH27 and SPH48 with a mean of 19.32 t ha^{-1}, both. According to results on the fresh root yield, the highest fresh root yield of 23.50, 21.87 and 21.02 t ha^{-1} were recorded on the check variety Elengi, and the hybrids SPH23 and SPH48, respectively. The average fresh root yield was 9.40 t ha^{-1}. Regarding the fresh biomass weight, hybrids SPH26, SPH15 and SPH29 recorded the highest biomass weight with 63.69, 61.57 and 59.45 t ha^{-1}, respectively. However, genotypes SPH27, SPH59, SPH33, SPH49 and SPH20 yielded fresh biomass weight below 26.00 t ha^{-1}. The hybrid SPH27 (80.46 %) had the highest harvest index followed by the check variety Elengi (79.04 %) and the hybrid SPH48 (61.88 %). The lowest harvest index (0.00 %) was observed in the sweet potato hybrids SPH18, SPH03, SPH22 and SPH34. All the coefficients of variation were superior to 30 %, suggesting the presence of heterogeneity among sweet potato genotypes (Table 4).

Table 2. Means for root yield and yield related components of sixty-four sweet potato genotypes under Butembo agro-ecological conditions.

Genotypes	NT (no)	NMR (no)	WMR (t ha^{-1})	FRY (t ha^{-1})	FBW (t ha^{-1})	HI (%)
Sweet potato F_1 Hybrids						
SPH01	5.70	2.00	7.00	9.98	42.47	23.50
SPH10	9.00	4.00	12.95	16.77	33.97	49.37
SPH11	5.30	1.70	6.16	8.92	38.22	23.34
SPH12	9.30	3.00	16.14	20.38	38.22	53.32
SPH13	10.00	3.70	12.74	17.62	48.83	36.08
SPH14	6.30	2.70	14.86	18.47	44.59	41.42
SPH15	6.00	2.30	6.37	9.13	61.57	14.83
SPH16	6.30	2.00	5.10	7.86	31.85	24.68
SPH17	6.30	0.00	0.00	5.31	36.10	14.71

Genotypes	NT (no)	NMR (no)	WMR (t ha^{-1})	FRY (t ha^{-1})	FBW (t ha^{-1})	HI (%)
Sweet potato F_1 Hybrids						
SPH18	0.00	0.00	0.00	0.00	40.34	0.00
SPH19	5.00	2.00	6.58	8.49	57.32	14.81
SPH02	4.00	2.30	17.62	19.32	31.85	60.66
SPH20	9.30	1.30	2.76	5.73	21.23	26.99
SPH21	8.30	1.00	2.97	4.88	38.22	12.77
SPH22	0.00	0.00	0.00	0.00	29.73	0.00
SPH23	10.70	4.00	15.07	21.87	50.95	42.92
SPH24	1.70	0.00	0.00	1.06	44.59	2.38
SPH25	7.70	2.70	10.83	11.04	36.10	30.58
SPH26	5.70	0.00	0.00	5.31	63.69	8.34
SPH27	9.70	4.70	19.32	20.50	25.48	80.46
SPH28	10.30	2.00	7.22	14.01	29.73	47.12
SPH29	5.70	1.00	2.76	6.16	59.45	10.36
SPH03	0.00	0.00	0.00	0.00	42.46	0.00
SPH30	5.70	1.70	3.82	6.37	38.22	16.67
SPH31	2.70	1.30	5.94	7.43	31.85	23.33
SPH32	5.00	2.00	6.16	8.07	48.83	16.53
SPH33	3.70	1.00	3.18	7.86	23.36	33.65
SPH34	0.00	0.00	0.00	0.00	44.59	0.00
SPH35	6.00	2.00	7.65	11.68	44.59	26.19
SPH36	8.00	3.30	12.31	15.50	33.97	45.63
SPH37	4.70	1.00	3.82	6.37	42.46	15.00
SPH38	6.30	0.70	2.12	8.28	42.47	19.50
SPH39	6.00	3.00	10.19	13.37	31.85	41.98
SPH04	6.00	0.00	0.00	6.80	36.10	18.84
SPH40	5.30	2.00	8.07	9.77	36.10	27.06
SPH41	2.70	1.00	3.61	4.46	27.60	16.16
SPH42	7.30	1.00	2.34	6.58	36.10	18.23
SPH43	1.00	0.00	0.00	2.12	27.60	7.68
SPH44	10.70	3.70	16.56	19.96	48.83	40.88
SPH45	3.70	0.00	0.00	2.33	29.73	7.84
SPH46	2.70	0.70	2.76	4.46	36.10	12.35
SPH47	8.30	2.00	5.95	9.34	46.71	20.00
SPH48	6.00	4.00	19.32	21.02	33.97	61.88

Note: NT = total number of roots per plant; NMR = number of marketable roots per plant; WMR = weight of marketable roots per ha; FRY = fresh root yield per ha; FBW = fresh biomass weight per ha and HI = harvest index.

Table 4. Means for root yield and yield related components of sixty-four sweet potato genotypes under Butembo agro-ecological conditions (continued).

Genotypes	NT (no)	NMR (no)	WMR (t ha^{-1})	FRY (t ha^{-1})	FBW (t ha^{-1})	HI (%)
Sweetpotato F_1 Hybrids						
SPH49	5.00	1.30	4.46	7.22	23.36	30.91
SPH05	2.70	1.00	2.55	3.40	42.47	8.01
SPH50	4.30	0.00	0.00	4.25	46.71	9.10
SPH51	6.70	0.00	0.00	4.88	44.59	10.94
SPH52	7.30	3.70	16.14	19.96	33.97	58.76
SPH53	7.00	0.30	1.06	7.60	38.22	19.88
SPH54	6.30	0.00	0.00	5.52	31.85	17.33
SPH55	8.20	2.10	8.96	13.47	26.22	51.37
SPH56	7.70	3.20	12.24	15.55	28.30	54.95
SPH57	9.30	3.30	10.83	14.44	29.73	48.57
SPH58	4.00	0.00	0.00	2.55	27.60	9.24
SPH59	4.00	2.30	8.92	10.61	25.48	41.64
SPH06	2.30	0.00	0.00	1.91	44.59	4.28
SPH60	5.00	1.70	5.10	8.28	33.97	24.37
SPH07	7.70	2.00	8.07	12.74	33.97	37.50
SPH08	1.00	0.00	0.00	0.64	46.71	1.37
SPH09	4.00	0.30	1.27	6.16	40.34	15.27
Check varieties						
Elengi	7.30	5.00	21.66	23.50	29.73	79.04
Anonym	0.30	0.00	0.00	0.42	55.20	0.76
CEMDL	7.70	3.70	12.95	15.71	46.71	33.63
Nairobi	7.70	3.30	12.53	18.26	40.34	45.27
Grand Mean	5.60	1.70	6.36	9.40	38.41	26.41
LSD (α = 0.05)	5.60	2.10	8.74	9.97	21.01	35.77
C.V. (%)	61.60	78.80	84.71	64.85	33.79	75.69

Note: LSD = least significant difference at P-value threshold of 0.05, C.V. = coefficient of variation, NT = total number of roots per plant; NMR = number of marketable roots per plant; WMR = weight of marketable roots per ha; FRY = fresh root yield per ha; FBW = fresh biomass weight per ha and HI = harvest index.

C. *Selected F_1 Sweet potato Hybrids*

Table 5 presents F_1 sweet potato hybrids which were selected based on their high yield potential. Ten percent best of the F_1 sweet potato hybrids at the first breeding sweet potato stage were SPH23, SPH48, SPH27, SPH12, SPH44 and SPH52.

Table 5. F_1 sweet potato hybrids selected for fresh root yield potential in Butembo agro-ecological conditions.

Genotypes	NT (no)	NMR (no)	WMR (t ha^{-1})	FRY (t ha^{-1})	FBW (t ha^{-1})	HI (%)
SPH23	10.70	4.00	15.07	21.87	50.95	42.92
SPH48	6.00	4.00	19.32	21.02	33.97	61.88
SPH27	9.70	4.70	19.32	20.50	25.48	80.46
SPH12	9.30	3.00	16.14	20.38	38.22	53.32
SPH44	10.70	3.70	16.56	19.96	48.83	40.88
SPH52	7.30	3.70	16.14	19.96	33.97	58.76

Note: NT = total number of roots per plant; NMR = number of marketable roots per plant; WMR = weight of marketable roots per ha; FRY = fresh root yield per ha; FBW = fresh biomass weight per ha and HI = harvest index.

D. *Pearson's Correlation Coefficients among Root Yeld and Yield Related parameters of F_1 sweet potato hybrids*

Fresh root yield was positively and significantly correlated with all yield related traits targeted in this study, except the fresh biomass weight (r = -0.118) (Table 6). Strongest correlation coefficients (r > 0.750) were observed between fresh root yield per ha and marketable root weight per ha, number of marketable roots per plant and marketable root weight per ha, number of marketable roots per plant and fresh root yield per ha, fresh root yield per ha and harvest index; and marketable root weight per ha and harvest index. Fresh biomass weight was negatively correlated with all other traits under consideration. Among yield related traits, the weight of marketable roots per ha was the most strongly correlated to fresh root yield (r = 0.96*) and could, therefore, be adopted by breeders as an indirect selection criterion for fresh root yield in sweet potato breeding programmes.

Table 3. Pearson's correlation coefficients among sweet potato yield components of F_1 hybrids grown in Butembo agro-ecological conditions.

Parameters	NT	NMR	WMR	FRY	FBW
NMR	0.688*				
WMR	0.611*	0.955*			
FRY	0.748*	0.928*	0.960*		
FBW	-0.067^{ns}	-0.115^{ns}	-0.140^{ns}	-0.118^{ns}	
HI	0.670*	0.877*	0.916*	0.930*	-0.401*

Note: ^{ns} and * = not and significant Pearson's correlation coefficient at P ≤ 0.05; NT = total number of roots per plant; NMR = number of marketable roots per plant; WMR = weight of marketable roots per ha; FRY = fresh root yield per ha; FBW = fresh biomass weight per ha and HI = harvest index.

IV. Discussion

A. *Analysis of Variance for Yield and Yield Related Traits among test F_1 sweet potato Hybrid lines*

Analysis of variance showed significant differences among sweet potato genotypes for fresh root yield and all yield related parameters (*$P \leq 0.05$*), suggesting the presence of a high genetic diversity among the tested sweet potato genotypes. This may be due to the origin of those genotypes involving the check variety Elengi as a female parent in a mating design of thirty sweet potato entries. It was stated by Chiona (2009), Ngailo (2015) and

Rukundo et al. (2017) that sweet potato root yield is mostly under genetic control, although environmental factors can also play a certain role in the gene expression. This statement is in accordance with our findings showing significant genotypic effects for all the traits.

B. *Agronomic Performance of test Lines and F_1 Sweet potato Hybrids Selection*

In this study, significant differences among sweet potato genotypes were observed on the total number of storage roots per plant, the number and weight of marketable roots, the fresh root yield, fresh biomass weight and the harvest index. Significant differences detected among sweet potato genotypes may be attributed to genetic package of each genotype. Previous reports by Mwololo et al. (2009), Adebala et al. (2013), Kathabwalika et al. (2013) and Rukundo et al. (2017) and Mbusa et al. (2018c) pointed highly significant effects of genotypes and environment on qualitative and quantitative traits including fresh root yield and yield related components in sweet potato. Kathabwalika et al. (2013) reported that the variation in sweet potato fresh root yield and yield components is mostly influenced by the genotype which contributed 43.40 % in yield variation. The overage fresh root yield of 9.40 was observed in this study. The obtained fresh root yield is high than the overage fresh root yield of 5.01 t ha^{-1} reported for DRC (FAO, 2019).

Best ten percent of F_1 sweet potato hybrids including SPH23, SPH48, SPH27, SPH12, SPH44 and SPH52 were selected. Those selected F_1 sweet potato hybrids presented higher fresh root yields compared to checks except the check variety Elengi which provided the highest fresh root yield (23.50 t ha^{-1}). The better performance recorded for that check variety may be attributed to its adaptation to Kivu high altitudes. In fact, this variety was developed and released by INERA Mulungu in agro-ecological conditions (1800 m asl) similar to the one of Butembo where this experiment was conducted. These tested clones are in the early selection phase and their yield response could be affected by their genetic constitution and the environment. This requires continuous selection of genetically fixed, stable and high yielding clones across representative sites in the eastern DRC.

C. *Pearson's Correlation among Root Yield and Yield Related traits of 64 Sweet potato Genotypes tested under Butembo Agro-ecological Conditions*

Significant and positive correlations were observed between fresh root yield and all target traits except the fresh biomass weight. These results showed that the increasing in any of the yield components including total number of roots per plant, number and weight of the marketable roots led to increase in fresh root yield. Similar results were reported by Mbusa et al. (2018b) who observed significant and positive Pearson's correlation coefficients between fresh root yield and all the yield component traits when evaluating sweet potato clones in Nairobi and Kiboko (eastern Kenya) conditions. Findings are in conformity with those of Birhan (2007) and Harriman et al. (2017) who suggested that total root weight per plant may be used as an indicator for storage root yield. According to them, improved root weight per plant would significantly complement storage root yield, thus increased root yield might be obtained by breeding cultivars with high root weights and high number of marketable roots and weight of marketable roots.

Fresh biomass weight and number of marketable roots, marketable root weight and fresh root weight were negatively correlated. This may be explained by the competition between vegetative growth and tuberisation. It was stated by Missanjo and Matsumura (2017) that one of the major difficulties faced by breeders is negative and unfavourable association among agronomic traits which make the indirect selection difficult.

V. Conclusion

First filiation (F_1) sweet potato hybrids, SPH23, SPH48, SPH12, SPH44 and SPH52 performed well in Butembo conditions. Marketable root weight was higher in the high yielding sweet potato genotypes. Most of the agronomic traits were significantly and positively correlated and the improvement and the selection can be done to one of the agronomic traits. These genotypes should be further tested in multiple sites to validate their performance or their use as parental lines in breeding programs in order to improve sweet potato productivity in Nord-Kivu, eastern DRC.

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Conflict of Interest

We declare that we have no conflict of interest. All the authors contributed on the realisation of the present study and agreed on the final manuscript content.

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