Plant Archives Vol. 17 No. 1, 2017 pp. 241-246 ***ISSN 0972-5210***

ESTIMATION OF GRAIN NUTRIENT AND THEIR ASSOCIATION WITH GRAIN YIELD IN FINGER MILLET [*ELEUSINE CORACANA* (L.) GAERTN]

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Abstract

The low protein content in finger millet grain is a matter for concern. So to identify genotypes having high protein and calcium content as well as their association with yield, present experiment was conducted with 48 genotypes of finger millet with 3 replication at NBPGR, regional station Hyderabad. White seeded genotype (SNVD-11-88) had higher protein contents (9.33 mg/100g grain), while among brown seeded types genotype SNVD-11-15 had the highest protein content (9.23mg/100g grain). Calcium content of the genotypes ranged from 188.66mg/100 g of grain (CMLS-01-336-SEL-11) to 324.33 mg/100 g of grain (SNVD-11-15) with an average value of 235.34 mg/100g.The genotypic coefficients of variability were moderate and high for protein (16.4) and calcium (31.21), respectively. Protein content, calcium content and grain yield have shown high heritability viz.,99.47, 97.74,75 respectibly. Genetic advance as percentage of mean was also high for these three characteristics, protein 34.5, calcium 46.44, grain yield/plot39.65. High heritability coupled with high genetic advance indicated their governance by additive gene action. A negative significant correlation was observed between protein content and grain yield (-0.4596) and correlation between calcium content and grain yield is not significant (0.0169). Protein content had significant positive association with calcium content (0.2597). Genotypes having higher protein and calcium content can be used in further breeding programme for the purpose of bio-fortification.

Key words : Finger millet, grain colors, protein, calcium, correlation, biofortification.

Introduction

Finger millet [*Eleusine coracana* (L.) Gaertn] also known as birds foot millet, ragi or African millet is an annual plant widely grown as an important food crop in the arid areas of Africa and South Asia. It ranks third in importance among the millets after sorghum and pearl millet in India. It is a hardy crop that can be grown in diverse environments from almost at sea level in south India to high lands of Himalayas (altitudes of 1850 to 2300 meters) and from poor soils on hill slopes to rich soils in the Indo-gangetic plains. The crop provides food grain as well as straw, which is valued animal feed especially in rainfed areas. In India, it is very popularly known as ragi and is grown in an area of 2 million hectares with a production of 2.6 million tonnes. Finger millet provides staple food for a large section of farming community and economically weaker sections in many parts of India. Important finger millet growing states are Karnataka, Tamil Nadu, Andhra Pradesh, Maharastra, Orissa, Jharkhand, Chattishgarh and Uttarakhand.

Finger millet grain is nearly globular in shape and is very small in size (1.0 to 1.5 mm in diameter). Brown is the predominant grain colour in finger millet although a few varieties have white seeds (Vadivoo *et al*., 1998). The nutritional quality of finger millet grain makes it an ideal food for infants and invalids. Among brown and white grain types, the latter are preferred because they contain higher protein, lower fiber and lower tannins. However, yield potential of the white grained types is generally lower than the browns. Finger millet is also a very rich source of calcium.

The basic information on the existence of genetic variability and diversity in a population and the relationship between different traits is essential for any successful

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plant breeding program (Sripichitt *et al*., 2007). Such genetic studies on protein and calcium contents along with yield and yield related characteristics will be useful in the development of high yielding finger millet varieties (Upadhyaya *et al*., 2011) with high protein and calcium contents. Hence, the present study of 28 finger millet genotypes having varying seed coat colors and nodal pigmentation was undertaken to determine the genetic variability for the above two nutrients and their relationship with yield, nodal pigmentation and grain color.

Materials and Methods

The present investigation was undertaken at the National Bureau of Plant Genetic Resources, Rajendranagar, Hyderabad. The experimental material comprised of 48 germplasm lines of finger millet. These lines were collected from different parts of India and raised in a randomized block design with three replications at NBPGR research farm at Rajendranagar Hyderabad.

Five random plants in each replication for each genotype were tagged for making observations and the mean of five plants was used for statistical analyses. Observations were recorded on lodging, stay-greenness, nodal pigmentation, grain colour, grain protein content grain calcium content and grain yield/plot. For the estimation of protein and calcium, grains from three random sample from each replication were selected. For the estimation of grain protein content, the micro-Kjeldahl method of Humphries (Humphries, 1956) was used and the calcium content was estimated by using the versenate titration procedure of Jackson 1956 using a triple acid extract solution and expressed in mg per 100 g of grain on a moisture free basis. Phenotypic and genotypic coefficients of variability (PCV and GCV) were determined. Broad sense heritability was computed using the method suggested by Hanson *et al*. (1956) and Genetic advance (GA), as a percentage of the mean, was computed using the method of Johnson (1955). Genotypic correlations also were determined.

For characters lodging (fig. 1), staygreen colour, nodal pigmentation (fig. 2) and grain colour have given code to describe their form of appearance which are presented in table 1. Nodal pigmentation is given code no. (0 absent/1 present), degree of lodging is given code no. (3 high/5 intermediate/7 low), stay green colour is given code no. (0 absent/1 present) and grain colour is given code no. (1 white/2 light brown/3 copper brown/4 purple brown). Scoring was done on the basis of coding.

Results

Analysis of variance for the experiment involving a set of 48 finger millet genotypes for protein content, calcium content and grain yield per plot (g), revealed that the variance were significant for all the characters indicating greater diversity among the 48 finger millet genotypes studied. The range of protein content was from 5.96 g (SRYA-333-SEL-1) to 9.33 g (SNVD-11-88) per 100 g of grain. Twenty two genotypes possessed significantly higher protein content than the general mean of 7.50 g per 100 g of grain.

The brown seeded genotype (SNVD-11-88) had higher protein contents than the general mean. The copper brown seeded genotypes PSR-10095-SEL-1,SRYA-333-SEL-1, SRS-13436, AR-2, AR-3, AR-5, SNVD-11-89, SNVD-11-38 and the purple brown seeded genotype SRS-13435, SRS-13433, SRS-13426, CMLS-01-336-SEL-03 had low protein contents (lower than the mean value) (table 2). Highest yield per plant was observed for the genotype NSS-7928-SEL-1 and was showing presence of nodal pigmentation and lowest yield for the genotypes PR-202 showing absence of nodal pigmentation. Different degree of lodging and staygreenness has been recorded in these germplasm.

The appearance of the characters degree of lodging, staygreen colour, nodal pigmentation and grain colour is shown in frequency, reveals that there is a huge variation in the appearance of these characters, which are presented in table 1. In case of nodal pigmentation genotypes without nodal pigmentation is more with 66.66% frequency and genotypes with pigment is less with 33.33%. Genotypes with higher susceptibility to lodging recorded higher in number among 48 genotypes with 66.66% frequency, genotypes with intermediate lodging having less genotypes than susceptible one with 27.08% frequency. Genotypes with green colour at maturity is less in no. with 33.33% frequency and genotypes without green colour at maturity recorded 66.66%. Genotypes having grain colour light brown occurred with 45.83% frequency, copper brown with 45.75% frequency and purple brown with 10.41% frequency. The results are conformity with Sripichitt *et al*. (2007).

Calcium content of the genotypes ranged from 188.66mg/100 g of grain (CMLS-01-336-SEL-11) to 324.33 mg/100 g of grain (SNVD-11-15) with an average value of 235.34. Eighteen genotypes possessed significantly higher calcium content than the general mean of 235.34 mg/100 g of grain (table 2).

The genotype NSS-7928-SEL-1 gave the highest grain yield of 1591 g per plot followed by NSS-7928-SEL-2 (1518g). The lowest value was noted in PR-202 (536 g). Thirteen entries had significantly higher grain

Fig. 1 : Lodging of finger millet plants in field.

Fig. 2 : Plant with nodal pigment and plant without nodal pigment.

yield than the general mean of 1010 g per plot. The genotype SNVD-11-88, which had the highest protein content, had 903 g of grain yield per plot. The grain yield of SNVD-11-15, which had the highest calcium content, was 598 g /plot. The grain yield of the genotype with the lowest protein content (SRYA-333-SEL-1) was 1085 g per plot and that of the low calcium containing type, CMLS-01-336-SEL-11, was 817 g per plot.

The knowledge of genetic variability present in a given crop species for the character under improvement is of paramount importance for the success of any plant breeding programme. Information on coefficient of variation is useful in measuring the range of variability present in the characters. Heritability and genetic advance are important selection parameters. Genotypic coefficient of variation (GCV) along with heritable estimates would provide a better picture of the amount of genetic advance to be expected by phenotypic selection (Burton and Devane, 2002). It is suggested that genetic gain should be considered in conjunction with heritability estimates (Johnson, 1955). Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone.

GCV for calcium content (31.62) and grain yield (25.41) was high, while for protein content it was moderate (16.4). PCV for calcium and yield is also high, where as for protein content it was moderate. Regarding heritability estimates, the genotypes of the present investigation had high values for all the above three characteristics, 99.47, 97.74,75 for protein content, calcium content and grain yield/plot respectably. Genetic advance as percentage of mean was also high for these three characteristics, protein 34.5, calcium 46.44, grain yield/plot 39.65 (table 3).

The protein content had a significant and positive genotypic correlation with calcium content (0.2597) and negative and significant genotypic correlation with grain yield (-0.4596). The genotypic correlation of calcium content with grain yield was not significant (0.0169).

Discussion

Finger millet is an excellent source of calcium (seven times more than rice) and protein. Among cereals, it possesses a reasonably high level of methionine, the major limiting amino acid of tropical regions, and the component least correctable by the addition of pulses to the diet. The low protein content in finger millet grain is a matter

Table 1 : Code no of four qualitative characters and Frequency at which qualitative characters occurs.

Character	Code no.	Description	Percentage frequencies of each character
Nodal pigmentation	0	Absent	66.66
	1	Present	33.33
Degree of lodging at maturity	3	High	66.66
	5	Intermediate	27.08
	7	Low	6.25
Staygreen colour	0	Absent	66.66
	1	Present	33.33
Grain colour	1	White	2.02
	2	Light brown	45.83
	3	Copper brown	45.75
	4	Purple brown	6.4

for concern.

Qualitative characters are useful criteria for characterization of germplasm accessions, as they show high heritability and stable expression. Further, if qualitative characters show association with yield components, it can serve as a marker in selection process. The variability for four qualitative characters *viz*., nodal pigmentation, degree of lodging at maturity, staygreenness and grain colour present in national collection of finger millet accession are discussed here. Hence, in this investigation, 48 genotypes with different degree of lodging,staygreenness, seed coat colors, nodal pigmentation were evaluated for protein and calcium contents and grain yield.

Present investigation showed significant difference between the genotypes for protein content and calcium content of grain ranged from 5.96mg/100 g grain (SRYA-333-SEL-1) to 9.33mg/100 g grain (SNVD-11-88). Upadhyaya et al, Sonnad and Vadivoo et al. noted wide differences in protein content. The protein content of white seeded types have been found to be higher when compared to that of brown seeded types, but variation in protein content is maximum in brown seeded types. Similar result has been reported by (Vadivoo *et al*., 1998; Parida *et al*., 1989). It has been clear from the result that most of the lines having high yield showed presence of nodal pigmentation although lines which is having low yield also showed presence of pigmentation. It has been recorded that in maximum cases the genotypes having intermediate lodging and lack of senescence counted higher yielding. The result is conformity with several authours (Shigeta, 1985; Sripichitt *et al*., 2007; Vadivoo *et al*., 1998).

The estimates of heritability act as predictive instrument in expressing the reliability of phenotypic value. Therefore, high heritability helps in effective selection for a particular character. Heritability in broad sense is the ratio of genotypic variance to the phenotypic variance and is expressed in percentage. In the present study all quantitative characters show high heritability (broad sense). High heritability for quantitative characters indicates the scope of genetic improvement of these characters through selection.

Moderate GCV estimates obtained for protein content indicated fairly large extent of genetic variation for this characteristic. High heritability coupled with high genetic advance as a percentage of the mean observed for this characteristic. In the present investigation, high heritability coupled with high genetic advance as per cent of mean was observed for three character protein content, calcium content and grain yield per plot. Thus, these traits are predominantly under the control of additive gene action and hence these characters can be improved by selection. The results are conformity with Vadivoo *et al*. (1998).

A negative significant correlation was observed between protein content and grain yield in this investigation, indicating an increase in protein content due to the decrease in grain yield. Similar results were obtained by Vadivoo *et al*. (1998), Dineshkumar (1987). No significant correlation has been found between grain calcium content and grain yield. This was conformity with the findings of Bothikar *et al*. (2014). Protein content was significantly and positively correlated with calcium content. Similar results were reported by Bothikar *et al*. (2014), Sripichitt *et al*. (2007).

To conclude, in the present study white seeded finger millet genotypes had higher protein contents, while brown

Table 2 : Degree of lodging, stay green colour, nodal pigmentation, grain colour and yield performance of 48 germplasm lines for protein and calcium.

S. no.	Genotype	Degree of lodging at maturity (3 high/5 intermediate /7 low)	Stay green colour (0 absent/ 1 present)	Nodal pigmentation (0 absent/ 1 present)	Grain colour (1 white/2 light brown/ 3 copper brown/4 purple brown	Protein content Mg/100 g grain	Calcium content Mg/100 g grain	Grain yield/ plot(g)
1	SNVD-11-5	3	0	1	2	8.4	219	1270.66
2	SNVD-11-15	3	0	1	2	9.23	324.33	598.33
3	snvd-11-28	3	0	0	2	8.1	228	789.33
4	SNVD-11-38	3	0	0	3	7.28	232	696.66
5	SNVD-11-41	7	1	0	2	7.4	258	874
6	SNVD-11-54	5	1	0	3	7.7	222	996
7	SNVD-11-72	7	0	1	2	8.1	238	1140.33
8	SNVD-11-77	3	0	0	2	7.98	238.33	1169
9	GPU-67	3	0	0	3	7	219	1258
10	SNVD-11-88	3	1	1	2	9.33	301	903
11	SNVD-11-89	5	1	1	3	7.23	225	847.66
12	SNVD-11-99	3	0	1	3	7.9	255	790.33
13	SNVD-11-112	3	0	0	3	7.7	189.33	1193
14	PR-202	5	0	0	3	7.1	192	536.33
15	AR-1	3	0	0	3	7.8	231	1251
16	SNVD-11-118	5	0	1	2	7.75	198.66	1162.66
17	AR-2	3	0	0	3	6.84	199.33	829.33
18	AR-3	5	1	0	3	7.1	201	1099
19	SRS-13466	3	0	1	2	8.22	288	1013
20	AR-4	3	0	1	3	7.8	205	889
21	AR-5	7	1	1	3	7.44	217.66	889
22	BAR-174	5	1	1	2	8.42	286.33	1269.33
23	CMLS-01-336-SEL-01	3	0	0	3	6.83	220.33	1183.66
24	CMLS-01-336-SEL-03	5	1	1	4	7.1	222.33	1225.33
25	CMLS-01-336-SEL-06	3	1	0	3	7	204.66	832.66
26	CMLS-01-336-SEL-07	3	1	0	2	6.85	199	867
27	CMLS-01-336-SEL-08	3	0	1	2	7.55	201.66	886
28	CMLS-01-336-SEL-09	3	0	0	1	8.73	255.33	734
29	Gpu-45	3	0	1	2	7.64	194.33	1100.33
30	CMLS-01-336-SEL-11	5	0	0	2	7.74	188.66	817.66
31	CMLS-01-336-SEL-12	3	0	0	3	7.71	198	1048
32	NSS-7928-SEL-1	5	1	0	3	6.71	213.66	1591.66
33	NSS-7928-SEL-2	5	1	0	2	6.55	239	1518.66
34	NSS-7928-SEL-3	3	0	0	2	7.11	222	1108.66
35	NSS-7928-SEL-4	3	0	0	2	7	238	1023.66
36	PSR-10095-SEL-1	3	1	1	3	6.57	240	1103.33
37	PSR-10121	5	1	0	2	6.64	280	657.33
38	SRYA-333-SEL-1	3	0	0	3	5.96	266	1085

Table 2 continued...

Table 2 continued...

39	SRYA-333-SEL-2	3	0	0	2	7.11	252	1153.66
40	SRYA-333-SEL-3	5	1	0	2	7.1	259.33	1348.66
41	SRS-13426	5	0	0	4	6.96	261.33	1121.66
42	SRS-13433	3	0	0	4	7.1	244.33	1061
43	SRS-13434	5	0	1	2	7.26	284.33	1303.66
44	SRS-13435	3	0	0	4	7	285	888.66
45	SRS-13436	3	0	0	3	6.5	220	922.66
46	SRS-13448	5	0	0	3	8.3	207	545.66
47	SRS-13439	3	0	0	3	8.2	234	817.66
48	SNVD-11-5	5	0	0	3	8.2	301	1069.33

g-Gram

Table 3 : Genetic parameters and correlation coefficients (r) of three traits.

Character	Mean	Range	PCV %	GCV %	Heritability	Genetic advance as % of mean	r with protein	r with calcium	r with yield
Protein content mg/100g grain	7.50	5.96 -9.33	16.6	16.4	99.47	34.5	-	0.2597	-0.4596
Calcium content mg/100 g grain	235.34	188.66-324.33	31.21	31.62	97.74	46.44	0.2597	-	0.0169
Grain yield/plot(g)	1010.01	536-1591	22.12	25.41	75	39.65	-0.4596	0.2597	-

g- Gram

seeded genotypes exhibited a wide range of variation. Performance indicated that moderate levels of calcium were present in the white seeded types and protein content and calcium content exhibited significant positive association. High heritability coupled with high genetic advance found for the two nutrients indicated availability of heritable variation for the improvement of these characters.

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