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EVALUATION OF PHYSIOLOGICAL EFFICIENCY AND YIELD POTENTIAL OF RAGI GENOTYPES UNDER IMPOSED MOISTURE STRESS CONDITONS

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ABSTRACT

The work was conducted with the purpose of to evaluate the effect of moisture stress on physiological and yield parameters in ten ragi genotypes viz. (GP-3, GP-23, GP-24, GP-25, GP-104, GP-111, GP-149, GP-153 and GP-160). The experiment was conducted in factorial randomized block design with three replications. Moisture stress was imposed from panicle initiation to grain filling stage *i.e.* (35-60 DAT). Moisture stress reduced the all physiological and yield parameters. The genotype gp-153 performed better than other genotypes, it recorded higher CGR (16.75 g m^{-2} day^{-1}), higher LAI (2.15), higher LAD (33.71 cm^2 g^{-1}) and higher grain yield (2560.0 Kg ha^{-1}), higher straw yield (6966.67 Kg ha^{-1}) and higher harvest index (26.80) followed by GP-111. Hence these genotypes can perform better under moisture stress conditions and are suitable for rain fed situations.

INTRODUCTION

Finger millet or Ragi (*Eleusine coracana* G.) is the third most important millet crop of India. It is also an important food crop in South Asia and Africa. Its wide adaptability to diverse environments and cultural conditions makes it a potential food crop.

High temperature or heat stress is often accompanied by drought stress under field conditions. Moisture stress during crop growth period especially in kharif growing season accounts for 70 per cent loss in productivity. Any effort to mitigate the loss due to drought could be useful to enhance the food production in the country. It has been suggested that crop improvement in yield could be achieved more efficiently by identifying characteristics that allow a plant to escape, avoid or tolerate water stress. So plants possess various morphological and physiological adaptations in order to survive under moisture stress and complete its life cycle.

Screening and selection of plants of different crops with considerable water stress tolerance has been considered an economic and efficient means of utilizing drought-prone areas when combined with appropriate management practices to reduce water loss (Rehman *et al*., 2005).

As ragi crop is mostly cultivated in sub marginal lands and limited moisture conditions, it is prone for recurrent drought, which affects crop growth due to moisture as well as temperature stress. Hence the morphological, physiological and yield traits are the reliable drought tolerance traits for evaluating the genotypes. Therefore information on physiological potential of ragi genotypes is more important in the crop improvement programme to evolve varities suitable for rainfed situations.

MATERIALS AND METHODS

The experiment was conducted in wetland farm of College of agriculture, Tirupati during late rabi, 2012-13 in a Factorial Randomized Block Design (FRBD) replicated thrice. Major treatments were irrigated and moisture stress and sub treatments were ten ragi genotypes. In case of irrigated treatments, irrigations were applied at critical growth stages, whereas in moisture stress treatment irrigation was withheld from panicle initiation to grain filling stage (35-60DAT) and no rainfall was received during this period. Prophylactic measures were taken for protecting the crop from pest and diseases. Destructive analysis of plant samples was done at 15, 30, 45, 60, 75 and 90 DAT and dried in oven at 80 for 48 hours. Leaf area was measured by LI-COR 3000 leaf area meter. The Leaf Area Index was calculated by using the formula (L/P), where L is the leaf area and P is the ground per plant as suggested by Watson (1952). Crop growth rate (CGR) was calculated following (Radford, 1967) CGR = $(l/P)\ (W_2\text{-}W_l)/(t_2\text{-}t_1)$, Leaf area duration (LAD) was then calculated (Watson, 1952) LAD = $(LAI_1 + LAI_2)\ (t_2 - t_1) / 2$. The data on seed yield and yield components were recorded at the time of harvest. The data were statistically analyzed as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The genotype GP-153 and GP-111 maintained higher dry

Table 1: Evaluation of ragi genotypes for total dry weight (g plant^{-1}) under imposed moisture stress conditions

Genotype	15 DAT			30 DAT			45 DAT			60 DAT			75 DAT			90 DAT		
	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean
GP-3	0.48	0.45	0.46	6.37	6.23	6.30	28.24	22.48	23.36	35.25	18.47	28.86	40.48	37.82	39.15	37.34	23.16	30.25
GP-23	0.66	0.63	0.65	8.29	8.09	8.19	14.31	16.37	13.16	26.48	12.01	21.43	31.09	27.43	29.26	29.36	22.03	25.70
GP-24	0.68	0.66	0.67	6.01	5.74	5.88	36.78	19.34	28.04	39.64	19.31	29.49	42.79	36.12	39.46	36.25	28.56	32.40
GP-25	0.58	0.49	0.54	4.84	4.67	4.76	27.58	14.00	21.66	29.28	15.74	21.64	35.71	32.71	34.21	32.81	22.35	27.58
GP-27	0.57	0.56	0.57	7.62	7.42	7.52	24.11	15.56	20.76	37.55	17.42	26.55	43.01	37.01	40.01	36.00	26.10	31.05
GP-104	0.36	0.32	0.34	7.16	6.95	7.05	14.68	11.59	12.48	34.42	10.29	23.00	39.20	34.87	37.04	37.01	29.02	33.02
GP-111	0.47	0.45	0.46	9.06	8.96	9.01	22.49	21.88	18.56	33.34	14.63	27.61	37.47	34.48	35.97	41.12	27.03	34.08
GP-149	0.38	0.36	0.37	6.98	6.55	6.76	19.52	18.26	16.62	35.85	13.72	27.05	44.38	39.38	41.88	42.11	23.81	32.96
GP-153	0.67	0.65	0.66	9.33	9.24	9.29	24.44	21.79	22.09	27.33	19.74	24.56	38.27	34.94	36.61	41.05	27.82	34.44
GP-160	0.54	0.52	0.53	7.62	7.42	7.52	33.35	20.59	25.92	37.29	18.50	28.94	44.85	40.85	42.85	38.58	25.06	31.82
Mean	0.54	0.51		7.33	7.13		24.55	18.19		33.64	15.98		39.73	35.56		37.16	25.49	
	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G
SE m ±	0.01	0.03	0.05	0.10	0.23	0.33	0.65	1.72	2.06	0.77	1.46	2.44	0.73	1.64	2.32	0.95	2.12	2.99
C.D (P = 0.05)	0.04	0.09	0.13	0.30	0.66	0.93	1.87	4.94	5.91	2.21	4.18	6.99	2.10	4.70	6.65	2.71	6.06	8.57

T0- Control T1- Treatment

Table 2: Evaluation of ragi genotypes for leaf area index under imposed moisture stress conditions

Genotype	15 DAT			30 DAT			45 DAT			60 DAT			75 DAT			90 DAT		
	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean
GP-3	0.1460	0.1345	0.1402	2.84	2.83	2.84	5.25	2.75	4.00	3.24	1.80	2.78	1.77	1.68	1.73	1.70	1.49	1.60
GP-23	0.1976	0.1979	0.1978	1.85	1.75	1.80	1.21	1.24	1.23	1.43	0.64	1.04	1.78	1.65	1.72	1.43	1.20	1.32
GP-24	0.2728	0.2161	0.2444	2.34	2.40	2.37	4.12	3.51	3.81	3.91	1.84	2.88	1.83	1.79	1.81	1.80	1.72	1.76
GP-25	0.1905	0.2111	0.2008	2.15	2.22	2.19	4.60	3.88	4.24	2.90	1.36	2.13	1.97	1.54	1.76	1.92	1.44	1.68
GP-27	0.2310	0.2363	0.2337	3.65	3.65	3.65	3.92	3.62	3.77	1.62	1.25	1.44	1.82	1.64	1.73	1.73	1.60	1.67
GP-104	0.0842	0.1342	0.1092	2.23	2.15	2.19	2.47	2.40	2.43	3.97	1.25	2.61	2.19	1.42	1.80	1.71	1.87	1.79
GP-111	0.1537	0.1579	0.1558	3.60	3.40	3.50	4.22	4.25	4.24	2.90	1.72	2.31	1.79	1.88	1.84	1.80	1.93	1.87
GP-149	0.0986	0.0724	0.0855	3.01	2.91	2.96	2.94	3.16	3.05	2.90	1.57	2.23	2.01	1.60	1.80	2.16	1.23	1.70
GP-153	0.1500	0.1534	0.1517	3.45	3.30	3.37	4.99	3.73	4.36	1.60	1.85	1.72	2.00	1.75	1.87	1.89	2.41	2.15
GP-160	0.2011	0.1956	0.1983	2.67	2.31	2.49	3.97	3.54	3.75	1.87	1.23	1.55	1.98	1.35	1.67	1.61	1.69	1.65
Mean	0.1725	0.1709		2.78	2.69		3.77	3.21		2.63	1.50		1.90	1.63		1.93	1.78	
	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G
SE m ±	0.0054	0.0120	0.0170	0.04	0.09	0.13	0.07	0.15	0.21	0.13	0.29	0.41	0.05	0.12	0.17	0.06	0.12	0.17
CD (P = 0.05)	0.0154	0.0344	0.0486	0.11	0.25	0.36	0.19	0.42	0.59	0.37	0.83	1.18	0.15	0.34	0.48	0.16	0.35	0.50

T0- Control T1- Treatment

Table 3: Evaluation of ragi genotypes for leaf area duration ($cm^2\ g^{-1}$) under imposed moisture stress conditions

Genotype	15-30 DAT			30-45 DAT			45-60 DAT			60-75 DAT			75-90 DAT		
	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean
GP-3	22.41	22.27	22.34	60.70	41.92	51.31	63.67	38.10	50.88	36.06	28.57	32.32	26.50	23.82	25.16
GP-23	15.39	14.64	15.01	22.98	22.47	22.72	19.83	14.11	16.97	24.74	17.17	20.96	24.13	21.37	22.75
GP-24	19.62	19.62	19.62	48.44	44.30	46.37	60.19	40.11	50.15	45.41	26.71	36.06	27.59	26.22	26.91
GP-25	17.55	18.25	17.90	50.66	45.74	48.20	56.30	39.30	47.80	34.63	20.05	27.34	29.14	21.36	25.25
GP-27	29.10	29.11	29.11	56.74	54.47	55.61	41.54	36.52	39.03	24.11	21.42	22.77	26.36	24.25	25.30
GP-104	17.37	17.17	17.27	35.24	34.14	34.69	48.28	27.32	37.80	45.18	19.96	32.57	37.37	30.05	27.90
GP-111	28.15	26.68	27.42	58.68	57.40	58.04	53.45	44.78	49.11	36.91	26.98	31.95	32.65	25.86	29.25
GP-149	23.32	22.37	22.84	44.65	45.55	45.10	43.79	35.47	39.63	37.94	23.74	30.84	25.44	26.76	26.10
GP-153	26.97	25.89	26.43	63.28	52.69	57.99	49.39	41.80	45.60	27.20	26.94	27.07	28.66	27.13	33.71
GP-160	21.56	18.80	20.18	49.80	43.91	46.86	43.74	35.77	39.75	23.25	19.33	21.29	29.83	24.59	27.21
Mean	22.14	21.48		49.12	44.26		48.02	35.33		33.54	23.09		28.77	25.14	
	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G
SE m ±	0.30	0.67	0.95	0.64	1.44	2.03	1.04	2.32	3.28	1.26	2.81	3.97	0.72	1.61	2.28
CD (P = 0.05)	0.86	1.93	2.72	1.84	4.11	5.82	2.97	6.64	9.38	3.59	8.04	11.37	2.07	4.62	6.54

T0- Control T1- Treatment

Table 4: Evaluation of ragi genotypes for crop growth rate ($g\ m^{-2}\ day^{-1}$) under imposed moisture stress conditions

Genotype	15-30			30-45			45-60			60-75			75-90		
	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean
GP-3	17.43	15.80	16.62	28.09	23.42	25.76	24.08	19.74	21.91	12.84	9.51	11.18	9.32	8.64	8.98
GP-23	22.58	21.92	22.25	21.16	22.83	22.00	26.03	24.03	25.03	15.20	11.87	13.53	13.62	9.62	11.62
GP-24	15.78	15.18	15.48	40.42	35.42	37.92	21.79	18.12	19.95	14.06	9.40	11.73	9.61	6.77	8.19
GP-25	12.60	12.47	12.54	23.98	22.65	23.32	18.37	15.03	16.70	17.10	13.77	15.44	9.94	7.94	8.94
GP-27	20.87	19.87	20.37	25.47	30.47	27.97	29.79	19.79	24.79	17.06	13.72	15.39	12.46	9.79	11.13
GP-104	20.13	19.80	19.96	22.25	20.58	21.42	35.13	24.11	29.62	14.69	8.02	11.36	14.81	12.86	13.84
GP-111	25.43	24.10	24.77	39.75	38.09	38.92	32.13	25.46	28.80	13.28	10.94	12.11	15.79	12.12	13.96
GP-149	19.52	18.85	19.18	37.14	35.14	36.14	45.00	31.67	38.33	25.19	22.53	23.86	13.75	10.08	11.91
GP-153	25.64	23.98	24.81	44.73	31.39	38.06	35.22	27.22	31.22	28.67	24.67	26.67	18.58	14.92	16.75
GP-160	20.97	19.97	20.47	40.81	33.80	37.30	24.99	11.66	18.32	13.82	10.16	11.99	12.74	10.41	11.58
Mean	20.10	19.19		32.38	29.38		29.25	21.68		17.19	13.46		13.06	10.31	
	T	G	T ´ G	T	G	T ´ G	T	G	T ´ G	T	G	T ´ G	T	G	T ´ G
SE m ±	0.29	0.65	0.92	0.97	2.17	3.07	1.37	3.06	4.32	1.20	2.69	3.80	0.58	1.30	1.84
C.D (P = 0.05)	0.83	1.86	2.63	2.78	6.22	3.07	3.92	8.76	12.39	3.44	7.70	10.89	1.67	3.73	5.28

T0- Control T1- Treatment

matter accumulation, probably due to higher photosynthesizing area (Table 1). Among the genotypes, GP-153 recorded significantly higher total dry matter (34.44) followed by GP-111 (34.08) and GP-104 (33.02) under both irrigated as well as moisture stress conditions compared to other genotypes. GP-23 and GP-25 recorded lowest total dry matter accumulation. Such decrease in dry matter accumulation of ragi genotypes due to moistures stress was reported by Muhammod Maqsood and Azam Ali (2007).

Leaf area per plant is an important determinant in production and photosynthesis (Watson, 1947). Positive correlation between leaf area and yield (Alluwar and Deotale, 1991) suggests its importance in determining yield. Total chlorophyll content in chickpea genotypes was reduced under moisture stress conditions reported by Pradeep *et al.* (2013)

LAI determines the leafyness of a plant over land area and increased upto 45 DAT and declined thereafter. Moisture stress at panicle initiation stage i.e. from 35-60 DAT decreased mean LAI significantly (Table 2). The extent of decrease was 14.85 per cent at 45 DAT, 42.9 per cent at 60 DAT, 14.21 per cent at 75 DAT and 7.7 per cent at 90 DAT compared to irrigated control.

Under moisture stress conditions GP-153 recorded significantly higher LAI (2.15) followed by GP-111(1.87), GP-3(1.60) and GP-24(1.76) maintained significantly higher leaf area index at 60 DAT. The higher LAI in these genotypes may be attributed to their higher number of green leaves per plant. Such decrease in LAI of ragi genotypes due to moistures stress was reported by Muhammod Maqsood and Azam Ali (2007), rice varieties Renuka Devi *et al.* (2013) and in rice under SRI by MD.Riton *et al* (2014).

Chetti and Sirohi (1995) releaved that LAD as useful growth parameter indicating the efficiency of photosynthetic system, with high degree of association with dry matter accumulation. Similar to LAI, GP-153 and GP-111 recorded highest LAD (Table 3). The genotypes GP-23 and GP-3 recorded lowest LAD. Similar results of reduction of LAD under moisture stress was also reported in ragi by Krishnasastry *et al.* (1981), in rice by Chauhan *et al.* (1996) and in aerobic rice by Renuka Devi *et al.* (2013).

CGR increased in all the genotypes under irrigated and moisture stress conditions upto 30-45 DAT and thereafter

Table 5: Evaluation of ragi genotypes for yield and yield attributes under imposed moisture stress conditions

Genotype	No. of tillers per plant			No. of fingers/plant			1000 grain weight			Grain yield Kg ha^{-1}			Straw yield kg ha^{-1}			Harvest index		
	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean	T0	T1	Mean
GP-3	3.60	2.87	3.23	20.80	15.00	17.90	2.35	2.12	2.23	2146.7	986.7	1566.7	5063.33	4306.67	4685.00	29.77	18.64	24.21
GP-24	3.47	2.93	3.20	19.17	15.60	17.38	2.43	2.23	2.33	1603.3	913.3	1258.3	4546.67	4056.67	4301.67	26.07	18.38	22.22
GP-25	2.40	2.40	2.40	18.57	15.80	17.18	2.20	2.17	2.18	1440.0	898.3	1169.2	3500.00	4253.33	3876.67	29.15	17.44	23.29
GP-27	2.60	2.33	2.47	16.15	16.67	16.41	2.16	2.28	2.22	2240.0	1423.3	1831.7	4240.00	3436.67	3838.33	34.57	29.29	31.93
GP-23	3.20	2.67	2.93	21.85	16.42	19.56	2.43	2.21	2.32	2706.7	1674.0	2358.3	3203.33	2736.67	2970.00	45.80	42.35	44.07
GP-104	4.60	3.40	4.00	23.40	21.93	22.67	2.78	2.37	2.58	2943.3	2033.3	2488.3	6923.33	4866.67	5895.00	29.83	29.47	29.65
GP-111	4.07	4.07	4.07	24.40	23.13	23.77	2.90	2.45	2.67	3316.7	2376.7	2846.7	8343.33	7230.00	7786.67	28.44	24.74	26.59
GP-149	3.13	3.20	3.17	20.37	16.80	18.58	2.47	2.43	2.45	2683.3	1610.0	2146.7	6455.3	6290.00	8615.00	19.70	20.38	20.04
GP-153	5.20	3.13	4.17	27.77	23.67	25.72	2.93	2.52	2.73	2840.0	2280.0	2560.0	7096.67	6836.67	6966.67	28.58	25.01	26.80
GP-160	2.73	2.67	2.70	20.58	18.47	19.53	2.25	2.29	2.27	2863.3	1393.3	2128.3	6850.00	5556.67	6203.33	29.48	20.05	24.76
Mean	3.50	2.97		21.31	18.25		2.49	2.31		2478.33	1558.90		5622.20	4957.00		30.14	24.57	
	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G	T	G	T × G
SE m ±	0.11	0.24	0.35	0.45	1.01	1.43	0.02	0.05	0.07	147.47	329.75	466.34	285.14	637.60	901.71	1.97	4.41	6.24
CD(P=0.005)	0.31	0.70	0.99	1.29	2.89	4.09	0.07	0.15	0.21	422.32	944.33	1335.49	816.5916	1825.954	2582.289	5.65	12.63	17.86

T0-Control T1-Treatment

decreased up to harvest (Table 4). Similar genotypic variability for CGR among rice genotypes under rainfed upland conditions were also reported by Chauhan *et al.* (1995) and in aerobic rice by Renuka Devi *et al.* (2013). Among the genotypes, GP-153 (16.75) and GP-111 (13.96) recorded significantly higher CGR compared to other genotypes in accordance to LAI. These genotypes sustained crop growth under moisture stress conditions than other entries. GP-23 and GP-25 recorded lowest CGR. Similar result was also reported in rice under SRI by MD.Riton *et al* (2014).

Among the genotypes GP-111 recorded significantly higher grain yield of 2846.7kg ha^{-1} followed by GP-153 2560 kg ha^{-1}(Table5).The genotypes GP-23, GP-149, GP-160 recorded poor yield under moisture stress conditions. Similar results of decrease in the grain yield due to moisture stress were reported in prosomillet (Seghatoleslami *et al.*, 2008). The genotypes GP-153(8615.0 kg/ha) and GP-111 (7786.67 kg ha^{-1}) recorded significantly high mean straw yield followed by GP-104 (6966.67 kg ha^{-1}). The genotypes GP-23 (2220.0kgha^{-1}) and GP-27 (3838.3 kg ha^{-1}) recorded lowest straw yields.

The higher harvest index of these genotypes represents an increased physiological capacity to mobilize photosynthates and translocate them efficiently to organs of economic value, i.e. grain yield as opined by Wallace *et al.* (1972). Among the tested genotypes GP-153 recorded highest mean harvest index (44.32%) followed by GP-111 (35.99%) compared to other genotypes. The study reveals that GP-111 and G.P-153 were superior in terms of physiological efficiency and final yields.

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