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Impact of foliar application of plant bio-regulators on yield traits and economics of bottle gourd [*Lagenaria siceraria* (Molina) Standl.]

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Abstract: The present investigation entitled "Impact of foliar application of Plant Bio-regulators on yield traits and economics of Bottle gourd [*Lagenaria siceraria* (Molina) Standl.]" was conducted at Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut during summer season of 2013 and 2014. The experiment was laid out in Randomized Block Design with three replications. The treatments involved in the study were 16 in numbers *i.e.* T_1 GA_3 5 ppm, T_2 GA_3 10 ppm, T_3 GA_3 20 ppm, T_4 GA_3 50 ppm, T_5 GA_3 75 ppm, T_6 NAA 50 ppm, T_7 NAA 75 ppm, T_8 NAA 100 ppm, T_9 NAA 150 ppm, T_{10} NAA 200 ppm, T_{11} ETHREL 50 ppm, T_{12} ETHREL 75 ppm, T_{13} ETHREL 100 ppm, T_{14} ETHREL 150 ppm, T_{15} ETHREL 200 ppm and T_{15} CONTROL (WATER SPRAY) and they were applied at 2 and 4 leaf stages with an objective to study the effect of GA_3, NAA and Ethrel on yield traits and economics of bottle gourd. On the basis of result obtained and summarized from the present study, it can be concluded that all the observations taken for bottle gourd were found to be superior with the application of bio-regulators. In the present study, it was observed that the foliar application of Ethrel 200 ppm increased all the yield traits [*i.e.* days to first picking, number of marketable fruits plant^{-1}, fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield plant^{-1} (Kg) and total yield (q/ha)] followed by 200 ppm NAA and 5 ppm GA_3 whereas, Ethrel 200 ppm also found significantly most economical in terms of net return and cost benefit ratio. Therefore among all the concentrations of bio-regulators applied Ethrel 200 ppm was found significantly most effective in increasing the yield and yield attributing traits.

Keywords: Bio-regulators, GA_3, NAA, Ethrel, yield and economics

Introduction

Among the major contributing vegetables, Bottle gourd [*Lagenaria siceraria* (Molina) Standl.; 2n=22] is an important cucurbitaceous crop which is extensively grown in India and also in tropical and sub- tropical countries of the World. It is probably the only plant known both in New as well as Old World since early pre-historic times (Richardson, 1972). Though the vegetable is quite bland and tasteless, it has many nutritional benefits. This veggie popular these days are its enormous impact on the treatment of high blood pressure and heart disease. Different parts of the bottle gourd have got a lot of medicinal values too (Indira and Peter, 1988). It is believed to have a cooling effect and prevents constipation. The seed oil forms an emollient application for the health and suppressant for headache (Chauhan, 1965). While the tender fruits are widely used as a vegetable, the dry hard shells of the fruits have been used for making a wide range of articles of common use, including bowls, bottles, ladles, containers, floats for fishing nets, pipes and musical instruments.

Bottle gourd exhibits a fascinating range of floral morphology, including staminate and pistillate flowers occurring in various arrangements (Rafeekher *et al*., 2002). Reduced production of female flowers in proportion to male is the main handicap in decreasing fruit production in this monoecious crop. In recent years, plant growth, flowering and yield have been manipulated with the help of growth regulating substances. Some PGR'$_s$ have important effect on sex expression in various cucurbitaceous crops. Also, by decreasing or increasing the male or female flowers, it causes changes in yield (Hilli *et al*., 2010). The term plant growth regulators (also known as plant bio-regulators) cover the broad category of organic substances (other than vitamins and nutrients) that in minute amounts, promote, inhibit or otherwise modify physiological processes (Wareing and Phillips, 1978). The PGRs where endogenous or exogenous, elicit essentially the same plant responses. Presently, PGR$_s$ are used to control a host of physiological processes in crop production, including flowering and fruiting (fruit set and parthenocarpy), partitioning of assimilate, germinate, growth suppression and post-harvest ripening (Weaver, 1975).The principle in sex modification in cucurbits lies in altering the sequence of flowering and sex ratio. Besides the environmental factors, endogenous levels of auxins, gibberellins, ethylene and abscisic acid, at the time and the seat of ontogeny determine the sex ratio and sequence of flowering (Leopold and Kriedemann, 1978). Exogenous application of plant growth regulators can alter the sex ratio and sequence, if applied at 2 and 4 leaf stages, the critical stage at which the suppression or promotion of either sex is possible. Hence, modification of sex to desired direction has to be manipulated by exogenous application of plant growth regulators once, twice or even thrice, at different intervals (Devies, 1987). Ethylene is a plant growth regulator known to alter sex expression in plants belonging to the cucurbitaceous family, increasing the number of pistillate flowers when applied to monoecious plants (Papadopoulou *et al*., 2005).Though the PGR's have great potentialities to influence plant growth morphogenesis, its application and accrual assessments have to be judiciously planned in terms of optimal concentrations, stage of application, species specificity, seasons, etc. which constitute the major impediments in PGR's applicability. In view of their wide spectrum effectiveness on every aspect of plant growth, even a modest increase of 10-15 per cent could bring about an increment in the gross annual productivity by 10-15 million tones. Growth, yield and biochemical analysis in crop plants helps in understanding the contribution of various growth processes in dry matter accumulation and yield production. Such analysis in group of plants will help in identifying the plant growth and yield components for higher productivity. Every plant has the potential of yielding its maximum but maximum production may be achieved, if plant growth regulators are being properly used. The growth regulators include both growth promoters and retardants, which have been shown to modify the canopy structure and other yield attributes (Basra, 2000).Sex mechanism in cucurbits has long been the subject of intensive study by botanists, plant physiologists, geneticists and cytologists. Early efforts to modify the sex ratio in cucurbits were made through the environmental and nutritional manipulating with the advent of growth regulating chemicals. The work on this aspect was initiated with great enthusiasm in many parts of the World with positive results. Therefore, keeping in view of these above facts, the present investigation was carried out with prime objective to study the effect of GA_3, NAA and Ethrel on yield traits of Bottle gourd and to work out the economics of different treatments.

Materials and Methods

A field experiment was conducted at the Horticultural Research Centre, SVPUA & T, Meerut during the year of 2013 and 2014 with the view to study the effect of different levels of growth regulators on yield and economics of bottle gourd cv. Pusa Naveen. The experiment was laid out in a Randomized Block Design with three replications and consisted of 16 treatments, namely five concentration each of GA_3 (5, 10, 20, 50 & 75 ppm), NAA (50, 75, 100, 150 & 200 ppm), Ethrel (50, 75, 100, 150 & 200 ppm) and control (water spray). The seeds were dibbled on each pit at a distance of 2.5 X 1m between rows and plants. All the recommended agronomic practices and crop husbandry were followed to raise a good crop. Two foliar spray of plant growth regulators were done at 2 and 4 true leaf stages. Five vines were selected randomly from each net plot to record the observation namely, days to first picking, number of marketable fruits per plant, fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield per plant (Kg), Yield (q/ha), cost of cultivation (Rs./ha), Gross income (Rs./ha), net profit (Rs./ha) and cost : benefit ratio. The data recorded on different parameter during two consecutive years of investigation were statically analyzed as per the statistical methods described by (Panse and Sukhatme, 1985).

Results and Discussion

Yield parameters:

Days to first picking: Early harvesting fetches good prize of produce in the market. The harvesting period is also extended if first harvesting is advanced. Ethrel (200 ppm) treated plants in the present study had minimum days to first harvesting followed by plants sprayed with NAA (200 ppm) and GA_3 (5 ppm). These results are in closing confirmatory with the findings of Marbhal *et al*. (2005) who reported minimum days to harvesting in bitter gourd when Ethrel was applied on foliage. Minimum days to first harvesting was also recorded in bitter gourd when 200 ppm Ethrel was applied 2 times as foliar application at 2 and 4 leaf stages (Mia *et al*., 2014). These findings also supported by Sulochanamma *et al*. (2001) who observed that foliar application of 250 and 500 ppm Ethrel significantly minimized the number of days to first harvesting in muskmelon. Since Ethrel has a role in stimulating early female flowering therefore Ethrel application in the present study caused early harvesting. The reduction in harvesting time is also possible due to early fruit maturation in plants. This might be due to the fact that ethylene played significant role in the regulation of fruit maturation (Mahala *et al.,* 2014).

Number of marketable fruits per plant: The results obtained on this aspect in the present study indicate the production of maximum number of fruits $plant^{-1}$ with Ethrel (200 ppm) followed by NAA (200 ppm) and GA_3 (5 ppm). These results are similar with the findings of Mahala *et al.,* (2014) who also reported maximum production of fruits per $plant^{-1}$ in bottle gourd when Ethrel (300,200 & 100 ppm) was applied as foliar spray. These results are in conformity with those of Kumar *et al.* (2006), Belherkar *et al.* (2006) and Singh and choudhary (1989) in Bottle gourd. Significantly higher number of fruits in bitter gourd was recorded when foliar application of Ethrel was applied (Imamsaheb and Hanchinmani, 2014). Thappa (2011) while studying the effect of Ethrel had reported that two applications of 100 ppm Ethrel at 2 and 4 leaf stage significantly increased the fruit formation in cucumber. With the increase in the frequency of foliar application of Ethrel the fruit formation in ridge gourd was also significantly increased (Hilli *et al.,* 2010). The significant improvement in fruit formation due to the foliar spray of Ethrel and NAA in the present study might be because of the fact that they increases the metabolic activity of plant, which resulted in enhancement of reproductive phase in plants.

Weight of fruit (g): Fresh weight of fruit is an important yield contributing trait. Therefore, higher female flowers and fruits production is essential. In the present study, it was observed that the foliar application of Ethrel, NAA and GA_3 at different concentrations significantly influenced the weight of fruit. Experimental results clearly indicate that with the increase in Ethrel and NAA concentration, the weight of fruit also increased. The maximum weight of fruit was recorded with Ethrel (200 ppm), followed by NAA (200 ppm) and 5 ppm GA_3 as compared to control. These findings correlate with the results obtained by Mahala *et al.* (2014) who found Ethrel at 100 ppm concentration as the best treatment in increasing the fresh

Table-1: Effect of bio-regulators on yield parameters of bottle gourd cv. Pusa Naveen during 2013-2014

Treatments (ppm)	Days to first picking		No. of marketable fruits plant^{-1}		Weight of fruit (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit yield plant^{-1}		Yield (q/ha)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
GA_3-5	62.12	63.95	9.47	9.55	886	888	35.54	34.49	9.85	9.80	8.32	8.43	333.20	337.400
GA_3-10	65.87	65.52	8.54	8.65	860	863	32.17	31.74	9.14	9.24	7.31	7.42	292.40	296.140
GA_3-20	70.16	70.84	7.97	8.04	842	846	29.94	30.23	8.54	8.43	6.65	6.76	266.31	270.50
GA_3-50	77.22	76.92	7.52	7.49	812	815	28.03	28.25	7.55	7.42	6.11	6.08	244.40	243.75
GA_3-75	77.55	77.83	7.41	7.45	819	800	27.95	27.65	7.35	7.25	6.06	5.96	242.30	238.60
NAA-50	76.73	76.05	7.57	7.55	820	818	28.65	28.46	7.74	7.63	6.20	6.17	248.20	247.58
NAA-75	74.83	75.93	7.60	7.58	830	827	29.24	28.83	7.96	7.84	6.30	6.26	252.20	250.37
NAA-100	68.33	68.94	8.15	8.27	856	849	30.01	30.84	8.84	8.62	6.93	6.96	277.20	278.54
NAA-150	64.44	65.11	8.76	8.84	870	868	33.05	32.66	9.35	9.44	7.56	7.63	302.60	305.71
NAA-200	60.35	61.12	9.63	9.74	895	889	37.34	36.20	9.86	9.89	8.50	8.62	337.00	344.73
Ethrel-50	74.34	74.74	7.64	7.69	836	837	29.45	29.54	8.13	8.06	6.38	6.43	255.40	257.43
Ethrel-100	73.76	73.94	7.75	7.84	840	839	29.84	29.65	8.36	8.25	6.46	6.54	258.60	261.64
Ethrel-150	67.24	68.15	8.36	8.46	860	858	31.46	30.95	8.95	9.12	7.13	7.20	284.54	288.63
Ethrel-150	63.35	64.05	9.02	9.36	876	879	33.94	33.43	9.55	9.74	7.88	7.97	315.37	318.66
Ethrel-200	58.41	59.86	9.87	9.95	900	903	39.41	38.70	9.99	9.91	8.88	8.93	355.33	357.42
Control	77.93	78.53	6.98	6.95	784	796	27.35	26.83	7.15	6.96	5.48	5.32	219.27	221.40
S.E.m.+	0.821	0.910	0.140	0.164	9.33	7.79	0.30	0.30	0.12	0.22	0.07	0.07	3.136	2.333
C.D.@ 5%	2.370	2.627	0.404	0.475	26.96	22.51	0.88	0.86	0.36	0.63	0.20	0.20	9.056	6.737

Table-2: Effect of bio-regulators on the economics of bottle gourd cv. Pusa Naveen during 2013-2014

Treatments (ppm)	Cost of cultivation (Rs./ha)		Gross income(Rs./ha)		Net return (Rs./ha)		B:C ratio	
	2013	2014	2013	2014	2013	2014	2013	2014
GA_3-5	55763.6	56433.6	266560	303660	210796.4	247226.4	3.78	4.38
GA_3-10	55986.3	56656.3	233920	266526	177933.7	209869.7	3.18	3.70
GA_3-20	56418.6	57088.6	213048	243450	156629.4	186361.4	2.78	3.26
GA_3-50	57728.6	58398.6	195520	219375	137791.4	160976.4	2.39	2.75
GA_3-75	58815.9	59485.9	193840	214740	135024.1	155254.1	2.69	2.60
NAA-50	55635.8	56305.8	198560	222822	142924.2	166516.2	2.57	2.95
NAA-75	55676.75	56346.75	201760	225333	146083.3	168986.3	2.62	2.99
NAA-100	55718.16	56388.16	221760	250686	166041.8	194297.8	2.98	3.44
NAA-150	55800	56470	242080	275139	186280	218669	3.34	3.87
NAA-200	55882.3	56552.3	269600	310257	213717.7	253704.7	3.82	4.48
Ethrel-50	55982	56652	204320	231687	148338	175035	2.65	3.08
Ethrel-100	56196.6	56866.6	206880	235476	150683.4	178609.4	2.68	3.14
Ethrel-150	56447.9	57117.9	227632	259767	171184.1	202649.1	3.03	3.54
Ethrel-150	56876.7	57546.7	252296	286794	195419.3	229247.3	3.44	3.98
Ethrel-200	57341.2	58011.2	284264	321678	226922.8	263666.8	3.96	4.54
Control	55554	56224	175416	199260	119862	143036	2.16	2.21

weight of fruit in bottle gourd. Das *et al.* (2001) also recorded a marginal increase in weight of fruit of cucumber with the foliar application of 250 ppm Ethrel at 2 and 4 leaf stages. An increase in fruit weight may be attributed to the reason that plant remained physiologically more active to build up sufficient food stock for developing flowers and fruits, ultimately leading to higher fruit weight. These findings are in close consonance with those of Kshirsagar *et al.* (1996) in cucumber, Gill *et al.* (2005), Kumar *et al.* (2006) in bottle gourd and Jadav *et al*. (2010) in cucumber.

Fruit length (cm): Bottle gourd fruits having 32-38 cm length are most desirable for the market and export point of view. However, for higher seed production, the larger fruits are preferred. Experimental data clearly indicate the significant response of bio-regulators on fruit length. The maximum fruit length in the present study was noticed with the foliar application of Ethrel (200 ppm) followed by NAA (200 ppm) and GA_3 (5 ppm). However, shortest fruits were born in control plants. The findings obtained here have confirmed the findings of Mahala *et al.* (2014) who observed significant increase in fruit length of bottle gourd when Ethrel 100 ppm was applied.The findings of another researchers revealed that Ethrel treated plants of bitter gourd had largest fruit (Chovatia *et al.,* 2010). Similarly, as reported by Kumar *et al*. (2006) foliar application of 300 ppm Ethrel significantly increased the fruit length in Bottle gourd. These findings further supported by Belherkar *et al*. (2006) who reported that foliar application of Ethrel @ 250 ppm increased length of bottle gourd fruit. Another researcher has found that foliar application of Ethrel 200 ppm significantly increased the fruit length in bitter gourd (Damodhar *et al.*, 2004).

The beneficial influence of Ethrel on fruit length may be explained as that sole function of fertilized ovules or seeds in relation to growth of fruit are to synthesize one or more hormone, which initiate and maintain a metabolic gradient along with food that can be transferred from parts of plants towards the fruits. Probably another reason may be attributed to higher respiration and photosynthesis in treated plants as compared to control. This may be due to the greater accumulation of carbohydrates, owing to photosynthesis, which resulted into increased size of fruit.

Fruit diameter (cm): Present investigation revealed the influence of bio-regulators application on fruit diameter. Maximum fruit diameter was recorded with the foliar application of Ethrel (200 ppm) followed by NAA (200 ppm) and GA_3 (5 ppm). GA_3 also found significantly effective in increasing the fruit thickness in bottle gourd. Similarly, another researchers also observed significant improvement in fruit diameter of cucumber when 100 ppm Ethrel was applied (Thappa *et al*., 2011).The findings of this study further confirmed by Chovatia *et al*. (2010) in bitter gourd and kumar *et al.* (2006) in bottle gourd who reported that foliar application of 100-300 ppm Ethrel increased the fruit size in terms of length and diameter. The beneficial effect on Ethrel on fruit diameter may be explained as that exogenous application of Ethrel increased endogenous levels of auxins (Singh, 1980). The diameter of fruit may be owing to the enlargement of cells. The elongation of cells of the fruit by auxins is diametric leading to the simultaneous increase in fruit diameter. The finding confirms the finding of Mandal *et al*. (1990) and Singh and Choudhary (1989), in bottle gourd.

Fruit yield plant^{-1} (Kg): In the present study, bio-regulators application had profound influence on fruit yield plant^{-1}. Foliar application of Ethrel (200 ppm) in the present study resulted in maximum increase in fruit yield plant^{-1} followed by NAA (200 ppm) and GA_3 (5 ppm). These findings are in agreement with the findings of Mahala *et al.* (2014) who observed that two applications of 100 ppm Ethrel at 2 and 4 leaf stages significantly increased fruits plant^{-1} in bottle gourd. With the increase in Ethrel level, there was corresponding increase in fruit yield in bottle gourd (Kumar *et al*., 2006). Imamsaheb and Hanchinmani (2014) and Hilli *et al*., 2010 also reported that the foliar application of Ethrel 150 ppm significantly increased the fruit yield plant^{-1} in biter gourd and ridge gourd respectively. Significant increase in fruit yield plant^{-1} by Ethrel application could be due to increase in female flowers plant^{-1} and metabolic activity of plants.

Yield (q/ha): The fruit yield (q/ha) of bottle gourd, in the present study was significantly increased with the foliar application of Ethrel, NAA and GA_3. The earlier researchers also observed beneficial effect of growth regulators on yield of bottle gourd (Thappa *et al*., 2011). Data revealed that the maximum increase in fruit yield of bottle gourd with the foliar application of Ethrel (200 ppm) followed by NAA (200 ppm) and GA_3 (5 ppm). Similarly, Mahala *et al*. (2014) also recorded highest fruit yield due to foliar application of 200 ppm Ethrel .Similarly, Imamsaheb and Hanchinmani (2014) while studying the response of various growth regulators on bitter gourd had also observed maximum increase in fruit yield when foliar spray of Ethrel was applied. The findings of Jadav *et al.* (2010) also confirmed the results of this study and observed an increase in yield due to the application of 200 ppm Ethrel in cucumber. Other researchers also found significant increase in yield of bottle gourd when foliar application of Ethrel 250 ppm was applied. (Kalantar *et al*., 2008). Kumar *et al.* (2006) observed that exogenous application of Ethrel at 2 and 4 leaf stages resulted in highest yield in bottle gourd. The same result was also observed in cucumber (Das *et al.,* 2001), bottle gourd (Baruah and Das, 1997 and Mandal *et al.,* 1990) and water melon (Dixit *et al*., 1996). The maximum yield is because of the fact that Ethrel suppressed the number of male flower and promote the number of female flowers there by increasing the number the fruits and ultimately produced more yield.

Economics:

Cost of cultivation: In the present study, highest cost of cultivation among all the treatments was recorded with 75 ppm GA_3 followed by 50 and 20 ppm GA_3. The lowest cost of cultivation however was registered with control since water was used as spray solution.These findings are close resonance to Mahala *et al.,* 2014 and Imamsaheb and Hanchinmani, 2014. Among all the treatments, the highest cost of cultivation recorded with 75 ppm GA_3 was due to higher cost of growth substance as compared to other treatments.

Gross income: In the present study, the highest gross income was recorded with 200 ppm Ethrel followed by 200 ppm NAA and 5 ppm GA_3. The lowest gross income however was registered with control. These findings are also observed by Mahala *et al.,* 2014. It may be because of the fact that bottle gourd fruit production was found to be maximum with this treatment over other treatments.

Net return per hectare: In the present study, maximum net return among all the treatments was recorded with 200 ppm Ethrel followed by 200 ppm NAA and 5 ppm GA_3 while control treatment registered the lowest net return per hectare. These findings are in accordance with the results of Mahala *et al*. (2014) who reported maximum net return with foliar application of 100 ppm Ethrel. While control treatment had lowest net return per hectare.

Cost: Benefit ratio: Among the treatments applied in the present study, the maximum cost: benefit ratio was recorded with 200 ppm Ethrel followed by 200 ppm NAA due to maximum net return per hectare. The lowest cost: benefit ratio in the present study was recorded with control. The findings of another study revealed that 200 ppm Ethrel was the most economic treatment which recorded highest cost benefit ratio (1:5.60) in comparison to control (Mahala *et al*., 2014). Similar, observations were also made by Thappa *et al*. (2011) and Imamsaheb and Hanchinmani, 2014.

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