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Research Article

MOISTURE STRESS EFFECT ON PIGEON PEA (*Cajanus cajan* L.) YIELD AND GROWTH ATTRIBUTING CHARACTERS

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Abstract- A field experiment was conducted to examine the effect of moisture stress on growth and yield of pigeon pea under deep black soil during *the khariff season* of 2013 and 2014. Results indicated that moisture stress imposed at flowering stage was recorded detrimental for growth and yield and the treatment T_3 and T_1 (control) imposed at flowering stage increased moisture content by 8.50 and 37.91 % over moisture stress at 50 % flowering stage, but the treatment T_3 was at par with the treatment T_1 in all the stages. The increased pod yield was recorded 2.24 % over the control at grain development stage. Treatment T_3 and T_1 imposed at flowering stage increased plant height (8.90 % and 8.65 %) and number of branches (5.00 % and 15.00 %) respectively, over 50 % flowering stage. Significantly treatment T_1 had lower values for growth and yield parameters due to different reasons *viz.*, moisture stress, pest attack, temperature effect the 70 % pods were damaged. The higher number of pods (6570 nos. ha^{-1}) was recorded in Treatment T_3 and exhibited its superiority over rest of the treatments. This indicated that among different growth stages, the flowering stage is most critical for irrigation in the pigeon pea crop.

Keywords- Moisture stress,Pigeon Pea, Biometric Parameter, Yield

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Introduction

Soil is key natural resources for crop yield. It is the important factor for crop to obtain water and nutrient for growth, anchorage and stability. [16, 17]. For productive use of scares soil and water resources, it is essential to increase food production on a sustainable basis. A heavy soil erosion (5.3 Mt) and nutrient loss (8.0Mt) occurred each year due to faulty land use management practices at field level [4, 8]. Water stress occurring at the anthesis increased the post-harvest dormancy of the grains. Period of water stress occurring later in grain development stage was variable in effect, tending to decrease grain dormancy in comparison with grains which are not subjected to water stress. The water stress induced grain responsible for breaking dormancy by removing the covering layers of the grain. The variability in the dormancy of the grains at season to season concluded that other environmental factors may also affect grain dormancy [1].

Pigeon pea (*Cajanus cajan* (L.) Millsp.) is commonly known as red gram an important legume component in the dry-land agriculture, mainly because of its ability to produce large biomass and protein-rich leguminous seeds [7]. It is mainly grown in the rainy season (June –Nov). Pigeon peas are drought resistant crop, so it can be grown in areas where annual average rainfall is less than 650 mm. Moisture stress is one of the major constraints in productivity of pigeon-pea. More than 50 % loss in the yield of pigeon-pea has been recorded due to drought [14, 15, and 20]. Water stress affects the final yield due to the reduction in plant height, number of pods, reduction in pod weight etc. [10]. The effect of water stress on pigeon pea has not been deeply studied outside of certain physiological processes [9, 13], and additional studies are needed to better understand morphological changes that take place in this species when water is limited. Soil moisture management is a key factor when trying to enhance agricultural production by improving the precipitation, the availability of moisture in the soil and water use efficiency in rainfed areas. The moisture lost through runoff and evaporation must be reduced and the total amount of water that enters into the soil must be increased. The physiological processes of the plant has effected due to water stress in the plant [11, 12]. Some studies reported that moisture stress is critical during early growth and grain filling stages, which influence the reduction of the plant's biometric growth and ultimately reduce the grain yield [5]. When the moisture stress was imposed during the flowering stage and at the pod formation stage, it significantly reduced the yield of pigeon-pea crop and the reduction was highest [18]. In this region i.e. in rainfed areas, the study of soil conservation tillage systems was mainly focused in runoff and soil losses with little information on moisture content in the soil profile. With these points, an field experiment was conducted to study the effect of moisture stress on growth and yield of *khariff* pigeon pea. The translocation of photosynthates and other nutrients influenced when the moisture stress influenced at crop growth stage [2], photosynthesis [3], mineral nutrition, metabolism, growth and groundnut yield [19].

Materials and Methods

A field experiment was conducted during *the khariff season* of 2013 and 2014 at All India Coordinated Research Project (AICRP), for Dry Land Agricultural, Farm, Vasantarao Naik Marathwada Agricultural University, Parbhani (Lattitude- 17^0 36' N, Longitude- 76^0 47' E and Altitude- 406 m above msl). Parbhani is situated in middle Maharashtra, which falls under sub-tropical and semi-arid region. The soil type of the field was medium black in texture (having depth up to 60 cm) with pH 8.2 and electrical conductivity 0.2 dS/m with field capacity 16.2 % and permanent wilting point 6.8 %, while the bulk density was 1.27 g/cc.

The present investigation on water stress management through *in-situ* moisture conservation techniques (T_1- Sowing of pigeon pea crop along the slope (control), T_2 - Sowing of pigeon pea crop across the slope, T_3- Opening of furrow after two rows across the slope in the crop, T_4 - Opening of furrow after three rows across the slope in the crop, T_5- Opening of furrow after four rows across the slope in the crop, T_6-Opening of furrow after five rows across the slope in the crop, T_7- Opening of furrow after six rows across the slope in the crop) was carried out in a randomized block with three replications each along with a prominent pigeon pea variety (BDN-2010). The observations like, height of plant, number of branches per plant and number of pods per plant were recorded from five plants randomly selected from each treatment from each replication. Besides these, seed yield and economics of treatments (gross monetary returns, net monetary return and B: C ratio) were also calculated for the *khariff* season of 2013 and 2014. Soil moisture content using a screw auger at various stages like, branching stage (45 DAS), flowering stage (110 DAS), 50 % flowering stage (120 DAS), pod formation stage (140 DAS), grain development stage (160 DAS) and maturity stage (180 DAS), was determined by gravimetric method at sowing, at regular interval during crop growth stages and at harvest at the depth of 15 cm, 30 cm and 45 cm in soil profile. The results obtained after pooled analysis is summarized and discussed in results and discussion.
(DAS: Days after Sowing)

Estimation of Evapotranspiration

The reference evapotranspiration was estimated by using DSS-ET software. All the data were arranged according to the program developed in MS-Excel. The results obtained from the software were further analyzed according to crop growth stages and Crop Evapotranspiration (ET_c). For the estimation of ET_c, crop coefficient (K_c) value of pigeon at different stages was considered and multiplied to ET_o on a daily basis. Crop growth stage wise soil moisture content, ET_o and ET_c was recorded for analysis. The moisture stress for the pigeon pea crop was found out by the water balance study.

Results and Discussion

Plant height, number of branches and number pods per plant were significantly influenced due to moisture stress [Table-1]. Treatment T_3 recorded significantly higher soil moisture content and it was remained significant over all other treatments. Treatment T_3 and T_1 (control) imposed at flowering stage increased moisture content by 8.50 and 37.91 % respectively over moisture stress at 50 % flowering stage. And at grain development stage moisture content was increased by 50 and 51.57 % in treatment T_3 and T_1 respectively over moisture stress at maturity stage. Significantly, lower values for moisture content were recorded for treatment T_1. It indicates that the opening of furrows across the slope helps to conserve the soil moisture. Similar results were also recorded by [5] for the soybean crop through furrow opening for management of water stress in soybean. Plant height, number of branches and number pods per plant were significantly higher in treatment T_3. Treatment T_3 and T_1 imposed at flowering stage increased plant height (8.90 %, 8.65 %) and number of branches (5.00 %, 15.00 %) respectively over 50 % flowering stage. And at grain development stage, were imposed by plant height (0.97 %, 0.17 %) and number of branches (2.95 %, 0.21 %) in treatment T_3 and T_1 respectively, over maturity stage. Significantly lower values for growth and yield parameters were observed in Treatment T_1, due to different reasons *viz.*, moisture stress, pest attack, temperature effect the 70 % pods were damaged. Treatment T_3 recorded a significantly higher number of pods (6570 nos ha^{-1}) [Table-1] and exhibited its superiority over the rest of the treatments.

Table-1 *Effect of in situ Rainwater conservation practices on moisture status and biometric parameters at root zone of pigeon pea (pooled)*

Stages		T_1	T_2	T_3	T_4	T_5	T_6	T_7	CD@5%
Branching Stage	MC(mm)	16.44	16.49	18.12	17.70	17.06	16.72	16.55	0.60
	Ht (cm)	44.34	44.65	47.12	46.28	45.96	45.36	44.90	1.91
	Br	2.73	2.86	3.13	3.00	2.98	2.93	2.88	0.43
Flowering Stage	MC(mm)	14.44	14.49	16.04	15.93	15.65	14.99	14.72	0.24
	Ht (cm)	96.62	96.90	98.59	98.00	97.65	97.40	97.05	1.21
	Br	10.20	10.55	13.20	12.32	11.85	11.06	10.80	0.74
50% Flowering Stage	MC(mm)	10.47	11.88	14.77	14.46	14.13	13.46	12.07	0.74
	Ht (cm)	104.98	105.25	107.37	106.44	105.94	105.63	105.56	1.57
	Br	11.73	12.00	13.86	12.85	12.60	12.40	12.26	0.57
Pod Formation Stage	MC(mm)	10.70	11.95	14.60	14.44	13.65	13.22	12.16	0.44
	Ht (cm)	110.39	110.85	113.28	112.45	111.50	111.25	111.05	1.94
	Br	14.60	14.73	15.73	15.53	15.46	15.20	14.93	1.03
	Pods	23.23	23.49	26.63	26.29	26.01	25.81	25.63	0.22
Grain Development Stage	MC(mm)	8.63	9.89	12.48	11.97	10.93	10.71	10.21	0.91
	Ht (cm)	116.00	117.67	119.80	119.23	118.81	118.10	118.01	1.97
	Br	14.25	14.73	16.73	15.85	15.46	15.20	14.93	0.94
	Pods	62.92	63.14	64.33	64.12	63.84	63.73	63.54	0.28
Maturity Stage	MC(mm)	8.21	8.96	11.98	11.18	10.44	9.86	9.62	1.66
	Ht (cm)	116.80	117.95	120.97	119.56	118.96	118.35	118.01	1.97
	Br	14.28	14.78	16.25	15.85	15.55	15.30	14.98	0.94
	Pods	72.60	72.64	74.20	74.13	73.23	73.40	73.20	1.21

(MC: Moisture Content. Ht: Height of Plant. Br.: Number of Branches. Pods: Number of Pods DAS: Days after Sowing).

The magnitude of decrease in pod yield at maturity stage was to the extent of 20.98, 15.38 % over the grain development stage in treatment T_3 and T_1 respectively. The low yield was attributed due to almost less improvement in growth and yield parameters. Significantly, the no pod yield was recorded when moisture stress imposed at flowering stage. This indicated that among different growth stages, the flowering stage is most critical for irrigation in the pigeon pea crop. A temporary soil moisture stress at branching stage did not affect the pod yield significantly, but was highly detrimental when it was imposed at flowering stage. Increase in day temperature and decrease in relative humidity, leads to soil moisture stress in the root zone of the pigeon pea crop and reduced the grain yield due to flower obsession and pod abortion in pigeon pea under moisture stress condition.

These results corroborate the findings of for groundnut crop [21]. The increase in pod yield under the opening of furrow across the slope treatment could be due to increase in the total amount of available soil water to plants and also maintenance of plant water status at its optimum level. The reduction in pod yield due to moisture stress was mainly because of decrease in the number of branches and mature pods per plant. At no moisture stress condition produced 33.70 % higher pod yield of groundnut over moisture stress imposed at flowering stage, but no moisture stress was at par with moisture stress at pre-flowering for growth and yield attributes and pod yield [6].

Among the treatments, treatment T_3 accrued the highest net realization of Rs. 4995.50 ha^{-1} with BC ratio value of 0.26:1 [Table-2] and [Fig-1]. Significantly lowest net realization was accrued in treatment T_1 of Rs. -3565.70 ha^{-1} with B: C

ratio value of -0.20:1. Furrow opening after three rows in soybean crop showed significantly higher gross monetary returns (Rs. 28384 ha^{-1}), net monetary returns (Rs. 16884 ha^{-1}) and B:C ratio (2.46:1) over those in furrow opening after six rows, nine rows and flat sowing [6].

The daily crop water use by the pigeon pea crop was calculated by using daily climatic parameters. It was concluded that crop water used by the pigeon pea crop was a bit higher than rainfall received in a particular crop period [Table-3] and [Fig-2]. Therefore, significantly lowest yield was recorded.

Table-2 *Mean effect of opening of furrows across the slope on GMR, NMR and B: C in pigeon pea crop (pooled)*

Treatments	Cost of Cultivation (Rs.ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C
T_1	17009	13444	-3565.70	-0.20
T_2	17009	16622	-386.830	-0.023
T_3	18634	23630	4995.50	0.26
T_4	18309	20778	2468.80	0.13
T_5	17984	19352	1367.90	0.076
T_6	17659	17722	63.17	0.003
T_7	17334	16296	-1037.70	-0.063
CD @ 5% level	**486.30**	**1198.50**	**1347.00**	**0.187**

Table-3 *Pigeon pea growth stage wise crop water use and rainfall received in a crop period (pooled)*

Crop Stages	Rainfall (mm)	ET$_c$ (mm)
Branching stage	210.40	115.22
Flowering stage	97.23	120.23
50 % Flowering stage	32.56	45.82
Pod filling stage	22.01	87.36
Grain development stage	17.46	56.84
Maturity stage	9.20	84.56

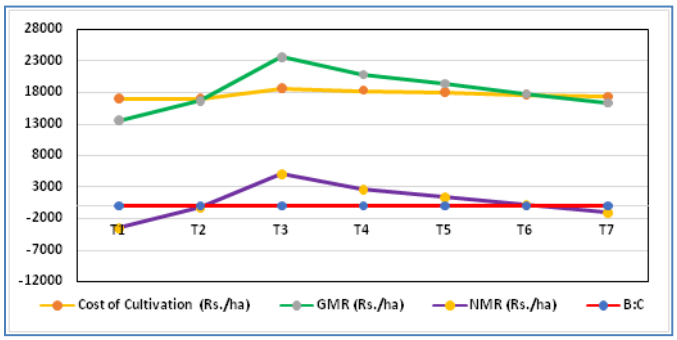

Fig-1 Mean GMR, NMR and B: C in pigeon pea crop

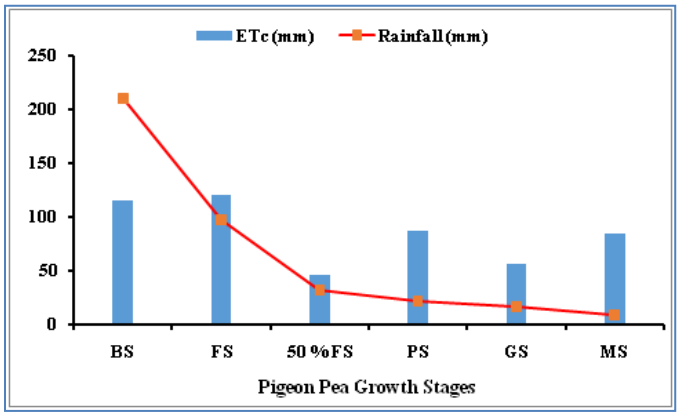

Fig-2 Pigeon pea growth stage wise crop water use and rainfall received in a crop period

(Note: BS: Branching Stage, FS: Flowering Stage, 50 % FS: 50 % Flowering Stage, PS: Pod Filling Stage, GS: Grain Development Stage, MS: Maturity Stage)

Conclusion

Treatment T_3 imparted significant effect on moisture conservation in the root zone of the pigeon pea growth and development for getting higher yield. This subsequently might have led the highest Gross Monetary Return (Rs. 23630.61 ha^{-1}, net monetary return (Rs. 4995.51) and B: C (0.26:1). Moisture stress was greatly affected to sowing along the slope treatment (T_1) i.e. control and was made negative net returns (Rs. -3565.65) and B: C was (-0.20:1). The performance of biometric parameters in terms of plant height, number of branches and number of pods per plant, and yield (537.04 kg ha^{-1}) were found significantly superior in treatment T_3 over the rest of the treatments.

Conflict of Interest: None declared

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