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PERFORMANCE OF THREE MORPHOTYPES OF GARLIC USING QUANTATIVE TRAITS BASED ON BULB CHARACTERS IN NIGER REPUBLIC

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ABSTRACT

Garlic (*Allium sativum* L.) is a bulbous plant from the Alliaceae family, mainly produced in the dry seasons under irrigation in Niger. The objective of this study was to assess garlic morphotypes for their agronomic performance traits. The experiment was conducted at the Université de Zinder in Niger Republic, in a randomised complete block design during the dry season of 2019-2020. Data were collected on bulb diameter, bulb length, bulb weight, number of cloves per bulb, clove diameter, clove length, clove weight, number of outer clove lets per clove, outer clove lets diameter, outer clove lets length, and outer clove lets weight. There were significant differences for all characters, except bulb weight, clove diameter and number of outer clove lets per clove. The morphotypes Pink and Dark purple revealed good performances and could be useful for a breeding programme.

Key Words: *Allium sativum,* bulb weight, clove lets

RESUME

L'ail (*Allium sativum* L.) est principalement produit en saison sèche sous irrigation au Niger. L'objectif de cette étude était d'évaluer les morphotypes d'ail pour leurs caractères de performance agronomique. L'expérience a été menée dans un bloc complet randomisé avec trois répétitions pendant la saison sèche 2019-2020. Les caractères suivants ont été évalués : diamètre du bulbe, longueur du bulbe, poids du bulbe, nombre gousses par bulbe, diamètre des gousses, longueur des gousses, poids des gousses, nombre des caïeux par gousse, diamètre des caïeux, longueur des caïeux, poids des caïeux. Des différences significatives ont été observées pour tous les caractères, à l'exception du poids des bulbes, du diamètre des gousses et du nombre caïeux par gousse. Les morphotypes Rose et Violet foncé ont montré de bonnes performances et pourraient être utiles pour un programme de sélection.

Mots Clés: *Allium sativum,* poids des bulbes, caïeux

INTRODUCTION

Garlic (*Allium sativum* L.) is a bulbous plant from the Alliaceae family. Its bulb is a rich source of nutrients as vitamins (B1, B2, and B3), sulfur compounds (Aliin, Allicin, Ajoine, Allylpropyl disulfide) and minerals (Pandey, 2012; Avgeri *et al.,* 2020). This nutritional value makes it an important component of human diets. Garlic is also an important source of income for farmers in Niger.

Garlic is consumed largely as a spice and used for boosting immunity. Several studies have shown that garlic is rich in antioxidants, which help to eliminate the free radicals and particles that damage cell membrane and DNA (Ashfaq *et al.,* 2021). The ingestion of fresh garlic is suggested to decrease the atherosclerotic process (El-Sabban and Abouazra, 2008; Harini *et al.,* 2013). Garlic extract increases the rate of wound healing; fibrinogen activated by allicin, which is present in garlic (Ashfaq *et al.,* 2021). It can also be used to confer protection against lead toxicity, which is a hazard for domestic animals (Khan *et al.,* 2008). Garlic has also a benefit cost ration (1.85) which indicates that its cultivation is profitable (Hasan *et al.,* 2012; Meena *et al.,* 2013).

In Niger Republic, garlic is mainly produced in the dry season under irrigation. It is cultivated on an area of 365.02 ha producing about 4,937.08 metric tonnes and a yield of 12.08 kg ha^{-1} (MAE, 2018). Unfortunately, production of garlic is hampered by several biotic and abiotic constraints, including attacks by insects in the field and during storage. Also, other factors like length of the cycle and fluctuation of prices on the market lead the abandonment of the crop for the benefit of others. In a similar vein, there is an outstanding challenge for the conservation of the genetic diversity of the species. In the quest for conservation and valorisation of genetic diversity, morphological characterisation is one of the important steps.

The existence of significant variability for most morphological characters has been highlighted on several cultivated spices (Saidou *et al.,* 2014; Moussa *et al.,* 2019), especially bulbous plants such as onion and garlic (Abdou *et al.,* 2015; Bonasia *et al.,* 2021). However, studies related to garlic genetic resources are very limited in West Africa and particularly in Niger Republic. In this economically challenged West African country, despite the economic importance of garlic (source of income for farmers), the agronomic performance traits of this agricultural product are yet to be fully identified or documented.

The objective of this study was to assess garlic morphotypes for their agronomic performance traits in Niger Republic.

MATERIALS AND METHODS

This study was carried out on three morphotypes of garlic (Pink, Purple, and Dark purple) from Université de Zinder in Niger (Photo 1), during the dry season of 2019-2020. The experiment was laid out in a randomised complete block design with three replications at the research farm of the Department of Biology, School of Sciences and Techniques, Université de Zinder (Niger Republic). The local soil is classified as sandy clay (Mamadou, 2014).

Uniform cloves of each morphotypes were planted during the middle of September for the season 2019-2020. The cloves seeds of each morphotypes were randomised separately in each replication. Each plot consisted to five rows spaced at 20 cm; the space between the cloves was fixed to 10 cm. Six cloves were planted in each row and a total of 30 cloves per plot. Weeds were removed manually every after two weeks, starting from one month after sowing five plants were randomly selected and marked from each morphotype in each plot, ignoring those on the peripheries.

The data recorded on the middle five randomly selected plants from each

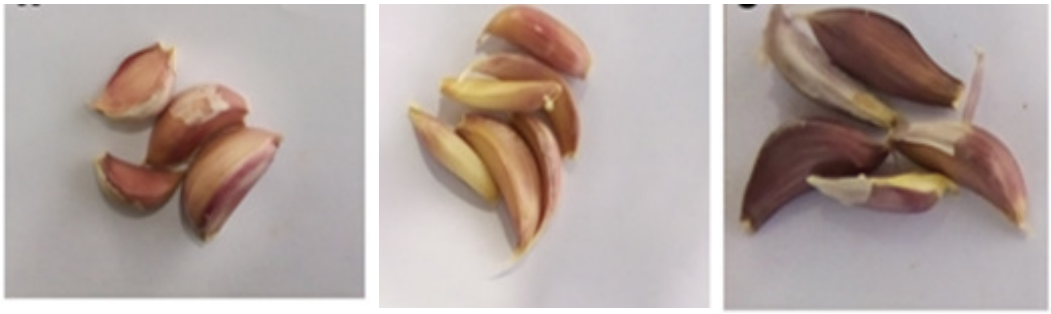
morphotype were used for analysis by adapting the procedure of IPGRI (2001). Descriptive statistics including mean, standard deviation was calculated by using MS Excel 2013. Data collected were subjected to analysis of variance (ANOVA) using XlStat version 7.1 and the means separated by using Turkey's Method at 0.05 level of significant if differences are found significant.

RESULTS

Bulb diameter and length. Differences in bulb diameter among three garlic are presented in Table 1. Morphotype pink had the highest mean value of bulb diameter (6.46 cm); followed by morphotypes purple and lastly by dark purple (5.81 and 5.53 cm, respectively) with significant differences between their mean values ($P<0.05$).

There were also significant ($P<0.01$) differences in bulb length, with morphotype Pink having the highest bulb length (4.27 cm) (Table 1). In contrast, the lowest bulb length (3.65 cm) was recorded from morphotype dark purple (Table 1).

Cloves per bulb and bulb weight. The three morphotypes showed highly significant ($P<0.001$) variations in the number of cloves per bulb (Table 1). The highest number of cloves per bulb was shown by morphotype



(a) (b) (c)

Photo 1. Morphotypes (a) Pink, (b) Purple, (c) Dark purple

TABLE 1. Analysis of variance for bulb characters of the morphotypes of garlic

Morphotypes	Bulb diameter (cm)	Bulb length (cm)	Bulb weight (g)	Number of cloves /bulb
Pink	6.46a	4.26a	70.49	13.53a
Purple	5.80b	4.21a	62.45	10.53b
Dark purple	5.53b	3.65b	49.58	9.26b
Means±SD	5.93±1.07	4.04±0.62	60.84±26.59	11.09±3.43
F	3.239	5.229	2.523	8.345
Significance	*	**	ns	**

Values with different letters within a column differ significantly. * = significant at 0.05 probability level; ** = significant at 0.01 probability level; ns = non-significant, SD = Standard deviation

pink (13.53); while purple and dark purple displayed the minimum number of cloves per bulb (10.53 and 9.2, respectively).

There were differences in bulb weight among three garlic morphotypes (Table 1). Although the largest bulb diameter was observed from morphotype pink (70.5 g), there was no significant difference (P>0.05) for this parameter between morphotypes.

Clove characters, diameter and length. The analysis of variance for clove characters of the three morphotypes of garlic are presented in Table 2. Morphotypes had no significant (P=0.640) difference in terms of clove diameter (Table 2); although the largest value was shown by morphotype Pink (2.52 cm). On the other hand, there were highly significant differences (P<0.0001) in clove length among the morphotypes (Table 2). The longest clove length (29.93) was obtained from morphotype Dark purple; while the lowest value was recorded from morphotype pink. However, there were no significant differences (P>0.05) between morphotypes Dark purple and Pink.

Clove weight and characters of outer clove lets. The morphotypes had significant differences (P=0.036) in terms of clove weight (Table 2), with morphotype Pink having the greatest weight (8.79 g). The lowest bulb length (7.16 g) was recorded from morphotype Purple.

Number and diameter of outer clove lets per clove. There were no significant differences (P=0.180) between the morphotypes for the number of outer clove lets per clove; although the highest number of outer clove lets per clove (58.60) was obtained from morphotype Pink (Table 2).

The three morphotypes of garlic significantly differed (P<0.001) in terms of outer clove lets diameter. The morphotype pink had the highest mean (13.6 mm); followed by the morphotype dark purple (10.9 mm).

Outer clove lets length and weight. A significant difference (P<0.01) in outer clove lets length among garlic morphotypes was observed. The outer clove lets length of morphotype Pink (30.4 mm) was significantly different from other morphotypes (Table 3).

Differences of outer clove lets weight among three garlic morphotypes are shown in Table 3. Morphotype Pink (2.44 g) had the highest value, although with insignificant

TABLE 2. Analysis of variance for clove characters of the three morphotypes of garlic

Morphotypes	Clove diameter (cm)	Clove length (cm)	Clove weight (g)	Number of outer clove lets/clove
Pink	2.52	3.56b	8.79a	58.60
Purple	2.38	29.06	6.04	55.93
Dark purple	2.30	29.93a	7.16b	46.40
Means±SD	2.4±0.6	20.85±12.8	7.33±2.97	53.64±18.91
F	0.452	298.323	3.608	1.787
Significance	ns	***	*	ns

Values with different letters within a column differ significantly. * = significant at 0.05 probability level ; ** = significant at 0.01 probability level; *** = significant at 0.001 probability level ns = non-significant ; SD = Standard deviation

TABLE 3. Analysis of variance for outer clove lets characters of garlic

Morphotypes	Outer clove lets diameter (mm)	Outer clove lets length (mm)	Outer clove lets weight (g)
Pink	13.6a	30.4a	2.44a
Purple	9.46b	26.8b	1.60b
Dark purple	10.9b	26.28b	1.93ab
Means±SD	11.32±3.14	27.82±4.04	1.99±0.77
F	9.161	5.576	5.303
Significance	**	*	*

Values with different letters within a column differ significantly. * = significant at 0.05 probability level; ** = significant at 0.01 probability level; ns = Non-significant; SD = Standard deviation

differences between their mean values ($P<0.01$).

DISCUSSION

All the parameters of the bulb of three morphotypes of garlic were significantly different except the bulb weight. This means that the collection includes morphotypes whose weight of the bulb does not make it possible to differentiate. This is could be attributed to favourable experimental conditions. Previous studies have also shown that agro morphological traits are useful to evaluate the genetic diversity of garlic (Polyzos *et al.,* 2019; Ayed *et al.,* 2019; Sultan and Raina, 2020). Abedi *et al.* (2013) also reported that the ecotypes did not differ significantly from each other for the bulb weight. In contrast, El-Sayed *et al.* (2020) and Thapa *et al.* (2021) detected significant difference among the Egyptian garlic clones for the bulb weight. These differences in the results may be due to the genetic variation, environment and the interaction between the two factors. Significant differences in bulb diameter, bulb length, number of cloves per bulb among different garlic ecotypes have been reported by other researchers (Yeshiwas and Negash, 2017; Singh *et al.,* 2018; Tesfaye *et al.,* 2021). The morphotype dark purple had the highest value for these characters. This could be attributed to a good potential genetics of this morphotype. Similar results have been reported by Fanaei *et al.* (2014) for ten genotypes of garlic in Iran. Statistical analysis did not show significant differences on the clove diameter and number of outer clove lets per Clove. These findings contrast with those of Kowser *et al.* (2017) who found out that there were a significant differences on the clove diameter and number of outer clove lets per clove The contrast between the results could be attributed to the genotypes or the different climatic effects of the experimental site conditions and the planting methods (Akbarpour *et al.,* 2021).

All morphotypes of garlic used showed significant differences among the morphotypes for all the characters of outer clove lets studied. This response revealed the existence of wide variability in the germplasm, which is advantageous with regard to Hamissou *et al.* (2020). Our results reveal that the majority of the variation resides in the characteristics of outer clove lets and can be used to distinguish the different morphotypes. The morphotype Pink had the highest value for all the characters of outer clove lets. This is may be due to the potential genetic of this morphotype, which enhanced more division of the cloves and good response to the planting methods used in the

study (El-Zohiri and Farag, 2014, Shree *et al.,* 2014; Kenea and Gedamu, 2018).

CONCLUSION

This study has shown that the garlic morphotype studied can be differentiated from one another depending on the bulb characters, clove characters and outer clove lets characters. The analysis of our collection has revealed significant differences are evident only for bulb diameter, bulb length, number of cloves per bulb, clove length, clove weight, outer clove lets diameter, outer clove lets length, and outer clove lets weight. The morphotypes Pink and Dark Purple showed good performances and could be useful for a breeding programme. It will be interesting to conduct the study of the nutritional quality of the bulbs to make a better selection of the collection.

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