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STUDIES ON GENETIC PARAMETERS FOR BETA CAROTENE CONTENT AND YIELD ATTRIBUTES IN RECOMBINANT INBRED LINES OF PEARL MILLET (PENNISETUM GLAUCUM (L.) R. BR.)

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ABSTRACT

Estimation of genetic variability parameters will be useful in developing effective breeding and progressive selection strategies. Two hundred and fifty recombinant inbred lines (RILs) of pearl millet were raised at Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore during summer 2015. Analysis of variance manifested significant differences among the genotypes for all the traits taken for study. Phenotypic coefficient of variation (PCV) was closer to genotypic coefficient of variation (GCV) indicating negligible environmental influence on the traits taken for the study. High PCV and GCV were observed for beta carotene content and grain yield per plant. High estimates of broad sense heritability were recorded for all the traits except for 1000- grain weight. Greater magnitude of broad sense heritability coupled with higher genetic advance as per cent of mean for SPAD chlorophyll meter reading (SCMR), plant height, number of productive tillers per plant, ear head length, single ear head grain weight, beta carotene content and grain yield per plant revealed that these traits were controlled by additive gene effects. Hence, simple selection for these traits would lead to a fast genetic improvement of the pearl millet RILs taken for the study.

KEY WORDS
Pearl millet
RILs
Beta carotene content
Heritability, genetic advance

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INTRODUCTION

Pearl millet or bajra (*Pennisetum glaucum* L. (R.) Br.) is an important coarse grain cereal cultivated for grain and fodder on about 30 million hectares worldwide. India is the largest producer of this crop with 7.97 million tonnes of grain from an area of 9.30 million hectares with a middling output of 86 kg/ha (Shukla *et al.*, 2015). Pearl millet is a quick growing summer cereal, mainly cultivated in semi arid regions and forms the stable food in Indian subcontinent and in Africa. It is the fourth important stable food in India after rice, wheat and sorghum and nutritionally superior to sorghum and maize. The main emphasis so far in pearl millet improvement was on grain yield and biotic stress resistance, yet the effort to improve quality traits will definitely enhance the value of this crop in terms of consumer preference and industrial uses. At this juncture, the nutritional quality improvement of this crop suitable for food and industrial use should be concentrated in future breeding programmes.

Pearl millet grains are nutritionally rich and contain sufficient amount of beta-carotene which is the precursor of vitamin A. Globally vitamin A deficiency is rampant and accounts for about 70 per cent of childhood death. Supplementation, food fortification and diet diversification have been used to try and address vitamin A deficiency (Chandler *et al.,* 2013). Increasing the concentration of provitamin A in the edible portions of staple crops through plant breeding, termed biofortification, may have greater promise to reduce the incidence of vitamin A deficiency (Bouis and Welch, 2010). Biofortification, relies on conventional plant breeding and modern biotechnology. Increasing the nutrient density of staple crops holds great promise for improving the nutritional status and health of deficient population across the globe. A well planned plant breeding programme for increasing the nutrient content of genotypes requires complete knowledge on the existence of genetic variability for nutrients, yield and yield contributing traits and their heritability. Heritability in conjunction with genetic advance has a greater role to play in determining the effectiveness of selection of a trait (Panse, 1957).

With this background information, the present study was conducted to evaluate 250 diverse RILs of pearl millet to assess the magnitude of variability and to understand the heritable component of variation present for grain yield and yield attributing traits as well as quality trait such as beta carotene content.

MATERIALS AND METHODS

The experimental material comprised of a set of 250 recombinant inbred lines (RILs) in $F_{2:8}$ generation of pearl millet. This RIL population was developed from a cross between PT 6029, an agronomically superior inbred with low beta carotene content of 0.059 μg/g and PT 6129, golden millet having high beta carotene content of 2.417 μg/g. Parental lines *viz*. PT 6029 and PT 6129 were sown along with the RILs whereas promising inbred line, PT 6067 and commercial varieties, CO (Cu) 9 and CO 10 were used as checks.

The research experiment was carried out during summer 2015 under the prevailing environmental conditions at Millet Breeding Station, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore which lies between 11° North latitude and 77° East longitude. The RILs along with checks were hand sown in nine homogeneous blocks following line sowing during mid of February 2015 with inter row spacing of 45 cm in a Randomized Block Design (RBD) with three replications. Thinning was performed two weeks after germination when the seedling height was 10 -15 cm to ensure single seedling per hill at inter plant spacing of 15 cm. All recommended cultural practices and inputs including fertilizer, hoeing, irrigation and pest control were applied same for all the RILs and checks from sowing to harvest and the crop was grown under uniform conditions to minimize environmental variability to the maximum possible extent. Weeding was terminated by hand two times per season. Harvest was made during the end of May 2015 on single plant basis and threshing was performed manually.

The biometrical observations were recorded on five randomly selected plants in each RIL in all the three replications for 12 traits *viz*. days to 50 per cent flowering, SPAD chlorophyll meter reading (SCMR), plant height (cm), number of productive tillers per plant, ear head length (cm), ear head girth (cm), days to maturity, single ear head weight (g), single ear head grain weight (g), 1000- grain weight (g), beta carotene content (μg/g) and grain yield per plant (g) at respective stages of growth. Beta carotene content in the harvested pearl millet grains was estimated by water soluble n-butanol (WSB) method as described by Santra *et al*. (2006) and Sathya *et al*. (2014a) with slight modifications.

Analysis of variance (ANOVA) was performed for RBD as described by Steel and Torrie (1980) for all the traits taken for the study. Statistical methods suggested by Burton (1952) for variability, Lush (1940) for heritability, Johnson *et al*. (1955) for genetic advance as per cent of mean were adopted to find out the respective estimates. Further categorization of estimates was made based on the suggestions of Sivasubramanian and Madhavamenon (1973) for variability, Johnson *et al*. (1955) for heritability and genetic advance as per cent of mean. Analysis of variance and genetic variability studies were done using TNAUSTAT software (Manivannan, 2014).

RESULTS AND DISCUSSION

Analysis of variance was carried out to partition the variances into its components. Highly significant differences ($P < 0.01$) were observed among genotypes for all the traits taken into consideration for the study demonstrating the presence of considerable amount of genetic variation among genotypes (Table 1). A similar conclusion was reported by Govindaraj *et al*. (2010), Kumar *et al*. (2013), Dapke *et al*. (2014), Kannan *et al*. (2014) and Dhedhi *et al*. (2016). This suggests that selection based on these traits will be meaningful in predicting grain yield per plant in pearl millet. The variability parameters showing mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2) and genetic advance as per cent over mean (GAM) along with mean are presented in table 2.

In general, the PCV values for most of the traits were closer to the corresponding GCV values except for ear head girth and 1000- grain weight suggesting little environment effect on the expression of these traits. The phenotypic coefficient of variation (PCV) was slightly higher than the genotypic coefficient of variation (GCV) for ear head girth and 1000-grain weight indicating the presence of substantial environmental influence on the expression of these traits. Moderate to high PCV and GCV values for SPAD chlorophyll meter reading (SCMR), plant height, number of productive tillers per plant, ear head length, ear head girth, single ear head weight and single ear head grain weight, beta carotene content and grain yield per plant could be evidence for the existence of a wide range of variation for these traits. This is in accordance with the findings of Sumathi *et al*. (2010), Subi and Idris (2013), Sabiel *et al*. (2014) and Sathya *et al*. (2014b). Higher amount of genetic variability exists among the RILs indicating an increased opportunity for the selection of desirable RILs, provided variation is highly heritable. Selection on a phenotypic basis may be effective for the genetic improvement of such traits. Days to 50% flowering, days to maturity and 1000- grain weight showed low PCV and GCV values implying the difficulty of improving these traits through simple selection. Similar results were obtained by Govindaraj *et al*. (2010), Sumathi *et al*. (2010), Sabiel *et al*. (2014), Sathya *et al*. (2014b) and Singh *et al*. (2014). However, contradicting results were obtained from the works of Subi and Idris (2013).

Total variability present for a trait is indicated by the coefficient of variation. However the extent of variability which could be transferred from parent to offspring would determine response to selection and this is provided by the estimates of heritability. High heritability was exhibited for almost all the traits studied *viz*. days to 50 per cent flowering (79.26%), SPAD chlorophyll

Table 1: Analysis of variance for beta carotene content, grain yield per plant and its component traits in RIL population of pearl millet

Trait	Degrees of freedom	Days to 50 per cent flowering	SCMR	Plant height (cm)	Number of productive tillers per plant	Ear head length (cm)	Ear head girth (cm)	Days to maturity	Single ear head weight (g)	Single ear head grain weight (g)	1000-grain weight (g)	Beta carotene content (μg/g)	Grain yield per plant (g)
Replication	2	3.44	2.96	57.35	0.07	2.73	2.58	2.88	3.46	4.10	1.20	0.02	3.20
Genotypes	254	21.71**	78.92**	802.15**	1.18**	29.03**	5.14**	15.62**	61.32**	43.72**	1.94**	0.77**	2181.56**
Error	508	1.74	0.99	28.72	0.02	0.98	0.90	1.79	4.06	1.44	0.40	0.01	38.52

** Significant at 1 % level

Table 2: Variability parameters for beta carotene content, grain yield per plant and its component traits in RIL population of pearl millet

S. No.	Trait	Mean	Range	PCV(%)	GCV(%)	Heritability (%)	GAM (%)
1	Days to 50 per cent flowering	47.50±0.76	42.00 - 54.80	6.10	5.43	79.26	9.96
2	SCMR	49.56±0.58	35.18 - 63.38	10.48	10.28	96.32	20.79
3	Plant height (cm)	155.24±3.09	97.68 - 190.02	10.90	10.34	89.98	20.21
4	Number of productive tillers per plant	3.23±0.09	2.00 - 4.60	19.78	19.22	94.49	38.49
5	Ear head length (cm)	25.89±0.57	15.56 - 33.28	12.42	11.81	90.50	23.15
6	Ear head girth (cm)	10.25±0.55	5.16 - 33.28	14.83	11.60	61.10	18.67
7	Days to maturity	86.43±0.77	81.40 - 94.60	2.93	2.48	72.03	4.34
8	Single ear head weight (g)	40.92±1.16	28.93 - 56.53	11.76	10.68	82.45	19.97
9	Single ear head grain weight (g)	27.04±0.69	17.04 - 40.89	14.57	13.88	90.74	27.24
10	1000- grain weight (g)	9.58±0.37	6.23 - 13.53	9.99	7.48	56.08	11.55
11	Beta carotene content (μg/g)	1.63±0.07	0.24 - 2.93	31.72	30.91	94.95	62.05
12	Grain yield per plant (g)	84.35±3.58	34.24 - 154.92	32.53	31.69	94.88	63.59

meter reading (96.32%), plant height (89.98%), number of productive tillers per plant (94.49%), ear head length (90.50%), ear head girth (61.10%), days to maturity (72.03%), single ear head weight (82.45%), single ear head grain weight (90.74%), beta carotene content (94.75%) and grain yield per plant (94.88%) showing that these traits are governed by additive genes. High heritability indicates the reliability with which the high chance of the genotype to be recognized by its phenotypic expression. High heritability exhibited by majority of the traits indicates that these traits are highly genetically controlled and less affected by environment. Moderate heritability was observed for 1000- grain weight (56.08%) suggesting selection for this trait would not be effective due to predominant effects of environmental variation in this population.

Genetic advance expressed as per cent of mean showed wider range of variations for different traits studied. High estimates of genetic advance as per cent of mean (GAM) was recorded for SPAD chlorophyll meter reading (SCMR), plant height, number of productive tillers per plant, ear head length, single ear head grain weight, beta carotene content and grain yield per plant whereas moderate genetic advance as per cent of mean (GAM) was observed for ear head girth, single ear head weight and 1000- grain weight. Heritability gives information on the magnitude of inheritance of traits while genetic advance is helpful in formulating suitable selection procedures. The information on heritability alone may not help in pointing traits for enforcing selection. Nevertheless, the heritability estimates in conjunction with predicted genetic advance will be more reliable. Greater magnitude of broad sense heritability coupled with higher genetic advance as per cent of mean (GAM) for SPAD chlorophyll meter reading (SCMR), plant height, number of productive tillers per plant, ear head length, single ear head grain weight, beta carotene content and grain yield per plant is the evidence that these traits are under the control of additive genetic effects for inheritance of these traits. For additive genetic effects, selection would lead to a fast genetic improvement of the trait concerned. These are in line with the finding of Sabiel *et al.* (2014), Dapke *et al.* (2014) and Singh *et al.* (2014). However, high estimates of heritability with low genetic advance as per cent of mean (GAM) were found for days to 50% flowering and days to maturity. However, contradictory results were obtained by Subi and Idris (2013). The traits possessing low genetic advance with high heritability indicates the presence of non additive gene action, thus simple selection procedure in early segregating generation will not be effective for screening of such traits for an effective breeding programme. In such situations, recombination breeding may give better response for the genetic improvement of pearl millet.

The present study illustrated the existence of wide ranges of variations for most of the traits among the RILs of pearl millet and opportunities of genetic gain through selection or hybridization. High estimates of broad sense heritability coupled with high genetic advance as per cent of mean were attained for SPAD chlorophyll meter reading (SCMR), plant height, number of productive tillers per plant, ear head length, single ear head grain weight, beta carotene content and grain yield per plant. On the other hand, relatively high estimates of heritability with low genetic advance were exhibited for days to 50% flowering and days to maturity. This variation could be effectively manipulated with appropriate breeding methods and programmes of pearl millet to develop improved varieties and hybrids for use by farmers.

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