Agro-morphological evaluation of four morphotypes of *Chrysanthellum americanum* L. VATKE" in the Sudano-Sahelian zone of Burkina Faso.

ABSTRACT

Aims: *Chrysanthellum americanum* L. VATKE is a herbaceous plant widely used in traditional medicine to treat a wide range of illnesses (kidney stones, anemia, malaria, etc.). Knowledge of the growth potential, vegetative development and phytochemical potential of a number of *Chrysanthellum americanum* L. VATKE morphotypes could contribute to the development of the species. It is in this context that this study was initiated, with a view to gaining knowledge of the agro-morphological characteristics of *Chrysanthellum americanum* L. VATKE.

Methodology: The study was carried out at the experimental station of the Institut de l'Environnement et de Recherches Agricoles Saria (INERA/Saria). Four morphotypes (MT1, MT2, MT3 and MT4) from a mixture of *Chrysanthellem americanum* seed collected from Bobo, Nandiala and Tema were grown in a Fisher design with three replications.

Result: A total of 27 agro-morphological parameters, including 8 qualitative and 19 quantitative, were observed and measured. Morphotypes showed variation in achene color and stem habit. Significant differences between morphotypes were observed for parameters linked to growth, the phenological cycle of plants and yield. The MT3 morphotype was the best performer, with a wide plant spread (22.34±1.02 cm), longer (10.78±0.57 cm) and wider (6.28±0.21 cm) leaves, a high number of secondary branches (10.78±0.52), better achene (1.44±0.12 t/ha) and fresh haulm (10.08±0.31 t/ha) yields. Morphotype MT4 achieved the highest thousand achene weight (0.70 g), and morphotypes MT1 and MT4 recorded the highest fertile achene/flower frequencies (73%).

Conclusion :For cycle length, morphotypes MT1 and MT2 were early with 71.33±2.40 JAS and 69.00±2.52 JAS.MT1 and MT2 could be domesticated in the Sudano-Sahelian zone due to their short cycle.

Key words: *Chrysanthellum americanum,* morphotypes, agro-morphological parameters.

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1. INTRODUCTION

Traditional medicine still remains the first resort for many Burkinabè due to the inaccessibility of conventional medicines (CISSE MODY et al., 2019). In Burkina Faso, over 80% of the population regularly turn to traditional medicine and medicinal plants for their healthcare (WHO, 2020). These medicinal plants are therefore an integral part of Burkina Faso's cultural heritage. These plants include several woody and herbaceous species, such as Acacia macrostachya R, Adansonia digitata L, Azadirachta indica A. JUSS, *Chrysanthellum americanum* (L.) VATKE or Chrysanthellum indicum var afroamericanum B.L. TURNER.

Chrysanthellum americanum is a plant used in the wild. The whole plant is used. The leafy stems are used to treat yellow fever, hematuric icterus, dystonia, alcoholism, anuria, malaria, gallstones, salivary calculi, renal colic, urinary lithiasis, dyspepsia and intestinal fermentation [1]. However, in view of its medicinal use for human health, this species is under heavy anthropic pressure. Indeed, the population uses the whole plant (roots, stems and leaves). In order to meet local demand and contribute to the preservation of the plant in its natural habitat, one possibility would be to cultivate it. Consequently, knowledge of the agro-morphological and biochemical characteristics in terms of compounds and content, as well as antioxidant or biological activity, of a number of *Chrysanthellum americanum (*L.) VATKE morphotypes under cultivation conditions would be a very important first step towards domesticating the species. It is within this framework that this study falls. The general objective of this study is to learn about the agro-morphological characteristics of *Chrysanthellum americanum* L. VATKE. Specifically, the aim is to: (i) Describe the qualitative characteristics of *Chrysanthellum americanum* L. VATKE; (ii) Characterize the agro-morphological performance of four (04) morphotypes of Chrysanthellum americanum L. VATKE. (iii) Determine the Pearson correlations of agronomic parameters related to seedling growth, seedling phenological cycle and yield of *Chrysanthellum americanum* L. VATKE.

2. MATERIAL AND METHODS

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2.1. PLANT MATERIAL

The plant material used consisted of four of *Chrysanthellum americanum* morphotypes from a mixture of seeds collected in the localities of Tema, Nandiala and Bobo Dioulasso. *Chrysanthellum americanum* seeds were collected in August 2021. This mixture of collected seeds was sown in bulk in a trial at Saria during September 2021 in order to observe the growth and development of the plants. The four (04) morphotypes were selected on the basis of leaf size, plant height and stem habit within the plants obtained in this trial. Seed multiplication of these four morphotypes was carried out in June 2022, and the harvested seeds were used for this study.

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2.2 METHODS

2.2.1. Experimental set-up

A Fisher block design with three replicates was used. Pots with a depth of 0.215 m, a diameter of 0.2 m and a capacity of 9 L each were used to grow achenes (dry, indehiscent fruits of *C. americanum*). Each replication comprised 4 elementary plots, each with 6 pots in 2 rows, for a total of 24 pots. The spacing between successive pots in a row was 0.2 m, and the row spacing was 0.2 m. The distance between elementary plots was 0.5 m and the aisles between replicates were 1 m. Each pot was labelled with the repetition, pot and morphotype numbers. The surface area of each elementary plot was 1.292 m2 (1.9 m x 0.68 m). The surface area of the experimental set-up was 32.494 m2 (7.7 m x 4.22 m).

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2.2.2. Data collection

Data collected on the plants during the agro-morphological assessment covered eight qualitative and nineteen quantitative parameters.

- **Quality parameters**

Eight quality parameters related to plant morphology were observed at flowering and maturity-harvest stages. All plants on both lines were collected for these parameters. Stem color and habit, leaf color and shape, and flower color were observed at the flowering stage. On the other hand, seed color, shape and texture were observed at the maturity-harvest stage.

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- ***Quantitative parameters***

o Plant growth parameters.

At the seedling stage, the number of plants lifted was obtained by counting all the plants lifted in all the pots in the elementary plot at 28 DAS. At the flowering stage, plant height and spread, leaf length and width, length of peduncles and primary flowers and length of peduncles and secondary flowers were determined by measuring three randomly selected plants per elementary plot, using a graduated ruler. Neck diameter was determined by measuring three randomly selected plants per plot, using a 150 mm caliper. At the maturity-harvest stage, the number of secondary branches was obtained by counting those directly connected to the main stem.

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o Plant phenological cycle parameters

Date of appearance of the first flower bud, date of appearance of the first flower and date of 95% maturity were recorded by counting the number of days from the sowing date to the date of their appearance. These dates are expressed in JAS.

o Parameters related to yield and its components

A total of eight parameters were determined at the maturity-harvest stage. The weight of achenes per pot, the total weight of achenes per elementary plot, the total weight of fresh haulm per elementary plot, the total weight of dry haulm per elementary plot and the weight of 1000 achenes per elementary plot were assessed by weighing using a 2000 g/0.1g (maximum capacity/minimum capacity) series 5161 electronic balance. The number of plants harvested per elementary plot was obtained by counting the plants after harvest. The weight of tops (fresh and dry) per pot was not determined.

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From the three randomly selected plants per elementary plot, three flowers were randomly selected per plant and the ripe achenes per flower were harvested. These were counted to determine the number of fertile achenes per flower (NAFe/F) and the number of sterile achenes per flower (NASt/F) using a unocular magnifying glass. The total number of achenes per flower (NTA/F) was determined using the following formula:

$$NTA/F = \sum NAFe/F + NASt/F$$

The frequency of fertile achenes per flower (FqAFe/F) and the frequency of sterile achenes per flower (FqASt/F) were calculated using the following formulae:

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$$FqAFe/F\ (\%) = \frac{NAFe/F\ x\ 100}{NTA/F}$$

$$FqASt/F\ (\%) = \frac{NASt/F\ x\ 100}{NTA/F}$$

The average achene yield was obtained using the following formula:

$$Rdt\ \ average\ in\ achenes\ (t/ha) = \frac{Weight\ of\ achenes/potx\ 10000\ m^2}{harvested\ pot\ area}$$

Fresh haulm yield (Rdt FF) and dry haulm yield (Rdt FS) were calculated using the following formulas:

$$Rdt\ FF(t/ha) = \frac{Weight\ of\ fresh\ tops/PE\ x\ 10000\ m^2}{total\ area\ of\ pots\ harvested/PE}$$

$$Rdt\ FS\ (t/ha) = \frac{Dry\ leaf\ weight/PE\ x\ 10000\ m^2}{total\ area\ of\ pots\ harvested/PE}$$

NB: 10.000 m^2 is equivalent to one hectare.

3.RESULTS

3. 1. Variation in qualitative characteristics

In all morphotypes, no variation was observed in stem, leaf and flower colorations. Indeed, purple stems, green-dark leaves and yellow flowers were observed in all morphotypes. However, the achenes of the morphotypes were either pale black or dark black. Morphotypes MT1 and MT2 produced pale-black achenes, while morphotypes MT3 and MT4 produced dark-black achenes (Table I).

Table I: Color of morphotype parts

Morphotypes	Col T	Col Feuil	Col Fl	Col A
MT1	Violet	Dark green	Yellow	Pale Black
MT2	Violet	Dark green	Yellow	Pale Black
MT3	Violet	Dark green	Yellow	Dark black
MT4	Violet	Dark green	Yellow	Dark black

Legend: Col T: stem color; Col Feuil: leaf color; Col Fl: flower color; Col A: achene color.

For all morphotypes, no variation was observed in achene texture and shape, nor in leaf shape (Table VII). In fact, all morphotypes developed hairy-textured, ovoid achenes

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and triangular-shaped leaves. However, a variation was observed between morphotypes for stem habit. Thus, morphotypes MT1 and MT2 developed creeping stems, morphotype MT3 semi-ramping stems and morphotype MT4 erect stems (Table II).

Table II: mosrphology of morphotype plants

Morphotypes	Text A	Fr A	Fr Feuil	Pt Tig
MT1	Hairy	Ovoid	Triangular	Rampant
MT2	Hairy	Ovoid	Triangular	Rampant
MT3	Hairy	Ovoid	Triangular	semi-creeper
MT4	Hairy	Ovoid	Triangular	Erected

Legend: Text A: Achene texture; Fr A: Achene shape; Fr Feuil: Leaf shape; Pt Tig: Stem habit.

3.2. Variation in quantitative characteristics

3. 2.1. Variation in plant growth parameters

For parameters related to plant growth, analysis of variance showed no significant difference (P>0.05) between morphotypes for the variables number of plants lifted, length of peduncles and primary flowers and length of peduncles and secondary flowers (Table III). On the other hand, within morphotypes, a highly significant difference (P=0.000) was recorded for the variables plant height and spread, collar diameter, leaf length and width, and number of secondary branches. Thus, the MT3 morphotype obtained plants with larger wingspans (22.34±1.02 cm), longer leaves (10.78±0.57 cm), wider leaves (6.28±0.21 cm) and a higher number of secondary branches (10.78±0.52). Also, morphotypes MT2, MT3 and MT4 all produced plants with a large crown diameter (0.37±0.02 cm; 0.40±0.02 cm and 0.34±0.02 cm).

In addition, the MT4 morphotype was the one whose plants were the tallest (22.58±0.88 cm) with a moderately high number of secondary branches (7.11±0.20). In contrast, morphotypes MT1 and MT2 had the lowest values for plant height (10.58±0.29 cm and 10.87±0.81 cm), plant spread (11.56±0.28 cm and 12.07±0.55 cm), leaf length (5.00±0.12 cm and 5.25±0.25 cm) and leaf width (3.42±0.11 cm and 3.54±0.17 cm). The MT1 morphotype was the only one to have plants with a low crown diameter (0.26±0.02 cm) and a moderately low number of secondary branches (6.67±0.24). The MT2 morphotype had the lowest number of secondary branches (5.78±0.15). On the other

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hand, the MT4 morphotype recorded intermediate values for plant span (17.33±0.85 cm), leaf length (8.19±0.37 cm) and leaf width (4.89±0.21 cm). The MT3 morphotype also recorded an intermediate value for plant height (15.24±1.08 cm).

Table III: ANOVA results for plant emergence and growth parameters

Morphotypes	**NPL**	**Haut Pl (cm)**	**Env Pl (cm)**	**Diam Col (cm)**	**Long Feuil (cm)**	**Larg Feuil (cm)**	**Long PF I^{re} (cm)**	**Long PF 2nd (cm)**	**NB 2nd**
MT1	9,33±0,67^{a}	10,58±0,29^{c}	11,56±0,28^{c}	0,26±0,02^{b}	5,00±0,12^{c}	3,42±0,11^{c}	2,25±0,08^{a}	3,55±0,09^{a}	6,67±0,24^{bc}
MT2	10,33±0,67^{a}	10,87±0,81^{c}	12,07±0,55^{c}	0,37±0,02^{a}	5,25±0,25^{c}	3,54±0,17^{c}	2,67±0,21^{a}	4,00±0,27^{a}	5,78±0,15^{c}
MT3	9,33±0,88^{a}	15,24±1,08^{b}	22,34±1,02^{a}	0,40±0,02^{a}	10,78±0,57^{a}	6,28±0,21^{a}	2,17±0,12^{a}	3,20±0,20^{a}	10,78±0,52^{a}
MT4	6,67±0,88^{a}	22,58±0,88^{a}	17,33±0,85^{b}	0,34±0,02^{a}	8,19±0,37^{b}	4,89±0,21^{b}	2,24±0,20^{a}	3,42±0,26^{a}	7,11±0,20^{b}
Probability (P)	0,51	0,000	0,000	0,000	0,000	0,000	0,152	0,088	0,000

Legend: NPL: number of plants raised; Haut Pl: plant height; Env Pl: plant span; Diam Col: collar diameter; Long Feuil: leaf length; Larg Feuil: leaf width; Long PF Ire: length of peduncles and primary flowers; Long PF 2nd: length of peduncles and secondary flowers, NB 2nd: number of secondary branches.

3. 2.2. Variation in plant phenological cycle parameters

Analysis of variance showed a significant difference (P<0.05) between morphotypes for all parameters related to the plants' phenological cycle (Table IV). In fact, significant differences were observed within morphotypes for the variables dates of appearance of first flower bud, first flower and 50% flowering and the date of 95% maturity. Thus, morphotypes MT1 and MT2 were the earliest to have the first floral bud (25.00±1.00 JAS and 23.33±0.33 JAS), the first flower (30.67±0.88 JAS and 29.33±0.33 JAS), the 50% flowering (33.67±0.88 JAS and 32.67±1.20 JAS) and the 95% maturity (71.33±2.40 JAS and 69.00±2.52 JAS). On the other hand, morphotype MT4 was the latest to have the first flower bud (38.33±0.67 JAS), the first flower (44.67±0.33 JAS), the 50% flowering (51.00±2.08 JAS) and the 95% maturity (85.33±0.67 JAS). Morphotype MT3 obtained an intermediate date for first flower bud (30.00±1.15 JAS), first flower (36.00±1.53 JAS), 50% flowering (40.33±1.33 JAS) and 95% maturity (77.67±3.28 JAS).

Table IV: ANOVA results for parameters related to plant phenological cycle

Morphotypes	1[er] BF (JAS)	1[ère] F (JAS)	50% F (JAS)	95% Mat (JAS)
MT1	25,00±1,00[c]	30,67±0,88[c]	33,67±0,88[c]	71,33±2,40[b]
MT2	23,33±0,33[c]	29,33±0,33[c]	32,67±1,20[c]	69,00±2,52[b]
MT3	30,00±1,15[b]	36,00±1,53[b]	40,33±1,33[b]	77,67±3,28[ab]
MT4	38,33±0,67[a]	44,67±0,33[a]	51,00±2,08[a]	85,33±0,67[a]
Probability (P)	0,000	0,000	0,000	0,006

Legend: **1st BF**: date of appearance of first flower bud; **1st F:** date of appearance of first flower; 5**0% F**: date of 50% flowering; **95% Mat:** date of 95% maturity.

3.2.3. Variation in yield parameters and components

According to the analysis of variance, significant differences (P<0.05) were revealed between morphotypes for the variables achene and dry haulm yields, while no significant differences (P>0.05) were observed for the variables number of plants harvested and fresh haulm yield (Table V). The MT3 morphotype recorded a higher average achene yield (1.44±0.12 t/ha) and a higher dry haulm yield (4.23±0.26 t/ha). On the other hand, the MT4 morphotype had a low average achene yield (0.88±0.14 t/ha) and a low dry haulm yield (1.50±0.18 t/ha). However, morphotypes MT1 and MT2 recorded intermediate values for average achene yield (1.04±0.17 t/ha and 1±0.10 t/ha) and dry haulm yield (2.54±0.82 t/ha and 2.83±0.24 t/ha).

Table V: ANOVA results for parameters related to yield and its components

Morphotypes	NPIR	Rdt A (t/ha)	Rdt FF (t/ha)	Rdt FS (t/ha)
MT1	5,00±1,15[a]	1,04±0,17[ab]	7,06±1,91[a]	2,54±0,82[ab]
MT2	7,00±0,58[a]	1±0,10[ab]	4,28±0,81[a]	2,83±0,24[ab]
MT3	5,66±0,88[a]	1,44±0,12[a]	10,08±0,31[a]	4,23±0,26[a]
MT4	5,00±0,58[a]	0,88±0,14[b]	6,52±1,58[a]	1,50±0,18[b]
Probability (P)	0,345	0,025	0,078	0,018

Legend: NPIR: number of plants harvested; ***Rdt A:*** achene yield***; Rdt FF:*** fresh haulm yield***; Rdt FS:*** dry haulm yield.

Figure 1 shows the histogram of 1000 achene weight as a function of morphotype. Analysis of variance showed no significant difference (P=0.111) between morphotypes for the 1000 achene weight variable. Morphotypes recorded 1000 achene weights

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ranging from 0.5 g to 0.7 g.

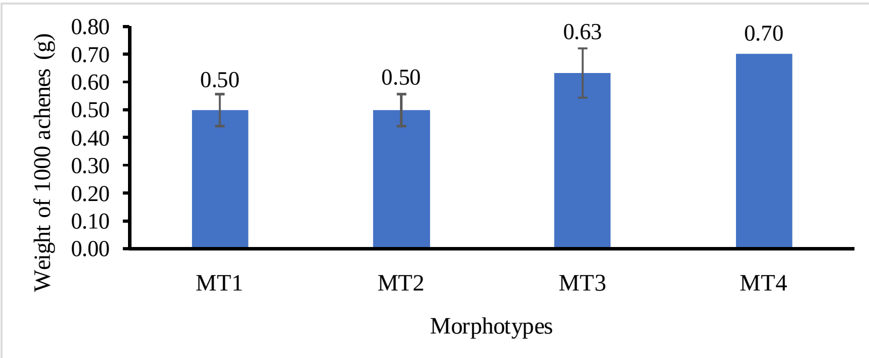

Figure 1: weight of a thousand (1000) achenes of *C. americanum* morphotypes

No significant differences (P=0.254) were revealed within morphotypes for the frequency of fertile achenes per flower and sterile achenes per flower. The frequency of fertile achenes per flower ranged from 70% to 73%, while that of sterile achenes per flower varied from 27% to 30% (Figure 2).

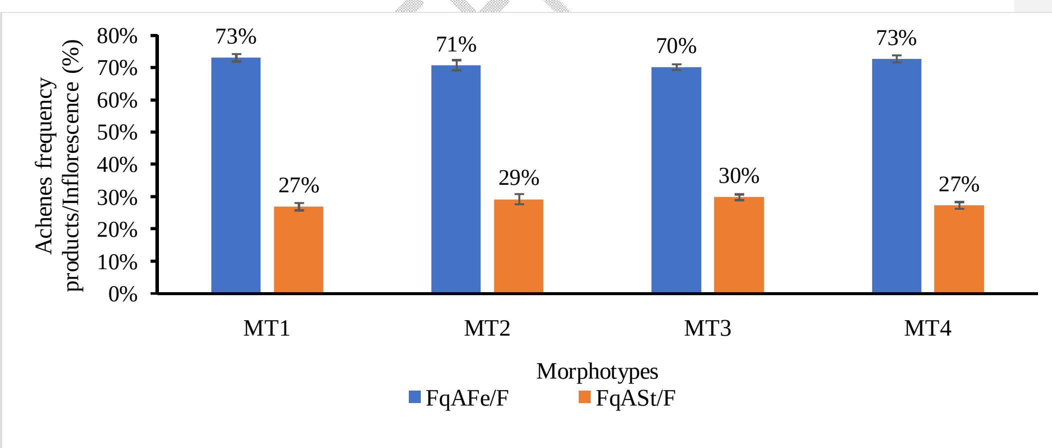

Figure 2: Achenes frequency per flower of C. americanum morphotypes

Legend: **FqAFe/F:** average frequency of fertile achene production per flower; **FqASt/F**: average frequency of sterile achene production per flower.

Pearson correlations of agronomic parameters related to seedling growth, seedling phenological cycle and yield of *Chrysanthellum americanum* L. VATKE.

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3.2.4.The correlation test highlighted relationships within agronomic parameters related to plant growth, plant phenological cycle and yield.

The level of correlation was observed through correlation coefficients in Pearson's correlation matrix with a significance threshold of 5% (Table VI).

Positive correlations were observed between : plant height and 1000 achene weight (r=0.629); plant span and collar diameter (r=0.657); plant span and leaf length (r=0.973); plant span and leaf width (r=0.978); plant span and number of secondary branches (r=0.837); collar diameter and leaf length (r=0.610) ; collar diameter and leaf width (r=0.623); leaf length and leaf width (r=0.992); leaf length and number of secondary branches (r=0.850); leaf width and number of secondary branches (r=0.869); number of secondary branches and yield of fresh tops (r=0.777).

Table VI**:** Pearson correlation matrix between agronomic parameters linked to plant growth, their phenological cycle and their yield.

Characters	Haut Pl	Env Pl	Diam Col	Long Feuil	Larg Feuil	NB 2nd	P1000 A	Rdt A	Rdt FF
Haut Pl	1								
Env Pl	0,509	1							
Diam Col	0,292	**0,657**	1						
Long Feuil	0,501	**0,973**	**0,610**	1					
Larg Feuil	0,496	**0,978**	**0,623**	**0,992**	1				
NB 2nd	0,270	**0,837**	0,495	**0,850**	**0,869**	1			
P1000 A	**0,629**	0,517	0,250	0,496	0,469	0,331	1		
Rdt A	-0,174	0,341	0,261	0,333	0,374	0,556	0,281	1	
Rdt FF	0,287	0,505	0,238	0,533	0,576	**0,777**	0,133	0,462	1

*Legend: **Top Pl**: height of the plants; **Env Pl**: size of the plants; Collar diameter: collar diameter; **Long Leaf:** length of leaves; **Width** Leaf: width of the leaves; **NB 2nd**: number of secondary branches; **1st F**: date of appearance of the first flower; **50% F**: date of 50% flowering; **95% Mat**: date of 95% maturity; **P1000 A**: weight of 1000 achenes; **Yield A**: achene yield; **Yield FF**: yield of fresh tops*

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4. DISCUSSION

The significant differences recorded among the agro-morphological characteristics of *Chrysanthellum americanum* morphotypes show the existence of variation within this plant material. Indeed, among the qualitative parameters linked to plant morphology, only achene coloration and stem habit varied between morphotypes. [2] earlier study of the flora of Senegal revealed a dark color in *Chrysanthellum americanum* seeds. This variation can be explained by the genotypic factor of the morphotypes. According to [3], seed color is conditioned by the C gene, which combines with other genes to produce different seed colors.

For parameters related to the phenological cycle of the plants, analysis of variance showed a highly significant difference between morphotypes. Morphotypes MT1 and MT2 recorded early cycles (71 JAS and 69 JAS). This early cycle is reflected in the greater viability of the seeds of these morphotypes, which took less time to germinate than the other morphotypes.

Among the parameters related to plant growth, a significant variation was observed within morphotypes. The MT3 morphotype performed best in plant span (22.34±1.02 cm), leaf length (10.78±0.57 cm), leaf width (6.28±0.21 cm) and number of secondary branches (10.78±0.52), while the MT4 morphotype performed best in plant height (22.58±0.88 cm). These parameters were observed by [4], who obtained an average plant height of 5±0.57 cm; a number According to [5], biotic and abiotic stresses during the various stages of plant development have a negative impact on yield.

Pearson's correlation matrix revealed that plant span is positively correlated with collar diameter, leaf length, leaf width and number of secondary branches. This correlation may reflect the fact that the morphotypes with the most developed plants had the longest and widest leaves, the largest collar diameter and the highest number of secondary branches. Furthermore, plant height was positively correlated with 1000 achene weight. This relationship would indicate that morphotypes with taller plants recorded the highest 1000 achene weights.of secondary branches of 03±0.2 and a collar diameter ranging from 0.6±0.15 cm to 0.7±0.14 cm. This variation in growth could be explained by the genetic character (genotypic and phenotypic) of the plants.

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As regards yield-related parameters, only achene and dry haulm yields discriminated between morphotypes. Generally speaking, all morphotypes had low achene and haulm yields. This could be explained by insects, toads, rodents and heavy rainfall accompanied by strong winds during September, which caused achenes to fall off at the early ripening-harvest stage, considerably reducing achene productivity, and also by the desiccation observed in some plants at this stage.

5. **CONCLUSION**

The results obtained made it possible to characterize agro-morphological performance, identify phyto_chemical compounds and assess antioxidant activity. The MT3 and MT4 morphotypes achieved the best agronomic performances, and the MT3 morphotype was richer in biochemical compounds than the others. The latter had a good content of phenolic compounds (polyphenols and flavonoids) and high antioxidant activity (DPPH and FRAP). The MT3 morphotype could be recommended for agricultural production as well as in the treatment of oxidative stress-related diseases to meet the needs of the population. This study could be considered as an important source of basic information for scientific studies.

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