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Effect of planting dates on the quantitative traits of *Solenostemon rotundifolius* [(Poir.) J. K. Morton]

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The present study aimed to evaluate 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 on 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 the 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 developing suitable agronomic practices for *S. rotundifolius* production and for breeding purposes.

Key words: Planting date, agro-morphological evaluation, agronomic practices, yield.

INTRODUCTION

Solenostemon rotundifolius (fabirama or frafra potato) is an herbaceous species belonging to the family of Lamiaceae. The plant completes its life cycle within a year (Sugri et al., 2013). *S. rotundifolius* can grow up to 15 cm, but up to 60 cm in optimal conditions. It produces very small, pink, white, pale violet, or blue hermaphrodite flowers (Enyiukwu et al., 2014). *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* tubers flour can be used for the production of gluten-free bread (Tutu et al., 2024). *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 soil 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

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Table 1. *Solenostemon rotundifolius* accessions and their characteristics.

Accessions name	Countries of origin	Characteristics	Traits	Value
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

al., 2009). Because of its nutritional, economical and agronomical potentials, *S. rotundifolius* is one of the current minor crops that could play an important role in the improvement of food security (Nanema et al., 2019; Nyawudzo et al., 2019).

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 and Perrot (1905) and Nanema (2010). Many studies have contributed to the description of *S. rotundifolius* and its cultivation system in Burkina Faso (Nanema, 2010; Nanema et al., 2019). However, work to assess the variation in agromorphological characteristics as a function of the period of cultivation of *S. rotundifolius* remains to be elucidated. 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 was carried out to analyse the influence of planting dates on the quantitative traits of *S. rotundifolius* and to identify the optimum planting date.

MATERIALS AND METHODS

Plant

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 extent of the variation in traits related to plant cycle, canopy size, and yield (Table 1).

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 establishing three plots on three different dates: April 3rd (D1); June 3rd (D2) and July 8th (D3). The first date (D1) is the early planting date for it marks the end of the tuber dormancy after the harvest. It corresponds to the dry hot season. The second date (D2) corresponds to the main planting date of *S. rotundifolius* in Burkina Faso at the beginning of the rainy season. The third date (D3) was identified by farmers as the beginning of the unfavorable planting period during the rainy season.

The experimental design was a completely randomized block with three replications for each date tested.

A total of one hundred and eighty 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. The total surface area of each experiment was 83.6 m^2 (9.5 m × 8.8 m). Each pot was labelled 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 (volume/volume) of 3/5, 1/5, and 1/5, respectively.

During the rainy season, a total of 1010.3 mm of rain was recorded. The highest rainfall was recorded in August (345.7 mm) when the lowest rainfall was observed during the month of October (33 mm). The average temperature for April was 34.49°C, making it the warmest month. The lowest monthly temperature was recorded during December (26.74°C) (Figure 1). It was also the month with the shortest daylight hours, with an average of 11:33. The longest daylight hours were recorded in June (average 12:52:12) (Figure 2).

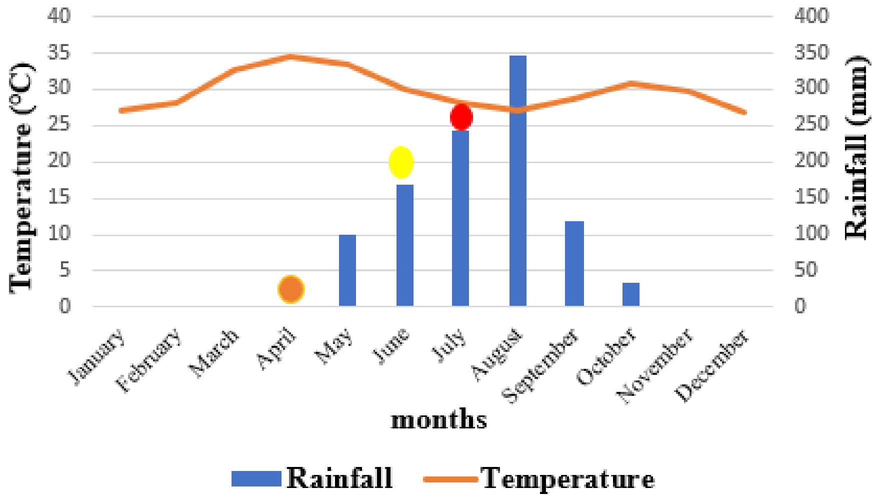

Figure 1. Ombrothermic diagram of the test site and the three test periods. ●: D1; ●: D2; ●: D3.

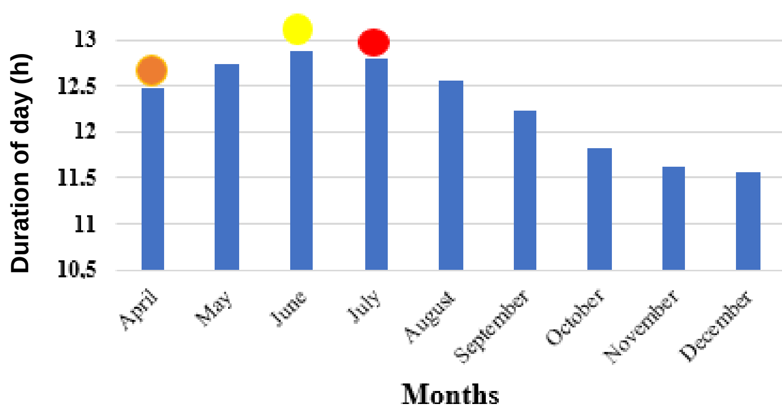

Figure 2. Variation of daylight in the test site. ●: D1; ●: D2; ●: D3.

Quantitative traits

Fourteen quantitative traits related to canopy and leaf size, plant cycle, and yield were evaluated. These traits were suggested as descriptors for *S. rotundifolius* by Nanema et al. (2019). 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 (LRa = LWi/LLe), main stem length (MSL), fresh and dry leaf weight (FLW and DLW).

One trait was related to the cycle. This was the number of days between planting and maturity of the last plant on the line (DLM). 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 with a maximum weight of 1 kg. The mean tuber weight (MTW) was calculated using the formula: MWT= WTP/NTP. The tuber diameter and length were measured on nine randomly selected tubers per plant using a calliper.

Data analysis

The data was analysed firstly to assess the effect of the genotype-planting date interaction on the quantitative traits studied. Further analysis was carried out by category of traits (canopy size, cycle and yield). This was an analysis of variance (ANOVA) performed to compare and classify the accessions using the Newman-Keuls (SNK) test at the 1 and 5% thresholds. All the data analyses were carried out using XLSTAT 18.02.01.

RESULTS

Genotype-planting date interaction

The planting date influenced all the parameters related to the cycle, canopy and size, and yield, except for the leaf area ratio (LRa). The analysis of the genotype-planting date interaction was significant for many traits including

Table 2. Genotype-planting date interaction for *S. rotundifolius* accessions.

Traits	Planting date effect		Interaction	
	F value	Pr > F	F value	Pr (>F)
DLM (days)	1876.150	< 0.001**	6.38	< 0.001**
FHE (cm)	103.970	< 0.001**	2.07	0.005**
MSL (cm)	13.970	< 0.001**	1.67	0.035*
CIC (cm)	576.060	< 0.001**	1.5	0.076^{NS}
LLe (cm)	134.960	< 0.001**	1.16	0.283^{NS}
LWi (cm)	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 (g)	117.920	< 0.001**	4.03	< 0.001**
MWT (g)	10.220	< 0.001**	0.91	0.58^{NS}
MTL (mm)	32.710	< 0.001**	1.6	0.049*
MTD (mm)	51.510	< 0.001**	1.18	0.268^{NS}
FLW (g)	108.410	< 0.001**	1.13	0.316^{NS}
DLW (g)	51.930	< 0.001**	1.28	0.188^{NS}

*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.

those related to the cycle (number of days to last maturity), canopy size (main stem length, foliage height), and yield (mean tuber length, number and weight of tubers per plant) (Table 2).

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 3). 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) (except 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 except for accessions E164 and E30. 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 while the least vegetative development was observed at D3.

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 4). For accessions E30, E82, E95, and E150, no significant difference was observed in the 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 the 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, except for accessions E30 and E82. Accessions E150, E173, and E95 recorded the same performance between D1 and D3 for the number of tubers (NTP) and weight of tubers (WTP) per plant. Only accessions E173 and E82 showed significant differences in the 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 except for accession E82.

Table 3. Variation of accessions from Burkina Faso in traits related to canopy and leaf size according to the planting date.

Date	Accessions							
	FHE (cm)	MSL (cm)	CIC (cm)	LLe (cm)	LWi (cm)	LRa	FLW (g)	DLW (g)
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]	4.66b	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	22.48b	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	42.43[a]	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[b]
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]	4.20b	2.63[b]	0.63	835.07[b]	91.28[c]
Pr > F	0.000	0.912	0.000	0.000	0.006	0.803	0.002	0.000
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

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.

Table 4. Variation of accessions from Burkina Faso in traits related to yield and plant cycle according to the planting date.

Date	Accessions					
	NTP	WTP (g)	MWT (g)	MTL (mm)	MTD (mm)	DLM (days)
E150 D1	14.37[b]	64.51[b]	4.11	29.27	17.46	204.37[a]
E150 D2	87.00[a]	323.25[a]	3.63	34.72	18.19	154.50[b]
E150 D3	1.83[c]	9.87[c]	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	23.00[b]	104.98[b]	4.57	31.93	17.04[b]	210.67[a]
E164 D2	33.12[a]	185.92[a]	5.33	34.03	20.97[a]	155.50[c]
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]	5.93[a]	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]

Table 4. Contd.

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]	181.15[a]	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	24.66[b]	14.33[b]	162.33[b]
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[c]	9.27[c]	3.64	29.62	15.21[b]	163.33[b]
Pr > F	0.001	0.002	0.332	0.104	0.005	0.000

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.

Overall, the accessions showed better yield at D2 when late maturity was observed at D1.

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 5). Each of the accessions showed a significant difference in the circumference of the 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 leaf size (LLe and LWi); foliage height (FHE); to fresh and dry leaf weight (FLW and DLW), except for the accessions AACO/022YT and UW70KG. Only accessions UE081, UW62KG, and UW70KG showed a significant difference in 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.

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 except for UW70KG (Table 6). For traits related to yield, each of the accessions showed significant difference 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, except for accession UW066YA. However, accessions AACO/022YT and UW70KG showed the same performance between D1 and D3. For mean tuber diameter (MTD), accessions AACO/022YT, UE081, UW62KG; and UW70KG recorded their best performances at date D2 when the difference between D1 and D3 was not significant with the exception of UW066YA. For mean tuber length (MTL), only accession UW62KG did not show a significant difference according to the planting date. Accessions AACO/022YT, QA99005, UE081, and UW066YA showed the same performances between D1 and D3. Accessions AACO/022YT, UW62KG, and UW70KG showed significant differences in 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.

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 (G×E) interaction is therefore significant for many 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

Table 5. Variation of accessions from Ghana in traits related to canopy and leaf size according to the planting date.

Date	Accessions							
	FHE (cm)	MSL (cm)	CIC (cm)	LLe (cm)	LWi (cm)	LRa	FLW (g)	DLW (g)
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]	33.75[b]	215.36[b]	4.98[a]	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	24.96[b]	30.70	150.86[b]	4.14[b]	2.77[b]	0.67[a]	861.08[b]	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	1562.18[a]	166.03[a]
UW62KG D2	36.30[a]	39.54[a]	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]	2.60[b]	0.68	576.96[b]	64.44[b]
Pr > F	0.005	0.001	0.000	0.005	0.036	0.205	0.0008	0.002
UW70KG D1	25.61[b]	27.88[b]	223.77[b]	4.93[a]	3.13[b]	0.64	1656.50[a]	169.94[a]
UW70KG D2	35.00[a]	45.82[a]	255.95[a]	5.4[a]	3.62[a]	0.67	1613.47[a]	164.13[a]
UW70KG D3	20.41[c]	39.18[a]	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

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.

different planting dates. However, the leaf ratio proved to be highly indiscriminate. The accessions from Burkina or Ghana showed better performance in the trials set up in dates D1 and D2. D3 was the date with the lowest performance. There was 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 the 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 favourable 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, a large canopy could help produce more cuttings that can be used as planting material. The use of cuttings is an interesting alternative to increase planting material could be an alternative. The favourable planting period for canopy development could be useful for producing planting materials. Such a 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 cycle of the accessions between the different planting dates also revealed significant differences ($P < 0.05$). All accessions from both countries 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

Table 6. Variation of accessions from Ghana in traits related to yield and plant cycle according to the planting date.

Date	Accessions					
	NTP	WTP (g)	MWT (g)	MTL (mm)	MTD (mm)	DLM (days)
AACO/022YT D1	14.02[b]	59.77[b]	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	33.36[a]	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	33.62[ab]	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[c]	11.79[c]	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]	1.69[c]	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[c]	3.200[c]	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

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.

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. The present 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 was 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 observation concerns accessions from both countries. 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. In the same vein, Ayimbire et al. (2022), in their tudies comparing the growth and yield of six different varieties of *S. rotundifolius*, showed that leaf area, and leaf size is not a yield determinant in case of this crop. Therefore, an increase in plant leaf area beyond a certain critical value, depending on the level of growth of the plant, promotes the growth of vegetative parts, by influencing the conduction of photosynthesized food to these parts, leading to an increased vegetative biomass production at the expense of tuber yield (Ayimbire et al., 2021; Fleck et al., 2012; Widaryanto et al., 2017). Tuber production in *S. rotundifolius* is highly dependent on the quantity and pattern of rainfall distribution, with moderate and evenly distributed rains favouring good tuber production, while heavy rainfall is counter-productive (Enyiukwu et al., 2014; Nkansah, 2004; Alleman et al., 2002). According to Ayimbire et al. (2022), moderate moisture, particularly at the reproductive phase of the crop promotes better tuber mass and size. This may better explain the good yield obtained at date D2, since the heading date, which began in the second week of September and marks the start of the reproductive phase in *S. rotundifolius*, corresponds to the period of moderate rainfall in Burkina Faso.

The planting date remains a determining factor in the growth and development of *S. rotundifolius*. In the farming environment, the best time to transplant *S. rotundifolius* is between May and June, as soon as the first rains arrive. This is therefore the ideal period for optimising the yield and cycle of *S. rotundifolius*, as is the case at D2. However, in this study, some accessions showed a satisfactory level of tuber production under early transplanting conditions (D1) to the detriment of the so-called favourable period. Consequently, it would be preferable to choose accessions that best respond to the specific conditions at each date to ensure their greater adaptability.

These results showed the importance of considering planting date in *S. rotundifolius* production. Canopy size, cycle and yield traits were strongly influenced by planting date.

Conclusion

Planting dates had significant effects on the fourteen variables evaluated in the present study. Accessions showed significant variation in vegetative development, cycle, and yield traits according to the different planting dates. However, it is suggested that uch an experiment is to be replicated; one needs to take into account the different climatic zones of the country. In addition, there is the need to explore the genetic and physiological mechanisms that control tuber production of *S. rotundifolius.*

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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