Morphological and agronomic characterization of some tomato (*Lycopersicon esculentum*) germplasm in Ghana

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SUMMARY

In a study of morphological and agronomic characteristics of eight tomato accessions, a high variability was detected in plant height at flowering, fruit set, number of fruits per plant, fruit weight, number of locules per fruit, and yield. The variation in percent total soluble solids (3.9-5.0) and *p*H (3.9-4.4) was very small. The *p*H of the fruits in most of the accessions was close to 4.0 which is suitable for canning; however, the total soluble solids was below the 8 per cent required for canning. All of the accessions were highly sensitive to the high temperatures (28.6-32.2 °C) which prevailed during the period, resulting in low percentage fruit set (21.9-63.7). The overall correlations between number of fruits per plant, number of fruits per truss, fruit weight and yield were positive but very low (0.12-0.26). Some individual accessions, however, showed very high positive correlations between number of fruits per plant and yield (0.76-0.86) and number of fruits per truss and yield (r=0.63-0.89). The cultivar Wosowoso had a high negative correlation (-0.67) between number of fruits per truss and yield.

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RÉSUMÉ

BLAY, E. T., DANQUAH, E. Y., OFFEI, S. K. & KUDADJIE, C.: *La caractérisation morphologique et agronomique de quelques germeplasmes de tomate* (Lycopersicon esculentum) *au Ghana.* Pendant une étude des caractéristiques morphologiques et agronomiques de huit accessions de tomate, une grande variabilité était découverte dans la taille de plante en fleurs, la porte-fruit, la quantité de fruits par plante, le poids de fruit, la quantité de loge par fruit et le rendement. Une très petite variation se produisait dans le pourcentage de la totalité des solides solubles (3.9-5.0) et *p*H (3.9-4.4). Le *p*H des fruits de la plupart des accessions était près de 4.0 qui est convenable pour la mise en conserve, toutefois, la totalité des solides solubles était au-dessous du 8 pour cent exigé pour la mise en conserve. Toutes les accessions étaient extrêmement sensitives aux températures élevées (28.6-32.2 °C) qui prédominaient au cours de la période, donnant le résultat d'un faible pourcentage de porte-fruit (21.9-63.7). L'ensemble de corrélations entre la quantité de fruits par plante, la quantité de fruits par grappe, le poids de fruit et le rendement étaient positives mais très faible (0.12-0.26). Quelques accessions individuelles, cependant, montraient des corrélations très fortes et positives entre la quantité de fruits par plante et le rendement (0.76-0.86) et la quantité (r = 0.63-0.89). La variété Wosowoso avait une corrélation forte négative (-0.67) entre la quantité de fruit par grappe et le rendement.

Introduction

Tomato (*Lycopersicon esculentum*) is the most important vegetable crop in Ghana in acreage under cultivation as well as usage (NARP, 1993). The crop was introduced into Ghana between the 16th and 17th centuries (Norman, 1992). Since then, local selections have been made by farmers resulting in the production of several land varieties. Besides these, the crop has undergone some research to produce adapted cultivars suitable for growing under local conditions. Also, new varieties developed elsewhere are continually introduced for screening and the adapted ones are imported regularly, for commercial production.

The tomato farms in Ghana are rarely planted to single pure varieties. A combination of intensive introduction of new varieties, voluntary out-crossing, and varietal admixtures caused by extraction of seed by non-professionals has resulted in low genetic purity and a wide variability of the tomato cultivars in Ghana. This problem is worsened by the confusion in varietal names. For example, the same variety may be given different names in different localities while those bearing the same name may be different.

This study aimed at characterizing eight accessions of tomato based on morphological and agronomic characteristics, and at evaluating their fruit quality to identify élite accessions for release or incorporation into the local tomato improvement programme.

Materials and methods

The experiment was conducted between August and November 1996 in the Sinna's Garden, Department of Crop Science, University of Ghana, Legon. The accessions used for the study were part of the germplasm collections maintained at the Plant Genetic Resources Center (PGRC), Bunso.

Characterization of accessions

Eight accessions were characterized by their growth form, agronomic performance, and fruit quality. Seeds of the accessions were nursed in August 1996 and transplanted at 3 weeks to the field. The experimental design was a randomized complete block with three replications. Each replication comprised rows with 12 plants per row at a spacing of 40 cm between plants and 80 cm between the rows. A starter solution of 5 g/l of NPK 15-15-15 was applied at the rate 100 ml per plant (156 kg/ha) at transplanting. Two weeks later NPK 15-15-15 fertilizer was applied at 10 g per plant (312 kg/ha), followed by sulphate of ammonia at the rate of 312 kg/ha 3 weeks later. Kocide (5 ml/l) and Kocide (2 g/l) were sprayed fortnightly to control fungal and insect infestations. All of the plants were pruned to single stems and staked. Watering and weeding were done when necessary. Records were taken on five randomly selected non-border plants.

Data collected

Data were collected on growth habit, leaf shape, number of days of flowering, plant height at flowering, number of flowers per truss, percent fruit set, number of fruits per plant, number of locules/fruit, mean fruit weight, total soluble solids, and *p*H. Analysis of variance was used to analyze the data. Where the F test was significant, Duncan's Multiple Range Test was used to compare the means. Correlations among characters were also studied.

Results and discussion

Growth habit

The accessions showed one to two growth patterns, determinate or indeterminate. Accession BTB96/109 was determinate in growth habit while the others were indeterminate (Table 1).

TABLE 1

Growth Habit of Eight Accessions

Accession	*Growth habit*
BTB96/202	Intermediate
BTB96/109	Determinate
Laurano 70	Indeterminate
BTB96/209	Indeterminate
BTB96/094	Indeterminate
Wosowoso	Indeterminate
BTB96/074	Indeterminate
BTB96/075	Indeterminate

Number of days to flowering

Significant differences were observed between the accessions for the number of days to flowering. It ranged between 39.4 days in line BTB96/202, and 46.8 days in Laurano 70 (Table 2). Lines BTB96/202, BTB96/109, BTB96/094, and BTB96/074 did not differ significantly in flowering. Wosowoso and line BTB96/075 flowered later than

TABLE 2

Number of Days to Flowering (DAF), Plant Height at Flowering (PHF), Number of Days after Flowering to Fruit Ripening (DFR), and Percent Fruit Set (FS) in Eight Accessions of Tomato

Accession	*DAF (cm)*	*PHF*	*DFR*	*FS*
BTB96/202	40.0^{c}	29.0^{c}	31.8	41.9^{c}
BTB96/109	40.3^{c}	28.8^{c}	34.9	40.1
Laurano 70	46.8	41.8^{a}	32.7^{bc}	34.2^{cd}
BTB96/209	39.4^{c}	30.1^{c}	34.3^{b}	42.4^{b}
BTB96/094	39.5^{c}	30.1^{c}	34.3^{b}	31.0^{cd}
Wosowoso	42.1^{b}	29.0^{c}	34.8^{a}	21.9^{d}
BTB96/074	40.6^{c}	29.0^{c}	33.3^{bc}	63.7^{a}
BTB96/075	41.5^{b}	30.5^{b}	39.6^{cd}	39.6^{cd}

Means in the same column followed by the same letter are not significantly different from each other (P=0.05), according to Duncan's Multiple Range test.

the others. Generally, flowering appeared early in all of the accessions (39 to 42 days after sowing), since flowering in tomato usually starts from 50 to 65 days after sowing (Sinnadurai, 1992).

Plant height at flowering

Significant differences were observed among the accessions for plant height at flowering (Table 2). Plant height ranged from 28.8 to 41. 8 cm. Laurano was the tallest at flowering (41.8 cm) and differed significantly from the other accessions. Accession BTB96/075 was intermediate in height (30.5 cm) and BTB96/109 was the shortest (28.8 cm), probably due to its determinate growth habit. Generally, plant height and other vegetative growth were suppressed probably due to the harsh environmental conditions during the growth period. Messiaen (1992) reported that tomato plant height may vary up to 2 m tall.

Fruit set

There were significant differences between accessions in fruit setting ability (Table 2). Accession BTB96/074 had the highest percent fruit set (63. 7) and was significantly different from the others. With the exception of BTB96/074, fruit set in the other accessions was lower than 50 per cent. McGillivary (1960) reported that fruit set was greatly influenced by temperature. The temperatures recorded during the experiment ranged between a maximum of 28.6 to 32.2 °C and a minimum of 23.1 to 24.3 °C. According to Norman (1992), tomato thrives best at day temperatures of 23.9 to 29.4 °C and night temperatures between 15.6 and 21.1°C. Extreme temperatures during flowering may cause tomato pollen abortion, bud drop, failure of anther to dehisce, and other flower abnormalities resulting in low fruit set (El-Ahmadi & Stevens, 1979). The poor fruit set observed in this study could, therefore, be attributed to the high temperatures which probably caused a decrease in pollen fertility as observed by George (1985). In addition, the high incidence of flower drop observed further suggests an explanation for the poor fruit set.

Number of days to fruit ripening

Table 2 shows that there were significant differences between the accessions in the number of days to fruit ripening. The range was between 31.8 and 34.8 days after flowering. This was 9 to 10 days earlier than values reported by Sinnadurai (1992). Accession BTB96/109 had the highest number of days to flowering (34.9), but was not significantly different from Wosowoso. They were followed by BTB96/094, BTB96/209, BTB96/074, BTB96/202, and BTB96/075 in that order.

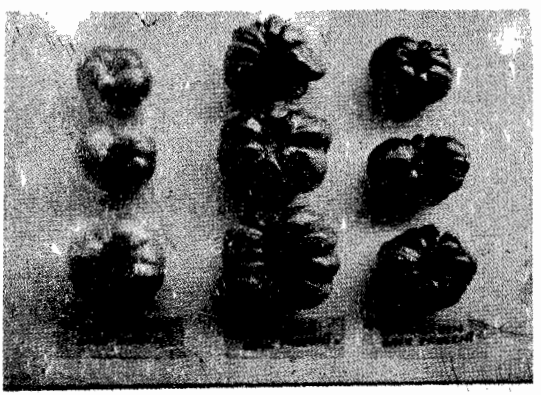
Fruit shape and colour

Based on the IBPGR descriptor for tomatoes, the types of fruit shapes in the accessions could be classified into lengthened cylindrical, round, scalloped and slightly flattened (Table 3 and Fig. 1). Purseglove (1968) also describes rounded, ribbed, elongated or pear-shaped tomato fruits. Fruits from Wosowoso were all scalloped while those from Laurano 70 were lengthened cylindrical. Fruits on BTB96/074 were all round. Fruits on the plants in the remaining five accessions showed variable shapes, with the round and scalloped being the most predominant. Table 4 and Fig. 2

TABLE 3

Percentage of Fruits with Scalloped (SCA), Lengthened Cylindrical (LC), Round (RD), and Slightly Flattened (SF) Shapes in Eight Accessions

Accession	*SCA*	*LC*	*RD*	*SF*
BTB96/202	40	10	50	-
BTB96/109	70	-	30	-
Laurano 70	-	100	-	-
BTB96/209	40	-	60	-
BTB96/094	60	-	30	10
Wosowoso	100	-	-	-
BTB96/074	20	-	80	-
BTB96/075	-	-	100	-



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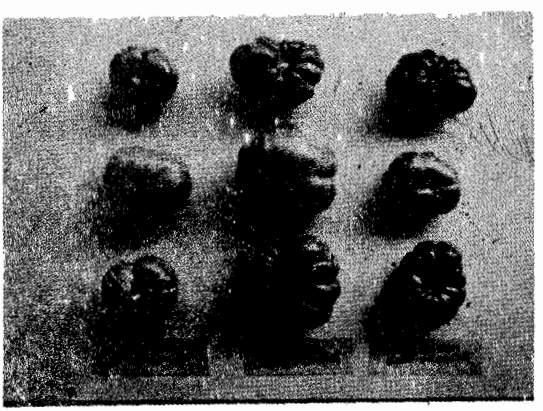

b

Fig. 1. External colour of immature fruit.

TABLE 4

Fruit Size and External Colour of Immature Fruit of Eight Accessions

Accession	*Size*	*Colour*
BTB96/202	1	1
BTB96/109	4	3
Laurano 70	2	3
BTB96/209	4	3
BTB96/094	1	3
Wosowoso	2	5
BTB96/074	1	1
BTB96/075	1	3

Size
1 = Very small (<3 cm)
3 = Small (3-5 cm)
5 = Medium (5-8 cm)

Colour
1 = Dark, green back present
2 = Light, green back present
3 = Dark, green back absent
4 = Light, green back absent

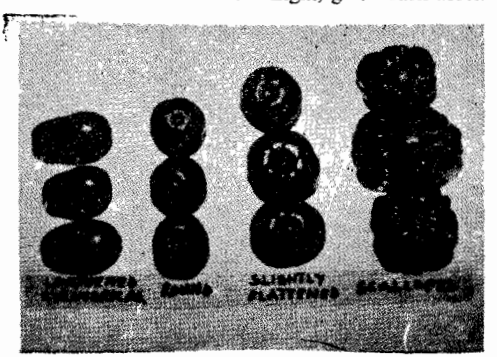

Fig. 2. Types of fruit shape.

show the external immature fruit colours.

Number of fruits/plant, fruit weight (g) and fruit yield (kg/ha)

Accession BTB96/074 produced the highest number of fruits per plant (14.7). This was significantly different from the number produced by all the other accessions (Table 5). There were no significant differences among the others for this character.

For fruit weight, significant differences were observed among the accessions (Table 5). Wosowoso had the highest fruit weight of 55.1 g which was significantly different from all of the

TABLE 5

Number of Fruits/plant (NFP), Fruit Weight (FW), and Fruit Yield, in Eight Accessions of Tomato

Accession	*NFP*	*FW (g)*	*FY (kg/ha)*
BTB96/202	7.5^{b}	30.4^{c}	8107.0
BTB96/109	7.9^{b}	40.3^{b}	11,359.2
Laurano 70	6.5^{b}	31.7^{c}	7403.6
BTB96/209	5.8^{b}	29.5^{c}	6117.3
BTB96/094	5.4^{b}	32.1^{c}	6190.9
Wosowoso	4.0^{b}	55.1^{a}	7866.0
BTB96/074	14.7^{a}	15.0^{d}	7872.9
BTB96/075	6.9^{b}	30.7^{c}	7535.7

Means in the same column followed by the same letter are not significantly different from each other (P=0.05) according to Duncan's Multiple Range test.

other accessions. Accession BTB96/074 had lowest mean fruit weight of 15.0 g, which was also significantly different from the rest. This accession produced relatively many very small-sized fruits. The other accessions had fruit weights ranging from 25.5 g for accession BTB96/094 to 40.3 g for accession BTB96/109. Tomato shows a wide variability in fruit weight, attributable to genetic differences and/or extraneous factors including environmental factors and husbandary practices (Doku, 1968; Sinnadurai & Doku, 1976; Zahara & Timm, 1973).

The fruit yield per hectare of the accessions were not significantly different from each other (Table 5). Yields were generally low. This may be attributable to the poor rainfall and high day and night temperatures during the experimental period. Norman (1974), Sinnadurai & Doku (1976), and Villareal (1981) reported that tomato yields are drastically reduced in the dry season by 6 to 45 per cent due to low moisture supply, depending on the cultivar and growing conditions. The high incidence of rootknot nematode attack may also be a contributing factor. According to Sinnadurai (1973), rootknot nematodes could reduce tomato yields drastically by as much as 90 per cent.

Fruit quality

Number of locules. Tomato fruits may be bilocular or multilocular (Purseglove, 1968). Generally, the more scalloped the fruit, the greater the number of locules observed. The accessions showed significant differences in the number of locules per fruit. Wosowoso had the highest number of locules (8.9) and was significantly different from all the others (Table 6). Accessions BTB96/109, BTB96/209, BTB96/094, and BTB96/202 were not significantly different from each other. Accessions BTB96/074 and Laurano 70 had the least number of locules but their number of locules was not significantly different from that of BTB96/075.

TABLE 6

Number of Locules (NL), Percent Total Soluble Solids (TSS), and pH for Eight Accessions.

Accession	*NL*	*TSS*	*pH*
BTB96/202	5.2^{bc}	4.6^{abcd}	4.0^{c}
BTB96/109	5.9^{b}	4.0^{cd}	4.1^{b}
Laurano 70	2.5^{d}	3.9^{d}	4.4^{a}
BTB96/209	5.8^{b}	4.9^{abc}	4.0^{c}
BTB96/094	6.7^{b}	5.2^{a}	4.1^{b}
Wosowoso	8.9^{a}	4.2^{bcd}	4.1^{b}
BTB96/074	2.7^{d}	5.0^{ab}	3.9^{c}
BTB96/075	3.7^{cd}	4.6^{abcd}	4.0^{c}

Means in the same column followed by the same letter are not significantly different from each other (P=0.05) according to Duncan's Multiple Range test.

Total soluble solids. There were significant differences between the accessions for total soluble solids. The highest, BTB96/094, had a value of 5.0 per cent and the lowest, Laurano 70, had a value of 3.9 per cent (Table 6). Generally, the total soluble solids were below the optimum of 8 per cent per fruit required for canning.

pH. Significant differences were observed between the accessions for the *p*H of the fruits (Table 6). Laurano 70 had the highest *p*H of 4.4 while BTB96/109, BTB96/094 and Wosowoso had

the same *p*H of 4.1. These values are similar to those reported by Norman (1974) from his study of 13 tomato cultivars in Ghana. The apparent uniformity in *p*H for accessions BTB96/202, BTB96/209, and BTB96/075 may be due to genotypic similarity for this character (Kattan, Stark & Kramer, 1957; Hannan, 1991; Apte *et al.*, 1969). According to Sinnadurai & Amuti (1970), Norman (1974), and Sinnadurai & Amable (1970), the *p*H of tomato fruits is primarily determined by varietal characteristics.

Correlation among fruiting characteristics and yield

With the exception of BTB96/109 which had a low but positive correlation (0.63) between number of flowers/truss and fruit set, the number of flowers per truss was negatively correlated with fruit set (-0.23). Correlation values were -0.75 for Wosowoso and -0.40 for BTB96/209. The number of fruits per plant, number of fruits per truss, and fruit weight had a low positive correlation with yield when all of the accessions were taken together (Table 7). However, BTB96/109, BTB96/209, and Wosowoso had high positive correlations between number of fruits per plant and yield. This corroborates the Shoba & Arumugam (1991) report of high and positive correlation between number of fruits per plant and yield.

TABLE 7

Correlations between Number of Fruits/plant (NFP), Number of Fruits/Truss (NFT), Fruit Weight (FW) and Yield

	Fruiting characteristics		
Accession	*NFP*	*NFT*	*FW*
BTB96/109	0.76	0.63	0.16
BTB96/209	0.81	0.89	0.55
Wosowoso	0.86	-0.67	0.40
All accessions	0.23	0.12	0.26

The correlations between mean fruit weight and yield were also positive but lower. BTB96/109 and BTB96/209 again had high and positive correlation values between the number of fruits/truss and yield. Singh *et al.* (1990) also had positive and significant correlations between tomato yield and number of fruits per plant average fruit weight, number of trusses per plant, number of fruits per truss, and number of primary branches per plant. Wosowoso, on the other hand, had a high negative correlation between the number of fruits per truss and yield. The number of fruits per plant, number of fruits per truss, and fruit weight contributed positively towards yield and tended to compensate for each other. The selection for these characters together with number of trusses/plant and percent fruit set should considerably improve yield.

Conclusion

The study showed wide variations among the accessions in plant height at flowering, fruit set, number of fruits per plant, fruit shape, fruit weight, and fruit yield. This indicates the high potential of the collections to improve the crop. According to Powell (1992), the success of any breeding programme depends on the availability and use of genetic variation. An important problem met with during the study was a high incidence of rootknot nematode attack. All of the accessions were susceptible but Wosowoso and BTB96/094 had higher incidence. The authors are currently screening the germplasm collection in the country with morpho-agronomic and molecular markers to identify gene tags for agronomically important traits.

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