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Enhancing the growth and yield of pigeon pea through growth regulators

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Abstract
Pulses are the important sources of proteins, vitamins, minerals and are popularly known as Poor man's meat" and "rich man's vegetable", contribute significantly to the nutritional security of the country. Besides being rich organic source of protein, they maintain soil fertility through biological nitrogen fixation and improve the soil organic matter by defoliation at maturity. Hence, they occupy prominent place in various inter cropping systems and crop rotations. Thus pulses play a vital role in furthering the sustainable agriculture Pulses are a vital source of plant-based proteins and amino acids for people around the globe and should be eaten as part of a healthy diet to address obesity, as well as to prevent and help manage chronic diseases such as diabetes, coronary conditions and cancer; they are also an important source of plant-based protein for animals. Pulses accounts for 42.34 and 36.86 percent of total world pulse area total world's pulse production respectively (Agricultural statistics at a glance, 2016).
Plant growth retardants play key role in contributing internal mechanisms of plant growth by interacting with key metabolic processes such as, nucleic acid metabolism and protein synthesis. Growth retardants are known to reduce inter-nodal distance, thereby enhancing source-sink relationship and stimulate the translocation of photo-assimilates to the seeds (Luib *et al*., 1*987*). Growth regulators exert their influence on foliar transport in a number of ways. These could enhance the absorption by the leaf at the site of application, increase the migration within the leaf and stimulate the transport out of leaf in the acropetal and basipetal direction.

Keywords: Growth, yield, pigeon pea, growth regulators

Introduction
Pigeonpea [*Cajanus cajan* (L.) Millsp.] also known as arhar or tur or redgram, is the second most significant pulse crop of India after Bengalgram. In Punjab pigeonpea was grown on an area of 2.6 thousand hectares and the total production was 2.63 thousand tonnes with average yield of 10.13 quintals hectare^{-1}. In Marathwada region area under pigeonpea was 5.95 lakh hectares with the production and productivity of 9.14 lakh tonnes and 1373 kg/ha, respectively. (Anonymous 2017) [1].
Pulses occupy an indispensable place in our daily diet as a source of protein. Pulse crops also have the unique potentiality to associate symbiotically with Rhizobium sp. and fix atmospheric nitrogen, thereby enriching the soil. The production of pulses has remained almost stagnant at around 13-14 million tonnes for the last many years. As a result of ever increasing population, the per capita availability of pulses has shown a sharp decline in recent years and it has come to less than 40 g/day at present, against a normal requirement of 69 g/day. To alleviate the problem of protein malnutrition in the country, it is very much imperative to enhance the production of pigeonpea, as it is an important pulse crop in the country as well as in the state. It is mainly grown in almost all the states and larger portion of the area is in the states like Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka and Gujarat. 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 (Udaya *et al.,* 2015) [20].
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) [8]. So to achieve optimum vegetative growth and to effect better translocation of photosyntates into the developing pods, use of growth retardants appears to be

an effective approach. The Plant growth regulators are also known to enhance the source sink relationship and stimulate the translocation of photo assimilates, thereby increase the productivity. Several studies on different crops have shown that the exogenous application of GA_3, an important GAs can enhance the productivity of crops affecting the vital physiological processes (Khan *et al*., 2002; Bora and Rahman *et al*., 2004) [9] .

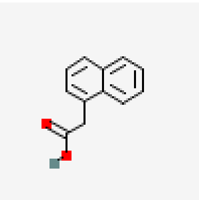
Plant growth regulators in general, increase the number of flowers on the plant when applied at flowering stage. Flower and pod drop may be reduced to some extent by spraying various growth regulators (Ramesh and Thirumuguran, 2001), which prove that yield and quality parameters in food legumes may be enhanced by suitable application of Plant growth regulators.

The pod set, as percentage of flowers produced, varies widely in pigeon pea. The effect growth regulators like of TIBA (2, 3, 5-triiodobenzoic acid) on soybeans has been studied by several workers, NAA (1-naphthalene acetic acid) has been reported to increase yields of *P. mungo* Roxb. There is scant information on the influence of growth regulators on pigeon pea.

Growth regulators

The chemical control of the plant growth to reduce the size through the use of plant growth regulators is a common practice to make a plant more compact and commercially more acceptable. A number of synthetic compounds are known to manage shoot growth in higher plants without being phytotoxic or causing malformation or damage (Salisbury & Ross 1994). Some of these substances have been found in agricultural practices , since they reduce the rate of stem elongation and have been shown to be involved in the regulation of photosynthesis and the movement of photosynthetic products from their site of synthesis in the leaf to the site of accumulation (Thomas, 1986; Krishnamoorthy, 1993; Khan 1996; Khan *et al.*, 2000, Lone 2001, Mir 2002 Mir *et al*. 2008; Mir *et al.*, 2009) [19, 10, 12, 14, 15, 13]. So to achieve optimum vegetative growth and to effect better translocation of photosyntates into the developing pods, use of growth regulators appears to be an effective approach.

i. NAA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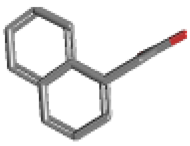
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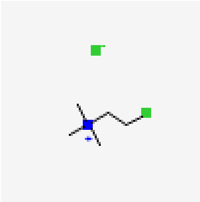
1-naphthylacetic acid is a naphthylacetic acid substituted by a carboxymethyl group at position. Plant growth regulator. 1-Naphthaleneacetic acid is used for control of preharvest fruit drop, flower induction and fruit thinning in various crops such as apples, potatoes, olives and citrus fruits. 1-Naphthaleneacetic acid (NAA) is a plant hormone in the auxin family. 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. Pandey (1975) recorded that the application of NAA enhanced biomass production and seed yield in pigeonpea and soybean.

ii. Chlormequat chloride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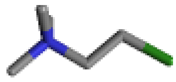
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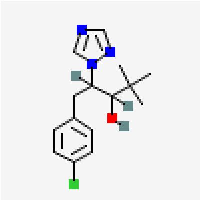
Growth regulators have been found to affect palnt height (Sauerbrey *et al*., 1987; Guruprasad and Gurupasad, 1988; Djkstra and Kuiper, 1989; Kishnamooerthy, 1993) [16 5, 10]. Trtiary ammonium compounds like CCC produced reduction in height without any malformation by reducing cell elongation and also by lowering cell division (Rademacher and Jung, 1986; kar *et al*., 1989; Choudhary and Gupta *et al*., 1996 Lone 2001) [4, 12] Ghora *et al* (2000) [6]-Found that the application of cycocel at 500 ppm, applied at 45 cm plant height, reduced primocane height without reducing the number of nodes, and enhanced anthesis and fruit ripening by about 10 days. Yield significantly increased by 90% without affecting berry size compared to the control or 100 ppm Cyclocel application. Cycocel at 1000, 2000 or 4000 ppm caused phytotoxicity. And higher concentrations and/or double application caused excessive plant dwarfness. Kshirsagar *et al*. (2008) [11] observed that application of cycocel @ 150 ppm was found beneficial in decreasing plant height, number of leaves and leaf area per plant. It was also observed that there was increase in number of nodules and number of lateral branches per plant.

iii. Paclobutrazol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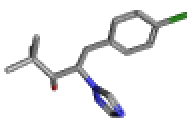
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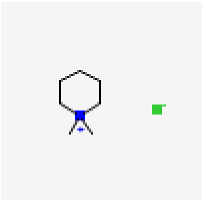
Paclobutrazol as reported point to its height reducing ability while taking into cognizance the possibility of synergism in interaction of these PGRs, which couldlead to better morphological and yield performances (Tekalign and Hammes 2005; Kalyankar *et al*., 2008). Plant growth regulators are known to regulate metabolism in the plant.

Paclobutrazol coded as PP333, is recently introduced among other growth retardants, which counteract the gibberellin biosynthesis. The chemical was first used in England in 1978, followed by different European countries, including U.S.A.in

1982. However, in India, utility of this chemical was first reported on commercial scale for introduction of early and regular cropping in Alphonso mango by Burondkar *et al*. (1991) [3]. Berova and Zlatev (2000) [2] observed that the paclobutrazol (PBZ) accelerates fruit formation and increases early fruit yield. Husen *et al*. (2012) [7] showed that paclobutrazol accelerate the induction of flowering as indicated by the number of flowering plant, the more flower, faster emergence, rate of flowers, the more petals, but the length and width of inflorescences is shorter than the control. Valle and Dealmedia (1991) [21] reported by paclobutrazol decrease the diameter, height, leaf number and leaf area in all concentrations.

iv. Mepiquat chloride



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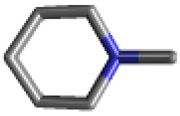

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The use of growth regulators can prove propitious in managing physiological flaws, altering the growth behaviour and quality of crops and their produce (Jaidka *et al*, 2018). As per Solamani *et al* (2001), growth regulators can improve the physiological efficiency including photosynthetic ability and can enhance the effective partitioning of accumulates from source to sink in the field crops. Application of chlormequat chloride @ 187.5 g a.i./ha resulted in significantly higher seed protein content (20.63%) followed by mepiquat chloride 5% AS and chlormequat chloride @ 162.5 g a.i./ ha (Rajesh *et al*, 2014). Rajput *et al*. (1996) noticed morpho-physiological attributes, which differed significantly due to the rate and stage of plant growth promoter application. Cycocel @ 50 ml ha^{-1} and mepiquat chloride @ 1.25 lit ha-1 at flower initiation stage were statistically *at par* with each other but significantly reduced plant height, increased biomass and number of branches per plant in mustard.

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