Influence Of Maleic Hydrazide And Triiodobenzoic acid On Morpho-Physiological Traits, Yield And Yield Contributing Parameters Of Mustard

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Abstract: An experiment was conducted at farm of botany section, college of agriculture, Nagpur during rabi 2015-16 to study the effect of one foliar spray of MH and TIBA at different concentrations (25 ppm, 50 ppm, 75 ppm, 100 ppm, 125 ppm, 150 ppm MH and 25 ppm, 50 ppm, 75 ppm, 100 ppm, 125 ppm, 150 ppm TIBA with the control) on the morpho-physiological and yield and yield contributing parameters of mustard cv. ACN-Shatabdi. Data revealed that foliar application of 50 ppm TIBA followed by 100 ppm MH significantly enhanced morpho-physiological parameters viz., number of branches plant⁻¹, leaf area plant⁻¹, total dry weight of plant and NAR and RGR over control. Similarly yield and yield contributing parameters viz., number of siliqua plant⁻¹, number of seeds 20⁻¹ siliqua, 1000 seed weight and seed yield ha⁻¹ also significantly increased over control. Significant reduction in plant height was noted in treatments receiving MH and TIBA when compared with control. The highest B:C ratio was observed by the foliar application of 100 ppm MH (2.18) followed by 50 ppm TIBA (2.16) and 125 ppm MH (2.09) and can be considered as the most effective and beneficial treatments in mustard.

Key words: Mustard, MH, TIBA, Morpho-physiological traits and yield

INTRODUCTION

Indian mustard (Brassica juncea) locally called as “rai” “raya” or “laha”, is an important oilseed crop belonging to Brassica group. The English word “mustard” derives from the Anglo-Norman mustarde and Old French mostarde. Mustard (Brassica juncea) is a second important oil seed crop in India after groundnut in area and production. Major states producing mustard in India are Rajasthan, Gujarat etc. At present, mustard is mostly grown as oil seed crop in Maharashtra.

Oil content of Indian mustard seed varies from 30 to 48%. It is known, that Indian mustard seed is largely crushed for oil which is rich sourced of energy, predominantly in vegetarian diet. Mustard seed is considered as excellent source of dietary protein.

Mustard yield can be increased either by breeding lines which retain a large proportion of flower producing siliqua or through physiological manipulations such as spray of growth regulators which reduce flower drop. Many workers have observed the changes in physiological and morphological aspects of plants due to application of growth regulators and on this aspect a considerable amount of literature has been accumulated. MH (Maleic hydrazide), TIBA (2, 3, 5-triiodobenzoic acid), a-indolebutyric acid, a-napthalene acetic acid, 2, 4, 5-trichlorophenoxy acetic acid, cytocel, mepiquat chloride, dynamic acid, B-nine (N-dimethyl amino succinamic acid), gallic acid etc. are the common growth retardants. The plant growth regulators are compounds that as chemical signals, controlling the plant development. They normally bind to receptors in the plant, triggering a series of cellular changes, which may affect the initiation or modification of tissues and organs (Taiz and Zeiger, 2009).

Hence present study was undertaken to find out the effect of MH and TIBA with different concentrations to improve morpho-physiological, yield and yield contributing parameters of mustard.

MATERIALS AND METHODS

A field experiment on mustard was conducted at an experimental farm of Botany section, College of agriculture, Nagpur. The present investigation was undertaken during the rabi season of 2015-16. The field experiment was laid out in Randomized block Design (RBD) with three replications consisting of thirteen treatments with different concentrations of MH and TIBA (25 ppm, 50 ppm,
75 ppm, 100 ppm, 125 ppm, 150 ppm MH and 25 ppm, 50 ppm, 75 ppm, 100 ppm, 125 ppm, 150 ppm TIBA). One foliar spray of MH and TIBA was done at 35 DAS with hand sprayer. Plot size of individual treatment was gross 3.15m X 3.30m and net 2.25m X 3.00m. Observations on plant height, number of branches, leaf area plant$^{-1}$, total dry weight of plant, NAR, RGR were recorded at 35, 50, 65 and 80 DAS. Similarly observations on number of siliqua plant$^{-1}$, number of seeds 20'siliqua, 1000 seed weight and seed yield ha$^{-1}$ were also recorded after harvesting. Percent increase and B:C were also calculated. The crop was kept free from disease and pest during the growth period. Harvesting was undertaken after the crop attained maturity. Data were analysed by statistical method suggested by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

**Plant height (cm)**

Data regarding plant height were recorded at four observational stages viz., 35, 50, 65 and 80 DAS.

At 35 DAS the data regarding plant height was found non-significant, because foliar sprays of Maleic hydrazide and TIBA of different concentrations were given at 35 DAS.

Significant variation with gradual increase (50, 65, 80 DAS) was observed regarding plant height at all the stages of observations.

The data recorded about the plant height at 50 DAS were found statistically significant. At 50 DAS range of plant height was recorded 130.50 – 148.20 cm. Significantly reduced plant height was recorded with the foliar application of 100 ppm MH (T$_{5}$) followed by foliar application of 125 ppm TIBA (T$_{6}$), 25 ppm MH (T$_{2}$), 75 ppm MH (T$_{6}$) and 150 ppm TIBA (T$_{13}$) when compared with control (T$_{1}$) and rest of the treatments under observation. Similarly foliar application of 75 ppm TIBA (T$_{10}$), 50 ppm TIBA (T$_{9}$), 75 ppm MH (T$_{4}$), 150 ppm MH (T$_{7}$), 25 ppm TIBA (T$_{8}$) and 100 ppm TIBA (T$_{11}$) also reduced significantly plant height when compared with control (T$_{1}$). Treatments T$_{3}$ (50 ppm MH) and T$_{12}$ (125 ppm TIBA) were found at par with treatment T$_{1}$ (control).

At 65 DAS plant height was significantly influenced by different treatments. The range of plant height was recorded 139.80 – 158.80 cm. At this stage foliar application of 100 ppm MH (T$_{5}$) showed significantly minimum plant height followed by foliar application of 25 ppm MH (T$_{2}$), 125 ppm MH (T$_{6}$), 150 ppm TIBA (T$_{13}$), 75 ppm TIBA (T$_{10}$) and 75 ppm MH (T$_{4}$) when compared with control (T$_{1}$) and rest of the treatments under observation. Similarly foliar application of 150 ppm MH (T$_{7}$) and 25 ppm TIBA (T$_{8}$) also reduced significantly plant height when compared with control (T$_{1}$). Treatments T$_{11}$ (100 ppm TIBA), T$_{1}$ (50 ppm MH) and T$_{12}$ (125 ppm TIBA) were found at par with treatment T$_{1}$ (control).

Adam and Jahan (2014) evaluated the effect of TIBA (0, 20, 50, 100, 150 ppm) on the growth and yield attributes of BARI Mung-5. Results indicated that foliar spray of TIBA at the age of 30 days after sowing significantly reduced the plant height.

Jahan and Khan (2014) evaluated the effects of 20, 50, 100 and 150 ppm TIBA on growth and yield of BARI soybean -5. Plant height reduced significantly due to application of 50, 100 and 150 ppm TIBA.

Mahipal Singh and Sanjay kumar (2014) conducted an experiment to find out impact of variety and growth regulators treatments on morpho-physiological and quality of mungbean. Maximum decrease of plant height was induced by the 10$^{-1}$ dose of TIBA as compared to control.

**Number of branches plant$^{-1}$**

Branches are the sites of the leaves, flower and siliqua formation. Hence, they are closely associated with the photosynthetic activity and yield of plant. So, number of branches is a desirable attribute for higher biomass production and yield.

Data showed that there were no significant differences in number of branches plant$^{-1}$ up to 35 DAS but at 50, 65 and 80 DAS, number of branches plant$^{-1}$ were significantly influenced due to various treatments.
At 35 DAS the data regarding number of branches plant⁻¹ were found to be non-significant because foliar sprays of Maleic hydrazide and TIBA with different concentrations were given at 35 DAS. At 50 DAS the data noted about number of branches plant⁻¹ were statistically significant. At 50 DAS range of number of branches plant⁻¹ recorded was 2.86 - 4.73. The significantly highest number of branches plant⁻¹ was recorded with the foliar application of 50 ppm TIBA (T₉) followed by foliar application of 75 ppm TIBA (T₁₀), 100 ppm MH (T₅), and 125 ppm MH (T₆) when compared with control (T₁) and rest of the treatments under observation. Similarly foliar application of 25 ppm MH (T₂), 50 ppm MH (T₃), 150 ppm MH (T₇), 100 ppm TIBA (T₁₁), 25 ppm TIBA (T₈) and 125 ppm TIBA(T₁₂) also increased number of branches plant⁻¹ when compared with control (T₁) and rest of the treatments. Treatments T₁₃ (150 ppm TIBA) and T₄ (75 ppm MH) remained at par with treatment T₁ (control).

At 65 DAS the data gave significant variation. The range of number of branches plant⁻¹ recorded was 3.19 - 4.89. Foliar application of 50 ppm TIBA (T₉) followed by 100 ppm MH (T₅), 75 ppm TIBA (T₁₀) and 125 ppm MH (T₆) were recorded maximum number of branches plant⁻¹ when compared with control (T₁) and rest of the treatments under observation. While, foliar application of 25 ppm MH (T₂), 50 ppm MH (T₃) and 150 ppm MH (T₇) in a descending manner also significantly increased number of branches plant⁻¹ when compared with control (T₁). Treatments T₁₁ (100 ppm TIBA ), T₁₂ (125 ppm TIBA), T₈ (25 ppm TIBA), T₁₃ (150 ppm TIBA) and T₄ (75 ppm MH) were found at par with T₁ (Control).

At 80 DAS data showed significant variation in respect of number of the branches plant⁻¹. The range of number of branches plant⁻¹ recorded was 3.53 – 5.10. Treatment T₉ (50 ppm TIBA) followed by T₅ (100 ppm MH) and T₁₀ (75 ppm TIBA), also recorded significantly more branches when compared with the treatment T₁ (control). Next to this, treatments T₈ (125 ppm MH), T₁₂ (25 ppm MH), T₇ (50 ppm MH), T₁₃ (100 ppm MH) and T₁₀ (100 ppm TIBA) in a descending manner also recorded more number of the branches over control (T₁) and rest of the treatments under study. Treatments T₁₂ (125 ppm TIBA), T₈ (25 ppm TIBA), T₁₃ (150 ppm TIBA) and T₄ (75 ppm MH) were found at par with control (T₁).

Yadav et al. (2008) studied the effects of different growth hormones were given to field pea at 30 and 60 days after sowing, i.e. control (water spray), TIBA (2, 3, 5-triiodobenzoic acid) @ 20 ppm, kinetin @ 5 ppm, NAA @ 50 ppm, Miraculan [triacanotanol] at 5 ppm, ascorbic acid (AA) at 50 ppm, IAA @ 50 ppm, gibberellic acid (GA₃) @ 50 ppm, and CCC [chlormequat] @ 4000 ppm. The bioregulators had influenced on the number of branches, the maximum being with TIBA treatment.

Thappa et al. (2011) recorded maximum number of primary branches (5.75) with the spray of 100 ppm maleic hydrazide on cucumber long green variety.

**Leaf area plant⁻¹**

Leaf area gives a fairly good idea of the photosynthetic capacity of the plant. Leaf area depends upon the number and size of leaves. Leaf area plays an important role in absorption of light radiation and using it in photosynthesis process. Leaf size is influenced by light, moisture and nutrients. Hence, yield is dependent on leaf area of crop.

Data regarding leaf area were recorded at 35, 50, 60 and 80 DAS. Significant variations were observed at 50, 60 and 80 DAS. At 35 DAS the data regarding leaf area was found non-significant, because foliar sprays of MH and TIBA were given at 35 DAS.

At 50 DAS significantly maximum leaf area was noticed with the foliar application of 50 ppm TIBA (T₉) followed by 75 ppm TIBA (T₁₀), 100 ppm MH (T₅) and 125 ppm MH (T₆) when compared with control (T₁). But treatments T₁₃ (150 ppm TIBA), T₈ (25 ppm TIBA), T₇ (150 MH), T₄ (75 ppm MH), T₁₂ (125 ppm TIBA), T₁₁ (100 ppm TIBA), T₃ (50 ppm MH) and T₂ (25 ppm MH) could not achieved more leaf area at this stage and these treatments were found at par with treatment T₁ (control).

At 65 DAS significantly maximum leaf area was recorded in treatment 50 ppm TIBA (T₉) followed by 75 ppm TIBA (T₁₀), 100 ppm MH (T₅) and 125 ppm MH (T₆) when compared with control. Treatments T₇ (75 ppm MH), T₈ (25 ppm TIBA), T₉ (150 MH), T₄ (75 ppm MH), T₁₂ (125 ppm TIBA), T₁₁ (100 ppm TIBA), T₃ (50 ppm MH) and T₂ (25 ppm MH) could not achieved more leaf area at this stage and these treatments were found at par with treatment T₁ (control).

At 80 DAS significantly maximum leaf area recorded in treatment 50 ppm TIBA (T₉) followed by 75 ppm TIBA (T₁₀), 100 ppm MH (T₅), 125 ppm MH (T₆), 125 ppm TIBA(T₁₂), 100 ppm TIBA (T₁₁) and 150 ppm TIBA (T₁₃) when compared with control. Similarly treatments 75 ppm MH (T₃), 150 ppm MH (T₇), 50 ppm MH (T₄), 25 ppm MH (T₂) and 25 ppm TIBA (T₉) were found at par with control (T₁).

At 65 DAS significantly maximum leaf area was recorded in treatment 50 ppm TIBA (T₉) followed by 100 ppm MH(T₃), 75 ppm TIBA (T₁₀), 125 ppm MH (T₆), 125 ppm TIBA(T₁₂), 100 ppm TIBA (T₁₁) and 150 ppm TIBA (T₁₃) when compared with control. Similarly treatments 75 ppm MH (T₃), 150 ppm MH (T₇), 50 ppm MH (T₄), 25 ppm MH (T₂) and 25 ppm TIBA (T₉) were found at par with control (T₁).

At the 80 DAS significantly maximum leaf area recorded in treatment 50 ppm TIBA (T₉) followed by 75 ppm TIBA (T₁₀), 100 ppm MH (T₃) and 125 ppm MH (T₇) when compared with the control (T₁). But treatments 125 ppm TIBA (T₁₂), 150 ppm MH (T₇), 100 ppm TIBA (T₁₁), 150 ppm TIBA (T₁₃), 50 ppm MH (T₃), 75 ppm MH (T₄), 25
ppm MH (T3) and 25 ppm TIBA (T8) were found at par with control (T1).

Sawant (2014) studied the effect of foliar sprays of growth retardant TIBA (25, 50, 75, 100, 125 and 150 ppm) on growth of chickpea cv. Jaki-2181. Data revealed that two foliar sprays of TIBA at 50 ppm at 25 and 40 DAS significantly enhanced leaf area of plant over control.

Bobade (2015) studied the effect of foliar spray of growth retardants maleic hydrazide (50 ppm, 75 ppm, 100 ppm, 125 ppm, 150 ppm, 200 ppm) and TIBA (50 ppm, 75 ppm, 100 ppm, 125 ppm, 150 ppm, 175 ppm, 200 ppm) with one control (water spray) on the morphophysiological parameters of green gram cv. PKV mung 8802. The resulted indicated that the foliar sprays of MH 100 ppm followed by TIBA 50 ppm at 25 and 35 DAS significantly enhanced leaf area of plant over control.

Dry weight plant

Dry matter production is determined by the source sink relation. Data on dry matter production plant was recorded at the four growth stage i.e 35, 50, 65 and 80 DAS. Data on dry matter showed significant variation at 50 DAS, 65 DAS and 80 DAS. At 35 DAS data noticed non-significant because foliar sprays of MH and TIBA were given at 35 DAS.

At 50 DAS the data recorded about the dry matter production were found statistically significant. Significantly maximum dry matter was noticed with the foliar application of 50 ppm TIBA (T9) followed by foliar application of 100 ppm MH (T3), 75 ppm TIBA (T10), 125 ppm MH (T6), 75 ppm TIBA (T11) and 100 ppm TIBA (T11) when compared with control (T1). But treatments T8 (25 ppm TIBA), T10 (150 ppm MH), T12 (125 ppm TIBA), T13 (150 ppm TIBA), T3 (50 ppm MH) and T2 (25 ppm MH) were found at par with T1 (control).

The data recorded about the dry matter production were statistically significant at 65 DAS. Significantly maximum dry matter was recorded with the foliar application of 50 ppm TIBA (T9) followed by 75 ppm (T10), 150 ppm TIBA (T13) and 100 ppm TIBA (T11) when compared with control (T1). But treatments T5 (25 ppm TIBA), T8 (125 ppm TIBA), T9 (75 ppm MH), T12 (125 ppm MH) and T13 (150 ppm TIBA) were found at par with T1 (control).

At 80 DAS significantly maximum dry matter was noticed in treatment T9 (50 ppm TIBA) followed by T8 (100 ppm TIBA), T6 (125 ppm MH), T10 (75 ppm TIBA) and T7 (150 ppm MH) when compared with control and rest of the treatments under observations. Treatments T11 (100 ppm TIBA), T12 (125 ppm TIBA), T3 (75 ppm MH), T13 (100 ppm TIBA), T3 (50 ppm MH) and T2 (25 ppm MH) were found at par with treatment T1 (control).

Relative growth rate

Relative growth rate (RGR) represents total dry weight gained over existing dry weight in unit time. This was originally termed an “efficiency index” because it expresses growth in terms of a rate of increase in size unit3 of size. The increment in RGR might be associated with maximum leaf area expansion and growth of stem and root. Increment in NAR is related with the increase in total dry weight of plant unit1 of leaf area.

Considering all the treatments under study, significantly maximum RGR was noted in treatment 50 ppm TIBA i.e 0.0397 g g−1 day−1 at 35-50 DAS, 0.1240 g g−1 day−1 at 50-65 DAS and 0.0390 g g−1 day−1 at 65-80 DAS respectively. While it was lowest in control i.e 0.0337 g g−1 day−1 at 35-50 DAS, 0.1161 g g−1 day−1 at 50-65 DAS and 0.0322 g g−1 day−1 at 65-80 DAS respectively.

At 35 – 50 DAS significantly highest RGR was recorded with the foliar application of 50 ppm TIBA (T9) followed by foliar application of 100 ppm MH (T3), 75 ppm TIBA (T9), 125 ppm MH (T3), 25 ppm TIBA (T3), and 100 ppm TIBA (T11) when compared with control (T1) and rest of the treatments under observation. Treatments T4 (75 ppm MH), T12 (125 ppm TIBA), T1 (150 ppm MH), T3 (50 ppm MH), T13 (150 ppm TIBA) and T2 (25 ppm MH) were found at par with treatment T1 (control).

At 50 – 65 DAS Significantly more RGR was recorded with the foliar application of 50 ppm TIBA (T9) followed by foliar application of 100 ppm MH (T3), 75 ppm TIBA (T9), 125 ppm MH (T3), 75 ppm MH (T3), 150 ppm MH (T3) and 100 ppm MH (T3).
ppm TIBA (T11) when compared with control (T1) and rest of the treatments. While, treatments T6 (25 ppm TIBA), T3 (150 ppm TIBA), T12 (125 ppm TIBA), T8 (50 ppm MH) and T2 (25 ppm MH) were found at par with treatment T1 (control).

At 80-65 DAS all the treatments gave significant variation in respect of RGR when compared with control. Significantly more RGR was noticed in treatment T9 (50 ppm TIBA) followed by T5 (100 ppm MH), T4 (75 ppm MH) and T8 (25 ppm TIBA) when compared with T1 (control). Treatments T11 (100 ppm TIBA), T13 (150 ppm TIBA), T7 (150 ppm MH), T3 (50 ppm MH) and T2 (25 ppm MH) were also found at par with control (T1).

Tripathi and Kumar (2006) studied the response of pea cv. Rachana to different plant growth regulator treatments i.e. TIBA (50 ppm), GA (50 ppm), AA [ascorbic acid] (50 ppm), IAA (50 ppm), NAA (50 ppm), cytokinin (5 ppm), miraculon [triacontanol] (10 ppm) and CCC [chlormequat] (4000 ppm). The growth regulators were sprayed twice at 35 and 75 days after sowing. Relative growth rate (RGR) significantly increased with the application of TIBA followed by ascorbic acid.

Sawant (2014) investigated the influence of foliar sprays of growth retardant TIBA (25, 50, 75, 100, 125 and 150 ppm) on growth of chickpea cv. Jaki-9218. Two foliar sprays of 50 ppm TIBA at 25 and 40 DAS significantly enhanced RGR (Relative growth rate) when compared with control and rest of the treatments.

Net assimilation rate

Net assimilation rate (NAR), synonymously called as unit leaf rate expresses the rate of dry weight increase at any instant on a leaf area basis with leaf representing an estimate of the size of the assimilatory surface area (Gregory, 1926). Increase in NAR during reproductive phase might be due to increase efficiency of leaves for photosynthesis as a response to photosynthetic apparatus to increase demand for assimilates by growing seed fraction and also due to photosynthetic contribution by pod and sink demand on photosynthetic rate of leaves.

NAR was significantly maximum in treatment T9 (50 ppm TIBA) i.e 0.0499 g dm$^{-2}$ day$^{-1}$ at 35-50 DAS, 0.3301 g dm$^{-2}$ day$^{-1}$ at 50-65 DAS, and 0.2379 g dm$^{-2}$ day$^{-1}$ at 80-65 DAS while the values under control were 0.0306 g dm$^{-2}$ day$^{-1}$ at 35-50 DAS, 0.2823 g dm$^{-2}$ day$^{-1}$ at 50-65 DAS and 0.2025 g dm$^{-2}$ day$^{-1}$ at 65-80 DAS respectively.

At 35-50 DAS, treatment T9 (50 ppm TIBA) followed by T3 (100 ppm MH), T10 (75 ppm TIBA), T6 (125 ppm MH), T11 (100 ppm TIBA), T8 (25 ppm TIBA) and T7 (150 ppm MH) were found superior over T1 (control). But treatments T11 (150 ppm TIBA), T12 (125 ppm TIBA), T5 (50 pm MH) and T7 (25 ppm MH) were found at par with (T1) control.

At 50 – 65 DAS data showed significant variation in respect of NAR. At this stage foliar application of 50 ppm TIBA (T9) followed by 100 ppm MH (T5), 75 ppm MH (T6), 75 ppm MH (T4) and 100 ppm TIBA (T11) recorded significantly more NAR when compared with control (T1) and rest of the treatments. But treatments T7 (150 ppm MH), T8 (25 ppm TIBA), T13 (150 ppm TIBA), T12 (125 ppm TIBA), T3 (50 ppm MH) and T2 (25 ppm MH) were found at par with treatment T1 (control).

At 65-80 DAS NAR was significantly maximum in treatment T9 (50 ppm TIBA) followed by treatment T5 (100 ppm MH), T10 (75 ppm TIBA), T6 (125 ppm MH), T4 (75 ppm MH), T7 (150 ppm MH) and T8 (25 ppm TIBA) in a descending manner also gave significantly more NAR over control. But treatments T11 (100 ppm TIBA), T13 (150 ppm TIBA), T12 (125 ppm TIBA), T3 (50 ppm MH) and T2 (25 ppm MH) were found at par with T1 (control).

Sawant (2014) reported that two foliar sprays of TIBA @ 50 ppm at 25 and 40 DAS was found more effective in enhancement of NAR (net assimilation rate) as compared to control in chickpea.

Bobade (2015) studied the effect of foliar spray of growth retardants maleic hydrazide (50 ppm, 75 ppm, 100 ppm, 125 ppm, 150 ppm, 175 ppm, 200 ppm) and TIBA (50 ppm, 75 ppm, 100 ppm, 125 ppm, 150 ppm, 175 ppm, 200 ppm) with one control (water spray)on the morpho-
physiological, parameters of green gram cv. PKV mung 8802. The resulted indicated that the foliar sprays of MH 100 ppm followed by TIBA 50 ppm at 25 and 35 DAS significantly enhanced NAR over control.

Yield and yield contributing parameters

Number of siliqua plant\(^1\)

Significantly increases in number of siliqua plant\(^1\) were observed with the foliar application of 50 ppm TIBA (T\(_9\)) followed by foliar application of 100 ppm MH (T\(_3\)), 75 ppm TIBA(T\(_{10}\)), and 125 ppm MH (T\(_9\)) when compared with control (T\(_1\)) and rest of the treatments under observation. Similarly foliar application of 25 ppm TIBA (T\(_8\)), 75 ppm MH (T\(_4\)), 50 ppm MH (T\(_3\)) and 150 ppm MH (T\(_7\)), in a descending manner alsoincreased number of pods plant\(^1\) over the control (T\(_1\)). But, the treatments T\(_{11}\), (100 ppm TIBA), T\(_2\) (25 ppm MH),T\(_{12}\) (125 ppm TIBA) and T\(_{13}\) (150 ppm TIBA) were found at par with T\(_1\) (control).

Kumar et al. (2006) reported that foliar application of TIBA (50 ppm), cycocel (250 ppm) and mepiquat chloride (1000 ppm) on soybean recorded highest number of pods plant\(^{-1}\) and shelling percentage as compared to control.

Number of seeds 20\(^1\) siliqua

Significantly more number of seeds 20\(^1\) siliqua were recorded with the foliar application of 50 ppm TIBA (T\(_9\)) followed with 100 ppm MH (T\(_3\)), 125 ppm MH (T\(_8\)) and 75 ppm TIBA (T\(_{10}\)) when compared with control (T\(_1\)) and rest of the treatments under observation. Similarly foliar application of 100 ppm TIBA (T\(_{11}\)), 75 ppm MH (T\(_3\)) and125 ppm TIBA (T\(_{12}\)) significantly increased more number of seeds 20\(^1\) siliqua when compared with control (T\(_1\)) and rest of the treatments under observation. Treatments T\(_8\) (25 ppm TIBA), T\(_3\) (50 ppm MH), T\(_7\) (150 ppm MH), T\(_2\) (25 ppm MH) and T\(_{13}\) (150 ppm TIBA) were found at par with T\(_1\) (control).

Adam and Jahan (2014) evaluated the effect of different concentrations of TIBA (0, 20, 50, 100, 150 ppm) were spray at the age of 30 days after sowing. Results indicated that application of TIBA @ 20 mg l\(^{-1}\) significantly increased number of seeds plant\(^{-1}\) over the control of mung.

1000 seed weight (g)

Significantly maximum 1000 seed weight was recorded by treatment T\(_9\) (50 ppm TIBA) followed by T\(_5\) (100 ppm MH), T\(_{10}\) (75 ppm TIBA), T\(_6\) (125 ppm MH), T\(_{11}\) (100 ppm TIBA), T\(_{12}\) (125 ppm TIBA), T\(_7\) (150 ppm MH), T\(_4\) (75 ppm MH), T\(_8\) (25 ppm TIBA) and T\(_{13}\) (150 ppm TIBA) in descending manner when compared with treatment T\(_1\) (control) and rest of the treatments under study. Treatment T\(_5\) (25 ppm MH) also gave significantly more 1000 seed weight when compared with treatment T\(_1\) (control).

Jahan and Khan (2014) tested 20, 50, 100 and 150 ppm TIBA on growth and yield of BARI soybean.-5. They observed that application of 100 and 150 ppm TIBA significantly increased 100 seed weight.

Seed yield ha\(^{-1}\) (q)

Significantly maximum seed yield ha\(^{-1}\) were recorded with the foliar application of 50 ppm TIBA (T\(_9\)) followed by 100 ppm MH (T\(_3\)), 75 ppm MH (T\(_{10}\)), 25 ppm TIBA (T\(_4\)) and 125 ppm MH (T\(_7\)) over control (T\(_1\)). Next to these treatments, treatment T\(_4\) (75 ppm MH) was also recorded maximum seed yield ha\(^{-1}\) when compared with the treatment T\(_1\) (control). Treatments T\(_{11}\) (100 ppm TIBA), T\(_7\) (150 ppm MH), T\(_3\) (50 ppm MH), T\(_{12}\) (125 ppm TIBA), T\(_2\) (25 ppm MH) and T\(_{13}\) (150 ppm TIBA) were found at par with (T\(_1\)) control.

Field studies conducted by Shinde (2010) revealed that the application of TIBA (100 ppm) recorded significantly maximum seed yield in soybean.

Suryawanshi et al. (2013) investigated the effect of foliar spray of CCC (500 ppm) and MH (100 ppm) at 45, 50, 55 and 60 DAS on yield of mung bean. The foliar application of growth regulators significantly enhanced yield.

Per cent increase in yield ha\(^{-1}\) and B:C ratio

The highest per cent increase in yield over control was observed in treatment sprayed with 50 ppm TIBA i.e. 23.93 % followed by 100 ppm MH i.e. 20.12 %. The highest B:C ratio was observed by the foliar application of 100 ppm MH (1.2.18) followed by 50 ppm TIBA (1.2.16) and 125 ppm MH (1:2.09).

Sawant (2014) studied the effect of foliar sprays of growth retardant TIBA with different concentrations (25, 50, 75, 100, 125, 150, 175
ppm) with one control at 25 and 40 DAS on chickpea cv. Jaki-9218. Foliar application of TIBA @ 50 ppm significantly enhanced per cent increase in yield ha\(^{-1}\) and B:C ratio over control and rest of the treatments.

**REFERENCES**


### Table 3. Effect of maleic hydrazide and TIBA on number of siliqua plant⁻¹, number of seeds 20⁻¹ siliqua, 1000 seed weight, seed yield ha⁻¹ (q), per cent increase in yield ha⁻¹ and B : C ratio in mustard

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of siliqua plant⁻¹</th>
<th>Number of seeds 20⁻¹ siliqua</th>
<th>1000 seed weight (g)</th>
<th>Seed yield ha⁻¹ (q)</th>
<th>Per cent increase in yield ha⁻¹</th>
<th>B : C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ (Control)</td>
<td>128.37</td>
<td>228.87</td>
<td>3.01</td>
<td>6.31</td>
<td>-</td>
<td>1.81</td>
</tr>
<tr>
<td>T₂ (25 ppm MH)</td>
<td>130.90</td>
<td>235.93</td>
<td>3.40</td>
<td>6.52</td>
<td>3.16</td>
<td>1.87</td>
</tr>
<tr>
<td>T₃ (50 ppm MH)</td>
<td>133.77</td>
<td>240.83</td>
<td>3.53</td>
<td>6.71</td>
<td>6.33</td>
<td>1.93</td>
</tr>
<tr>
<td>T₄ (75 ppm MH)</td>
<td>136.53</td>
<td>244.70</td>
<td>3.55</td>
<td>7.02</td>
<td>10.45</td>
<td>2.01</td>
</tr>
<tr>
<td>T₅ (100 ppm MH)</td>
<td>142.90</td>
<td>257.17</td>
<td>3.67</td>
<td>7.58</td>
<td>20.12</td>
<td>2.18</td>
</tr>
<tr>
<td>T₆ (125 ppm MH)</td>
<td>139.73</td>
<td>255.50</td>
<td>3.64</td>
<td>7.25</td>
<td>14.89</td>
<td>2.09</td>
</tr>
<tr>
<td>T₇ (150 ppm MH)</td>
<td>132.60</td>
<td>239.70</td>
<td>3.57</td>
<td>6.74</td>
<td>6.81</td>
<td>1.94</td>
</tr>
<tr>
<td>T₈ (25 ppm TIBA)</td>
<td>137.17</td>
<td>242.87</td>
<td>3.51</td>
<td>7.30</td>
<td>15.68</td>
<td>2.06</td>
</tr>
<tr>
<td>T₉ (50 ppm TIBA)</td>
<td>143.60</td>
<td>260.70</td>
<td>3.73</td>
<td>7.82</td>
<td>23.93</td>
<td>2.16</td>
</tr>
<tr>
<td>T₁₀ (75 ppm TIBA)</td>
<td>140.10</td>
<td>246.93</td>
<td>3.66</td>
<td>7.40</td>
<td>17.27</td>
<td>2.01</td>
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<tr>
<td>T₁₁ (100 ppm TIBA)</td>
<td>131.20</td>
<td>244.77</td>
<td>3.61</td>
<td>7.27</td>
<td>15.21</td>
<td>1.94</td>
</tr>
<tr>
<td>T₁₂ (125 ppm TIBA)</td>
<td>130.50</td>
<td>243.97</td>
<td>3.59</td>
<td>6.87</td>
<td>8.87</td>
<td>1.80</td>
</tr>
<tr>
<td>T₁₃ (150 ppm TIBA)</td>
<td>128.80</td>
<td>235.80</td>
<td>3.50</td>
<td>6.53</td>
<td>3.48</td>
<td>1.68</td>
</tr>
<tr>
<td>SE(m)±</td>
<td>1.340</td>
<td>5.057</td>
<td>0.107</td>
<td>0.269</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>3.911</td>
<td>14.762</td>
<td>0.313</td>
<td>0.785</td>
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</tr>
</tbody>
</table>

### Table 1. Effect of maleic hydrazide and TIBA on morpho-physiological traits in mustard

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height plant⁻¹ (cm)</th>
<th>Number of branches plant⁻¹</th>
<th>Leaf area plant⁻¹ (dm²)</th>
<th>Total dry weight plant⁻¹ (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ (Control)</td>
<td>52.50</td>
<td>148.20</td>
<td>156.20</td>
<td>158.80</td>
</tr>
</tbody>
</table>
Table 2. Effect of maleic hydrazide and TIBA on relative growth rate (RGR g g\(^{-1}\) day\(^{-1}\)) and net assimilation rate (NAR g dm\(^{-2}\) day\(^{-1}\)) of mustard

<table>
<thead>
<tr>
<th>Treatments</th>
<th>RGR ( g g(^{-1}) day(^{-1}))</th>
<th>NAR ( g dm(^{-2}) day(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35-50 DAS</td>
<td>50-65 DAS</td>
</tr>
<tr>
<td>T(_1) (Control)</td>
<td>0.0337</td>
<td>0.1161</td>
</tr>
<tr>
<td>T(_2) (25 ppm MH)</td>
<td>0.0338</td>
<td>0.1174</td>
</tr>
<tr>
<td>T(_3) (50 ppm MH)</td>
<td>0.0342</td>
<td>0.1177</td>
</tr>
<tr>
<td>T(_4) (75 ppm MH)</td>
<td>0.0345</td>
<td>0.1231</td>
</tr>
<tr>
<td>T(_5) (100 ppm MH)</td>
<td>0.0352</td>
<td>0.1236</td>
</tr>
<tr>
<td>T(_6) (125 ppm MH)</td>
<td>0.0348</td>
<td>0.1232</td>
</tr>
<tr>
<td>T(_7) (150 ppm MH)</td>
<td>0.0341</td>
<td>0.1230</td>
</tr>
<tr>
<td>T</td>
<td>0.0390</td>
<td>0.1180</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>T9 (25 ppm TIBA)</td>
<td>0.0397</td>
<td>0.1240</td>
</tr>
<tr>
<td>T10 (50 ppm TIBA)</td>
<td>0.0396</td>
<td>0.1235</td>
</tr>
<tr>
<td>T11 (75 ppm TIBA)</td>
<td>0.0390</td>
<td>0.1229</td>
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<tr>
<td>T12 (100 ppm TIBA)</td>
<td>0.0387</td>
<td>0.1178</td>
</tr>
<tr>
<td>T13 (125 ppm TIBA)</td>
<td>0.0393</td>
<td>0.1179</td>
</tr>
<tr>
<td>SE (m) ±</td>
<td>0.0017</td>
<td>0.0017</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.0049</td>
<td>0.0050</td>
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</tbody>
</table>