Research Article

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Evaluation of African oil palm germplasm for drought tolerance

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Abstract

A field experiment was conducted at ARS Campus, Gangavati, University of Horticultural Sciences, Bagalkot to evaluate the oil palm genotypes for drought tolerance under medium black soils of Tungabhadra Command area of Karnataka. Nine oil palm genotypes were collected from Zambia and Tanzania for drought tolerance studies under rainfed conditions. The genotype ZS-3 recorded significantly higher fresh fruit bunch (FFB) yield 7.0 t ha^{-1} over Z-6, ZS-8, ZS-8, ZS-9, TS-5 and TS-7. Number of bunches were significantly higher in the genotypes ZS-3 (4.4) followed by ZS-1 (4.1) and ZS-9 (4.0). Bunch weight was significantly higher in the genotype ZS-3 (11.2 kg $bunch^{-1}$) followed by ZS-5 (10.8 kg $bunch^{-1}$) and ZS-6 (9.4 kg $bunch^{-1}$). The number of fruits per bunch was significantly higher in the genotype ZS-8 (3031) over all other genotypes. The number of male inflorescence was lower with the genotype ZS-5 and TS-5 (7.8 and 8.0 respectively). The number of female inflorescence was higher with the genotypes ZS-3 and TS-5 (7.0 and 7.0, respectively). Per cent sex ratio was higher with the genotype TS-5 and ZS-5 (46.2 and 44.8, respectively). The genotype ZS-1 and ZS-5 recorded higher annual leaf production of 21.4 and 20.3, respectively. The genotype ZS-1 recorded significantly lower number of leaf scorched per palm of 2.2 over other genotypes but it was on par with genotype ZS-3 (3.6). The data on various physiological and biochemical parameters revealed that the genotype ZS-1 and ZS-3 recorded higher relative water content, lower electrolyte leaching and significantly lower peroxidase activity indicating relatively more stress tolerant than other tested genotypes.

Keywords: Drought tolerance, genotypes, oil palm

Introduction

Oil palm, the present and future vegetable oil economy of the world, has good consumer acceptance as cooking medium because of its price advantage. Palm oil contains α carotene and β carotene and tocopherols and tocotrienols. ‘Palm olein’ is balanced oil with respect to saturated and unsaturated fatty acid contents and helps increasing HDL cholesterol and lowering LDL cholesterol. Palm oil reduces tendency for blood to clot and behaves as a powerful antioxidant.

The demand for edible oil is expected to increase to 21.3 million tonnes by 2015. The world production of palm oil is set to increase to 35 million tonnes at the rate of 2.8 per cent growth rate per annum. Based on the growth rate of 2.3 per cent per annum, palm oil production is projected at 49 million tonnes (as per FAO perspective). During 2008-09, the per capita consumption of edible oils by an average Indian was only 14 kg, which is lower than the recommendations of World Health Organization and much lower than the world per capita consumption (23.89 kg). In India, these factors coupled with growing population lead increasing per capita consumption and will push the vegetable oils and fats requirement to higher levels in the years to come. Oil palm could be a potential crop to meet the future demands of edible oil.

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In India it is being grown under non-traditional climatic conditions like high temperature, low humidity and less number of rainy days. It is therefore necessary to develop oil palm varieties which have high water use efficiency coupled with high temperature tolerance. Hence, an experiment was initiated with the objectives of screening of African oil palm germplasm for drought tolerance and selecting potential dura mother palm(s) for further hybridization programmes.

Materials and methods

A field experiment was conducted at ARS Campus, Gangavati, University of Horticultural Sciences, Bagalkot to evaluate the oil palm genotypes for drought tolerance under medium black soils of Tungabhadra Command area of Karnataka. The mean rainfall of the station for a period of 26 years was about 520 mm distributed over 35-36 rainy days. The maximum temperature was observed in the month of May (36.7 ^{o}C) and minimum temperature was in the month of December (12.8 ^{o}C) and relative humidity was higher in the month of August (83%) and lowest in the month of February (71%). Nine oil palm genotypes were collected from Zambia and Tanzania *viz.* ZS – 1, ZS – 3, ZS – 5, ZS – 8, ZS – 6, ZS – 9, TS – 4, TS – 5 and TS - 7 and planted in RBD design with three replications during October 1998. The palms were raised under rainfed conditions. The soil of the experimental site was medium deep black clay in texture and the fertility status of the soil was 200:33:698 kg of N:P_2O_5:K_2O per ha. Palms were planted in hexagonal method at a spacing of 9 x 9 x 9 m.

Removal of male and female inflorescence (Ablation) during the initial three years was done to promote palm girth. Pollinating weevils (*Elaedobius camerunicus*) were released during later years to enhance pollination and fruit setting. Regular yield was collected from fourth year onwards. Data on rate of leaf production, number of bunches per palm, bunch weight and fresh fruit bunch (FFB) yield, relative water content, electrolyte leaching and lipid peroxidation were recorded and statistically analyzed.

Relative water content

Relative water content was measured according to Gonzalez and Gonzalez-Vilar (2001). Leaf discs from three middle leaflets were collected and immediately weighed to obtain fresh weight. They were subsequently immersed in deionised water overnight at 4 °C. The next day, leaf discs were reweighed after blotting and then dried to obtain dry weight. Relative water content (RWC) was obtained as follows:

RWC= (FW-DW)/ (SW-DR) x 100;
where, FW = fresh weight, DW = dry weight, SW = water saturated weight

Electrolyte leaching

Relative electrolyte leakage (%) was determined according to the Dionisio-Sese and Tobita, (1998). Leaf tissue (100 mg) was incubated in distilled water at 25 °C for 2 hr in test tubes and initial conductivity (E1) of the bathing medium was measured. The tubes were boiled for 30 min to release all the electrolytes and cooled to 25 °C. The conductivity (E2) was measured and the electrolyte leakage was calculated as follows:

REL = (E1/E2) × 1000.

Lipid peroxidation

Lipid peroxidation was estimated by determining the malondialdehyde (MDA) contents in the leaves according to method of Rajinder *et al.* (1981) and the MDA concentration was determined using the extinction coefficient 155 mM^{-1} cm^{-1}.

Results and discussion

Morpho-physiological parameters

The annual leaf production did not differ significantly among the various genotypes (Table 1). Significant variation was observed for leaf scorching per palm, drying of FFBs per palm and number of leaf drooping per palm. The genotype ZS-1 recorded significantly lower number of leaf scorched per palm of 2.2 over other genotypes but it was on par with genotype ZS-3 (3.6). The genotype ZS-6 recorded significantly lower number dried FFB per palm over TS-5 and TS-7. The genotype ZS-1, ZS-3 and ZS-8 recorded significantly lower number of leaf drooping per palm of 0.2 each over ZS-5 (2.2).

Inflorescence production

There was no significant difference for number of male and female inflorescence and sex ratio among different genotypes (Table 1).

Table 1. Inflorescence production and morpho-physiological parameters as influenced by drought in oil palm genotypes during the year 2011

Genotypes	Male inflorescence	Female inflorescence	Total inflorescence	Sex ratio	Annual leaf production (No.)	No. of leaf scorching per palm	Drying of FFBs per palm	No of leaf drooping per palm
ZS-1	10.0	5.7	15.7	36.7	21.4	2.2	0.8	0.2
ZS-3	9.2	7.0	16.2	43.6	19.8	3.6	0.8	0.2
ZS-5	7.8	6.2	14.0	44.8	20.3	5.4	0.8	2.2
ZS-8	10.6	5.8	16.4	38.9	18.8	4.8	0.5	0.2
ZS-6	9.5	5.0	14.5	34.9	18.2	5.1	0.0	0.3
ZS-9	8.8	6.2	15.0	43.9	17.6	5.3	1.2	1.0
TS-4	8.7	5.2	13.9	40.3	19.6	5.7	1.2	0.7
TS-5	8.0	7.0	15.0	46.2	18.9	5.7	2.5	0.8
TS-7	10.0	6.7	16.7	43.3	18.7	5.4	3.0	1.8
S. Em+/-	2.2	0.9	1.9	8.4	1.2	0.7	0.7	0.6
CD (P=0.05)	NS	NS	NS	NS	NS	2.2	2.1	1.8

FFB yield and yield attributes

The FFB yield (t ha^{-1}) during 2011 differed significantly among the various genotypes (Table 2). The genotype ZS-3 recorded significantly higher FFB yield of 7.0 t ha^{-1} over ZS-6, ZS-8, ZS-9, TS-5 and TS-7 (Fig. 1). The genotypes ZS-1 and ZS-5 with FFB yields of 5.1 and 4.9 t ha^{-1} respectively were on par with ZS-3. The cumulative FFB yield (2003-2011) was significantly higher in the case of ZS-3 (28.8 t ha^{-1}) over all other genotypes. Genotype ZS-1 with FFB yield of 23.0 t ha^{-1} and ZS -3 with FFB yield of 22.9 t ha^{-1} were the next best treatments.

Number of bunches were significantly higher in the genotypes ZS-3 followed by ZS-1 and ZS-9. Bunch weight was significantly higher in the

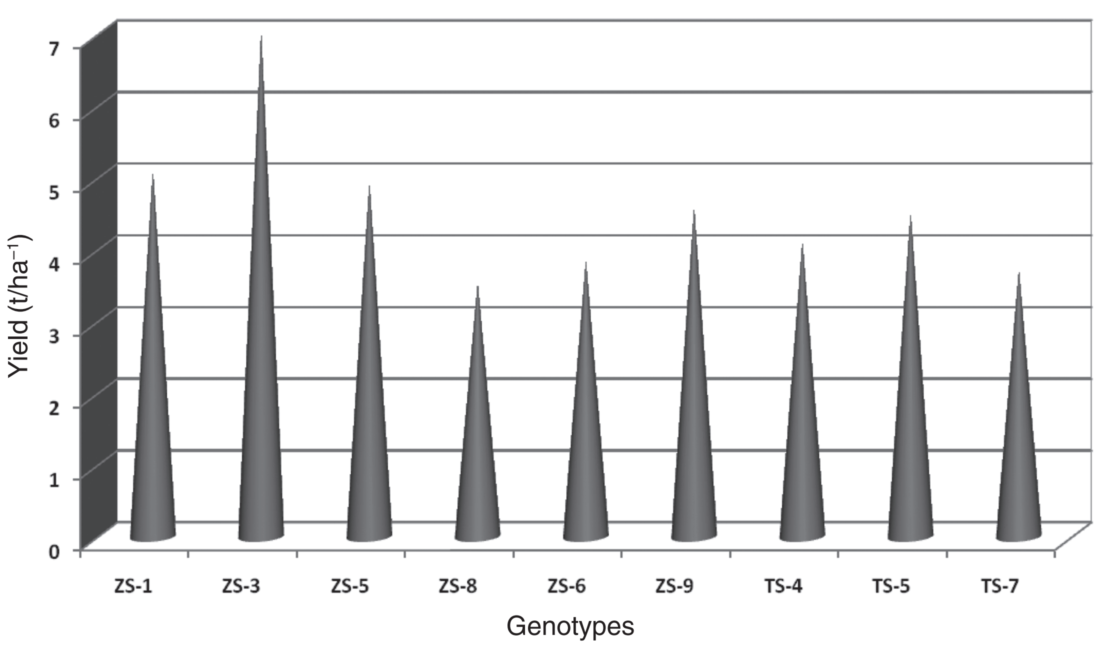

Fig. 1. FFB yield during 2011

Table 2. FFB yield, yield attributing parameters, RWC (%), electrolyte leaching (%) and lipid peroxidation (OD) in different drought tolerant oil palm genotypes

Genotype	FFB Yield ($t\ ha^{-1}$)	FFB Yield ($t\ ha^{-1}$)	No. of bunches	Bunch weight (kg)	No. of fruits per bunch	Fruit weight (g)	RWC (%)	Electrolyte leaching (%)	Lipid peroxidation
	2011	Cumulative (2003-2011)	2011	2011	2011	2011	Mean (2007-2011)	Mean (2007-2009)	Mean (2007- 2009)
ZS-1	5.1	23.0	4.1	8.7	1135.3	7.2	90.7	24.7	0.078
ZS-3	7.0	28.8	4.4	11.2	1534.7	7.5	90.0	29.1	0.149
ZS-5	4.9	22.9	3.2	10.8	1143.7	9.6	87.4	31.1	0.181
ZS-8	3.5	17.6	3.1	7.9	3031.0	4.4	87.5	28.0	0.124
ZS-6	3.8	20.9	2.8	9.4	1345.0	8.5	88.7	32.7	0.186
ZS-9	4.5	21.9	4.0	7.9	1437.7	8.3	88.3	32.0	0.143
TS-4	4.1	19.5	3.2	8.9	1147.3	7.9	87.9	32.8	0.094
TS-5	4.5	22.0	3.5	8.9	1464.0	6.9	86.2	34.8	0.122
TS-7	3.7	19.7	3.7	6.9	1655.7	6.7	88.2	31.0	0.132
S. Em+/-	0.76	1.72	0.22	1.07	56.89	0.608	2.4	1.3	0.005
CD (P=0.05)	2.23	5.05	0.64	3.14	167.36	1.79	NS	3.88	0.015

genotype ZS-3 (11.2 kg $bunch^{-1}$) followed by ZS-5 (10.8 kg $bunch^{-1}$) and ZS-6 (9.4 kg $bunch^{-1}$). The number of fruits per bunch was significantly higher in the genotype ZS-8 (3031) over all other genotypes. Fruit weight was significantly higher in the genotype ZS-5 (9.6 g $fruit^{-1}$) followed by ZS-6 (8.5 g $fruit^{-1}$) and ZS-9 (8.3 g $fruit^{-1}$). Such differences in oil palm FFB yield with Tanzanian and Zambian genotypes were also reported by Mathur *et al*. (2012). Under irrigated environment Tanzanian accessions were the higher yielders than Zambian accessions where as under water stress condition Zambian accessions were the higher yielders.

Biochemical components

The relative water content (RWC) was recorded for the stress period (month of May 2007, 2008, 2009, 2010 & 2011). RWC was higher in the genotype ZS-1 and ZS-3 (Table 2). However, there was no significant difference among the genotypes.

The data on electrolyte leaching for the stress period expressed as the per cent of final conductivity test. The mean data of all three years differed significantly among genotypes for electrolyte leaching. The genotype ZS-1 recorded significantly lower (24.7%) electrolyte leaching percentage over other genotypes.

Drought, salinity, high and low temperatures damage the structure of the cell membrane, leading to an increase in membrane permeability, and resulting in leakage of intracellular contents (Abbas, 2012).

Oil palm genotypes showed significant differences for lipid peroxidation. Significantly lower lipid peroxidation was shown by ZS-1 over all other genotypes. TS-4 and TS-5 were the next best genotypes.

At the cellular level, the impact of stress is generally seen on the integrity of membranes and extent of solute leakage, which is regulated by the cell membrane stability. Normal cell functions are affected due to changes in peroxidation of cell wall lipids during stress resulting in increased cell membrane permeability and solute leakage (Rajagopal *et al*., 2005).

The data on various physiological and biochemical parameters revealed that the genotype ZS -1 recorded higher mean relative water content, lower electrolyte leaching and significantly lower peroxidase activity indicating relatively more stress tolerant than other genotypes.

Conclusion

The genotype ZS-1 & ZS-3 recorded higher yield and yield attributes, higher relative water content, lower electrolyte leaching and significantly lower peroxidase activity indicating relatively more stress tolerant than other tested genotypes. Therefore, ZS-1 and ZS-3 can be used as Dura mother palm for further hybridization programmes.

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