

1 **Assessment of phenology and morphological diversity of 3 species of Asteraceae:**
2 ***Anacyclus clavatus*, *Chamaemelum fuscatum* and *Tanacetum parthenium***

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22 **Abstract**

23 The present paper deals with three species of Asteraceae : *Anacyclus clavatus*, *Chamaemelum*
24 *fuscatum* and *Tanacetum parthenium* that have a wide range of uses in medicine and in industry. The
25 detailed morphological characterization and the phenology are discussed. These species were
26 characterized by inter-specific variations using 18 morphological characters and the study of
27 phenological activities like vegetatif study, flowering time, fruiting time and seed formation for two
28 consecutive years from 2009 till 2010.

29 The results of phenological study show that the 3 species studied have distinct phenologies. The
30 longest phenological cycle is observed for *Tanacetum parthenium*. The results of the variance
31 analysis showed significant differences to highly significant for the majority of the traits studied. The
32 comparison of means reveals that *Anacyclus clavatus* and *Chamaemelum fuscatum* form a single
33 group for most of the traits measured, while *Tanacetum parthenium* is clearly distinct from these two
34 species. In addition, the principal component analysis confirms the results of the variance analysis
35 and the comparison of means. It showed that *Anacyclus clavatus* and *Chamaemelum fuscatum* are
36 divided into two overlapping groups, the group where *Tanacetum parthenium* is located is quite
37 distant.

38 **Keywords:** *Anacyclus clavatus*; *Chamaemelum fuscatum*; *Tanacetum parthenium*; morphological;
39 phenology.

40 1. Introduction

41 Phenological study is important in plant management and combating deforestation, honey analysis,
42 floral biology, estimation of reproductivity and regeneration [1]. It is important also in understanding
43 species interrelations and their interaction with the environment. Variations in phenophases among
44 individuals of different species have been linked to environmental perturbations [2]. A clear
45 understanding of phenological behavior on time of anthesis, time and duration of stigma receptivity,
46 fertilization, mode of pollination, seed development is necessary for breeding programs to obtain
47 better traits [3]. Thus plant phenological study has great significance because it not only provides
48 knowledge about the plant growth pattern but it also provides the idea on the effect of environment
49 and selective pressure on flowering and fruiting behavior [4].

50 Evaluation and characterization through morphological parameters of different crop germplasm is
51 therefore so much important for all plant breeders [5]. Therefore, it is important to make proper
52 strategies for the collection and evaluation of germplasm sources which are locally used in different
53 regions of the world and save them from being vanished [6]. To have a variety of better traits of any
54 crop we need information's about its genetic diversity [7]. Thus, characterization and estimation of
55 genetic diversity is an important step for the competent and successful maintenance and utilization of
56 different crop germplasm [8].

57 Genetic diversity is an inherited variation among and between populations, created, activated and
58 maintained by evolution [9]. Morphological traits provide a simple way of measuring genetic diversity
59 while studying genotype performance under normal growing conditions, but are influenced by
60 environmental factors ([10]; [11]). Plants have the potential to response to the changed environments
61 by changing their morphology and there for, the intra-specific variation in plant characteristics is
62 usually regarded as the adaptive mechanism to different environments [12].

63 The Asteraceae is one of the largest families, comprising 250.000 species. It is known for its wide
64 range of uses not only in medicine but also some plants are grown as ornamental plants such as
65 chamomile (*Tanacetum parthenium*), others can provide different products: natural rubber, colorants,
66 insecticides and spices [13].

67 *A. clavatus* (*Anacyclus clavatus* (Desf.) Pers.) is an annual self-incompatible herb, belonging to the
68 Asteraceae family, is an herbaceous, annual and spontaneous plant that is found almost everywhere
69 in the Mediterranean region [14]. It's 20 to 50 cm tall, hairy, green or whitish-green, with an upright or
70 ascending stem, woolly and rowdy whose branches are divorced. Leaves are bipinnate, long to very
71 narrow segments terminated by a small mucron [15]. The convex or somewhat conical receptacle
72 carries triangular bracts, ovals in the shape of sequins. The inflorescences have two types of
73 hermaphrodite flowers: the central flowers are yellow-colored and the peripheral flowers are tongued,
74 long and white. They flourished from March to June [14]. The fruits in the form of akene are small,
75 very compressed cuneiform and of grey to beige colour [15]. The number of chromosomes of this
76 species is $2n = 18$ [16]. It's a plant that grows on the edges of fields and roads and in the wastelands
77 of the entire Mediterranean coast [15]. In Tunisia, it's is located in the north (Kroumirie, Oued
78 Medjerda and Cap Bon), and in the center. The use of this species is very limited. The aerial part of *A.*

79 *clavatus* is used as a powder against stomach pain. It may also be one of the components of tobacco
80 [17].

81 *C. fuscatum* (*Chamaemelum fuscatum* (Brot.) Vasc.), belonging to the Asteraceae family,
82 anthemidae tribe, and Ormenis sub-section, is an annual, herbaceous, glabrous 30 cm rowing,
83 ascending or upright. The leaves are bipinnate. The heads are heterogeneous with yellow disc and
84 white ligules; their flowering is very early from November to April. The akene is very small, striated,
85 tetragonal and brown to yellow in colour. It's a very widespread plant on the banks of the seguias.

86 In Tunisia, *C. fuscatum* is found in the north (Ain Drahim, Kef), in the center (Sousse, Enfidha) and
87 in the South (Gabes). Internationally, It's located in the western Mediterranean basin of Spain, Greece
88 and North Africa (Tunisia, Morocco and Algeria) [15]. The number of chromosomes of this species is
89 $2n = 18$ [18]. It's known for its anti-malaria property and its protective effect against cell damage [19].

90 *L. parthenium* (*Leucanthemum parthenium* (L.) Gren. & Godr) ou *Tanacetum parthenium* (L.) Schulz
91 Bip. belongs to the Asteraceae family too, the Anthemidae tribe and the Asteroida subfamily [20]. This
92 chamomile is a very fragrant, perennial, rooted plant, with flowering stem erect without hair. The
93 leaves are deeply divided into 4 to 12 toothed segments. The internal tubular flowers are yellow and
94 the ligulate external flowers are white. They flourish from June to August in European conditions [14]
95 and from July to October in Iran [21]. The ripe fruits are brown, glandular and surmounted by a very
96 short membranous crown.

97 *Tanacetum parthenium* (L.) Schulz Bip. is a medicinal plant used primarily for the prevention and
98 reduction of migraine attacks frequency, against stomach aches and malaria [22]. It's also known for
99 its properties: antiseptic, stomachic, antihysterical, vermifuge and insecticide. It's found spontaneously
100 on the edges of roads and often in the vicinity of dwellings and it can also be grown in gardens as an
101 ornamental plant. Internationally, *Tanacetum parthenium* (L.) Schulz Bip. is found almost all over
102 Europe except the boreal zone and it is also found in South-Western Asia [14].

103 However, there is little information on the morphological diversity and the phenology of *Anacyclus*
104 *clavatus* (Desf.) Pers., *Chamaemelum fuscatum* (Brot.) Vasc. and *Tanacetum parthenium* (L.) Schulz
105 Bip. and the potential of these species in breeding programs. The aim of this study is to assess the
106 variations in morphology and phenology of these 3 species.

107 **2. Materials and methods**

108 **2.1. Plant material and experimental design**

109 Three species of Asteraceae have been studied in this work: *Anacyclus clavatus*, *Chamaemelum*
110 *fuscatum* and *Tanacetum parthenium*. These species were grown on an experimental plot at the
111 Faculty of Sciences of Tunis, Tunisia under uncontrolled conditions. The seeds used originate from
112 Esbikha for *A. clavatus*, Haouz (Morocco) for *C. fuscatum* whereas the seeds of *Tanacetum*
113 *parthenium* are available in the laboratory of Genetics and Bioresources of the Faculty of Sciences of
114 Tunis.

115 **2.2. Phenological characters**

116 Different phenological stages presented by the individuals of each species are defined:

117 ✓ **Vegetative period**

118 This stage spreads from the planting to the beginning of flowering. This is the phase of vegetative
119 growth.

120 ✓ **Flowering**

121 This is the period during which the flowers appear. The method of study is based essentially on the
122 visual observation of the appearance of the flowers.

123 ✓ **Fruiting**

124 This phase is characterized by the formation of the fruit. It begins with the formation of the first
125 seeds and ends with the general ripening of the seeds.

126 **2.3. Morphological traits**

127 In order to compare the various species studied, we describe the characters of their vegetative
128 part: The type of branching, the stem, the structure of the leaves, the structure of the inflorescences
129 and flowers, the structure of akene and the weight of 100 akenes.

130 Measurements of the morphological characters were performed on three samples of *Anacyclus*
131 *clavatus*, *Chamaemelum fuscatum* and *Tanacetum parthenium* grown in the Faculty of Sciences of
132 Tunis, for each species, we have studied 10 individuals. The 18 morphological quantitative traits were
133 assessed to characterize and estimate genetic diversity among the 3 species studied, the quantitative
134 traits measured were:

- 135 • Length of main axis in cm: LAP
- 136 • Average length of primary branches in cm: LMRP
- 137 • Average length of branches in cm: LMRS
- 138 • Average length of the tertiary branches in cm: LMRT
- 139 • Length of main root in cm: LRP
- 140 • Number of leaves per plant: NF
- 141 • Average diameter of the receptacle in cm: DMR
- 142 • Average number of leaflets per leaf: NLL
- 143 • Average length of the leaf rachis in cm: LMRF
- 144 • Number of inflorescence per plant: NI
- 145 • Number of primary branches: NRP
- 146 • Number of secondary branches: NRS
- 147 • Number of tertiary branches: NRT
- 148 • Average number of ligules per head: NML
- 149 • Number of ligules of the main axis head: NLCAP
- 150 • Length of the smallest branch in cm: LPR
- 151 • Length of the longest branch in cm: LLR
- 152 • Weight of 100 akenes : P₁₀₀ A

153 2.4. Data analysis

154 The evaluation of a collection of genetic resources is commonly based on the simultaneous
155 examination of many populations for various morphological characters. In this context, data on the
156 different morphological traits measured were:

- 157 • An analysis of variance with one classification criterion followed by a comparison of means.

158 • An estimate of the degrees of association between the different traits studied by the Pearson
159 correlation coefficient [23].

160 • A principal component analysis (PCA) based on the derivation of orthogonal variables [24].

161 In order to evaluate morphological diversity and to establish relationships among studied species,
162 several statistical procedures were conducted. Quantitative data were computed using the software
163 XLSTAT version 2011 to perform analysis of variance, comparison of mean using the Duncan test
164 and to calculate the Pearson correlation coefficient. Principal component analysis (PCA) was also
165 done using the software XLSTAT.

166 3. Results and discussion

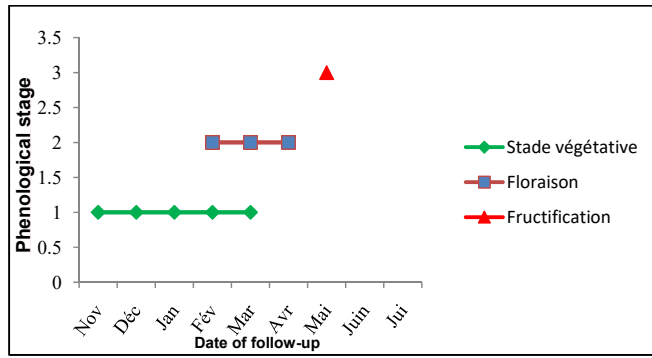
167 3.1. Phenology study

168 ✓ Vegetative period

169 The vegetative period is characterized by a strictly herbaceous development and extends from
170 seedling to full bloom. We divided this phase into 2 stages:

- 171 • **Stage of germination:** it is characterized by the appearance of the primordial leaves. In all
172 three species, the germination begins after 10 days.
- 173 • **Stage of foliage:** Observation of the phenological spectrum reveals that this stage is the
174 longest of the phenological cycle. This stage, which is characterized by the growth of the
175 stems in length and by the formation of the leaves, lasts 6 months for *Chamaemelum*
176 *fuscatum* (Figure 1) and 7 months for *Anacyclus clavatus* (Figure 2). *Tanacetum parthenium*
177 is a perennial herb plant (Figure 3).

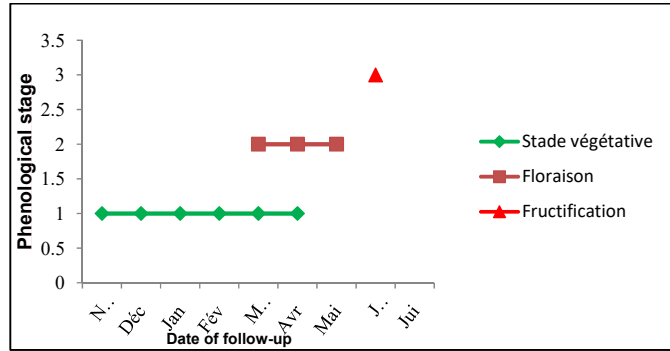
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Fig.1. Different phenological phases of *Chamaemelum fuscatum*

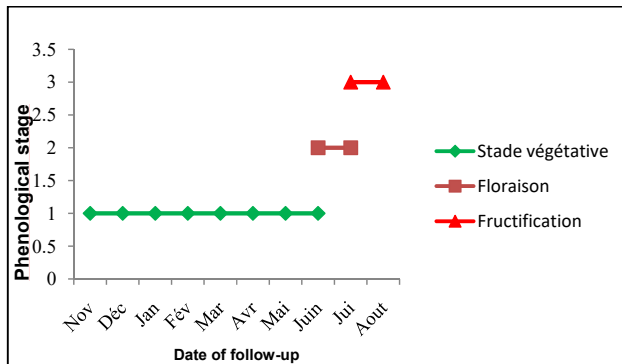
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Fig.2. Different phenological phases of *Anacyclus clavatus*

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Fig.3. Different phenological phases of *Tanacetum parthenium*

184 ✓ **Flowering**

185 Flowering is considered from the formation of the first flower until most flowers have evolved this
186 period differs from one species to another: For *Chamaemelum fuscatum*, the flowering period ranges
187 from mid-February to the end of April (Figure 1). For *Anacyclus clavatus*, this period extends from the
188 end of March to mid-May (Figure 2). For *Tanacetum parthenium*, the first flower blooms in early June
189 and full bloom is observed around mid-July (Figure 3).

190 Flowering appears to be highly favoured during the rainy season for *Anacyclus clavatus* and
191 *Chamaemelum fuscatum*, only *Tanacetum parthenium* flowers during the dry season. We find that the
192 species *Chamaemelum fuscatum* characterized by a very early flowering date has a spread flowering
193 period. In addition, the species *Tanacetum parthenium* characterized by a late flowering date has a
194 relatively short flowering stage and this to escape the water stress.

195 ✓ **Fruiting**

196 It is the formation of fruit in the form of akene. We have noticed that the appearance of the first
197 akene coincides with the peak of flowering, while the full fructification characterized for the 3 species
198 by the change of color flowers in tubes from yellow to light grey and the fall of the white ligules is
199 generally obtained after two weeks of the appearance of the first fruit (Figure 1, 2 and 3).

200 In fact, the study of [25] reveals that **akenes** of *A. clavatus* that germinated earlier produced plants
201 with higher biomass and higher reproductive effort. In addition, this work show that the phenology of
202 *Anacyclus clavatus* **akene** germination was the main factor affecting post dispersal life-history traits
203 related to competitive ability and reproductive success.

204 In addition, the study of [26] showed a high phenological diversity for the four phenological patterns
205 (buds, flowers, fruits and seeds) among fifteen leguminous plant species growing in Amritsar.

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210 **3.2. Morphology study**

211 ✓ **Vegetative part**

212 A comparative morphological characteristics of the 3 species studied is shown in Table 1.

213 **Table 1:** Morphological characteristics of *Anacyclus clavatus*, *Chamaemelum fuscatum* and
214 *Tanacetum parthenium*.

Species	NR	Leafs	Flowers	Akenes	P ₁₀₀ A (mg)	DR (cm)
<i>Anacyclus clavatus</i>	T+5	Dark green bipinnate	White ligulated flowers	Beige	45.23	1.56 ± 0.01
<i>Chamaemelum fuscatum</i>	T+5	Green bipinnate	Flowers in yellow tubes	Brown to yellow	26.63	0.67 ± 0.05
<i>Tanacetum parthenium</i>	T+3	Greenish-yellowish divided into wide	White ligulated flowers	Brown	9.96	0.65 ± 0.02

215
216 **NR:** number of ramifications, **P₁₀₀ A:** weight of 100 akenes, **T:** number of branches, **DR:** diameter of
217 the receptacle.

218

219 ✓ **The inflorescences and the flowers**

220 The inflorescence of *Anacyclus clavatus*, *Chamaemelum fuscatum* and *Tanacetum parthenium* is a
221 flower head containing two types of flowers: yellow flowers tubulated in the center and white flowers
222 ligated at the periphery. The flowers of the 3 species have the same floral biology, but show a
223 difference in floral structure. Indeed, the liguled flowers of *Chamaemelum fuscatum* are long and
224 beaked at the tip, while those of two other species are similar; they are short and more or less
225 rounded.

226 The diameter of the receptacle varies from one species to another. It is 0.65 ± 0.02 cm in
227 *Tanacetum parthenium*, 0.67 ± 0.05 cm in *Chamaemelum fuscatum* and 1.56 ± 0.01 cm in *Anacyclus*
228 *clavatus*.

229

230 ✓ Fruit

231 The fruits differ between the 3 species studied. The fruit of *Anacyclus clavatus* (Figure 4) is an
232 indelible akene, beige at maturity, of rectilinear shape to flattened cone. This akene is surrounded by
233 two membranous wings, clear, very thin, parchment and truncated at the apex. In the case of an
234 akene without these wings, the fruit appears mottled and has four longitudinal ribs.

235

236 The fruit of *Chamaemelum fuscatum* (Figure 5) is an indehiscent akene, very small, not marginated,
237 flattened ovoid, raised by 3 ribs weak and finely striated. Their color is brown to yellow at maturity.
238 The fruit of *Tanacetum parthenium* (Figure 6) is an indehiscent akene, very small, brown at maturity,
239 glandular and surmounted by a very short membranous crown and crenate.

240

241

242 ✓ **Weight of 100 akenes**

243 The mean weight of 100 akenes of *A. clavatus* is 45.23 mg. For *C. fuscatum*, it is 26.63 mg. An
 244 average weight of 9.96 mg was calculated in *Tanacetum parthenium* (Table 1).

245 **3.2.2. Analysis of morphological variability**

246 **3.2.2.1. Analysis of variance**

247 The analysis of variance with one classification criterion (species effect) showed highly significant
 248 differences between the three species studied (Table 2) for the majority of the quantitative traits
 249 measured such as: Length of the longest branch (LLR), Length of the smallest branch (LPR), number
 250 of secondary branches (NRS), number of primary branches (NRP), mean leaf spine length (LMRF),
 251 average number of leaflets (NLL), mean diameter of the receptacle (DMR), length of the main root
 252 (LRP), mean length of the tertiary branch (LMRT), average length of secondary branch (LMRS),
 253 average length of primary branch (LMRP) and length of the main axis (LAP). The difference between
 254 the three species is not significant for: The number of the principal axis head ligules (NLCAP), the
 255 average number of ligules per capitule (NML) and the number of tertiary branches (NRT). This result
 256 reflects a phenotypic heterogeneity between the 3 species studied, taking into account the measured
 257 parameters.

258 **Table 2: Variance analysis of the morphological characters.**

Characters	df	Average square	F _{obs}	Pr > F
LAP	2	3730,630	68,058	< 0,0001 HS
LMRP	2	982,641	26,382	< 0,0001 HS
LMRS	2	862,412	52,589	< 0,0001 HS
LMRT	2	360,894	26,359	< 0,0001 HS
LRP	2	40,961	11,73	0,000 HS
NF	2	338256,13	5,355	0,011 S
DMR	2	2,701	108,846	< 0,0001 HS
NLL	2	150,633	75,039	< 0,0001 HS
LMRF	2	11,796	36,769	< 0,0001 HS
NI	2	30601,433	2,983	0,068 NS
NRP	2	185,633	14,312	< 0,0001 HS
NRS	2	14770	15,244	< 0,0001 HS

NRT	2	4548,433	0,867	0,432	NS
NML	2	226,9	1,258	0,3	NS
NLCAP	2	0,7	1,086	0,352	NS
LPR	2	15,74	22,619	< 0,0001	HS
LLR	2	935,217	8,415	0,001	HS

259

260 **df** : degree of freedom; **F_{obs}** : F observed ; **HS**: highly significant; **S**: significant ($P < 0.05$) ; **NS**: no
261 significant ($P \geq 0.05$).

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264 **3.2.2.2. Comparison of means**

265 According to the Duncan test, we distinguish 5 types of groups (Table 3). Comparison of means
266 shows that *A. clavatus* and *C. fuscatum* are distinctly different from *Tanacetum parthenium* for: the
267 length of the main axis (LAP), the mean length of the secondary branch (LMRP), the average length
268 of the tertiary branch (LMRT), Root length (LR), number of leaves (NF), number of primary branches
269 (NRP) and number of secondary branches (NRP).

270 *A. clavatus* is distinguished from *Tanacetum parthenium* and *C. fuscatum* for the mean diameter of
271 the receptacle (DMR), the length of the smallest branch (LPR) and the length of the longest branch
272 (LLR). In fact, the three species did not differ significantly in the mean diameter of the receptacle
273 (DMR), the length of the smallest branch (LPR) and the length of the longest branch (LLR).

274 The parameters discriminating the three species are: the average length of the primary branch
275 (LMRP), the mean number of leaflets per leaf (NMf) and the average length of the spine (LMRF). For
276 the number of inflorescence per plant (NI), *Anacyclus clavatus* is not significantly different from
277 *Chamaemelum fuscatum* or *Tanacetum parthenium*. Therefore, *Anacyclus clavatus* and
278 *Chamaemelum fuscatum* are much alike for more than half the morphological characters studied.
279 Most of the highest averages of the morphological traits are observed in *Anacyclus clavatus*, while the
280 majority of the lowest averages are observed in *Tanacetum parthenium* (Table 3).

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284 **Table 3: The Duncan test of the 3 species studied.**

Traits	<i>Anacyclus clavatus</i>	<i>Chamaemelum fuscatum</i>	<i>Tanacetum parthenium</i> ⁸⁵
LAP	19,8 B	20,71 B	53,7 A 286
LMRS	20,6 A	17,91 A	3,39 B
LMRT	12,12 A	12,5 A	1,91 B 287
LR	8,1 B	7,72 B	11,4 A
NF	629,5 A	524,5 A	271,7 B 288
NRP	11,4 B	11,9 B	19,1 A
NRS	39,6 A	29,6 B	100,6 A 289
DMR	1,56 A	0,67 B	0,65 B
LPR	3,21 A	1,4 B	0,8 B 290
LLR	46,69 A	29,97 B	29,91 B 291
NRT	53,7 A	37,3 A	79,6 A
NML	11,7 A	19,9 A	11,6 A 292
NLACP	13,3 A	13,4 A	12,9A
LMRP	36,12 A	24,34 B	16,42 C 293
NMf	15,6 A	10,9 B	7,9 C
LMRF	4,36 A	3,19 B	2,19 C 294
NI	116,5 A and B	82,4 B	190,6 A

295

296 **3.2.2.3. Matrix of correlation coefficients**

297 The matrix of correlation coefficients between the characters studied (Table 4) shows: A positive
 298 correlation of the following traits: LMRP and LMRS correlate positively with each other and with all the
 299 parameters of LMRT, NF, DMR, NLL, LPR and LLR ; The character LAP is strongly correlated
 300 positively with the parameters LR, LMRF, NI, NRP and NRT ; A highly significant positive correlation
 301 between LMRF with NI, NRP and NRS ; NI correlates strongly with the parameters : NRP, NRS and
 302 NRT and weakly with LLR ; NRP is strongly correlated with NRS and weakly correlated with the
 303 characters NRT and LPR. The LAP has a highly significant negative correlation with the parameters
 304 (LMRS, LMRT, NLL) and significant with the characters (LMRP, NF, DMR, LPR); LMRS. It is
 305 important to note that NLACP and NML are not correlated with any of the other characters and that
 306 LMRP is the most positively correlated with the other traits (Table 4).

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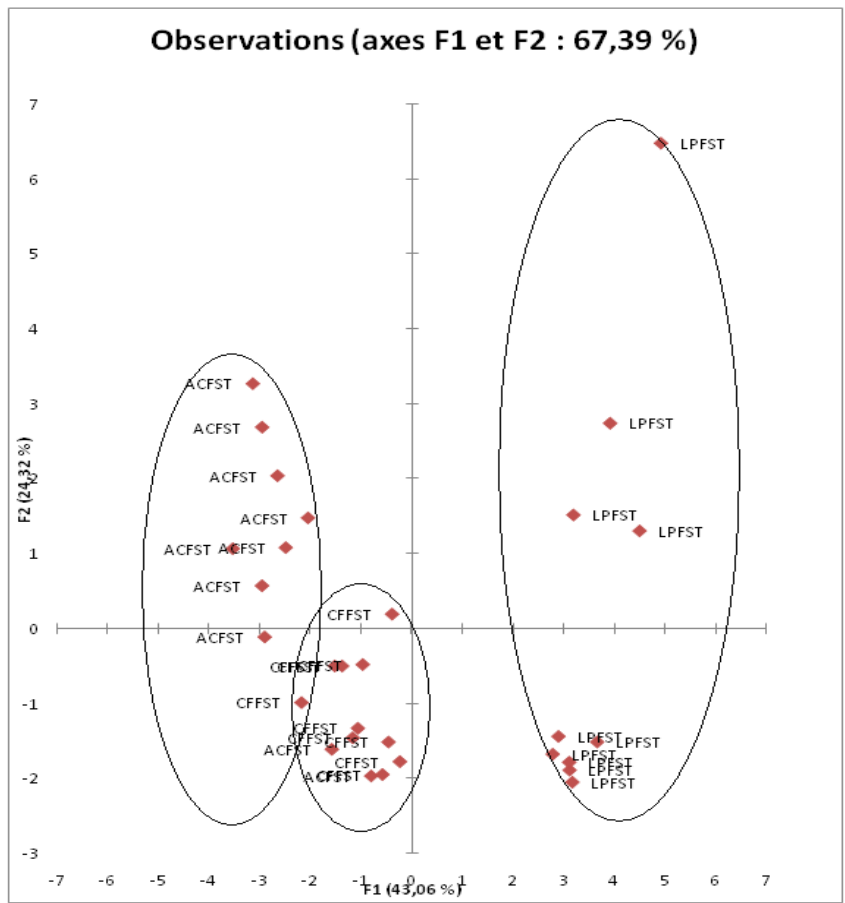
308 **3.2.2.4. Principal component analysis**

309 The graphical representation of the individuals dispersion of the 3 species studied reveals a
310 homogeneous grouping of the species studied forming 3 clear groups (Figure 7).

311 Indeed, there is a slight overlap between the two groups: *Anacyclus clavatus* and *Chamaemelum*
312 *fuscatum*, whereas, *Tanacetum parthenium* group seems very distinct from the two others species.
313 These results confirm those of the variance analysis which showed a strong resemblance between
314 *Anacyclus clavatus* and *Chamaemelum fuscatum*.

315 It is also observed that the individuals of the species *Chamaemelum fuscatum* occupy a rather
316 restricted part of the plane and are located entirely in the negative part of the two axes F1 and F2.
317 While, the individuals belonging to *Anacyclus clavatus* are scattered on the two axes (F1 and F2) with
318 a trend towards the positive values of the F1 axis (Figure 7).

319 Furthermore, individuals of *Tanacetum parthenium* are the best dispersed on the 2 axes (F1 and F2)
320 with a tendency towards the negative values of F1 axis (Figure 7).



321

322 **Fig.7.** PCA analysis for *Anacyclus clavatus*, *Chamaemelum fuscatum* and *Tanacetum parthenium*

323

Table 4: Correlation of the morphological traits.

Traits	LAP	LMRP	LMRS	LMRT	LR	NF	DMR	NMF	LMRF	NI	NRP	NRS	NRT	NML	NLCAP	LPR	LLR
LAP	1																
LMRP	-0.536	1															
LMRS	-0.810	0.842	1														
LMRT	-0.766	0.707	0.918	1													
LR	0.607	-0.270	-0.572	-0.544	1												
NF	-0.388	0.797	0.763	0.764	-0.281	1											
DMR	-0.451	0.679	0.496	0.315	-0.290	0.271	1										
NMF	-0.670	0.691	0.662	0.522	-0.511	0.423	0.798	1									
LMRF	0.780	-0.266	-0.629	-0.677	0.451	-0.269	-0.048	-0.283	1								
NI	0.532	0.220	-0.123	-0.143	0.417	0.377	-0.176	-0.195	0.523	1							
NRP	0.803	-0.291	-0.579	-0.594	0.575	-0.135	-0.410	-0.572	0.673	0.528	1						
NRS	0.828	-0.119	-0.494	-0.461	0.603	0.014	-0.314	-0.455	0.701	0.872	0.774	1					
NRT	0.410	0.329	-0.007	-0.004	0.303	0.462	-0.104	-0.080	0.373	0.946	0.473	0.798	1				
NML	-0.130	0.052	0.090	0.095	0.014	0.269	-0.160	-0.031	-0.136	0.025	0.171	-0.172	0.048	1			
NLCAP	-0.179	0.282	0.282	0.325	-0.357	0.254	0.153	0.161	-0.267	0.006	-0.058	-0.016	0.075	-0.020	1		
LPR	-0.529	0.576	0.492	0.378	-0.385	0.289	0.762	0.787	-0.142	-0.224	-0.478	-0.387	-0.153	-0.114	0.247	1	
LLR	-0.184	0.868	0.597	0.465	-0.051	0.722	0.541	0.485	0.088	0.495	0.058	0.248	0.526	-0.094	0.194	0.396	1

332 In fact, the morphological study of [27] showed variations among the 33 accessions of *Ricinus*
333 *communis* L. from Andaman and Nicobar Islands for all the 18 traits studied. This work reveals also
334 that plant height exhibited high significant positive correlations with the number of nodes on the main
335 stem. In addition, the cluster analysis based on morphological traits grouped the 33 accessions of
336 *Ricinus communis* L. into two major clusters [27].

337 Furthermore, the study of [28] was found a significant amount of genetic variability for all the twenty
338 morphological parameters studied among safflower germplasm. In addition, this work reveals that
339 seed yield plant had high significant and positive correlation with branches plant, capitulum plant,
340 seeds capitulum and 100 seed weight. Furthermore, the hierarchical cluster analysis based on agro-
341 morphological parameters divided the 121 accessions of safflower into 5 main clusters [28].

342 The morphological study of [29] in rice varieties showed high phenotypic variability ($P < 0.0001$) for
343 the characters: leaf length and leaf width, primary branching, maturity and grain thickness. In addition,
344 this work revealed a positive and strong correlation (0.77) between the height at maturity and leaf
345 length. The cluster analysis of this morphological study based on Euclidian distances between the 98
346 genotypes of Rice has allowed identifying three major clusters.

347 **4. Conclusion**

348 The phenological study shows that the 3 species studied have distinct phenologies. The longest
349 phenological cycle is observed for *Tanacetum parthenium*. The variance analysis showed significant
350 differences to highly significant for the majority of the traits studied. Furthermore, this study allowed us
351 to validate the morphological and phenological approach as tools for selection of suitable genotypes.
352 This genetic diversity will be more evidenced using molecular markers. Although, the morphological
353 descriptors of *Anacyclus clavatus*, *Chamaemelum fuscatum* and *Tanacetum parthenium* must be
354 completed by a molecular analysis using RAPD, SSR or AFLP to understand the genetic organization
355 of these species in Tunisia.

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