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Original Research Paper

High Temperature Tolerant Genotypes of Finger Millet (*Eleusine coracana* L.)

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ABSTRACT

Finger millet varieties grown by farmers can grow and sustain well up to a temperature maximum of 36°C. However, increase in temperature above these limits has a drastic effect on production and leads to crop failure. The aim of the study is to screen and evaluate existing variation among distant genotypes with respect to high temperature stress tolerance. Screening involved, 422 germplasm accessions of finger millet that were evaluated under field condition. Kharif sown accessions were considered as standard control, which performed normal in all stages of plant growth, reproductive and seed development stages under a temperature range of 28°C to 32°C. Whereas, summer sown accessions, which were subjected to high temperature stress (upto 42°C to 44°C), with lower rainfall pattern, severely affected plant growth and development. Prominent traits such as plant height, chlorophyll content, number of branches, ear head length, finger length, grain size and grain yield were significantly reduced in summer grown accessions in comparison to Kharif crop. Only 133 accessions out of 422 could reach flowering stage and 289 accessions failed to flower in higher temperatures of summer. However, few genotypes which exhibited better tolerance against high temperature of summer are recorded and further carried over to breeding stress tolerant programme.

INTRODUCTION

Finger millet is the second most important food and fodder crop of the dry lands in southern Karnataka. It has a high level of regional or local adaptation and grown by poor and marginal farmers of dry arid regions of Eastern Africa, India and Srilanka. Finger millet is also known as African millet, Koracan, Ragi (India), Bulo (Uganda), Wimbi (Swahili) and Telebun (Sudan). Finger millet grains are highly nutritious with good quality protein, vitamins, high fibre and high calcium. It has proved to be very effective in controlling the blood glucose level in diabetic patients. Consumption of finger millet also prevents constipation and cholesterol problems.

In India, finger millet occupies an area of 11.34 lakh ha, with 18.78 lakh tones production and productivity of 1656 kg ha^{-1}. The southern states of India, Karnataka support an area of 6.3 lakh ha, with 11.12 lakh tones production and productivity of 1759 kg ha^{-1} (Anonymous 2013). In tropical and subtropical regions, heat stress will become a major limiting factor for crop production in coming decades. High temperature (HT) stress has been reported as one of the most important causes of change in plant morphology, physiology and biochemical aspects, which reduces plant growth and development in many crops leading to terrible loss of productivity and grain yield (Sato et al. 2002, Abdelmageed et al. 2003).

The study aimed at evaluation and characterization of variation existing in distant ragi accessions in response to high temperature stress, under field condition. Field trials during summer season in Bellary district of Karnataka provided potent heat stress up to 45°C subjecting the genotypes to severe heat stress. The growth performance of genotypes were compared to non-stressed kharif grown phenotypes, in order to enlist potential “Heat Stress Tolerant” genotypes with better yields. Selected genotypes were further used in “Heat Stress Breeding Programme”.

MATERIALS AND METHODS

A field experiment was carried out at Agricultural Research Station, Bellary, Karnataka. Bellary is a hotspot region for screening temperature tolerant accessions, as ambient temperature records highest in this district of Karnataka (max temp reaches here 46°C). Four hundred and twenty two finger millet distant accessions were obtained from All India Coordinated Small Millet Improvement Project, ZARS, Bangalore. The planting material was sown in augmented design along with checks and evaluated in the field in summer 2013.

Summer crop sowing was sown in the second week of

January 2013 and was initially supported with protective irrigation. The vegetative and reproductive stage of crop falls in high temperature months of April (38.5°C) and May (40°C) (Fig. 1) imposing a high temperature stress. The soil of experimental site is black cotton soil and during the summer season, it also imposes severe stress to plants. The recommended NPK fertilizer dose was applied (100:50:50 kg/ha) as per package of practice for finger millet. The spacing between plant to plant 10 cm and row to row 30 cm was maintained. The observations viz., days to 50% flowering, straw yield (g/m^2), total dry matter (g/m^2), earhead weight (g/m^2), threshing percentage, harvest index and grain yield (g/m^2) were recorded in crucial stages of plant growth. Data were analyzed with different statistical packages such as MINI TAB, SPAR2 and Excel.

RESULTS AND DISCUSSION

Screening for heat tolerance in finger millet accessions revealed wider genotypic variations in grain yield and yield attributing traits specially the harvest index. Due to high temperatures that prevailed during the summer cropping season, only 133 genotypes (31.2%) could flower, out of

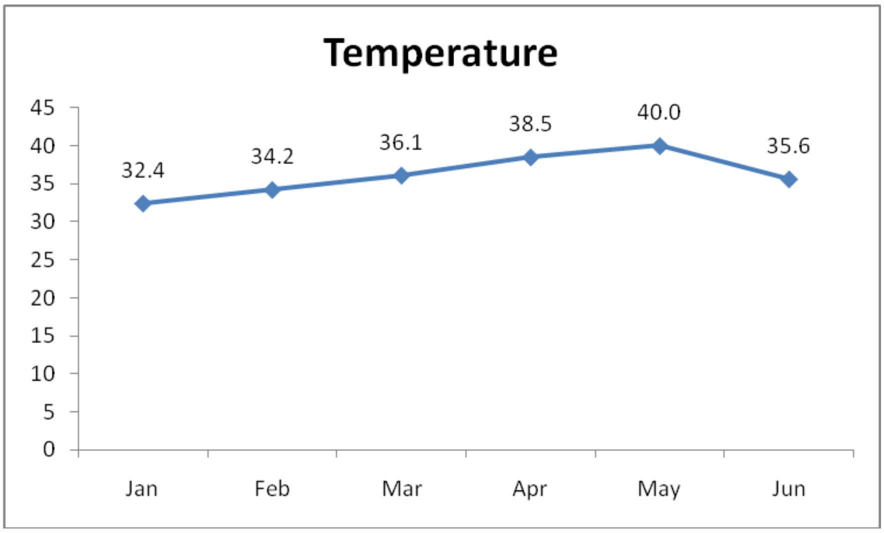
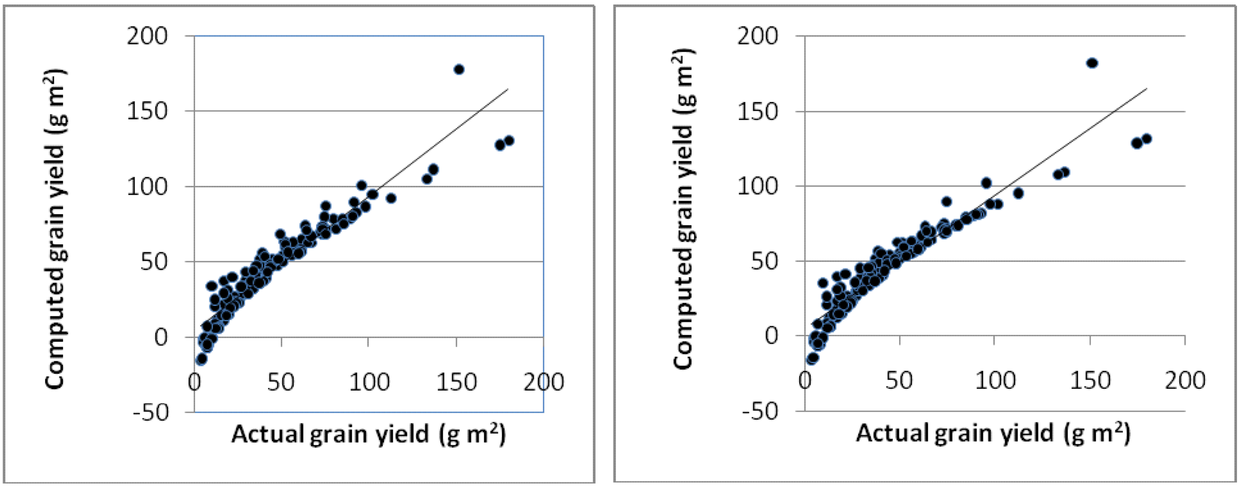


Fig. 1: Monthly mean maximum temperature at experimental site (Hagari, Bellary).



(Y= 0.89 x +4.07, R2=0.898 (EHW x Th % x HI)

Y= 0.89 x +4.75, R2=0.894, (EHW x Th %)

Fig. 2: Relationship between actual and calculated grain yield based on MLR.

Table 1: Relationship between yield and yield attributes under high temperature stress in finger millet.

Parameters	DFF	Straw (g m^{-2})	EHW (g m^{-2})	GY (g m^{-2})	Thr. (%)	TDM (g m^{-2})
Straw (g m^{-2})	0.06					
EHW (g m^{-2})	-0.25*	0.14				
GY (g m^{-2})	-0.09	0.18	0.74**			
Threshing (%)	0.19*	0.12	0.00	0.58**		
TDM (g m^{-2})	0.03	0.99**	0.23*	0.25*	0.12	
HI	-0.05	-0.47**	0.38**	0.59**	0.45**	-0.43**

Note: EHW (Ear weight), GY (Grain yield), TDM (Total biomass), HI (Harvest index)

Table 2: Correlation between actual and calculated grain yield through MLR.

Parameter	'r'	Parameter	'r'
Ear weight	0.74	Threshing % × HI	0.69
Threshing %	0.58	EHW × Thr %	0.95
HI	0.59	EHW × Thr % × HI	0.95

Table 3: Selected accessions for high temperature tolerance based on yield attributes in finger millet.

Parameter	Checks		Mean	>	Tolerant varieties/ accessions
	GPU-28	PES-110			
Grain yield (g m^{-2})	41.6	85.2	44.4	85.2	PES-110, RAU-8, VL-315, GE-18, 40, 314, 400, 805,1052,1559, 4006, 4955, 5079
Ear head weight (g m^{-2})	85.2	107.4	84.1	150	VL-315, RAU-8, GE-50, 208, 325, 808, 1052, 1294, 1306, 1559, 3670, 4006, 6493
Threshing (%)	51.2	79.3	52.9	85	RAU-8, GPU-45, GE-64, 97, 400, 404, 532, 1052, 1687, 4720, 4995
Harvest index	0.05	0.04	0.05	0.15	GE-40, 208, 314, 414, 813, 1687, 3884, 4437
Biomass (g m^{-2})	1162.7	1970.4	1059.5	1900	PES-110, GN-2, GE-400, 554, 942, 1128, 1321, 1559, 4898

422 genotypes sown. Interestingly, the days to flower was extended to a larger extent as high as 183 days compared to normal 72-75 days for medium duration varieties during kharif season. Many of the genotypes did not flower and remained in vegetative stage due to high temperature stress. Few genotypes died after germination and during the seedling stage. Venkatesh Babu et al. (2013) reported that ragi seedlings exposed to the sub lethal temperature of 38-54°C (for 5 hours), the shoot and root growth were completely affected, despite the recovery conditions were maintained at optimum level.

It is evident that, the heat stress had a severe effect on chlorophyll formation and maintenance, as many genotypes exhibited yellowing of leaves and later wilted. The plant height, chlorophyll content, number of branches, ear head length, finger length, grain size and grain yield were drastically reduced. High temperature results in the reduction of leaf greenness in finger millet (Maqsood & Ali 2007). Tewari & Tripathy (1998) observed that heat stress significantly reduced chlorophyll content in wheat which was due to inhibition of porphobilinogen deaminase activity and thus reduction in protochlorophyllide content in the seedlings upon exposure to short duration of heat stress (42°C). The grain yield was highly correlated to ear weight followed by threshing percent and harvest index (Table 1). However, the duration of flowering was not correlated to grain yield under high temperature conditions as generally expected under normal situations. Even the correlation value between biomass and grain yield is also recorded low (r= 0.25*). Further, the correlation between actual and calculated grain yield through multiple regression analysis (Table 2 and Fig. 2) show higher relatedness of ear weight in combination with threshing percent (r=0.95). Additional harvest index in MLR did not contribute to improvement of relationship (r=0.95). Hence, under high temperature conditions, the ear weight and threshing percent are the two major yield contributing traits. Jana et al. (2013) reported that rice plants grown under high temperature (summer season) conditions during reproductive phase (flowering period, grain formation and grain ripening stages) under aerobic conditions resulted in decreased grain yield and was attributed mainly to spikelet sterility at high temperature.

Based on these traits, a few out performing, promising genotypes which exhibited heat stress tolerance have been identified (Table 3). The tolerant accessions like PES-110, RAU-8, VL-315, GE-18, GE-40, GE-314, GE-400, GE-805, GE-1052, GE-1559, GE-4006, GE-4955 and GE-5079 produced a better grain yield as comparable to commercial check varieties at high temperature stress during summer 2013. However, the variation were not significant in comparison to Kharif data.

CONCLUSION

Use of these selected genotypes for future breeding and research may benefit selection of high temperature tolerant lines. With the raising importance to healthy food, demand of finger millet and its byproducts, and other minor millets, elaborate exploration in search of better quality and abiotic stress tolerant breeding programs will remain a major scope for the plant scientific community which has to meet the future needs and demands of human health.

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