

Planting date and variation in quantitative traits of *Solenostemon rotundifolius* [(Poir.) J. K. Morton].

Ignace Tonde

ignace.tonde15@gmail.com

University of Ouagadougou

K.Romarc Nanema

University of Ouagadougou

Zakaria KIEBRE

University of Ouagadougou

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Abstract

The present study aimed to verify the effect of the planting date on quantitative traits of *S. rotundifolius*. To this end, twelve accessions of *S. rotundifolius*, including six (6) from Burkina Faso and six (6) from Ghana, were subjected to agro-morphological evaluations using a Fisher block design with three replications at three dates: April 3rd (D1); June 3rd (D2) and July 8th (D3). Fourteen (14) quantitative traits related to the canopy and leaf size, the cycle, and the yield were recorded. Comparative analysis of the performance of accessions according to planting dates revealed significant differences for all the traits. These results showed that late planting (July) resulted in low canopy size. Late maturing of the accessions was observed in case of early planting (April). Planting in June (D2) resulted in good yielding and large canopy development. These results revealed that the planting date is a crucial parameter in *S. rotundifolius* phenotype. They could be useful for the development of suitable agronomic practices for *S. rotundifolius* growing and for breeding purpose.

INTRODUCTION

Solenostemon rotundifolius (fabirama or frafra potato) is an herbaceous species belonging to the family of Lamiaceae. The plant is 20–30 cm up, with thick and fragile stems. The leaves give off an ocimum scent when crumpled (CHEVALIER et PERROT, 1905). The flowers are small, pale purple, and the inflorescence is an elongated terminal cluster (SUGRI *et al.*, 2013). *S. rotundifolius* is cultivated for its edible tubers. The potential yield reported in West Africa ranged from 5 to 15 t/ha (ENYIUKWU *et al.*, 2014; KWARTENG *et al.*, 2018). Raw tubers are exceptionally nutritious (HUA *et al.*, 2018). Tubers are consumed as curry, baked or fried (NANEMA *et al.*, 2019).

S. rotundifolius usefulness extends beyond food, and its tubers are popular for pharmaceutical and traditional medicine applications (HUA *et al.*, 2018). For example, the tubers are used to treat dysentery in rural Nigerian communities (TINDALL, 1983). *S. rotundifolius* is known to be one of the most adapted tuber crops in West Africa. It is adapted for cultivation in marginal areas in dry savannah regions with low soils fertility (ACULEY *et al.*, 2011). It is also grown on all types of arable soil: clay, gravel and sand. The whole zone of cultivation of *S. rotundifolius* in Burkina Faso covers areas receiving annual rainfall ranging from 400 to 1200 mm (NANEMA *et al.*, 2009).

Despite its adaptation to a large zone of cultivation, previous research works reported that *S. rotundifolius* is a weather-sensitive crop. Some changes in plant development (absence of flowering) and yield in various planting periods were mentioned by CHEVALIER et PERROT (1905) and NANEMA (2010). NANEMA *et al.* (2009) reported that the main planting period for farmers ranged from May to June in Burkina Faso. Such a narrow planting period of *S. rotundifolius* is a constraint for its cultivation under irrigation during the dry season. Evaluating the variation in the main quantitative traits of *S. rotundifolius* according to the planting date is a key step toward a better understanding of the effect of growing conditions on the potential development and production of this species.

This study aimed to analyze the influence of the planting date on the quantitate traits of *S. rotundifolius*.

MATERIAL AND METHOD

Plant material

The plant material consisted of tubers of *S. rotundifolius* collected from the gene bank of Biosciences Laboratory of the Joseph KI-ZERBO University (Burkina Faso). This gene bank consisted of 174 accessions of *S. rotundifolius* from Burkina Faso and Ghana. Twelve (12) accessions, 6 from each country, were selected to cover the amplitude of the variation in traits related to plant cycle, canopy size and yield (Table 1).

Table 1
List of accessions of *Solenostemon rotundifolius*

Accessions names	Countries of origin	Characteristics	Traits	Values
E150	Burkina Faso	Late maturing	Days to maturity	141
UW066YA	Ghana			141
E164	Burkina Faso	Early maturing	Days to maturity	120
UW62KG	Ghana			110
E173	Burkina Faso	Large canopy size	Canopy circumference (cm)	220.7
UW70KG	Ghana			200.4
E82	Burkina Faso	Small canopy	Canopy circumference (cm)	37.5
AACO/022YT	Ghana			40.5
E95	Burkina Faso	High productivity	Weight of tubers per plant(g)	409.9
UE081	Ghana			402.4
E30	Burkina Faso	Low productivity	Weight of tubers per plant (g)	13.6
QA99005	Ghana			14.6

Study area and experimental design

The study was carried out on the research farm of the Faculty of Earth and Life Sciences of Joseph KI-ZERBO University (12°21'56" N; 1°32'01" W). The experiment consisted of three plots established three dates : April 3rd (D1); June 3rd (D2) and July 8th (D3). These dates were used to cover the planting period of *S. rotundifolius* in Burkina Faso. The experimental design was a completely randomized block with

three replications. A total of one hundred and eighty (180) pots of 50 cm diameter and 30 cm depth were prepared for each trial. The pots were arranged in 12 rows of 5 pots each, giving a total of 60 pots per replication. The distance between two consecutive lines was 0.8 m. The distance between two pots in the same row was 0.5 m and the distance between two replications was 1 m. Each pot was labeled with the replication number, the line number and the accession number. The growing medium was a mixture of sand, potting soil, and organic fertilizer in proportions of 3:5, 1:5, and 1:5 respectively.

Quantitative traits

Fourteen quantitative traits related to canopy and leaf size, plant cycle and yield were evaluated. The traits related to the canopy and leaf size (8 traits) were recorded after spike initiation. These were: foliage height (FHE), circumference of canopy (CIC), length and width of the limb of the leaf in position 3 (LLe and LWi), leaf ratio ($L Ra = LWi / LLe$), main stem length (MSL), fresh and dry leaf weight (FLW and DLW).

One trait was related to the cycle. This was days to last maturity (DLM) which was the number of days between planting and maturity of the last plant on the line. Five traits related to yield were recorded. These were the number and weight of all tubers per plant (NTP and WTP), mean tuber weight (MTW), mean tuber length (MTL) and mean tuber diameter (MTD). The weight was estimated using an electronic scale of a maximum weight 1 Kg. The mean tuber weight (MTW) was calculated using the formula $MWT = WTP / NTP$. The tuber diameter and length were measured on 9 randomly selected tubers per plant using a calliper.

Data analysis

Data analysis consisted of the evaluation of the performance of accessions according to the three planting dates. Analysis of variance (ANOVA) was carried out and the difference between means was verified using the Student-Newman-Keuls test at the significant level $P = 0.05$. The evaluation of the effect of the genotype-environment interaction on the quantitative traits was carried out. All the data analysis were carried out using XLSTAT 18.02.01.

RESULTS

Variation of the accessions from Burkina Faso in traits related to canopy and leaf size according to the planting date

The canopy and leaf size of the accessions from Burkina Faso varied according to the planting dates (Table 2). Most of the accessions showed better vegetative development at D2, followed respectively by D1 and D3 for the circumference of the canopy (CIC) and leaf size (LLe and LWi). Therefore, accession E150 showed no significant difference in leaf width (LWi) between dates D1 and D2, as well as E173 for leaf length (LLe) between D1 and D2 and leaf width (LWi) between D1 and D3. In addition, accession E30 showed no significant difference in the circumference of the canopy (CIC) and leaf size (LLe and LWi) between D1 and D2. The accession E82 showed no significant difference in leaf size between D1 and D2.

The accessions showed significant differences in foliage height (FHE) (with the exception of E150) and above-ground biomass (fresh weight (FLW) and dry weight (DLW) of foliage). However, the accessions showed no significant difference between D1 and D2 for above-ground biomass excepted for accessions E164 and E30. The majority of the accessions did not show significant differences between the three dates for leaf ratio (LRa) and main stem length (MSL). Only accessions E150 and E173 showed significant differences in leaf ratio (LRa). Accessions E173 and E30 showed a significant difference in main stem length (MSL). Overall, the accessions showed a high vegetative development at D2 and D1 when the least vegetative development was observed at D3.

Table 2

Variation of accessions from Burkina Faso in traits related to canopy and leaf size according to the planting date

Accessions	FHE	MSL	CIC	LLe	LWi	LRa	FLW	DLW
E150 D1	33,96	39,46	210,88 b	4,87 b	3,18 a	0,65 b	1531,57 a	158,10 a
E150 D2	36,83	33,21	270,46 a	5,43 a	3,40 a	0,62 b	1724,81 a	181,10 a
E150 D3	31,61	26,13	150,85 c	3,96 c	2,76 b	0,69 a	736,90 b	78,69 b
Pr>F	0,308	0,207	0,000	0,000	0,004	0,003	0,000	0,000
E164 D1	31,75 b	30,53	227,27 b	4,66 b	3,03 b	0,65	1978,14 a	199,02 a
E164 D2	39,16 a	35,86	260,42 a	5,30 a	3,31 a	0,62	1455,20 b	143,20 b
E164 D3	28,39 b	28,90	157,75 c	4,23 c	2,70 c	0,64	702,23 c	76,70 c
Pr>F	0,000	0,078	0,000	0,000	0,000	0,66	0,000	0,000
E173 D1	26,35 b	26,70 b	205,65 b	4,85 a	3,00 b	0,62 b	1310,45 a	133,66 a
E173 D2	45,17 a	45,75 a	277,05 a	5,57 a	3,60 a	0,65 ab	1538,93 a	158,57 a
E173 D3	22,48 b	28,52 b	141,28 c	3,88 b	2,68 b	0,69 a	551,93 b	58,80 b
Pr>F	0,000	0,017	0,000	0,000	0,000	0,023	0,000	0,000
E30 D1	37,61 b	38,58 a	257,69 a	5,50 a	3,32 a	0,61	1940,98 a	198,68 a
E30 D2	42,43a	36,33 a	267,52 a	5,75 a	3,55 a	0,62	1734,53 a	167,88 b
E30 D3	33,82 b	26,08 b	151,68 b	4,39 b	2,83 b	0,65	693,56 b	74,65 c
Pr>F	0,003	0,005	0,000	0,000	0,000	0,187	0,000	0,000
E82 D1	32,98 a	35,91	226,34 b	5,10 a	3,36 a	0,65	1419,98 a	146,51 a
E82 D2	37,39 a	37,25	263,64 a	5,70 a	3,67 a	0,64	1634,32 a	273,92 a
E82 D3	26,02 b	34,08	155,35 c	4,20 b	2,63 b	0,63	835,07 b	91,28 b
Pr>F	0,000	0,912	0,000	0,000	0,006	0,803	0,002	0,030
E95 D1	29,80 a	25,50	211,18 b	4,72 b	3,04 b	0,64	1311,84 a	135,15 a
E95 D2	34,42 a	29,33	259,12 a	5,47 a	3,42 a	0,62	1323,47 a	131,03 a
E95 D3	26,23 b	32,37	150,17 c	4,22 c	2,70 c	0,64	612,28 b	68,05 b
Pr>F	0,000	0,51	0,000	0,000	0,000	0,64	0,030	0,040

Legend : ; **a**, **b**, and **c**: classes of values from the comparison by the Newman and Keuls test such as a > b > c; **FHE** : foliage height ; **MSL** : main stem length ; **CIC** : circumference of canopy ; **LWi**: leaf width; **LLe**:

leaf length; **LRa**: leaf ratio ; **FLW** : Fresh leaf weight ; **DLW** :dry leaf weigh.

Variation of the accessions from Burkina Faso in traits related to yield and plant cycle according to the planting date

All the accessions showed the longest cycle when planted at date D1 (DLM) (Table 3). For accessions E30, E82, E95 and E150, no significant difference was observed in plant cycle between D2 and D3. Therefore, an early maturing was observed at D2 for the accessions E164 and E173. For traits related yield, each of the accessions showed significant differences in number of tubers (NTP) and weight of tubers (WTP) per plant according to the planting date. The accessions showed their best performance in terms of tuber number and weight at date D2, excepted accessions E30 and E82. Accessions E150, E173 and E95 recorded the same performance between D1 and D3 for number of tubers (NTP) and weight of tubers (WTP) per plant. Only accessions E173 and E82 showed significant differences in mean weight of the tubers (MWT) and mean tuber length (MTL), respectively. Each of the accessions E164, E173; E82 and E95 showed significant differences for mean tuber diameter (MTD) and their best performances were recorded at date D2 with the exception of accession E82. Overall, the accessions showed better yield at date D2 when late maturing was observed for D1.

Table 3
Variation of accessions from Burkina Faso in traits related to yield and plant cycle
according to the planting date

ACCESSIONS	NTP	WTP	MWT	MTL	MTD	DLM
E150 D1	14,37 b	64,51 b	4,11	29,27	17,46	204,37 a
E150 D2	87,00 a	323,25a	3,63	34,72	18,19	154,50 b
E150 D3	1,83 b	9,87 b	5,75	30,59	18,47	160,00 b
Pr > F	0,000	0,000	0,320	0,246	0,899	0,000
E164 D1	23,00b	104,98 b	4,57	31,93	17,04 b	210,67a
E164 D2	33,12 a	185,92a	5,33	34,03	20,97 a	155,50c
E164 D3	1,71 c	5,63 c	3,84	32,59	14,91 b	162,86 b
Pr > F	0,000	0,000	0,600	0,840	0,002	0,000
E173 D1	9,50 b	22,10 b	2,88 b	31,53	16,69 b	213,00 a
E173 D2	36,43 a	201,97 a	5,93a	33,85	20,07 a	146,28 c
E173 D3	3,83 b	14,13 b	2,30 b	31,14	16,33 b	171,50 b
Pr > F	0,002	0,002	0,000	0,190	0,005	0,000
E30 D1	45,00 a	131,66 ab	2,89	30,77	19,47	217,33 a
E30 D2	37,83 a	181,15a	4,59	30,82	20,32	160,17 b
E30 D3	7,33 b	23,00 b	3,41	28,71	17,25	165,00 b
Pr > F	0,015	0,047	0,084	0,380	0,085	0,000
E82 D1	47,11 a	159,99 a	3,41	33,33 a	17,96 a	224,67 a
E82 D2	34,500 a	135,225 a	5,223	35,926 a	19,165 a	159,250 b
E82 D3	3,89 b	11,17 b	2,93	24,66b	14,33 b	162,33b
Pr > F	0,000	0,002	0,169	0,000	0,010	0,000
E95 D1	14,25 b	53,99 b	3,25	28,48	15,87 b	222,62 a
E95 D2	33,167 a	158,85 a	4,597	35,807	19,761 a	159,667 b
E95 D3	2,83 b	9,27 b	3,64	29,62	15,21 b	163,33b
Pr > F	0,001	0,002	0,332	0,104	0,005	0,000

Legend : **a, b, and c:** classes of values from the comparison by the Newman and Keuls test such as a > b > c ;**NTP:** number of tubers per plant; **WTP:** weight of tubers per plant; **MWT:** mean weight of the tuber;

MTL: mean tuber length; **MTD**: mean tuber diameter ; **DLM** : days to the last maturity.

Variation of the accessions from Ghana in traits related to canopy and leaf size according to the planting date

Significant differences (at level $P = 0.05$) were observed in traits related to canopy and leaf size based on planting dates (Table 4). Each of the accessions showed a significant difference for circumference of canopy (CIC) and the best performances were recorded at date D2 followed by dates D1 and D3 respectively, excepted for the accessions QA99005 and UW066YA. Only accession UW066YA showed a significant difference for leaf ratio (LRa). The accessions showed the same performances between D1 and D2 for the traits related to the leaves size (LLe and LWi); foliage height (FHE); to fresh and dry leaf weight (FLW and DLW), with the exception of the accessions AACO/022YT and UW70KG. Only, accessions UE081, UW62KG and UW70KG showed a significant difference for the main stem length (MSL). Overall, the accessions showed the best vegetative development at D2 followed by D1. The least vegetative development was observed for D3.

Table 4

Variation of accessions from Ghana in traits related to canopy and leaf size according to the planting date

Accessions	FHE	MSL	CIC	LLe	LWi	LRa	FLW	DLW
AACO/022YT D1	29,00 b	27,57	209,44 b	4,55 b	3,35 ab	0,78	1776,03 a	182,29 a
AACO/022YT D2	34,51 a	35,96	251,36 a	5,60 a	3,63 a	0,65	1201,33 ab	123,63 ab
AACO/022YT D3	27,59 b	27,04	144,69 c	4,44 b	2,89 b	0,65	598,61 b	64,59 b
Pr>F	0,006	0,055	0,000	0,011	0,011	0,202	0,007	0,008
QA99005 D1	31,90 ab	34,34	228,63 a	4,81 a	3,19	0,66	1586,53 a	162,87 a
QA99005 D2	37,00 a	37,33	253,0 a	5,23 a	3,41	0,65	1385,68 a	139,33 a
QA99005 D3	26,54 b	30,54	149,70 b	4,27 b	3,02	0,70	517,09 b	57,12 b
Pr>F	0,004	0,367	0,000	0,006	0,222	0,187	0,000	0,000
UE081 D1	32,45 a	33,75b	215,36 b	4,98a	3,12 a	0,63	1643,52 a	168,14 a
UE081 D2	33,67 a	43,60 a	262,26 a	5,26 a	3,379 a	0,64	1563,94 a	158,43 a
UE081 D3	23,07 b	24,61 b	148,89 c	3,97 b	2,48 b	0,62	743,28 b	84,87 b
Pr>F	0,000	0,001	0,000	0,000	0,000	0,77	0,000	0,001
UW066YA D1	32,79 a	31,36	239,91 a	5,16 a	3,48 a	0,68 a	1324,05 ab	137,99 ab
UW066YA D2	34,44 a	36,50	254,90 a	5,17 a	3,23 a	0,62 b	1657,54 a	170,34 a
UW066YA D3	24,96b	30,70	150,86 b	4,14 b	2,77 b	0,67 a	861,08b	95,60 b
Pr>F	0,011	0,538	0,000	0,000	0,000	0,018	0,016	0,024
UW62KG D1	32,05 a	34,30 a	231,55 b	5,25 a	3,31 a	0,63	1562,18a	166,03 a
UW62KG D2	36,30 a	39,54a	270,50 a	5,40 a	3,36 a	0,62	1844,74 a	180,78 a
UW62KG D3	24,53 b	22,50 b	128,76 c	3,83 b	2,60b	0,68	576,96 b	64,44 b

Accessions	FHE	MSL	CIC	LLe	LWi	LRa	FLW	DLW
Pr>F	0,005	0,001	0,000	0,005	0,036	0,205	0,0008	0,002
UW70KG D1	25,61 b	27,88b	223,77 b	4,93 a	3,13 b	0,64	1656,50 a	169,94 a
UW70KG D2	35,00 a	45,82a	255,95 a	5,43 a	3,62 a	0,67	1613,47 a	164,13a
UW70KG D3	20,41 c	39,18a	163,97 c	4,32 b	2,82 b	0,65	791,85 b	83,82 b
Pr>F	0,000	0,001	0,000	0,003	0,005	0,615	0,010	0,014

Legend : **a, b, and c:** classes of values from the comparison by the Newman and Keuls test such as a > b > c; **FHE** : foliage height ; **MSL** : main stem length ; **CIC** : circumference of canopy ; **LWi**: leaf width; **LLe**: leaf length; **LRa**: leaf ratio ; **FLW** : Fresh leaf weight ; **DLW** :dry leaf weigh.

Variation of the accessions from Ghana in traits related to yield and plant cycle according to the planting date

The accessions showed the longest cycle at date D1, followed by dates D3 and D2 respectively; excepted UW70KG (Table 5). For traits related to yield, each of the accessions showed significant differences in tuber number (NTP) and weight (WTP). All the accessions showed their best performance in terms of tuber number (NTP) and weight (WTP) at date D2, with the exception of accession UW066YA. However, accessions AACO/022YT; UE081; UW62KG and UW70KG recorded the same performances between D1 and D3. For mean tuber diameter (MTD), accessions AACO/022YT; UE081; UW62KG; UW70KG and UW066YA recorded their best performances at date D2 when the difference between D1 and D3 was not significant; excepted UW066YA. For mean tuber length (MTL), only the accession UW62KG did not show significant difference according to the planting date. The accessions AACO/022YT; QA99005; UE081; and UW066YA showed the same performances between D1 and D3. The accessions AACO/022YT, UW62KG and UW70KG showed significant differences for mean weight of the tuber (MWT). Overall, the accessions showed better tuber yield at date D2. The cycle of the accessions was long at date D1.

Table 5
Variation of accessions from Ghana in traits related to yield and plant cycle according to the planting date

ACCESSIONS	NTP	WTP	MWT	MTL	MTD	DLM
AACO/022YT D1	14,02 b	59,77b	4,06 b	39,77 a	17,60 b	219,71 a
AACO/022YT D2	84,37 a	519,23 a	6,11 a	45,33 a	20,94 a	161,00 c
AACO/022YT D3	12,87 b	68,41 b	3,63 b	30,33 b	15,87 b	167,43 b
Pr > F	0,000	0,000	0,005	0,005	0,010	0,000
QA99005 D1	39,43 b	98,64 b	2,40	29,99 ab	14,64	207,43 a
QA99005 D2	60,50 a	187,30 a	3,19	33,36a	18,56	148,00 c
QA99005 D3	2,86 c	8,31 c	2,85	25,87 b	14,67	164,00 b
Pr > F	0,000	0,000	0,621	0,017	0,127	0,000
UE081 D1	20,25 b	69,34 b	3,211	33,62ab	15,79 b	213,75 a
UE081 D2	68,55 a	339,93 a	5,18	39,90 a	20,79 a	124,11 c
UE081 D3	3,44 b	11,79 b	4,41	29,27 b	16,63 b	164,33 b
Pr > F	0,000	0,000	0,118	0,040	0,002	0,000
UW066YA D1	45,00 a	240,93 a	5,47	45,892 a	19,713 ab	210,00 a
UW066YA D2	47,14 a	246,27 a	6,36	39,947 ab	21,826 a	153,43 c
UW066YA D3	3,25 b	20,81 b	7,54	34,323 b	18,463 b	162,00 b
Pr > F	0,000	0,001	0,45	0,001	0,037	0,000
UW62KG D1	25,83 b	55,450 b	1,69c	28,11	13,28 b	211,33 a
UW62KG D2	68,60 a	231,25 a	3,332 a	31,56	19,17 a	151,20 c
UW62KG D3	1,33 b	3,200 b	2,48 b	27,28	11,94 b	160,00 b
Pr > F	0,010	0,006	0,036	0,772	0,004	0,000
UW70KG D1	9,33 b	24,32 b	2,49 b	31,11 b	14,61 b	217,00 a
UW70KG D2	117,83 a	495,90 a	4,19 a	38,65 a	20,95 a	157,33 b
UW70KG D3	1,75 b	4,66 b	2,88 b	27,25 b	13,50 b	166,00 b
Pr > F	0,000	0,000	0,012	0,009	0,000	0,000

Legend : a, b, and c: classes of values from the comparison by the Newman and Keuls test such as a > b > c ;**NTP:** number of tubers per plant; **WTP:** weight of tubers per plant; **MWT:** mean weight of the tuber;

MTL: mean tuber length; **MTD**: mean tuber diameter ; **DLM** : days to the last maturity.

Genotype-planting date (GxE) interaction

The planting date influenced all the parameters related to the cycle, vegetative development and yield, with the exception of the leaf area ratio (LRA). The analysis of the genotype-environment interaction was significant for many traits including those related to the cycle (number of days to last maturity), vegetative development (main stem length, foliage height) and yield (mean tuber length, number and weight of tubers per plant) (Table 6).

Table 6
Genotype-environment interaction for *S. rotundifolius* accessions

Traits	Planting date effect		Interaction	
	F value	Pr > F	F value	Pr(> F)
DLM	1876.150	< 0.001**	6.38	< 0.001**
FHE	103.970	< 0.001**	2.07	0.005**
MSL	13.970	< 0.001**	1.67	0.035*
CIC	576.060	< 0.001**	1.5	0.076 NS
LLe	134.960	< 0.001**	1.16	0.283 NS
LWi	88.300	< 0.001**	1.02	0.447 NS
LRA	2.170	0.116 NS	1.16	0.287 NS
NTP	128.160	< 0.001**	4.85	< 0.001**
WTP	117.920	< 0.001**	4.03	< 0.001**
MWT	10.220	< 0.001**	0.91	0.58 NS
MTL	32.710	< 0.001**	1.6	0.049*
MTD	51.510	< 0.001**	1.18	0.268 NS
FLW	108.410	< 0.001**	1.13	0.316 NS
DLW	51.930	< 0.001**	1.28	0.188 NS

Legend: Min. : * significant difference at $P < 0.05$; ** significant difference at $P < 0.01$; **NS**: not significant
DLM : days to the last maturity ; **FHE** : foliage height ; **MSL** : main stem length ; **CIC**: circumference of canopy; **LWi**: leaf width; **LLe**: leaf length; **LRA**: leaf ratio ; **NTP**: number of tubers per plant; **WTP**: weight of tubers per plant; **MWT**: mean weight of the tuber; **MTL**: mean tuber length; **MTD**: mean tuber diameter ;**FLW** : Fresh leaf weight ; **DLW** :dry leaf weigh.

DISCUSSION

The results observed in this study showed significant phenotypic variability of *S. rotundifolius* depending on the planting date. This variability concerned the canopy and leaf size, the cycle and the yield (number, weight and size of tubers). The genotype-planting date (GxE) interaction is therefore significant for a large number of traits related to the cycle, vegetative development and yield.

At the vegetative stage, the traits related to canopy and leaf size showed significant differences according to the different planting dates. The accessions from Burkina or Ghana showed better performance in the trials set up in date D1 and D2. D3 was the date with the lowest performance. There is a reduction in the vegetative development of accessions in case of late planting. The decrease in vegetative development potential observed in the present study in case of late planting of *S. rotundifolius* was also observed by KAWAKAMI *et al.* (2005) in potato. THONGAM *et al.* (2017) argued that large vegetative development is attributable to the prevalence of favorable temperatures. On cereal plants, TAIPODIA and SHUKLA (2013) also showed that the size of the stalks, and the number of leaves of maize varied according to the planting date.

Since *S. rotundifolius* is a vegetatively propagated plant, large canopy could help produce more cuttings that can be used as planting material. The use of the entire length of the stem could be an alternative to increase the number of cuttings. The favorable planting period for canopy development could be useful to produce planting material. Such technique is applied in sweet potato and yam production (CHAUHAN *et al.*, 2021). In traditional medicine, plants with high vegetative growth could be useful because the leaves of *S. rotundifolius* have healing and antiseptic properties (KWARTENG *et al.*, 2018).

The traits related to the yield and cycle of the accessions between the different planting dates also revealed significant differences ($P < 0.05$). All the accessions showed a long cycle at date D1. This difference in accession cycle length between the different planting dates confirmed the hypothesis of NANEMA (2010) on the variation in cycle and yield according to the planting periods of *S. rotundifolius*. THONGAM *et al.* (2017) found similar results on the effect of eight planting dates (D1, D2, D3, D4, D5, D6, D7, D8) on potato growth, cycle and yield. These planting dates influenced the potato cycle, which varied from 78 to 96 days depending on the planting date. Our results also corroborated those of VAKSMANN *et al.* (1996) on the sorghum plant. Their results showed that, depending on the sowing date, the length of the sorghum cycle varied from 90 to 190 days and that the photoperiod sensitivity of local varieties is high, even with photoperiod differences of a few minutes. According to the results of the present study, planting at the beginning of June (D2) resulted in good tuber production (in number, weight and size) compared to the other planting dates. This performance of accessions at the D2 date could be linked to the heavy foliage observed during the vegetative stage. According to DJINET *et al.* (2015), large vegetative development leads to greater accumulation of the photosynthate necessary for tuber formation. However, the accessions at date D1, which also showed large vegetative development, did not show an important yield. These results showed that the large canopy was not a sufficient condition for good yielding. Growing conditions at tuber production stage could have a significant effect on *S.*

rotundifolius yielding potential.. This similar trend has also been observed in other vegetatively propagated species such as *Solanum tuberosum*. THONGAM *et al* (2017) showed that the size and weight of *Solanum tuberosum* tubers were influenced by the staggering of planting dates, based on eight planting dates.

CONCLUSION

Planting dates had significant effects on the fourteen variables evaluated in the present study. Resulting variations of the cycle, vegetative development and yield of the accessions. However, we suggest that such a study be carried out, taking into account the different climatic zones of the country. And also to explore the genetic and physiological mechanisms that control tuber production of *S. rotundifolius*.

Declarations

COMPETING INTERESTS

There is no conflict of interest between the authors

AUTHORS' CONTRIBUTIONS

All the authors contributed to the realization of this work and to the preparation of the manuscript.

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