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Vol. 23(2)

May-August, 2025

CONTENTS

Bioaccumulation of heavy metals in soils and <i>Telfairia occidentalis</i> leaf grown around a river bank and dump site	139
ORHUE, E. R., EMOMU, A., JUDAH-ODIA, S. A., AIGBOGHAEBHOLO, O. P. and NWAEKE, I. S.	
Evaluation of maize cultivars for spring season in Indo-Gangetic plain of India	149
AMIT BHATNAGAR, N. K. SINGH and R. P. SINGH	
Weed management approaches for improving maize productivity in <i>Tarai</i> Belt of India	157
AKHILESH JUYAL and VINEETA RATHORE	
Effect of <i>Aloe vera</i> based composite edible coatings in retaining the postharvest quality of litchi fruits (<i>Litchi chinensis</i> Sonn.) cv. Rose Scented	163
GOPAL MANI, OMVEER SINGH and RATNA RAI	
Effect of chemical treatments on seed yield and quality in parthenocarpic cucumber (<i>Cucumis sativus</i> L.)	178
DHIRENDRA SINGH and UDIT JOSHI	
Assessment of chrysanthemum (<i>Dendranthema grandiflora</i> Tzvelev) varieties for their suitability for flower production under <i>Tarai</i> region of Uttarakhand	183
PALLAVI BHARATI and AJIT KUMAR KAPOOR	
Population dynamics of brown planthopper and mirid bug in relation to weather factors in the <i>Tarai</i> region	194
DEEPIKA JEENGAR and AJAY KUMAR PANDEY	
Influence of weather parameters on the population dynamics of Papaya mealybugs, <i>Paracoccus marginatus</i> and its natural enemies in Pantnagar, Uttarakhand	200
DIPTI JOSHI and POONAM SRIVASTAVA	
<i>In vitro</i> phosphate solubilizing and phyto stimulating potential of Rhizospheric <i>Trichoderma</i> from Hilly areas of Kumaun Region	208
DIVYA PANT and LAKSHMI TEWARI	
Economics of interventions and diversifications in existing farming systems in hills of Uttarakhand	221
DINESH KUMAR SINGH, AJEET PRATAP SINGH and ROHITASHAV SINGH	
Brucellosis surveillance and reproductive performance in an organized dairy herd of Uttarakhand: A seven-year retrospective analysis (2018–2024)	227
ATUL YADAV, SHIVANGI MAURYA, MAANSI and AJAY KUMAR UPADHYAY	
Effects of nanosilver administration on immune responses in Wistar Rats	230
NEHA PANT, R. S. CHAUHAN and MUNISH BATRA	

Antibacterial activity of Clove bud extract on MDR bacteria KANISHK A. KAMBLE, B. V. BALLURKAR and M. K. PATIL	240
Effect of iron oxide and aluminium oxide nanoparticles on biochemical parameters in Wistar rats NISHA KOHLI and SEEMA AGARWAL	247
Comprehensive case report of a mast cell tumor in a dog: clinical, cytological and histopathological analysis SWASTI SHARMA, SONALI MISHRA and GAURAV JOSHI	257
Evaluation of <i>In vitro</i> digestibility, functional and sensory characteristics of pre-digested corn and mungbean composite flour MANISHA RANI and ANJU KUMARI	261
Prevalence and public health correlates of constipation among adults in U. S. Nagar, Uttarakhand AKANKSHA SINGH, RITA SINGH RAGHUVANSHI and APURVA	270
Formulation and quality assessment of cheeses enriched with sapota pulp DELGI JOSEPH C. and SHARON, C. L.	279
Application of RSM for optimizing 7-day fermentation conditions in rice wine production RIYA K ZACHARIA, ANEENA E. R and SEEJA THOMACHAN	289
Investigating the mechanical properties and water absorption behavior of hemp-based natural fiber-reinforced bio-composites for humidity-resistant applications DEEPA SINGH and NEERAJ BISHT	303
Evaluating the performance of a forced convection solar drying system for chhurpi: A comparative analysis with traditional drying techniques SYED NADEEM UDDIN, SANDEEP GM PRASAD and PRASHANT M. DSOUZA	317
Digitization of G. B. Pant University Herbarium (GBPUH) and development of Virtual Herbarium Pantnagar, Uttarakhand (INDIA) RUPALI SHARMA, DHARMENDRA SINGH RAWAT and SANGEETA JOSHI	326
Constraints grappled with by rural communities during the implementation of Viksit Krishi Sankalp Abhiyan 2025 in Udham Singh Nagar District ARPITA SHARMA KANDPAL, B. D. SINGH, AJAY PRABHAKAR, SWATI and MEENA AGNIHOTRI	332

Effect of chemical treatments on seed yield and quality in parthenocarpic cucumber (*Cucumis sativus* L.)

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ABSTRACT: Cucumber is a cross-pollinated crop exhibiting diverse flower morphology including male, female and hermaphrodite flowers. Parthenocarpic cucumber varieties produce female or gynoeceious flower leading to formation of fruit without fertilization, which poses a challenge in seed production due to the absence of male flowers. Hence, the present study aimed to access the impact of chemical treatments on male flower induction, seed yield and quality in parthenocarpic cucumber (Pant Parthenocarpic Cucumber-3). The experiment was conducted at the V. R. C., Pantnagar, from 2021-22 to 2023-2024 in a RBD layout with three replications. Nine treatments, including different concentrations of silver nitrate, gibberellic acid (GA₃), and silver thiosulphate, were applied at the 2 and 4 true leaf stages. On the basis of 3-year pooled data it was observed that application of silver nitrate at 500 ppm induced the maximum number of male flowers (60) followed by 250 ppm (56.89) and 750 ppm (47) silver nitrate. Application of silver nitrate at 500 ppm also recorded the maximum number of seeds per fruit (82.62) and seed yield (462.48 Kg/ha) with no significant difference in seed quality parameters of different treatments. The benefit cost ratio was highest (3.46) in application of silver nitrate at 500 ppm followed by application of 750 ppm silver nitrate (3.22). Therefore, it can be concluded that foliar spray of silver nitrate at 500 ppm at 2 and 4 true leaf stages might be recommended for induction of male flowers in parthenocarpic cucumber under *Tarai* region of Uttarakhand.

Key words: Cucumber, GA₃, parthenocarpic, seed quality, seed yield, silver nitrate

Cucumber (*Cucumis sativus* L.) is a very important horticultural crop which is a crucial member of Cucurbitaceae family grown globally for its consumption as salad or pickle (Dhall *et al.*, 2024). It exhibits a wide range of floral morphology having male, female and hermaphrodite flowers which are generally borne solitary (Mandal *et al.*, 2022 and Acharya *et al.*, 2024). Although the monoecious sex form is found predominantly in cucumber but the gynoeceious sex form has been exploited for production of F₁ hybrids and induction of parthenocarp (Rao *et al.*, 2017 and Dhall *et al.*, 2022). Parthenocarp in cucumber is a desirable trait for greenhouse cultivation, ensuring fruit set without pollination (Kim *et al.*, 1992). However, in seed production, the absence of male flowers necessitates exogenous intervention to induce their formation (Zhang and Wang, 2017). Hence, there is a need to develop an approach for overcoming a significant challenge in the seed production of parthenocarpic cucumbers i.e., the absence of male flowers. Various chemicals

including silver nitrate, gibberellic acid (GA₃), and silver thiosulphate, have been tested for their ability to induce male flowers in gynoeceious and parthenocarpic cucumber lines (Choudhary and Singh, 2020 and Basu and Sinha, 2021). The present study hence, evaluates the efficacy of several chemical treatments in initiating male flowers and enhancing the seed yield and quality in Pant Parthenocarpic Cucumber-3. By assessing the efficacy of various chemical treatments, including silver nitrate (AgNO₃), gibberellic acid (GA₃), and silver thiosulphate (STS), the research was attempted to identify the effective methods for inducing male flower formation and enhancing seed yield and quality in Pant Parthenocarpic Cucumber-3.

MATERIALS AND METHODS

The field trial was conducted at the Vegetable Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, U. S. Nagar, Uttarakhand

from 2021-22 to 2023-24. The experiment followed a Randomized Block Design (RBD) layout using Pant Parthenocarpic Cucumber-3 as the test variety. Geographically, Pantnagar lies in the *Tarai* foothills of the Shivalik range of the Himalayas. The region experiences a humid subtropical climate, with summer temperatures ranging from 32°C to 43°C (May-June) and winter temperatures from 0°C to 9°C (January). Summers are hot and dry, while winters are cold, with frost occurring from late December to late January. Nine treatments were applied as foliar sprays at the 2 and 4 true leaf stages of parthenocarpic cucumber (Table 1) with each treatment replicated thrice. Observations were recorded on the fruit yield per plot (kg), number of seeds per fruit, 100 seed weight (g), seed yield per plot (g), seed yield (Kg/ha), seed germination (%), seed vigour index-I, seed vigour index-II and B:C ratio. The data were collected from randomly selected and tagged plants and were analyzed using ANOVA statistical method devised by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Effect of chemical treatments on fruit yield per plot

The Table 2 and fig.2 presents the effects of different chemical treatments on fruit yield in Pant Parthenocarpic Cucumber-3. The maximum fruit yield (44.94 kg) was recorded in T₂ (500 ppm silver nitrate), followed by T₁ (250 ppm silver nitrate) with the yield of 35.54 kg and T₃ (750 ppm silver nitrate) with 32.89 kg. The lowest fruit yield was observed in T₈ (3mM silver thiosulphate) with the yield 28.91 kg. This superior yield aligns with the findings by Gao *et al.* (2019), who emphasized that silver nitrate promoted male flower formation, thereby facilitating better pollination and fruit set. In contrast, lower yields in GA₃ and silver thiosulphate treated plants suggest limited effectiveness in male flower induction when applied alone.

Effect of chemical treatments on seed yield parameters

Table 2 fig.1 and fig.2 present the impact of various foliar spray treatments on different parameters re-

lated to seed production in Pant Parthenocarpic Cucumber-3. The highest number of seeds per fruit (82.62) were produced by the treatment T₂ (500 ppm silver nitrate), indicating its effectiveness in promoting male flowers and pollination. The lowest seed count (54.44) was recorded in T₇ (1mM silver thiosulphate) also the GA₃ treated plants (T₄-T₆) had lower seed numbers, ranging between 58.55 and 72.24 seeds per fruit which suggests that these treatments were less effective in promoting seed formation likely due to their suboptimal influence on pollen availability. Basu and Sinha (2021) observed that GA₃ at 50-100 ppm could promote male flowers, but the present findings show that AgNO₃ at 500 ppm had a more pronounced effect. This discrepancy might be attributed to the cultivar specific response or environmental conditions under which the present study was conducted. The highest 100-seed weight (3.76 g) was observed in T₂ (500 ppm silver nitrate), followed by T₈ (3.55 g) and T₁ (3.55 g). GA₃ treated

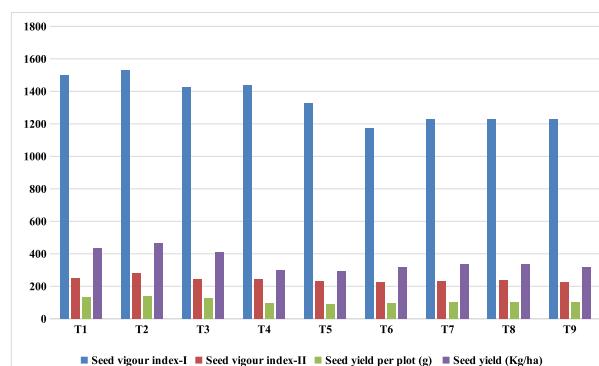


Fig.1: Effect of various foliar spray treatments on seed vigour index and seed yield of Pant Parthenocarpic Cucumber-3 based on 3 years pooled data

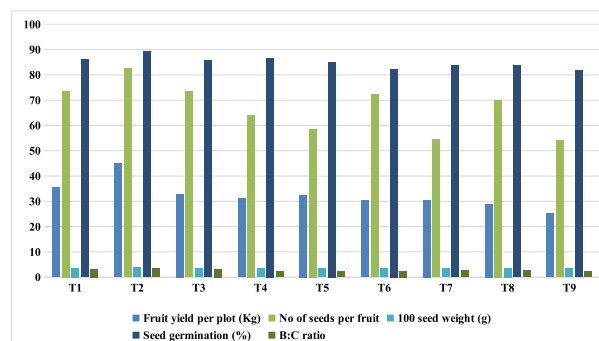


Fig.2: Effect of various foliar spray treatments on fruit yield, seed parameters and economics of Pant Parthenocarpic Cucumber-3 based on 3 years pooled data

Table 1: Treatments for standardization of initiation of male flowers

S. No.	Treatment	Treatment Details
T ₁	250 ppm silver nitrate	Foliar spray at 2 and 4 true leaf stages
T ₂	500 ppm silver nitrate	Foliar spray at 2 and 4 true leaf stages
T ₃	750 ppm silver nitrate	Foliar spray at 2 and 4 true leaf stages
T ₄	50 ppm GA ₃	Foliar spray at 2 and 4 true leaf stages
T ₅	100 ppm GA ₃	Foliar spray at 2 and 4 true leaf stages
T ₆	150 ppm GA ₃	Foliar spray at 2 and 4 true leaf stages
T ₇	1 mM silver thiosulphate	Foliar spray at 2 and 4 true leaf stages
T ₈	3 mM silver thiosulphate	Foliar spray at 2 and 4 true leaf stages
T ₉	Control	Foliar spray of water at 2 and 4 true leaf stages

Note: True leaf stages of the cucumber plant are the mature, lobed, and serrated leaves.

Table 2: Impact of various foliar spray treatments on fruit and seed yield parameters in Pant Parthenocarpic Cucumber-3 based on 3 years pooled data

Entry	Treatment details	Fruit yield per plot (Kg) 3x1 m ²	No of Seed per fruit	100 seed weight (g)	Seed yield per plot (g) 3 x 1 m ²	Seed yield (Kg/ha)
T ₁	Foliar spray of 250 ppm silver nitrate at 2 and 4 true leaf stage	35.54	73.65	3.55	132.88	435.20
T ₂	Foliar spray of 500 ppm silver nitrate at 2 and 4 true leaf stage	44.94	82.62	3.76	139.78	462.48
T ₃	Foliar spray of 750 ppm silver nitrate at 2 and 4 true leaf stage	32.89	73.47	3.54	127.06	411.14
T ₄	Foliar spray of 50 ppm GA ₃ at 2 and 4 true leaf stage	31.22	64.12	3.48	96.71	299.26
T ₅	Foliar spray of 100 ppm GA ₃ at 2 and 4 true leaf stage	32.43	58.55	3.50	89.72	289.68
T ₆	Foliar spray of 150 ppm GA ₃ at 2 and 4 true leaf stage	30.39	72.24	3.45	95.52	316.75
T ₇	Foliar spray of 1mM sliver thiosulphate at 2 and 4 true leaf stage	30.49	54.44	3.53	100.76	337.00
T ₈	Foliar spray of 3mM sliver thiosulphate at 2 and 4 true leaf stage	28.91	70.02	3.55	101.89	335.34
T ₉	Foliar spray of water at 2 and 4 true leaf stages	25.24	54.14	3.41	100.00	315.41
	CD at 5%	3.12	2.04	9.54	6.83	3.65
	CV (%)	6.41	3.94	15.29	12.97	8.9

Table 3: Impact of various foliar spray treatments on fruit and seed quality and economic parameters in Pant Parthenocarpic Cucumber-3 based on 3 years pooled data

Entry	Treatment details	Seed germination (%)	Seed vigour index-I	Seed vigour index-II	B:C ratio
T ₁	Foliar spray of 250 ppm silver nitrate at 2 and 4 true leaf stage	86.11	1499.33	246.35	3.19
T ₂	Foliar spray of 500 ppm silver nitrate at 2 and 4 true leaf stage	89.22	1527.86	278.47	3.46
T ₃	Foliar spray of 750 ppm silver nitrate at 2 and 4 true leaf stage	85.78	1424.67	245.12	3.22
T ₄	Foliar spray of 50 ppm GA ₃ at 2 and 4 true leaf stage	86.67	1437.02	244.85	2.22
T ₅	Foliar spray of 100 ppm GA ₃ at 2 and 4 true leaf stage	85.11	1326.11	230.89	2.30
T ₆	Foliar spray of 150 ppm GA ₃ at 2 and 4 true leaf stage	82.33	1171.49	225.01	2.38
T ₇	Foliar spray of 1mM sliver thiosulphate at 2 and 4 true leaf stage	83.78	1226.35	228.25	2.58
T ₈	Foliar spray of 3mM sliver thiosulphate at 2 and 4 true leaf stage	83.67	1227.53	236.20	2.72
T ₉	Foliar spray of water at 2 and 4 true leaf stages	81.85	1225.85	224.85	2.12
	CD at 5%	3.05	2.21	9.32	3.12
	CV (%)	8.72	8.72	3.28	6.41

plants had the lowest seed weight (3.45 g in T₆), indicating a possible negative effect on seed development. This reinforces the idea that AgNO₃ not only increases the number of seeds but also enhances their development and maturation. Supporting this, Kim

and Lee (2018) reported that silver nitrate plays a critical role in improving seed development when used in conjunction with GA₃ although the present findings suggest that silver nitrate alone at higher concentrations may be sufficient. Similar trends were

seen in seed yield per plot and per hectare with T_2 (500 ppm silver nitrate) yielding 139.78 g per plot and 462.48 Kg/ha, respectively. These values further substantiate the role of silver nitrate in maximizing seed output, in agreement with Patel and Verma (2022), who observed increased seed productivity in cucumber plants with ethylene inhibitors like silver thiosulphate and silver nitrate. However, the present study suggests that silver nitrate at 500 ppm alone can outperform these combinations.

Effect of chemical treatments on seed quality parameters

The data regarding germination percentage and seed vigour indices showcased in Table 3 and depicted in fig.2 respectively. The highest germination (89.22%) was observed in T_2 (500 ppm silver nitrate), confirming its beneficial effect on seed viability. The lowest germination (82.33%) was recorded in T_6 (150 ppm GA_3). Treatments with silver nitrate showed higher germination percentages compared to GA_3 and silver thiosulphate. Seed vigour index-I (based on seedling length) and seed vigour index-II (based on seedling dry weight) indicated seedling strength and quality. The highest SVI-I was observed under T_2 (1527.86), followed by T_1 (1499.33). Whereas, the lowest SVI-I was observed under T_6 (1171.49), showing that 150 ppm GA_3 negatively affected seedling vigour. The highest SVI-II was also recorded under T_2 (278.47), followed by T_8 (236.20). Whereas, lowest SVI-II was recorded under T_6 (225.01). These results demonstrate the dual benefits of silver nitrate in improving both seed quantity and quality. Susaj and Susaj (2010) and Ranjan and Sharma (2023) highlighted the importance of precisely timed growth regulator applications to improve male flower production and seed yield, which may explain the outstanding results in application of 500 ppm silver nitrate due to optimized application timing.

Effect of chemical treatments on overall economics of parthenocarpic cucumber seed production

Economically, the highest benefit-cost (B:C) ratio (3.46) was achieved with T_2 making it the most com-

mercially viable treatment followed by T_1 (3.19) and T_3 (3.22). The lowest B:C ratio (2.22) was recorded in T_4 (50 ppm GA_3). The significantly lower B:C ratio in GA_3 treated plots emphasizes the inefficiency of GA_3 alone for profitable seed production (Table 3 and Fig.2). Singh and Mehta (2021) emphasized the role of ethylene inhibition in modulating sex expression and the present findings support that silver nitrate, as an effective ethylene inhibitor, contributes not only to enhanced agronomic traits but also economic returns.

In contrast to earlier studies that suggested combined use of GA_3 and silver nitrate or silver thiosulphate for optimal results (Zhang and Wang, 2017), the current study provides strong evidence that a single application of silver nitrate at 500 ppm is sufficient to induce high male flower counts (around 60 flowers), improves seed yield and quality and ensure economic sustainability in seed production of parthenocarpic cucumber. This highlights the need to revisit standard protocols and explore simpler, cost-effective strategies for hybrid seed production.

CONCLUSION

Parthenocarpic cucumber varieties, being naturally female-flowered and seedless, require external interventions for male flower induction to enable hybrid seed production. The application of growth regulators like silver nitrate plays a crucial role in modifying sex expression and ensuring pollination. The results obtained from the present study concluded that the foliar spray of silver nitrate at 2 and 4 true leaf stages at 500 ppm was the most effective treatment for enhancing seed yield, seed quality and economic returns in parthenocarpic cucumber. It significantly improved male flower induction, fruit yield, seed yield and economics compared to GA_3 and silver thiosulphate treatments. Therefore, silver nitrate at 500 ppm might be recommended under *Tarai* regions of Uttarakhand after field testing in specific environments as a reliable and efficient strategy for commercial hybrid seed production in parthenocarpic cucumber, offering both agronomic and economic advantages. Future studies may explore the synergistic effects of silver nitrate with other growth regu-

lators to further optimize seed production techniques.

REFERENCES

- Acharya, V. R., Kumar, S., Acharya, Z., Gor, D., Patel, N. and Parihar, A. (2024). Modification of the sex expression and maintenance of gynoecious parthenocarpic line in cucumber (*Cucumis sativus* L.). *International Journal of Advanced Biochemistry Research*, 8 (11): 928-931. DOI: <https://doi.org/10.33545/26174693.2024.v8.i11.2977>
- Basu, A. and Sinha, P. (2021). Influence of gibberellic acid and silver nitrate on male flower induction in gynoecious cucumber lines. *Journal of Horticultural Science*, 48 (2): 125-134.
- Choudhary, B. R. and Singh, D. (2020). Role of silver thiosulphate in inducing male flowers in cucumber (*Cucumis sativus* L.). *Plant Growth Regulation*, 39 (3): 295-302.
- Dhall, R. K., Hegde, S. N. and Malhotra, P. K. (2022). Standardized Protocol for In Situ and In Vitro Maintenance of Newly Developed Parthenocarpic Gynoecious Cucumber Inbred. *Brazilian Archives of Biology and Technology*, 65: 1-10. DOI: <https://doi.org/10.1590/1678-4324-2022200792>
- Dhall, R. K., Kaur, H., Manchanda, P. and Sharma, E. (2024). Recent advances in genetics and molecular breeding of parthenocarpic cucumber (*Cucumis sativus* L.) under protected conditions. *Euphytica*, 220 (7): 104. DOI: <https://doi.org/10.1007/s10681-024-03366-7>
- Gao, S., Zhao, Y. and Liu, W. (2019). Effects of GA₃ and AgNO₃ on floral sex expression and seed production in parthenocarpic cucumber. *Scientia Horticulturae*, 253: 95-102.
- Kim, Il. S., Okubo, H. and Fujieda, K. (1992). Genetic and hormonal control of parthenocarpy in cucumber (*Cucumis sativus* L.). *Journal of the Faculty of Agriculture*, 36 (3-4): 173-181. DOI: <https://doi.org/10.5109/23983>
- Kim, H. J. and Lee, J. S. (2018). Application of growth regulators for male flower induction in seedless cucumber varieties. *Horticultural Research*, 7: 47-56.
- Mandal, N. K., Kumari, K., Kundu, A., Arora, A., Bhowmick, P. K., Iquebal, M. A. and Dey, S. S. (2022). Cross-talk between the cytokinin, auxin, and gibberellin regulatory networks in determining parthenocarpy in cucumber. *Frontiers in Genetics*, 13: 1-18. DOI: <https://doi.org/10.3389/fgene.2022.957360>
- Panse, V. G. and Sukhatme, P. V. (1967). Statistical methods for agricultural workers 2nd eds. ICAR New Delhi, 381p.
- Patel, R. K. and Verma, P. (2022). Comparative study on the effectiveness of GA₃, silver nitrate, and STS in inducing male flowers in gynoecious cucumbers. *Proceedings-21st Scientific-Expert Conference of Agriculture and Food Industry, Neum 2010*, 65 (1): 18-29.
- Ranjan, R. and Sharma, A. (2023). Standardization of male flower induction techniques for hybrid seed production in parthenocarpic cucumbers. *International Journal of Agricultural Research*, 12 (4): 215-230.
- Rao, G. P., Behera, T. K., Munshi, A. D. and Dev, B. (2017). Estimation of genetic components of variation and heterosis studies in bitter melon for horticultural traits. *Indian Journal of Horticulture*, 74 (2): 227-232. DOI: [10.5958/0974-0112.2017.00047.0](https://doi.org/10.5958/0974-0112.2017.00047.0)
- Singh, V. and Mehta, P. (2021). Ethylene inhibition and its role in male flower induction in cucumbers. *Acta Horticulturae*, 1315: 89-96.
- Susaj, E. and Susaj, L. (2010). Induction of staminate flowers in gynoecious cucumber lines (*Cucumis sativus* L.) using silver nitrate. *Proceedings-21st Scientific-Expert Conference of Agriculture and Food Industry, Neum 2010*, 65 (1): 407-414.
- Zhang, X. and Wang, L. (2017). Influence of plant growth regulators on floral development in cucumber (*Cucumis sativus* L.). *SciELO Brazil*, 9 (2): 112-124.

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