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GROWTH, SEX EXPRESSION AND NUTRIENT COMPOSITION OF CUCUMBER (*CUCUMIS SATIVUS*) AS INFLUENCED BY MALEIC HYDRAZIDE

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Abstract

The present experiment was aimed to evaluate the effect of maleic hydrazide (MH) with the concentration of (i) Control: 0 ppm (MH_0); (ii) 150 ppm (MH_{150}), (iii) 250 ppm (MH_{250}) and (iv) 350 ppm (MH_{350}) at the three stages of (i) Seed soaking (SS), (ii) Vegetative (VS) and (iii) Flowering (FS) on physiological growth, sex expression and nutrient composition of cucumber (*cucumis sativus*). Sex modification and fruit setting was enhanced by MH. Number of leaves, leaf area and fruit yield were also remarkably increased except plant height after MH application at different stages. MH increased the dry biomass of fruit resulted from higher chlorophyll content in leaves transferred photosynthates to the fruit. Chlorophyll content and mineral nutrient concentration in fruits did not affect significantly by MH. As the effect on sex modification and yield attributes, MH @ 150 ppm at vegetative stage would be a good choice.

Key words: Bioactive compound, Growth retardant, Sex modification, Sex ratio, Cucumber.

Introduction

Cucumber (*Cucumis sativus*) is one of the most popular and high value crop in Bangladesh. Bangladesh produce about 63 thousand metric tons of cucumber from 23 thousand acres of land (Anon., 2016), thus farmers are facing with low yield potential. Cucurbitaceous plants are monoecious and there are fewer pistillate flowers and high sex ratio. These characters are affected greatly by gene as well as environment. Several plant hormones, termed as growth regulators and retardants have been found useful in many cucurbitaceous vegetables. Some plant hormones promote femaleness, while others promote maleness.

Maleic hydrazide is a growth retardant generally used for enhancing flowering especially increasing female and male flower sex proportion, ultimately escalating the yield by better fruit setting. Changing the sex ratio of male and female flower is the most important in sex modification of cucurbits. MH affected the growth and sex expression in bottle gourd (Kooner *et al.*, 2000). The 2nd leaf and flowering stages significantly contributed to early flowering, fruit setting and harvesting also when NAA was applied at these stages (Ghani *et al.*, 2013). GA_3 showed positive effect on vegetative growth, flowering, modification of sex expression and fruit traits in bitter gourd when sprayed twice at 3rd leaf and tendril initiation stage (Sandra *et al.*, 2015). Cucumber is a plant with strong tendency towards maleness, thereby, fruit yield depends on the number of female flowers. Albeit MH is different in nature than NAA and GA_3 may have influence on plant growth and also their sucess increases when applied at various stages (Sandra *et al.*, 2015). Thereafter, cucumber selection for commercial cultivation and also breeding purpose is very specific cultural management (Fan *et al*., 2018). Pertaining to Bangladeshi local variety of cucumber 'Baromashi', present experiment was aimed to modify the sex ratio usefully and evaluating the potentiality of MH at various stages.

Materials and Methods

Experimental site: The experiment was conducted during October 2016 to March 2017 in open field provision at 24.09^{0}N and 90.26^{0}E longitude with an elevation of 8.20 m from sea level. This site is under intense and sparse cloudburst from April to September and October to March, respectively. Soil was loamy type that full of 36.40% sand, 41.22% silt, and 22.38% clay.

Experimental design: The experiments were conducted using Randomized Complete Block Design where each treatment was repeated four times overall for 120 days. Four levels of maleic hydrazide (MH) were studied as follows: (i) Control: 0 ppm (MH_0), (ii) 150 ppm (MH_{150}), (iii) 250 ppm (MH_{250}) and (iv) 350 ppm (MH_{350}) at (i) Seed soaking (SS), (ii) Vegetative (VS) and (iii) Flowering (FS) stages.

Growing conditions: Seeds of cucumber were collected from regional seed sale center of Bangladesh Agricultural Development Corporation. The experimental plot was opened using power tiller in 1st week of October, 2016 and sun dried for a week. Pits of 40 x 40 x 30 cm size were prepared 1 m apart in the bed keeping pits top slightly raised. Inorganic fertilizers- N, P, K, S, Zn and B @ 60, 10, 30, 6.5, 1, 0.5 g pit^{-1} and organic fertilizer @10 kg pit^{-1} were used for the commercial production in the area in the form of urea, triple superphosphate, muriate of potash, gypsum, zinc sulphate, boric acid and cowdung, respectively (Chowdhury & Hassan, 2013). All doses of fertilizers were applied ten days prior to transplant except K and N where 2/3rd and 1/3rd K was applied at 10 days before and 10 days after transplanting. On the other hand, N was applied in 6 installments at 12 days interval starting from transplanting. Seedlings of 20 days old were transplanted in the pit on 3rd week of October. Intercultural operation was done as and when required. As per treatments MH was applied following the three stages of plant. The fruits were harvested at green edible stage looking shiny, bright, and of standard size but not over matured.

Data collection: Data was collected on plant growth features (i.e. days to emergence, plant height, branch number, node number, leaf number, leaf area and root length); floral features (i.e. days to 1st flowering, number of male flower, number of female flower and their sex ratio); physiological features (i.e. relative chlorophyll content of leaves, fresh and dry biomass of plant, fruit and root) and yield components (i.e. number of fruit per plant, fruit set percentage, fruit length and diameter). Chlorophyll content in leaves was determined by using SPAD meter (CCM-200, Opti-Science, USA), and water content in fruit was simply recorded by the difference in mass of fresh and dry fruit and calculated as percentage.

Procedure of the determination of TSS and nutrient compositions: Total soluble solids (TSS) were measured by portable hand refractometer (ERMA- 0-32°B, Tokyo, Japan) at room temperature. Every single fruit was blended and juice was collected to measure ^{0}brix. For nutrient composition, fruit samples were dried at 70°C for 3 days till constant weight achieved, ground and analyzed for total N, P, K, Ca, Mg and Na concentration. The dried fruit samples were digested in H_2SO_4:$HCLO_4$:HNO_3 (1:4:10 v/v) mixture (Piper, 1966) and the digests were used to quantify total P using spectrophotometer (model UV-1601, Shimadzu, Japan) Total K and Na concentration was determined by using flame photometer (model PFP7, Jenway, UK), while, Ca and Mg in the digests were analyzed followed by determination on atomic absorption spectrophotometer (model no. 170-30, HITACHI, Japan) following the procedure proposed by Miyazawa *et al.,* (1984). Total N concentration of fruit samples was separately analyzed by modified micro Kjeldahls' method (Yoshida *et al.,* 1976).

Statistical analysis

Analysis of variance was performed in order to evaluate the significance of the effect of MH in cucumber for plant growth, sex expression, physiological and quality parameters. Tukey's HSD test (Tukey, 1977) was used to determine variances among the treatments where $p<0.05$ was considered as significant.

Results and Discussion

Plant growth features: Maleic hydrazide at different stages of application showed non-significant effects on the days of emergence, number of nodes and leaves, leaf area and root length (Table 1), except in case of plant height and number of branches (Figs. 1, 2). The plant height of cucumber had a steady increase at lower concentrations (Fig. 1). It ranged between 110.88 cm in $MH_{250}SS$ to 153.25 MH_0SS, showing a percent decrease of 27.65. Seeds which were soaked with MH @ 250 ppm inhibited plant height to an intense degree. During flowering stage, maleic hydrazide had no remarkable inhibitory effect on this trait. It was resulted due to MH, that temporarily arrest the growth of apical tissue and causes decrement in plant height. It was a good agreement with the earlier findings of (Mansurogle *et al.,* 2009; Caprita & Caprita, 2005) who suggested that plant growth retardants arrest the metabolic activities and consolidated the vegetative development. MH have significant ceasing effect on vegetative growth (Sarkar *et al.,* 2014; Hoffman & Parups, 1964; Brian & Hemming, 1957).

Seed soaking and vegetative stages were remarkably sensitive to branch development when incorporated with MH (150-350 ppm) that significantly increase the side branch while the least number of branch (ranged from 3.75 to 4.50) contributed by control (Fig. 2). Number of branches was increased because of reduced plant height as a result of growth retardant (Brian & Hemming, 1957), which retarded cell division and elongation and contributed maximum number of leaves that was not significant (Table 1). These results were in conformation with the results reported by Sarkar *et al.,* (2014) in tomato.

Floral features: Number of female flowers per plant were significantly affected by MH when treated at seed soaking, vegetative and flowering stages of cucumber. However, days to 1st flowering, number of male flowers and their sex ratio did not respond significantly (Table 2). MH rates ranging between 150-350 ppm, produced maximum number of female flowers over control (Table 2). Number of female flowers were increased about 31.56% and were maximum in $MH_{250}SS$ (35.65) while the least in MH_0SS (24.40). Among stages of application, flowering stage had minimum response to MH, both at lower and higher concentrations. On the other hand, seed soaking treatment was the best for female flowering, followed by vegetative stage. The increased number of female flowers was the consequence of MH that had sex balancing effect through lower respiration and higher accumulation of photosynthates in plants. The results were in conformation with the earlier findings by (Desai *et al.,* 2011; Pandya & Dixit, 1997) reported that, low temperature and short days facilitate to reduce respiration and photosynthates accumulation that might be probable reason for reducing male flowers. These results also corresponded with the results reported by Hidayatullah *et al.,* (2009) where pistillate flowers of cucumber increased with MH application at 450 µM/l concentrations.

Physiological features: Relative chlorophyll content of leaves (Fig. 3), fresh and dry biomass of plant, fruit fresh biomass of plant, fruit fresh biomass, fresh and dry biomass of root did not significantly increase due to different concentrations of MH in any applied stages except fruit dry biomass (Table 3). Each fruit attained the maximum value (4.02 g) of this parameter in $MH_{350}VS$, while the plant growing in MH_0FS (2.60 g) gave the lowest value (Table 3). This advancement of dry matter content in fruit may be due to sink effect of TSS accumulation that subsequently helps in increased dry biomass. Indication in provision of this perception originates from the findings given in (Fig. 5). Although, there was no supporting recorded data of MH regarding this parameter.

Table 1. Plant growth parameters (mean ± standard errors) as influenced by different maleic hydrazide concentrations and growth stages.

Maleic hydrazide	Application stages	Days to emergence	Number of node plant^{-1}	Number of leaves plant^{-1}	Leaf area (cm^{-2})	Root length (cm)
MH_0	SS	4.75 ± 0.85^a	69.50 ± 3.30^b	65.75 ± 7.11^a	208.84 ± 14.80^a	18.35 ± 1.16^a
	VS	6.25 ± 1.11^a	72.75 ± 3.40^{ab}	66.00 ± 3.92^a	219.55 ± 11.72^a	17.00 ± 0.71^a
	FS	5.75 ± 0.75^a	81.50 ± 5.85^{ab}	64.00 ± 7.45^a	252.22 ± 8.91^a	17.70 ± 0.72^a
MH_{150}	SS	5.63 ± 1.03^a	84.25 ± 1.65^{ab}	54.25 ± 7.72^a	257.65 ± 23.21^a	14.75 ± 0.63^a
	VS	4.88 ± 0.43^a	78.75 ± 2.46^{ab}	60.00 ± 1.87^a	259.96 ± 29.83^a	15.38 ± 0.85^a
	FS	4.25 ± 0.48^a	91.00 ± 3.19^{ab}	79.50 ± 3.52^a	252.58 ± 13.21^a	17.25 ± 2.50^a
MH_{250}	SS	3.75 ± 0.75^a	80.50 ± 3.12^{ab}	59.50 ± 4.11^a	225.56 ± 12.98^a	14.75 ± 0.75^a
	VS	4.38 ± 0.69^a	95.50 ± 11.47^a	72.50 ± 9.00^a	226.64 ± 17.84^a	17.13 ± 0.66^a
	FS	5.00 ± 0.82^a	87.75 ± 4.33^{ab}	79.75 ± 3.57^a	264.44 ± 39.13^a	16.13 ± 0.97^a
MH_{350}	SS	7.75 ± 1.31^a	82.25 ± 3.04^{ab}	66.50 ± 4.35^a	263.13 ± 13.74^a	14.50 ± 1.19^a
	VS	5.50 ± 0.65^a	85.75 ± 2.17^{ab}	81.00 ± 2.48^a	230.75 ± 15.89^a	15.63 ± 0.75^a
	FS	6.50 ± 1.32^a	83.25 ± 3.25^{ab}	73.25 ± 4.85^a	250.36 ± 18.46^a	15.38 ± 0.38^a
F-value		1.11	1.38	1.90	0.46	0.82
P-value		0.37	0.25	0.11	0.84	0.56

Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage

Table 2. Sex expression parameters (mean ± standard errors) as influenced by different maleic hydrazide concentrations and growth stages.

Maleic hydrazide	Application stages	Days to 1st flowering	Number of male flower plant^{-1}	Number of female flower plant^{-1}	Sex ratio
MH_0	SS	19.38 ± 0.24^a	155.75 ± 10.44^b	24.40 ± 0.91^g	6.41 ± 0.50^{ab}
	VS	18.50 ± 0.20^a	174.50 ± 6.60^{ab}	27.50 ± 0.96^{efg}	6.37 ± 0.35^{ab}
	FS	19.00 ± 0.20^a	175.00 ± 9.76^{ab}	26.98 ± 0.72^{fg}	6.50 ± 0.38^{ab}
MH_{150}	SS	19.38 ± 0.55^a	176.75 ± 5.89^{ab}	34.25 ± 0.63^{abc}	5.16 ± 0.12^{bc}
	VS	19.05 ± 0.17^a	176.50 ± 3.66^{ab}	37.75 ± 0.85^a	4.68 ± 0.02^c
	FS	19.05 ± 0.33^a	194.25 ± 10.36^a	31.70 ± 0.72^{bcd}	6.13 ± 0.28^{abc}
MH_{250}	SS	18.75 ± 0.14^a	186.75 ± 1.11^{ab}	29.69 ± 1.16^{def}	6.32 ± 0.27^{ab}
	VS	19.38 ± 0.24^a	181.25 ± 3.94^{ab}	35.65 ± 1.16^{ab}	5.10 ± 0.14^{bc}
	FS	19.55 ± 0.16^a	172.25 ± 1.49^{ab}	27.23 ± 0.47^{fg}	6.33 ± 0.13^{ab}
MH_{350}	SS	19.23 ± 0.14^a	174.75 ± 10.87^{ab}	26.43 ± 0.79^{fg}	6.65 ± 0.51^a
	VS	19.25 ± 0.25^a	170.00 ± 4.26^{ab}	31.55 ± 0.68^{cde}	5.39 ± 0.08^{abc}
	FS	19.00 ± 0.41^a	177.50 ± 4.73^{ab}	26.75 ± 0.48^{fg}	6.65 ± 0.27^a
F-value		1.72	1.73	4.63	1.78
P-value		0.15	0.14	0.00	0.13

Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage.

Table 3. Physiological parameters (mean ± standard errors) as influenced by different maleic hydrazide concentrations and growth stages.

Maleic hydrazide	Application stages	Fresh biomass plant^{-1} (kg)	Dry biomass plant^{-1} (g)	Fresh biomass fruit^{-1} (g)	Dry biomass fruit^{-1} (g)	Fresh biomass root^{-1} (g)	Dry biomass root^{-1} (g)
MH_0	SS	3.03±0.21^a	149.93±1.88^e	163.00±1.78^a	2.29±0.09^b	12.00±0.71^a	1.30±0.14^a
	VS	3.11±0.03^a	153.61±4.07^e	166.25±4.87^a	3.12±0.08^{ab}	12.75±0.95^a	1.23±0.08^a
	FS	3.21±0.08^a	154.95±4.64^{de}	167.00±8.44^a	2.60±0.13^{ab}	12.00±0.91^a	1.20±0.23^a
MH_{150}	SS	4.48±0.22^a	185.03±5.79^{abc}	165.50±1.94^a	3.93±0.65^a	12.10±0.84^a	1.42±0.04^a
	VS	4.98±0.14^a	196.83±4.31^a	172.75±5.68^a	3.13±0.14^{ab}	11.75±1.38^a	1.16±0.19^a
	FS	4.75±0.29^a	192.55±1.40^{ab}	166.75±9.74^a	3.98±0.36^{ab}	12.75±0.48^a	1.43±0.10^a
MH_{250}	SS	4.72±0.24^a	186.25±4.96^{abc}	168.25±3.84^a	3.06±0.09^{ab}	13.75±0.48^a	1.45±0.08^a
	VS	5.05±0.19^a	187.80±3.96^{abc}	166.25±17.43^a	2.84±0.32^{ab}	13.75±1.31^a	1.36±0.17^a
	FS	4.96±0.22^a	170.50±4.57$^{b\text{-}e}$	171.75±12.78^a	3.65±0.42^{ab}	14.00±1.78^a	1.42±0.07^a
MH_{350}	SS	4.58±0.25^a	169.13±6.82^{cde}	170.75±10.87^a	3.37±0.25^{ab}	11.75±0.63^a	1.28±0.06^a
	VS	5.02±0.20^a	190.88±4.95^{abc}	165.25±6.69^a	4.02±0.46^a	13.00±1.22^a	1.28±0.06^a
	FS	4.44±0.22^a	177.18±4.78$^{a\text{-}d}$	183.75±11.84^a	3.02±0.22^{ab}	13.50±1.19^a	1.41±0.07^a
F-value			0.60	2.92	0.33	2.70	0.24
P-value			0.73	0.06	0.92	0.03	0.96

Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage

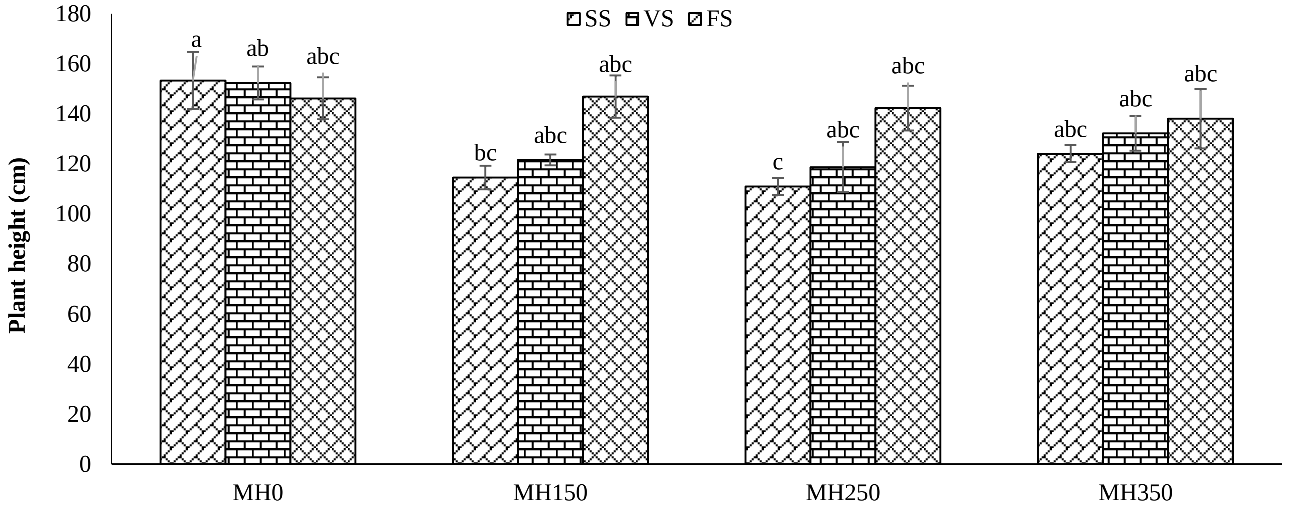

Fig. 1. Comparison of plant height reduction as influenced by different maleic hydrazide concentrations and growth stages.
Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Vertical bars imply standard errors of means. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage

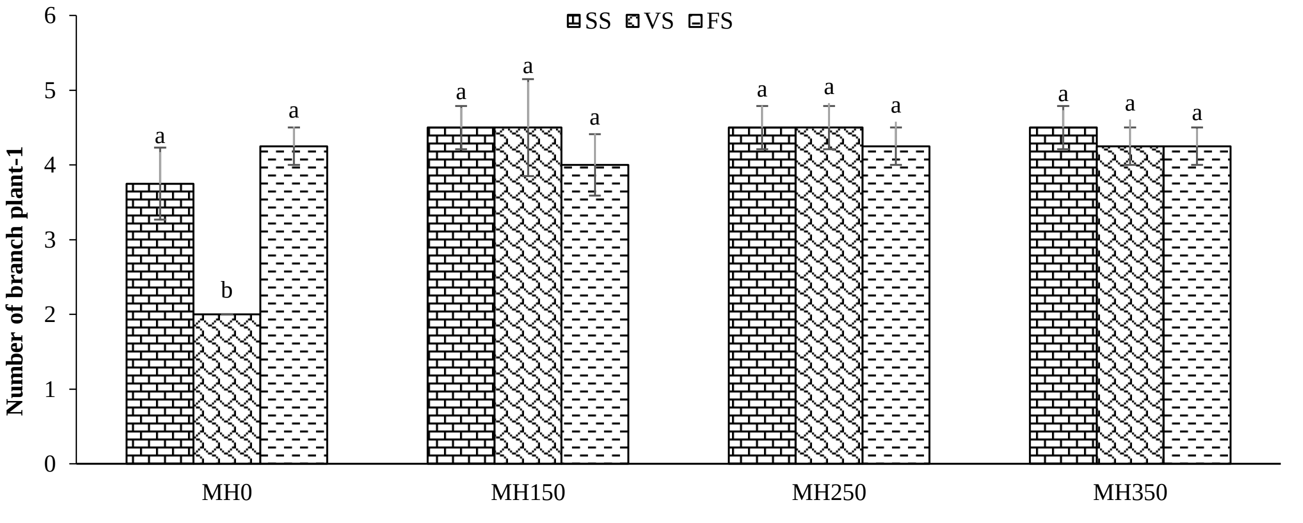

Fig. 2. Number of branch as influenced by different maleic hydrazide concentrations and growth stages.
Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Vertical bars imply standard errors of means. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage.

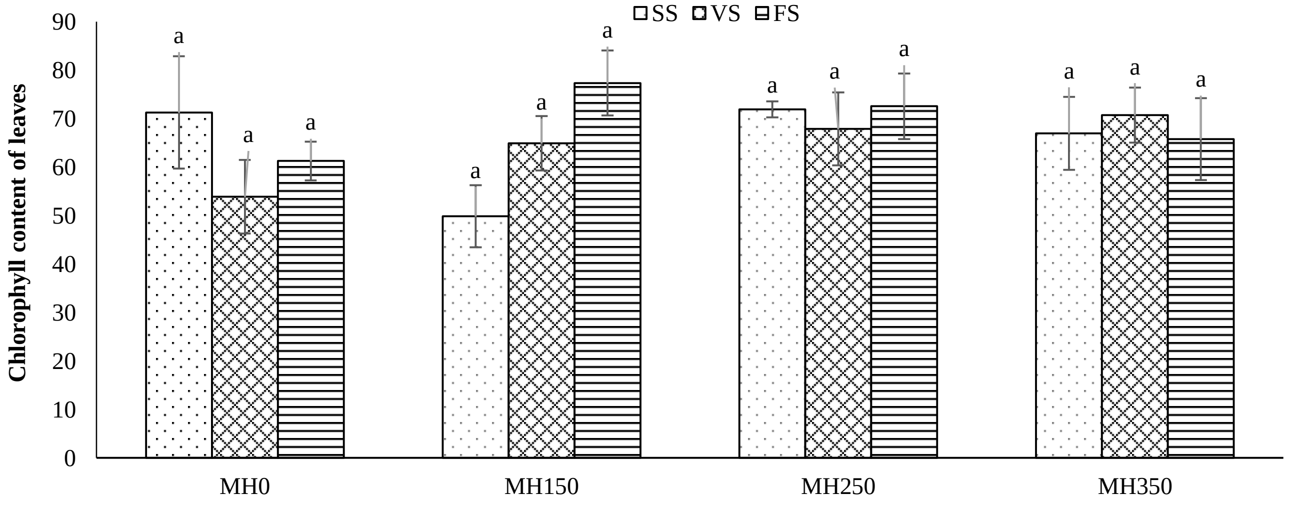

Fig. 3. Chlorophyll content of leaves as influenced by different maleic hydrazide concentrations and growth stages.
Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Vertical bars imply standard errors of means. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage.

Yield components: Number of fruits per plant and fruit set percentage under the influence of MH at different application stages was significantly higher over control. It was noticed that, fruit length and diameter were non-significant (Table 4) having no treatment effects. In this experiment, MH_{150}VS favors the higher fruit number and fruit set compared to other treatments. Fruits number and their percentage depend on the fruit setting that is also dependent on the number of female flower setting. The maximum number of female flowers (about 48.88%) were in MH_{250}VS compared to MH_{150}SS and fruits number was decreased with the higher concentrations of MH that hampered the fruit setting. Similar type of result was found by Verma and Choudhury (1980), reporting a 12% increase in fruit set in cucumber with the application of MH. It was reported by Thappa *et al.,* (2011) in cucumber; Bhat *et al.,* (2004) in water melon and Arora *et al.,* (1982) in bottle gourd, that lower concentration of MH facilitated the fruit yield. MH helps to regulate the C:N ratio in plants that contribute to the maximum female flowering and fruit yield also (Ries, 1985). It was also reported that an increase in yield could be attributed to earliness and increased number of female flowers as well as narrowed male: female sex ratio with paclobutrazol in summer squash by Arora *et al.,* (1989) and with maleic hydrazide in bottle gourd by Ingle *et al.,* (2000).

Water content, TSS and nutrient compositions of fruits: Data presented in (Figs. 4, 5) revealed that, water content and total soluble solids were significantly increased with MH concentration while nutrient concentrations were not affected by MH. (Table 5). The increment of water content and total soluble solids in fruit might be due to increased metabolic activity. Ries (1985) reported that, MH helped to regulate the ethylene synthesis, metabolic activity and C:N ratio in plants that contribute to fruit mass.

Table 4. Yield components parameters (mean±standard errors) as influenced by different maleic hydrazide concentrations and growth stages.

Maleic hydrazide	Application stages	Number of fruit plant^{-1}	Fruit set (%)	Fruit length (cm)	Fruit diameter (cm)
	SS	9.56 ± 0.26^{f}	39.22 ± 0.58^{def}	14.61 ± 0.80^{a}	4.67 ± 0.23^{a}
MH_0	VS	10.25 ± 0.75^{ef}	37.35 ± 2.77^{ef}	14.38 ± 0.38^{a}	4.85 ± 0.22^{a}
	FS	9.61 ± 0.24^{f}	35.76 ± 1.65^{f}	15.05 ± 0.51^{a}	4.72 ± 0.13^{a}
	SS	12.04 ± 0.54^{def}	35.13 ± 1.14^{f}	14.13 ± 0.77^{a}	4.45 ± 0.16^{a}
MH_{150}	VS	22.25 ± 1.25^{a}	59.23 ± 4.51^{ab}	15.55 ± 1.63^{a}	4.49 ± 0.14^{a}
	FS	14.36 ± 0.93^{cd}	45.19 ± 2.07^{cdef}	14.00 ± 0.54^{a}	4.64 ± 0.17^{a}
	SS	10.88 ± 0.72^{def}	36.90 ± 3.40^{ef}	14.73 ± 0.68^{a}	4.78 ± 0.31^{a}
MH_{250}	VS	19.94 ± 0.77^{ab}	56.08 ± 2.58^{abc}	15.13 ± 0.47^{a}	4.83 ± 0.19^{a}
	FS	13.75 ± 1.25^{de}	50.50 ± 4.37^{bcde}	14.38 ± 0.43^{a}	4.44 ± 0.12^{a}
	SS	18.13 ± 0.59^{bc}	68.72 ± 2.70^{a}	14.33 ± 0.95^{a}	4.63 ± 0.23^{a}
MH_{350}	VS	18.90 ± 0.90^{ab}	60.06 ± 3.47^{ab}	14.83 ± 0.92^{a}	4.59 ± 0.21^{a}
	FS	14.15 ± 0.68^{de}	52.84 ± 1.85^{bcd}	14.50 ± 0.79^{a}	4.74 ± 0.09^{a}
F-value		11.92	9.56	0.37	0.59
P-value		0.00	0.00	0.89	0.73

Values with analogous letters imply non-significant ($p<0.05$) variations among the treatments. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage

Table 5. Nutrient composition (mean ± standard errors) as influenced by different maleic hydrazide concentrations and growth stages.

Maleic hydrazide	Application stages	N	P	K	Ca	Mg	Na
	SS	3.08 ± 0.05^{a}	0.40 ± 0.01^{a}	3.52 ± 0.04^{a}	1.03 ± 0.04^{a}	0.21 ± 0.00^{a}	0.15 ± 0.01
MH_0	VS	3.13 ± 0.09^{a}	0.41 ± 0.01^{a}	3.48 ± 0.06^{a}	0.97 ± 0.02^{a}	0.21 ± 0.01^{a}	0.14 ± 0.01
	FS	3.23 ± 0.13^{a}	0.41 ± 0.00^{a}	3.72 ± 0.14^{a}	0.99 ± 0.01^{a}	0.22 ± 0.01^{a}	0.14 ± 0.01
	SS	3.33 ± 0.11^{a}	0.39 ± 0.00^{a}	3.55 ± 0.07^{a}	1.06 ± 0.07^{a}	0.22 ± 0.01^{a}	0.16 ± 0.01
MH_{150}	VS	3.24 ± 0.08^{a}	0.40 ± 0.00^{a}	3.61 ± 0.08^{a}	1.03 ± 0.07^{a}	0.22 ± 0.00^{a}	0.15 ± 0.01
	FS	3.30 ± 0.09^{a}	0.42 ± 0.01^{a}	3.58 ± 0.07^{a}	1.03 ± 0.03^{a}	0.21 ± 0.01^{a}	0.13 ± 0.01
	SS	3.40 ± 0.08^{a}	0.41 ± 0.01^{a}	3.48 ± 0.10^{a}	1.08 ± 0.06^{a}	0.21 ± 0.01^{a}	0.14 ± 0.01
MH_{250}	VS	3.34 ± 0.13^{a}	0.40 ± 0.01^{a}	3.60 ± 0.06^{a}	1.10 ± 0.06^{a}	0.21 ± 0.01^{a}	0.13 ± 0.01
	FS	3.37 ± 0.13^{a}	0.39 ± 0.00^{a}	3.64 ± 0.12^{a}	1.10 ± 0.06^{a}	0.22 ± 0.01^{a}	0.15 ± 0.01
	SS	3.37 ± 0.14^{a}	0.41 ± 0.01^{a}	3.58 ± 0.15^{a}	1.02 ± 0.03^{a}	0.22 ± 0.01^{a}	0.16 ± 0.01
MH_{350}	VS	3.33 ± 0.05^{a}	0.42 ± 0.01^{a}	3.71 ± 0.10^{a}	1.07 ± 0.04^{a}	0.20 ± 0.00^{a}	0.14 ± 0.01
	FS	3.20 ± 0.14^{a}	0.42 ± 0.02^{a}	3.59 ± 0.04^{a}	1.07 ± 0.05^{a}	0.21 ± 0.01^{a}	0.14 ± 0.01
F-value	0.43	0.82	0.75	0.30	0.52	1.20	

Values with analogous letters imply non-significant ($p<0.05$) variations among the treatments. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage

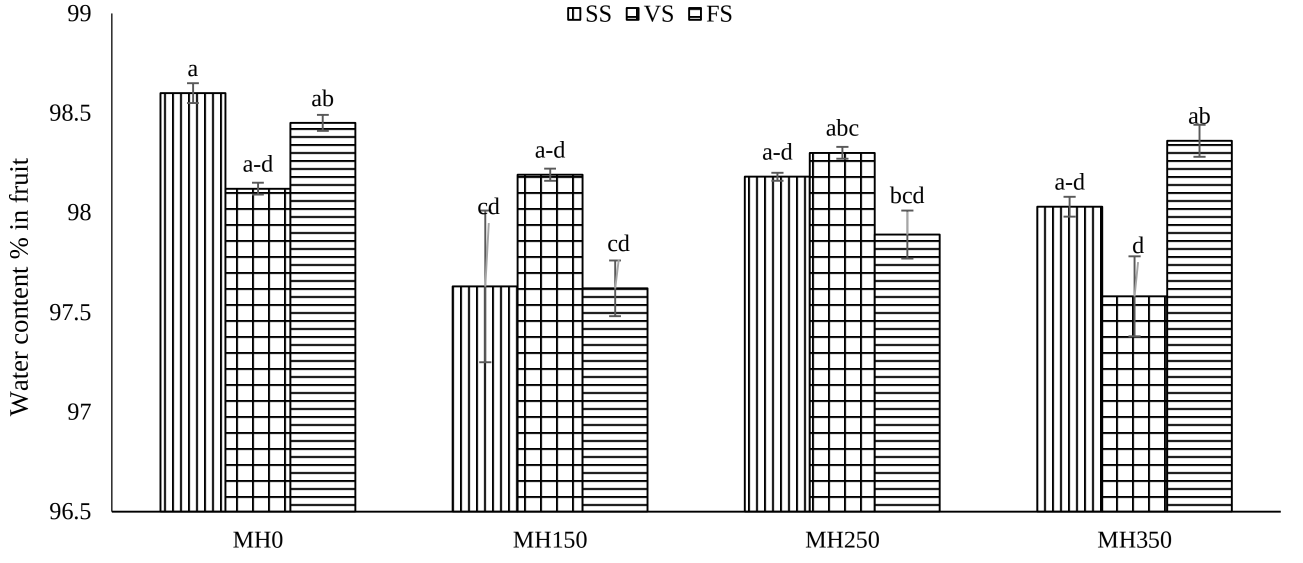

Fig. 4. Water content variation in fruits as influenced by different maleic hydrazide concentrations and growth stages
Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Vertical bars imply standard errors of means. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage.

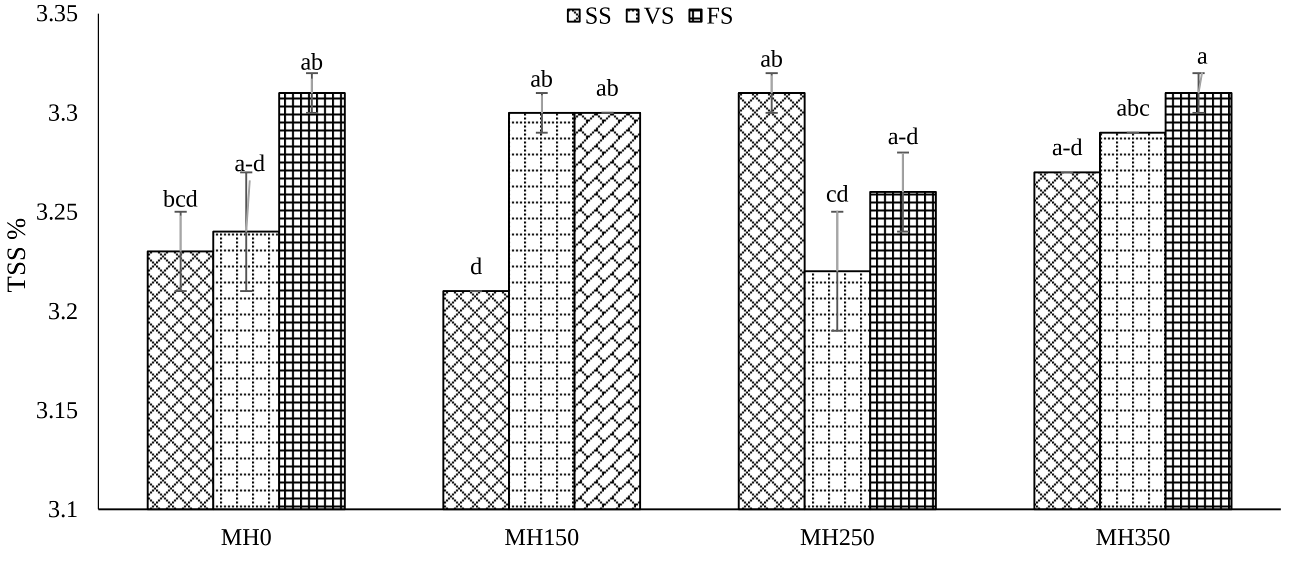

Fig. 5. TSS variation in fruits as influenced by different maleic hydrazide concentrations and growth stages
Values with analogous letters imply non-significant (p<0.05) variations among the treatments. Vertical bars imply standard errors of means. Abbreviations are as follows, MH; maleic hydrazide, SS; seed soaking, VS; vegetative stage and FS; flowering stage.

Conclusion

Growth features, fruit yield components and dry biomass accumulation in cucumber were significantly sophisticated after MH application at seed soaking, vegetative and flowering stages. Under different MH application, significant differences were found for plant height and number of branches per plant. Whereas, days to emergence, number of leaves, leaf area and root length were not significantly affected by MH. Subsequently, MH ceased the plant growth and facilitate to branch development. MH had no significant effect on chlorophyll content of leaves, fresh and dry biomass of plant and root respectively, in relation to different growth stages. Therefore, considering the results, it is eviendent that MH @ 150 ppm could be a better technique in modification of sex expression for cucumber.

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