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Effect of drought mitigation strategies on growth parameters of pigeon pea [*Cajanus cajan* (L.) Millsp.] Under rainfed conditions

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Abstract
The field experiment was conducted during season of 2018 at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P) Effect of drought mitigation strategies on growth parameters of pigeon pea [*Cajanus cajan* (L.) Millsp.] Under rainfed conditions. The trial was laid out in randomized block design with three replications. The results revealed that the plant height was observed significantly higher under T_3: FYM @ 5 t/ha + 2% KH_2PO_4 spray at FL + 2% KNO_3 spray at pod development stage and T_6: Seed hardening with $CaCl_2$ + pusa hydrogel @ 2.5 kg/ha respectively followed by T_9: Pusa hydrogel @ 2.5 kg/ha + mulching with organic residue @ 5 t/ha and minimum plant height was noted in T_{11}: control both stages. Number of primary and secondary branches/plant was noted numerically higher under T_6: Seed hardening with $CaCl_2$ + Pusa hydrogel @ 2.5 kg/ha and Tertiary branches/plant was recorded marginally higher under T_7: Vermicompost @ 2.5t/ha+ pusa hydrogel @ 2.5kg/ha (3.87) followed by Vermicompost @ 2.5 t/ha (3.80). Number of trifoliate leaves was noted markedly higher under T_5: Pusa hydrogel @ 2.5 kg/ha (80.13) and T_3: FYM @ 5 t/ha + 2% KH_2PO_4 spray at FL + 2% KNO_3 spray at pod development stage (180.73). At 60 and 90 DAS, produced higher dry matter accumulation/plant was recorded under T_7: application of vermicompost @ 2.5 t/ha + pusa hydrogel @ 2.5 kg/ha (8.90) and T_6: Seed hardening with $CaCl_2$ + pusa hydrogel @ 2.5 kg/ha (22.30) followed by others treatments. Maximum number of root nodules and root dry weight/plant was recorded numerically higher under T_{10}: Pusa hydrogel @ 2.5 kg/ha applied at 45 DAS (19.22) and T_9: Pusa hydrogel @ 2.5 kg/ha + mulching with organic residues @ 5 t/ha (0.82). Days to 50% flowering, pod formation and 75% maturity was noted numerically higher under T_8: FYM @ 5t/ha + Pusa hydrogel @ 2.5 kg/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development and T_5: Pusa hydrogel @ 2.5kg/ha.

Keywords: Drought, growth, mitigation, pigeonpea, FYM, yield

Introduction
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. Our national production of 4.87 lakh tones is realized from an area of 5.33 lakh ha^{-1} with low productivity of 913 kg ha^{-1} in world area. Madhya Pradesh is one of the important pigeonpea growing states of India, which accounts for nearly cultivated over 6.90 lakh ha^{-1} area with a production of 7.81 lakh tones and productivity of 1133 kg ha^{-1} (Anonymous, 2016-17) [1]. Pigeonpea is frequently affected with vagaries of monsoon under *kharif* rainfed upland situation. 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.

The pre-sowing seed hardening with chemicals is one of the simple techniques being employed to modify the marpho-physio-biochemical nature of seed, so as to induce the characters that are favorable for drought resistance. This situation is more intensive in light soil with low organic matter content. Moisture conservation technologies like mulching, foliar sprayings and seed treatments enhanced yield in Pigeon pea (Selvi *et. al.* 2009) [8]. Seed hardening induce drought resistance in the plant.

Such seeds as indicated by it capacity to with stand dehydration and overheating. Cristopher Lourduraj *et al.* (1996) [4] reported that pre sowing seed hardening of groundnut with $CaCl_2$ (0.5%) recorded the higher pod yield over control. Similarly pre sowing seed hardening of wheat with $CaCl_2$ (2.5%) produced significantly higher grain yield over control (Ugale and Mungse, 2001) [10]. Foliar spray of KNO_3 gave beneficial effect on grain filling and yield in wheat with spray at flowering stage of crop (Sarkar and Tripathi, 1994) [7]. 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 one consecutive years at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot Satna (M.P.),Sandy loam with neutral PH, low carbon and nitrogen, potassium while medium in phosphorus during *kharif* seasons of 2017. The farm is situated under agro-climatic zone-Kymore Plateau of Northern Madhya Pradesh. Geographical Chitrakoot is situated between 25^0 10' N latitude, 80^0 32' E longitude and 190-210 meter above mean sea level. A total of eleven drought management treatments consisted, *viz.,* 1. Seed hardening with $CaCl_2$ (2%), 2. Vermicompost @ 2.5 t/ha, 3. FYM @ 5 t/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage, 4. Mulching with organic residues @ 5 t/ha, 5.Pusa hydrogel @ 2.5 kg/ha, 6. Seed hardening with $CaCl_2$ + Pusa hydrogel @ 2.5 kg/ha, 7. Vermicompost @ 2.5 t/ha + Pusa hydrogel @ 2.5 kg/ha, 8. FYM @ 5 t/ha + pusa hydrogel @ 2.5 kg/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage, 9.Pusa hydrogel @ 2.5 kg/ha + Mulching with organic residues @ 5 t/ha, 10. Pusa hydrogel @ 2.5 kg/ha at 45 DAS and 11. Control. Check was laid out in randomized block design (RBD) with three replications. The crop (var. UPAS-120) was sown with the spacing of 60 x 15 cm^2 and seed @ 18 kg ha^{-1} on 18 July during rainy seasons of 2017 as per the Kymore Plateau of Northern Madhya Pradesh recommendations. The recommended dose of fertilizers for chickpea was 20:60:30 kg N: P_2O_5: K_2O per ha, which were provided through DAP and muriate of potash as basal. A total of 905 mm rainfall 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

Effect on plant height and number of branches per plant

Excluding Plant height all the remaining growth parameters and yield *viz.* Plant height, number of branches $plant^{-1}$, number of trifoliate leaves, dry matter accumulation per plant (g), number of root nodules per plant, root nodules dry weight per plant, at days to 50% flowering, 50% pod formation and 75% maturity and yield were significantly improved by drought mitigation strategies measured at harvesting (Table 1 and 2). Result revealed that the plant height at 60 DAS was significantly higher under the treatment T_3: FYM @ 5 t/ha + 2% KH_2PO_4 spray at FL + 2% KNO_3 spray at pod development stage followed by T_9: Pusa hydrogel @ 2.5 kg/ha + mulching with organic residue @ 5 t/ha (195.13) and non-significant difference at 90 DAS. Number of primary, secondary branches/plant was noted numerically higher under $T_{6:}$ Seed hardening with $CaCl_2$ + Pusa hydrogel @ 2.5 kg/ha (13.73). And tertiary branches/plant was recorded marginally higher under $T_{7:}$ Vermicompost @ 2.5t/ha + pusa hydrogel @ 2.5kg/ha(3.87).

Effect on number of trifoliate leaves and dry matter accumulation per plant (g)

Number of trifoliate leaves and dry matter accumulation per plant (g) was recorded not significantly under at 60 and 90 days stage, number of trifoliate leaves was noted markedly higher under T_5: Pusa hydrogel @ 2.5 kg/ha (80.13) followed by $T_{4:}$ mulching with organic residues @ 5 t /ha (78.07) and T_{11}: control (77.67) which were statistically on par. At 90DAS highest number of trifoliate leaves was registered in T_3: FYM @ 5 t/ha + 2% KH_2PO_4 spray at FL + 2% KNO_3 spray at pod development stage(180.73). followed by $T_{9:}$ Pusa hydrogel @ 2.5 kg/ha + mulching with organic residue @ 5 t/ha(169.87). The dry weight/plant was observed almost same at most of the treatment. Application of vermicompost @ 2.5 t/ha + pusa hydrogel @ 2.5 kg/ha (T_7) produced higher dry matter at 60 DAS. However, at 90 DAS it was found higher dry matter in $T_{6:}$ Seed hardening with $CaCl_2$ + pusa hydrogel @ 2.5 kg/ha(22.30).

Effect on number of root nodules and nodules dry weight per plant

Result revealed that number of root nodules per plant was not significantly influenced due to different drought mitigation treatments at 60 and 90 DAS stage, maximum number of root nodules/plant was recorded numerically higher under $T_{10:}$ Pusa hydrogel 2.5 kg/ha applied at 45 DAS (19.22). while minimum root nodules/plant were observes in $T_{2:}$ Vermicompost @ 2.5 kg/ha(17.22). Nodules dry weight/ plant was recorded that it was not significantly affected by different drought mitigation treatments at 60 and 90 DAS stages, dry weight/plant was recorded numerically higher under $T_{9:}$ Pusa hydrogel @ 2.5 kg/ha + mulching with organic residues @ 5 t/ha(0.82). While minimum nodules dry weight/plant was observed in T_3: FYM @ 5 t/ha + 2% KH_2PO_4 spray at FL + 2% KNO_3 spray at pod development stage(0.51). 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) [9], Qiao *et al.* (2011) [5] and Habibzadesh *et al.* (2014) [3] in mungbean and pigeonpea, respectively.

Table 1: Effect of drought mitigation strategies on plant height, primary, secondary and tertiary branches of pigeonpea

Treatments		Plant height (cm)		Number of branches/plant		
		60 DAS	90 DAS	Primary	Secondary	Tertiary
T_1:	Seed harding with $CaCl_2$ (2%)	140.27	192.70	12.47	6.80	3.33
T_2:	Vermicompost @ 2.5 t/ha	124.05	188.53	12.33	6.13	3.80
T_3:	FYM @ 5 t/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage	141.47	193.20	11.80	5.93	3.60
T_4:	Mulching with organic residues @ 5 t/ha	132.83	190.20	13.13	7.07	2.93
T_5:	Pusa hydrogel @ 2.5 kg/ha	134.97	187.20	12.87	7.00	2.93
T_6:	Seed harding with $CaCl_2$ + Pusa hydrogel @ 2.5 kg/ha	131.87	199.13	13.73	7.07	3.13
T_7:	Vermicompost @ 2.5 t/ha + Pusa hydrogel @ 2.5 kg/ha	137.53	186.60	12.73	6.93	3.87
T_8:	FYM @ 5 t/ha + Pusa hydrogel @ 2.5 kg/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage	129.70	191.77	12.87	7.00	3.53
T_9:	Pusa hydrogel @ 2.5 kg/ha + Mulching with organic residues @ 5 t/ha	139.20	195.13	12.00	5.73	3.53
T_{10}:	Pusa hydrogel @ 2.5 kg/ha applied at 45 DAS	124.19	191.20	11.87	6.53	3.27
T_{11}:	Control	119.12	186.47	12.73	6.47	3.53
S.Em		3.04	7.21	0.62	0.56	0.23
C.D.(P=0.05)		8.97	NS	NS	NS	NS
C.V. (%)		3.94	6.53	8.51	14.58	11.54

Table 2: Effect of treatment at days to 50% flowering, 50% pod formation and 75% maturity of pigeon pea

Treatments		Days to 50% flowering	Days to 50% pod formation	Days to 75% maturity
T_1:	Seed harding with $CaCl_2$ (2%)	101.33	121.00	144.00
T_2:	Vermicompost @ 2.5 t/ha	100.33	120.33	142.67
T_3:	FYM @ 5 t/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage	100.33	120.67	142.67
T_4:	Mulching with organic residues @ 5 t/ha	98.00	117.67	137.67
T_5:	Pusa hydrogel @ 2.5 kg/ha	103.00	122.67	147.33
T_6:	Seed harding with $CaCl_2$ + Pusa hydrogel @ 2.5 kg/ha	101.00	120.33	142.67
T_7:	Vermicompost @ 2.5 t/ha + Pusa hydrogel @ 2.5 kg/ha	102.00	120.67	143.67
T_8:	FYM @ 5 t/ha + Pusa hydrogel @ 2.5 kg/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage	105.00	119.00	144.67
T_9:	Pusa hydrogel @ 2.5 kg/ha + Mulching with organic residues @ 5 t/ha	102.33	122.00	146.67
T_{10}:	Pusa hydrogel @ 2.5 kg/ha applied at 45 DAS	99.33	120.00	143.33
T_{11}:	Control	100.00	120.33	143.67
S.Em		1.63	1.96	3.15
C.D.(P=0.05)		NS	NS	NS
C.V. (%)		2.79	2.82	3.80

Table 3: Effect of drought mitigation strategies on trifoliate leaves per plant and dry weight per plant (g) of pigeon pea

Treatments		Number of trifoliate leaves / plant at		Dry weight / plant (g)		Number of nodules / plant	Nodules dry weight (g)/plant
		60 DAS	90 DAS	60 DAS	90 DAS	90 DAS	90 DAS
T_1:	Seed harding with $CaCl_2$ (2%)	72.07	150.00	6.83	20.62	18.22	0.71
T_2:	Vermicompost @ 2.5 t/ha	72.87	164.13	7.43	21.45	17.22	0.71
T_3:	FYM @ 5 t/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage	76.73	180.73	6.77	21.60	17.22	0.51
T_4:	Mulching with organic residues @ 5 t/ha	78.07	166.53	7.93	21.45	17.44	0.52
T_5:	Pusa hydrogel @ 2.5 kg/ha	80.13	155.47	7.63	21.07	17.78	0.80
T_6:	Seed harding with $CaCl_2$ + Pusa hydrogel @ 2.5 kg/ha	76.87	160.80	8.80	22.30	18.44	0.75
T_7:	Vermicompost @ 2.5 t/ha + Pusa hydrogel @ 2.5 kg/ha	43.40	160.67	8.90	21.42	17.44	0.58
T_8:	FYM @ 5 t/ha + Pusa hydrogel @ 2.5 kg/ha + 2% KH_2PO_4 spray at flowering + 2% KNO_3 spray at pod development stage	70.67	162.73	8.20	21.77	17.55	0.68
T_9:	Pusa hydrogel @ 2.5 kg/ha + Mulching with organic residues @ 5 t/ha	76.73	169.87	8.17	22.17	17.44	0.82
T_{10}:	Pusa hydrogel @ 2.5 kg/ha applied at 45 DAS	75.53	157.80	8.60	21.35	19.22	0.75
T_{11}:	Control	77.67	162.07	8.53	19.43	18.33	0.77
S.Em		7.85	14.47	0.59	0.72	0.70	0.16
C.D.(P=0.05)		NS	NS	NS	NS	NS	NS
C.V. (%)		18.11	15.39	12.72	5.81	6.84	36.67

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