Int.J.Curr.Microbiol.App.Sci (2021) *10*(03): 1666-1673

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 10 Number 02 (2021)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2021.1003.207

Influence of Drought Mitigation Techniques on Growth and Yield of Pigeonpea Under Rainfed Conditions

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A B S T R A C T

Research work entitled on **"**Influence of Drought Mitigation Techniques on Growth and Yield of Pigeonpea Under Rainfed Conditions" was carried out during *kharif* seasons of 2015 and 2016 at RARS, Lam on deep black cotton soil. The treatments comprising of ten different practices pertaining to drought mitigation with three replications in randomized block design. The findings from the study revealed that all the drought management practices recorded significantly higher growth, yield attributes and grain yield over control. The maximum grain yield (2000 kg ha^{-1}) was recorded with application of Pusa hydrogel @ 2.5 kg ha^{-1} + mulching with organic residues @ 5 t ha^{-1} which was closely followed by addition of FYM @ 5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1} + spraying of 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage (1868 kg ha^{-1}). The highest values of gross returns (Rs.103200/-), net returns (Rs. 75335/-) and B:C ratio (2.7) were recorded with application of Pusa hydrogel @ 2.5 kg ha^{-1} + mulching with organic residues @ 5 t ha^{-1}.

Keywords

Drought, Mitigation, Pigeonpea, Growth, Yield attributes and yield

Article Info

Accepted:
15 February 2021
Available Online:
10 March 2021

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is a deep rooted and drought-tolerant (Troedson *et al.,* 1990) leguminous food crop used in several countries particularly in India as a source of quality protein. It is an important legume component of dryland agriculture, mainly because of its ability to produce large biomass and protein rich leguminous seeds (Jat and Ahlawat, 2010). It is mainly cultivated in the rainy season (June –Nov) under rainfed conditions characterized by erratic distribution of low rainfall leading to occurrence of frequent mid season or terminal dry spells finally resulting poor yields. In view of global climate change, frequency of dry spells may still aggravate the problem of soil moisture stress leading to low yields. The production is constrained by less productive land, excess water or dry spells at sensitive stages of crop growth, pest and disease problems, and lack of drought-resistant, high-yielding genotypes, and appropriate agronomic practices.

India is the major pulse producer, accounting for about one third of the total world area under pulses and one-fourth of the world production of pulses. India is the largest producer of pigeonpea with 2.6 M.t of production 3.0 M.ha with an average productivity of 865 kg ha^{-1} in 2017-18. Whereas, in AP the average production of pigeonpea in an area of 2.75 Lakh ha is 1.2 Lakh tonnes with productivity of 621 kg ha^{-1} in 2017-18 (www.indiastat.com). Uncertainty in weather conditions coupled with early cessation of monsoon is one of the most important factors responsible for this gap. Management of soil moisture is an important major factor when trying to enhance agricultural production by improving the effective utilization of precipitation, the soil moisture availability and water use efficiency in drought prone areas. Moisture conservation technologies like mulching, foliar sprayings and seed treatments enhanced yield in Pigeonpea (Selvi *et al.*, 2009).

Hydrogels are polymers with superabsorbent in nature holding 332-465 times more water holding over its weight and release slowly in drought situation in light soils (Dehkordi, 2016). Because of their three dimensional hydrophilic nature, hydrogels are subjected to swelling and retain huge amount of water (act as ‘miniature reservoirs’). They gradually releases up to 95% of its stored water when its surroundings begin to dry out and replenished when water comes in contact. Many authors have reported positive (Rehman *et al.*, 2011) and negative (Mandal, 2015) findings in terms of moisture conservation and yield enhancement in several crops with an exception of economic feasibility. However, its’ usage is not being explored so far in rainfed pigeonpea. Therefore, the present trial was envisaged to assess the influence of drought mitigation techniques on performance of pigeonpea under rainfed conditions.

Materials and Methods

The research work was executed for two consecutive years at Lam, Guntur during *kharif* season of 2015 and 2016 on deep black cotton soil. The farm is situated at $25^0$18' N latitude, $83^0$36' E longitude and at an altitude of 128.93 m above mean sea level (MSL). The experiment consisted of 10 drought management treatments, *viz.*, 1. Seed hardening with $CaCl_2$ @ 2%; 2. Vermicompost @ 2.5t ha^{-1}; 3. FYM @ 5 t ha^{-1} + spraying of 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage; 4. Mulching with organic residues @ 5 t ha^{-1}; 5. Pusa hydrogel @ 2.5 kg ha^{-1}; 6. Seed hardening with $CaCl_2$ @ 2% + Pusa hydrogel @ 2.5 kg ha^{-1}; 7. Vermicompost @ 2.5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1}; 8. Farm yard manure (FYM) @ 5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1} + spraying of 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage; 9. Pusa hydrogel @ 2.5 kg ha^{-1} + mulching with organic residues @ 5 t ha^{-1}; 10. Control. The experiment was laid out in randomized block design (RBD) with three replications.

The test variety used for the experiment was LRG -52 and sowing was done on 25th July in both the years (2015 and 2016) with the spacing of 180 cm x 20 cm. The recommended seed rate (5 kg ha^{-1}) was used on actual area basis. All the treatments given equal quantity of chemical fertilizers (20-50-0 kg NPK ha^{-1}). The crop was harvested on 11th February, 2016 and 1st February, 2017. An amount of 707.1 mm rainfall was received in 44 rainy days in 2015 and 522.1 mm in 34 rainy days in 2016 during the period of 26^{th} to 52^{nd} standard meteorological weeks (SMW). The rainfall pattern depicted in figure 1 indicated that, in 2015, rainfall received during crop growth period was uniformly distributed up to 41^{st} SMWs and resulted in excessive vegetative growth with good number of primary and secondary branches. Excess rainfall was received during 29-39th SMWs period coincided with vegetative phase and from 40^{th} week onwards was scanty except 46^{th} SMW it coincided with flowering initiation phase. But in 2016, lower amount of rainfall (26%) and rainy days (22%) were observed when compared to 2015. Similarly during 2016, rainfall received up to 41^{st} SMW was excessive as compared to that of normal (Fig. 1).

Thereafter, it was scanty for the rest of crop period. The data on growth and yield attributes, grain yield were recorded at the time of harvest. The observations like, plant height, number of branches plant^{-1} and number of pods plant^{-1} were recorded from randomly selected five plants from each treatment from each replication. The benefit cost ratio was worked out by dividing the gross returns by cost of cultivation. The data were subject to standard statistical methods described by Gomez and Gomez (1984). The results obtained after analysis is summarized and discussed in results and discussion part.

Results and Discussion

Growth and yield attributes

The positive effect of different drought management techniques could be noticed on growth and yield components (Table 1) at harvesting stage. The data of two years field investigation revealed that application of Pusa hydrogel @ 2.5 kg ha^{-1} and mulching with organic residues @ 5 t ha^{-1} (T_9) registered significantly the maximum plant height (231 cm) than control (181 cm). These moisture conservation technologies enhance 28% of growth as compared to that of control. The number of branches plant^{-1} (23.0), number of pods plant^{-1} (515) and 100 seed weight (11.2g) were also recorded more with incorporation of Pusa hydrogel @ 2.5 kg ha^{-1} and mulching with organic residues @ 5 t ha^{-1} (T_9) which was statistically at par with the respective values obtained from T_8, T_5, T_6 & T_4.

This might be due to conservation of soil moisture as well as reducing the loss of soil fertility status by organic residue mulching. Crop residue mulching after sowing also helped in preservation of soil moisture, which consequently lead to superior plant growth and development. However, control plot recorded the lowest figures in respect to all growth and yield components. These results are in close conformity with the earlier findings of Reddy *et al.,* (2009), Selvi *et al.,* (2009) and Panda *et al.,* (2017).

Grain yield

The perusal of data depicted in table 2 highlighted that basal application of Pusa hydrogel @ 2.5 kg ha^{-1} and mulching with organic residues @ 5 t ha^{-1} (T_9) recorded the higher grain yield of 2000 kg ha^{-1} than that of control plot (1137 kg ha^{-1}).

The differences between these two treatments were statistically significant. The highest grain yield of pigeonpea recorded with application of Pusa hydrogel @ 2.5 kg ha^{-1} and mulching with organic residues @ 5 t ha^{-1} (T_9) which was very close with FYM @ 5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1} + spraying of 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage (T_8). Overall, implementation of drought mitigation techniques on an average enhanced 47.7% more grain yield when compared to control (Table 1).

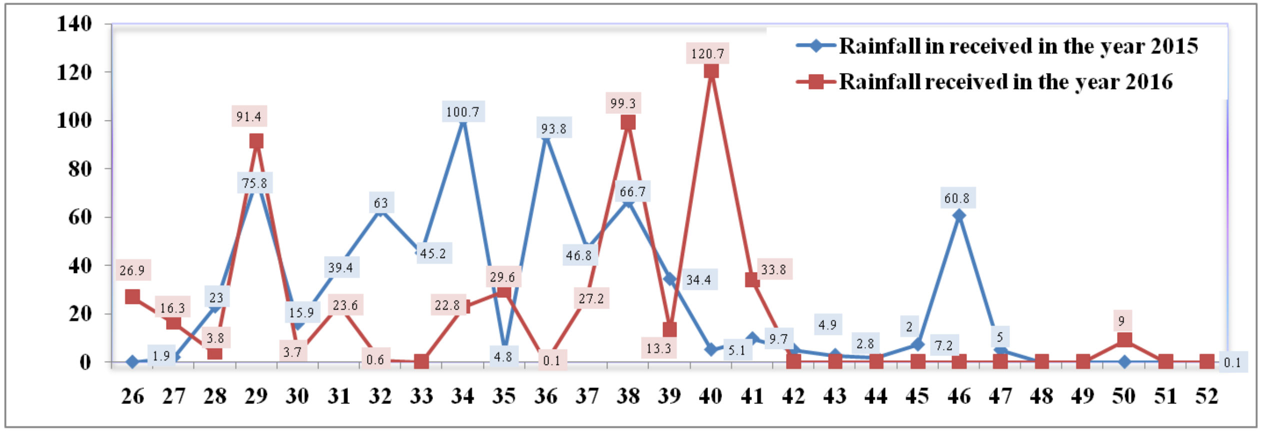
Table.1 Response of drought management practices on growth and yield attributes of pigeonpea (*Cajanus cajan*) under rainfed conditions

Treatments	Plant height at harvest (cm)			Branches plant^{-1}			Pods plant^{-1}			100 grain weight (g)		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
1. Seed hardening with $CaCl_2$ 2%	227.7	163.7	196	20.3	18.3	19.3	450	306	378	10.56	10.2	10.4
2.Vermicompost @ 2.5t ha^{-1}	240.3	179.0	210	21.2	18.8	20.0	452	365	409	10.58	11.0	10.8
3.FYM @ 5 t ha^{-1} + 2% KH_2PO_4 spray at flowering + 2% KNO_3 at pod development stage	244.3	183.0	214	21.8	20.0	20.9	508	392	450	10.72	11.1	10.9
4.Mulching with organic residues @ 5 t ha^{-1}	243.0	186.0	215	22.4	20.7	21.6	475	437	456	11.05	10.8	10.9
5. Pusa hydrogel @ 2.5 kg ha^{-1}	246.0	174.0	210	23.2	20.8	22.0	487	349	418	11.06	10.7	10.9
6. Seed hardening with $CaCl_2$ @ 2% + Pusa hydrogel @ 2.5 kg ha^{-1}	243.7	184.0	214	23.5	19.9	217	464	404	434	11.08	11.0	11.1
7. Vermicompost @ 2.5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1}	239.0	175.0	207	22.2	18.0	20.2	488	438	464	10.80	11.2	11.0
8. FYM @ 5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 spray at flowering + 2% KNO_3 at pod development stage	246.3	187.7	217	24.4	21.1	22.7	516	456	490	11.14	10.6	10.9
9. Pusa hydrogel @ 2.5 kg ha^{-1} + Mulching with organic residues @ 5 t ha^{-1}	263.3	198.0	231	24.6	21.4	23.0	577	453	515	11.15	11.3	112
10. Control	208.7	153.7	181	17.3	17.6	17.4	363	294	329	10.08	10.1	10.1
SEm±	8.54	7.68	5.88	0.83	0.9	0.66	26.67	21	23	0.13	0.3	0.14
CD (0.05)	25.4	23	17.5	2.5	2.5	1.9	79	63	67	0.4	0.7	0.4
CV (%)	6.2	7.5	4.9	6.5	7.6	5.5	9.7	9.4	9	2.1	4.0	2.3

Table.2 Response of drought management practices on yield and economics of pigeonpea (*Cajanus cajan*) under rainfed conditions

Treatments	Grain yield (kg ha^{-1})			Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C ratio		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
1. Seed hardening with $CaCl_2$ 2%	1299	1503	1401	67029	84920	75975	43164	56850	50007	1.81	2.03	1.92
2.Vermicompost @ 2.5t ha^{-1}	1359	1674	1516	70125	94581	82353	34260	54511	44386	0.96	1.36	1.16
3.FYM @ 5 t ha^{-1} + 2% KH_2PO_4 spray at flowering + 2% KNO_3 at pod development stage	1450	1816	1633	74820	102604	88712	46955	70534	58745	1.69	2.20	1.95
4.Mulching with organic crop residues @ 5 t ha^{-1}	1575	1682	1628	81270	95033	88152	55905	65463	60684	2.20	2.21	2.21
5. Pusa hydrogel @ 2.5 kg ha^{-1}	1585	1613	1599	81786	91135	86461	55921	61065	58493	2.16	2.03	2.10
6. Seed hardening with $CaCl_2$ 2% + Pusa hydrogel @ 2.5 kg ha^{-1}	1640	1801	1720	84624	101757	93191	58259	71187	64723	2.21	2.33	2.27
7. Vermicompost @ 2.5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1}	1477	1939	1708	76213	109554	92884	37848	66984	52416	0.99	1.57	1.28
8. FYM @ 5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 spray at flowering + 2% KNO_3 at pod development stage	1766	1970	1868	91126	111305	101216	60761	76735	68748	2.00	2.22	2.11
9. Pusa hydrogel @ 2.5 kg ha^{-1} + mulching with organic crop residues @ 5 t ha^{-1}	1956	2043	2000	100930	115430	108180	73065	83360	78213	2.62	2.60	2.61
10. Control	1032	1242	1137	53251	70173	61712	29886	42603	36245	1.28	1.55	1.42
SEm±	83.56	85	58.9									
CD (0.05)	249	253	175									
CV (%)	9.6	8.5	6.3									

Fig.1 Rainfall distribution pattern during crop growth period in 2015 and 2016



This was mainly due to the favorable soil atmosphere created by cultural mulches by reducing evaporation of soil moisture and thereby improving better uptake of essential nutrients from deeper soil. All drought mitigation techniques were found to have positive and significant impact on conservation of moisture in soil and yield advantage over control. Similar findings were also reported by many researchers (Selvi *et al.,* 2009; Sharma *et al.,* 2010 and Venkata Rao *et al.,* 2019) in different locations across the country.

Further, the better performance of pigeonpea was observed by drought mitigation techniques over the check in two years of field investigation. It might be because of the impact of rainfall distribution pattern and length of moisture holding period in soil (Fig 1). The maximum grain yield (2043 kg ha^{-1}) was reported in 2016 even though low rainfall (522.12 mm in 34 rainy days) was received with uniform distribution than in 2015 (1956 kg 124. ha-1) with 707.1 mm rainfall in 44 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 2015. But in 2016, comparatively low rainfall with uniform distribution during vegetative stage resulted in better source-sink relationship and led to higher grain yields. The crop 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 and Venkata Rao *et al.*, 2019 reported higher yields on pigeonpea.

Economics

The economics of drought mitigation strategies was calculated on pooled grain yield and presented in Table 1. The maximum gross returns (Rs.1,03,200 ha^{-1}), net returns (Rs. 75,335 135. ha^{-1}) and B:C ratio (2.7) were obtained with application of Pusa hydrogel @ 2.5 kg ha^{-1} and mulching with organic crop residues @ 5 t ha^{-1} (T_9). This was due to the increased yield registered by the above said treatment.

Based on the present experiment, it could be concluded that application of Pusa hydrogel @ 2.5 kg ha^{-1} and mulching with organic crop residues @5t ha^{-1} can be recommended to mitigate the drought prevailing during the *kharif* season in Andhra Pradesh for realizing better yield in pigeonpea.

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How to cite this article:

Venkata Rao, P., A. Subbarami Reddy and Ramana, M. V. 2021. Influence of Drought Mitigation Techniques on Growth and Yield of Pigeonpea Under Rainfed Conditions. *Int.J.Curr.Microbiol.App.Sci.* 10(03): 1666-1673.
doi: https://doi.org/10.20546/ijcmas.2021.1003.207