RESEARCH ARTICLE

Influence of Drought management practices in Pigeonpea under rainfed conditions of Karnataka, India

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ABSTRACT

Drought is a major abiotic constraint for optimum yield under changing environmental conditions. Because of slow initial growth and long duration, pigeon pea crop suffers badly due to moisture stress, especially during flowering and pod formation stages. Any management techniques to mitigate drought under stress period will help to boost its productivity.A field experiment was conducted during kharif season of 2017-18, 2018-19 and 2019-20 at Zonal Agricultural Research Station, Kalaburagi, University of Agricultural Sciences, Raichur (Karnataka) on shallow black soil.The experiment was laid out in a complete randomized block design with three replications.The pooled data of three years indicated that application of FYM @ 5 t ha-1 + Pusa hydrogel @ 2.5 kg ha-1 + 2% KH2PO4 at flowering + 2% KNO3 at pod development stage recorded significantly higher seed (1392 kg ha-1) and stalk (4037 kg ha-1) yield and monetary advantage (gross returns ₹ 83520 ha-1, net returns ₹ 42520 ha-1 and B:C ratio 2.04) as compared to rest of the treatments but it was on par with FYM @ 5 t ha-1+2% KH2PO4 at flowering + 2% KNO3 at the pod development stage. Significantly lower seed and stalk yield, gross returns, net returns and B: C ratios were recorded in control (RDF only).

Keywords: *Drought mitigation, mulching, pigeonpea, Pusa hydrogel, seed hardening*

INTRODUCTION

Pigeonpea is an important pulse crop of the country. In Karnataka, it is extensively grown in the northern part of the state, particularly in the Kalaburagi district and is popularly known as the "Pigeonpea bowl of Karnataka". Any adverse effect on pigeonpea in this district will affect the state production and productivity. In Karnataka state, this crop occupies 8.81 lakh ha, producing 5.80 lakh tonnes with an average productivity of 658 kg ha^{-1}. The productivity of pigeonpea in Karnataka is very low compared to the national productivity of 875 kg ha^{-1} [1].The lower productivity of pigeonpea in the state is mainly due to erratic and scanty rainfall; prolonged dry spells during critical growth stages such as flowering and pod formation lead to a heavy reduction in the yield. Drought is one of the abiotic stresses that limit agricultural productions.The adverse effects of drought stress can be mitigated by soil management practices, crop establishment, and foliar application of nutrient elements by maintaining an appropriate water level in the leaves due to osmotic adjustment and stomatal performance [5]. It is well established that drought mitigation techniques such as seed treatment with chemicals, foliar application of nutrients and *insitu* moisture conservation practices play an important role in crop stand establishment and higher production of pigeonpea [8]. Because of slow initial growth and long duration, pigeonpea crop suffers badly due to moisture stress especially during flowering and pod formation stages. Any management techniques to mitigate drought under stress period will help to boost its productivity.

MATERIALS AND METHODS

The field experiment was conducted on shallow black soils at Zonal Agricultural Research Station, Kalaburagi, University of Agricultural Sciences, Raichur (Karnataka), during *kharif* season of 2017-18, 2018-19 and 2019-20 to findout the effect of drought management practices on growth and productivity of pigeonpea. Eleven treatments were laid out in simple RCBD design with three replications and each consisted of Seed hardening with 2% $CaCl_2$ (T_1), Vermicompost @ 2.5 t ha^{-1} (T_2), FYM @ 5 t ha^{-1}+2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage (T_3), Mulching with residues @ 5 t ha^{-1}(T4), Pusa hydrogel @ 2.5 kg/ha (T_5), Seed hardening with 2% $CaCl_2$ + Pusa hygrogel @ 2.5 kg ha^{-1}(T_6), Vermicompost @ 2.5 t ha^{-1} + Pusa hygrogel @ 2.5 kg ha^{-1} (T_7), FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage (T_8), Pusa hydrogel @ 2.5 kg ha^{-1} + Mulching with residues @ 5 t ha^{-1}(T_9), Pusa hydrogel @ 2.5 kg ha^{-1} applied at 45 DAS (T_{10}) and Control (T_{11}). Seed hardening with 2% $CaCl_2$ was done one day before sowing and application of vermicompost, FYM and Pusa hydrogel were done before sowing [19]. Foliar application of 2 % KH_2PO_4 and 2 % KNO_3 was done in the morning hours at flowering and pod development stages. Pigeonpea crop residues (mulches) were applied between two pigeonpea rows to conserve moisture. Pigeonpea variety TS 3R was sown at a 90 cm x30 cm spacing. The soil of the experimental field was clay loam having organic carbon 0.50%, the N status of the experimental field was low (180 kg ha^{-1}), medium in available P_2O_5 (25 kg ha^{-1}) while available K_2O status was in high range (350 kg ha^{-1}). The pH of the experimental site was 8.80 and ECe 0.41 dS/m. The recommended dose of fertilizers, i.e., 25 kg ha^{-1} N and 50 kg ha^{-1} P_2O_5 were applied in the form of urea and diammonium phosphate respectively as a basal dose. The annual rainfall of 974.9 mm 37 rainy days, 549.80 mm in 38 rainy days and 605.8 mm in 50 rainy days were received during 2017, 2018 and 2019. The observations on plant growth and yield parameters were recorded manually on five randomly selected representative plants from each replication plot separately as per the standard method. The seed and stover yield was recorded from net plot area of each treatment. Economics was calculated based on market price of pigeonpea and cost of cultivation. The data obtained from various growth and yield characters under study were statistically analyzed by analysing variance as described by [3].

RESULTS AND DISCUSSION

Available Soil moisture Dynamics

The beneficial effect ofdifferent drought mitigation techniques could be seen in available soil moisture content at different stages of observations (Table 1).Among the different treatments, maximum soil moisture content was observed under the treatment FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stageand which was found to be at par with FYM @ 5 t ha^{-1}+ 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage. During the peak flowering stage (90 DAS), pod filling stage (120 DAS) sufficient soil moisture was recorded during all the 3 years of experimentation and reflected grain yield [13]. Application of FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage was found to increase soil moisture availability than rest of the treatmentsand produced greater infiltration by reduced runoff and subsequent arresting the evaporation on the infiltrated water apparently contributes to soil moisture gains [2].

Growth andYield Attributes

The data in Table 2 show that treatments had significant effect on growth and yield attributes of pigeonpea. The pooled data of three years indicated that FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage recorded significantly higher growth and yield attributing characters *viz.,* plant height (187.0 cm), number of primary branches (12.1 $plant^{-1}$), secondary branches (14.9$plant^{-1}$), pods (147.9 $plant^{-1}$), seed yield (47.7 g $plant^{-1}$) and 100 seed weight (10.53 g) over control. But, it was found on par with FYM @ 5 t ha^{-1}+ 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage (T_3). All the drought mitigation practices maintained higher growth and yield attributes as compared to control [4]. The enhanced growth and yield parameters may be attributed to increase in aeration and

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Table.1: Soil moisture content (%) upto 90 cm soil depth at different stages of pigeonpea as influenced by different drought mitigation techniques

Treatments	2017				2018				2019			
	60 DAS	90 DAS	120 DAS	Harvest	60 DAS	90 DAS	120 DAS	Harvest	60 DAS	90 DAS	120 DAS	Harvest
T_1: Seed hardening with $CaCl_2$ (2%)	26.31	27.96	23.13	16.66	23.93	25.20	20.59	15.01	25.09	26.43	22.49	15.40
T_2: Vermicompost @ 2.5 t ha^{-1}	28.22	29.99	24.81	17.87	25.66	27.02	22.08	16.10	26.91	28.35	24.12	16.52
T_3: FYM @ 5 t ha^{-1}+2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	31.25	33.21	27.47	19.79	28.42	29.93	24.45	17.83	29.80	31.39	26.71	18.29
T_4: Mulching with residues @ 5 t ha^{-1}	27.32	29.03	24.01	17.30	24.85	26.16	21.38	15.59	26.05	27.45	23.35	15.99
T_5: Pusa hydrogel @ 2.5 kg/ha	25.92	27.54	22.78	16.41	23.57	24.82	20.28	14.79	24.72	26.04	22.16	15.17
T_6: Seed hardening with $CaCl_2$ (2%) + Pusa hygrogel @ 2.5 kg ha^{-1}	26.58	28.24	23.36	16.83	24.17	25.45	20.80	15.17	25.34	26.70	22.72	15.56
T_7: Vermicompost @ 2.5 t ha^{-1} + Pusa hygrogel @ 2.5 kg ha^{-1}	28.52	30.31	25.07	18.06	25.94	27.31	22.32	16.28	27.19	28.65	24.38	16.69
T_8: FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	**31.82**	**33.81**	**27.97**	**20.15**	**28.94**	**30.47**	**24.90**	**18.16**	**30.34**	**31.97**	**27.20**	**18.62**
T_9: Pusa hydrogel @ 2.5 kg ha^{-1} + Mulching with residues @ 5 t ha^{-1}	27.45	29.17	24.13	17.38	24.96	26.29	21.48	15.67	26.17	27.58	23.46	16.07
T_{10}: Pusa hydrogel @ 2.5 kg ha^{-1} applied at 45 DAS	24.98	26.54	21.96	15.82	22.72	23.92	19.55	14.26	23.82	25.10	21.35	14.62
T_{11}: Control	23.20	24.65	20.39	14.69	21.10	22.22	18.15	13.24	22.12	23.31	19.83	13.58
S.Em±	0.65	0.69	0.57	0.41	0.58	0.62	0.52	0.37	0.60	0.66	0.58	0.45
C D at 5%	1.92	2.05	1.66	1.19	1.70	1.83	1.53	1.08	1.77	1.93	1.69	1.26

maintenance of soil moisture, which consequently resulted in better crop growth and development. Enhanced growth and yield parameters in crops grown under moisture conservation technique [12], [18], [22]. Higher growth and yield parameters of pigeonpea grown under 100% RDF + FYM + opening of shallow furrows between two rows at 30 DAS was reported by several workers across the country [2], [21].

Crop Productivity

The data analysed on three years mean basis of crop productivity was given in (Table 4). Among the different drought management practices, FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage recorded significantly higher seed yield (1392 $kgha^{-1}$), stalk yield (3943 $kgha^{-1}$) and harvest index (0.25) when compared to rest of the drought mitigation practices. Still, it was found at par with FYM @ 5 t ha^{-1}+ 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage. Significantly lower seed yield, stalk yield and harvest index were registered under control treatment.The increased productivity of grain and stalk under the above-mentioned treatment resulted from the favourable effects of moisture conservation on growth and yield attributes. Thus, application of FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stageshowed superiority over other drought mitigation practices particularly during low rainfall years [7], [14], [17], [22].

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Table. 2: Growth parameters of pigenopea as influenced by different drought mitigation techniques

Treatments	Plant height (cm)				No. of primary branches/ plant				No. of secondary branches/ plant			
	2017	2018	2019	Pooled	2017	2018	2019	Pooled	2017	2018	2019	Pooled
T_1: Seed hardening with $CaCl_2$ (2 %)	230.3	93.1	171.6	165.0	11.6	8.2	9.5	9.77	13.0	9.2	11.2	11.1
T_2: Vermicompost @ 2.5 t ha^{-1}	233.0	106.1	195.4	178.2	12.6	9.2	11.2	11.00	15.0	11.1	13.2	13.1
T_3: FYM @ 5 tha^{-1}+2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	235.3	109.8	206.5	183.9	12.8	10.2	12.1	11.70	16.6	11.8	14.0	14.1
T_4: Mulching with residues @ 5 t ha^{-1}	232.3	101.4	188.2	174.0	12.1	8.8	10.1	10.33	13.4	10.6	12.1	12.0
T_5: Pusa hydrogel @ 2.5 kg ha^{-1}	225.3	90.3	165.3	160.3	11.4	8.0	9.1	9.50	12.6	9.0	10.4	10.7
T_6: Seed hardening with $CaCl_2$ (2%) + Pusa hygrogel @ 2.5 kg ha^{-1}	232.1	95.6	175.4	167.7	11.6	8.6	9.8	10.00	13.0	9.6	11.7	11.4
T_7:Vermicompost @ 2.5 t ha^{-1} + Pusa hygrogel @ 2.5 kg ha^{-1}	233.3	107.2	200.2	180.2	12.8	9.6	11.6	11.33	15.2	11.5	13.6	13.4
T_8: FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 $kgha^{-1}$ + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	237.7	112.4	210.8	187.0	13.0	10.8	12.4	12.07	17.8	12.2	14.8	14.9
T_9: Pusa hydrogel @ 2.5 $kgha^{-1}$ + Mulching with residues @ 5 t ha^{-1}	233.0	104.3	190.7	176.0	12.4	9.0	10.6	10.67	13.8	10.8	12.6	12.4
T_{10}: Pusa hydrogel @ 2.5 kg ha^{-1} applied at 45 DAS	222.7	87.1	162.4	157.4	9.2	7.8	8.8	8.60	11.2	8.8	10.0	10.0
T_{11}: Control	221.4	75.3	145.3	147.3	10.3	7.6	8.2	8.70	12.0	8.2	9.6	9.9
S.Em±	7.0	3.7	8.2	5.7	0.45	0.50	0.44	0.40	0.7	0.7	0.6	0.57
C D at 5%	NS	10.8	24.0	17.0	1.32	1.50	1.31	1.19	2.2	1.9	1.78	1.67

The impact of Pusa hydrogel application alone was not significant on grain and stalk yield, but has a positive response when applied with organic manures like FYM or vermicompost. Similarly, moisture conservation techniques like vermicompost + Pusa hydrogel improved the grain yield of pigeonpea [6]. Significant improvement in wheat yield was also reported due to hydrogel application [11]. Enhanced yield of Urd crop grown under Pusa hydrogel @ 2.0 kg ha^{-1} compared to control [9]. Establishing soil mulch through additional intercultural practices at early and mid stress periods gave yield advantage in different crops [10], [15]. Many authors have reported positive [8] and negative [6] findings in terms of moisture conservation and yield [20].

Economics

Application of FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage recorded significantly higher gross returns (₹ 83520 ha^{-1}), net returns (₹ 42520 ha^{-1}) and B:C ratio (2.04) when compared to the gross returns, net returns and B:C ratio obtained from rest of the drought mitigation practices. However, all the drought mitigation practices recorded significantly higher gross returns, net returns and B: C ratio than RDF only (control) [16]. Significantly higher gross monetary returns, net returns and B: C ratio were obtained in moisture conservation techniques like FYM @ 5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4

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Table.4: Seed yield, stalk yield and harvest index of pigeonpea as influenced by different drought mitigation techniques

Treatments	Seed yield (kg/ha)				Stover yield (kg/ha)				Harvest index (%)			
	2017	2018	2019	Pooled	2017	2018	2019	Pooled	2017	2018	2019	Pooled
T_1: Seed hardening with $CaCl_2$ (2%)	1421	785	1200	1135	4063	2251	4685	3666	0.26	0.26	0.20	0.24
T_2: Vermicompost @ 2.5 t ha^{-1}	1498	890	1282	1223	4114	2444	4977	3845	0.27	0.27	0.20	0.25
T_3: FYM @ 5 t ha^{-1}+2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	1547	1003	1385	1312	4185	2578	5065	3943	0.27	0.28	0.21	0.25
T_4: Mulching with residues @ 5 t ha^{-1}	1459	833	1210	1167	4094	2298	4812	3735	0.26	0.27	0.20	0.24
T_5: Pusa hydrogel @ 2.5 kg/ ha	1402	766	1165	1111	4025	2168	4522	3572	0.26	0.26	0.20	0.24
T_6: Seed hardening with $CaCl_2$ (2%) + Pusa hygrogel @ 2.5 kg ha^{-1}	1446	802	1205	1151	4075	2277	4752	3701	0.26	0.26	0.20	0.24
T_7: Vermicompost @ 2.5 t ha^{-1} + Pusa hygrogel @ 2.5 kg ha^{-1}	1518	900	1310	1243	4156	2464	5042	3887	0.27	0.27	0.21	0.25
T_8: FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	1598	1128	1450	1392	4201	2613	5298	4037	0.28	0.30	0.21	0.26
T_9: Pusa hydrogel @ 2.5 kg ha^{-1} + Mulching with residues @ 5 t ha^{-1}	1473	851	1265	1196	4105	2365	4899	3790	0.26	0.26	0.21	0.24
T_{10}: Pusa hydrogel @ 2.5 kg ha^{-1} applied at 45 DAS	1355	749	1152	1085	3897	2154	4497	3516	0.26	0.26	0.20	0.24
T_{11}: Control	1298	652	1032	994	3968	2110	4253	3444	0.25	0.24	0.20	0.23
S. Em±	45	31	40	36	108	91	174	104	0.007	0.009	0.005	0.006
C D at 5%	130	91	120	107	NS	268	513	308	NS	0.027	NS	NS

Table. 5: Economics of pigeonpea as influenced by different drought mitigation techniques (Pooled data of 3 years)

Treatments	Gross returns (Rs. ha^{-1})	Cost of Cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C Ratio
T_1: Seed hardening with $CaCl_2$ (2%)	68120	30800	37320	2.21
T_2: Vermicompost @ 2.5 t ha^{-1}	73400	34750	38650	2.11
T_3: FYM @ 5 t ha^{-1}+2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	78700	38250	40450	2.06
T_4: Mulching with residues @ 5 t ha^{-1}	70040	33500	36540	2.09
T_5: Pusa hydrogel @ 2.5 kg ha^{-1}	66660	33250	33410	2.00
T_6: Seed hardening with $CaCl_2$ (2%) + Pusa hygrogel @ 2.5 kg ha^{-1}	69060	33300	35760	2.07
T_7: Vermicompost @ 2.5 t ha^{-1} + Pusa hygrogel @ 2.5 kg ha^{-1}	74560	37500	37060	1.99
T_8: FYM @ 5 t ha^{-1}+ Pusa hydrogel @ 2.5 kg ha^{-1} + 2% KH_2PO_4 at flowering + 2% KNO_3 at pod development stage	83520	41000	42520	2.04
T_9: Pusa hydrogel @ 2.5 kg ha^{-1} + Mulching with residues @ 5 t ha^{-1}	71780	36000	35780	1.99
T_{10}: Pusa hydrogel @ 2.5 kg ha^{-1} applied at 45 DAS	65120	33250	31870	1.96
T_{11}: Control	59640	30500	29140	1.96
S. Em±	2335	-	2335	0.06
C D at 5%	6889	-	6889	0.19

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at flowering + 2% KNO_3 at pod development stage [6]. Application of 100% RDF + FYM @ 5 t ha^{-1} + opening of shallow furrows in between two rows and 5% RDF + FYM @ 5 t ha^{-1} + opening of shallow furrows in between two rows registered additional gross returns over control during early and mid stress periods in medium duration pigeonpea by conserving moisture [2].

From the above findings, it can be concluded that application of FYM @ 5 t ha^{-1} + Pusa hydrogel @ 2.5 kg ha^{-1} + 2 % KH_2PO_4 at flowering + 2% KNO_3 at pod development stageis the best option for mitigating the drought situations. Also, it is economically beneficial for realizing the higher productivity of pigeonpea under rainfed conditions of Karnataka state.

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