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RESEARCH PAPER

Variability for root traits in early growth stages of pigeonpea [*Cajanus cajan* (L.) Millsp.]

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Abstract : Assessment of genotypic variation for root traits among 20 genotypes of pigeonpea chosen from core collection was done. Root traits were measured at 30 days after sowing. Analysis of variance for the 4 quantitative root traits studied revealed highly significant differences among the genotypes. UPAS-120 recorded highest root volume, number of lateral roots, root to shoot dry weight ratio and total dry matter indicating that it has desirable root traits to tolerate drought in later stages of growth. Very low difference between PCV and GCV values were observed for number of lateral roots indicating little influence of environment on the expression of these traits in this set of genotypes. Very high heritability estimates were observed for the characters like root volume, number of lateral roots, root to shoot dry weight ratio and total dry matter. This reveals considerable genotypic component of variability which might be of much value in the selection programme.

Key Words : *Cajanus cajan*, Root traits, Diversity, GCV, PCV

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INTRODUCTION

Improvement of crop root systems has lagged behind that of above ground plant characteristics. This disparity may be attributed to the root system's concealment in the soil and its highly variable nature in relation to soil conditions, both of which enormously complicate observation and experimentation. Differences in rooting pattern can change the amount and duration of water availability to plants. Greater root depth and extent of soil water extraction could increase the amount of water available at critical growth stages. Deeper roots increased yield by 20 per cent (Jordan and Miller, 1980). Increased root depth, density, increased conductance and better root to shoot dry weight ratio would help the crop in sustaining its growth during moisture stress period (Sharp and Davies, 1989, Ingram *et al.*,1994). An increase in the simulated root zone depth has been shown to increase leaf area growth, photosynthesis and transpiration and yield of crops under drought (Jones and Zur, 1984).

Pulses are basic ingredients in the diets of a vast majority of Indian population as they provide a perfect mix of high biological value when supplemented with cereals. Pigeonpea (*Cajanus cajan*) is one of the most important pulse crops of India, which accounts for 90 per cent of the world production, occupying an area of 3.47 m ha with a production of 2.7 m tons and the national average yield is 797 kg/ha. It is normally cultivated as a rainfed crop and is often subjected to water stress at one or several stages of crop growth and development, since it is a long duration crop.

The rooting system was investigated and studied in many crop species. A difference in rooting morphology among different varieties of soybean was observed (Raper and Barber, 1970). Similar genetic variability in root system was observed in sorghum and their implications for drought tolerance were reported. The adoptive mechanism of plant to water and high temperature stress was studied, but not inheritance of rooting traits (Jordan and Miller, 1980).

Narayananan and Sheldrake (1979) compared the late

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and medium maturing genotypes of pigeonpea during *Rabi* season and observed the high dry matter production by late genotypes than early maturing genotypes. The cultivar ICP 7065 (late) produced the highest dry matter (7098 kg ha^{-1}) as compared to medium types *viz*., C-11 (6297 kg ha^{-1}), ICP-1 (6026 kg ha^{-1}) and early types *viz*., $T\text{-}_2$(4534 kg ha^{-1}). Similar observations were also made by Venkatarathnam and Green (1979) in a set of 18 cultivars, and reported that the late maturing types produced the highest total dry matter as compared to the medium and early maturing types. They further observed that taller plants (89.58 cm) in late maturing pigeonpea cultivars and shorter plants of 63.0 and 49.5cm were observed in medium and early maturing varieties, respectively.

Root system is known to play a role in drought resistance of crops. Breeding and selection for drought resistance in wheat was mainly for high rooting depth density. Root length density can vary from 0.3 to 0.6 cm/root/cm soil in temperate cereals and legumes. But they did not affect soil extraction (Richards, 1982).

Plants have evolved several mechanisms such as *viz.*, drought escape, drought avoidance or dehydration postponement and drought tolerance to combat drought stress (Jones *et al.*,1982). Drought tolerance is closely related to the distribution of root systems in the soil (Sarker *et al.*,2005). In North Karnataka and some regions of Andhra pradesh, where drought is an ever-present restraint on maximum pigeonpea production, genetic improvement of root systems may provide better-adapted cultivars. This study was undertaken to determine the variability of root traits and relative drought tolerance of twenty genotypes of pigeonpea.

MATERIALS AND METHODS

Twenty genotypes of pigeonpea *viz,* Black tur, BSMR-736, CORG-9701, GC-11-39, GRG-206, GRG-263, GRG-264, GS-1, Gullyal red, Gullyal white, ICP-8863, ICP-84060, ICP-87119, ICP-96058, ICP-96053, PG-12, PT-221, TS-3, UPAS-120 and WRP-1 were selected from the core collection at Agricultural Research Station, Gulbarga for present investigation. These genotypes comprised of advanced breeding lines, popular varieties and land races.

This experiment was conducted to assess genotypic variation in root associated traits under non stress condition. The experiment was laid out in RCD design with 6 replications in which genotypes were raised in the plastic bags of size 30 cm x 18 cm. Initially 2-3 seeds are sown in each pot and at 2-3 leaf stage, single plant was maintained per poly bag. Plants were irrigated every day to maintain sufficient soil moisture in the bags till the plants were 30 days old. After 30 DAS plants from all the pots were removed with their root system intact. The soil with intact roots were removed from the bag as clump and watered through a jet of water to the root system to separate adhering soil without damaging roots. Observations on root associated traits such as shoot length (cm), root length (cm), root dry weight (g), shoot dry weight (g), root volume (cm^3) and number of lateral roots were recorded.

RESULTS AND DISCUSSION

Root traits recorded marked variability among genotypes studied. The results of the analysis of variance for the 4 quantitative root traits studied revealed highly significant differences among the genotypes (Table 1). Enhanced water uptake by efficient root characteristics is a desirable physiological mechanism of dehydration postponement under water limiting conditions. Hence, identifying genotypes with desirable root traits for moisture condition would be very useful. From the results of root typing (Table 2), UPAS-120 recorded highest root volume and lowest was recorded by PG-12. ICP-96058 recorded the least number of roots and UPAS-120 recorded the highest number of roots. GC-11-39 recorded lowest root to shoot dry weight ratio and UPAS-120 recorded the highest. Gullyal red recorded the lowest total dry matter and UPAS-120 recorded the maximum total dry matter. The genotype UPAS-120 recorded the highest root volume, number of lateral roots, root to shoot dry weight ratio and total dry matter, indicating that it has desirable root traits to tolerate drought in later stages of growth.

Very low difference between PCV and GCV values were observed for number of lateral roots indicating little influence of environment on the expression of these traits in this set of genotypes. The heritability estimate separates the variance due to environmental effects from the total variability and indicates the accuracy with which a genotype can be identified by its phenotypic performance, thus, making the selection more effective. Very high heritability estimates were observed

Table 1 : Analysis of variance (ANOVA) for root traits of pigeonpea genotypes at early growth stage

Source of variation	Degrees of freedom	Root volume (cm^3)	Number of lateral roots	Root to shoot dry weight ratio	Total dry matter (g/plant)
Replication	1	0.1	3.60	0.002	0.015
Genotype	19	3.25**	3656.91**	0.315*	0.768**
Error	19	0.17	96.07	0.032	0.042
C.D.(1%)		1.19	2.1	0.51	0.58
C.V.(%)		5.4	8.5	6.67	5.34
S.E.±		0.29	0.93	0.12	0.14

* and ** Indicate significance of value P= 0.05 and 0.01, respectively

Table 2: Root traits of 20 pigeonpea genotypes grown under well watered condition at early growth stages

Sr. No.	Genotypes	Root volume (cm^3)	Number of lateral roots	Root to shoot dry weight ratio	Total dry matter (g/plant)
1.	Black Tur	2.50	102.50	1.30	1.15
2.	BSMR-736	4.15	138.00	0.69	1.35
3.	CORG-9701	2.75	88.00	0.61	0.73
4.	GC-11-39	2.75	90.50	0.25	2.00
5.	GRG-206	3.25	89.50	0.68	1.60
6.	GRG-263	5.10	199.50	0.92	1.25
7.	GRG-264	3.90	141.50	1.13	1.70
8.	GS-1	3.30	105.00	1.17	0.65
9.	Gullyal red	2.50	107.50	1.00	0.50
10.	Gullyal white	1.50	61.50	0.55	1.55
11.	ICP-8863	3.50	118.00	1.17	1.95
12.	ICP-84060	3.20	125.50	0.71	0.60
13.	ICP-87119	5.15	170.00	0.64	0.90
14.	ICP-96058	1.05	60.00	1.00	0.70
15.	ICP-96053	2.50	92.00	0.55	1.55
16.	PG-12	1.00	62.00	0.63	1.55
17.	PT-221	4.05	150.50	0.32	2.05
18.	TS-3	3.35	120.00	0.64	0.90
19.	UPAS-120	5.20	208.50	1.95	2.95
20.	WRP-1	1.40	74.00	1.13	1.70
	Mean	3.10	115.2	0.85	1.36
	Range	1-5.2	60-208.5	0.25-1.95	0.5-2.95
	C.D.(1%)	1.19	2.1	0.51	0.58
	C.V.(%)	7.4	8.5	12.67	9.90
	S.E. ±	0.29	0.93	0.12	0.14
	PCV	42.18	37.60	48.31	46.57
	GCV	39.99	36.63	43.49	44.12
	Heritability (Broad sence) (%)	89.87	94.87	81.04	89.72

for all the characters. The results of these characters revealed considerable genotypic component of variability which might be of much value in the selection programme.

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