

**Original Research Article**  
**Influence of growth regulators application on seed  
development and maturation in pigeon pea  
(*Cajanus cajan*(L.))**

**ABSTRACT**

The experiment was carried out at National Pulses Research Centre (NPRC), Vamban, Tamil Nadu Agricultural University to assess the effect of growth regulators foliar spray on seed development and maturation in pigeon pea VBN (Rg) 3. Plant growth regulators viz., GA<sub>3</sub> (200 ppm) and chlormequat chloride (CCC) @ 200 ppm were sprayed at vegetative (65 DAS) and flowering stage (80 DAS). The plants without any foliar spraying treatment considered as control. When 50 percent of the plants in a population have reached bud initiation stage, the buds were tagged and collected at five days interval from 5<sup>th</sup> day upto 45<sup>th</sup> days after initiation (DAI). The variation in pod color, changes in pod length and weight, seed fresh and dry weight, moisture content, germination and seedling vigor were recorded at regular intervals of five days up to 45 days after flower initiation. The results revealed that the maximum pod length, fresh and dry weight of pod and seed, seed germination and seedling vigor was observed in pigeon pea at 30 days after floral initiation (DAI) in chlormequat chloride (CCC) @ 200 ppm foliar treatment. The control i.e. without any foliar treatment had attained the physiological maturity at 35 DAI by recording all the physiological parameters viz. maximum pod length, fresh and dry weight, seed germination and seedling vigor. In pigeon pea, application of CCC @ 200 ppm as foliar treatment leads to attain physiological maturity at 30 days after initiation of flowering (DAI) by recording the highest seed weight, germination and seedling dry weight over control.

**Keywords:** Pigeon pea, Foliar spray, CCC, development and maturation, germination, vigour

**INTRODUCTION**

Pigeon pea (*Cajanus cajan*(L.)) belongs to the family Fabaceae is drought resistant and can be grown in areas with less than 650mm annual rainfall and with low input requirement. The protein content of the pigeon pea seeds is about 2-3 times more than the cereals. In addition to its nutritional value, it also has a unique property of maintaining and restoring soil fertility through biological nitrogen fixation and improvement of physical properties of the soil by virtue of its deep root system. One of the chief factors that affect seed quality during storage and its performance under field conditions is the maturity stage at which the crop is harvested. At physiological maturity, seed attains maximum vigour and viability

(Khattra and Singh, 1995) and the changes that occur beyond the physiological maturity would be only dehydration without accumulation of reserves. Hence, a precise determination of physiological maturity will permit an accurate measure of seed filling period. Dehydration of seeds on the mother plant till harvestable maturity may not bring any additional input in seed quality and sometimes it may even be deleterious to seed quality (Ellis *et al.*, 1987).

Harvesting at the right time has commercial implications as it permits quick harvesting at appropriate time, resulting in better field management particularly in multi cropping system. In addition, these would result in reducing losses due to biological and climatic hazards. Though there are contradictions about maximum seed quality beyond physiological maturity in some crops (Zanakiset *al.*, 1994), optimum time of harvest on the basis of physiological maturity has been precisely determined in soybean (Crookston and Gill, 1978), sunflower (Dorell, 1978), cotton (Changadeet *al.*, 1990) and amaranthus (Menaka and Balamurugan, 2003) and several other crops. Plant growth regulators (PGR's) are known to improve physiological efficiency including photosynthetic ability of plant and offer significant role in realizing higher crop yields. The PGR's are also known to enhance the source sink relationship and stimulate the translocation of photo assimilates, thereby increase the productivity. With this background, the present investigation was carried out to assess the effect of growth regulators application on physiological maturity in pigeopea.

**Comment [RM1]:** References regarding the use or influence of Plant growth regulators viz., GA<sub>3</sub> (200 ppm) and chlormequat chloride (CCC)@ 200 ppm need to be added

## MATERIALS AND METHODS

The investigation was carried to assess the influence of growth regulators on seed development and maturation in pigeon pea VBN (Rg) 3 at National Pulses Research Centre (NPRC), Vamban, Tamil Nadu Agricultural University during 2017-18. Seeds of pigeon pea VBN (Rg) 3 acquired from NPRC, Vamban and dried to a uniform moisture content in a drying cabinet at  $30 \pm 1^{\circ}\text{C}$  for four days to reach 9.0 % moisture content and used for this research.

Sowing was done in Randomized Block Design with four replications during *Rabi* 2017-18 (October-February) at experimental field of National Pulses Research Centre, Vamban, Tamil Nadu ( $11^{\circ} 30'$ North and,  $79^{\circ} 26'$ East and altitude of 122 m above MSL). The soil texture of the experimental field was red lateritic with acidic pH 4.7-6.5. The recommended crop management practices were followed. Plant growth regulators viz., GA<sub>3</sub> (200 ppm) and chlormequat chloride (CCC)@ 200 ppm were sprayed at vegetative stage (65 DAS) and flowering stage (80 DAS). The plants without any foliar spraying considered as control. To document the optimum physiological maturity stage, the plants in the rows were observed daily for bud initiation. When 50 percent of the plants in a population have reached bud initiation stage, the buds were tagged with 4 x 4 cm white-coloured tags (approx. 200 buds) and collected at five days interval from 5<sup>th</sup> day upto 45<sup>th</sup> days after initiation (DAI). The variation in pod colour changes was recorded at regular intervals of five days. The length of the pod was measured in cm with a thread and the mean arrived. Fresh weight was recorded by weighing individual pod in g using an electronic balance. The pod used for fresh weight were dried under ambient conditions for five days followed by

**Comment [RM2]:** DAS = days after sowing?

**Comment [RM3]:** How many replications are there for each treatment and control?

**Comment [RM4]:** It is necessary to clarify the determination of DAS and DAI

drying at 80°C for 16 h, weighed in g using electronic balance and arrived the dry weight. The seeds extracted from individual pod were weighed in g using electronic balance and fresh weight of seed arrived. The seed used for fresh weight were dried at 80°C for 16 h., weighed in g using an electronic balance and calculated the dry weight of seeds. The seed moisture content was estimated using hot air oven at 105°C for 16 ± 1h (ISTA, 2015).

The germination test was carried out with four replicates of hundred seeds each using paper medium in a germination room maintained at 25 ± 2 °C temperature and 95 ± 3 per cent RH, illuminated with fluorescent light (ISTA, 2015). After the test period of seven days, the seedlings were evaluated. The mean germination was determined and reported as a percentage based on the mean number of normal seedlings produced. Root length of all the normal seedlings from the germination test was measured from collar region to the root tip, the mean recorded and expressed in cm and shoot length of all normal seedlings was measured from collar region to the apex, the mean recorded and expressed in cm. For dry weight measurement, all the normal seedlings used for growth measurements were placed in paper cover and dried under shade for 24h. and then in a hot air oven maintained at 80°C for 16h. The dried seedlings were cooled in desiccator containing silica gel and the weight recorded using an electronic balance and the dry weight was expressed in g10 seedlings<sup>-1</sup>.

The results of experiments were subjected to an Analysis of Variance and treatment differences tested (t test) for significance (Gomez and Gomez, 1984). Wherever necessary, the percentage values were transformed in to arc sine values prior to statistical analysis.

## RESULTS AND DISCUSSION

The pod colour was dark green at five days after initiation (DAI), turned to dark green with slight purple stripes at 15DAI, light yellow with purple stripes at 25 DAI, brown colour at 30 DAI and finally became dark brown at 40 DAI and blackish brown at 45 DAI in CCC @ 200 ppm foliar spray treatment (Table 1). Whereas pods in control plant and GA<sub>3</sub>@ 200 ppm foliar spray treatment turned to brown colour at 35 DAI and dark brown at 45 DAI. In control, the mean pod length increased from 0.73 cm at five DAI to 4.80 cm at 35 DAI. Thereafter the length decreased to 4.57cm at 45 DAI (Table 1). Whereas in CCC @ 200 ppm foliar spray treatment, the mean pod length increased from 0.81 cm at five DAI to 5.26cm at 30 DAI thereafter it decreased to 5.04cm and in GA<sub>3</sub>@ 200 ppm foliar spray treatment, the maximum pod length was 5.06 cm at 35 DAI and thereafter it reduced to 4.85 cm at 45 DAI (Table 1). The fresh weight of the developing pod increased considerably from 0.022 g at five DAI to 0.846 g at 35 DAI in control plant and thereafter the fresh weight decreased to 0.786 g at 45 DAI (Table 2). The CCC @ 200 ppm foliar spray treatment recorded the maximum pod fresh weight of 0.896g at 30 DAI when compared to GA<sub>3</sub>@ 200 ppm (0.864 g) and control (0.757g) (Table 2.). The dry weight of the pod increased from 0.020 g at five DAI, attained the maximum of 0.627 g at 30 DAI and decreased to 0.602 at 45 DAI in CCC @ 200 ppm foliar spray treatment. The GA<sub>3</sub>@ 200 ppm foliar treatment also registered the maximum pod

dry weight (0.611g) at 30 DAI whereas in control the maximum pod dry weight (0.462) was recorded at 35 DAI but the effect was lesser when compared to the results of foliar treatments (Table 2).

The seed development was started at 10 DAI in all the treatments. Fresh weight of developing seed increased progressively from 0.026 g at 10 DAI to the maximum of 0.756 g at 35 DAI in control, 0.034g at 10 DAI to 0.786g at 30 DAI in CCC @ 200 ppm foliar spray treatment and 0.030 g to 0.684g at 30 DAI in GA<sub>3</sub>@ 200 ppm foliar treatment and thereafter decreased the seed fresh weight in all the treatments (Table 3). The maximum seed dry weight of 0.495g was recorded in CCC @ 200 ppm foliar spray treatment at 30 DAI which was followed by GA<sub>3</sub>@ 200 ppm foliar treatment (0.471g) whereas control recorded the seed dry weight of only 0.486g at 35 DAI (Table 3).

The highest moisture content of the seed was observed at 15 DAI (46.07% in control, 45.47% in CCC @ 200 ppm and 45.86% in GA<sub>3</sub>@ 200 ppm) and then the moisture content gradually reduced and reached the lowest at 45 DAI in all the treatments (Fig.1). The first germination was observed at 15 DAI in CCC @ 200 ppm (12%) and GA<sub>3</sub>@ 200 ppm (8%) but in control the germination was started only at 20 DAI (14%) (Fig.2). The maximum germination of 91% was recorded in CCC @ 200 ppm foliar treatment followed by GA<sub>3</sub>@ 200 ppm (88%) whereas the control recorded only 85% at 35 DAI. The germination was maintained with minimum reduction up to 40 DAI and after that the germination was reduced in all the treatments (Fig. 2.). In control, the root length of seedlings increased gradually from 8.44 cm at 20 DAI to 19.13 cm at 35 DAI and decreased at later stages. The longest root was observed in CCC @ 200 ppm foliar treatment (20.32 cm) followed by GA<sub>3</sub>@ 200 ppm (19.64 cm) at 30 DAI (Table 3). Similar trend of result was also observed for shoot length. The maximum shoot length was observed in CCC @ 200 ppm foliar treatment (25.47 cm) followed by GA<sub>3</sub>@ 200 ppm (23.77cm) at 30 DAI whereas the control recorded the shoot length of 23.17cm at 35 DAI (Table 3). In CCC @ 200 ppm foliar treatment, the seedling dry matter accumulation increased gradually from 0.018 g at 15 DAI to 0.422 g at 30 DAI and thereafter decreased and attained the lowest value of 0.403 g at 45 DAI (Fig.3). The GA<sub>3</sub>@ 200 ppm treatment recorded the dry weight of 0.403g at 30 DAI when compared to control which recorded 0.409 g of dry weight at 35 DAI (Fig.3).

In the present study, the maximum pod length, fresh and dry weight was evident in pigeon pea at 30 days after floral initiation (DAI) in CCC @ 200 ppm foliar treatment. At this stage, the seed fresh weight, dry weight and germination were maximum. In addition, the seedling length and dry matter production was also greater which was followed by GA<sub>3</sub>@ 200 ppm treatment. The moisture content declined considerably. Beyond this stage, the seed quality parameters in terms of dry weight, germination, root length and seed length did not bring any added advantage. The control *i.e.* without any foliar treatment had attained the physiological maturity by recording all the physiological parameters *viz.* maximum pod length, fresh and dry weight, germination and seedling vigour at 35 DAI. The growth regulators foliar treatment requires lesser number of days for attaining physiological maturity (30 DAI) with maximum seed quality parameters whereas control plants took five days higher for physiological maturity (35 DAI). It is inferred from the study that the phenological stages *viz.*, pod initiation, pod filling and

Comment [RM5]: Not related data

physiological maturity are early due to use of plant growth regulators as foliar treatment at vegetative and flowering stage when compared to control. Growth regulators play a significant role in modifying growth and flowering of pigeon pea. Plant growth regulators change both morphology and physiology of crop and also capable of redistribution of photo- assimilates into different organs of the plant and thereby bring about better source–sink relationship and yield improvement (Vanitha and Kathiravan, 2019). When growth regulator is used in appropriate concentration influence the plant architecture in a typical fashion and improve the yield potential. Similar reports have been made by Guimaraset *et al.* (2015) in pigeon pea, Sheng *et al.* (2019) in cotton, Garai and Datta(2003) in green gram, Berova and Zlatev (2000) in tomato. Foliar application of Brassinolide@0.25 ppm significantly increased flower :fruit ratio, pollen viability, pod weight, pod length and reduced days to maturity (65 days) in greengram (Dilip *et al.*, 2017).

**Comment [RM6]:** How about GA3 and CCC?

## CONCLUSION

The results of the present investigation are suggestive of the fact that application of CCC @ 200 ppm as foliar treatment at vegetative stage (65 days after treatment) and flowering stage (80 days after treatment) favors the seeds of pigeopeato attain physiological maturity at 30 days after initiation of flowering (DAI) as indicated by the highest seed weight, germination and seedling dry weight over control.

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**Comment [RM7]:** References need to be more up to date

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Table 1. Effect of foliar spraying with growth regulators on pod characters during development and maturation in pigeon pea VBN(Rg)3

Stages	Pod colour			Pod length (cm)		
	Control (Without foliar spray)	CCC@ 200 ppm	GA <sub>3</sub> @200 ppm	Control (Without foliar spray)	CCC@ 200 ppm	GA <sub>3</sub> @200 ppm
5 DAI	Dark green	Dark green	Dark green	0.73± SE	0.81± SE	0.78± SE
10 DAI	Dark green	Dark green	Dark green	1.55	1.64	1.59
15 DAI	Dark green	Dark green with slight stripes	Dark green	3.39	3.54	3.46
20 DAI	Dark green with purple stripes	Green with purple stripes	Dark green with purple stripes	4.43	4.62	4.55
25 DAI	Green with purple stripes	Light yellow with purple stripes	Yellowish Green with purple stripes	4.79	5.17	4.86

30 DAI	Light yellow with purple stripes	Brown	Yellow with purple stripes	4.96	5.26	5.11
35 DAI	Brown	Dark Brown	Brown	4.80	5.20	5.06
40 DAI	Dark Brown	Dark Brown	Dark Brown	4.60	5.06	4.87
45 DAI	Dark Brown	Blackish Brown	Dark Brown	4.57	5.04	4.85
<b>Mean</b>	-	-	-	<b>3.76</b>	<b>4.03</b>	<b>3.90</b>
SEd	-	-	-	0.14	0.24	0.19
CD (p=0.05)	-	-	-	0.29	0.51	0.40

**Comment [RM8]:** Average data should be calculated for each observation age, not for the entire period from the beginning to the end of the observation. Each age of observation is compared between control and treatment.

n = .....

Table 2. Effect of foliar spraying with growth regulators on pod weight during development and maturation in pigeon pea VBN(Rg)3

Stages	Pod Fresh weight(g)			Pod dry weight (g)		
	Control (Without foliar spray)	CCC@ 200 ppm	GA <sub>3</sub> @200 ppm	Control (Without foliar spray)	CCC@ 200 ppm	GA <sub>3</sub> @200 ppm
5 DAI	0.022± SE	0.036± SE	0.027± SE	0.014± SE	0.020± SE	0.017± SE
10 DAI	0.053	0.064	0.056	0.035	0.046	0.040
15 DAI	0.080	0.093	0.088	0.052	0.068	0.061
20 DAI	0.320	0.367	0.345	0.163	0.218	0.204
25 DAI	0.513	0.610	0.540	0.315	0.486	0.457

30 DAI	0.757	0.896	0.864	0.462	0.627	0.611
35 DAI	0.846	0.889	0.857	0.591	0.625	0.609
40 DAI	0.791	0.882	0.854	0.540	0.621	0.607
45 DAI	0.786	0.815	0.772	0.528	0.602	0.593
<b>Mean</b>	<b>0.463</b>	<b>0.516</b>	<b>0.489</b>	<b>0.300</b>	<b>0.368</b>	<b>0.355</b>
SEd	0.011	0.023	0.017	0.002	0.008	0.006
CD (p=0.05)	0.023	0.045	0.034	0.004	0.017	0.013

**Comment [RM9]:** Average data should be calculated for each observation age, not for the entire period from the beginning to the end of the observation. Each age of observation is compared between control and treatment.

n = .....

Table 3. Effect of foliar spraying with growth regulators on seed weight during development and maturation in pigeon pea VBN(Rg)3

Stages	Seed fresh weight(g)			Seed dry weight (g)		
	Control (Without foliar spray)	CCC@ 200 ppm	GA <sub>3</sub> @200 ppm	Control (Without foliar spray)	CCC@ 200 ppm	GA <sub>3</sub> @200 ppm
5 DAI	-	-	-	-	-	-
10 DAI	0.026	0.034	0.030	0.009	0.015	0.012
15 DAI	0.051	0.066	0.057	0.021	0.033	0.027
20 DAI	0.190	0.235	0.216	0.109	0.135	0.123
25 DAI	0.382	0.569	0.478	0.211	0.365	0.312

30 DAI	0.624	0.786	0.684	0.447	0.495	0.471
35 DAI	0.756	0.782	0.678	0.486	0.492	0.468
40 DAI	0.682	0.780	0.675	0.461	0.487	0.460
45 DAI	0.646	0.776	0.667	0.418	0.472	0.447
<b>Mean</b>	<b>0.420</b>	<b>0.503</b>	<b>0.435</b>	<b>0.270</b>	<b>0.311</b>	<b>0.290</b>
SEd	0.007	0.014	0.010	0.001	0.009	0.006
CD (p=0.05)	0.014	0.029	0.021	0.002	0.018	0.013

**Comment [RM10]:** Average data should be calculated for each observation age, not for the entire period from the beginning to the end of the observation. Each age of observation is compared between control and treatment.

Fig.1. Effect of foliar spraying with growth regulators on seed moisture (%) during seed development and maturation in pigeon pea VBN(Rg)3

**Comment [RM11]:** Figure title is in below the figure

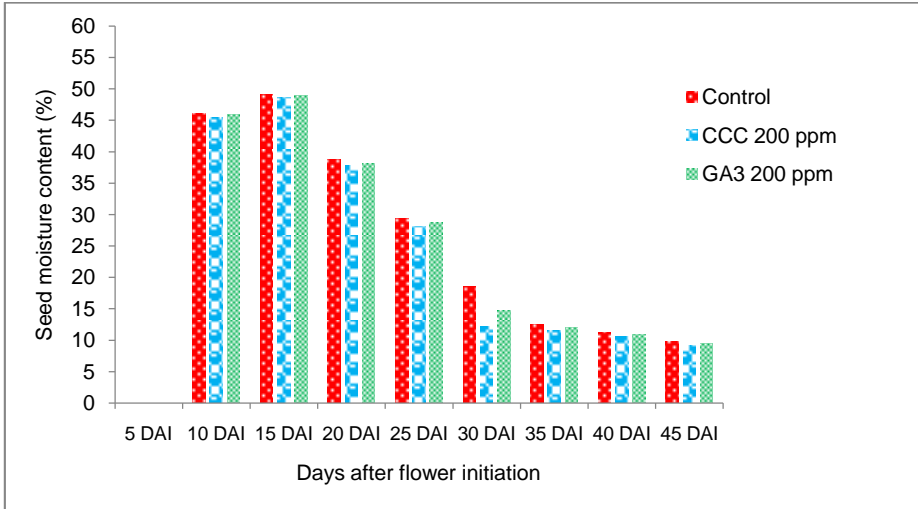


Fig. 2. Effect of foliar spraying with growth regulators on seed germination (%) during seed development and maturation in pigeon pea VBN(Rg)3

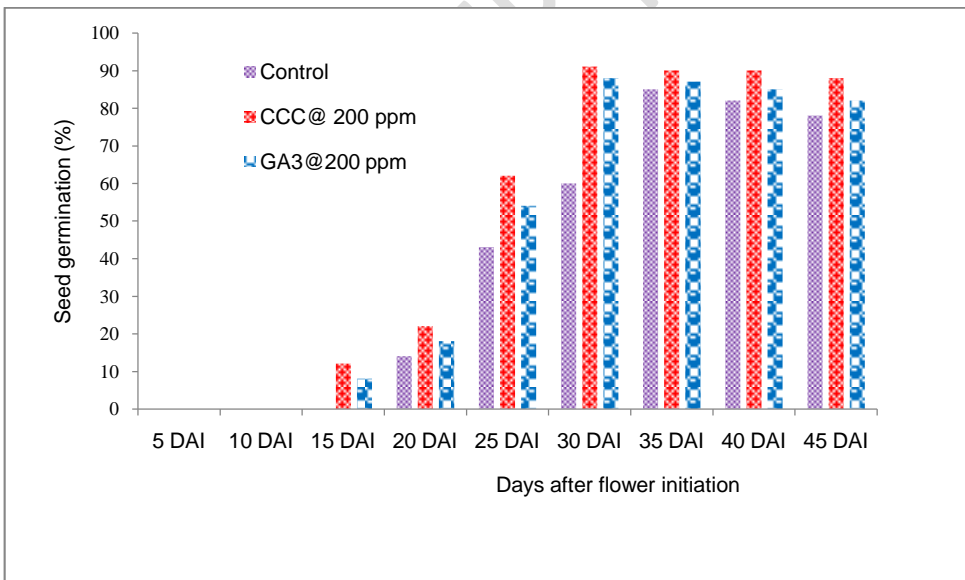
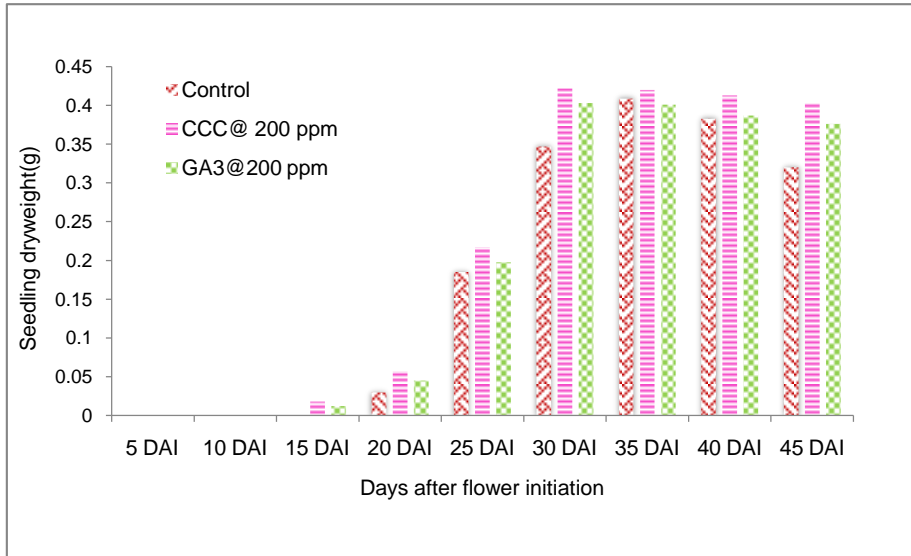


Fig. 3. Effect of foliar spraying with growth regulators on seedling dryweight (g) during seed development and maturation in pigeon pea VBN(Rg)3



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