Journal of Applied and Natural Science
Special Issue: 14 (SI), 65 - 72 (July, 2022)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Influence of nutrients and plant growth regulators on growth parameters and yield of Pigeonpea (*Cajanus cajan (L.) Millsp.)*

G. Karuppusamy*
Department of Crop Physiology, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641003 (Tamil Nadu), India.
P. Jeyakumar
Department of Crop Physiology, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641003 (Tamil Nadu), India.
C.N. Chandrasekhar
Department of Crop Physiology, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641003 (Tamil Nadu), India
P. Jayamani
Department of Pulses, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641003 (Tamil Nadu), India
N.O. Gopal
Department of Agricultural Microbiology, Agriculture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore-641003 (Tamil Nadu), India

*Corresponding author Email: karuppusamy627@gmail.com

Article Info
https://doi.org/10.31018/jans.v14iSI.3570
Received: March 10, 2022
Revised: April 19, 2022
Accepted: May 20, 2022

How to Cite
Karuppusamy, G. *et al.* (2022). Influence of nutrients and plant growth regulators on growth parameters and yield of Pigeonpea (*Cajanus cajan (L.) Millsp.*). *Journal of Applied and Natural Science*, 14 (SI), 65 - 72. https://doi.org/10.31018/jans.v14iSI.3570

Abstract
Pigeonpea is the second most important pulse crop after chickpea in India. The yield of pigeonpea is very low due to indeterminate growth habit and poor source-sink relationship. Plant growth regulators are known to influence the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance productivity of the crops. With this background, a field experiment was conducted with pigeonpea (CO Rg 7) under irrigated condition in Tamil Nadu Agricultural University, Coimbatore. An experiment was aimed at determining the effect of various nutrients and growth-promoting hormones on the growth parameters and yield of pigeonpea (C*ajanus cajan (L.) Millsp.)*. The Factorial Randomised Block Design was used in the field trial and was replicated three times. At the vegetative stage, the treatments included foliar sprays of growth inhibitors such as M_2-Mepiquat chloride (MC) @ 500 pp, M_3-Chlormequat chloride (CC) @ 500 ppm and M_1- Control. At flower initiation and 15 days later, various plant growth regulators, such as T_2-SA (100 ppm), T_3-BR (0.1 ppm), T_4-Napthyl acetic acid (40 ppm), T_5-Nutrients ($ZnSO_4$ @ 0.5 percent + H_3BO_3 @ 0.3 percent, T_6-Mono Ammonium Phosphate @ 2 percent, and T_7-TNAU Pulse Wonder @ 1 percent), T_8-Nutrient consortia I (1%) and T_9-Nutrient consortia II (1%), were used. Among the treatments, the combination of Chlormequat chloride and nutrient consortia treatments (M_3T_8&M_3T_9) had better performances in growth parameters and yield of pigeonpea (CO Rg 7). Foliar application of M_3T_8-Chlormequat chloride and Nutrient consortia I (1%) resulted significantly ($P<0.05$) in the highest Total dry matter production (64.85; 82.96 g plant^{-1}), Leaf area (1629; 1873 cm^{-2} plant^{-1}), Leaf area index (1.358; 1.561), Specific leaf weight (7.29; 10.34 mg cm^{-2}) and Seed yield (1133 kg ha^{-1}) when compared to other treatments. The present study that the application of a combined formulation of hormones and nutrients present in the nutrient consortia at the flowering and pod formation stages influenced the growth parameters and resulted in higher seed yield.

Keywords: Crop growth rate, Foliar application, Leaf area index, Seed yield

INTRODUCTION

Pigeonpea is one of most major grain legume crops in the world. Pigeon pea seems to be another high-protein food that can be eaten as a dhal or as a green vegetable. Pigeon pea dry grains contain 20-22% protein. Green pigeon pea seeds have ten times the fat, five times the vitamin A, and three times the vitamin C of regular peas, in addition to a variety of minerals (Saxena *et al.,* 2008). The crop's extensive root structure helps recycle nutrients to plants from various layers, and the acid released by its roots boosts phosphorus absorption in the soil. Its root system also aids in the sustainability of agriculture in rainfed and semiarid farming areas by enhancing the physical composition of the soil by enhancing water infiltration for succeeding crops (Lambers H *et al.,* 2006)

In pigeon pea, the vegetative and reproductive stages occur concurrently; as a result, the vegetative and reproductive sinks are always competing for available assimilates. On the other hand, there is a source limitation (leaves), particularly during the flowering and pod development stages. PGRs have thus been characterized as the agriculturist's most effective component for increasing crop yields. Plant hormones are compounds that, when given in minute quantities stimulate or restrict natural plant development (Kumar, 2001). It improves photoassimilation and the source–sink relationship and thus increases the photosynthetic capacity of the plant, which is helpful in increasing productivity and thus leads to higher crop yield (Amanullah *et al.,* 2010). The foliar application of nutrients at critical stages of crop growth is the most appropriate and accurate method of correcting nutrient deficiencies and helps to achieve maximum potential yield of the crop, and ultimately sufficient plant nutrition is absolutely essential for improving productivity. (Thakur *et al.,* 2017). Keeping the above background, the present investigation was taken up on growth parameters and yield of pigeon pea as influenced by nutrients and plant growth regulators.

MATERIALS AND METHODS

A study was conducted at Tamil Nadu Agricultural University, Coimbatore, with a variety of pigeon pea CO Rg 7 under surface irrigated conditions in the Eastern Block. The FRBD design was used in the field trial and was replicated three times. At the vegetative stage, the treatments included foliar sprays of growth inhibitors such as M_2-Mepiquat chloride (MC) @ 500 ppm,M_3-Chlormequat chloride (CC) @ 500 ppm and M_1 - Control. At flower initiation and 15 days later, various plant growth regulators, such as T_2-SA (100 ppm), T_3-BR (0.1 ppm), T_4-Napthyl acetic acid (40 ppm), T_5-Nutrients ($ZnSO_4$ @ 0.5 percent + H_3BO_3 @ 0.3 percent, T_6-Mono Ammonium Phosphate @ 2 percent, and T_7-TNAU Pulse Wonder @ 1 percent), T_8-Nutrient consortia I (1%) and T_9-Nutrient consortia II (1%), were used. Observation of morphological characteristics, such as the dry weight of whole plants and the seed weight, was performed, and the values were expressed as g $plant^{-1}$. Plant samples were first shade dried before being oven dried for 24 hours at 80 degrees Celsius. Leaf area was measured for the entire sampling unit using a leaf area meter (Licor Model 3100) and expressed as cm^2 $plant^{-1}$. Leaf area index (Williams, 1946). Specific leaf weight (Pearce *et al.*, 1968) is expressed in mg cm^{-2}. The crop growth rate (Watson, 1956) is expressed in g m^{-2} day^{-1}. At harvest stage, seed yield were recorded and statistically analysed.

RESULTS AND DISCUSSION

Total dry matter production

Photosynthesis is the foundation of dry matter production in plants. Dry matter production (DMP) is considered a marker for the increased photosynthetic efficiency of plants, which has a direct relationship between photosynthesis and yield (Sultana *et al.,* 2001). In this investigation, a linear increase in total dry matter accumulation was observed from flowering to pod filling stages. Foliar spray of CC (500 ppm) and nutrient consortia I (1%) (M_3T_8) recorded significantly ($P<0.05$) higher TDMP (64.85, 82.96) compared to other treatments at both stages (Table. 1). This finding was supported by Chandrasekhar and Bangarusamy (2003), who stated that foliar spray of macronutrients and PGRs during the flowering stage significantly ($P<0.05$) increased TDMP in greengram. The significant role of Mepiquat chloride and Chlormequat chloride in improving biomass production was also demonstrated by Kashid (2010) in sunflower. The results of our investigation are similar with the findings Vijaysingh (2017) in black gram, Mannan (2014) in soybean, Upaydhyay and Rajeev (2015) in soybean and Nabi *et al.,* (2016) in cowpea. Similarly, Surendar *et al.* (2013) reported that a combined effect of nitrogen and PGRs resulted in higher TDMP in blackgram.

Leaf area

Leaf area is a vital factor that is closely connected to the physiological process controlling dry matter production and yield. The LA improved dramatically from the flowering to pod filling stage in the current study. The results of the present investigation indicated that Chlormequat chloride (500 ppm) and Nutrient consortia I (1%) (M_3T_8) exhibited maximum leaf enlargement (1629, 1873) over the control at the flowering and pod filling stages, respectively (Table. 2). The exceeding findings corroborated those obtained by Thakur *et al.* (2017) in black gram, who reported that foliar spray of pulse magic (a combination of nutrients and PGRs) maintained more leaf area at various stages of crop growth. The application of salicylic acid resulted in a higher leaf area, as recorded by Sivakumar (2002) in pearl millet. Avinash *et al.* (2020) reported that the combination of nutrients and growth regulators was found to be increased higher leaf area as compared to control. Similar results were obtained by Sutar V. K. (2019) in pigeonpea and Korade *et al.,* (2019) in wheat.

Table 1. Impact of nutrients and PGRs on TDMP (g plant^{-1}) in pigeonpea (C*ajanus cajan (L.) Millsp.)* (CO Rg 7) at different crop growth stages

Treatments	Flowering stage (75 DAS)				Pod filling stage (95 DAS)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
T_l : Control	49.40	49.85	51.08	50.11	60.71	61.56	63.67	61.98
T_2 : Salicylic acid (100 ppm)	49.72	51.44	55.28	52.15	62.64	65.05	70.59	66.09
T_3 : Brassinosteroid (0.1 ppm)	51.57	59.07	59.97	56.87	65.41	72.69	74.78	70.96
T_4 : NAA (40 ppm)	54.81	59.54	60.78	58.38	69.11	74.53	76.13	73.26
T_5 : $ZnSO_4$ (0.5 %) + H_3BO_3 (0.3%)	53.04	57.88	60.00	56.97	65.11	71.88	74.98	70.66
T_6 : MAP (2%)	53.59	55.39	58.25	55.74	67.96	72.23	74.18	71.46
T_7 : TNAU Pulse Wonder (1%)	58.20	59.17	61.98	59.78	72.48	76.40	78.26	75.71
T_8 : Nutrient consortia I (1%)	60.40	63.27	64.85	62.84	76.63	80.50	82.96	80.03
T_9 : Nutrient consortia II (1%)	59.30	61.56	60.92	60.59	74.12	77.55	80.01	77.23
Mean	54.45	57.46	59.23	57.05	68.24	72.49	75.06	71.93
Factors	M	T	M x T		M	T	M x T	
SEd	0.36	0.63	1.09		0.56	0.97	1.69	
CD (P:0.05)	0.73	1.26	2.19		1.13	1.95	NS	

* M1 – Control, M2 - Mepiquat chloride @ 500 ppm and M3 - Chlormequat chloride @ 500 ppm at Vegetative stage
* TI to T9 (2 sprays: at flower initiation & 15 days thereafter)

Table 2. Impact of nutrients and PGRs on leaf area (cm^{-2} plant^{-1}) in pigeonpea (C*ajanus cajan (L.) Millsp.)* (CO Rg 7) at different crop growth stages

Treatments	Flowering stage (75 DAS)				Pod filling stage (95 DAS)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
T_l : Control	1109	1347	1359	1272	1252	1432	1487	1390
T_2 : Salicylic acid (100 ppm)	1299	1385	1475	1386	1732	1734	1766	1744
T_3 : Brassinosteroid (0.1 ppm)	1338	1476	1526	1447	1752	1755	1779	1762
T_4 : NAA (40 ppm)	1200	1379	1479	1353	1622	1726	1744	1697
T_5 : $ZnSO_4$ (0.5 %) + H_3BO_3 (0.3%)	1141	1354	1374	1290	1391	1541	1605	1512
T_6 : MAP (2%)	1197	1407	1415	1340	1703	1705	1716	1708
T_7 : TNAU Pulse Wonder (1%)	1349	1391	1392	1377	1772	1780	1794	1782
T_8 : Nutrient consortia I (1%)	1389	1585	1629	1534	1812	1855	1873	1847
T_9 : Nutrient consortia II (1%)	1378	1495	1575	1483	1788	1826	1835	1816
Mean	1267	1424	1469	1387	1647	1706	1733	1695
Factors	M	T	M x T		M	T	M x T	
SEd	9.80	16.98	29.41		12.99	22.49	38.96	
CD (P:0.05)	19.67	34.07	59.01		26.06	45.13	78.17	

* M_1 – Control, M_2 - Mepiquat chloride @ 500 ppm and M_3 - Chlormequat chloride @ 500 ppm at Vegetative stage
* T_l to T_9 (2 sprays: at flower initiation & 15 days thereafter)

Leaf area index (LAI)

The leaf area index is a significant trait that indicates TDMP and good corroboration of leaf area over unit ground area with the photosynthetic surface. LAI improved from the flowering to pod filling stage in response to PGR and nutrient application. A significant ($P<0.05$) increase in LAI was observed in nutrient consortia I (1%) (T_8) treated plants. This finding is very similar to the results of Nithila (2007) in groundnut. The significant role of the combination of PGRs and nutrients in improving the LAI was also revealed in the current study. When compared to M_1, the data revealed that LAI was higher in M_3 followed by M_2. Among the treatments (T_1-T_9), T_8 recorded the highest leaf area index, followed by T_9- Nutrient consortia-2 and T_7-TNAU Pulse wonder (1%). With respect to the interactions between the treatments, M_3T_8 showed significantly ($P<0.05$) the maximum leaf area index (1.358, 1.561) at the flowering and pod filling stages (Table 3). The favourable effect of combination of PGR and nutrients in improving LAI was reported by Avinash *et al.,* (2020). Similarly, these results are quite in line with the

Table 3. Impact of nutrients and PGRs on LAI in pigeonpea (C*ajanus cajan (L.) Millsp.)* (CO Rg 7) at different crop growth stages

Treatments	Flowering stage (75 DAS)				Pod filling stage (95 DAS)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
T_I : Control	0.924	1.122	1.133	1.060	1.043	1.193	1.239	1.158
T_2 : Salicylic acid (100 ppm)	1.083	1.154	1.229	1.155	1.443	1.445	1.472	1.453
T_3 : Brassinosteroid (0.1 ppm)	1.115	1.230	1.271	1.205	1.460	1.463	1.483	1.469
T_4 : NAA (40 ppm)	1.000	1.149	1.233	1.127	1.352	1.438	1.453	1.414
T_5 : $ZnSO_4$ (0.5 %) + H_3BO_3 (0.3%)	0.950	1.128	1.145	1.074	1.159	1.284	1.338	1.260
T_6 : MAP (2%)	0.998	1.173	1.179	1.117	1.419	1.421	1.430	1.423
T_7 : TNAU Pulse Wonder (1%)	1.124	1.159	1.160	1.148	1.477	1.483	1.495	1.485
T_8 : Nutrient consortia I (1%)	1.157	1.321	1.358	1.279	1.510	1.546	1.561	1.539
T_9 : Nutrient consortia II (1%)	1.149	1.246	1.313	1.236	1.490	1.522	1.529	1.514
Mean	1.056	1.187	1.225	1.156	1.373	1.422	1.444	1.413

Factors	M	T	M x T	M	T	M x T
SEd	0.007	0.013	0.022	0.010	0.017	0.030
CD (P:0.05)	0.015	0.026	0.044	0.020	0.034	0.060

* M_1 – Control, M_2 - Mepiquat chloride @ 500 ppm and M_3 - Chlormequat chloride @ 500 ppm at Vegetative stage
* T_I to T_9 (2 sprays: at flower initiation & 15 days thereafter)

Table 4. Impact of nutrients and PGRs on SLW (mg cm^{-2}) in pigeonpea (C*ajanus cajan (L.) Millsp.)* (CO Rg 7) at different crop growth stages

Treatments	Flowering stage (75 DAS)				Pod filling stage (95 DAS)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
T_I : Control	5.15	5.35	5.47	5.32	6.99	7.58	7.81	7.46
T_2 : Salicylic acid (100 ppm)	5.97	6.21	6.48	6.22	7.59	7.74	7.90	7.74
T_3 : Brassinosteroid (0.1 ppm)	6.14	6.29	6.47	6.30	8.69	8.82	8.95	8.82
T_4 : NAA (40 ppm)	5.55	6.30	6.72	6.19	8.55	8.65	8.79	8.66
T_5 : $ZnSO_4$ (0.5 %) + H_3BO_3 (0.3%)	5.29	5.99	6.30	5.86	7.20	7.62	8.09	7.64
T_6 : MAP (2%)	5.53	5.42	5.68	5.54	7.62	8.45	8.70	8.26
T_7 : TNAU Pulse Wonder (1%)	6.19	6.46	6.96	6.54	8.78	9.10	9.38	9.09
T_8 : Nutrient consortia I (1%)	6.36	7.00	7.29	6.88	8.97	10.10	10.34	9.80
T_9 : Nutrient consortia II (1%)	6.32	6.67	6.96	6.65	8.86	9.40	9.53	9.26
Mean	5.83	6.19	6.48	6.17	8.14	8.61	8.83	8.53

Factors	M	T	M x T	M	T	M x T
SEd	0.04	0.07	0.13	0.06	0.10	0.17
CD (P:0.05)	0.09	0.15	0.26	0.12	0.20	0.35

* M_1 – Control, M_2 - Mepiquat chloride @ 500 ppm and M_3 - Chlormequat chloride @ 500 ppm at Vegetative stage
* T_I to T_9 (2 sprays: at flower initiation & 15 days thereafter)

Table 5. Impact of nutrients and PGRs on CGR (g cm^{-2} day^{-1}) in pigeonpea (*Cajanus cajan (L.) Millsp.)* (CO Rg 7) at different crop growth stages

Treatments	Flowering stage (75 DAS)			
	M_1	M_2	M_3	Mean
T_1 : Control	4.71	4.88	5.25	4.95
T_2 : Salicylic acid (100 ppm)	5.38	5.67	6.38	5.81
T_3 : Brassinosteroid (0.1 ppm)	5.77	5.68	6.17	5.87
T_4 : NAA (40 ppm)	5.96	6.25	6.40	6.20
T_5 : $ZnSO_4$ (0.5 %) + H_3BO_3 (0.3%)	5.03	5.83	6.24	5.70
T_6 : MAP (2%)	5.99	7.02	6.64	6.55
T_7 : TNAU Pulse Wonder (1%)	5.95	7.18	6.78	6.64
T_8 : Nutrient consortia I (1%)	6.76	7.18	7.55	7.16
T_9 : Nutrient consortia II (1%)	6.18	6.66	7.95	6.93
Mean	5.75	6.26	6.60	6.20
Factors	M	T	M x T	
SEd	0.04	0.08	0.13	
CD (P:0.05)	0.09	0.15	0.27	

* M_1 – Control, M_2 - Mepiquat chloride @ 500 ppm and M_3 - Chlormequat chloride @ 500 ppm at Vegetative stage
* T_1 to T_9 (2 sprays: at flower initiation & 15 days thereafter)

findings of Veerabhadrappa and Yeledhalli (2004) in groundnut, Gupta *et al*. (2010) in green gram and Surendar *et al*. (2013) in black gram. The combination of nutrients and pant growth regulators might as arrest the chlorophyll degradation resulting in more assimilatory surface area for longer period. Potassium foliar spray at the flowering stage increased the LAI of cotton genotypes (Hussain *et al.,* 2020).

Specific leaf weight

The current study found that the specific leaf weight (SLW) of pigeonpea genotypes increased significantly (P<0.05) from the flowering to pod filling stage of the crop. The combined application of CC @ 500 ppm & nutrient consortia I (1%) (M_3T_8) increased SLW over the control. M_3T_8 showed significantly (P<0.05) the highest specific leaf weight (7.29, 10.34 mg cm^{-2}) compared to the control at both stages (Table 4). The above findings were supported by Sivakumar *et al.,* 2018, who found that the application of plant growth regulators and nutrients was increased the specific leaf weight in black gram. This is might be due to enhancement of photosynthesis through increases the activity of rubisco leads to increased photo assimilates. This result was supported by Gograj Jat *et al*. (2012). In a similar study, an increased SLW from the vegetative to pod filling stage with the application of growth-promoting hormones and nutrients was reported by Surendar *et al*. (2013) in black gram.

Crop Growth Rate (CGR)

The increase in assimilates per unit ground area and unit time on a unit of land over time in plants is defined as CGR. In the present study, the highest crop growth rate (CGR) was observed in foliar spray of CC @ 500 ppm & Nutrient consortia I @ 1% (M_3T_8) treated plants over control (Table 5) The above results are confirmed by Hanchinamath (2005) found that applying Lihocin (1000 ppm) and MC (1000 ppm) to cluster bean increased CGR values at growth stages. Plant growth hormones and nutrients play a significant role in the improvement of CGR, which was observed in our study. This enhancement in CGR values is mainly due to faster translocation of assimilates and utilization of carbohydrates by the sink in an efficient way. Similar results were reported in black gram due to the application of a mixture of nutrients and PGRs (Shashikumar *et al.,* 2013; Sritharan *et al.,* 2015). Higher accumulation of dry matter due to increased photosynthetic activities along with enhanced cell multiplication might reflect the rapid increase in CGR reported under the influence of nutrients and growth regulators compared to control. These findings have been consistent with the findings of Vijaysingh (2017) in black gram and Gagandeep *et al.* (2015) in pigeon pea.

Seed yield (kg ha^{-1})

The treatments showed a significant influence on the seed yield of pigeon pea. The increased seed yield

Table 6. Impact of nutrients and PGRs on seed yield (kg ha^{-1}) in pigeonpea (*Cajanus cajan (L.) Millsp.)* (CO Rg 7) at different growth stages

Treatments	Flowering stage (75 DAS)			
	M_1	**M_2**	**M_3**	**Mean**
T_1 : Control	798	891	904	864
T_2 : Salicylic acid (100 ppm)	850	946	964	920
T_3 : Brassinosteroid (0.1 ppm)	896	984	994	958
T_4 : NAA (40 ppm)	921	1008	1026	985
T_5 : $ZnSO_4$ (0.5 %) + H_3BO_3 (0.3%)	842	925	987	918
T_6 : MAP (2%)	902	999	1050	984
T_7 : TNAU Pulse Wonder (1%)	936	1038	1033	1002
T_8 : Nutrient consortia I (1%)	992	1124	1133	1083
T_9 : Nutrient consortia II (1%)	954	1044	1048	1015
Mean	899	995	1015	970

Factors	M	T	M x T
SEd	7.4	12.8	22.2
CD (P:0.05)	14.8	25.7	44.5

* M_1 – Control, M_2 - Mepiquat chloride @ 500 ppm and M_3 - Chlormequat chloride @ 500 ppm at Vegetative stage
* T_1 to T_9 (2 sprays: at flower initiation & 15 days thereafter)

caused by growth regulators showed that plants treated with plant hormones continued to remain physiologically more active to accumulate adequate food reserves for developing flowers and seeds. Thus, the plants showed improved flower production with high fruit set and better seed development. The current study found that the treatment combination of CC (500 ppm) and nutrient consortia I (1%) (M_3T_8) was significantly ($P<0.05$) more effective in improving seed yield (1133 kg ha-1) than the control (Table 6). The findings of the current study corroborate those of Thakur *et al*. (2017) black gram. CCC at 1000 ppm significantly ($P<0.05$) increased yield attributes in mung bean, according to Shah and Prathapasenan (2008). A combination of NAA @ 30 ppm at 30 and 45 DAS and Mepiquat Chloride @ 120 ppm at 60 DAS improved black gram yield (Prakash *et al.,* 2003). The application of macronutrients with chelated micronutrients enhanced black gram seed yield, according to Manivannan et al. (2002). When compared to the control, a combined spray of 0.5% ferrous sulfate and 0.5% zinc sulfate at 45 DAS resulted in a significantly ($P<0.05$) increased yield by 43.1% (Anitha et al., 2005). Similarly, these findings are similar to the findings of Vijaysingh Thakur (2017) in black gram and Teggelli *et al*. (2016) in pigeon pea. Further, the results are in agreement with those of Lateef *et al.* (2012) in mungbean, Kuttimani and Velayutham (2011) in green gram and by Shashikumar *et al.* (2013) in black gram, Jadhav *et al*., (2017) and Giri *et al.,* (2018) in pigeonpea

Conclusion

The combined effect of Chlormequat chloride (500 ppm) and Nutrient consortia I (1%) (M_3T_8) treatment showed significant ($P<0.05$) increase in leaf area (cm^{-2} $plant^{-1}$), total dry matter accumulation (g $plant^{-1}$), leaf area index, specific leaf weight (mg cm^{-2}), crop growth rate (g cm^{-2} day^{-1}) and seed yield (kg ha^{-1}) compared to control. It is concluded from the present study that the application of a combined formulation of hormones and nutrients present in the nutrient consortia at the flowering and pod formation stages influenced the growth parameters and resulted in higher seed yield.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Amanullah, M. M., Sekar, S. & Vincent, S. (2010). Plant growth substances in crop production: a review. *Asian Journal of Plant Sciences,* 9(4), 215-222.
2. Anitha, S., Sreenivasan, E. & Purushothaman, S. M. (2005). Response of cowpea (*Vigna unguiculata* (L.) Walp.) to foliar nutrition of zinc and iron in the oxisols of Kerala. *Legume Research-An International Journal*, 28(4), 294-296.
3. Avinash, J. R., Patil, R. P. & Rathod, S. P. (2020). Influence of foliar application of pulse magic, PGRs & nutrients on growth parameters and yield of Pigeon Pea. *Journal of Pharmacognosy and Phytochemistry*, *9*(5), 3304-3307.

4. Chandrasekhar, C. N. & Bangarusamy, U. (2003). Maximizing the yield of mung bean by foliar application of growth regulating chemicals and nutrients. *Madras Agricultural Journal,* 90(1/3), 142-145.
5. Gagandeep, K., Navita, G., Jagmeet, K. & Sarvjeet, S. (2015). Growth efficiency and yield of pigeonpea (*Cajanus cajan* L.) as affected by foliar application of mineral nutrients. *J. Pl. Sci. Res*, 2(2), 1-9.
6. Giri, M. D., Jaybhaye, C. P., Kanwade, D. G. and Bharti Tijare. (2018).Effect of foliar application of gibbrellic acid on pigeonpea [*Cajanus cajan* (L.)] under rainfed conditions. *Journal of Pharmacognosy and Phytochemistry.* 7 (2), 617-620
7. Gograj Jat, D.L., Bagdi, B.L., Kakralya and Shekhawat, P.S. (2012). Mitigation of salinity induced effects using brassinolide in cluster bean (*Cyamopsis tetragonoloba* L.). Crop Res., 44: 4550.
8. Gupta, S., Sengupta, K. & Banarjee, H. (2010). Effect of foliar application of nutrients and brassinolide on summer greengram (*Vigna radiata*). *Int. J Tropical Agri.*, 28, 1-2.
9. Hanchinamath, P.V. (2005). "Effect of plant growth regulators, organics and nutrients on growth physiology and yield in clusterbean (*Cyamopsis tetragonoloba* L. Taub)." M. Sc. (Agri.), UAS, Dharwad.
10. Hussain, Mubshar, Ahmad Faizan Tariq, Ahmad Nawaz, Muhammad Nawaz, Abdul Sattar, Sami Ul-Allah, and Abdul Wakeel. (2020). Efficacy of fertilizing method for different potash sources in cotton (*Gossypium hirsutum* L.) nutrition under arid climatic conditions. *PloS one* 15 (1), e0228335.
11. Jadhav, G. N., Deotale, R. D., Gavhane, D. B., Chute, K. H. (2017). Implant of foliar sprays of polyamine (Putrescine) and NAA on chemical and biochemical parameters and yield of pigeonpea. *Bull. Env.Pharmacol. Life Sci*.,6 (3): 407-412
12. Kashid, D. A. (2010). Effect of growth retardants on growth, physiology and yield in sunflower (*Helianthus annuus* L.)." UAS, Dharwad.
13. KoradeS, B., Deotale, R. D., Jadhav, N. D., Guddhe, V. A. & Thakre, O. G. (2019). Effect of cow urine and NAA on morpho-physiological parameters and yield of wheat. *J. Soils and Crops,* 29 (2), 274-279
14. Kumar, K. A. (2001). Effect of plant growth regulators on morpho-physiological traits and yield attributes in hybrid cotton *(Gossypium hirsutum L.)* (Doctoral dissertation, University of Agricultural Sciences).
15. Kuttimani, R. & Velayutham, A. (2011). Foliar application of nutrients and growth regulators on yield and economics of green gram. *Madras Agric. J,* 98,141-143.
16. Lambers, H., Shane, M. W., Cramer, M. D., Pearse, S. J. & Veneklaas, E. J. (2006). Root structure and functioning for efficient acquisition of phosphorus: matching morphological and physiological traits. *Annals of Botany*, 98(4), 693-713. DOI: https://doi.org/10.1093/aob/mcl114.
17. Lateef, E. M., Tawfik, M. M., Hozyin, M., Bakr, B.A., Elewa, T. A. & Farrag, A. A. (2012). Soil and foliar fertilization of mungbean (*Vigna radiate* (L) wilczek) under Egyptian conditions. *Elixir Int. J*, 47, 8622-8628
18. Manivannan, V., Thanunathan, k., Imayavaramban, V. & Ramanathan, N., (2002). Effect of foliar application of NPK and chelated micronutrients on rice-fallow urdbean. *Legume Res.,* 25(4), 270-272.
19. Mannan, M. A. (2014). Foliar and soil fertilization effect on seed yield and protein content of soybean. *Bangladesh Agronomy Journal*, *17*(1), 67-72.
20. Nabi A, Hawlader M. H. K., Hasan, M. M., Haque, M. Z. & Rahaman, M. L. (2016). Growth and yield difference due to application of various levels of gibberellic acid in local and BARI falon-1. *Progressive Agriculture*, 27 (2): 94-100
21. Nithila, S. (2007). Physiological evaluation of groundnut (*Arachis hypogaea* L) Varieties for salt tolerance and amelioration for salt stress, *Research Journal of Agriculture and Forestry Sciences,* 1 (11), 1-8
22. Pearce, R. B., Brown, R. H. & Blaser, R. E. (1968). Photosynthesis of Alfalfa Leaves as Influenced by Age and Environment 1. *Crop Science*, *8*(6), 677-680.
23. Prakash, M., Kumar, J. S., Kannan, K., Kumar, M. S., & Ganesan, J. (2003). Effect of plant growth regulators on growth, physiology and yield of blackgram. *Legume Research-An International Journal*, 26(3), 183-187.
24. Sachin, A. S., Sivakumar, T., KrishnaSurendar, K. & Senthivelu, M. (2019). Influence of plant growth regulators and nutrients on biometric, growth and yield attributes in Blackgram (*Vigna mungo* L.). *Journal of Agriculture and Ecology*, *7*, 55-63.
25. Saxena, K.B. (2008). Genetic improvement of pigeon pea—a review. *Tropical Plant Biology,* 1(2),159-178.
26. Shah, T, and Prathapasenan, G. (2008). Effect of CCC on the Growth and Yield of Mung Bean (*Vigna radiata* [L.] Wilczek var. Guj2). *Journal of Agronomy and Crop Science* 166 (1), 40-47.
27. Shashikumar, R., Basavarajappa ,S. R., Salakinkop Hebbar, M., Basavarajappa, M. P., Patil, H.Y. (2013). Influence of foliar nutrition on performance of black gram (*Vigna mungo* L.) nutrient uptake and economics under dry land ecosystems, *Legume Res,* 36(5),422-428.
28. Sivakumar, R., Pathmanaban, G., Kalarani, M. K. Vanangamudi, M., & Srinivasan, P. S. (2002). Effect of foliar application of growth regulators on biochemical attributes and grain yield in pearl millet. *Indian Journal of Plant Physiology*, 7(1), 79-82.
29. Sritharan, N., Rajavel, M. & Senthilkumar, R. (2015). Physiological approaches: Yield improvement in blackgram. *Legume Research-An International Journal*, 38(1), 91-95.
30. Sultana, N., Ikeda, T. & Kashem, M. A. (2001). Effect of foliar spray of nutrient solutions on photosynthesis, dry matter accumulation and yield in seawater-stressed rice. *Environmental and Experimental Botany*, 46(2), 129-140.
31. Surendar, K. K., Vincent, S., Wanagamundi, M. & Vijayaraghavan, H. (2013). Physiological effects of nitrogen and growth regulators on crop growth attributes and yield of black gram (*Vigna mungo* L.). *Bull. Env. Pharmacol. Life Sci*, *2*(4), 70-76.
32. Surendar, K. K., Vincent, S., Wanagamundi, M. & Vijayaraghavan, H. (2013). Physiological effects of nitrogen and growth regulators on crop growth attributes and yield of black gram (*Vigna mungo* L.). *Bull. Env. Pharmacol. Life Sci*, *2*(4), 70-76.
33. Sutar, V. K., Narkhede, W. N., Nayak, S. K. & Jadhav, K. T. (2020). Effect of land configuration, growth regulators and integrated nutrient management on yield and eco-

nomics of pigeonpea. *J. of Crop and Weed,* 16(2), 227-232.

34. Teggell, R. G., Salagunda, S., Ahamed, B. Z. (2016). Influence of pulse magic application on yield and economics of transplanted pigeon pea. *Int. J Sci. Nat.,* 7(3), 598- 600.
35. Thakur, V., Patil, R. P., Patil, J. R., Suma, T. C. & Umesh, M. R. (2017). Influence of foliar nutrition on growth and yield of blackgram under rainfed condition. *Journal of Pharmacognosy and Phytochemistry*, 6(6), 33-37.
36. Thakur, V., Patil, R. P., Patil, J. R., Suma, T. C. & Umesh, M. R. (2017). Influence of foliar nutrition on growth and yield of blackgram under rainfed condition. *Journal of Pharmacognosy and Phytochemistry*, *6*(6), 33-37.
37. Upadhyay, R. G. & Rajeev, R. (2015). Effect of growth hormones on morphological parameters, yield and quality of soybean (*Glycine max* L.) during changing scenario of climate under mid hill conditions of Uttarakhand. *International Journal of Tropical Agriculture*, *33*(2 (Part IV)), 1899-1904.
38. Upadhyay, R. G. & Rajeev, R. (2015). Effect of growth hormones on morphological parameters, yield and quality of soybean (*Glycine max* L.) during changing scenario of climate under mid hill conditions of Uttarakhand. *International Journal of Tropical Agriculture*, 33(2) (Part IV)), 1899-1904.
39. Veerabhadrappa, B. H and Yeledhalli, N. A. (2004). Effect of soil and foliar application of nutrients on growth and yield of groundnut. Karnataka, *J Agric. Sci.* 18(3), 25.
40. Vijaysingh T. (2017). Studies on effect of foliar nutrition on morpho-physiological changes and productivity in rainfed black gram (*Vigna mungo* L.), M.Sc. (Agri) thesis, Univ. Agri. Sci., Raichur.
41. Vijaysingh, T. (2017). Studies on effect of foliar nutrition on morpho-physiological changes and productivity in rainfed black gram (*Vigna mungo* L.), M.Sc. (Agri) thesis, Univ. Agri. Sci., Raichur.
42. Watson, D. J. (1956). Comparative physiological studies on the growth of field crops I. Variation in net assimilation rate and leaf area between species and varieties and within and between years. *Annals of Botany,* 11, 41-46.
43. Williams, S.R.F. (1946). Methods of growth analysis. *Plant photosynthetic production manual and methods, Drow, Jenk, NU Publishers, The Hague*,348-391.