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Research Note

Study of morpho-physiological and root characters of ragi (*Eleusine coracana*) entries under rainfed conditions

K. Krishna Surendar* and S. Mohammad Jalaludhin[1]
*Assistant Professor (Crop Physiology), Regional Research Station, TNAU, Paiyur.
[1]Professor and Head, Regional Research Station, TNAU, Paiyur.
E-mail: surendartnau@gmail.com

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Abstract
The field experiment was conducted during August – December 2014 to study the morpho-physiological and root characters of ragi entries under rainfed conditions. The experiment was laid out in a Randomized Block Design with three replications. Seven entries were subjected to rainfed conditions viz., (V_1) Paiyur 2, (V_2) CO7, (V_3) CO 15, (V_4) L 5, (V_5) GPU 28, (V_6) KRI 007-01 and (V_7) KRI 009-01 with the spacing of 22.5 x 10 cm after receiving the rainfall of 37.4mm. The total amount of rainfall during August, September, October and November is 37.4 mm, 106.2 mm, 248.7 mm and 35.8 mm**.**. The plant height, root length and root volume and leaf area index were measured at 45th, 60th, 75th DAS and at Harvest stages. The physiological observations of total chlorophyll and relative water content were analyzed at 50per cent flowering stages. The morphological, physiological and root characters were significantly enhanced by the entries of KRI 009-01 and showed its superiority when compared to other entries at 45th , 60th , 75th DAS and at Harvest stages, which was followed by PYR 2. The lowest performance was noticed in CO 15 and GPU 28 under rainfed conditions. Comparing the seven entries, KRI 009-01 and PYR 2 had the highest plot yield (5.16 kg and 5.05 kg plot^{-1}) and hectare yield (74.9 Q and 74.6 Q ha^{-1}). Therefore, the entries of KRI 009-01 and PYR performed superior and were identified suitable entries for growing under rainfed conditions.

Key words
Morpho-physiology, root length, root volume, total chlorophyll, RWC, Ragi, rainfed

Finger millet or *Mandua* or Bird's foot millet commonly known as ragi (*Eleusinecoracana* (L.) Gaertn.) is an essential small millet crop ranked third in India in area and production and has the pride of place in having the highest productivity among the millets after sorghum and pearl millet (Saravanapandian *et al*., 2005). It is a staple food crop in many hilly regions of the country. It is grown both for grain and fodder purposes. The crop is well adapted to very poor and marginal uplands where other crops cannot be grown successfully (AICSMIP, 2008).The cultivated area of finger millet in India is 15.4 lakh ha, production is 2.15 million tonnes with an average productivity of 1402 kg ha^{-1}. In Tamil Nadu, finger millet is the most important traditional millet crop grown over an area of 82,335 ha, with production of 1.61 lakh tonnes and the productivity of 1955 kg ha^{-1} and provides food and nutritional security to the marginal farmers in the rainfed drylands and hilly tribal areas (Season and crop report, 2010).

Drought adversely affects some of the important physiological, biophysical and biochemical processes of the plants, like chlorophyll destruction, enzymatic activities and protein synthesis. It has been documented that root growth, leaf area development, and osmatic adjustment under stress are some of the guidelines in characterizing the genotypes for stress tolerance in ragi (Blum and Sullivan, 1987). Screening varieties for relative drought tolerance has been attempted by various workers using different physiological and biochemical mechanism in various crops but very limited attempt available in ragi crop. Thus, this experiment was conducted for screening the ragi cultivars under rainfed conditions through the morpho-physiological, root characters and total chlorophyll, Relative Water Content will be taken in to consideration to assess the response of the various ragi entries under rainfed condition.

Plant height (cm): The time trend of plant height of ragi entries revealed a progressive increase from 45th DAS to harvest stage (Table 1). Among the seven entries, KRI009-01 observed to be the tallest plant with the height of 57.4 to 96.1 from 45th DAS to harvest stages, which was followed by Paiyur 2 with height ranging from 44.3 cm to 93.0 cm. The entries of KRI007-01, CO 15 and CO 7 were found to be the dwarfed plant with height of 81.4 cm, 82.8 cm and 82.9 cm at harvest stage. Squire and Black, (1981) concluded that, the mechanism of reduction in plant height due to water deficit might be attributed to reduction in cell expansion, cell growth and development.

Root length (cm) and Root volume (mL): The data on root length and root volume revealed that, a steady increased from 45th DAS to harvest stage (table 1). Significant differences were observed among the seven entries. Comparing the seven entries, KRI009-01 maintained its superiority in root length of 21.9 cm and root volume of 14.2 ml at harvest stage, followed by Paiyur 2 of 23.1 cm in root length and 13.5 ml in root volume at harvest stage. The lowest value was observed in

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KRI007-01 (18.3 cm and 11.9 ml) at harvest stage, which was on par with GPU 28 and CO7.

Leaf Area Index: The time trend of LAI followed a similar pattern of LA, with a steady increase up to 60th DAS with a decline towards harvest (Table 2). The entries of KRI009-01 recorded considerably higher LAI of 4.72 at 60th DAS. KRI007-01, CO7 and L5 showed lowest LAI of 2.93, 3.34 and 3.46 at 60th DAS respectively. LAI is one of the principle factors influencing canopy net photosynthesis of the crop plants (Hansen, 1972). The capacity of a canopy of leaves in a plantation to intercept light and fix carbon is measured by the LAI.

Leaf Area Duration (days): The result of LAD revealed a differential trend and significantly differed among the cultivars (Table 2). Among the seven entries, KRI009-01 recorded the longest LAD of 69.6, 76.2 and 77.5 days at 45th-60th DAS, 60th-75th DAS and 75thDAS harvest stages, which was followed by Paiyur 2. LAD represents the functionality of the leaf over its life period. Watson, (1952) reported that the LAD of a crop is a measure of its ability to produce leaf area in a unit area of land throughout its growth period and hence it's whole opportunity for carrying out carbon assimilation. The LAD is a measure of the duration of photosynthetic apparatus up to which it can accumulate the dry matter for growth and development of the plant (Watson, 1952). Formation of optimum photosynthetic area and maintenance of photosynthetically active leaves for a longer duration especially during the reproductive phase of the crop is essential for increasing the photosynthetic rate, dry matter accumulation and crop yield (Watson, 1956).

Physiological characters: The chloroplast in green plants constitutes the photosynthetic apparatus. Chlorophylls and other photosynthetic pigments are found in the form of protein pigment complexes mainly in thylakoid membranes of grana. Photosynthetic pigments play major role in plant productivity, as they are responsible for capturing light energy and using it as a driving force for producing the assimilates. Water deficit induces disintegration of thylakoid membranes and causes degradation of chlorophyll pigments. This could substantially contribute to the overall inhibition of photosynthesis in leaves of water deficit plants (Farquhart *et al.,* 1982). As observed in the present study, the data on physiological and biochemical parameters were significantly differed between the entries and was recorded at 50 % flowering stage. Comparing the entries, KRI009-01 showed its superiority over the other entries. The entries of KRI009-01 had the highest value for total chlorophyll content, relative water content (1.57 mg g^{-1} and 77.2 %) (Table 3). However, the lowest value was observed in CO 15 and GPU 28.

The variety KRI 009-01 recorded the maximum plant height and had highest growth attributes like, Leaf Area and Leaf Area Index. The entries KRI 009-01 had maximum photosynthetic pigments with more RWC and yield. Based on this result, the entries of KRI 009-01 was found to be superior over the other entries for tolerance to drought under rainfed conditions.

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Table 1. Responses of ragi cultivars under rain-fed conditions on plant height, root length and root volume at different growth stages

Cultivars	Plant height (cm)				Root length (cm)				Root volume (mL)			
	45th DAS	60th DAS	75th DAS	Harvest Stage	45th DAS	60th DAS	75th DAS	Harvest	45th DAS	60th DAS	75th DAS	Harvest
Paiyur 2	44.3	73.7	93.0	93.0	13.3	19.5	19.8	23.1	8.5	10.6	10.6	13.5
CO7	48.4	62.0	83.0	82.9	13.9	17.1	17.2	18.7	8.5	10.0	10.0	13.4
CO15	52.4	66.1	82.9	82.8	13.4	21.6	21.6	21.7	7.0	9.0	9.0	12.3
L5	51.9	65.0	84.0	84.0	14.9	18.2	18.6	18.8	6.5	10.0	10.0	13.3
GPU 28	51.4	68.6	86.6	86.6	18.4	18.8	19.1	19.9	8.5	8.3	8.3	11.9
KRI007-01	56.4	63.5	81.4	81.4	13.9	15.6	16.8	18.3	6.5	8.3	8.3	11.9
KRI009-01	57.4	75.4	96.1	96.1	16.4	16.9	19.8	21.9	9.5	11.3	11.3	14.2
Mean	51.75	67.77	86.72	86.67	14.90	18.25	18.99	20.34	7.9	9.6	9.6	12.92
SEd	0.93	1.27	1.63	1.73	0.57	0.72	0.88	0.84	0.42	0.68	1.10	0.85
CD=P (0.05)	1.98	2.70	3.47	3.67	1.20	1.53	1.88	1.79	0.91	1.45	2.33	1.81

Table 2. Responses of ragi cultivars under rainfed conditions on leaf area, leaf area index and leaf area duration at different growth stages

Cultivars	Leaf Area (cm^2)				LAI				LAD (days)		
	45th DAS	60th DAS	75th DAS	Harvest	45th DAS	60th DAS	75th DAS	Harvest	45-60th DAS	60- 75th DAS	Harvest
Paiyur 2	443.8	1061.9	955.8	917.6	1.97	4.72	4.25	4.08	50.2	67.3	62.4
CO7	654.6	751.7	697.1	658.8	2.91	3.34	3.10	2.93	46.9	48.3	45.2
CO15	737.1	875.7	853.8	815.5	3.28	3.89	3.79	3.62	53.8	57.6	55.6
L5	594.0	779.0	742.0	703.8	2.64	3.46	3.30	3.13	45.8	50.7	48.2
GPU 28	403.3	960.4	917.8	879.6	1.79	4.27	4.08	3.91	45.5	62.6	59.9
KRI007-01	571.5	658.3	720.5	682.3	2.54	2.93	3.20	3.03	41.0	46.0	46.8
KRI009-01	983.0	1105.5	1181.9	1143.7	4.37	4.91	5.25	5.08	69.6	76.2	77.5
Mean	**626.77**	**884.65**	**867.00**	**828.75**	**2.79**	**3.93**	**3.85**	**3.68**	**50.38**	**58.39**	**56.52**
SEd	3.97	8.94	20.90	18.25	0.01	0.02	0.06	0.06	0.32	0.74	0.97
CD=P(0.05)	8.42	18.96	44.32	38.69	0.03	0.06	0.14	0.12	0.69	1.58	2.07

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Table 3. Total chlorophyll, Relative Water Content (RWC) responses of ragi cultivars under rainfed conditions @at75th DAS (50 % flowering stage) and yield (Q ha^{-1}) at harvest stage

Cultivars	Total chlorophyll (mg g^{-1})	RWC (%)	Yield (Q ha^{-1})
Paiyur 2	1.55	76.2	38.07
CO7	1.27	70.9	37.68
CO15	1.43	74.7	37.53
L5	1.05	72.2	37.47
GPU 28	1.38	73.9	37.23
KRI007-01	1.33	72.1	39.16
KRI009-01	1.57	77.2	39.95
Mean	**1.37**	**73.90**	**38.16**
SEd	0.029	0.235	0.101
CD=P (0.05)	0.050	0.513	0.203

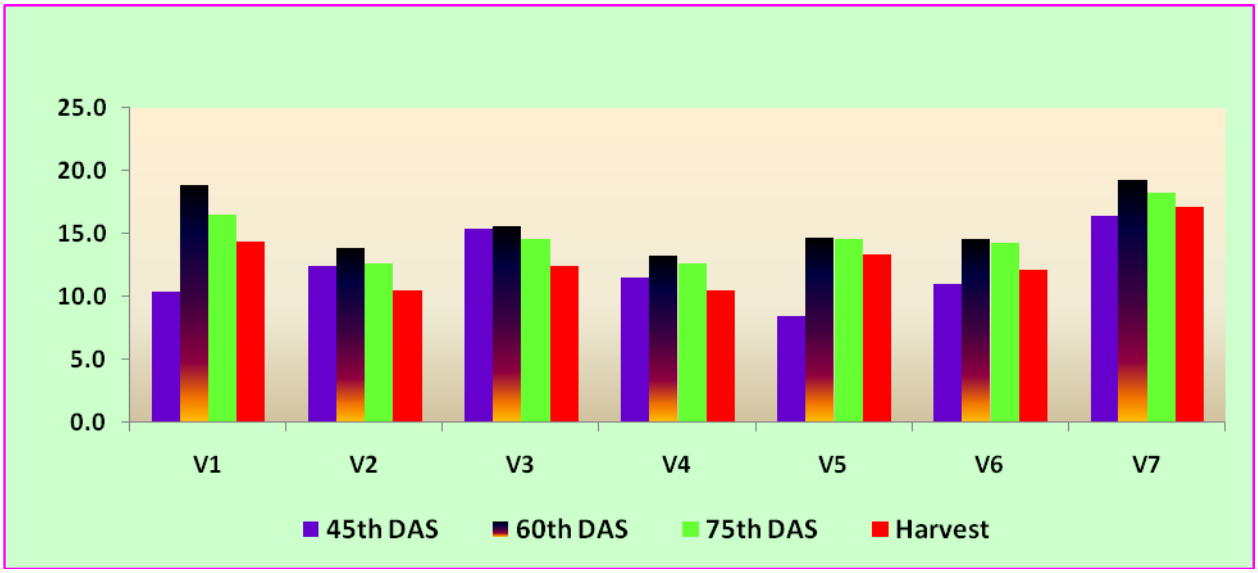

Fig. 1. Responses of ragi entries under rainfed conditions in number of leaves