Impact of gametocides on pollen sterility and growth traits in Chilli*(Capsicum annuum* L.*)*.

Abstract

This study, conducted at the College of Agriculture Vellayani, Thiruvananthapuram during 2023-2024, investigated the effects of gametocides on pollen sterility and plant growth in two chilli varieties, Jwalamukhi and Ujwala. The experiment followed a Factorial Completely Randomized Design with 18 treatments (2 varieties x 9 gametocide concentrations x 3 stages), replicated thrice. Pollen sterility was significantly affected by gametocide treatments, with Maleic Hydrazide (MH) at 200 ppm applied at 20+40 days after transplanting (DAT) resulting in the highest sterility in both varieties. Plant height also varied significantly, with the highest growth observed in Jwalamukhi treated with GA3 at 2.5% in stage III. The study found that GA3 increased plant height and branching, while MH treatments, especially at higher concentrations, reduced plant height, with Ujwala showing the most pronounced effect. These findings highlight the potential of gametocide treatments in modifying pollen sterility and growth traits in chilli plants.

Keywords: pollen sterility, gametocides, CHA's, factorial CRD, chilli

Introduction

Chili pepper (Capsicum annuum L.) is the fruit of plants in the Capsicum genus, which is part of the Solanaceae family. This crop originated in Mexico and Central America. Today, chili peppers are grown globally, widely used as a spice in various cuisines, and utilized in the pharmaceutical industry for extracting bioactive compounds called capsaicinoids. (Khaitov et al., 2019).

Chillies are a great source of vitamins and contain minerals such as molybdenum, magnesium, potassium, and copper. (Gokul et al., 2020).Nutritionally, it provides a significant amount of vitamin C (111 mg/100 g), vitamin A (298 I.U./100 g), vitamin E, small amounts of protein (2.9 g/100 g), fats, carbohydrates, and minerals. Chilli is also low in sodium and free from cholesterol. Its strong spiciness is attributed to a crystalline, bitter volatile alkaloid called capsaicin (C18H27NO3), which has various preventive and therapeutic applications in both allopathic and ayurvedic medicine. (Bhattacharyya *et al.*, 2018).Chilli is an often-cross-pollinated, with cross-pollination ranging from 7 to 36 percent. The fruit is a berry, varying in color from green to red. The current method of manually removing the male parts of the plant for hybrid seed production is labor-intensive and raises seed production cost.The emasculation step in hybrid seed production represents about 40 percent of the labor costs. Therefore, developing methods to eliminate this process is a priority. Although there are different male sterility systems such as GMS, CMS, and CGMS, chemically induced male sterility (CIMS) is essential to bypass the labor-intensive emasculation procedure. Chemically induced male sterility refers to a type of sterility that is not inherited and is triggered by chemicals that cause the male reproductive parts to fail. Unlike other systems, there is no need to identify and maintain separate male sterile and restorer lines. Additionally, challenges arise in identifying, eliminating, and restoring the genetically controlled sterility in male sterile lines. Therefore, the use of gametocides is highly beneficial in chili cultivation, as it ensures complete male sterility (Kempe and Gils, 2011).

The chemical method for inducing sterility can eliminate the typically lengthy process needed to develop male-sterile and restorer lines, which is usually required before assessing hybrid performance. As a result, chemicals gained attention as both breeding tools and as a way to produce hybrids on a large scale commercially (Mc, Rae D.H. 1985).To produce a hybrid through chemically induced male sterility, a gametocide or chemical hybridizing agent (CHA) must first be applied to the fertile female parent. The gametocide prevents pollen production, rendering the female parent male sterile. This male sterile female parent is then crossed with a male fertile pollen parent, resulting in an F1 generation that is male fertile (Kempe and Gils, 2011).The efficiency of the chemicals also depends on the stage of application.

Keeping all these things in view, the present study was formulated with the objective of standardizing the concentration, number and time of application of chemicals namely Maleic hydrazide, gibberellic acid and Dalapon to induce maximum male sterility in chilli.

MATERIALS AND METHODS

Description of study work

The experiment was conducted at college of Agriculture Vellayani, Thiruvananthapuram during 2023 to 2024. The chilli varieties used for the study was jwalamukhi and ujwala. Seeds of these varieties were sown in portrays and maintained well under polyhouse. The seeds germinated within a week and were transplanted to the grow bags one month after sowing. The seedlings were raised in plastic pro-trays filled with coir pith and vericompost in the ratio 2:1 and the crop was maintained as per the KAU POP (Vani and Podikunju, 2020)

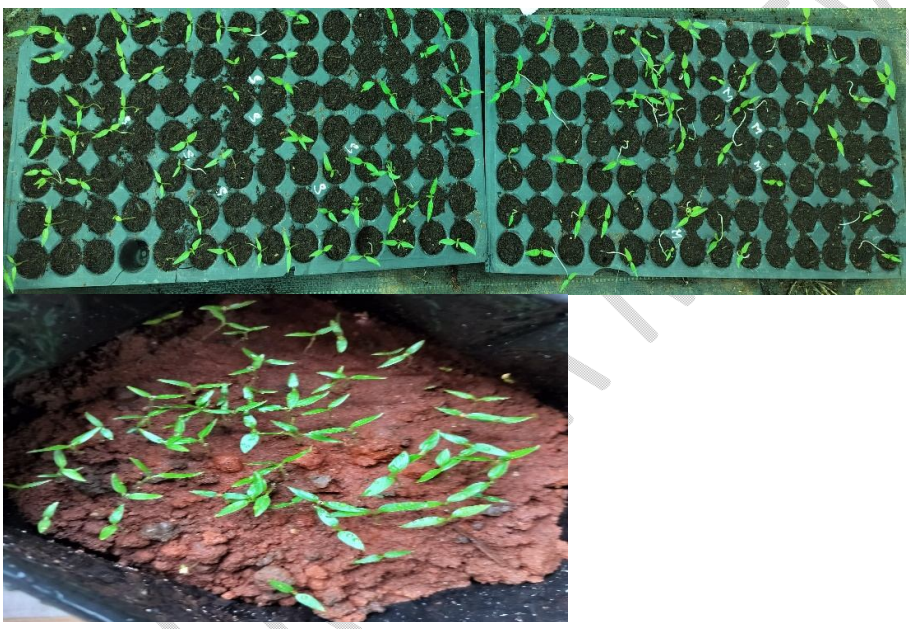

Fig 1: Nursery preparation

Treatments Design and experimental procedures

The experiment was laid out in Factorial completely Randomized Design with 2 x 9 x 3 treatments replicated thrice. The study comprised at two varieties and nine different concentrations of the three gametocides in three stages.

List-1 Classification of plants based on pollen sterility (Virmani et al., 1997)

Category	Pollen sterility %
Completely sterile	100%
Sterile	90-99%
Partially sterile	71-90%
Partially fertile	31-70%
Fertile	21-30%
Fully fertile	0-20%

Treatment details were follow as Varieties (V_1 – jwalamukhi, V_2 – ujwala); gametocides treatments (T_1- maleic hydrazide@50ppm, T_2- maleic hydrazide@100ppm, T_3- maleic hydrazide@150ppm, T_4- maleic hydrazide@200ppm, T_5- GA3@2%, T_6- GA3@2.5%, T_7- Dalapon @0.2%, T_8- Dalapon@0.2%, T_9-control(water spray)); stages (S_1- 20DAT, S_2- 20+40DAT, S_3-40DAT).

Pollen sterility of jwalamukhi and ujwala were recorded following the standard procedures (Deepak *et al.*, 2007) and the pollen sterility can be calculated by using formula

$$\text{Pollen sterility \%} = \frac{\text{number of unstained pollen grains}}{\text{total number of pollen grains}} \times 100$$

The data generated from the experiment were statistically analyzed using analysis of variance (ANOVA) technique as applied to completely randomized design (Panse and Sukhatme,1985). The General R based Analysis Platform Empowered by Statistics (GRAPES 1.0.0) software developed by (Gopinath *et al.*,2021) was used for under taking statistical analysis.

Results and discussion

The data pertaining to pollen sterility (table 1) indicates significant difference among treatments as influenced by the gametocides. In jwalamukhi treatments T_4 with the application of MH 200 ppm at 20 and 40 DAT had the highest pollen sterility (93.280%) which was on par with T_4 MH at 200ppm at 40 DAT (89.560%) followed by T_3 with the application of MH 150ppm at 20 and 40 DAT (81.530%).

In ujwala treatments T_4 with the application of MH 200 PPM at 20 and 40 DAT had the highest pollen sterility (84.170%) followed by T_4 with the application of MH 200 ppm at 40 DAT (80.177%).The pollen sterility per cent recorded lowest in case of control (12.933%) in jwalaukhi and in ujwala (19.153%) and among the treated plants T_1 MH 50ppm at 20 DAT (44.270%) in ujwala recorded the lowest.

Application of 200 ppm MH 10 days before bud initiation (DBBI) and at bud initiation (BI) resulted in male sterility in brinjal (Chintal, 2001). Muthuvel (2003) reported that with the increased concentrations of MH and GA, pollen sterility percentage increased in varieties (Arka Lohit, Ujwala, Punjab Lal, and PKM1) of chilli.

Table 1. Effect of gtametocides on pollen sterility

Mean sum of squares

Character	Pollen sterility	SE(m)	CD(0.001)
Factor A (variety)	2301.962***	0.078	0.22
Factor B (gametocides)	6699.0819***	0.166	0.467
Factor C (stages)	1460.8944***	0.096	0.269
Factor A x B (variety x gametocides)	151.0653***	0.235	0.66
Factor A x C (variety x stages)	39.6088***	0.136	0.381
Factor B x C (gametocides x stages)	39.2941***	0.288	0.808
Factor A x B x C (variety x gametocides x stages)	5.5424***	0.408	1.143
Error	0.4987		

*** Significant at 0.001 level

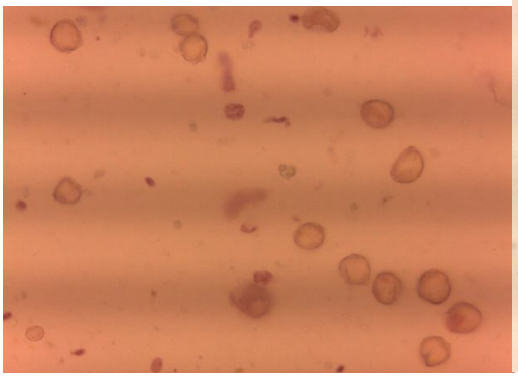

Fig 2: MH@200PPM at 20+40 DAT-Jwalamukhi

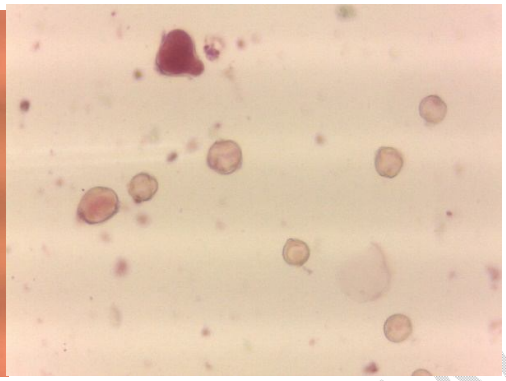

Fig 3: MH@200PPM at 20+40 DAT – Ujwala

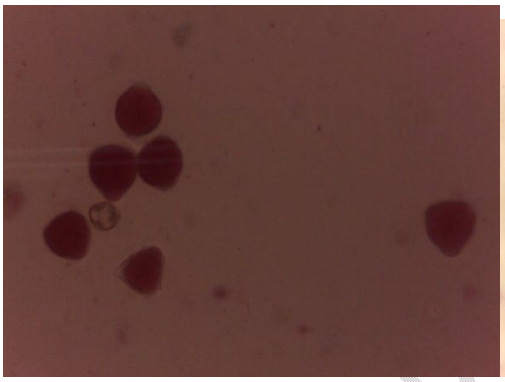

Fig 4: control – jwalamukhi

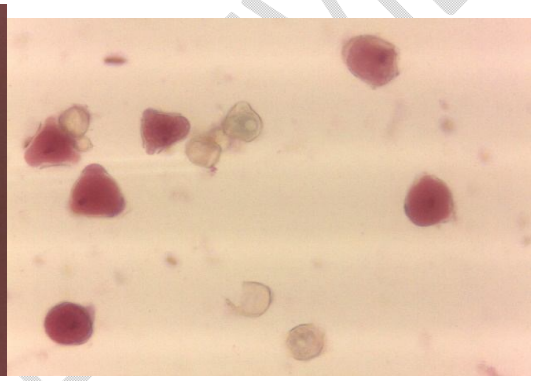

Fig 5: control - Ujwala

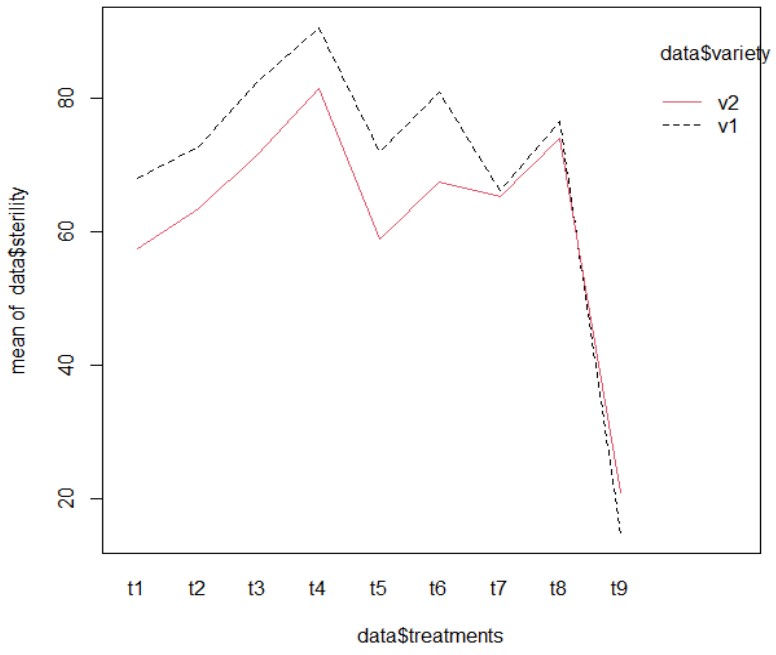

Fig 6: Comparison of pollen sterility recorded in different treatments between two varieties

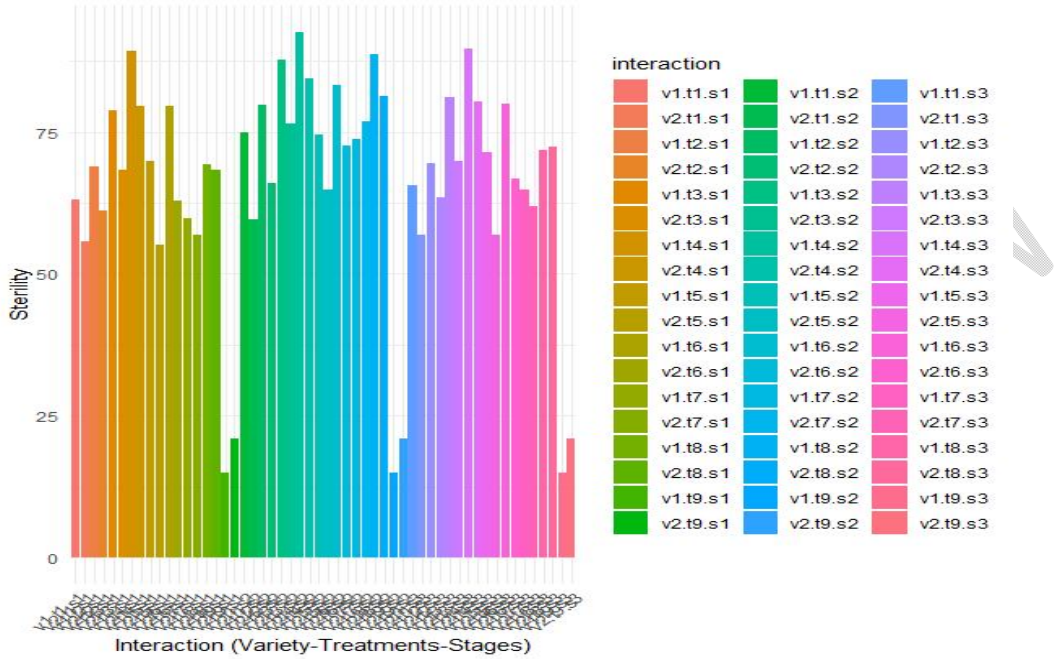

Fig 7: comparison of factors and its interactions with pollen sterility

Table 2. Effect of gametocides on plant height (cm)

	Mean sum of squares		
Character	Plant height (cm)	SE(m)	CD(0.001)
Factor A (variety)	1215.5737	0.105	0.294***
Factor B (gametocides)	980.6629	0.223	0.624***
Factor C (stages)	60.6006	0.128	0.36***
Factor A x B (variety x gametocides)	7.7141	0.315	0.882***
Factor A x C (variety x stages)	0.4646	0.182	NS
Factor B x C (gametocides x stages)	24.0629	0.385	1.08***
Factor A x B x C (variety x gametocides x stages)	1.3253	0.545	NS
Error	0.8912		

*** Significant at 0.001 level

The height of the plants was measured from ground to the tip of the leaf bud, the average was calculated and expressed in cm. The data on plant height recorded in table 2. The data pertaining plant

height indicated significant difference among the factors. Significantly higher plant height was recorded in jwalamukhi (54.911cm) and treatment T_6 with the application of GA3@2.5% (64.168cm) in stage III (52.976cm). The interactions between varieties and gametocides T6V1 highest plant height was recorded in T_6 with the application of GA3@2.5% in jwalamukhi (67.556cm) and the combination of gametocide and stages T_6S_2 was recorded highest plant height (66.425cm).

Lowest plant height was recorded in ujwala (49.433cm) and treatment T_4 with the application of maleic hydrazide@ 200ppm (40.979cm) in stage II (50.971cm). The treatment combination in T_4V_2 (ujwala with the application of maleic hydrazide @200ppm) was recorded lowest plant height (38.272cm). The combination of gametocide and stage T_4S_2 resulted the lowest plant height (39.627cm).

The plant height and number of branches/plant increased significantly with the increasing level of GA3 (Prasad et al., 2013) This might be due to rapid increase in cell division and cell elongation in the meristematic region (Gupta and Gupta (2000) and Rai et al., (2006).

MH indicated that the higher concentration may have inhibited cell elongation as well as mitosis. Reported that cell elongation was inhibited at a late stage than cell division (Greulach and Haesloop, 1954)

Conclusion

The study proved the efficacy of MH 200 ppm at 20 and 40 DAT induced highest pollen sterility, but it needs further research to standardize the time and frequency of application to obtain 100 percent pollen sterility for hybrid seed production in jwalamukhi and ujwala varieties.

References

Bhattacharyya, R., Baruah, U. and Bhattacharyya, R.K. 2018. Quint Essential Chillies of Northeast India. *Int. J. Food Sci. Nutr*. 10.21088/ijfnd.2322.0775.6318.

Chintal, S.V. 2001. Physiological and histochemical changes associated with the male sterility in brinjal using plant growth regulators. M.Sc. (Ag) thesis, University of Agricultural Sciences, Dharwad,106p.

Gokul, D., Poonkodi, P. and Angayarkanni, A., 2020. Effect of integrated nutrient management on the growth and nutrient content of chilli (Capsicum annuum L.). *Int J Chem Stud*, *8*(4), pp.2647-51.

Gopinath PP, Parsad R, Joseph B, Adarsh VS. Grapes Agril: Collection of shiny apps for data analysis in agriculture. J. Open source Software. 20216;(63): 3437-3441.

Greulach, V.A. and Haesloop, J.G., 1954. Some effects of maleic hydrazide on internode elongation, cell enlargement, and stem anatomy. *American Journal of Botany*, pp.44-50.

Gupta PK and Gupta AK (2000) Efficacy of plant growth regulators (IAA and NAA) and micronutrient mixture on growth, flowering, fruiting and shelf life of tomato. (Lycopersicon esculentum Mill.). Bioved 11: 25-29.

Kempe, K and Gils, M. 2011. Pollination control technologies for hybrid breeding. *Mol. Breed.* 27(4): 417-437.

Khaitov, B., Umurzokov, M., Cho, K.M., Lee, Y.J., Park, K.W. and Sung, J., 2019. Importance and production of chilli pepper; heat tolerance and efficient nutrient use under climate change conditions. *Korean Journal of Agricultural Science*, *46*(4), pp.769-779.

McRae, D.H. 1985. Adv.in chemical hybridization. *Plant Breed. Rev.3*: 169-191.

Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers (4th Ed.). Indian Council of Agricultural Research, New Delhi, India. 1985;347.

Prasad, R.N., Singh, S.K., Yadava, R.B. and Chaurasia, S.N.S., 2013. Effect of GA3 and NAA on growth and yield of tomato. *Vegetable science*, *40*(2), pp.195-197.

Rai N, Yadav DS, Patel KK, Yadav RK, Asati BS and Chaudey T (2006) Effect of plant growth regulators on growth, yield and quality of tomato (Lycopersicon esculentum Mill).Veg Sci 33(2): 180-182.

Vani, C. and Podikunju, B. 2020. Extent of adoption of KAU practices on chilli cultivation in the homesteads of Kollam district. *Int. J. of Agric. Sci. 16*(1): 45-47.

Virmani, S.S., Virakmanth, B.C., Casal, C.L.,Toledo, R.s., Lopez, M. T. and Manalo, J.O. 1997. Hybrid rice breeding manual, International Rice Research Institute, Manila, p.151.