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Effect of drought mitigation strategies on growth and productivity of pigeonpea (*Cajanus cajan (*L.) Millsp.) under rainfed conditions

P. VENKATA RAO, A. SUBBARAMI REDDY, AND M. V. RAMANA

Regional Agricultural Research Station, ANGRAU, Lam-522034, Guntur, AP, India

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ABSTRACT

A field study was executed in rainy seasons of 2017 and 2018 to know the impact of drought management strategies on pigeonpea under rainfed situations. The trial was laid out in randomized block design with three replications. The findings of the investigation revealed that all the drought mitigation techniques resulted superior performance in aspects of growth, yield components and grain yield over check. Highest seed yield of 2448 kg ha^{-1} was registered with inoculation of VAM fungi @12.5 kg ha^{-1} and crop residue mulching@ 5 t ha^{-1} followed by addition of 100% P which was statistically commensurate with VAM fungi @12.5 kg ha^{-1} and supply of 100% P (2370 kg ha^{-1}). However, the highest monetary values of gross returns (Rs.1,08,660/-) and net returns (Rs. 72,306/-) were realized with inoculation of VAM fungi @12.5 kg ha^{-1} followed by crop residue mulching @ 5 t ha^{-1} and supply of 100% P but B:C ratio was higher (2.03) with VAM fungi @12.5 kg ha^{-1} and supply of 100% P.

Keywords : Drought, growth, mitigation, pigeonpea, VAM, yield components and productivity.

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is a versatile deep rooted and drought tolerant leguminous food crop used for several countries particularly in India as a major source of dietary protein. Certain unique features of pulses *viz*., their N fixing ability through symbiotic association with *rhizobium* and deep root system enabling them to draw moisture from deeper soil. India is the largest producer of pigeonpea with 2.6 M.t of production in an extent of 3.0 M.ha and productivity of 865 kg ha^{-1} in 2017-18. Whereas, the production in AP is about 1.2 L.t was cultivated in an extent of 2.75 L.ha and productivity of 621 kg in 2017-18 (*www.indiastat.com*). Pigeonpea is frequently affected with vagaries of monsoon under *kharif* rainfed upland situation. Abnormal weather conditions associated with early cessation of monsoon is primary cause for the lower productivity in AP. The productivity is mainly constrained by use of less productive land, water logging or dry spells during sensitive stages of crop growth, pest and disease incidence, non-availability of high yielding varieties tolerant to drought and non-adoption of appropriate agronomic practices. Management of soil moisture is one of the key factor when trying to get additional productivity by holding of more soil moisture through techniques adopted for moisture conservation in rainfed conditions. Moisture conservation technologies like mulching, foliar sprayings and seed treatment improved yield in Pigeonpea. Vesicular Arbuscular Mycorrhizal (VAM) fungi used to enhance biomass production, uptake of moisture and essential plant nutrients under drought environment. VAM fungi can also enrich soil and soil water retention ability through stabilization and development of soil aggregates (Habibzadesh *et al*.2014). VAM fungi produces a glycoprotein (Glomalin), which plays a vital role in improving soil structure and it can explore and extend a large soil volume though the extra radical mycelium which helps in higher nutrient uptake and moisture. Good management techniques are very important tools for drought mitigation and higher yield under prolonged moisture stress conditions. Keeping this in view, a field study was executed to know the impact of drought on pigeonpea under rainfed areas.

MATERIALS AND METHODS

The field trail was undertaken for two consecutive years at RARS, ANGRAU, Lam, Guntur on deep black clay loam soil during *kharif* seasons of 2017 and 2018. The farm is located at 25^{0}18' N latitude, 83^{0}36' E longitude and at an altitude of 128.93 m. A total of nine drought management treatments consisted, *viz.*, 1.Phosphorus-100 %; 2.Phosphorus-50%; 3.VAM fungi @12.5 kg ha^{-1}; 4. VAM fungi @12.5 kg ha^{-1}+100% P; 5. VAM fungi @12.5 kg ha^{-1}+50% P; 6. VAM fungi @12.5 kg ha^{-1}+ crop residue mulching @ 5 t ha^{-1}; 7. VAM fungi @12.5kg ha^{-1}+ crop residue mulching @5 t ha^{-1}+ P 100%; 8.VAM @12.5 kg ha^{-1}+ crop residue mulching @ 5 t ha^{-1}+ P 50% and 9.Check were laid out in randomized block design (RBD) with three replications.

The crop (var.LRG52) was sown with the spacing of 180 x 20 cm and seed @ 5 kg ha^{-1} on 25^{th} and 17^{th} July during rainy seasons of 2017 & 2018 as per the Krishna Agro-climatic zonal recommendations. The treatments received equal quantity of nitrogen (20 kg N ha^{-1}) through Urea fertilizer and phosphorous (100 % P = 50 kg P_2O_5 ha^{-1}) through Single Super Phosphate (SSP). VAM fungi (from ARS, Amaravathi) @ 12.5 kg ha^{-1} applied in plough furrows while sowing and harvested the crop on 5^{th}

*Email : venkatraoptn@gmail.com*can

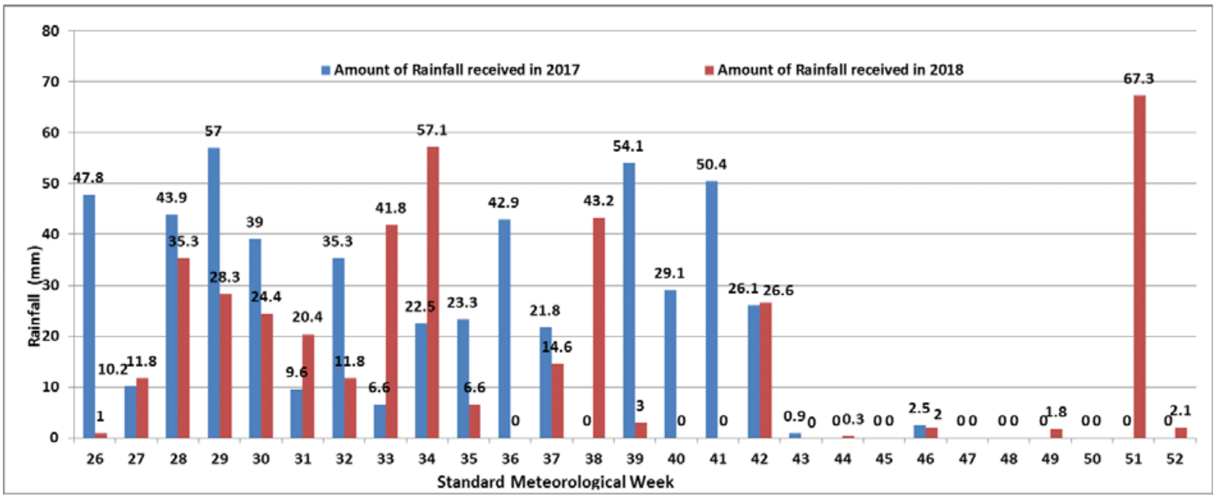

Fig: Distribution pattern of rainfall in 2017 and 2018

February, 2018 and 1st February, 2019. A total of 475.2 mm and 496.5 mm rainfall (49 and 39 rainy days, respectively) was realized during crop season. The biometric data on all required parameters were collected at harvesting from five plants randomly selected from each treatmental plot from each replication. All the data taken while experimentation were analyzed by the standard statistical procedures (Gomez and Gomez, 1984) and final results are presented in results and discussion part.

RESULTS AND DISCUSSION

Growth and yield attributes

Excluding Plant height all the remaining growth and yield parameters *viz.* branches plant^{-1}, pods plant^{-1} and 100 seed weight were significantly improved by drought mitigation strategies measured at harvesting (Table 1). Findings from two years of field investigation (pooled data) indicated that among the drought mitigation strategies, soil application of VAM fungi @ 12.5 kg ha^{-1} and crop residue mulching @ 5 t ha^{-1} along with supply of 100% P registered more crop growth and improvement in yield attributing characters *viz.*, plant height (225 cm), branches plant^{-1} (12.8), pods plant^{-1} (507) and test weight (11.32 g) than other treatments. Betterment in growth and yield attributing characters under alluded practice might be reported due to extra radical mycelium of VAM fungi habituated to explore and extend large volume of soil leads to better assistance in nutrients and water uptake out of deeper soil layers. Crop residue mulching after sowing also helped in preservation of soil moisture, which consequently lead to superior plant growth and development. Similar interactions reported earlier by Sharma *et al.* (2010), Qiao *et al.* (2011) and Habibzadesh *et al.* (2014) in mungbean and pigeonpea, respectively.

Grain Yield

The results of the study highlighted that maximum grain yield of 2448 kg ha^{-1} produced with soil application of VAM fungi @ 12.5 kg ha^{-1} and crop residue mulching @ 5 t ha^{-1} along with addition of 100% P, but this was a on par with that (2370 kg ha^{-1}) produced by VAM fungi @12.5 kg ha^{-1} and with supply of 100% P. Significantly lowest grain yield (1623 kg ha^{-1}) was registered in check which was significantly inferior to drought management strategies. Overall, an additional yield advantage of 32.6% was realized with implementation of drought management techniques than check (1623 kg ha^{-1}). The more yield of pigeonpea resulted from congenial effect of soil moisture conservation ability through stabilization of soil aggregates by integrated effect of VAM fungi and mulching. Phosphorous nutrition improved photosynthesis, stomatal conductance, leaf water potential, membrane stability and root prolifiration. Similar superior performance of pigeonpea reported from varied agro-climatic conditions (Sharma *et al.*, 2010 and Qiao *et al.*, 2011).

Further, superior performance of pigeonpea was observed by drought management practices over the check in two years of field trail. It perhaps because of the impact of rainfall pattern and period of moisture holding period in soil (Fig 1). The Highest grain yield (2940 kg ha^{-1}) was reported in 2017 even though low rainfall (475.2 mm in 39 rainy days) was received with uniform distribution than in 2018 (1955 kg ha^{-1}) with 496.5 mm rainfall in 29 rainy days. This high rainfall with erratic distribution induces more vegetative growth, higher plant height resulted in poor source-sink relationship, leading to low yield in 2018. But in 2017, comparatively low rainfall with uniform distribution during vegetative stage resulted in better source-sink relationship and led to higher grain yields. The crop

Table 1: Growth and yield attributes of pigeonpea as influenced by drought mitigation strategies under rainfed conditions

Treatments	Plant height (cm)			Branches plant^{-1}			Pods plant^{-1}			Test weight (g)		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
T_1: Phosphorus-100 %	226	200	213	13.3	10.5	11.9	397	485	441	10.17	12.11	11.14
T_2: Phosphorus-50%	226	201	214	12.0	10.4	11.2	348	441	394	9.76	12.25	11.01
T_3: VAM @12.5kg ha^{-1}	223	186	209	12.0	10.4	11.2	370	440	405	9.99	11.90	10.95
T_4: VAM@12.5kg ha^{-1} +100% P	234	204	219	13.7	10.4	12.0	463	527	495	10.03	12.56	11.30
T_5: VAM@12.5kg ha^{-1} +50% P	229	199	214	12.2	10.6	11.4	365	465	415	9.71	12.30	11.01
T_6:VAM @12.5kg ha^{-1}+ crop residue mulching @5t ha^{-1}	230	187	214	12.1	10.7	11.4	342	465	404	9.84	12.43	11.14
T_7:VAM @12.5kg ha^{-1}+ crop residue mulching @5t ha^{-1}+ 100% P	239	211	225	14.1	11.5	12.8	465	549	507	10.33	12.31	11.32
T_8:VAM @12.5kg ha^{-1}+ crop residue mulching @5t ha^{-1}+ 50% P	241	204	223	13.4	11.3	12.3	372	489	431	9.69	12.40	11.05
T_9: Check	216	180	198	10.8	9.4	10.100	278	379	329	9.24	11.88	10.56
SEM (+)	**11.353**	**10.628**	**8.167**	**0.3**	**0.308**	**0.192**	**15.505**	**19.275**	**12.106**	**0.13**	**0.114**	**0.077**
LSD (0.05%)	**NS**	**NS**	**NS**	**0.8**	**0.900**	**0.600**	**46.000**	**58.000**	**37000**	**0.4**	**0.340**	**0.230**
C V (%)	**8.600**	**9.200**	**6.600**	**3.6**	**5.100**	**2.900**	**7.100**	**7.100**	**4.900**	**2.2**	**1.600**	**1.200**

Table 2: Yield and economics of Pigeonpea as influenced by drought mitigation practices under rainfed conditions

Treatments	**Grain yield (kg ha^{-1})**			**Gross returns (Rs.)**			**Net returns (Rs.)**			**B:C Ratio**		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
T_1: Phosphorus-100 %	2721	1800	2261	114282	86400	100341	77597	54500	66049	2.12	1.71	1.93
T_2: Phosphorus-50%	2378	1638	2008	99876	78624	89250	64597	48130	56364	1.83	1.58	1.71
T_3: VAM @12.5kg ha^{-1}	2315	1545	1930	97230	74160	85695	62920	44635	53778	1.83	1.51	1.68
T_4: VAM@12.5kg ha^{-1} +100% P	2892	1848	2370	121464	88704	105084	84341	56366	70354	2.27	1.74	2.03
T_5: VAM@12.5kg ha^{-1} +50% P	2527	1597	2062	106134	76656	91295	70417	45724	58071	1.97	1.48	1.74
T_6:VAM @12.5kg ha^{-1} + crop residue mulching @5t ha^{-1}	2315	1692	2004	97230	81216	89223	60417	49188	54803	1.64	1.54	1.59
T_7:VAM @12.5kg ha^{-1} + crop residue mulching @5t ha^{-1} + 100% P	2940	1955	2448	123480	93840	108660	84733	59878	72306	2.19	1.76	1.99
T_8:VAM @12.5kg ha^{-1} + crop residue mulching @5t ha^{-1} + 50% P	2535	1730	2133	106470	83040	94755	68691	50046	59369	1.82	1.52	1.68
T_9: Check	1901	1345	1623	79842	64560	72201	45970	35473	40722	1.36	1.22	1.29
SEM(+)	**104.0**	**64.68**	**47.06**									
LSD (0.05%)	**312.0**	**194.00**	**141.00**									
C V (%)	**7.2**	**6.70**	**3.90**									

Cost of cultivation: 2017-Rs.33872/- and 2018- Rs.29087/- per hactare, Value of pigeonpea: Rs. 4200/- and Rs.4800/- per hactare in 2017 and 2018 respectively mainly influenced by precipitation received and amount of moisture in soil for a prolonged period especially at critical growth stages. Similarly Panda *et al*., 2017 reported higher yields on pigeonpea.

Economics

Maximum gross returns (Rs.1,08,660 ha^{-1}) as well as net returns (Rs. 72,306 ha^{-1}) were realized with soil application of VAM fungi @12.5 kg ha^{-1} and crop residue mulching @ 5 t ha^{-1} with supply of 100 % P than that of other treatments, however, benefit:cost ratio was registered higher (2.03) with VAM fungi @12.5 kg ha^{-1} and addition of 100 % P (T_4). Realization of higher returns due to more yield and higher B:C ratio (2.03) resulted by the less investment of production(Table 2).

From field study conducted for two years, it could be concluded that inoculation of VAM fungi @12.5 kg ha^{-1} followed by crop residue mulching @ 5 t ha^{-1} and supply of 100 % P realized more returns and economically viable resulting higher productivity under rainfed upland conditions.

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