The Pharma Innovation Journal 2022; SP-11(7): 4061-4065

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(7): 4061-4065

www.thepharmajournal.com
Received: 08-04-2022
Accepted: 11-05-2022

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Evaluation of mid-early, medium and late duration pigeonpea genotypes in rainfed arid regions of Andhra Pradesh

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Abstract
A field experiment was conducted to evaluate the yield response of ten pigeonpea (four mid-early, four medium and two late duration) genotypes in sandy loam soils of scarce rainfall zone under rainfed conditions for two consecutive years during *kharif*, 2019-20 and 2020-21 at Dryland Farm near to S.V Agricultural College, Tirupati. Number of pods plant^{-1} was significantly influenced by genotypes. The medium duration genotype, LRG 52 registered more number of pods plant^{-1} which was at par with the mid-early duration genotype, CO-6 and least performance was registered in the late duration genotypes ICPL 15062 and ICPL 17103. Among the genotypes evaluated, LRG 52 recorded the highest seed yield of 1682 Kg ha^{-1} which in turn on par with CO-6 (1572 kg ha^{-1}) and the lowest seed yield was recorded in ICPL 17103 (965 kg ha^{-1}) followed by ICPL 15062 (972 kg ha^{-1}). Number of seeds per pod, seed yield and harvest index were positively and significantly correlated with number of pods per plant.

Keywords: Yield, redgram genotypes, rainfed

Introduction
Pigeonpea [*Cajanus cajan* (L.) Millsp] is an important grain legume crop in the semi-arid tropics of Asia and Africa due to its high protein (20-22%) content which is almost twice the protein in wheat and three times that of rice. India is the largest producer and consumer because pigeonpea plays an important role in food security, balanced diet and alleviation of poverty (Rao *et al*., 2002). Pigeonpea ranks second after chickpea in area and production.

Its deep rooting and drought tolerant characters makes it a successful crop in the areas of low and uncertain rainfall. Pigeonpea is a C_3 plant originated from Africa. It is commonly known as redgram or Arhar and grown in *kharif* as well as *rabi* seasons mostly under rainfed conditions with less than 650 mm of average annual rainfall.

In India, it is grown in an area of 48.24 lakh hectares with an annual production 38.8 lakh tonnes production and productivity is 804 kg ha^{-1} (https://www.indiastat.com. In dry farming areas of Andhra Pradesh, rainfall is not only scanty but also erratic. Thus soil moisture becomes the most limiting factor in production of redgram. The area and production of redgram in Andhra Pradesh is 4.63 lakh ha and 3.02 lakh tonnes respectively, but the productivity of redgram remained stagnant for many years with a seed yield of 455 kg ha^{-1} (Ministry of Agriculture, 2014) [12]. The productivity of pigeonpea is too low and almost static for the last five decades due to cultivation of long duration genotypes that are prone to climatic variations (Singh, 2018) [16]. The major constraints of pigeonpea productivity are moisture deficit at critical growth stages, inadequate availability of drought tolerant varieties, long duration, photosensitivity, excessive flower drop, low harvest index, lack of information regarding production and partitioning efficiencies, low input conditions associated with the complex socio-economic problems of rainfed agriculture.

Recurrent droughts in *kharif* causes moisture stress at one or several stages of crop growth and development resulting in poor yields under rainfed conditions. The problem is more acute as most of the cultivars growing in Andhra Pradesh are long duration and prone to moisture stress at flowering and pod filling stages. Occurrence of mid-season and terminal droughts of 1 to 3 weeks consecutive duration during reproductive period happens to be the dominant reason for crop (and investment) failures and low crop yields (Rijks, 1986) [15] under rainfed conditions.

In drought prone Southern Zone of Andhra Pradesh, the crop is cultivated in an area of 0.4 lakh hectares, and development of medium duration and drought tolerant genotypes is a long

term goal and identifying the drought tolerant and medium duration genotypes among the existing pre-released genotypes is considered as a viable appraoach especially under rainfed conditions. Hence, identification of tolerant genotypes having high yield potential is a research priority under rainfed conditions in order to recommend to the farmers. Keeping these points into consideration, the present experiment was conducted to study the performance of redgram varieties in red sandy loam soils under rainfed situations.

Materials and Methods

A field experiment was conducted to evaluate the yield response of ten pigeonpea genotypes in sandy loam soils of scarce rainfall zone under rainfed conditions for two consecutive years during kharif, 2019-20 and 2020-21 at Dryland Farm, near to S.V. Agricultural college, Tirupati. The soil of the experimental site was sandy loam with shallow depth, low in organic carbon (0.46%) and low in available nitrogen (194 kg ha^{-1}), medium in available phosphorous (28 kg ha^{-1}) and potassium (276 kg ha^{-1}). The experiment was laid out in randomized block design with three replications. The treatments consisted of ten genotypes *viz*., four (mid early duration genotypes): PRG 176, CO-6, AKTE 12-04, ICPL-8863, four (medium duration genotypes): MPV 106, RVSA 16-1, LRG-133-33, LRG- 52 and two (late duration genotypes): ICPL-15062 and ICPL-17103. The experimental field was prepared by working with a tractor drawn disc plough and then tractor drawn cultivator was drawn along the field. Healthy seeds of redgram genotypes with good germination percent (95%) used for sowing purpose. Sowing was taken up as per the treatments. The seeds were sown by dibbling in furrows at a depth of 5 cm. The furrows were covered immediately after sowing and compacted sufficiently for better germination. Thinning was done at 20 DAS by retaining one healthy seedling $hill^{-1}$. The recommended dose of 120, 60 and 40 N, P_2O_5 and k_2O kg ha^{-1} was applied through urea and single super phosphate respectively. Thinning and gap filling was done wherever necessary, weeding and hoeing were taken up depending on the intensity of weeds at critical stages of crop weed competition. Pre-emergence application of Velore @ 1.0 litre $acre^{-1}$ was sprayed to all the plots. Hand weeding was taken up at 35 DAS to keep the plots weed free and all other cultural practices were kept normal and uniform for all treatments.

Results and Discussion

1. Rainfall and crop performance

The crop was raised completely under rainfed conditions in both the years. During *kharif* 2019-20, a total rainfall of 823.9 mm was recorded in 48 rainy days during the crop growth period from 29-7-2019 to 18-2-2020. A total of four dry spells were recorded during the crop growth period. All the genotypes were exposed to one dry during initial stage of the crop at 15 DAS. Medium and long duration genotypes were exposed to three continuous dry spells during flowering and pod formation stages at 165 DAS to 205 DAS.

During *kharif* 2020-21, a total rainfall of 1015.8 mm was received in 47 rainy days during the crop growth period from 22-7-2020 to 16-2-2021. A total of four dry spells were recorded during the crop growth period. Medium and long duration genotypes were exposed to one dry spell at pod formation stage i.e., from 142 to 163 DAS, whereas long duration genotypes were exposed to three continuous dry spells especially at post flowering and pod formation stages i.e., from 178 to 210 DAS.

2. Plant height (cm)

Plant height is a genetically controlling character which is being influenced by environmental condition. At harvest, higher plant height was recorded in the mid-early duration genotype, CO-6 (292.38 cm) which was at par with the medium duration genotype, LRG-52(289.68 cm). Lower plant height was registered in the late duration genotype ICPL 15062 (249.87 cm) which was at par with ICPL 17103 (253.58 cm). The remaining genotypes were significantly superior over ICPL 15062 and ICPL 17103 and inferior over CO-6 and LRG-52. In the present study, CO-6 exhibited superior performance and increased the plant height by 17.0 percent, and LRG-52 by 16.0 percent over ICPL 15062. Kondawar and Ingel, (2018) [9] reported that mid late genotypes, AKTHR-2001-18 (169.16 cm) and AKTHR-2001-01 (165.79 cm) statistically recorded more plant height over checks (ASHA, PKV-TARA) at 120 DAS.

3. Number of branches

At harvest, CO-6 and LRG-52 recorded more number of branches (25), and lesser number of branches was recorded in ICPL 15062 (16) and ICPL 15062 (16). The remaining genotypes were significantly superior over ICPL 15062 and ICPL 17103 and inferior over CO-6 and LRG-52. In the present study, CO-6 and LRG-52 exhibited superior performance by possessing 9 (nine) more branches over ICPL 17103 and ICPL 15062 at harvest. Similar results at maturity are seen in the variety LRG 52 i.e., 23 by Deva *et al*. (2019) [3]. Hanumanthappa *et al*. (2020) [6] found that number of branches plays a major role in determining pigeonpea yield since it is closely related to number of pods per branches in a single plant. They stated that GRG-2009 recorded more number of branches per plant (57.01), whereas PRIL-B-165 recorded less number of branches per plant (39.16) at harvest.

4. Number of pods per plant

The genotype LRG-52 recorded more number of pods (354) which was at par with CO-6 (342). Less number of pods were recorded in the genotype ICPL 17103 (208) which was at par with ICPL 15062 (210). The remaining genotypes were significantly superior over ICPL 15062 and ICPL 17103 and inferior over CO-6 and LRG-52. Similar genotypic differences among the redgram genotypes was recorded by Deshmukh *et al*. (2009) [2] who reported that the genotypes JSA 59 and TTB 7 were characterized by higher number of pods per plant under moisture stress as well as stress free condition. In the current study, LRG-52 exhibited superior performance and increased the number of pods per plant by 70.2 per cent and CO-6 by 64.4 per cent over the genotype ICPL 17103. This might be due to increase in number of branches $plant^{-1}$ where balance was maintained between vegetative and reproductive phase. The findings are supported by Tirumala Rao (2011) and Kaur *et al*. (2017) [17, 8]. Eventhough the medium and late duration genotypes were exposed to continuous 2 to 3 dryspells during flowering and pod formation stages in both the seasons, but the medium duration genotype LRG 52 recorded higher yield compared with other genotypes, which might be due to more number of pods per plant resulted in higher yield under rainfed conditions.

5. Number of seeds per pod

The genotypes CO-6 and LRG-52 recorded numerically higher number of seeds per pod (4.2). Less number of seeds

per pod was recorded in the genotypes ICPL 15062 and ICPL 17103 (3.3). Sidhu *et al*. (2017) found that the seeds per pod differed non significantly, and the redgram variety AL 1578 exhibited highest value (3.86 seeds per pod). Similar results were also reported by Dhingra *et al*. (1980) [4] in redgram. Tirumala Rao (2011) [17] noticed that LRG-41 and WRG-53 registered numerically higher (4) seeds pod^{-1} and PRG-158 variety registered (3) seeds pod^{-1}.

6. 100 seed weight

LRG-52, a medium duration genotype recorded the maximum 100 seed weight of 12.93 g which was at par with the mid-early duration genotype CO-6 (12.84 g). The minimum 100 seed weight of 9.53 g was recorded in the late duration genotype ICPL 17103 which was at par with ICPL 15062 (10.11 g). The remaining genotypes were significantly superior over ICPL 15062 and ICPL 17103 and inferior over CO-6 and LRG-52, and it is mainly attributed to its higher efficiency in translocating the photosynthates to the reproductive parts. The results are in accordance with Tirumala Rao (2011) [17] and Kumari and Reddy (2021) [10].

7. Seed yield (kg/ha)

The medium duration genotype, LRG-52 recorded higher seed yield of 1682 kg ha^{-1} which was at par with the genotype CO-6 (1572 kg ha^{-1}). Lesser seed yield was recorded in the genotype ICPL 17103 (965 kg ha^{-1}) which was at par with the genotype ICPL 15062 (972 kg ha^{-1}). The remaining genotypes were significantly superior over ICPL 15062 and ICPL 17103 and inferior over CO-6 and LRG-52. In the current study, LRG 52 a medium duration genotype exhibited superior performance and increased the seed yield by 74.3 per cent and CO-6 by 63.0 per cent over the long duration genotype ICPL 17103. The results are in accordance with Ezeaku *et al*. (2016) [5], Arunkumar *et al*. (2018) [1], Rao and Rajaamani (2018) [13] and Hanumanthappa *et al*. (2020) [6].

8. Stalk yield (kg/ha)

CO-6 recorded higher stalk yield of 4390 kg ha^{-1} which was at par with the genotype LRG-52 (4233 kg ha^{-1}). The lesser stalk yield was recorded in the genotype ICPL 15062 (3565 kg ha^{-1}) which was at par with the genotype ICPL 17103 (3596 kg ha^{-1}). The remaining genotypes were significantly superior over ICPL 15062 and ICPL 17103 and inferior over CO-6 and LRG-52. In the current study, CO-6 increased the stalk yield by 23.1 per cent and LRG-52 by 18.8 per cent over the genotype ICPL 15062. Similar findings are reported by Tuppad *et al*. (2012) [18] and Meher *et al*. (2020) [11] in pigeonpea crop under rainfed conditions. This may be due to higher number of branches per plant and higher leaf area which determines the photosynthetic ability, growth and dry matter production of a plant.

9. Harvest index (%)

Kaur *et al*. (2017) [8] stated that harvest index is a measure of physiological productivity potential of crop cultivars. Harvest index is the ability of a plant to convert the dry matter into economic yield. The medium duration genotype, LRG-52 recorded higher HI of 28.44 % which was at par with the mid-early duration genotype CO-6 (26.37 %). Lesser HI was recorded in the late duration genotype ICPL 17103 (21.16 %) which was at par with 15062 (21.42%). The remaining genotypes were significantly superior over ICPL 15062 and ICPL 17103 and inferior over CO-6 and LRG-52.

Correlation between yield components and yield of redgram varieties

Number of seeds per pod, seed yield and harvest index were positively and significantly correlated with number of pods per plant (Table 4). Test weight was also positively correlated to number of pods per plant. There was positive correlation between number of seed per pod and seed yield. There was positive correlation between seed and stalk yield. Harvest index was significantly and positively related with seed and stalk yield.

Table 1: Evaluation of pigeonpea genotypes for plant height (Cm) and number of branches under rainfed conditions

	Plant height (cm)			Number of branches		
Genotypes	**At harvest**			**At harvest**		
	2019	**2020**	**pooled**	**2019**	**2020**	**pooled**
Mid-early Duration						
PRG 176	291.50	255.17	273.33	21.0	21.0	21.0
C0-6	295.93	288.83	292.38	26.0	23.0	25.0
AKTE 12-04	287.73	257.33	272.53	19.0	20.0	20.0
ICPL 8863	280.83	259.87	270.35	22.0	18.0	20.0
Medium Duration						
MPV 106	280.50	264.00	272.25	21.0	19.0	20.0
RVSA 16-1	283.73	257.67	270.70	22.0	23.0	23.0
LRG 133-33	282.73	257.67	270.20	18.0	20.0	19.0
LRG-52	304.87	274.50	289.68	25.0	24.0	25.0
Late Duration						
ICPL 15062	266.90	232.83	249.87	16.0	16.0	16.0
ICPL 17103	255.67	251.50	253.58	15.0	16.0	16.0
SEm±	8.58	7.94	6.47	1.26	1.45	0.80
CD(P=0.05)	25.69	23.77	19.37	3.78	4.33	1.39
CV(%)	5.23	5.35	4.14	10.64	12.46	6.73

Table 2: Evaluation of pigeonpea genotypes for Yield and Yield attributes under rainfed conditions

Genotypes	No of pods per plant			No of seeds per pod			100 seed weight (gm)		
	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled
Mid-early Duration									
PRG 176	266	249	258	3.7	3.7	3.3	11.17	10.66	10.91
C0-6	336	348	342	4.0	4.3	4.2	13.00	12.68	12.84
AKTE 12-04	268	267	268	3.7	3.7	3.7	11.38	10.41	10.90
ICPL 8863	266	257	262	3.7	3.7	3.7	11.58	11.37	11.48
Medium Duration									
MPV 106	295	260	277	3.7	3.7	3.7	10.40	10.67	10.54
RVSA 16-1	266	269	267	3.7	3.7	3.7	10.52	10.19	10.36
LRG 133-33	265	265	265	3.7	3.7	3.7	10.50	10.55	10.53
LRG-52	356	352	354	4.0	4.3	4.2	12.85	13.01	12.93
Late Duration									
ICPL 15062	209	212	210	3.3	3.3	3.3	10.61	9.61	10.11
ICPL 17103	204	211	208	3.3	3.3	3.3	9.37	9.69	9.53
SEm±	9.34	9.89	7.34	0.30	0.34	0.31	0.55	0.56	0.45
CD (P=0.05)	27.96	29.60	21.98	NS	NS	NS	1.66	1.67	1.36
CV (%)	5.92	6.37	4.69	14.31	16.20	14.86	8.61	8.86	7.12

Table 3: Evaluation of pigeonpea genotypes for Yield and Harvest index under rainfed conditions

Genotypes	Seed Yield (kg ha^{-1})			Stalk Yield (kg ha^{-1})			HI (%)		
	2019	2020	pooled	2019	2020	Pooled	2019	2020	pooled
Mid-early Duration									
PRG 176	1,267.00	1,173.00	1,220.00	4,023.00	4,097.00	4,060.00	23.95	22.26	23.11
C0-6	1,555.00	1,589.00	1,572.00	4,399.00	4,381.00	4,390.00	26.12	26.62	26.37
AKTE 12-04	1,289.00	1,296.00	1,292.00	4,134.00	3,965.00	4,049.00	23.77	24.63	24.19
ICPL 8863	1,364.00	1,313.00	1,338.00	3,971.00	4,104.00	4,038.00	25.57	24.24	24.89
Medium Duration									
MPV 106	1,397.00	1,237.00	1,317.00	4,118.00	4,135.00	4,126.00	25.33	23.03	24.20
RVSA 16-1	1,326.00	1,393.00	1,359.00	4,101.00	4,229.00	4,165.00	24.43	24.78	24.60
LRG 133-33	1,300.00	1,296.00	1,298.00	4,067.00	4,045.00	4,056.00	24.22	24.27	24.24
LRG-52	1,724.00	1,639.00	1,682.00	4,246.00	4,219.00	4,233.00	28.88	27.98	28.44
Late Duration									
ICPL 15062	977.00	968.00	972.00	3,437.00	3,693.00	3,565.00	22.13	20.77	21.42
ICPL 17103	930.00	999.00	965.00	2,983.00	4,208.00	3,596.00	23.77	19.19	21.16
SEm±	78.85	60.58	50.99	111.55	108.93	77.86	1.37	1.11	0.84
CD (P=0.05)	236.08	181.39	152.68	334.00	326.16	233.11	3.45	3.32	2.52
CV (%)	10.4	8.1	6.7	4.8	4.5	3.3	9.5	8.0	6.0

Table 4: Correlation coefficient between yield components and yield of redgram varieties (Mean of 2 years)

	Plant height (cm)	No of Branches	pods per plant	Seeds per pod	Test wt (g)	Stalk yield (kg/ha)	HI	Seed yield (kg/ha)
Plant height (cm)	1							
No of Branches	0.942**	1						
pods per plant	0.973**	0.927**	1					
Seeds per pod	0.886**	0.841**	0.944**	1				
Test wt (g)	0.901**	0.840**	0.927**	0.869**	1			
Stalk yield(kg/ha)	0.944**	0.923**	0.887**	0.818**	0.756*	1		
HI	0.918**	0.900**	0.960**	0.940**	0.896**	0.855**	1	
Seed yield(kg/ha)	0.959**	0.941**	0.977**	0.941**	0.893**	0.920**	0.989**	1

** Correlation is significant at the 0.01 level (2-tailed).

Conclusion

In the current study, medium and late duration genotypes exposed to terminal moisture stress (*i.e.*, 2 to 3 continuous dry spells) during flowering and pod formation stages in both the years of study. The medium duration genotype LRG-52, even though faced with terminal drought, performed better over other maturing groups (*i.e.*, late duration genotypes) by possessing more number of branches, number of pods per plant that resulted in higher seed yield. However, the mid-early duration genotype CO-6 was also comparable with that of medium duration genotype LRG-52 with regards to seed yield due to its early maturing character, and it is considered to use where early maturity of the crop is required, especially under rainfed conditions to escape the terminal moisture stress. The genotypes ICPL 15062 and ICPL 17103 were late maturing and encountered moisture stress during flowering and pod formation stages during both the years of study that resulted in lesser seed yield and its components.

From the above results it can concluded that among the genotypes tested, among the medium duration genotypes, LRG 52 and among the mid-early duration genotypes, CO-6 were found to be suitable for Southern rainfall zone of Andhra Pradesh under rainfed conditions.

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