Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 617-620
Received: 24-01-2018
Accepted: 25-02-2018

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Effect of foliar application of gibbrellic acid on pigeonpea [*Cajanus cajan* (L.)] under rainfed conditions

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Abstract

A field experiment was conducted at the Agriculture Research Station (Dr. PDKV), Buldana during 2016, to study the effect of foliar application of gibbrellic acid on pigeonpea [*Cajanus cajan* (L.)] under rainfed conditions. In pigeonpea, 10 treatments comprising gibbrellic acid–management practices (application of 25, 50, 75 ppm GA_3 at flowering, pod development stages and control) were tested. Results indicated that two applications of 75 ppm GA_3 at flowering and pod development stages recorded significantly number of branches /plant, number of pods/ plant, seed index and grain yield than no application of the GA_3. The same treatment recorded higher rain water use efficiency and higher gross returns.

Keywords: pigeonpea, foliar application, GA_3, rain water use efficiency (RUE)

Introduction

Pigeonpea commonly known as red gram, arhar or tur is a very old crop of India. After gram, pigeonpea is the second most important pulse crop in the country. It accounts for about 11.8% of the total pulse area and 17% of total pulse production of the country. It is a rich source of protein and supplies a major share of the protein requirement of the vegetarian population of the country. It is mainly eaten in the form of split pulse as 'dal': Seeds of pigeonpea are also rich in iron, iodine, essential amino acids like lycine, tyrocene, cystine and arginine. The outer covering of its seed together with part of the kernel, provides a valuable feed for milch cattle. The husk of pods and leaves obtained during threshing constitute a valuable cattle feed. Woody parts of the plant are used for fuel. It is a legume crop and, consequently, possesses valuable properties as restorer of nitrogen to the soil (Tiwari and Shivhare, 2016) [7].

The country's total area coverage and production of tur were 38.35 lakh hectares and 29.92 lakh tonnes respectively. The state-wise trend shows that Maharashtra ranked first both in respect of area and production (29.19 % and 29.68 %) followed by Karnataka (19.23 % and 15.96 %). The third place occupied by Madhya Pradesh (13.17% and 13.30 %). The highest yield recorded by Bihar (1739 kg/ha) followed by Haryana (1111 kg/ha) (Tiwari and Shivhare, 2016) [7].

A number of biotic and abiotic factors limit realization of the true potential of pigeonpea. The economic loss in pigeonpea production from abiotic constraints is higher than that from biotic constraints. Frequent droughts are a major abiotic constraint to enhancing productivity and production. Frequent droughts in the low-rainfall, semi-arid areas, and waterlogging in the high-rainfall areas cause considerable loss in pigeonpea production. In the semi-arid tropics, pigeonpea is often grown as an intercrop in the rainy season and its reproductive growth occurs on residual moisture left after the harvest of a companion crop. Lack of moisture during the reproductive phase, especially in regions where farmers grow medium-to-long duration varieties, often leads to a situation of terminal drought, affecting crop yield substantially (Parthasarathy, *et al.*, 2010) [6].

In pigeonpea vegetative and reproductive stage, occurs side by side and hence always there is competition for available assimilates between vegetative and reproductive sinks. 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 pigeonpea's yield are flower and fruit drop (Ojeaga and Ojehomon, 1972) [4]. There is possibility to overcome these constraints by agronomic interventions such as the use of plant growth regulators. Plant hormones are group of structurally unrelated compounds which plays diverse and vital role in plant growth and development. Almost all the developmental stages of plant are controlled by plant hormones.

Plant growth regulators are known to improve physiological efficiency including photosynthetic ability of plant and offer significant role in realizing higher crop yields. The plant growth regulators are also known to enhance the source sink relationship and stimulate the translocation of photo assimilates, thereby increase the productivity.
With this background in view, the present investigation was planned with the following

Objectives

- To assess the effect of GA_3on growth and yield of pigeonpea
- To assess the effect of GA_3 on economics of pigeonpea production

Materials and Methods

The present experiment was conducted at the Agriculture Research Station (Dr. PDKV), Buldana, Maharashtra, India during 2016. The soil of experimental plot was clayey and slightly alkaline (pH 8.0), with available nitrogen (232.5kg/ha), phosphorus (20.6 kg/ha) and potassium (358.3 kg/ha) content. Geographically Buldana is situated between $20^0$32'07.27N $76^0$11'24.43E and its mean height above sea level is 654 m. It receives most of the rainfall from South-West monsoon, commencing from middle of June. The normal monsoon season precipitation approximates to about 720 mm receives in about 40 to 45 rainy days from the middle of June to September. The details of the crop season rainfall during the experimentation period are given in Table 1. For studying the effect of foliar application of gibbrellic acid on pigeonpea [*Cajanus cajan* (L.)] under rainfed conditions, randomized block design was used. The details of the treatments and symbols used are given in Table 2. In all, there were ten treatments replicated three times. The experimental field was laid out in 30 unit plots, each plot measuring 43.20 m^2 (7.2m x 6.0m). There were twelve rows of pigeonpea crop in each plot and thirty plants in each row. One row of crop from both sides of length and also both sides of breadth were left as guard rows. The net plot consisted of ten rows with twenty eight plants per row (6.0m x 5.4m).
Seeds of pigeonpea variety TAT-9629 popularly known as PDKV- Tara were sown @ 15 kg/ ha (83320 plants/ ha) with the spacing of 60cm between rows and 20cm between plants on 8^{th} July 2016. A fertilizer dose of 25 kg N, 50 kg P_2O_5 and 20 kg K_2O/ ha through urea, single super phosphate and muriate of potash was applied at the time of sowing (basal application) to all the plots. Foliar application of gibberellic acid was done as per the treatments. For the foliar application of gibberellic acid a stock solution of 1000ppm was prepared by using 1.1g gibberellic acid technical (90%) along with promix (solvent) dissolved in distilled water and made the volume to 1000ml using volumetric flask and from this stock solution required amount of the gibbrellic acid as per the treatments was utilized for foliar application (Table 2).
Timely recommended plant-protection measures for pigeonpea crop were followed to save the crop from pests and diseases. The pigeonpea crop was harvested manually on 16^{th} January 2017. Different growth and yield components were recorded periodically.
The data on various parameters recorded from experimental plots were statistically analyzed as suggested by Panse and Sukhatme (1995) [5] by using 'F' test at P=0.05.

Results and Discussion

Growth and yield parameters

The effect of foliar application of GA_3 on plant height in pigeonpea was found non- significant (Table 3). However, two applications of 50 and 75 ppm GA_3 at flowering and pod development stages recorded the highest plant height in pigeonpea (158.87 cm), whereas no application of GA_3 (control) recorded the lowest plant height in pigeonpea (147.87 cm).
Foliar application of GA_3 significantly influenced the pigeonpea branches /plant, pods/ plant, seed index and grain yield/ plant (Table 3). Two applications of 75 ppm GA_3 at flowering and at pod development stages (T_{10}) recorded significantly higher number of branches /plant, number of pods/ plant, seed index and grain yield/ plant. Two applications of 75 ppm GA_3 recorded 38.8% more branches, 4.1% heavier grains and 44.7% more grain yield/ plant than that of control plot (T_1). Improvement in growth parameters of pigeonpea crop is due to the foliar application of different concentrations of GA_3 over untreated (control) is possibly due to the beneficial effects of GA_3 on cell elongation and cell division, increase in photosynthetic activity and better food accumulation. The foliar application of GA_3 at flower initiation and pod formation stage might have improved the reproductive development of pigeonpea crop and supported efficient translocation of photosynthates from source to sink. This might have significantly increased the number pods/ plant, grain mass and yield/ plant. Similar results were observed by Uddin (2001) [8] in greengram crop and by Akter *et al*., (2007) [1] in soybean crop.

Grain and straw yield

Application of GA_3 significantly influenced the pigeonpea crop grain yield (Table 4). Two applications of 75 ppm GA_3 at flowering and at pod development stages (T_{10}) recorded significantly higher grain yield (1970.16 kg/ ha) and it was higher by 19% than control treatment (1654.32 kg/ ha). The effect of foliar application of GA_3 on straw yield of the pigeonpea crop was found non- significant (Table 4). However, two applications of 75 ppm GA_3 at flowering and pod development stages recorded the highest straw yield (3981.48 kg/ ha), whereas no application of GA_3 (control) recorded the lowest straw yield (3364.20 kg/ ha). Assimilate translocation to reproductive sinks is vital for seed development. Seed set and filling cab be limited by availability and utilization assimilates (Asch et al., 2005).The grain yield of pigeonpea crop was increased due to cumulative effect of yield attributing characters, enhanced photosynthetic efficiency and improvement in the capacity of the reproductive sinks to utilize the incoming assimilates due to the foliar application of GA_3. Our results are in agreement with the work of Upadhyay and Ranjan (2015) in soybean crop.

Harvest index

The effect of foliar application of GA_3 on harvest index of the pigeonpea crop was found non- significant (Table 4). However, two applications of 50 ppm GA_3 at flowering and pod development stages recorded the highest harvest index (34.35%), whereas single application of 50 ppm GA_3at pod development stage (T_6) recorded the lowest harvest index

(32.27%). The higher harvest index indicated that, GA_3 application accelerated assimilate supply to sink and better utilization of the incoming assimilates by the reproductive sinks, which is in agreement with the results of Akter *et al.* (2007) [1].

Rain water use efficiency (RUE)

Rain water use efficiency (kg/ mm/ ha) was significantly influenced by the application of GA_3 (Table 4). Two applications of 75 ppm GA_3 at flowering and at pod development stages (T_{10}) recorded higher rain water use efficiency (2.86 kg/ mm/ ha). The lowest rain water use efficiency was observed with no application of GA_3 (2.40 kg/ mm/ ha). The best treatment recorded 19% more rain water use efficiency than that of the control treatment. Our results clearly indicate that application of GA_3 resulted in enhancing the effective use of rainfall by the pigeonpea crop.

Economics

Economics of pigeonpea production was significantly influenced by the GA_3 application (Table 5). Two applications of 75 ppm GA_3 at flowering and pod development stages (T_{10}) recorded significantly higher gross returns (Rs. 88660/-), which was higher by Rs. 14220/- than that of no application of the GA_3 (Rs. 74440/-). The effect of application of GA_3 on net monetary returns of the pigeonpea crop was found non- significant. The benefit: cost ratio was higher with the two applications of 25ppm GA_3 at flowering and pod development stages (T_8). Increased grain yield owing to application of GA_3 significantly increased the gross and net monetary returns. The results confirm the findings of Aziz *et al.* (2012) [3].

Table 1: Rainfall details during the experimental period

Standard Meteorological Week	Period		Rainfall received (mm)
23	04.06.2016	10.06.2016	32
24	11.06.2016	17.06.2016	0
25	18.06.2016	24.06.2016	45
26	25.06.2016	01.07.2016	65
27	02.07.2016	08.07.2016	41
28	09.07.2016	15.07.2016	124
29	16.07.2016	22.07.2016	19
30	23.07.2016	29.07.2016	80
31	30.07.2016	05.08.2016	85
32	06.08.2016	12.08.2016	5
33	13.08.2016	19.08.2016	3
34	20.08.2016	26.08.2016	18
35	27.08.2016	02.09.2016	0
36	03.09.2016	09.09.2016	8
37	10.09.2016	16.09.2016	35
38	17.09.2016	20.09.2016	89
39	24.09.2016	30.09.2016	40
40	01.10.2016	07.10.2016	1
41	08.10.2016	14.10.2016	0
42	15.10.2016	21.10.2016	0
43	22.10.2016	28.10.2016	0
		Total	690

Table 2: Experiment treatment details and symbols used

Sr. No.	Treatment details	Symbols used	Number of GA_3 applications	Quantity of 1000ppm GA_3 stock solution utilized
1	Control (no application of GA_3)	T_1	Nil	Nil
2	Foliar application of 25 ppm GA_3 at Flowering	T_2	01	25ml/ liter water
3	Foliar application of 50 ppm GA_3 at Flowering	T_3	01	50ml/ liter water
4	Foliar application of 75 ppm GA_3at Flowering	T_4	01	75ml/ liter water
5	Foliar application of 25 ppm GA_3 at Pod development	T_5	01	25ml/ liter water
6	Foliar application of 50 ppm GA_3 at Pod development	T_6	01	50ml/ liter water
7	Foliar application of 75 ppm GA_3 at Pod development	T_7	01	75ml/ liter water
8	Foliar application of 25 ppm GA_3 at Flowering & Pod development	T_8	02	25ml/ liter water
9	Foliar application of 50 ppm GA_3 at Flowering & Pod development	T_9	02	50ml/ liter water
10	Foliar application of 75 ppm GA_3 at Flowering & Pod development	T_{10}	02	75ml/ liter water

Table 3: Effect of different treatments on growth and yield parameters of pigeonpea

Treatments	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	Seed Index (g)	Grain yield/ plant (g)
T_1	147.87a	12.40b	150.13b	7.89e	29.57c
T_2	148.13a	13.93b	154.00b	7.96d	30.66c
T_3	153.53a	15.60a	166.13b	8.08c	33.56c
T_4	154.07a	16.40a	188.33a	8.12b	38.21b
T_5	154.07a	16.67a	193.93a	8.16b	39.55a
T_6	149.27a	14.13b	157.67b	8.11b	31.99c
T_7	151.87a	15.33a	158.00b	8.12b	32.08c
T_8	154.40a	16.80a	201.73a	8.19a	41.33a
T_9	157.27a	17.13a	204.40a	8.21a	41.94a
T_{10}	158.87a	18.07a	208.47a	8.22a	42.81a
SEm$\pm$	4.83	0.97	7.34	0.05	1.42
CD (P=0.05)	NS	2.89	21.81	0.15	4.23

Means followed by the same letter do not differ significantly at the 0.05 probability level

Table 4: Effect of different treatments on grain and straw yield, oil content, oil yield and rainfall use efficiency of pigeonpea

Treatments	Grain yield/ ha (kg)	Straw yield/ ha (kg)	Harvest Index (%)	Rain water use efficiency (kg/mm/ha)
T_1	1654.32b	3364.20a	33.03a	2.40
T_2	1673.87b	3467.08a	32.59a	2.43
T_3	1759.26a	3693.42a	32.38a	2.55
T_4	1771.61a	3662.55a	32.62a	2.57
T_5	1867.28a	3610.08a	34.17a	2.71
T_6	1713.99a	3600.82a	32.27a	2.48
T_7	1728.40a	3580.25a	32.82a	2.50
T_8	1895.06a	3641.98a	34.34a	2.75
T_9	1925.93a	3755.14a	34.35a	2.79
T_{10}	1970.16a	3981.48a	33.16a	2.86
SEm$\pm$	69.31	240.02	1.76	-
CD (P=0.05)	205.90	NS	NS	-

Table 5: Economics of pigeonpea as influenced by different treatments

Treatments	Cost of cultivation (x 10^3 Rs/ ha)	Gross Monitory Returns (x 10^3 Rs/ ha)	Net Monitory Returns (x 10^3 Rs/ ha)	B:C ratio
T_1	21.28	74.44b	53.17	3.50
T_2	21.75	75.32b	53.58	3.46
T_3	22.13	79.17a	57.03	3.58
T_4	22.45	79.72a	57.28	3.55
T_5	21.94	84.03a	62.09	3.80
T_6	22.09	77.13b	55.04	3.49
T_7	22.40	77.78a	55.38	3.47
T_8	22.42	85.28a	62.86	3.80
T_9	23.05	86.67a	63.62	3.76
T_{10}	23.69	88.66a	64.96	3.74
SEm±	-	3.12	3.05	-
CD (P=0.05)	-	9.26	NS	-

Means followed by the same letter do not differ significantly at the 0.05 probability level
Market rates of pigeonpea grains @ Rs. 4500/- per quintal

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