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FRUIT YIELD AND JUICE QUALITY ATTRIBUTES OF SIX EXOTIC TOMATO INTRODUCTIONS UNDER DIFFERENT CROPPING SYSTEMS IN THE SOUTHERN GUINEA SAVANNA OF NIGERIA

Olaoye, G., *Takim, F.O. and Bankole, F.
Department of Agronomy
University of Ilorin
P.M.B. 1515, Ilorin, Nigeria

ABSTRACT

Germplasm evaluation for yield, quality and general adaptation is prerequisite to their utilization either for direct cultivation or as parent in a breeding programme for development of future cultivars. To this end, six tomato introductions were evaluated at the Teaching and Research farm of the University of Ilorin in the southern Guinea savanna agro-ecology of Nigeria (Lat 8^0 $29^{'}$ N and Long 4^0 $35^{'}$ E) in replicated trials, under varying N-Fertilizer rates and irrigation treatments. The objectives were to determine the optimum N rate for tomato yield in the ecology and also identify those that could be used either as cultivars per se or as parents for the development of productive tomato varieties for the diverse ecosystems of the Nigeria Guinea savanna. Results from the study showed that increase in N-Fertilizer rate delayed transition to reproductive stage with corresponding high fruit yields. Fruit yield in the genotypes increased with increasing N-Fertilizer rate up to 60kgN/ha^{-1}. The differences between fruit yield at this optimum rate (60kgN/ha^{-1}) and other dosages (0, 30 and 90kgN/ha^{-1}) were 8, 6 and 3 tons/ha^{-1} respectively which translated to 33.3, 25 and 12.5% yield advantage. Post-anthesis moisture deficit resulted in delayed flowering and ripening of fruits as well as low fruit yield compared to well-watered condition. Three accessions (MBWT-1, Manuella and Roma) yielded significantly higher than others at the optimum N rate of 60kgN/ha^{-1} while two other accessions (CLN 1462-B and Periodontal) were superior to others when subjected to post-anthesis moisture deficit condition. However, genotypes with low mean productivity and geometric mean productivity exhibited very high tolerance to post-anthesis moisture deficit condition and so suffered the least injury (%). This observation tends to suggest that different pathways govern yield potential and moisture deficit tolerance in the tomato genotypes evaluated.

Key Words: Fruit yield, Lycopersicon escullentum L., N-Fertilizer, Post-anthesis moisture deficit, Well-Watered

****Corresponding author's Address: e-mail: felixtakim@yahoo.co.uk***

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop worldwide. In Nigeria, commercial tomato production relies mostly on exotic introductions, the production of which is essentially restricted to the northern Guinea savanna and the Sudan ecologies due to favourable climatic conditions, particularly high insolation and low relative humidity. However, because of its nutritive and commercial values, production of exotic tomatoes has also spread to the Southern and Derived Guinea Savanna ecologies where hitherto, the traditional varieties are produced. Consequently, it has almost replaced the traditional varieties of the southwest Nigeria.

Presently, there are tomato cultivars and hybrids which can be cultivated in climate different from the site of origin and which could also serve as sources of genes for improvement of adapted varieties. However, commercial cultivation of tomatoes in Nigeria exhibits seasonality with much of the production concentrated in the relatively cool and dry period under irrigation or in the 'fadamas'. Furthermore, yields of the introductions in the tropics are generally low compared with yields obtainable in the temperate region (McGraw *et al*., 1987; Anon. 1992; Surya, 1993). This has been attributed to several factors including high temperatures, high humidity, excessive rainfall (Opena *et al*., 1989), diseases and insect pests (Tee *et al*., 1979; Ma, 1985), lack of appropriate varieties (Villareal, 1979) and unsuitable cultural practices (žnidarčič *et al*., 2003). This underscores the importance of developing productive varieties for each of the different tomato growing ecologies in Nigeria.

The southern Guinea savanna (SGS) of Nigeria is suitable for tomato production because of high solar radiation and favourable temperature during the growing season. However, the zone is also characterized by moisture stress occasioned by erratic rainfall distribution, fragile soils with poor moisture holding capacity and low organic matter content especially nitrogen (N).Thus, apart from high yield potential, an ideal tomato variety for the ecology should also possess attributes such as drought tolerance, resistance to pest an diseases infestation as well as general adaptation to prevailing environmental conditions in the ecology.

Improved fruit quality as a major objective of tomato breeding programmes in developed countries, has been achieved through introgression of genes for adaptation and resistance to pest and diseases from the cherry tomatoes to cultivated species (Opena et al., 1992; David, 2002; Faria et al., 2003). However, while exotic tomato varieties as source of germplasm can similarly be exploited for improvement of cultivated va rieties in Nigeria, it is necessary to first assess them for fruit yield and quality attributes. Since tomato yield and biomass growth are closely linked to environmental, pedologic and climatic conditions (Maršić et al., 2005), the study reported herein was therefore undertaken to assess the (i) performance of six tomato introductions under different N-fertilizer rate and (ii) determine their response to induced post-flowering moisture deficit condition.

MATERIALS AND METHODS

Description of experimental materials

The materials used comprised five exotic tomato introductions (MBWT-1, MBWT-6, CLN1462-B, Periodontal and Manuella) and a standard check (Roma). The varieties were obtained from the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan, Nigeria.

Experimentation

Two separate studies were carried out at the Teaching and Research Farm, University of Ilorin (Lat. 8° 29'N & 8° 30'N; Long. 4° 30'E & 4° 32'E), Nigeria between April, 2010 and March 2011 respectively. The soil has been characterized as an alfisol with low inherent fertility status (0.14% Total N, 2.28% Organic matter, 0.28 cmol/kg Na, 0.45 cmo/kg K, 6.50 mg/kg available P, 1.12 cmol/kg Mg, 3.10 cmol/kg Ca and pH of 5.5).

Raising of seedling in the Nursery

Seedlings were first raised on nursery beds containing pulverized soil mixed with organic matter and maintained for three weeks after sprouting before transplanting to the field. The seedlings were thoroughly watered one (1) day before transplanting to the field and only healthy seedlings were used in order to ensure uniformity and avoid any bias to outcome of the studies.

Experiment I

The first study investigated the response of the varieties to four levels of N-fertilizer (0, 30, 60 and 90 kg N/ha^{-1}), during the 2010 full growing season and 2011 irrigated season respectively. The experiment was laid out each season as a randomized complete block design (RCBD) in a split plot arrangement with nitrogen (N) as the main plot and variety as the sub-plot. Each variety was replicated twice within N-fertilizer regime. The plot size was (1.8 x 4.8) m^2 with a spacing of 0.6m between and 0.40m within the rows. N-fertilizer 20-10-10 was used as the N-source and assigned to each treatment based on the results of soil test except that the control plots only received a basal application of P and K.

Data were collected on whole plot basis on days to first and 50% flower appearance (number of days from transplanting to the period when the first flower appeared in a plot and when half of the plants in a plot produced flowers respectively), plant height at first flower appearance (cm), days to first and 50% fruit appearance (number of days from transplanting to the period when the first fruit appeared in a plot and when half of the plants in a plot produced fruits), days to first and 50% fruit ripening (number of days from transplanting to the period when the first fruit ripened in a plot and when half of the plants in a plot produced ripened fruits). Others included numbers of fruits/pedicel, number of fruits/plant, total number of fruits/plot and fruit weight (kg).

Experiment II

In the second study, the varieties were exposed to two irrigation treatments (well-watered and post-anthesis drought moisture deficit condition). Healthy seedlings obtained from the nursery were also used for the study. The trials were laid similar to the N-fertilizer trial with irrigation treatment as main plot and varieties as the sub-plot. N-fertilizer 20-10-10 at the rate of 60kgN/ha^{-1} was first applied immediately after transplanting and the second dose after irrigation was resumed. One of the blocks hereafter referred to as well-watered condition, continued to receive irrigation throughout the duration of the study until maturity. In the second block, drought stress was imposed by withdrawing irrigation for four weeks when 50% of the plants have flowered and resumed thereafter. Cultural practices and data collection were similar to that of Experiments I except that quantitative tolerance index parameters were computed according to Rosielle and Hambling (1981) as follows: Tolerance index (TI) = $Y_p - Y_s$; Mean productivity (MP) = $(Y_p - Y_s)/2$; Geometric mean productivity (GMP) = $\sqrt{[(Y_p)(Y_s)]}$ and Percent injury (%I) = $\{(Y_p - Y_s)/ Y_p \times 100\}$ where

Y_p = mean trait performance under well-watered condition and

Y_s = mean trait performance under moisture deficit

RESULTS

Response of tomato genotypes to N-fertilizer application

The results from the analysis of variance showed significant effect ($P \leq 0.05$) of season on the expression of horticultural characters and fruit yield except days to flowering and first fruit appearance (Table 1). Days to flowering and fruiting were earlier under irrigation compared to the late growing season. However, fruit yield was significantly higher under irrigation by two (2) tons/ha^{-1} compared to the late cropping season representing 9.52 percent (%) yield advantage.

Table 1: The main effects of Season, Nitrogen level and Genotype for horticultural characteristics and fruit yield in six tomato introductions (Ilorin, Nigeria).

Season	Days to first flower appearance	Days to 50% flowering	Days to first fruit appearance	Days to 50% fruit appearance	Days to first fruit ripening	Fruit yield (t/ha^{-1})
2010 late	28	41	41	43	86	19
2011 Irrigation	27	40	32	42	84	21
S.E.$\pm$	0.029	0.088	5.690	0.059	0.044	0.7
0	23	34	27	39	79	16
30	25	39	30	42	79	18
60	28	41	34	42	86	24
90	34	47	53	49	96	21
S.E.$\pm$	0.390	0.402	8.080	0.712	0.274	3.3
Genotype						
MBWT-6	28	40	32	42	86	15
Manuella	28	40	32	42	85	17
CLN 1462-B	28	41	33	42	84	16
Periodontal	27	40	32	43	85	25
MBWT-1	27	41	32	43	85	23
Roma (Check)	28	41	42	47	85	23
Mean	28	40	36	43	85	20
S.E.$\pm$	0.395	0.524	9.710	0.362	0.412	4.2
Season (S)	7.04	5.04	1785.0	15.04*	61.76*	53.6*
Error A	0.04	0.38	1552.0	0.17	0.09	23.9
Nitrogen (N)	573.6**	676.82**	3055.0	41.38**	1502.8**	301.9*
S x N	7.04	5.04	1785.0	1.54	61.76**	642.3
Error B	3.65	3.88	1567.0	12.16	1.80	267.4
Genotype (G)	1.00	3.32	1601.0	3.14	3.54	308.9*
S x G	0.02	0.22	1498.0	0.27	3.09	225.1
N x G	19.29**	6.96	1584.0	5.08*	5.25	386.5
S x N x G	0.02	0.22	1498.0	0.28	3.09	262.0
Error C	2.5	4.4	1508.0	2.10	2.72	279.3
%CV	5.7	5.2	106	3.4	1.9	84.3

**; Significant F-test at 0.01 level of probability.

Application of N-Fertilizer produced significant effect (0.05< P 0.01) on all the characters measured except days to first fruit appearance (Table 1). Days to flowering and fruiting were earlier at lower dosages of N-Fertilizer (0 and 30 kgN/ha^{-1}) which is indicative of the plants adjusting to stress induced by nutrient deficiency, thus attempting to complete life cycle than when grown under adequate nutrient availability (60 and 90 kgN/ha^{-}1). Fruit yield increased with N-fertilizer application up to 60kgN/ha^{-1} and declined thereafter. For example, differences between fruit yield at the optimum rate (60kgN/ha^{-1}) and yields at other rates (0, 30 and 90kgN/ha^{-1}) were 8, 6 and 3 tons/ha^{-1} which represented 33.3, 25 and 12.5% yield advantage respectively.

Although the accessions were similar for expression of horticultural characters, Periodontal and MBWT-6 attained flowering earlier than other genotypes by one (1) day (Table 1). Response of the tomato introductions across N-Fertilizer application, revealed that Periodontal produced significantly higher fruit yield than three other accessions (MBWT-6, Manuella and CLN 1462-B) but similar to fruit yields recorded for MBWT-1 and Roma (Check). Differences in fruit yield between Periodontal and the three lowest yielding accessions were 10, 9 and 8 tons/ha^{-1} which translates to 40, 36 and 32% yield superiority respectively. Furthermore, the three highest yielding genotypes - Periodontal, MBWT-1 and Roma produced fruit weight that was higher than the overall mean yield by between three (3) and five (5) tons/ha^{-1}.

The interaction effects of season and N-fertilizer rate was significant only for days to first fruit ripening (Table 2). Similar days were observed across all levels of N-fertilizer except at the highest rate (90kgN/ha^{-1}) where the crops under irrigation attained fruit ripening by seven (7) days compared to fruiting during late season.

Nitrogen x genotype interaction effects were significant ($P \leq 0.05$) for days to flower and fruit appearance (Table 3). CLN 1462-B attained first fruit ripening across N-fertilizer levels earlier than others but was, similar to Manuella and MBWT-6. Increase in dosages of N-fertilizer delayed the expression of tomato horticultural characters. MBWT-6 produced the first flower later under the highest level of N-Fertilizer by 14, 12 and 6 days respectively compared to 0, 30, and 60 kgN/ha^{-1} respectively. Manuella flowered four (4) days later at in 0 kgN/ha^{-1} compared to Roma and MBWT-6, MBWT-1 on the other hand, flowered four (4) days later than Roma

Table 2: Means for Season x Nitrogen and genotype x nitrogen interaction effects for days to fruit ripening, flower and fruit appearance in six tomato introductions (Ilorin, Nigeria).

	Days to first fruit ripening			
	0Kg N/ha^{-1}	30Kg N/ha^{-1}	60Kg N/ha^{-1}	90Kg N/ha^{-1}
Season				
2010 late	79	79	86	99
2011 irrigation	79	79	86	92
S.E.±		0.388		
.	Days to first fruit ripening			
	0Kg N/ha^{-1}	30Kg N/ha^{-1}	60Kg N/ha^{-1}	90Kg N/ha^{-1}
Genotype				
MBWT-6	79	80	86	98
Manuella	79	78	86	96
CLN 1462-B	79	79	86	95
Periodontal	80	81	88	94
MBWT-1	80	78	88	95
Roma (Check)	80	77	87	96
SE±		0.824		

Table 3: Means for Nitrogen and genotype interaction effects for days to flower and fruit appearance in six tomato introductions (Ilorin, Nigeria)

.	Days to first fruit appearance			
	0Kg N/ha^{-1}	30Kg N/ha^{-1}	60Kg N/ha^{-1}	90Kg N/ha^{-1}
Genotype				
MBWT-6	40	39	42	48
Manuella	41	38	42	49
CLN 1462-B	40	39	42	49
Periodontal	39	42	42	50
MBWT-1	39	39	44	50
Roma (Check)	39	39	42	49
SE±		0.724		
.	Days to first flower appearance			
	0Kg N/ha^{-1}	30Kg N/ha^{-1}	60Kg N/ha^{-1}	90Kg N/ha^{-1}
Genotype				
MBWT-6	22	24	30	36
Manuella	26	25	30	32
CLN 1462-B	23	27	27	35
Periodontal	25	22	27	36
MBWT-1	23	28	27	33
Roma (Check)	22	24	31	34
SE±		0.791		

Table 4: Effects of moisture stress on horticultural characters and fruit yield in six tomato introductions (Ilorin, Nigeria).

	Days to						
	First flower appearance	50% flowering	100% flowering	First fruit appearance	First fruit ripening	Fruit yield (t/ha^{-1})	Total soluble solids
Moisture regime							
Normal watering	19	24	39	23	60	15.56	11
Post-anthesis stress	21	29	41	27	64	8.74	11
Mean	21	26	41	25	62	11.65	11
SE±	0.17	0.67	0.08	0.34	0.25	3.75	0.67
Genotype							
MBWT-6	22	28	42	29	65	11.51	12
Manuella	22	27	41	25	63	7.60	9
CLN 1462-B	22	26	40	24	62	12.39	11
Periodontal	20	25	39	24	59	17.03	11
MBWT-1	21	27	41	26	63	11.12	11
Roma (Check)	21	26	41	25	61	10.25	11
SE±	0.77	0.52	0.54	0.55	1.16	2.46	0.48
F-Test							
Replicate	1.5	0.17	2.04	0.01	0.04	362.24	0.01
Moisture regime	140.7*	192.7*	70.04*	96.0*	126.04*	2030.57*	0.67
Error A	0.17	2.67	0.04	1.5	0.38	8469.09	2.67
Genotype	3.27*	6.07*	5.44**	10.87**	15.44**	3853.52*	2.47
Error B	1.18	0.53	0.58	1.20	2.69	1207.92	0.91
%CV	5.1	2.8	1.9	4.3	2.7	29.8	8.9

*, **; Significant F-test at 0.05 and 0.01 levels of probability respectively.

Table 5: Moisture stress tolerance index in six tomato introductions (Ilorin, Nigeria).

Genotype	Mean productivity	Tolerance index	Geometric mean productivity	% Injury
MBWT-6	207.0	415.0	2.74	39.1
Manuella	301.0	89.0	2.22	66.0
CLN 1462-B	44.0	601.0	0.99	1.4
Periodontal	465.0	299.0	1.53	51.8
MBWT-1	217.0	433.0	1.02	42.9
Roma (Check)	22.0	44.0	1.03	0.6
Mean	209.0	314.0	1.59	33.6
SE±	91.0	220.5	0.619	15.12
F-Test				
Replicate	219270.0	328286.0	4.08	5489.1
Genotype	54302.0	92288.0	1.09	1447.4
Error	16559.	97229.0	0.77	457.2
%CV	61.5	99.4	55.1	63.6

Table 6: Fruit yield (t/ha-1) in six tomato introductions under different N-Fertilizer rates and moisture treatment (Ilorin, Nigeria).

	N-Fertilizer rate (kgN/ha^{-1})				Moisture regimes	
Genotype	0	30	60	90	Normal watering	Post-anthesis stress
MBWT-6	4.42	11.48	11.63	8.25	14.39	8.63
Manuella	6.59	10.34	13.44	6.82	11.78	3.42
CLN 1462-B	4.09	10.78	11.13	9.30	13.00	11.77
Periodontal	3.39	11.94	11.29	9.55	23.49	10.57
MBWT-1	5.15	12.31	15.79	9.67	14.13	8.11
Roma	4.19	12.27	13.28	10.46	10.56	9.94
Mean	4.64	11.52	12.76	9.09	14.56	8.74
Sed	1.8×10^{-3}				2.2×10^{-4}	

and MWBT-6 at 30 kgN/ha^{-1} three genotypes - CLN 1462-B, Periodontal and MBWT-1 attained flowering phase the same day at 30kgN/ha^{-1} which was significantly lower to the days obtained from other genotypes at 90 kgN/ha^{-1}. Manuella and MBWT-1 had relatively lower days to first flower appearance followed by Roma and CLN 1462-B while MBWT-6 and Periodontal had significantly higher days to first flower appearance. A similar trend was observed for first fruit appearance.

Response of tomato genotypes to different moisture condition

The effects of post-anthesis moisture deficit on horticultural characters and fruit yield in the tomato introductions are presented in Table 4. Moisture regimes had significant effect ($P \leq 0.05$) on all the traits investigated except total soluble solids (TSS). Differences between normal watering (IR) and post-anthesis moisture deficit (MS) conditions were high for many of the traits with moisture deficit resulting in delay to attain flowering and consequently, a significant reduction in fruit yield of about 5.82 tons/ha $^{-1}$ representing 40 percent (%) yield advantage over moisture deficit condition.

The genotypes also differed significantly ($P \leq 0.05$) for all the traits except for total soluble solids (Table 4). CLN 1462-B and Periodontal were the earliest to attain first fruit production while MBWT-6 was the latest. Periodontal and CLN 1462-B yielded significantly higher than other introductions when mean yields were averaged across moisture regimes. The yield advantage over the other introductions ranged between 4.73 and 9.43 tons/ha^{-1}. The difference between the two introductions and Manuella which is the lowest yielding genotype were 9.43 and 4.79 tons/ha^{-1} which represents 55.37% and 38.66% yield advantage respectively. However, the other genotypes were similar for fruit production. Manuella showed extreme sensitivity to induced post-moisture deficit condition by producing a significantly lower fruit yield than the overall mean (4.1 tons/ha^{-1}). MBWT-6 had the highest TSS but which was statistically similar to values obtained in respect of other varieties.

Although the tomato introductions were similar with respect to moisture deficit tolerance parameters (Table 5), different genotypes exhibited superiority for each of the moisture deficit tolerance indices. Periodontal with the highest fruit yield (Table 4) also had the highest value for mean productivity followed by Manuella and MBWT-1 in that order. Another high yielding genotype (CLN 1462-B) with the lowest mean productivity and geometric mean productivity exhibited very high tolerance to post-anthesis moisture deficit condition and so suffered the least injury (%). This observation tends to suggest that different pathways govern yield potential and moisture deficit tolerance in the tomato genotypes evaluated. Conversely, Manuella with high mean productivity had low tolerance index as well as high geometric mean productivity with corresponding highest level of injury.

The response of the tomato introductions to varying N-Fertilizer rates and moisture regimes are presented in Table 6. Fruit yield increased with increasing N-Fertilizer rate up to 60kgN/ha^{-1} in all the genotypes and decreased thereafter, indicating that beyond that rate is luxury consumption. MBWT-1, Manuella and Roma in that order were the highest yielding genotypes at that optimum N-Fertilizer rate with a difference of over 2 tons/ha^{-1} between them and CLN 1462-B which was the lowest yielding accession at that rate.

Under post-anthesis moisture deficit condition, CLN 1462-B which responded poorly to N-Fertilizer and Periodontal were the highest yielding accessions having yielded higher by 8.35 and 7.13 tons/ha^{-1} respectively than Manuella which showed extreme sensitivity to post-anthesis moisture deficit condition.

DISCUSSION

In this study, delay in flowering and fruiting which was also accompanied by significantly higher fruit yield was observed in the tomato introductions grown under irrigation compared to the late season cropping. This could be attributed to the existence of favourable environmental conditions in terms of continuous supply of moisture throughout the growth and reproductive periods of the crops during the irrigation season as compared to the late season cropping which is often characterized by erratic rainfall distribution in the SGS ecologies of Nigeria. Previous report (Birhanu and Tilahun, 2010) has shown that irrigation treatment positively influenced tomato productivity by more than 100 percent (%) for well-watered condition compared to 75% deficit irrigation.

Increase in N–Fertilization also resulted in increased fruit yield in the tomatoes up to the optimum dose of 60kgN/ha^{-1}. This shows that the economic yield in tomato especially in the SGS can be attained at this level and beyond this dosage represents luxury consumption. Balemi (2008), also noted that increase in tomato fruit yield of 80.5 kg/plot^{-1} was recorded with the optimal application of 110 kg N + 120 kg P_2O_5/ha^{-1} as compared to the application of 50 kg N + 60 kg P_2O_5/ha^{-1} which gave a total fruit yield of only 66 kg/plot^{-1}. Adekoya and Agbede (2009) in their own study conducted in the southwest rainforest ecology of Nigeria also reported similar increase in tomato yield in response to increase in N-Fertilizer dosages.

Yield per unit area at a fixed plant density is a function of harvested number of fruit per plant and average fruit weight, which often is determined by the inherent genetic potential of the individual varieties. Periodontal exhibited superiority for fruit yield under N-Fertilizer regime as well as when yields were averaged across moisture regimes, indicating that the accession has the potential as a cultivar *per se* and also a source of genes for the development of high yielding tomatoes which may be targeted to both favourable and less favourable environments in tomato production in the Nigeria's savannas. CLN 1462-B on the other hand, combined high yield potential along with high stress tolerance by having the lowest injury index. This also suggests that it is a good parent material for the development of moisture stress tolerant genotypes.

Conclusion

The yields obtained in this study under the different cropping systems are higher than 10 tons/ha^{-1} previously reported for Nigeria (Anon., 1993), which has been attributed to low soil fertility and soil management practices (Adekoya and Ojeniyi, 2002). This is because all the tomato introductions had yields that were either similar or higher than previously reported. With regards to optimum fertilizer rate for tomato production in this ecology, 60kgN/ha^{-1} N-rate *gave the highest yield in the tomato introductions, implying that this rate is the optimum for fruit yield in the SGS of Nigeria. Three accessions - MBWT-1, Manuella and Roma in that order were the highest yielding genotypes at the optimum rate of 60kgN/ha^{-1} with a over 2 tons/ha^{-1} higher than CLN 1462-B which was the lowest yielding accession at that rate. Under post-anthesis moisture deficit condition, accession CLN 1462-B which responded poorly to N-Fertilizer and Periodontal were the highest yielding accessions with a difference of 8.35 and 7.13 tons/ha^{-1} respectively over Manuella which showed extreme sensitivity to post-anthesis moisture deficit condition. Previous report (Birhanu and Tilahun, 2010) has shown that irrigation treatment positively influenced tomato productivity by more than 100 percent (%) for well-watered condition compared to 75% deficit irrigation. It therefore follows that MBWT-1, Manuella and Roma which performed well at 60kgN/ha^{-1} N rate can be used for direct cultivation in this ecology while accessions CLN 1462-B and Periodontal could be utilized in breeding programme for the development of moisture tolerant tomato varieties.

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