REVIEW ARTICLE

ROLE OF PLANT GROWTH REGULATORS IN HYBRID SEED PRODUCTION

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Abstract: The production potential of vegetable seed production depends on many factors, among them; plant growth regulators appreciably influence the growth, yield and quality of produced seed. Plant growth regulators play an important role in the formation of flowers, stems, leaves, shedding of leaves, and the development and ripening of fruit. Plant growth regulators shape the plant, affecting seed growth, time of flowering, the sex of flowers, senescence of leaves, fruit drop and quality seed. Therefore the available literatures relating to the response of plant growth regulators on seed yield, flowering and quality of seed crops carried out at various places in India and abroad have been briefly reviewed in order to throw light on our existing knowledge, for understanding role of plant growth regulators.

Keywords: PGR, Seed production, Gamotocides, Seed yield

INTRODUCTION

The plant growth substances are organic compounds, other than nutrients which in small concentration influence the physiological processes of plants. Growth regulators are also reported to improve yield of many horticultural crops those in which the seed is the economically important. Hormones regulate cellular processes in targeted cells locally and, moved to other locations, in other functional parts of the plant. Hormones also determine the formation of flowers, sex expression, stems, leaves, the shedding of leaves, and the development, ripening of fruit. The present study is to review the importance of these plant hormones in commercial hybrid seed production as these chemical substances are much useful in synchronous maturity of male and female lines, complete exertion of flower from leaf whorl, induction of more female flowers, formation of more sympodial (flowering) branches and induction of temporary male sterility in any line without affecting female sterility etc.

Table 1. Plant Hormones Vs Plant Growth Regulators

	Plant Hormones	**Plant Growth Regulators**
Definition	Chemicals produced naturally by the plants	Chemicals either produced naturally by the plants or synthesized artificially by humans
Synthesis	Synthesized as result of plant metabolic processes	Formulated by humans
Origin	These are Endogenous	These are Exogenous
Effect	These are long – lived chemicals. Hence, the effect is long lasting	These are short lived chemicals. Hence, the effects are temporary and reapplication is required.
Examples	Auxin, Gibberellin, Cytokinin, Ethylene and Abscisic Acid	NAA, IBA, Ethephon, etc

Jatindersingh (2014)

Table 2. Classification of PGR's

S.NO	GROWTH REGULATOR	EXAMPLE
1	Auxins	IAA, IBA, NAA, 2,4-D
2	Gibberellins	Gibberellic acid
3	Cytokinins	Kinetin, Zeatin
4	Ethylene	Ethylene
5	Dormins	Abscisic Acid
6	Flowering hormones	Florigen, Anthesin, Vernalin
7	Miscellaneous Natural substances	Cyclitols, Vitamins, Phytochrome, etc.
8	Phenolic substances	Coumarin
9	Synthetic growth retardants	CCC, Phosphon-D, Maleic hydrazide (MH) etc.

Jatindersingh (2014)

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Effect of plant growth regulators on seed germination and seed dormancy

Seed germination

Germination is the crucial and final event in the life of a seed. It can be defined as the resumption of active growth of the embryonic axis. A seed requires moisture, a favorable temperature and oxygen for germination. Rehydration of the seed sets in motion a chain of reactions which provide the energy and building blocks for the resumption of active growth and development of the young seedling. Germination failure is caused by many factors and conditions. These range from deterioration of the seed and loss of the germinative capacity to the mechanical impedance to emergence from soil crusts formed after sowing. (James C. Delouche)

Seed dormancy:

Seed dormancy is a mechanism that prevents a viable seed from germinating when placed in an ideal environment for germination. Dormancy also helps distribute the germination in time through its dependence on environment. Seed dormancy is main problem in potato, lettuce, tomato, muskmelon many other vegetable crops. Chemicals which have been reported to break the rest period are GA, Ethylene chlorhydrin and Thiourea.

Table 3. List of plant growth regulators on seed germination and seed dormancy

Growth regulators	Conc.	Method of application	Crops	Attributes affected	Reference
IAA, IBA and NAA	100 ppm	Pre sowing seed treatment	Tomato	Enhanced the seed germination	Olaiya *et al.*,2009
GA_3 and KNO_3	50 ppm	Pre sowing seed treatment	Endive and Chicory	Enhanced the seed germination	Tzortzakis, 2009
Ethephon (CEPA)	480 mg/liter	Seeds soaking	Muskmelon	Improves germination at low temperature	Meena, 2015
Indole-3-Acetic acid (IAA)	10-15 mg/liter	Foliar spray	Okra and Brinjal	Enhance seed germination,	Khan *et al.*, 2013
Naphthalene acetic acid (NAA)	25-30 mg/liter	Seed/ foliar	Okra , Brinjal, Onion, Cucurbits	Enhance seed germination,	Khan *et al.*, 2013
Naphthoxy-Acetic acid (NAA)	25-100 mg/liter	Seed/ foliar	Tomato, Okra	Enhance seed Germination	Prasad *et al.*, 2013
Thiourea	1% aqueous solution	Soak the tubers 1 hour	Potato	Break the dormancy	Prajapati S. *et al*., 2015
GA_3	5-10 ppm	Soak the tubers 10-20 min	Potato	Break the dormancy	Prajapati S. *et al*., 2015
GA_3 or Cytokinin	5-10 ppm	Seed treatment	Lettuce	Break the dormancy	Prajapati S. *et al*., 2015

Effect of plant growth regulators on flower characters

Induction of flowering which otherwise fails to flower has also been reported with the use of various growth regulators.

Table 4. List of plant growth regulators on flower characters

Growth regulators	Conc.	Method of application	Crops	Attributes affected	Reference
Cycocel (CCC)	250-500 mg/l	Foliar spray	Cucurbits, Tomato, Okra	Flowering	Prajapati S. *et al*., 2015
Ethephon (CEPA)	100-500 mg/l	Foliar spray	Cucurbits, Okra and Tomato	Flowering	
Gibberellic acid (GA)	300 ppm	Plant spray	Tomato	Early flowering	Sharma *et al.*,1992
Naphthalene acetic acid (NAA)	10-20 mg/l	Foliar sprays	Chillies and Tomato	Flower drop	Prajapati S. *et al*., 2015

Silver nitrate	500 mg/l	Foliar spray	Cucumber	Induction of male flower in gynoecious lines	Dalai, S. *et al*., 2015.
Silver thiosulphate	400 mg/l	-	Musk melon	Induction of male flower in gynoecious lines	Prajapati S. *et al*., 2015
2,3-5, tri-iodobenzoic acid (TIBA)	25-50 mg/l	Foliar sprays	Cucurbits	Flowering	Prajapati S. *et al*., 2015
Silver nitrate	500	Foliar spray	Cucumber	Induction of male flower in gyn, lines	Dalai. K. *et al*., (2015).

Effect of plant growth regulators on sex expression and parthenocarpy

The treatment with growth regulators has been found to change sex expression in cucurbits, okra and pepper. Female inducing hormones are Auxin and Ethylene, whereas male inducing hormone is Gibberellic acid. Studies on use of growth regulators in many vegetables have shown an increase in the fruit size with their applications. The role of plant growth regulators in fruit development can also be seen from the fact that with their help it is possible to stimulate fruit development without fertilization (parthenocarpic).

Table 5. List of plant growth regulators on sex expression and parthenocarpy

Growth regulators	Conc.	Method of application	Crops	Attributes affected	
Ethephon	100 ppm	Two true leaf stage	*Cucurbita maxima* and *C. pepo*	Suppression of male flowers, Increases female flowers. Increase in the ratio of female to male flowers per plant	Hume *et al.,* 1983
Ethephon (CEPA)	100-500 ppm	Foliar spray	Okra and Tomato	Sex expression	Ravat *et al.,* 2015
Gibberelic acid (GA)	10 mg/l	Foliar spray	Water melon, Tomato	Sex expression	Prajapati S. *et al.,* 2015
Cycocel (CCC)	250-500 mg/l	Foliar spray	Cucurbits, Tomato, Okra	Sex expression	
2,4- D at	50 ppm	Applied at anthesis	Kakrol	Parthenocarpic fruit development	Prajapati S. *et al.,* 2015
2,4- D	2-5ppm	Seed treatment	Tomato	Early fruit set and Leads to parthenocarpy	Prajapati S. *et al.,* 2015
GA3 and Silver nitrate	1500 ppm and 200-300ppm	Foliar spray	Cucumber	Staminate flowers were induced in parthenocarpic line	Sandra et al., 2015

Effect of plant growth regulators on fruit set and fruit yield

Poor fruit set is a major problem in tomato, brinjal and chillies which is frequently caused by adverse weather conditions during flowering. Plant growth regulators have been reported to enhance fruit set under both normal and adverse weather conditions.

Table 6. List of plant growth regulators on fruit set and fruit yield

Growth regulators	Conc. (mg/l)	Method of application	Crops	Attributes affected	
Cycocel (CCC)	250-500	Foliar spray	Cucurbits, Tomato, Okra	Increases fruit yield	Chauhan *et al.,* 2017

Para - Chloro Phenoxy Acetic acid (PCPA)	50	Foliar spray	Tomato	Increases fruit set and Yield	Prasad *et al.*, 2013
Ethephon (CEPA)	100-500	Foliar spray	Cucurbits, Okra and Tomato	Increases yield	Ravat *et al.*, 2015
Gibberellic acid (GA)	10	Foliar spray	Water melon, Tomato	Increases fruiting and Yield	Prajapati S. *et al*., 2015
Indole-3-Acetic acid (IAA)	10-15	Foliar spray	Okra, Tomato, Brinjal,	Increases fruit set and Yield	Ravat *et al.*, 2015
Naphthalene acetic acid (NAA)	0.2	Seedling deep roots deep	Tomato, Brinjal, Onion	Increases growth and yield	Prajapati S. *et al*., 2015
	10-20	Foliar sprays	Chillies and Tomato	Increases fruit set and Yield	Singh *et al.*, 2017
	25-30	Seed/ foliar	Okra ,Tomato, Brinjal, Onion, Cucurbits	Increases growth and Yield	Prajapati S. *et al*., 2015
Naphthoxy-Acetic acid (NAA)	25-100	Seed/ foliar	Tomato, Okra	Increases growth and Yield	Prajapati S. *et al*., 2015
2,3-5, tri-iodobenzoic acid (TIBA)	25-50	Foliar sprays	Cucurbits	Increases yield	Sandra *et al.*, 2015
Tricontanol	2	Foliar sprays	Chillies and Peas	Increases fruit set and Yield	Raj *et al.*, 2016
Maleic hydrazide (MH)	400ppm	2 and 4 leaf stage	Bottle gourd	Increases fruit set	Hidayatullah *et al.*,2012

Role of plant growth regulators as gametocides in hybrid seed production.

The failure of plant to produce functional flowers is known as sterility. Sterility can be induced by applications of certain plant growth regulators like auxins and anti-auxins like NAA, TIBA, 2,4-D , MH,GA, Ethephon and other arsenicals etc. They act by disruption of meiosis, exine layer formation resulting in thin layer with irregular non viable microspores formation. Decrease in starch deposition and abnormal vacuoles in microspores, persistence and abnormal growth of tapetal layer which is nutrition supply layer for developing microspores. They act at specific stage that is panicle initiation (pre- meiotic) bolting stage (meiotic) and flowering stage (post meiotic).They lead to pollen abortion and thereby causing male sterility. Therefore, there is no need to develop maintainer line and CMS lines by which it saves time, labor, space, resource, money and eases the commercial hybrid seed production at larger scale. It can be an effective substitute for hand emasculation thereby reducing very significantly the time normally required for emasculation in greenhouse o field breeding programs.

Table 7. List of plant growth regulators as gametocides in hybrid seed production

Growth regulators	Conc.	Method of application	Crops	Attributes affected	
Gibberellic acid (GA_3)	100mg/lit	10 days interval from onset of flowering for three times	Capsicum	Helps in induction of male sterility	Prajapati S. *et al*., 2015
Malaic hydrazide	100 to 500ppm	On set flowering	Egg plant, Okra, Pepper and Tomato,	High level of male sterility without detrimental effect on female sterility	Prajapati S. *et al*., 2015
Gebberelins	0.2 % to 0.8 %	When applied in the beginning of	Onion	Helps in induction of male sterility	Prajapati S. *et al*., 2015

		the bolting process			
2,3- dichloro-isobutyrate	0.2 % to 0.8 %	On set flowering	Muskmelon, Okra, Onion, Root crops, Spinach and Tomato	Possess gametocidal actions to produce male sterility	Prajapati S. *et al.*, 2015
TIBA	0.2 % to 0.8 %	On set flowering	Cucumber, Okra, Onion, and Tomato	Possess gametocidal actions to produce male sterility	Prajapati S. *et al.*, 2015

Table 8. List of gametocides found effective in vegetables

Sl. No.	Male gametocides	Vegetables on which found effective
1	Napthalene acitic acid (NAA)	Cucurbits
2	Gibberelins(GA)	Onion and Lettuce
3	Malic hydrazide (MH)	Tomato ,onion and cucurbits
4	FW450	Tomato ,Ground nut and sugar beet
5	Ethrel	Sugar beet, Wheat and Rice
		Prashanth *et al* .,2006

Role of plant growth regulators in hybrid seed production.

In India, to meet the increasing demand of quality seed, area under hybrids have to be increased which call for development and standardization of hybrid seed production technology. Plant growth regulators spray at flowering time also given very good seed yields in some crops. Some plant growth regulators posses gametocidal actions to produce male sterility which can be used for F_1 hybrid seed production (Akter and Rahman 2010).

Table 9. Role of plant growth regulators in hybrid seed production

Growth regulators	**Conc.**	**Method of application**	**Crops**	**Attributes affected**	
GA_3 Maleic Hydrazide Etherel	50 ppm 100 ppm 50 ppm	Plants spray at three leaf and tendril initiation stage	Bitter gourd	Production of hybrid seeds	Nagamani, 2015
GA_3	100 ppm	40 DAP	Onion	Maximum seed yield/ha	-
CCC (Cycocel)	500 ppm	45 days of transplanting of tomato seedlings	Tomato	Increased seed yield	Kaur *et al*., 2018
NAA NAA	40 ppm 60 ppm	Foliar spray	Chilli Capsicum	Maximum seed seed yield per fruit	Kaur *et al*., 2018
Thiourea	500 ppm	Foliar spray	Okra	Maximum number of seed per pod	Kaur *et al*., 2018
Silver nitrate	500 mg/l	Foliar sprays	Cucumber	Inducing male flowers on gynoecious lines	Prajapati S. *et al*., 2015
Silver thiosulphate	400 mg/ l	Foliar sprays	Muskmelon	Induction of male flower on gynoecious lines	Prajapati S. *et al*., 2015
Lithocin	500 ppm	Foliar sprays	Clusterbean	Maximum seed yield (Kg) / ac	Surwenshi *et al*., 2015

CONCLUSION

Plant growth regulators when applied exogenously no doubt modify the growth and seed yield of plant. But the concentration and the time of application should be taken care of to utilize properly the promoters. The important facet is seed production. Improvement of source-sink balance by the application of plant growth regulators is thus one important aspect of consideration. In the present review study we made an attempt to give the some important action of various plant growth regulators in seed production, sex expression, flower increase and improvement in hybrid seed and induction of male sterility in various crops.

In recent years, scientists have given due attention to the idea of improving the growth, flowering, yield and quality of flower crops with the application of plant growth regulators in various ways. Response of flowering plants to growth regulators treatments are being studied with a view of having compact plants with greater number of flowers and also to hasten or delay flowering according to the needs of growers.

Use of plant growth regulators help to improve the seed yield and quality in many crops. Similarly in flowering plants also plant growth regulators are effective to increase number of flowers and their quality.

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