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## Role of plant growth regulators in pulse production: A review

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### Abstract

India ranks first in terms of production and consumption of pulses. Pulses are good source of proteins required for human beings. The consumption of pulses are going to be increased, so there is need to increase the productivity of pulse crop production. To increase the productivity of pulses we have to identify the existing constraints that includes inherent physiological limitations *viz.*, lower germination percentage, indeterminate growth habit, slower dry matter accumulation, decline in nodule activity, photosynthetic characteristics. These limitations are controlled by the application of plant growth regulators (PGR's). Plant growth regulators are familiar to ameliorate the physiological efficiency as well as photosynthetic ability of plants. This paper reviews about application of plant growth regulators (PGR's) to improve these limitations and to increase the yield of pulse crops.

**Keywords:** Pulse, growth regulators, physiological limitations, yield

### 1. Introduction

The word "Pulses" in Indian agriculture refers to grain legumes that are used as food as whole seed. Pulses are most important food crops after cereals. India is largest consumer and producer of pulses in world. Pulses are generally group of 12 crops includes pigeon pea, chickpea, moong, urad, lentils, khesari, beans and peas etc. Pulses are important component of daily menu of millions of people of our country. Pulses can be grown on wide range of climatic and soil conditions, they play important role in crop rotation, mixed and intercropping maintain fertility of soil through nitrogen fixation. They contain high amount of proteins, fibre, vitamins and also provide amino acids. Pulse provide nutritious green fodder and feed for the livestock. Pulses are major source of proteins for vegetarians in India and compliment the cereals in diet with proteins, essential amino acids, vitamins and minerals (Pingoliya *et al.*, 2013) [36]. They contain 22 to 24% proteins that are twice as compared to wheat and thrice that of rice (Shukla *et al.*, 2013). Pulse play very important role in correcting the malnutrition, known to reduce several non-communicable diseases such as colon cancer and cardiovascular diseases (Jukanti *et al.*, 2012) [19]. The French bean green stage is beneficial for controlling night blindness in human beings that contain vitamin A (Birajdar *et al.*, 2006). They are known "reco-operative" crops with an excellent position in things like food, forage, and fertility. India is world largest producer of pulses accounting 27-28% of global pulses production. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and Karnataka are top five pulses producing states in India. Good source of proteins commonly known as 'poor man's meat'. Chickpeas confer the predominant part in India's trade of pulses about 70.92% and 80.02% share in total pulse export during 2017-18 and 2018-19 respectively. Peas form major share in total import of pulses followed by Moong/ Urad and Pigeon peas (Anonymous: Department of Commerce 2019). Mung bean is rich in protein and high in nutritional values (Tahir *et al.*, 2013). The government has been introduced National Pulse Development Programme (NPDP) to increase production productivity and acreage of pulse. Mung being a pulse crop most certainly not require high dose of nitrogen fertilizers (Shamim and Ali, 1987) [42]. Cowpea fixes atmospheric nitrogen up to 240 kg/ha (Nkaa *et al.*, 2014).

Chickpea grown mainly under rainfed conditions. Phosphorous is an important fertilizer in chickpea (Dotaniya *et al.*, 2013) [10]. Among pulse crops chickpea has relatively low protein content but of higher biological and protein digestibility. Among pulses black gram ranks fourth important pulse crop covering area about 3 million hectares with productivity 1.2 million tonnes (Deepalakshmi 2004).

Black gram referred as King of the pulses due to mouth-watering taste and nutritional qualities. Pigeon pea also known as tur or redgram. Due to deep root penetration this crop can tolerate the drought conditions.

To increase the productivity of pulses in India we need to identify the existing constraints in its production and appropriate measures are to be taken to improve the pulse production. In India pulse cultivation faces many problems like pest management, biotic and abiotic stresses, socio-economic constraints etc. Besides this, pulse crops have inherent limitations such as poor in germination, indeterminate growth habit, decrease in nodule activity, slow dry matter accumulation and reduced sink activity these leads to lower yield and productivity. These limitations can be managed with application of plant growth regulators (PGRs).

### 1.1 Plant growth regulators

Plant growth regulators are chemical substances that influence the growth of plant at low concentration. Plant growth regulators play key role in germination, vegetative growth, flowering, fruit development and physiological activities in crop plants. Plant growth regulators enhance source sink relationship, stimulates the translocation of assimilates, control the flower drop and increase the yield of crops. It is recognized that by application of small amount of growth regulators to foliar spray on plants the growth behaviour of many plants are controlled or modified. These are either endogenous (biochemicals that produced in plants) or synthetic which are applied exogenously. These are applied to improve the source-sink relationship, improve photosynthetic efficiency, vegetative growth and good pod development. Plant growth regulators are majorly divided into following Groups

**Classical plant hormones and growth regulatory substances:** Gibberellins, cytokinins, auxins, ethylenes and abscissic acid.

**Growth substances that have phyto-hormonal activities:** salicylates, polyamines, jasmonates, sterols, oligosaccharins, brassinosteroids, turgorins and systemins etc.

### 1.2 Role of plant growth regulators (PGRs)

Role of plant growth regulators becomes more vital in agriculture to enhance the production. Salicylic acid an endogenous growth regulator that participates in regulation of physiological process in plants such as stomata closure, ion uptake, transpiration and stress tolerance (Khan *et al.*, 2003) [25]. Gibberellin commonly available as GA3 and is known as gibberellic acid. Gibberellin generally increases cell elongation and cell division. Dormancy broken by gibberellic acid. The application of GA3 can modify morphological and yield characteristics in soybean (Kalyankar *et al.*, 2008). Auxins are organic substances that promote the apical dominance. The important functions of auxin are cell division and root formation. In many leguminous crops beneficial effects of growth regulators have been studied *viz.*, mung bean (*Vigna radiata*) (Kandagal *et al.*, 1990), black gram (*Vigna mungo*) (Prakash *et al.*, 2003), cow pea (*Vigna unguiculata*) (Mohandoss and Rajesh, 2003). These growth regulators when applied as foliar spray in optimum concentrations at proper growth stage play significant role in increasing crop yield and quality in different field crops (Nagasbramaniam, pathmanabhan and Mallika, 2007). Spraying of various plant growth regulators may reduce the flower and fruit drop to some extent (Ramesh

and Thirumuguran, 2001), prove that yield and quality parameters may be enhanced by suitable application of PGRs in food legumes. Application of mixtures of abscisic acid (ABA) and gibberellic acid (GA3) promotes floral bud initiation and flowering in long-day plants (kamuro *et al.* 1997; 2009). Phenolic compounds possess regulatory activity in preventing flower and pod shedding and thus improve the quality and yield of legumes (Awasthi *et al.* 1997). In short day plants growth hormones contributes the initiation and development of floral buds (Wain and Taylor, 1965). Cytokinin undertake in managing the flower and pod development in soybean (Reese *et al.*, 1995). Auxins has been found to increase number leaves per plant, plant height and seed yield in cowpea (Khalil and Mandurah, 1989). The application of GA3 (20ppm) at bud initiation and 50% flowering of soybean increased biological yield, seed yield and harvesting index (Upadhyay and Ranjan 2015). Salicylic acid a natural plant hormone play important role in tolerance of environmental stresses such as heat, salts and drought stress (El-Tayeb, 2005). Maity and Bera (2009) reported that foliar application of salicylic acid influences different biochemical and physiological aspects of green gram. Kamlesh *et al.*, (2017) registered that foliar spray of 1.0 ppm brassinolide increased grain yield and biological yield significantly under saline conditions. Therefore it was considered to study the effect of growth regulators on pulse crop production.

## 2. Discussion

The plant growth regulators are widely used in increasing the production of many crop plants. The plant growth is normally controlled by naturally occurring growth regulators, modification of growth can be achieved by application of exogenous growth regulators. The use of growth regulators improves yield potential and quality of produce in several crops. Khatun *et al.*, (2016) showed effect of plant growth regulators significantly on number of pods plant<sup>-1</sup>, number of seeds pod<sup>-1</sup>, 100 seed weight, stover yield, biological yield, moisture and protein content in seed of soybean. Aspirin gave largeb number of seeds pod<sup>-1</sup>, small size seed, protein and moisture content in seed (1.60, 19.47, 44.56 and 12.91 respectively). Devi *et al.*, (2011) reported that the plants treated with cycocel @ 500 ppm obtained maximum chlorophyll content and carotenoids. Bora and sharma calculated that reasonable application of cycocel and GA3 rise in yield and protein content in seeds of pea. Shah and prathapsenan (2008) found that there was increase in number of pod per plant, number seeds per pod, leads to increase seed yield per plant in green gram with application of CCC @ 1000 ppm. Resmi and Gopalkrishnan (2004) reported that CCC (300, 400 and 500 ppm), NAA (15, 30 and 45 ppm) and 2,4 -D (2 ppm) in cowpea plants increased pod length, pod weight, pod number per plant and seed yield. Prakash *et al.*, (2003) reported that decrease in plant height and increase number of branches and leaves in pigeon pea with the application of mepiquat chloride @ 120 ppm.

### 2.1 Effect of plant growth regulators / why do pulse need crop growth regulation

#### 2.1.1 Foliar sprays of agrochemicals on morpho-physiological parameter

Jadhav (2000) showed that application of GA3 and NAA increases the morphological and physiological parameters like RGR, CGR, LAR and NAR in soybean. Sarkar *et al.*, (2002) reported that double spraying of GA3 and IAA (100 ppm) at

20 and 42 DAS increased LAI, CGR and NAR in soybean. Prakash *et al.*, (2003) revealed that higher LAI and SLW in black gram by combined foliar application of planofix (30 ppm) at 30 and 45 DAS and chatatkar (120 ppm) at 60 DAS. Rahman *et al.*, (2004) reported that foliar spray of GA3 (100 ppm) at 30 DAS in soybean results in increase of LAI, CGR and NAR. Sarkar *et al.*, (2002) reported that double spraying of GA3 and IAA (100 ppm) at 20 and 42 DAS increased CGR, NAR and LAI in soybean. Hanchinamath (2005) revealed that application of cycocel (1000 ppm) in cluster bean increases total dry matter and crop growth rate. Bora and shrama (2006) reported that application of growth hormones in pea crop influences the RGR, CGR and NAR. The maximum CGR, NAR and RGR were observed in all concentrations of NAA followed by GA3 and kinetin at various growth stages. Ibrahim (2007) reported that application of GA3 (100 ppm) leads to increase in plant height, average number of leaves and dry weight of shoot in vicia faba. Amutha *et al.*, (2012) reported that foliar application of salicylic acid @ 100 ppm at 20, 30 and 40 DAS proved to improve LAI, LAD, specific leaf weight in urdbean. In soybean spraying of NAA (50 ppm) increased the plant height, number of branches and leaves per plant significantly as compared to control (Thakare *et al.*, 2006). Pothalkar and Nawalagatt (2007) found that application of miraculan (2.0 ml/l) followed by NAA (40 ppm) and NAA (20 ppm) significantly improve morpho-physiological characters, yield and yield components in pigeon pea

### 2.1.2 Germination percentage

Poor germination in different pulse seed is a general problem in grain pulse production. Due to some external factors like soil salinity, sensitivity to moisture regimes, heat and cold stress pulses suffer from lower germination percentage. These stresses can be managed by application of growth regulators to ensure higher germination percentage. There are evidences that different synthetic and natural growth regulators improve germination of seed and seedling vigour of many crops (Mohanty and Sahoo, 2006; Renugadevi and Vijayageetha, 2009). It was observed that seedling length of soybean was increased by soaking seeds in 25-50 ppm NAA (Maske *et al.*, 1997). The growth regulators from organic (Panchgavya, lemon) and inorganic sources (GA3, IAA) increase the germination and vigour of pulse crop seeds. Brassinolides are known to improve germination of seed and cause elongation of hypocotyls, epicotyls and peduncles in dicots. Akbari, *et al.*, (2008) reported that green gram germination and yield attributes significantly increased by application of gibberlic acid (GA3) in saline conditions. Chauhan, *et al.*, (2009) concluded that GA3 application increase germination percentage, also results in higher radicle and plumule length. Previous researchers have shown that, in germinating seeds GA3 plays important role in supplying stored assimilates to growing embryo, thus significantly improves germination percentage and ensures proper plumule and radicle development. Pramoda *et al.* (2018) application of NAA 40 ppm followed by Nitrobenzene 200 ppm recorded higher seed quality parameters like germination (91.53 %), root length (25.21 cm), seedling vigour index (4690), seedling dry weight (33.96 mg).

### 2.1.3 Indeterminate growth habit

Pulse crops possess indeterminate growth habit. Indeterminate growth causes inter-organ competition, overlapping of vegetative and reproductive phase, inefficient allocation of

photosynthates and delayed maturity. This causes failure of pods to set seeds, poor harvest index, low overall seed quality and low seed yields. Gibbrellin (GA3) application in pea @100 ppm resulted in lower number of days taken to first flowering (Thomson *et al.*, 2015). Upadhyay, (2002) observed application of kinetin in chickpea results that higher number of days taken to maturity which also corresponded to higher no. of grains/pod, pods/plant and seed yield. SA stimulate flowering and increased the flower life period and controls uptake of iron by roots and stomatal conductivity in pigeon pea (Bhupinder and Usha, 2003).

### 2.1.4 Decline in nodule activity mainly after pod initiation stage

All pulse crops require healthy root systems to maximize growth and yield. Healthy nodulation of pulse roots is important to maximise the nitrogen fixation. In pulses such as chickpea and cowpea up to flowering stage the number of nodules per plant increases but in post-flowering stage there is sudden decline in number of nodules due to disintegration. Sinha, *et al.*, (1988) reported at post-flowering stage there is decrease in nitrogen per plant. Dayal and Bharti (1991) and Garg *et al.*, (1995) observed kinetin induced increase in nodule dry weight and nitrogenous activity.

Sinha *et al.*, (2002) found that increase in nodule number and dry weight of ascorbic acid treated moong and pea plants. Senthil *et al.*, (2004) reported that foliar application of NAA @ 10 ppm was maximum protein accumulation in green gram. Medhi *et al.*, (2014) reported that NAA (50ppm) application in green gram led to significantly higher number of nodules per plant, nodule fresh weight and dry weight. Ali and Bano, (2008) studied the effect kinetin and ABA in chickpea on nodule senescence and observed that kinetin delayed senescence while ABA enhanced it.

### 2.1.5 Slow dry matter accumulation

Pulses are characterized with slow initial dry matter accumulation due to their lower leaf area index (LAI) and photosynthetic rates the dry matter accumulation takes place when photosynthesis is greater than respiration. Singh (2001) conducted an experiment to study the effect of mepiquat chloride (MC) in green gram at various concentrations reported that MC reduced plant height and increased dry matter accumulation over control. Application of TIBA and GA3 results higher total dry matter accumulation in cowpea (Ganiger, *et al.*, 2002). GA3 and NAA significantly improve translocation of assimilates resulting in dry matter accumulation and higher yield. Sengupta, *et al.*, (2001) found that application of brassinolide significantly improve the dry matter accumulation in green gram at 45 and 60 DAS. Ramesh and Ramprasad, (2013) reported that application of growth regulators such as NAA, brassinosteroids and mepiquat chloride result in higher net assimilation rate and higher crop growth rate (CGR).

### 2.1.6 Photosynthetic characteristics (C3 pulses)

The potential photosynthetic activity of plants determines the yield of a crop. In c3 plants rubisco catalyses carboxylation and oxygenation to initiate the photosynthesis. Higher Co2 compensation point and lower light saturation point of c3 pulses generally reduce the photosynthetic rate leads to reduce the yield. Decline in photosynthetic rate has been observed in post-flowering period which is attributed to factors like loss of activity of rubilose 1,5-biphosphate (RUBP) carboxylase. Application of NAA @ 20 ppm in green gram was found to significantly increase relative chlorophyll content and photosynthetic rate. Similar effect of growth regulators on chlorophyll content was found by Reddy, *et al.*, (2009). The



exogenous application of ABA on green gram under prolonged drought conditions resulted in improved water use efficiency with stable photosynthetic rates. Ramesh *et al.*, (2014) reported with the application of NAA (20ppm) the biochemical parameters like, chlorophyll content was increased significantly.

### 2.1.7 Flower and pod abscission

Growth regulators known to improve pod setting by decreasing the flower and pod abscission by altering hormonal balance of plant (Singh 1989; Datta *et al.*, 1977). In earlier sown crops growth retardants such as cycocel and maleic hydrazide are proved to be more effective, which suffers due to excessive vegetative growth and for late sown crops growth promoters such as cytokinin and auxin are proved to be beneficial, which suffers from limited vegetative growth resulting poor pod setting in both cases. In pulses each flower is capable of producing greater number of seeds, high flower shedding leads to reduction in yield. The disintegration of nodules due to limited nitrogen availability accelerate the shedding process. The flower and pod shedding is very common problem in pulses like green gram. This problem of flower shedding can be controlled by application of plant growth regulators at proper growth stages. Rao *et al.*, (2005) observed that application of 50 ppm MC, 1.25 ppm Tricontanol (TRIA), 0.2 % borax and 1 % potassium nitrate in chickpea results high flower setting and seed yield. Ibrahim *et al.*, (2007) reported that application of benzyl adenine (BA), IAA reduced flower abscission percentage in *Vicia faba*. Tripathi *et al.*, (2009) determined the response of growth regulators on flower drop, growth and yield of Pigeon pea TIBA @ 25 and 50 mg litre<sup>-1</sup>, IAA @ 25 and 50 mg litre<sup>-1</sup>, Kinetin @ 5 and 10 mg litre<sup>-1</sup> and NAA @ 25 and 50 mg litre<sup>-1</sup> was done twice at 35 and 75 DAS. Stated that application of TIBA @ 25 and 50 mg litre<sup>-1</sup> improved flower production and pod setting in pigeon pea. Shyam *et al.*, (2018) reported that application of ethrel @ 1.0 l/ha at 55-60 DAS in summer green gram improved the pod setting percentage by 15.4 %.

### 2.1.8 Growth attributes

Kumarvelu *et al.*, (2000) studied that impact of triacontanol (0.5 mg dm<sup>-2</sup>) increased plant height when sprayed at 15 and 20 DAS in green gram. Jeyakumar *et al.*, (2008) reported that in black gram at pre-flowering stage foliar application of NAA @ 40 ppm resulted in increased plant height, number of branches and higher leaf area index. Sengupta *et al.* (2011) revealed that application of brassinolide @ 0.25 ppm had significant influence on growth and seed yield of summer green gram. Leite *et al.*, (2003) reported that foliar application of GA3 in soybean increased the plant height, first nodal elongation and stem diameter. Patil *et al.*, (2005) studied that increase in plant height, number of branches per plant in mungbean spraying of NAA (25 ppm). Ibrahim *et al.*, (2007) reported that application of GA3 (100 ppm) in *Vicia faba* increases the plant height, average number of leaves and leaf area per plant. Aucharmal *et al.*, (2007) and Jeyakumar *et al.*, (2008) reported that application of NAA @ 40 ppm in black

gram increased plant height compared to control. Udensi *et al.*, (2013) reported that reduced plant height, increased the number of branches and also improve the seed yield by the treatment of pigeon pea seeds with paclobutrazol. Sumathi *et al.*, (2016) reported that increase in plant height, number of leaves and branches by the foliar application of gibberellic acid (GA3) in pigeon pea.

### 2.1.9 Grain yield

Kalita (1989) reported that foliar application of NAA 20 ppm on green gram cause significant increase in number of pods. The protein content of green gram was increased by foliar application of NAA 40 ppm (Singh and Awasthi 1998). The grain yield of pulse crops were significantly increased by application of growth regulators. Mohandoss and Rajesh (2003) reported in cowpea application of 200 ppm GA3 increased seed yield (254 percent) and dry matter (59 percent) compared to control. Growth regulators applied at proper time and stage, resulted in higher yield as reported by (Kumaran and Subramaniam 2001). GABA at 1.0mg L<sup>-1</sup> increased growth of the plant and seed yield in chickpea (Hoque, 2005) and in soybean (Rahim, 2005). Varma *et al.*, (2009) reported that number of branches plant<sup>-1</sup> and harvesting index in black gram are increased by foliar application of Triacontanol. The foliar application of brassinolide and salicylic acid improves grain yield and nutritional quality of green gram (Bera *et al.*, 2008). Application of 125 ppm salicylic acid to black gram plants increased seed yield (Jeyakumar *et al.*, 2008. Devi *et al.*, (2011) observed that application of 50 ppm salicylic acid in soybean at flower + pod initiation stage increased the grain yield. Tripathi *et al.*, (2009) reported that spraying of TIBA (25 mg and 50 mg l<sup>-1</sup>) and NAA (25 mg and 50 mg l<sup>-1</sup>) increased seed yield and harvesting index of pigeon pea of (20.9% and 25.0%) respectively. Pradeep kumar patel *et al.* (2012) reported yield of chickpea was increased by application of salicylic acid. Medhi *et al.*, (2014) reported that highest yield of green gram recorded by foliar application of NAA @50ppm. Rajesh *et al.* (2014) reported comparative study of effect of plant growth regulators on morphological, seed yield and quality parameters of green gram. The seed yield increased significantly with NAA @ 20 ppm followed by brassinosteroid (20 ppm). Rathod *et al.*, (2015) reported that application of GA3 100 ppm produced maximum number of green pods (44.57), yield (0.140) per plant and yield (119.70 q) per hectare in cowpea. Sumathi *et al.* (2016) concluded that increase in various yield components namely days to 50 percent flowering, days to maturity, number of flowers per plant, number of pods per plant and number of seeds per pod with the foliar application of 0.1 ppm Brassinosteroid. Khatun *et al.*, (2016) reported that salicylic acid gives the highest number of seeds pod<sup>-1</sup>, small size seed, harvest index (1.60, 19.47%, 39.06%). Salunkhe *et al.*, (2017) studied influence of growth regulators namely TIBA (100 ppm), NAA (50 ppm), GA3 (50 ppm), CCC (500 ppm), CC (1000 ppm) on soybean among these NAA (50 ppm) found to be higher grain yield.

**Table 1:** Application of different levels of plant growth regulators on black gram

Growth regulators	Test weight (g)	Germination (%)	Protein (%)
RDF+ foliar application of IAA @ 600ppm	56.81	86.30	24.22
RDF+ foliar application of Ethrel @ 250ppm	54.37	84.25	23.29
RDF+ foliar application of GA3 @ 30ppm	59.03	88.10	24.96
RDF + foliar application of SA @ 100ppm	54.18	82.80	23.55
RDF+ foliar application of NAA @ 40ppm	56.29	86.41	24.37

(Source: May-June, 2019; IJPAB)

**Table 2:** Effect of growth regulators on quality, yield attributes and yield of chickpea

Growth regulators	Pods per plant	Seed weight per plant (g)	Seed index	Seed yield (kg ha-1)	Stover yield (kg ha-1)	Biological yield (kg ha-1)	N content in seed (%)	Protein content in seed (%)
GA3 50ppm at flowering stage	64.67	20.00	20.00	2811	3041	5851	3.53	22.08
GA3 50ppm at pod filling stage	63.67	19.00	19.00	2394	2855	5249	3.27	20.42
GA3 100 ppm at flowering stage	67.67	22.66	20.67	2941	3241	6181	3.93	24.58
GA3 100 ppm at pod filling stage	61.33	17.00	17.67	1982	2655	4636	3.17	19.79
Kinetin 5 ppm at flowering stage	64.33	19.67	19.47	2696	2978	5674	3.47	21.67
Kinetin 5 ppm at pod filling stage	60.33	18.00	18.00	2266	2713	4979	3.20	20.00
Kinetin 10 ppm at flowering stage	65.00	21.00	20.33	2881	3136	6017	3.77	23.54
Kinetin 10 ppm at pod filling stage	61.00	18.67	18.67	2372	2757	5129	3.23	20.21

(Source: JPP 2018; 7(6): 669-672)

**Table 3:** Influence on morpho-physiological parameters and yield components on pulses

Crop	Chemical dosage and its stage of usage	Findings
Greengram	2.0 percent diammonium phosphate + naphthalene acetic acid @ 40 ppm + boron @ 0.2 percent + molybdenum @ 0.05 percent at 30 days after sowing	Higher plant height (32.27) at harvest
Blackgram	2.0 percent urea along with 1 ppm brassinollide at 25 days after sowing and 10 days after first spray	Higher leaf area index (0.34, 0.82, 1.89, 1.65) at vegetative and flowering stage
Blackgram	40 ppm naphthalene acetic acid + 0.5 percent chelated micro nutrient at 30 and 50 days after sowing	Higher leaf area (12.54 dm <sup>2</sup> plant <sup>-1</sup> ), leaf area index (4.18), leaf area duration (60.45 days), crop growth rate (0.19 g m <sup>-2</sup> day <sup>-1</sup> ) and total higher dry matter production (15.98 g plant <sup>-1</sup> ).
mungbean	2.0 per cent urea at flowering and pod initiation stage	Higher leaf area (520.83 cm <sup>2</sup> plant <sup>-1</sup> )
Blackgram	2.0 per cent diammonium phosphate + 100 ppm salicylic acid + 0.05 per cent sodium molybdate to at vegetative and flowering stage	Higher pods per plant (34), grain yield (928 kg ha <sup>-1</sup> ) and haulm yield (1230 kg ha <sup>-1</sup> ).
Blackgram	2.0 per cent urea + 1 ppm brassinollide at 25 days after sowing and 10 days after first spray	Higher no. of pods per plant (28.5), seeds per pod (7.20), 100 seed weight (5.1 g) and grain yield (893.3 kg ha <sup>-1</sup> ).
Transplanted pigeonpea	Pulse magic (It contains 10 per cent nitrogen, 40 per cent phosphorous, 3 per cent micronutrient and 20 PPM plant growth regulator) @ 10 g/l to at 50 per cent flowering stage and 15 days after first spray	Higher number of pods per plant (1365), number of seeds per pod (3.5), 100 seed weight (11.34 g), and seed yield (220 g plant <sup>-1</sup> )
Greengram	2 per cent Diammonim phosphate along with potassium chloride @ 1 per cent and naphthalene acetic acid @ 40 ppm at flowering stage	Increased total dry matter production (24.08 g plant <sup>-1</sup> ) over control (20.24 g plant <sup>-1</sup> ).
Blackgram	2.0 per cent urea and 0.1 ppm brassinollide at 25 days after sowing	Higher total dry matter at vegetative stage (2.12 g), flowering stage (4.85 g).

Ref: Int. J Pure App. Biosci. 2017; 5 (5): 787-795.

### 3. Conclusion

This review paper suggests that, plant growth regulators play important role in growth and development of pulse crops. Growth regulators deals with physiological limitations in pulse crops and improve their productivity. Improvement of source-sink relation is achieved by application of growth regulators. There is need to create awareness of plant growth regulators about usefulness as well as ensuring their availability at wider spread rate. The plant growth regulators effect on physiological limitations and enhances the pulse productivity.

Growth regulators like brassinollide and gibberellic acid ameliorate the germination parameters. The flowering and pod abscission get put off by the application of spermine, kinetin. Growth regulators such as IAA assure high nodule activity in pulses. NAA ensure greater dry matter partitioning and yield in pulses. Application of GA3 alone or in combination with ABA results higher yield of pulses.

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