ISSN 2349-0837

Bed behavioral assessment of tomato varieties in Côte d'Ivoire

N'ZI Jean-Claude[*], FONDIO Lassina[**], N'GBESSO Mako François De Paul[**], DJIDJI Andé Hortense[**] and KOUAME Christophe[***]

*Corresponding author, Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire, UFR Biosciences, 22 BP 582 Abidjan 22. Telephone: +225 47 39 56 20 / 22 44 03 07

[**]CNRA/Station de Recherche sur les Cultures Vivrières, 01 BP 633 Bouaké 01, Côte d'Ivoire

[***]World Agroforestry Centre (ICRAF) Côte d'Ivoire Country Program Cocody Mermoz, Abidjan, Côte d'Ivoire, 08 BP 2823 Abidjan 08

ABSTRACT

Thirty accessions of tomato including twenty eight introduced accessions from The World Vegetable Center-AVRDC and as controls, two commercial varieties Mongal and Calinago, were assessed for agronomic performances at the Experimentation and Production Station of Anguédédou of the National Agronomic Research Centre (CNRA) located in the South of Côte d'Ivoire. The trial was arranged in a randomized block with three replications. The following parameters were determined at vegetative development stage: plant height at flowering stage, susceptibility of accessions to diseases, day to 50% flowering and day of first harvest, production duration, fruit length, fruit diameter, total number of fruits, number of fruits per plant, potential yield, net yield and fruit damage rate. Results showed that the commercial variety Mongal, with a potential yield of 15.9 and a net yield of 13.1 t ha^{-1}, was the most productive. All the introduced accessions from AVRDC recorded the lowest potential yields from 2.2 to 9.7 t ha^{-1}, and net yields from 1.7 to 8.6 t ha^{-1}. In addition, accessions WVCT8, FMTT847 and WVCT13 were severely infested by bacterial wilt. The reduction of the net yield of tomato accessions resulted in the high fruit damage rates. For the future tomato breeding work, it would be appropriate to introduce into the trials bacterial diseases tolerant varieties. Moreover, some studies could be undertaken to determine the nature of the bacteria involved in the plant wilting and to find out the causal agent of the tomato plants burning at the fructification stage reducing the harvest duration.

Indexing terms/Keywords

Tomato; *Solanum lycopersicum*; yield; diseases; Côte d'Ivoire.

Academic Discipline And Sub-Disciplines

Agriculture, Agronomy, Horticulture

SUBJECT CLASSIFICATION

Horticulture, genetic and plant breeding

TYPE (METHOD/APPROACH)

Original research work, Morphological screening, variety evaluation

Council for Innovative Research

Peer Review Research Publishing System

Journal: JOURNAL OF ADVANCES IN AGRICULTURE

Vol. 4, No. 3

www.cirjaa.com jaaeditor@gmail.com

ISSN 2349-0837

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the most consumed vegetable in the world. It is an annual plant that has a very varied range of applications both in food and medicine. It is also the most popular garden vegetable in the world [1] whose fruits consumption contributes to the human health [2]. The world production of tomato was about 164 963 770 tons in 2013 [3].

In tropical Africa, tomato yields are generally low with 8 t ha^{-1} compared to the average of 27 t ha^{-1} for the global crop yields recorded in 2001 [4]. There is a need to increase tomato productivity in sub-Saharan Africa in order to contribute to food security of the population.

In Côte d'Ivoire, tomato has an important place among vegetable crops grown for the fresh consumption. Unfortunately, national production of 34 734 tons in 2013 is still insufficient to meet the needs of the Ivorian population estimated at over 100 000 t year^{-1} [5].

Previous works have shown that the climate and soil were the main factors which favoured the parasite pressure and significantly limited the production of tomato in Côte d'Ivoire ([6], [7], [8]). In addition, there is a lack of good agricultural practices of production by farmers and especially the lack of suitable varieties of tomato. The most grown varieties were introduced and susceptible to local diseases in the field ([9], [10]). Therefore, the development of tomato cropping requires the selection of such varieties adapted to local conditions.

The new varieties or accessions obtained from the World Vegetable Center-AVRDC could therefore help to increase the genetic variability and facilitate the selection of varieties better adapted to local biotic stresses. This trial was set up to identify productive tomato accessions adapted to climatic conditions in the Côte d'Ivoire.

2. MATERIALS AND METHODS

2.1. Study site

Trials were conducted from August 2008 to February 2009 at the Experimentation and Productions Station of the National Agricultural Research Centre (CNRA) of Anguédédou (5°22 North Latitude, 4°8 West Longitude and 95 m of altitude). This site is located at 30 Km in the West of Abidjan on the Abidjan-Dabou road. Climatic data obtained from Adiopodoumé Research Station located about 7 km near Anguédédou were used.

2.2. Site characteristics

The soils of the region are classified as Ferralsols and Gleysols. The climate is bimodal regime with two rainy seasons (March to June and September to November) and two dry seasons (July-August and December-February) in Figure 1. By comparing the recorded monthly rainfall in 2008 than the average over the last ten years (1998/2007), it appears that the first season (March to June) was rainier. On the other hand, the short rainy season (September-November) was marked by deficits over the ten-year average (1998/2007) especially for the months of September, October and November. Only the month of December 2008 was wetter than ten-year average for the same month. This rainfall is also characterized by poor distribution per decades of the month (Figure 2). Minimum temperatures averages were ranged between 20 and 25°C and the maximum between 29 and 35°C (Figure 3). The air humidity (relative humidity) is consistently high above 79%. These relatively high climatic parameters during the year created favorable conditions to the fungal diseases and insect pest outbreaks.

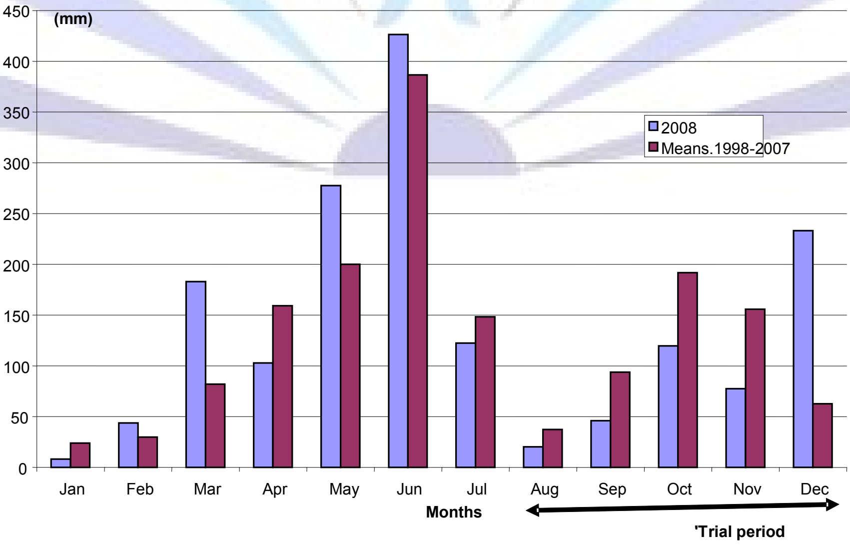

Figure 1: Monthly averages rainfall recorded in 2008 and average over the period of 1998-2007

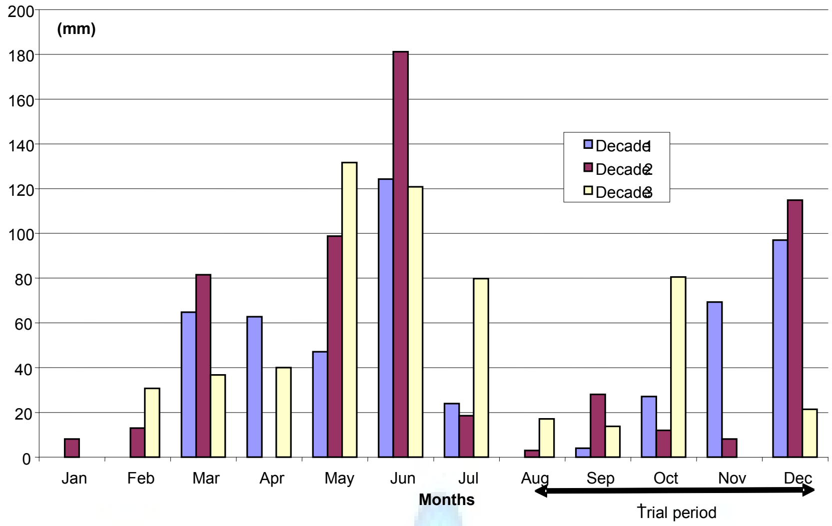

Figure 2: Distribution per decade of rainfall recorded in 2008 at the Station of Adiopodoumé

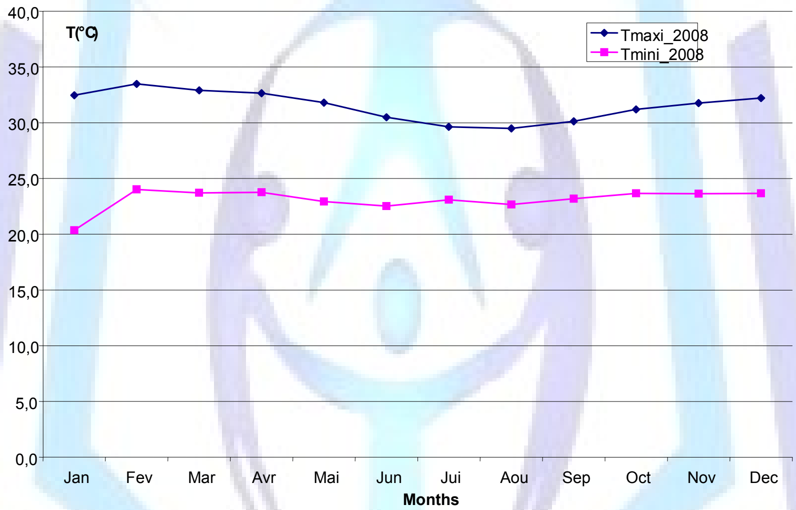

Figure 3: Maximum and Minimum temperatures recorded in 2008 at the Station of Adiopodoumé

2.3. Plant material

The trial involved 30 tomato accessions including 28 introduced varieties from AVRDC and 2 controls; Mongal and Calinago which are tomato varieties grown and marketed in Côte d'Ivoire (Table 1).

Table 1. List of evaluated accession of tomato

N°	Accession name	Origin
1	Mongal (Control 1)	Commercial variety
2	Calinago (Control 2)	Commercial variety
3	Tanya	AVRDC
4	Tengeru 97	AVRDC
5	Meru (LBR-19-20)	AVRDC
6	LBR-44-2	AVRDC
7	LBR-19-3	AVRDC
8	LBR-50-2	AVRDC
9	WVCT1	AVRDC
10	WVCT2	AVRDC

11	WVCT3	AVRDC
12	WVCT4	AVRDC
13	WVCT5	AVRDC
14	WVCT6	AVRDC
15	WVCT7	AVRDC
16	WVCT8	AVRDC
17	WVCT10	AVRDC
18	WVCT11	AVRDC
19	WVCT12	AVRDC
20	WVCT13	AVRDC
21	WVCT16	AVRDC
22	WVCT17	AVRDC
23	WVCT18	AVRDC
24	FMTT847	AVRDC
25	FMTT848	AVRDC
26	TLCV15	AVRDC
27	LBR-80-2	AVRDC
28	CLN2366C	AVRDC
29	CLN2366A	AVRDC
30	CLN1558A	AVRDC

2.4. Experimental design and cultural practices

The nursery was established on August 28th, 2008 on seedbeds (or nursery beds) of 4 m long and 1 m wide which have been disinfected with Furadan at 50 g per m². Fertilizer (NPK10-18-18) was applied at the rate of 20 g per m². Tomato seeds were sown in rows distant of 10 cm and 5 cm between the seed holes in the line. After sowing, the bed was covered with palm leaves for 3 days to favour the seeds germination before raising a shade up the beds for 3 weeks.

The experimental area has been cleared and manually ploughed of 30 cm dept. It has been enriched by 200 kg ha^{-1} of NPK10-18-18 and the soil was disinfected with Furadan at the rate of 20g/m². The plants were transplanted on September 22th, 2008 at 25 days after sowing in the nursery. The trial was arranged in a completely randomized block design with three replications. The basic plot consisted of 2 beds of 10m² (5m x 2m). The plants were transplanted in double rows with 1 m between rows and 0.5 m between plants in the line. During the trial, supplementary mixed manures of 100 kg ha^{-1} of urea and 100 kg ha^{-1} of potassium sulphate was applied at the second and fifth week after transplanting. Four phytosanitary treatments with Deltamethrin (1 l ha^{-1}) and Maneb (3.5 kg ha^{-1}) were performed. Six weeding were carried out to eliminate weeds.

2.5. Data collection

Data collection was focused on the following parameters: the behavior of accessions in nursery; vegetative development status on the scale of 1 to 5 (1 = very poor; 2 = poor; 3 = moderately good; 4 = good; 5 = very good) at 30 DAT (date after transplanting), plants height at the flowering stage sensitiveness of plants to diseases on a scale of 1 to 5 (1 = very poor; 2 = poor; 3 = moderately good; 4 = good; 5 = very good) at the stage of 30 DAT, flowering date, first harvesting date, last harvesting date; number of harvested fruits, number of healthy fruits and number of damaged fruits, length and diameter of the fruit; harvested fruits weigh, healthy fruits weigh and damaged fruits weigh.

2.6. Data analysis

All data collected were analyzed with the SAS software [11]. An analysis of variance was performed first. Then, the averages were separated by the method of Duncan's Multiple Range Test (DMRT) at 5% level.

ISSN 2349-0837

3. RESULTS AND DISCUSSION

3.1. Performance in nursery

The differential behavior observed among tomato accessions in the nursery can be explained by the difficulties of seed conservation of some accessions. Those, whose seeds have not germinated, would have lost their ability. On the over hand, for the second group, the seedlings have died after germination. Damping-off are often responsible for the mortality of tomato plants in a nursery. For the third group of tomato accession, seeds have well germinated and seedlings developed perfectly, these accessions could be considered to have good abilities in the nursery under the conditions of the study. Accessions of this group were therefore less susceptible to damping-off which is also a plague on tomato cropping system in hot and humid areas (Table 2).

Table 2. Distribution of accessions according to their behavior in nursery

Groups	Concerned accessions	Behavior in nursery
Group 1	LBR-50-2 LBR-80-2, CLN2366C, CLN2366A and CLN1558A	Seeds of these accessions have not risen at all
Group 2	Tanya, Tengeru 97, Meru (LBR-19-2), LBR-44-2, LBR-19-3, WVCT16, WVCT17 and WVCT18	Seeds germinated lower than 50%. But plants are not able to cover the 3 replications
Group 3	Mongal (Control 1), Calinago (Control 2), WVCT1, WVCT2, WVCT3, WVCT4, WVCT5, WVCT6, WVCT7, WVCT8, WVCT10, WVCT11, WVCT12, WVCT13, FMTT847 FMTT848 and TLCV15	Seeds of these accessions showed a germination rate upper than 80%. Plants were normal and have covered all 3 replications

3.2. Crop development and diseases sensitiveness

Evaluation of plant development at 30 DAT, showed that tomato accessions: Mongal (Control 1) WVCT2, WVCT3, WVCT7, WVCT8, WVCT10, WVCT13, WVCT12 and WVCT11, with an average score above 4 presented a better vegetative growth (Table 3). Accessions Calinago (Control 2) WVCT1, WVCT5, WVCT6, TLCV15, FMTT848 and FMTT847, with an average rating of 3 had a moderately better vegetative behavior. The WVCT4 accession, with an average score of less than 3 was less developed. At the flowering stage, there was a significant difference between the accessions for the plants height which varied between 43.3 cm (FMTT847, FMTT848) and 63.3 cm (WVCT1).

Regarding the susceptibility of accessions to diseases, WVCT10, WVCT11, FMTT848, TLCV15, WVCT1, WVCT3, WVCT6, WVCT5 and WVCT4, averaging a score of 4, were less attacked by diseases. Accessions Mongal (Control 1), Calinago (Control 2), WVCT12, WVCT7 and WVCT2, with a score of 3 were moderately attacked by the diseases. One the other hand, accessions WVCT8, FMTT847 and WVCT13, with an average of 2 have been severely attacked by the diseases dominated by the bacterial wilt which causes a sudden death of plant and the whole burning of plants at the stage of production due to bacterial canker resulting in the reduction of the plant cycle.

The difference between the vegetative developments of tomato accessions can be explained by the degree of adaptability of each accession to the study conditions. Accessions Mongal (Control 1) WVCT2, WVCT3, WVCT7, WVCT8, WVCT10, WVCT13, WVCT12 and WVCT11, which are better developed, could be considered to have supported the local climatic conditions. The least developed accessions were more susceptible to diseases; the most frequent were bacterial wilt (caused by *Ralstonia solani*) and the widespread burning of plants in fruiting stage [12]. *Corynebacterium michiganense* (responsible of bacterial canker) and *Xanthomonas vesicatoria* (bacterial gall) seem to be bacterial agents responsible of this widespread burning according to Ouédraogo (personal Communication). It would be interesting to conduct studies to characterize the strains of bacteria involved in the bacterial wilt and widespread burning of tomato plants at the Anguédédou Station.

3.3. Day of 50% flowering, day of first harvest, day to last harvesting production and production duration

Analysis of variance indicates that the difference between assessed tomato accessions was significant for the day of 50% flowering (P = 0.0004). The plants bloomed on average between 29 DAT (WVCT10 and Mongal) and 36 DAT (WVCT7). The first harvest took place about one month after flowering (Table 4). The harvest lasted between 16 days (WVCT1) and 21 days (Mongal). The crop cycle accessions lasted between 106 and 108 days after sowing.

The difference between the accessions for the day to flowering can be explained by the difference in their precocity which could be linked to their genotypes. In this study, variety Mongal has been harvested at 62 DAT. This result is similar to those obtained by [13]. Indeed, according to these authors, the variety of reference Mongal was earlier, with an average of 62 DAT which is less than the breeders data. The short duration of the harvest period is due to the development of diseases in fruiting stage that caused widespread burning plants. This shortening of the tomato cycle was already observed in previous trials of tomato at Anguédédou Station [8].

3.4. Fruits dimensions, total number of fruits and number of fruits per plant

The fruit had a flattened shape (Table 5). The lengths varied between 4.5 cm (FMTT848) and 5.6 cm (WVCT13). The diameter ranged from 4.4 cm (TLCV15) and 6.3 cm (WVCT13). The average fruit weight varied between 28.5 g (WVCT5) and 88.8 g (WVCT13).

The total number of fruits and the number of fruits per plant varied significantly depending on the tomato varieties (Table 6). With 38 and 2 fruits, accession WVCT13 obtained the lowest total number of fruits and the lowest number of fruits per plant. The commercial variety Mongal (control 1), with 279 and 14.6, produced the highest total number of fruits and the highest number of fruits per plant.

Table 3. Vegetative development status, plant height at flowering stage and sensitiveness of assessed tomato accessions to diseases

Accessions	State of vegetative development	Plant height at flowering stage	sensitiveness to diseases
Mongal (Control 1)	4.3 ab*	50 abc	3 a
Calinago (Control 2)	3.6 bcd	46.5 cd	3 a
WVCT1	3 de	63.3 a	4 a
WVCT2	4 abc	61.5 abc	3 a
WVCT3	4 abc	60.5 abc	4 a
WVCT4	2.7 e	47.7 bcd	4 a
WVCT5	3 de	58.8 abc	4 a
WVCT6	3 de	52.3 abcd	4 a
WVCT7	4 abc	58.5 abc	3 a
WVCT8	4.3 ab	58.4 abc	2 a
WVCT10	4 abc	61.7 ab	4 a
WVCT11	4 abc	56.8 abcd	4 a
WVCT12	4 abc	62.3 a	3 a
WVCT13	4.7 a	60.7 abc	2 a
FMTT847	3.3 cde	43.3 d	2 a
FMTT848	3 de	43.3 d	4 a
TLCV15	3.6 bcd	49.4 abcd	4 a
Means	3.7	51	3
Probability (%)	0.0001	0.01	0.49
CV (%)	12.8	13.8	29.3

*Means followed by the same letter in the same column are not significantly different at the 5% level

Table 4. Day to 50% of flowering, day to first harvest, day to last harvesting and production cycle duration

Accessions	Time of 50% flowering (DAT)	Time of first harvest (DAT)	Time production (D)	Duration of the crop cycle (D)
Mongal (Control 1)	29.3 e*	62 c	21 a	108 a
Calinago (Control 2)	33 abcde	64 abc	17 ab	106 a
WVCT1	32.3 abcde	65 abc	16 b	108 a
WVCT2	36 a	66 ab	17 ab	108 a
WVCT3	30 de	64 abc	19 ab	106 a

WVCT4	32 bcd	63 bc	18 ab	108 a
WVCT5	32.3 abcde	64 abc	19 ab	108 a
WVCT6	31.3 cde	63 bc	20 ab	108 a
WVCT7	36 a	66 ab	17 ab	108 a
WVCT8	34.7 abc	67 a	16 b	108 a
WVCT10	29.7 e	63 bc	20 ab	108 a
WVCT11	31.7 bcde	64 abc	19 ab	108 a
WVCT12	30.7 de	63 bc	20 ab	108 a
WVCT13	35 ab	66 ab	17 ab	108 a
FMTT847	33.7 abcd	66 ab	17 ab	108 a
FMTT848	35 ab	65 abc	18 ab	108 a
TLCV15	30.7 de	64 abc	19 ab	108 a
Means	32.6	64.4	18	107.6
Probability (%)	0.0004	0.075	0.26	0.60
CV (%)	5.9	2.6	13.2	1.3

*Means followed by the same letter in the same column are not significantly different at the 5% level

Table 5. Fruit dimensions

Accessions	Fruit length (cm)	Fruit diameter (cm)	Fruit mean weight (g)
Mongal (Control 1)	4.6 ab*	6 ab	57 bc
Calinago (Control 2)	5.04 ab	5.7 abc	87.5 a
WVCT1	4.9 ab	4.5 c	41.9 cd
WVCT2	5.5 ab	5.3 abc	56 bc
WVCT3	4.9 ab	4.6 bc	44.3 bcd
WVCT4	5 ab	4.7 bc	43.6 bcd
WVCT5	4.6 ab	4.6 bc	28.5 d
WVCT6	5.4 ab	5.5 abc	48.6 bc
WVCT7	4.6 ab	4.8 bc	44.3 bcd
WVCT8	5.5 ab	5.07 abc	62.9 b
WVCT10	5.4 ab	5.5 abc	52.2 bc
WVCT11	5.06 ab	5.3 abc	56.2 bc
WVCT12	5.03 ab	5.9 abc	41.6 cd
WVCT13	5.6 a	6.3 a	88.8 a
FMTT847	5.06 ab	5.8 abc	52.6 bc
FMTT848	4.5 b	4.6 bc	57 bc
TLCV15	4.9 ab	4.4 c	40.73 cd
Means	5.04	5.16	53.4
Probability (%)	0.29	0.05	0.0001
CV (%)	10.8	14	18.7

*Means followed by the same letter in the same column are not significantly different at the 5% level

Table 6. Total number of fruits and number of fruits per plant

Accessions	Total number of fruits	Number of fruits per plant
Mongal (Control 1)	279 a*	14.6 a
Calinago (Control 2)	51 gh	2.5 hi
WVCT1	107 defg	5.5 defgh
WVCT2	59 fgh	3 ghi
WVCT3	153 cd	7.6 cd
WVCT4	123 cde	6.6 cdef
WVCT5	72 fgh	3.8 fghi
WVCT6	146 cde	7.3 cde
WVCT7	80 efgh	4.1 efghi
WVCT8	51 gh	2.7 ghi
WVCT10	176 bc	9 bc
WVCT11	149 cd	7.7 cd
WVCT12	220 ab	11.8 ab
WVCT13	38 h	2 i
FMTT847	120 cdef	6 cdefg
FMTT848	89 efgh	4.8 defghi
TLCV15	240 a	12.3a
Means	126	6.6
Probability (%)	0.0001	0.0001
CV (%)	28	27.4

*Means followed by the same letter in the same column are not significantly different at the 5% level

3.5. Potential and net yields and fruit damage rate

The potential yield, net yield and rotten fruit rate varied significantly depending on the tomato varieties (Table 7). The commercial variety Mongal, with 15.9 and 13.1 t ha^{-1}, was the most productive. All the introduced varieties from AVRDC recorded the lowest potential and net yields (2.2 to 9.7 t ha^{-1} for the potential yield, and from 1.7 to 8.6 t ha^{-1} for the net yield). The best varieties from AVRDC were: TLCV15 (8.6 t ha^{-1} net yield), WVCT10 (7.7 t ha^{-1}) and WVCT12 (7.7 t ha^{-1}). The fruit rate was high and ranged between 9.9% (WVCT8) and 41.3% (WVCT4).

The potential yield recorded by tomato accessions was lower compared to those obtained by [13] at Mayotte on tomato with 21.3 t ha^{-1}. This result is related to susceptibility to diseases that have shortened the duration of the harvest. About the low level of net yield, it is linked to the high rate of damaged fruits (unmarketable fruits) registered by the tomato accessions. [10] confirmed similar results but yield obtained was higher at Bouaké in Côte d'Ivoire. The causes of these damages are multiple: apical rot, perforation by insects ([5], [10], caterpillar's presence in fruits, case of rot soft due to fungi, etc.

To improve the yield of tomato in the conditions of the Anguédédou Station, it would be appropriate to broaden the scope of the selection by integrating some tomato accessions tolerant to bacterial diseases.

Table 7. Potential yield, net yield and fruit damage rate

Accessions	Potential yield (t ha^{-1})	Net yield (t ha^{-1})	Fruit damage rate (%)
Mongal (Control 1)	15.9 a	13.1 a	17.1 bc
Calinago (Control 2)	4.6 defg	2.9 ef	38.1 ab
WVCT1	4.7 defg	3.8 def	16.9 bc
WVCT2	3.2 g	2.6 ef	19.8 abc
WVCT3	6.8 bcdef	4.9 cdef	20.3 abc
WVCT4	5.3 cdefg	3.1 ef	41.3 a
WVCT5	2.2 g	1.7 f	27.1 abc
WVCT6	6.6 bcdef	5.2 cdef	21.1 abc
WVCT7	3.7 g	3 ef	17.5 bc
WVCT8	3.1 g	2.8 ef	9.9 c
WVCT10	9.2 bc	7.7 bc	17 bc
WVCT11	7.8 bcd	6.5 bcd	16.9 bc
WVCT12	9.2 bc	7.7 bc	15.8 bc
WVCT13	3 g	2.6 ef	10.8 bc
FMTT847	7.4 bcde	5.5 bcde	27.8 abc
FMTT848	5.1 cdefg	3.7 def	30.6 abc
TLCV15	9.7 b	8.6 b	11.2 c
Means	6.3	5.04	21.1
Probability (%)	0.0001	0.0001	0.06
CV (%)	33.9	36.02	54.2

*Means followed by the same letter in the same column are not significantly different at the 5% level

4. CONCLUSION

It appears with this trial that the accessions LBR-50-2, LBR-80-2, CLN2366C, CLN2366A and CLN1558A have not raised in nursery. In the vegetative stage, accessions Mongal (Control 1), WVCT2, WVCT3, WVCT7, WVCT8, WVCT10, WVCT13, WVCT12 and WVCT11 were better developed. On the over hand, accessions WVCT8, FMTT847 and WVCT13 were severely infested by bacterial diseases. At the stage of fruiting, all accessions suffered from the widespread burning that shortened the plants cycle. Consequently, the number of harvests was reduced and the yield was low. The high fruit damage rates due to apical rot, insect's perforation, etc. contributed to further reduction of the tomato accessions net yields.

For the future the tomato breeding work, it would be appropriate to introduce into the plant material to be assessed, accessions tolerant to bacterial diseases. Furthermore, other studies should be conducted to characterize the nature of the bacteria responsible of tomato plant wilting and burning in field.

5. ACKNOWLEDGMENTS

The authors are grateful to AVRDC-The World Vegetable Center for supplying of seeds and providing financial support for this research.

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BIOGRAPHY OF THE CORRESPONDING AUTHOR

Dr, Jean-Claude N'ZI completed in 1998 his MSc Genetics and a PhD in 2010 in Genetics and plant improvement at the Félix Houphouët-Boigny University in Côte d'Ivoire. He worked on vegetables essentialy in tomato breeding. He conducted several trials in different localities of Côte-d'Ivoire to assess tomato varieties adapted to agroecological local conditions. His works approach also agronomic, epidemiological and molecular studies. His PhD doctorate thesis allowed him also to work on tomato breeding for resistance to tomato yellow leaf curl disease in Côte d'Ivoire.

Currently, Dr N'ZI Jean-Claude is a Researcher at the Félix Houphouët-Boigny University in Côte d'Ivoire in the Laboratory of Genetics. He is also a Research Scientist at the International Centre for Research in Agroforestry (ICRAF), Côte d'Ivoire Country Programme where he works in the ICRAF/Mars project to implement Research & Development that deliver progress against the Germplasm result framework for revitalization of cocoa orchards.