International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 1495-1498

Received: 15-09-2018
Accepted: 20-10-2018

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Effect of plant growth retardants on growth, yield and economics of kharif pigeonpea (*Cajanus cajan*. L)

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Abstract
A field experiment was at Agricultural Research Station, Tandur, Professor Jayashankar Telangana state Agricultural University for three consecutive Kharif seasons 2014-15 and 2015-16 2016-17 to assess the Effect of plant growth retardants on growth, yield and economics of Kharif Pigeonpea. Results indicated significant difference between the treatments over control, but there is non-significant difference among the treatments which received foliar sprays of growth retardants with regard to growth parameters like plant height, Primary branches and secondary branches. The treatment which received foliar spray of Mepiquat chloride 2000ppm recorded significantly higher yield of 1940 kg/ha with 69.4 percent of pod retention. Maximum harvest index 23.9 was registered with foliar spray of Mepiquat chloride 2000ppm, Benefit cost ratio ranged from 2to 3.8. Maximum benefit cost ratio was recorded by T5 (3.8) but it is on par with T4. Increase in seed yield of T5 was to the tune of 74% and 66% in T4 more over control.

Keywords: pigeonpea, growth retardants, yield and economics

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the major grain legume crops of the tropics and sub-tropics endowed with several unique characteristics. Pigeonpea occupies 6.5 per cent of the world's total pulse area and contributes 5.7 per cent to the total pulse production. India is the largest producer of pigeonpea accounting to about 64 per cent of total world production. Among the total pulses, pigeonpea a protein rich staple food accounts for 14.5 per cent in area and 15.5 per cent in productivity. In India it ranks second in area and 91% of the world Pigeonpea is produced in India. It is mainly grown in states of Maharashtra, Uttar Pradesh, Madhya Pradesh, Gujarat, Andhra Pradesh, Telangana, Karnataka and Tamil Nadu and these states constitute 90 per cent of the area. Being a legume crop, it acts as a soil ameliorant and is known to provide different benefits to the soil in which it is grown. The seeds, pods and leaves are used by human and livestock being rich in nutrition. Pigeonpea crop generally enhances soil fertility through leaf litter and biological nitrogen fixation. Pre-mature abscission of flowers is one of the most serious problems in pigeonpea (Fakir 1997) [5] and other legumes (Wiebold *et al* 1981) [28]. Pigeonpea produces large number of flowers, of which as much as 90% are shed (Wasike *et al* 2005 and Choudhury *et al* 2008) [27, 3]. So, the low yield of pigeonpea is due to poor pod set resulting from high flower and pod drops. According to Szalai (1994) [19] flower drop is caused by the appearance of ethylene which is produced auto catalytically. Nutrients and plant growth promoting substances had been used by several workers to increase number of flowers as well as their retention. Sharma and Dey (1986) [17] observed that the retention of flowers in soybean and pods could be increased by either foliar application of nutrients or plant growth regulators. The increase in seed yield of pulses with foliar application of nutrients could be attributed to reduce flower drop and increased fruit set percentage (Ganapathy *et al* 2008) [6]. In legume crops, many flowers are produced, but only a few set pods. Degree of flower shedding varies between 60-92% in soybean (Nahar and Ikeda 2002, Saitoh *et al* 2004) [14, 20], 70-90% in mungbean (Kumari and Verma 1983, Mondal *et al* 2011a), and 80-95% in *Cajanus cajan*. The high proportion of reproductive abscission is due to most of the later formed flower that mostly abscise in legumes (Kuroda *et al* 1998, Mondal *et al* 2011) [11, 12]. Most of the flowers in pigeonpea are abscised (75-96%) before forming pods or pods are abscised before maturation.

So, the actual yield of pigeonpea is quite low as compared to its yield potential (Tekale *et al* 2009) [23]. The evaluation of morpho-physiological and of pigeonpea namely, plant height, number of branches, number of leaves per plant, dry matter accumulation in leaf, stem and reproductive parts, flower abscission per cent and anatomical changes in the pedicel indicate crop growth patterns which are reflected in final yield and thus, influence crop productivity. Plant growth retardants are synthetic substances, which are mostly used to reduce the intermodal length of plants in a desired pattern without changing the development practice or being phytotoxic. Plant growth retardants are known to improve source-sink relationship, improve photosynthetic ability and better fruit retention by curtailing the excessive vegetative growth (Kaur *et al*., 2013) [7]. So to achieve optimum vegetative growth and to effect better translocation of photosynthates into the developing pods, use of growth retardants appears to be an effective approach. Maleic hydrazide (1, 2 dihydro-3, 6-pyridzinedione), cause inhibition of seedling growth by inhibiting mitotic cell division in plants. Maleic hydrazide (MH) acts by curtailing of excessive vegetative growth by inhibiting the biosynthesis of nucleic acid (Ranjan *et al.*, 2004) [15] and results in dwarfed plants with short internodes and dark green colour leaves without affecting the nodal length. Naphthalene acetic acid was reported to lower flower drop by preventing the formation of abscission layers in greengram and blackgram. Shindhe and jadhav. (1995) [18] observed that foliar spray of growth regulators (NAA and ethrel) and KNO3 in cowpea increased the pod yield plant-1, weight of individual pod and ultimately resulted in elevating the seed yield by 33 per cent. Mishra and Mahatim Singh (2001) opined that foliar application of NAA improved the pod number in pigeonpea. Singh and Singh (2000) reported that foliar application of NAA @ 30 ppm concentration increase number of leaves and branches. The foliar application of NAA 20 ppm + KNO3 0.5 percent significantly increased the dry matter production, seed yield. So, to achieve optimum vegetative growth and to effect better translocation of photosynthates into the developing pods, use of growth retardants appears to be an effective approach. In this context, the present study was conducted and results of this study are presented and discussed as under.

Materials and Methods

The field experiment was conducted on deep black cotton soils at Agricultural Research Station, Tandur, Vikarabad (Dist.), Telangana state of Professor Jayashankar Telangana state Agricultural University for three consecutive Kharif seasons 2014-15 and 2015-16 2016-17. The soil of the experimental site was having P^H 8.1, with low available nitrogen (189.0 $kgha^{-1}$), medium in available P (16.80 $kgha^{-1}$) and high in available K (330.20 $kgha^{-1}$) in all the years. The experiment was conducted in Randomized Complete Block Design comprising twelve treatment combinations including two plant growth retardant treatments and three times of application of sprays (control, water spray, MH @ 2000, ppm, NAA 20 ppm) with three replications. Crop was sown at a spacing of 100 cm x 30 cm on a well prepared seed bed. Recommended fertilizers (20:50:10 NPK kg ha^{-1}) were applied at the time of sowing. Data on various parameters was recorded periodically. Observations on five random plants from each plot were recorded for primary and secondary branches $plant^{-1}$, pods $plant^{-1}$ and seed pod^{-1}. The gross plot size was 10m x 8m. The experimental data were analysed statistically by following Fischer's method of analysis of variance as per procedure suggested by Gomez and Gomez (1984). F–test was significant at P=0.05 and the results have been compared among treatments based on critical difference. The gross returns are worked out based on the prevailing market rate of Pigeonpea seed (Rs. 50 per kg). The benefit cost ratio was worked out for different treatments by dividing the net returns by the corresponding cost of cultivation of the treatments.

Results and Discussion

Growth parameters

Even though there is significant difference between the treatments over control, but there is non-significant difference among the treatments which received foliar sprays of growth retardants with regard to growth parameters like plant height, Primary branches and secondary branches. The increase in number of branches with application of growth retardants was due to inhibition of apical dominance and breaking of lateral bud dormancy that resulted in more number of secondary branches.

Pod setting percentage

Seed yield in pigeonpea is mainly dependent upon number of pods harvested at maturity. The plant produces a large number of floral buds and flowers but all of them do not develop into mature pods. A great percentage of floral buds fail to develop into flowers and so is the case with flowers which do not develop into pod. The percent pod retention ranged from 38 to 69.4. Irrespective of the growth retardants used in the experiment percent pod retention increased with increase in the number of sprays. When compared to NAA 20ppm, Mepiquat chloride 2000ppm effect was superior in terms percent pod retention under similar number of sprays and time of spray. With increase in spray number there was incremental increase in the percent pod retention. When compared to control the percent increase in pod retention ranged from 6.5 to 41.7 in case of Mepiquat chloride 2000ppm, while it ranged from 6.3 to 16.3 in case of NAA 20ppm with increase in number of sprays. The retension of the flowers and pods are increased by the foliar spray of the plant growth regulators as reported by Sharma and Dey (1986) [17] in Soybean. The treatment which received foliar spray of Mepiquat chloride 2000ppm sprayed thrice i.e. at flower bud initiation stage, 10 days after flower bud initiation stage and 50% flowering recorded significantly higher yield of 1940 kg/ha with 69.4 percent of pod retension. It is fb foliar spray of Mepiquat chloride 2000ppm sprayed twice i.e. at flower bud initiation stage, 10 days after flower bud initiation stage (53.4%). Growth substances as a foliar spray increased the yield either by increasing the pod setting or seed number (Birari, 1986). Foliar application of the hormones increased the percent of pod retention, finally increasing the number of pods at harvest which have a positive influence on the final seed yield. (Subramanian and Palaniappan, 1981) [22]

Harvest index (HI)

Harvest index is the measure of how effectively the photosynthates were transferred from source to the sink. HI was significantly enhanced by different plant harmones over controls but non-significant differences were observed amongst the treatments. Maximum harvest index 23.9 was registered with foliar spray of Mepiquat chloride 2000ppm sprayed thrice i.e. at flower bud initiation stage, 10 days after flower bud initiation stage and 50% flowering, which was 8.2 % higher than the control (no spray with HI 22.0). The maximum harvest index may be accounted as a function of growth retardants which improved the source-sink relationship by enhancing the diversion of photosynthates towards vegetative parts to reproductive parts. TIBA application significantly increased the seed yield and harvest of pigeonpea (Tripathi *et al.,* 2009) [24].

Seed yield and Economics

Maximum seed yield of 1940 kg/ha was recorded by T5 foliar spray of Mepiquat chloride 2000ppm sprayed thrice i.e. at flower bud initiation stage, 10 days after flower bud initiation stage and 50% flowering, but it is on par with T4. Increase in seed yield of T5 was to the tune of 74% and 66% in T4 more over control. The reason for increase in seed yields are due to efficient translocation of assimilates to the developing sink. The results are in conformity with the findings of Revathy *et al* (1997) [16]. T5 recorded 100 seed weight of 10.01gm. The improvement in yield and yield attributing characters of pigeonpea by the application of growth retardants might be owing to its positive effect on growth which in turn resulted in the development of higher yield attributing characters and ultimately increased seed yield (Deotale *et al.,* 1995, Arora *et al.,* 1998, Upadhaya 2002 and Kiran *et al.,* 2005) [4, 1]. Benefit cost ratio ranged from 2to 3.8. Maximum benefit cost ratio was recorded by T5 (3.8) but it is on par with T4.

Table 1: Effect of harmones on Redgram on growth and pod retention during Kharif (2014-15, 15-16 &16-17)

Treatments	Plant height at harvest (cm)	Primary branches	Secondary branches	Seeds per Pods	% Pods retained	% increase in pod retension over control
T-1. Foliar spray with Mepiquat chloride @ 2000 PPM at flower bud initiation stage	172.3	2.3	23.8	3.02	4.34	6.5
T-2. Foliar spray with Mepiquat chloride @ 2000 PPM at 10 days after flower bud initiation stage	176.0	2.1	24.3	3.14	49.7	12.0
T-3. Foliar spray with Mepiquat chloride @ 2000 PPM at 50% flowering	173.0	2.1	26.0	3.45	48.0	12.2
T-4. T1 + T2	175.7	2.5	26.3	3.51	53.4	18.8
T-5. T1 + T2 + T3	180.3	2.9	27.4	3.57	69.4	41.7
T-6. Foliar spray with NAA @ 20 PPM at flower bud initiation stage	171.3	2.0	21.2	3.01	45.3	6.3
T-7 Foliar spray with NAA @ 20 PPM at 10 days after flower bud initiation stage	165.0	2.2	23.1	3.07	50.2	12.1
T-8 Foliar spray with NAA @ 20 PPM at 50% flowering	166.3	2.1	25.9	3.12	47.8	9.9
T-9 T6 + T7	170.7	2.1	26.2	3.31	56.8	5.6
T-10 T6 + T7 + T8	171.0	2.7	26.8	3.40	54.2	16.3
T11- water spray at 10 days after flower bud initiation stage	163.7	2.1	21.3	2.92	49.3	11.3
T12- control	159.3	1.8	16.0	2.83	38.0	
Sem±	8.4	0.5	0.48	0.3		
C.D. (0.05%)	NS	NS	NS	NS		

Table 2: Effect of harmones on Redgram on yield and economics during Kharif (2014-15, 15-16 &16-17)

Treatments	100 Seed weight	Harvest index	Seed yield (Kg/ha)	B:C ratio
T-1. Foliar spray with Mepiquat chloride @ 2000 PPM at flower bud initiation stage	9.45	23.2	1543	3.0
T-2. Foliar spray with Mepiquat chloride @ 2000 PPM at 10 days after flower bud initiation stage	9.52	2.3.4	1613	3.2
T-3. Foliar spray with Mepiquat chloride @ 2000 PPM at 50% flowering	9.54	23.5	1740	3.6
T-4. T1 + T2	9.76	23.7	1820	3.7
T-5. T1 + T2 + T3	10.01	23.9	1940	3.8
T-6. Foliar spray with NAA @ 20 PPM at flower bud initiation stage	9.01	23.0	1430	2.5
T-7 Foliar spray with NAA @ 20 PPM at 10 days after flower bud initiation stage	9.23	23.1	1600	3.2
T-8 Foliar spray with NAA @ 20 PPM at 50% flowering	9.31	23.3	1579	3.1
T-9 T6 + T7	9.43	23.5	1720	3.4
T-10 T6 + T7 + T8	9.45	23.7	1798	3.5
T11- water spray at 10 days after flower bud initiation stage	9.3	23.0	1557	2.5
T12- control	9.3	22.0	1114	2.0
Sem±	0.41	2.07	83.9	-
C.D. (0.05%)	NS	NS	241.5	-

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