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ADAPTABILITY AND FORAGE POTENTIAL STUDIES IN FINGER MILLET (*ELEUSINE CORACANA* L) ACCESSIONS

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SUMMARY

The present investigation was undertaken at Upland Research cum Instructional Farm, Lamker, SGCARS, IGKV, Raipur in *Kharif* 2018-19 with 100 germplasm accessions to evaluate the forage potential of finger millet (*Eleusine coracana* L.) in augmented randomized block design. Mean squares for analysis of variance indicated significant differences among blocks, check and test entries for crop duration, canopy length and fodder weight. The maximum canopy length was recorded in genotype GEC-5 (126cm) followed by GEC-186 (125 cm), GEC-92 (124 cm), GEC-310 (122 cm), GEC-314 (120 cm) and others. Referring to crop duration, genotype IC0476378, IC0477043, GEC-322, GEC-11, IC0477620, GEC-296, GEC-53 and GEC-352 can be considered as good for medium fertile soil and average monsoon regions in lieu of mid-durational maturity. For fodder yield, IC0476495 (1646 g/plot) was recorded as most dominating genotype referring to the breeding objective and subsequently GEC11 (1222 g), GEC92 (1112 g), IC0477620 (1042 g), GEC132 (1027 g) and IC0477556-X (990 g) also showed fair potential. To get establish general crop growth parameters in association with fodder as objective, we conclude that 95-105cm of canopy length and 105-115 DAS of crop may be opted to achieve the maximum forage potential in finger millet. We further suggest that IC0476495, GEC11, GEC92, IC0477620, GEC132, IC0477556-X, IC0476838, IC0477317, GEC274, IC0477560, IC0477591 and GEC135 shown good potential and should be revalidated in next crop season followed by incorporation in replicated trials.

Key words : Finger millet, forage potential, germplasm accessions

Finger millet (*Eleusine coracana* Gaertn L.) is an annually cultivated crop plant, which is native to the Ethiopian and African highlands and widely adapted to a range of different growing conditions of upland and midland agriculture. Finger millet is an important cereal crop in many drought-prone regions across the world (Upadhyaya *et al.*, 2010). Its primary growing area ranges from 20° N to 20° S in the semiarid to the arid tropics even though finger millet is grown in areas at 30° N (Himalayan regions of India and Nepal) (Baath *et al.*, 2018). A temperature range of 8-29^0 C is best suited for its optimal growth wherein, a minimum soil temperature of 8 to 10 °C is needed for germination and warm conditions involving an average temperature of 26 to 29 °C, which leads to its vegetative growth and development (Joshi, 2015). Finger millet yield potential of about 20 to 35 q/ha grain and 30 to 90 q/ha fodder under Indian dryland conditions. It also has high water use efficiency and consumes 10% to 20% less water than sorghum (*Sorghum bicolor* (L.) Moench) under irrigated conditions (Anonymous, 2006). Finger millet can tolerate some degree of waterlogging or salinity, but it is sensitive to frost (Satish *et al.*, 2016). Finger millet has emerged and served successfully as a malnutrition safeguard during the drought and is even staple food in some regions of India as well as Eastern and Central Africa (Singh & Raghuvanshi, 2012). It is consumed in many traditional and modern behaviours including bread, porridge, malt, popped products and in both alcoholic and non-alcoholic brewing industries (Shobana *et al.*, 2013). The finger millet grain ideally comprises 7–14% protein, 1.5% fat, 3.6% fiber and 73% carbohydrate. It's also rich in Ca, Zn, Fe, Mn, and P compare to other major cereals and therefore regarded as perfect food for growing children, pregnant and breastfeeding mothers and the infirmed (Devi *et al.*, 2014). Biochemical investigation and nutritional profiling have affirmed its utility in controlling blood glucose levels, which is recommended for diabetic patients (Kumari *et al*., 2002) and it's also considered ideal for celiac patients due to vary low or no gluten content.

In addition to human consumption for sustainability and dietary promising nature, finger millet forage is also is highly nutritious and fed to livestock in several African and Asian countries. The nutrient concentration of this crop is crude protein (CP; 10.7%), Ca (1.20%), P (0.44%), K (4.53%), and Mg (0.31%) that are higher than forage corn (*Zea mays* L.) and forage sorghum (Gowda *et al*., 2015). In accordance with recent report by Bath *et al*. (2018) Finger millet forage 598 to 734 g/kg neutral detergent fiber (NDF), 268 to 382 g/kg acid detergent fiber (ADF), 597 to 730 g/kg in vitro true digestibility, and 387 to 552 g/kg neutral detergent fiber digestibility. Despite of numerous beneficial properties, finger millet has limited fame as global forage crop which pertains to lack of elaborative scientific research including large number of genotypes for conclusive evidences. Consequently, there is a fundamental need to evaluate climate adaptability, drought tolerance and yield capabilities in order to assess the potential of finger millets forage crop. The specific objectives of this study were to: (1) assess the adaptability of 100 finger millet accessions to *kharif* conditions of the Bastar plateau regions of Chhattisgarh state and (2) define their capabilities as a potential forage crop.

MATERIALS AND METHODS

A preliminary fodder yield evaluation trial involving 100 germplasm accessions of finger millet (listed in Table 03), was conducted at New Upland Research cum Instructional Farm, SG College of Agriculture and Research Station, Lamker, IGKV, Raipur, Chhattisgarh during *Kharif* 2018-19 crop season. Each entry was directly seeded in paired row of 03-meter length where the inter row distance was maintained at 22.5cm. Three to four seeds were hand placed at the gap of 10cm in each row, which were later subjected to thinning in accordance with physical condition of plant. The experiment was divided into 10 blocks each of which comprised of 10 test entries and four check varieties. Check varieties namely Indira Ragi 01, CG Ragi 02, GPU-28 and GPU-67 were planted at random on paired rows within block in a way that same check varieties appeared in every block. The data was recorded for 17 quantitative and qualitative parameters were recorded, among them canopy length (cm), crop duration (DAS) and fodder yield per plot (g) are being discussed in current manuscript. Canopy length was measured at maturity by scaling from bottom soil-plant contact to top of flag leaf. Similarly crop duration was noted when the fifty percent plant population reached at physiological maturity by counting the number of days taken from seeding. Fodder yield was measured after crop harvested, the method followed was cutting the entire plant from bottom followed by removing the panicle and measurement of whole plot weight under green condition. The raw data was subjected to statistical analysis following the augmented techniques (Federer, 1956; Federer and Raghavarao, 1975).

RESULTS AND DISCUSSION

Mean squares for analysis of variance indicated significant differences among blocks, check and test entries for crop duration, canopy length and fodder weight (Table 1). The presence of significant variation among germplasm accessions expressed the scope of improvement for fodder and its associated parameters. Similarly, the result showed that the checks were extremes of the characters for as long as three important traits are therefore, the efficacy of checks to make different comparisons against new selections could not be ruled out. Saleem *et al*., (2009 & 2013) reported the worth of genetic variability for days to fruiting, number of fruits per plant and single fruit weight for checks. In routine evaluation of germplasm, two disadvantages have been recorded. Firstly, the checks are systematically placed and secondly no provision is made to adjust the mean

TABLE 1

Mean squares for analysis of variance for check and test entries

Source	d.f.	Mean Sum of squares		
		Crop duration	Canopy length	Fodder weight
Block	9	80.67	198.47	91385.25
Treatment	103	114.99	250.52	114863.70
Checks	3	222.03	939.18	203946.20
Test entry	99	98.22*	216.57*	88746.73*
Check vs Test	1	1454.00*	1545.78*	2433196.13*
Error	27	2.53	44.63	2115.61
Total	139	90.92	207.16	91442.80

performance of the traits due to soil or other differences from one part of experiment to another. To overcome these difficulties, four checks were assigned at random to rows with in the blocks, with same check genotype appearing in every block. And for managing the soil or other factors, adjusted mean was calculated based on estimating check effect, block effect and genotypic effect. The present study also provides estimates of standard errors of four different comparisons (Table 2) to compute least significant differences. However, the most useful comparison was the difference between adjusted means of selections and a check mean therefore, LSI at 0.05 level of probability using one tailed t-test at 27 degree of freedom (d.f.) for each trait was worked out.

The mean of checks and adjusted mean of block differences of new germplasm accessions for all traits undertaken for study are given in Table 3. Any adjusted mean performance of germplasm accessions less than or greater than overall performance (observed mean + LSI) was taken as base criteria to compare each check and test entry. The crop duration ranged between 80-128 DAS while the mean value was recorded as 106 DAS. In general, other parameters like grain yield, fodder yield, tillers count and some other traits are desired in ascending direction but in contrast some traits like crop duration and canopy length, the desireless varies with breeding objective and existing climatic scenario. Here, the medium type genotype is preferred because in very early type, fodder yield is very low and similar trend was in case of late plant type. However, regions with high rainfall and fertile soil type, comparatively long duration plant type may by opted (Kumar *et al.*, 2020a). Genotype IC0476378, IC0477043, GEC-322, GEC-11, IC0477620, GEC-296, GEC-53 and GEC-352 can be considered as good for medium fertile average monsoon regions. Similarly for area having late cessation of rainy season GEC-441 and GEC-122 can be included in further crop breeding. While selection for summer fodder crop IC0476495, IC0478838, IC0477317, IC0477152, GEC-352 and IC0477560 was shown to had great potential. The length of plant canopy, measured from lowest of plant-soil contact up to terminal end, is crucial when vegetative or forage part is targeted. However, like wise previous trait canopy length is not always upwardly desired because it may lead to lodging or toughness of stem due to cellulose deposition. Among the test population and check genotypes studied a wide variability was observed for the trait and it ranged from 50-126 cm with an average of 98 cm. The maximum canopy length was recorded in genotype GEC-5 (126 cm) followed by GEC-186 (125 cm), GEC-92 (124 cm), GEC-310 (122 cm), GEC-314 (120 cm) and others. When medium statured plant type was sorted out, IC0476676, GEC223, GEC108, GEC376, GEC131 IC0477560 (105 cm each), IC0477152 (104 cm), IC0477556-X, GEC62, IC0476959-X (103 cm each) and some others lied in this category. Among the germplasm accessions with dwarf canopy length, IC0477602 was seen to be shortest (50 cm) followed by IC0477569 (52 cm), IC0476299 (54 cm), IC0477047 (57 cm), IC0476786 (63 cm), GEC294 (69 cm) and some others. For dual purpose, both fodder and grain production, medium type of canopy length should be preferred. The close association between plant and associated traits such as leaf erectness and grain to straw ratio is of great significance. In relation to respiration-photosynthesis

TABLE 2

Standard Errors for various components

Differences	Crop duration	Canopy length	Fodder weight
Difference between adjusted means of two test entries in different block	2.25	9.45	65.05
LSD = $p \leq 0.05$	4.52	18.99	130.75
LSD = $p \leq 0.01$	6.03	25.32	174.33
Difference between adjusted means of two test entries in same block	2.52	10.56	72.73
LSD = $p \leq 0.05$	5.06	21.23	146.18
LSD = $p \leq 0.01$	6.74	28.31	194.90
Difference between means of check varieties	0.71	2.99	20.57
LSD = $p \leq 0.05$	1.43	6.01	41.35
LSD = $p \leq 0.01$	1.91	8.01	55.13
Difference between adjusted means of a test genotype and check	1.87	7.83	53.93
LSD = $p \leq 0.05$	3.75	15.75	108.41
LSD = $p \leq 0.01$	5.00	20.99	144.55

TABLE 3
Mean performance of checks and adjusted performance of genotypes of finger millet

Treatment	Crop Duration (DAS)		Canopy length (cm)		Fodder weight (g)		Treatment	Crop Duration (DAS)		Canopy length (cm)		Fodder weight (g)	
	Mean	Adj. mean	Mean	Adj. mean	Mean	Adj. mean		Mean	Adj. mean	Mean	Adj. mean	Mean	Adj. mean
IC0476378	110	108	93	96	888	868	IC0477317	100	101	78	78	970	963
GEC411	127	125	100	102	582	562	GEC5	110	111	126	126	536	529
IC0477325	82	80	70	72	210	190	IC0477304	114	115	85	86	250	243
IC0477890	102	100	105	107	700	680	IC0476921	105	106	95	95	134	127
IC0588007	95	93	111	113	608	588	IC0477467	103	104	110	110	537	530
GEC371	108	106	113	115	752	732	GEC137	103	104	99	99	814	807
GEC222	100	98	107	109	610	590	GEC266	102	103	88	89	200	193
IC0477043	121	119	116	118	892	872	GEC470	127	128	101	102	332	325
IC0477650	111	109	105	108	766	746	IC0477152	111	111	99	104	525	539
GEC41	113	111	96	98	316	296	GEC191	86	86	104	109	378	392
GEC453	98	98	92	89	330	318	GEC296	115	115	103	108	770	784
GEC322	115	115	101	98	851	839	GEC394	100	100	109	114	502	516
IC0477017	107	107	85	82	288	276	IC0477620	109	109	106	111	1028	1042
IC0477569	92	92	55	52	48	36	GEC376	118	118	100	105	182	196
GEC11	115	115	105	101	1234	1222	GEC108	84	84	100	105	418	432
GEC69	114	114	113	109	794	782	IC0477951	111	111	111	116	442	456
IC0476786	105	105	67	63	224	212	IC0476864	111	111	94	99	321	335
IC0476959-X	110	110	106	103	632	620	GEC226	85	85	90	95	737	751
IC0476707	101	101	90	87	448	436	IC0477507	100	100	107	108	800	818
GEC92	117	117	128	124	1124	1112	GEC280	118	118	87	88	586	604
IC0477787	103	103	102	98	270	300	IC0477673	106	106	97	98	575	593
IC0476495	109	109	86	82	1616	1646	IC0477678	118	118	78	79	133	151
IC0477556-X	113	113	107	103	960	990	IC0476663	105	105	89	90	632	650
IC0476669-X	118	118	90	87	490	520	IC0476913	105	105	112	112	474	492
GEC274	110	110	95	92	925	955	GEC348	97	97	86	86	702	720
GEC400	105	105	110	107	760	790	GEC297	105	105	97	98	363	381
GEC223	126	126	108	105	512	542	GEC535	117	117	114	115	180	198
GEC270	97	97	99	96	816	846	GEC93	100	100	117	117	772	790
GEC55	98	98	103	100	455	485	GEC186	100	101	123	125	842	830
IC0476838	109	109	112	109	936	966	GEC131	115	116	102	105	851	839
GEC517	124	123	93	86	580	587	IC0476720	114	115	96	98	514	502
GEC23	112	111	89	82	249	256	GEC122	127	128	105	108	762	750
IC0476299	113	112	61	54	417	424	IC0477591	112	113	92	95	933	921
GEC53	108	107	108	101	881	888	IC0477406	97	98	106	108	612	600
GEC249	99	98	89	82	426	433	GEC135	105	106	95	98	926	914
IC0477602	97	96	57	50	381	388	IC0477382	105	106	93	95	453	441
IC0477047	83	82	63	57	250	257	GEC233	110	111	109	111	278	266
GEC132	91	90	62	55	1020	1027	IC0477328	105	106	92	95	158	146
IC0476724	110	109	117	110	261	268	IC0477560	103	103	99	105	990	955
GEC-247	95	94	80	74	490	497	GEC294	93	93	63	69	121	86
GEC310	118	119	125	122	521	539	IC0476539	101	101	103	109	331	296
GEC187	106	107	93	90	276	294	GEC314	105	105	114	120	247	212
IC0476676	109	110	108	105	372	390	IC0477601	109	109	106	112	710	675
GEC352	108	109	85	82	866	884	GEC370	91	91	91	97	283	248
IC0477496	110	111	93	90	244	262	GEC485	85	85	111	116	220	185
GEC62	98	99	106	103	224	242	GEC144	89	89	105	111	180	145
GEC106	99	100	100	97	723	741	GEC127	94	94	96	102	310	275
GEC147	102	103	91	88	428	446	IC0476877	110	110	89	95	115	80
GEC254	99	100	102	99	255	273	CG Ragi 02*	115		104		676	
GEC313	114	115	112	109	724	742	IR 01*	120		121		973	
GEC347	105	106	101	101	242	235	GPU 28*	108		108		913	
GEC79	111	112	113	114	876	869	GPU 67*	115		98		980	

balance, short culm minimises the respiration loss and improves net gain thereby (Kumar *et al.*, 2020b). Reversibly tall stature is advantageous than dwarf for better light penetration and photosynthetic rise. However tall and weak straw variety lodge early at high nitrogen, which reduces the cross-section area of vascular bundle and alters translocation of assimilates and mineral nutrition.

Finger millet stover has been documented to make good fodder and contains up to 61% total digestible nutrients (Wafula *et al.*, 2017). Millet therefore offers opportunity for development of a thriving livestock industry. Major constraints that have hampered production and utilization of finger millet and its products include limited improved varieties and poor crop management practices. In our study we found genotypes with good forage potential and equally wide variation among accessions with respect to crop duration, plant type and ultimate produce. Different accessions tested achieved fodder yield that ranged from 36 to 1646 g/plot during the Kharif season in response to common set of conditions (location, environment, soil fertility, row spacing, plant spacing, fertilizer level, Table 3). IC0476495 (1646 g/plot) was recorded as most dominating genotype referring to the breeding objective and subsequently GEC11 (1222g), GEC92 (1112g), IC0477620 (1042 g), GEC132 (1027 g) and IC0477556-X (990 g) also showed fair potential. However, test accessions exhibiting more than 600g of the yield should also be considered for further replicated evaluations. To get establish general crop growth parameters in association with fodder as objective, we considered crop duration and canopy length and when top genotypes were compared and found that 95-105cm of canopy length and 105-115 DAS of crop may be opted to achieve the maximum forage potential in finger millet (Kumar *et al.*, 2020b). We further suggest that IC0476495, GEC11, GEC92, IC0477620, GEC132, IC0477556-X, IC0476838, IC0477317, GEC274, IC0477560, IC0477591 and GEC135 should be revalidated in next crop season followed by incorporation in replicated RBD trials.

While finger millet shows a degree of capacity to grow in the rainfed, dryland and marginally irrigated areas, there are issues to be addressed before its multipurpose use in the region especially the development of management strategies. There is little information regarding the optimal combination of row spacing, the amounts of fertilizers, and water availability for the use of finger millet for forage crop. Furthermore, there is a need for information on the growth responses with respect to genotype x environment interactions of finger millet in different soils of the region. Finger millet accessions sourced from different geographic locations exhibited a range of adaptation regarding the *Kharif* conditions of the Chhattisgarh Bastar Plateau. All finger millet lines tolerated the June to July hot and humid period and produced sufficient amounts of forage in response to precipitation that occurred during the rest of the growing season. Future research should focus on, identification of superior and stable genotypes, developing strategies for agronomic management and evaluating its capability in grazing and hay production systems for cattle.

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