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Dissection of Canopy Architecture Traits to Improve Growth Rates Under Water Limited Water Condition in Finger Millet (*Eleusine coracana* L.)

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Abstract

Finger millet is grown as a nutri-cereal crop grown under rainfed condition. Water is the major problem causing decrease in yield of ragi crop. Crop duration and leaf area (LA) are primary determinants of TBM in ragi. In this paper, an analysis of genetic variability in canopy architecture traits among a panel consisting of 350 diverse germplasm accessions of ragi is discussed. A strong correlation of biomass was noticed with LA, duration and shoot biomass. Since, LA is also associated with transpiration, increasing LA under water limited condition is not a good approach. We classified the panel of accessions based on duration to ear head emergence (EHE) as well as leaf area. The photosynthetic capacity, estimated from the ratio of TDM to TLA was highest among the mid duration lines. The study enforces the optimism in increasing plant biomass through increased canopy photosynthesis. Genotypes GE 3112 and GE 5421 were identified as a potential trait donor types.

Keywords: Finger millet, Germplasm, Canopy traits, Drought, Duration, NAR

Finger millet (*Eleusine coracana* L.) is widely grown as coarse cereal in arid and semiarid areas of Asia and Africa (Pallavi *et al.*, 2016). The cultivated *E. coracana* is a tetraploid (2n=4x=36) and has morphological similarity to both *E. indica* (2n=18) and *E. africana* (2n=36) (Sood *et al.,* 2016). Eleusine is derived from Greek word means goddess of cereals. Finger millet is one of the nutritionally superior crop rich in quality protein, dietary fiber and minerals especially Ca and Fe which greatly help in alleviating the problems associated with malnutrition and anaemia (Devi *et al*., 2014).

Leaves and other green tissues like green stem, etc, are original sources of assimilates. The leaf being the organ of photosynthesis is considered to be the important determinant which is characterized for higher photosynthetic capacity. Leaf traits and its architecture are very important for crop adaptation to stress conditions. Leaf area is considered to be an indicator of efficiency of crop growth, development and plant health and also has a strong relationship with leaf dry weight in crops. Leaf area growth determines light interception of a crop and is often used as a surrogate for plant growth in phenotyping systems (Weraduwage *et al.*, 2015). Finger millet being a rainfed crop grown normally under intermittent moistures stress situations, having higher leaf area would lose more water through transpiration and hence may not be that appropriate. It would be better to have high photosynthetic rate with lower leaf area so as to reduce the transpiration rates, increase the water use efficiency and crop yield. High dry matter production, lesser leaf area coupled with higher photosynthetic efficiency are desirable features in finger millet genotypes suited to rainfed conditions. Kumar *et al.* (2006) reported that grain yield was positively and significantly correlated with growth parameters like leaf area and total dry matter accumulation and the yield. Therefore, the objective of the experiment was to screen the genotypes for the canopy architectural traits to improve growth rates under water limited conditions.

Material and Methods

The main goal of the present study was to look for the canopy traits which help in improving the growth rates under water limited conditions in a panel of 350 Ragi germplasm accessions. This panel of Ragi lines including three checks *i.e.,* GPU-28, GPU-67 and

PR-202 were collected from different parts of the country which were available in AICRP on small millets, ZARS, UAS, Bangalore. The experiment was conducted during *kharif,* 2017 in the Root structures of Department of Crop physiology, UAS, GKVK, Bengaluru. Root structure was constructed above ground level of size 2 x 19 m and 3 m height and filled with 3:1 of fresh Soil & FYM. Panel of 350 Ragi germplasm lines were grown in seedling trays and seventeen day old seedlings were transplanted to root structure of spacing 30x10 cm in augmented design. As per the package of practice, field operations were taken care for good growth and healthiness of the seedlings. The panel of ragi germplasm was screened and examined the relevance of leaf area, and other canopy traits. The parameters observed to check the phenotypic variability during the study were shoot length (cm), total leaf area (cm^2), leaf weight (g), total dry matter (g), leaf area (cm^2), leaf width (cm), shoot weight (g), days to ear head emergence (EHE) (days), tiller number and SLW (g/cm^2) during the crop period.

Shoot length was measured from soil surface to the tip of the main tiller in centimeter from graduated scale. Tiller numbers were computed by counting the numbers of tiller per plant. Leaf weight (g) was measured by weighing the dried leaf per plant kept at 70 °C. Leaf area (cm^2) was measured by taking the third fully expanded leaf with the graduated scale. Total leaf area (cm^2) was calculated by multiplying specific leaf area and leaf dry weight. Leaf width (cm) was measured by maximum width of the leaf blade using graduated scale. Specific leaf weight (g/cm^2) was calculated by dividing individual leaf weight with dry weight of the same leaf kept at 70 °C. Total dry matter (g) was computed by biomass accumulated during the experimental period *i.e.,* summing up of leaf dry weight, stem dry matter and root dry weight. Days to EHE was recorded by observing the emergence of earhead in each of the accessions.

Growth rate is a function of leaf area and crop growth duration. DM/LA (expressed as mg/cm^2) was calculated based on duration of the crop *i.e.,* short (52 days), medium (62 days) and long (74 days) duration. The experimental data obtained from this experiment were analyzed using statistical software packages like MSTATC and MS EXCEL etc.

Results and Discussion

Government of India recently declared Ragi as one of the important nutri-cereal crops with its extraordinary high levels of calcium, high levels of Fe and Zn along with its inherent resilience to drought (Devi *et al.*, 2014). Finger millet indeed represents a potential coarse cereal that deserves further improvement. Despite its importance growth and productivity of Ragi generally remained low. Low production of tiller number, drooping canopy architecture, low partition of HI are often considered as major reason for lower production of Ragi compared to other cereals.

It is well accepted that yield is a function of Total biomass (TBM) and Harvest index (HI) (Luo *et al.,* 2015). Therefore increase in productivity can be achieved either by increasing TBM or HI. Significant efforts were made to improve HI in Ragi. The lower number of total tillers and constraints that associated with size of ear had hindered rapidity of increasing HI of Ragi. On the other hand, little attempt was made in enhancing TBM of Finger millet.

In the investigation an attempt was made to assess the genetic variation in specific traits that can lead to increase in TBM. A panel comprising of 350 diverse germplasm accession wild varieties and cultivated genotypes of Ragi were screened for some of the relevant traits that contribute to TBM. The plants were raised in specially designed root structures and harvested on 85 days after sowing. The panel showed significant variability in phenology which ranged from 47 to 76 days to EHE representing a significant genetic variability (Table 1). Several traits which are relevant as determinants of total biomass and crop growth rates were also recorded. All the parameters such as shoot length, tiller number, leaf weight and shoot weight showed significant genetic variability. However traits like tiller number and plant height did not show significant contribution to TBM.

TLA revealed a continuous distribution with a mean of 1438 cm^2 per plant with a range between 255 and

TABLE 1

Genotypic variation in the panel of 350 Ragi accessions

	Average	Minimum	Maximum	SD
Days to EHE (days)	62	47	76	6.36
Shoot Length (cm)	97.07	53.33	145.67	15.86
Tiller Number	2.421	1.000	6.667	0.944
SLW (g/cm^2)	6.248	2.811	9.603	1.133
Leaf Weight (g)	8.808	1.600	21.681	3.566
Shoot Weight (g)	18.84	5.09	47.89	8.08
Total Leaf Area (TLA) (cm^2)	1438.19	255.10	4221.05	616.53
Leaf Width (cm)	1.450	0.950	1.98	0.172
Total Dry Matter (TDM) (g)	31.86	8.23	69.91	11.77

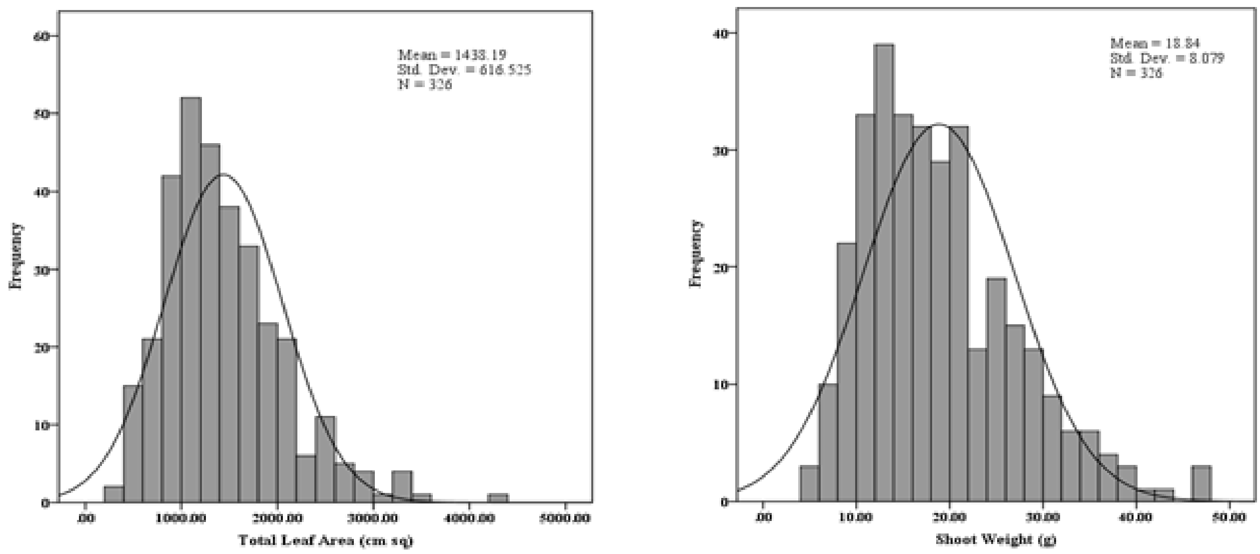

Fig. 1: Frequency distribution for total leaf area (cm^2) and shoot weight (g)

4221 cm^2 per plant. TLA was normally distributed over the mean indicating a polygenic control of LA and same for shoot weight with a mean of 18.84 g per plant with a range between 5.09 and 47.89 g (Fig. 1).

Among biometric traits, TLA and shoot weight were strongest determinants of TBM. The correlation of 0.589 showed a strong positive linear association between TLA and TDM among the panel of 350 Ragi accessions (Fig. 2).

The correlation of 0.887 showed a very strong positive linear association with respect to shoot weight and TDM in the panel of 350 Ragi accessions (Fig. 3).

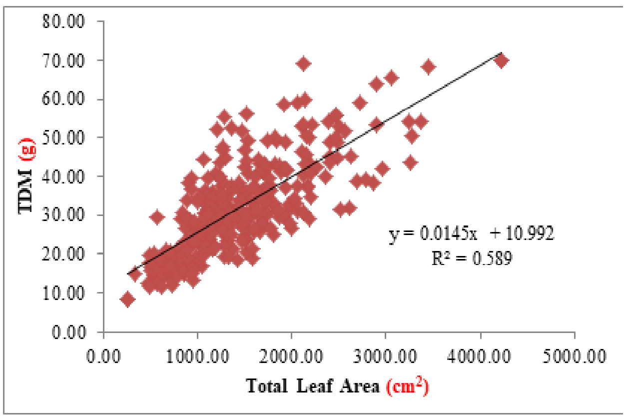

Fig. 2: Relationship between Total leaf area (cm^2) and Total biomass (g)

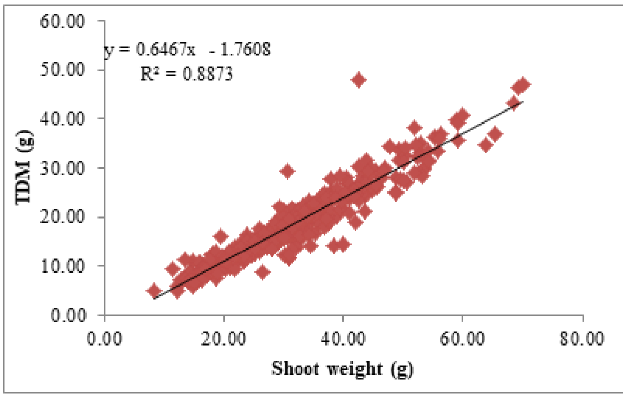

Fig.3: Relationship between Shoot weight(g) and Total biomass(g)

This depicts that increased shoot weight lead to increased biomass of the plant. There was significant BM locked up in shoot portion of the crop.

It is well documented that increasing crop growth duration can increase TBM accumulation in several crop species including Ragi. The panel of 350 germplasm accessions were classified as early, mid and late based on the days taken to EHE. The results illustrated in Fig. 4 and 5 revealed that long duration

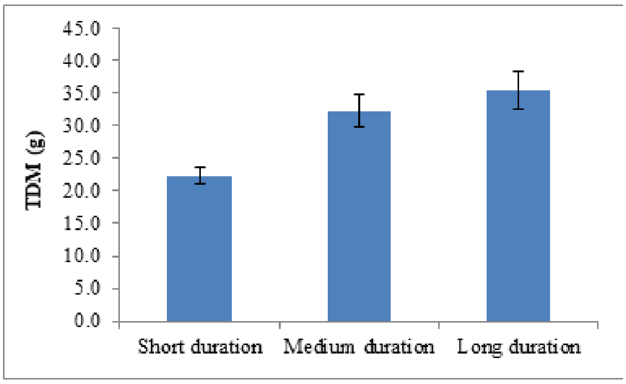

Fig .4: Variation in the genotypes for TDM of all genotypes

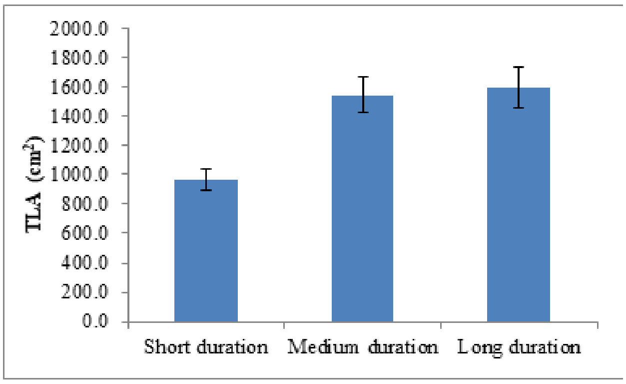

Fig.5: Variation in the genotypes for TLA of all genotypes

types had higher TBM and TLA than early duration types.

Therefore it is prudent to classify genotypes based on both duration and leaf area so that accurate assessment on capacity for accumulation of biomass can be determined. Genotypes with similar leaf area of around 1500 cm^2 where selected out of the panel of 350 accessions. TBM of mid and short duration types were similar among genotype with comparable leaf area (Fig. 6). Therefore, LA and duration are important determinants of TBM.

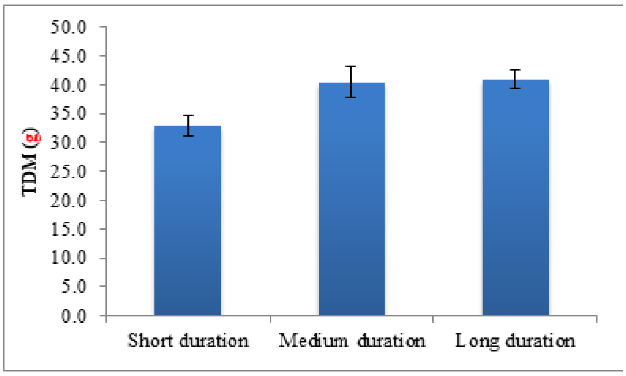

Fig.6: Differences in TDM of the duration of comparable LA types

The data clearly emphasize that increasing carbon assimilatory capacity would have a significant role in enhancing TBM, NAR computed as ration of TBM to TLA (Fig. 7). Mid duration types with similar LA have recorded significantly high NAR compared to other genotypes. This investigation clearly demonstrates the relevance of shoot traits especially LA and shoot biomass in determining total growth rates (TBM).

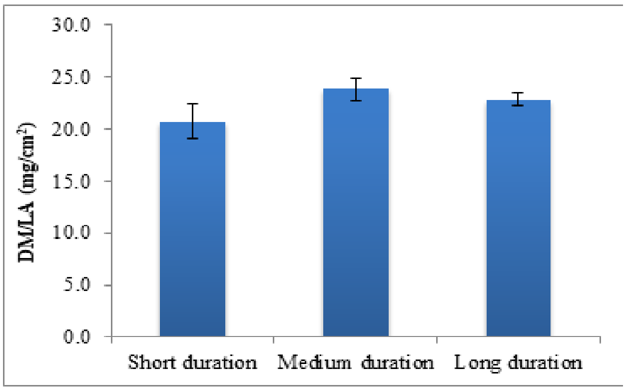

Fig. 7: Differences in DM/LA of the duration of comparable LA types

Among the panel of 350 Ragi germplasm accessions, phenotypic variability for canopy architecture traits was observed and very strong positive linear association was observed between leaf area and total biomass.

LA is important for photosynthesis but if they increase LA then increase surface area for transpiration and hence decreases WUE (Sheshshayee *et al.,* 2003). Therefore, high LA types are not good, but high LA is highly related to total biomass. Late duration types are not good, though they have higher TBM. Because, Ragi is grown predominantly as a rainfed crop, long duration is not useful. But increasing biomass of medium duration types has greatest relevance. Increasing TBM is an important goal besides improving harvest index (HI) to increase yield. We have identified high NAR (DM/LA) type with mid duration phenology.

Genotypes like GE 5421 and GE 3112 were identified as the most promising high yielding Ragi cultivars with significantly higher photosynthetic rates. These genotypes can serve as potential trait donor lines to improve productivity in subsequent breeding programs.

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