



Foliar application of plant growth regulators and nutrients induce changes in biochemical characters and yield attributes of pigeonpea

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Abstract

A field experiment was conducted during *kharif* season of 2019 at Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore to study the influence of different plant growth regulating compounds and nutrients on biochemical changes and yield attributes of pigeonpea genotype (ICPL 11255) under irrigated condition. The treatments consist of foliar spray of growth retardants *viz.*, mepiquat chloride @ 500 ppm and chlormequat chloride @ 500 ppm at vegetative stage and different PGRs (Salicylic acid @ 100 ppm, Brassinosteroid @ 0.1 ppm and NAA @ 40 ppm), Nutrients (ZnSO₄ @ 0.5 % + Boric acid @ 0.3%, MAP @ 2% and TNAU Pulse Wonder @ 1%) and two Nutrient consortia mixtures at flower initiation and 15 days thereafter. The results revealed that, foliar application of Chlormequat chloride and Nutrient consortia -1 recorded maximum soluble protein content (15.14, 14.48 mg g⁻¹), nitrate reductase activity (12.44, 9.01 µg NO₂ g⁻¹ h⁻¹), maximum number of flowers plant⁻¹ (52.30), number of pods plant⁻¹ (18.05), 100 seed weight (11.12 g) and Fertility co- efficient (34.50 %) compared to other treatments.

Keywords: PGRs, nutrients, biochemical, yield, pigeonpea

Introduction

Pulses are the chief source of vegetable protein in human diet and besides protein they provide complex carbohydrates, vitamins and minerals (Jukanti *et al.*, 2012) [7]. Among the pulses, the Pigeonpea is the second most important protein rich pulse crop after chickpea in India and fifth most important crop in the world. India is the largest producer of the crop contributing to 85% of the world total production. In India, it occupies an area of about 5.39 m ha with an annual production of 4.60 million tonnes and productivity of 913kg/ha (FAOSTAT, 2018) [3].

In pigeon pea, vegetative and reproductive stage occurs simultaneously and hence there is competition for available assimilates between vegetative and reproductive sink. On the other hand, always there is a limitation of source (leaves) particularly at flowering and pod development stages. Apart from its genetic makeup, the major physiological constraints limiting pigeon pea yield are flower and fruit drop (Ojeaga and Ojehomon 1972) [14]. In almost all the pulses, flower drop determines the yield and yield attributing parameters. The availability of assimilates, anatomical features of the vascular system and hormonal factors are possible to interact and play a key role in the abscission of reproductive organs. Therefore, flower and pod abortion result from a temporary shortage of assimilates produced by intense intra-plant competition between vegetative parts, especially the stem apex, and reproductive organs at the beginning of flowering and pod-setting (Karamanos and Gimenez 1991) [9]. Retention of flowers and pod conversion produced by the plant gives prospective yield which is possible through foliar application of growth regulators

and nutrients during flower initiation and pod development stages. Another restraint of the limited nitrogen fixation by legume- rhizobium symbiosis is the consequence of mineral nutrient deficiency, both macronutrients as well as micronutrients (Zn, Fe, B, Mo etc.) which limits the legume production (Bhuiyan *et al.*, 1999) [1]. The plant growth regulators in general, regulate the physiological processes and enhance the growth and development of field crops which results in increased yield. With the above constraints in view, a research was taken up to assess the influence of foliar application of plant growth regulators and nutrients on biochemical attributes and yield of pigeonpea.

Materials and methods

The field experiment was conducted during *kharif* season, 2019 at Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore in determinate Pigeonpea genotype ICPL 11255 to investigate the influence of foliar PGRs and nutrients on biochemical traits and yield attributes. The experimental field was laid out in Factorial Randomized Block Design (FRBD) with nine treatments and three replications. The treatments were growth retardants *viz.*, control (M₁), mepiquat chloride @ 500 ppm (M₂) and chlormequat chloride @ 500 ppm (M₃) sprayed at vegetative stage and then different PGRs and nutrients (T₁ - Control, T₂ - Salicylic acid @ 100 ppm, T₃ - Brassinosteroid @ 0.1 ppm, T₄ - NAA @ 40 ppm, T₅ - ZnSO₄ @ 0.5 % + Boric acid @ 0.3%, T₆ - MAP @ 2%, T₇ - TNAU Pulse Wonder @ 1%), and two nutrient mixtures (T₈ - Nutrient consortia- 1, T₉ - Nutrient consortia- 2) sprayed at flower

initiation and 15 days thereafter. In biochemical assay, soluble protein was estimated from leaf samples following Lowry *et al.* (1951) ^[10] method, Nitrate reductase activity was determined by Nicholas *et al.* (1976) ^[13] method and IAA oxidase activity using Parthasarathy *et al.* (1970) ^[15]. The total number of flowers produced from commencement to the end of the flowering period and total numbers of pods at harvest stage were recorded in five plants in each treatment for each replication and the mean value was worked out. The fertility coefficient per cent was calculated from flower to pod ratio. The data obtained from this study, was subjected to statistical analysis in FRBD as described by Gomez *et al.* (1984) ^[4].

Results & Discussion

Biochemical characters

Soluble Protein (mg g⁻¹)

Proteins in pulses are the main storage product and most of the soluble proteins act as enzymes which regulate a number of metabolic activities. Soluble protein content being a measure of RuBP carboxylase activity is considered as an index for photosynthetic efficiency. The soluble protein content of leaves increased from vegetative stage to flowering stage and declines slightly in pod filling stage (Table 1). Since the soluble proteins are the first nitrogenous compounds lost during pod filling, a declining trend in soluble protein was noted at pod filling stage as reported by Martignone *et al.* (1987) ^[12].

The relative efficacy of growth regulators and nutrients (Nutrient consortia 1- M₃T₈) on leaf soluble protein recorded maximum content (15.14, 14.48) followed by Nutrient consortia 2 - M₃T₉ (14.63, 14.02) at flowering and pod filling stages respectively and the lowest value was observed in T₁ (10.51, 9.86). In conformity, increase in nitrogen fixation and enhanced soluble protein content in groundnut by exogenous application of plant growth regulators have been reported by Vardhini and Rao (1999) ^[24]. Similar results were reported in soybean (Zhao LM and Zheng DF 2008; Raja Mohan, 1989; Kalarani, 1991) ^[25, 17, 8]. Rice plants treated with plant growth regulators showed increased amount of soluble protein content over control (Das T and shukla YM 2011) ^[2].

Nitrate reductase activity (NRase; µg NO₂g⁻¹ h⁻¹)

Nitrogen assimilation in plants is regulated by nitrate reductase and its activity plays a constructive role in nitrogen utilization by the plants through nitrogen metabolism. In the present study, high NRase activity was found in flowering stage and declined rapidly during pod filling stage (Table 1). This finding is in agreement with Sivakumar and Jaya Priya (2017) ^[20] in blackgram. Among the treatments, Nutrient consortia - 1 (M₃T₈) produced increased NRase activity (12.44, 9.01) followed by Nutrient consortia 2 (12.01, 8.84) compared to control. The increase in NR activity due to plant growth regulators could be attributed to increased availability of assimilates, enzyme synthesis and the substrates required for its activity.

IAA oxidase activity (µg of unoxidised auxin g⁻¹ h⁻¹)

The IAA oxidase activity determines the auxin levels and thereby apical dominance. It represents the amount of unoxidised auxin content in leaf sample. In this study, IAA oxidase activity was high in flowering stage and showed a decreasing trend up to pod filling stage.

The treatments effectively suppressed the enzyme activity and maintained higher level of auxin in leaves (Figure 1). The unoxidised auxin content was significantly increased by the foliar application of plant growth regulators and nutrients. Application of Nutrient consortia - 1 treatment (M₁T₈) proved to be superior (85.24, 76.16) in its activity compared to all other treatments. This finding was in close confirmity with the result of Han *et al.* (1988) ^[5], in which foliar application of plant growth regulators increased IAA synthesis in tobacco. Helmy *et al.* (1997) ^[6] also made similar statement, that foliar application of plant growth regulators had enhanced the auxin content in broad bean. Foliar application of nutrient consortia treatments have significantly influenced the auxin content compared to other treatments.

Yield characters

In almost all the pulses, flower drop limits the yield and yield attributing parameters (Table 2). The main reason for increasing yield is reduction of flower and pod drop which is possible through foliar application of growth regulators as well as nutrients during flower initiation and pod development stages. It is well known that in pigeonpea around 70-96 per cent flowers are abscised leading to poor yield and carry approaches to facilitate the abscission help in achieving potential yield. The flowers and pods of the inflorescence may not receive enough assimilates from the leaf due to inadequate in pigeonpea (Begum *et al.*, 2007) ^[16].

The present trial concludes that foliar application of nutrient consortia mixture at flower initiation and pod formation stages have reduced flower drop due to efficient translocation of photosynthates from source to sink. The maximum number of flowers per plant was recorded in M₃T₈ (52.30) followed by M₂T₈ (51.88) and minimum was in control (38.16). Similar results of reduction in flower drop due to foliar application of Pulse Magic have been reported by Teggelli *et al.* (2016) ^[22] in pigeonpea.

The results of present trial are in agreement with the findings of Marimuthu and Surendran (2015) ^[11] in blackgram.

Number of pods per plant has significance in contributing to the output of seed. The foliar treatment, Nutrient consortia 1 (M₃T₈) invariably resulted in maximum number of pods per plant (18.05), maximum 100 - seed weight (11.12 g) and higher fertility coefficient (34.50%) followed by M₂T₈ (17.60, 10.95 g and 33.92 % respectively) and it might be due to the application of PGR and nutrients at flowering and pod formation stage which has helped in more translocation of photosynthates to the developing pods which in turn helped in better filling of grains. Similarly, the influence of NAA on the fertility coefficient was reported by Karan Singh (1989) ^[19] in chickpea. Sujatha (2001) ^[21] reported that application of 40 ppm NAA increased the fertility co-efficient in green gram. Kulkarni (1988) ^[18] pointed out that foliar application of NAA significantly increased the 100 seed weight in soybean. The results of present investigations are in line with the findings of Vijaysingh *et al.* (2017) ^[23] that foliar application of Pulse Magic and nutrients enhanced yield in blackgram and soybean.

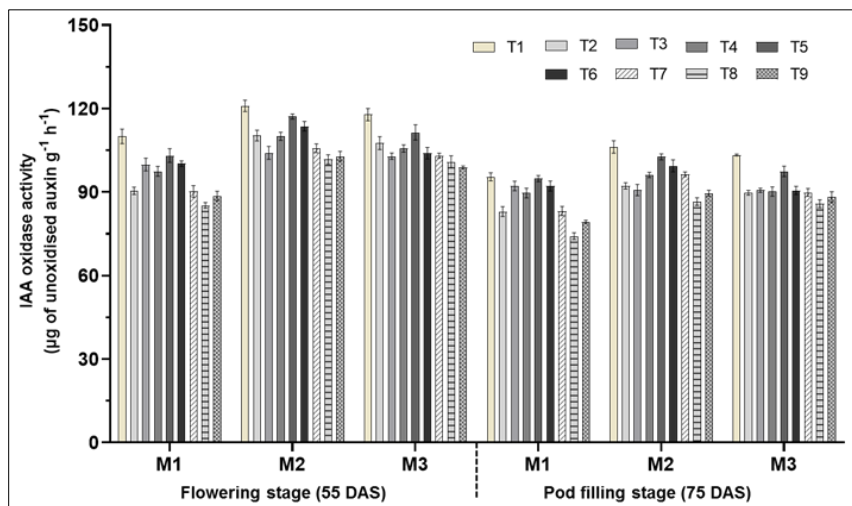


Fig 1: Effect of growth regulators and nutrients on IAA oxidase activity (μg of unoxidised auxin $\text{g}^{-1} \text{hr}^{-1}$) in determinate pigeonpea (ICPL 11255) at different growth stages.

Data are means of three replicates along with standard error bars. M₁: Control, M₂: Mepiquat chloride @ 500 ppm and M₃: Chloromequat chloride @ 500 ppm at Vegetative stage. T₁: Control, T₂: Salicylic acid (100 ppm), T₃: Brassinosteroid (0.1

ppm), T₄: NAA (40 ppm), T₅: ZnSO₄ (0.5 %) + H₃BO₃ (0.3%), T₆: MAP (2%), T₇: TNAU Pulse Wonder (1%), T₈: Nutrient consortia - 1, T₉: Nutrient consortia – 2 at flower initiation & 15 days thereafter.

Table 1: Effect of growth regulators and nutrients on soluble protein content (mg g^{-1}) and nitrate reductase activity ($\mu\text{mol NO}_2 \text{g}^{-1} \text{h}^{-1}$) in determinate pigeonpea (ICPL 11255) at different growth stages

Treatments	Soluble protein content (mg g^{-1})								Nitrate reductase activity ($\mu\text{mol NO}_2 \text{g}^{-1} \text{h}^{-1}$)							
	Flowering stage (55 DAS)				Pod filling stage (75 DAS)				Flowering stage (55 DAS)				Pod filling stage (75 DAS)			
	M ₁	M ₂	M ₃	Mean	M ₁	M ₂	M ₃	Mean	M ₁	M ₂	M ₃	Mean	M ₁	M ₂	M ₃	Mean
T ₁ : Control	10.51	11.15	11.41	11.02	9.86	10.57	10.75	10.39	9.16	9.94	10.21	9.77	6.75	7.30	7.65	7.23
T ₂ : Salicylic acid (100 ppm)	11.13	12.36	13.38	12.29	10.40	12.15	13.12	11.89	10.25	10.56	11.00	10.60	7.33	7.86	8.31	7.83
T ₃ : Brassinosteroid (0.1 ppm)	12.48	13.80	13.88	13.39	11.46	11.55	11.99	11.67	10.34	10.69	11.16	10.73	8.13	8.29	8.51	8.31
T ₄ : NAA (40 ppm)	12.98	13.59	14.13	13.57	12.76	13.03	13.19	12.99	9.77	10.38	10.74	10.30	7.24	8.16	8.24	7.88
T ₅ : ZnSO ₄ (0.5 %) + H ₃ BO ₃ (0.3%)	11.57	12.51	13.97	12.68	10.89	12.50	13.11	12.17	9.71	10.06	10.39	10.05	6.96	7.52	7.98	7.49
T ₆ : MAP (2%)	12.62	13.36	13.59	13.19	11.30	12.16	12.42	11.96	9.68	10.14	10.56	10.13	7.05	7.56	8.14	7.58
T ₇ : TNAU Pulse Wonder (1%)	12.49	13.92	14.17	13.53	12.06	13.20	13.59	12.95	10.74	11.03	11.50	11.09	8.01	8.37	8.67	8.35
T ₈ : Nutrient consortia - 1	13.10	14.44	15.14	14.23	12.34	13.12	14.48	13.31	11.56	11.96	12.44	11.99	8.37	8.91	9.01	8.76
T ₉ : Nutrient consortia - 2	12.92	14.24	14.63	13.93	12.04	13.52	14.02	13.19	11.23	11.60	12.01	11.61	8.17	8.74	8.84	8.58
Mean	12.20	13.26	13.81	13.09	11.46	12.42	12.96	12.28	10.27	10.71	11.11	10.70	7.56	8.08	8.37	8.00
Factors	M	T	M x T		M	T	M x T		M	T	M x T		M	T	M x T	
SEd	0.09	0.16	0.28		0.09	0.16	0.27		0.07	0.12	0.21		0.09	0.15	0.26	
CD (P:0.05)	0.19	0.32	0.56		0.18	0.31	0.54		0.14	0.24	NS		0.17	0.30	NS	

* M₁ – Control, M₂ - Mepiquat chloride @ 500 ppm and M₃ - Chloromequat chloride @ 500 ppm at Vegetative stage

* T₁ to T₉ (2 sprays: at flower initiation & 15 days thereafter)

Table 2: Effect of growth regulators and nutrients on yield characters in determinate pigeonpea (ICPL 11255) at different growth stages

Treatments	Number of flowers per plant				Number of pods per plant				100 seed weight (g)				Fertility co-efficient (%)			
	M ₁	M ₂	M ₃	Mean	M ₁	M ₂	M ₃	Mean	M ₁	M ₂	M ₃	Mean	M ₁	M ₂	M ₃	Mean
T ₁ : Control	38.16	41.13	42.21	40.50	38.16	41.13	42.21	40.50	38.16	41.13	42.21	40.50	38.16	41.13	42.21	40.50
T ₂ : Salicylic acid (100 ppm)	44.79	45.68	49.39	46.62	44.79	45.68	49.39	46.62	44.79	45.68	49.39	46.62	44.79	45.68	49.39	46.62
T ₃ : Brassinosteroid (0.1 ppm)	42.62	43.26	44.96	43.61	42.62	43.26	44.96	43.61	42.62	43.26	44.96	43.61	42.62	43.26	44.96	43.61

T ₄ : NAA (40 ppm)	44.26	46.32	47.12	45.90	44.26	46.32	47.12	45.90	44.26	46.32	47.12	45.90	44.26	46.32	47.12	45.90
T ₅ : ZnSO ₄ (0.5 %) + H ₃ BO ₃ (0.3%)	41.91	42.43	42.47	42.27	41.91	42.43	42.47	42.27	41.91	42.43	42.47	42.27	41.91	42.43	42.47	42.27
T ₆ : MAP (2%)	39.41	43.95	44.45	42.60	39.41	43.95	44.45	42.60	39.41	43.95	44.45	42.60	39.41	43.95	44.45	42.60
T ₇ : TNAU Pulse Wonder (1%)	47.97	47.80	48.93	48.23	47.97	47.80	48.93	48.23	47.97	47.80	48.93	48.23	47.97	47.80	48.93	48.23
T ₈ : Nutrient consortia - 1	50.19	51.88	52.30	51.46	50.19	51.88	52.30	51.46	50.19	51.88	52.30	51.46	50.19	51.88	52.30	51.46
T ₉ : Nutrient consortia - 2	48.38	49.05	49.62	49.02	48.38	49.05	49.62	49.02	48.38	49.05	49.62	49.02	48.38	49.05	49.62	49.02
Mean	44.19	45.72	46.83	45.58	44.19	45.72	46.83	45.58	44.19	45.72	46.83	45.58	44.19	45.72	46.83	45.58
Factors	M	T	M x T	M	T	M x T	M	T	M x T	M	T	M x T	M	T	M x T	M
SEd	0.32	0.56	0.97	0.10	0.17	0.29	0.07	0.12	0.21	0.32	0.55	0.96				
CD (P:0.05)	0.65	1.13	1.95	0.20	0.34	0.59	0.14	0.25	0.43	0.64	1.11	NS				

Conclusion

The plant performance is attributed to the genetic factors which are controlled by the differences in the biochemical reactions undergoing in plants that ultimately decide the plant growth and development and the final yield. It is concluded from the present study that, application of combined formulation of hormones and nutrients present in the nutrient consortia at flowering and pod formation stage have influenced the photosynthetic efficiency and resulted in higher yield.

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