Effect of maleic hydrazide foliar application on *in situ* germination, seed yield and seed quality parameters in groundnut (cv. Dh 86)

ABSTRACT

During *kharif* 2023 the field experiment was conducted in the All India Coordinated Research Project on Groundnut, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, to investigate the effect of maleic hydrazide foliar application on *in situ* germination, seed yield and seed quality parameters in groundnut (cv. Dh 86). The findings indicated that foliar spray of maleic hydrazide @ 3000 ppm resulted in lower *in situ* germination (24.64%), higher yield attributes like pod yield per plant(9.35 g), kernel yield per plant (6.67 g), shelling percentage (71.47%), hundred seed weight(39.65 g) and sound mature kernel (96%) and lower seed quality parameters like germination (66%), root length (13.50 cm), shoot length (8.13 cm), mean seedling length(21.63 cm), seedling dry weight (332 mg)and seedling vigour index I &II (1428 & 21912) as compared to control. Indicating induction of dormancy through foliar spray of maleic hydrazide.

Key words: *in situ* germination, maleic hydrazide, sprouted pods

---

INRODUCTION

Groundnut (*Arachis hypogaea L.*) is a significant crop globally, valued for its both oilseed and food uses. It is known as the "king of oilseed crops" and it is believed to have been initially domesticated and cultivated in the Paraguay Valley. It was introduced to India during the first half of the sixteenth century.

Groundnut is an important oil seed crop in India, with a significant area under cultivation and production. In world india ranks first in terms of groundnut acreage, with an area of 49.61 lakh ha, and second in production, with 102.97 lakh tonnes with productivity of 2.075 kg/ha. The major groundnut growing states in India are Gujarat, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Rajasthan, Maharashtra, and Karnataka, which contribute to 90 per cent of the total groundnut area in the country (Anon, 2022-2023).

Groundnut is valued for its ability to fix nitrogen, enhancing soil fertility. Desirable characteristics in groundnut cultivars include short duration, early maturity and high yield potential. However, it's noted that *in situ* germination can lead to yield losses ranging from 20 to 50 percent (Nagarjun and Radder, 1983). In order to prevent *in situ* germination in the field it is necessary to use growth inhibitors to achieve good yield. Maleic hydrazide, is a growth inhibitor, is employed to induce seed dormancy and prevent sprouting of tubers, roots, and bulbs during field and storage. The primary objective of using growth regulators is to manage growth processes, regulate the balance between source and sink, ultimately enhancing seed yield or storability (Mishra *et al.,* 2022). Techniques such as the use of growth regulators like maleic hydrazide treatments, can induce dormancy in groundnut seeds (Jagatap, 2000).

In the view of above facts to prevent *in situ* germination in the field condition this research investigation was carried out to know the effect of maleic hydrazide foliar application on *in situ* germination, seed yield and seed quality parameters in groundnut (cv. Dh 86).

MATERIALS AND METHODS

The highly sensitive genotype Dh 86 with respect to *in situ* germination was selected for this experiment. Experiment was conducted in randomized complete block design with 11 treatments and three replications. i.e. T_0: Un sprayed control, T_1: Foliar spray of maleic hydrazide @ 500 ppm, T_2: Foliar spray of maleic hydrazide @ 1000 ppm, T_3: Foliar spray of maleic hydrazide @ 1500 ppm, T_4: Foliar spray of maleic hydrazide @ 2000 ppm, T_5: Foliar spray of maleic hydrazide @ 2500 ppm, T_6: Foliar spray of maleic hydrazide @ 3000 ppm, T_7:

Foliar spray of maleic hydrazide @ 3500 ppm, T_8: Foliar spray of maleic hydrazide @ 4000 ppm, T_9: Foliar spray of maleic hydrazide @ 4500 ppm and T_{10}: Foliar spray of maleic hydrazide @ 5000 ppm. The spacing between plants and rows were 0.10 m and 0.30m, respectively. Field experiment was carried out in 2023 *Kharif* season in the All India Coordinated Research Project on Groundnut, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka.

In order to prepare a solution of 500 ppm, 1000 ppm, 1500 ppm, 2000 ppm, 2500 ppm, 3000 ppm, 3500 ppm, 4000 ppm, 4500 ppm and 5000 ppm concentrations, 0.5 g, 1.0 g, 1.5 g, 2.0 g, 2.5 g, 3.0g, 3.5 g, 4.0 g, 4.5 g and 5.0 g of the Maleic hydrazide chemical powder was dissolved in 1 litre of distilled water respectively. Then mixture was solubilized by adding KOH pellets with the use of magnetic stirrer. Maleic hydrazide was sprayed at 70 days after sowing except control plot (T_0). After attaining maturity, the plants were left in the field for 15 days with regular watering for the germination of pods *in situ.* After 15 days, the pods were lifted, and the number of pods sprouted in each treatment was counted.

Pod yield and kernel yield per plant were measured by selecting fully developed, mature pods from five randomly selected plants in each treatment. The pods were weighed to determine the average pod yield. After threshing and cleaning these pods, the average kernel yield was obtained from the kernels and both were expressed in grams (g). The shelling percentage was calculated based on the weight of kernel recovered from the pod was calculated and was expressed in terms of percentage. For hundred seed weight the weight of randomly selected 100 clean and undamaged seeds were measured and mean was expressed in grams (g). The percentage of sound mature kernels was estimated by randomly selecting fully matured and immature kernels from five plants in each treatment and expressing the proportion of mature kernels as a percentage.

The standard germination test was carried out by following between paper method as per ISTA procedure (Anon, 2015). Randomly selected ten normal seedlings were taken from each replication for measuring root length, shoot length and mean seedling length and expressed in centimetres (Anon., 2010). For seedling dry weight ten normal seedlings used for measuring root and shoot length was kept in a butter paper bag and dried in hot air oven at 70^0 C for 24 h. Then the seedlings were cooled in a desiccator for 30 minutes and the weights of the dried seedlings were recorded using electronic balance and expressed in mg / seedling. The seedling vigour indices were estimated by adopting the method of Abdul-Baki and Anderson (1973) using the fallowing formulas.

Seedling vigour index I = Germination (%) × [Root length (cm) + Shoot length (cm)]
Seedling vigour index II = Germination (%) × Seedling dry weight (mg)

RESULTS AND DISCUSSION

The results of the study on the effect of maleic hydrazide (MH) foliar application on *in situ* germination, seed yield and seed quality parameters in groundnut (cv. Dh 86) are presented in Table 1 and Table 2. The percentage of *in situ* germination (IG) significantly decreased with increasing concentrations of Maleic hydrazide. The *in situ* germination percentage significantly decreased as the concentration of maleic hydrazide increased, with the most substantial reduction observed at Foliar spray of maleic hydrazide @ 3000 ppm (T_6), achieving a 24.64% *in situ* germination, compared to 55.99% in the unsprayed control (T_0). Treatments from 2000 ppm to 2500 ppm (T_4 and T_5) also showed notable reductions and T_5 is statistically on par with T_6. This reduction can be attributed to ability of maleic hydrazides to suppress hormonal signals associated with seed germination, specifically by inhibiting gibberellin synthesis and action, there by induction of seed dormancy (Gupta *et al.,* 2024). Maleic hydrazide induces dormancy primarily through its interference with tryptophan metabolism, as demonstrated by Nagarjun and Gopalakrishnan (1958) and later confirmed by Ketring (1977). These findings align with previous reports suggesting that maleic hydrazide suppresses *in situ* germination by Jagatap (2000), Nautiyal (2004), Gowda *et al.* (2015) in ground nut.

The pod yield per plant, exhibited a significant increase with increasing concentrations of MH, with the highest pod yield per plant (9.35 g) recorded at foliar spray of maleic hydrazide @ 3000 ppm, marking a substantial improvement over the un sprayed control (4.76 g). Kernel yield per plant followed a pattern similar to pod yield, with the highest yield observed at Foliar spray of maleic hydrazide @ 3000 ppm (T_6) (6.67 g), a significant improvement over the control (2.94 g). This increase in pod yield and kernel yield might be due to alteration of drymatter distribution from vegetative parts to kernels (Srikant, 2024). Shelling percentage also increased with higher concentrations of MH, peaking at 71.47% in the Foliar spray of maleic hydrazide @ 3000 ppm (T_6), a notable improvement over the control (61.77%). Maleic hydrazide has been found to have dual effects on plants: while inhibiting growth, it can simultaneously enhance biomass accumulation and starch content in certain plant species. These effects are attributed to the upregulation of genes involved in multiple metabolic pathways, including carbon fixation, C_4 photosynthesis, and starch biosynthesis (Zhu *et al*., 2021).

The 100 seed weight was significantly higher in the Foliar spray of maleic hydrazide @ 3000 ppm (T_6) at 39.65 g, compared to 37.25 g in the un sprayed control (T_0). The increase in seed weight can be explained by the greater accumulation of reserves in the seeds. The percentage of sound mature kernels increased with increasing maleic hydrazide concentrations, reaching 96 per cent at Foliar spray of maleic hydrazide @ 3000 ppm (T_6), significantly higher than the control (88%). This outcome suggests that maleic hydrazide contributes to the uniform maturation of kernels, likely by synchronizing physiological processes related to seed development. These findings are consistent with those of Pushp and Virender (2013), who reported that the foliar application of growth retardants like mepiquat chloride and maleic hydrazide in groundnut modifies the source-sink relationship, resulting in the redirection of assimilates to the already formed pods. This shift leads to an increase in the number of mature pods, which, in turn, contributes to a proportional rise in seed weight. The increase in seed weight is primarily due to the mature seeds, as confirmed by Pushp Sharma *et al*. (2013).

Table 1. Effect of maleic hydrazide foliar application on *in situ* germination and seed yield parameters in groundnut (cv. Dh 86)

Treatments	IG (%)	PY/P (g)	KY/P (g)	SP (%) (g)	HSW (g)	SMK (%)
$T_{0:}$ Un sprayed control	55.99 (48.42)	4.76	2.94	61.77 (51.79)	37.25	88 (69.70)
T_1: Foliar spray of maleic hydrazide @ 500 ppm	36.01 (36.86)	6.95	4.45	64.17 (53.21)	37.50	90 (71.54)
T_2: Foliar spray of maleic hydrazide @ 1000 ppm	32.30 (34.62)	7.47	5.01	67.30 (55.10)	38.20	91 (72.51)
T_3: Foliar spray of maleic hydrazide @ 1500 ppm	29.67 (32.99)	8.02	5.43	67.91 (55.47)	38.65	93 (74.63)
$T_{4:}$ Foliar spray of maleic hydrazide @ 2000 ppm	29.41(32.82)	8.05	5.51	68.38 (55.76)	38.80	94 (75.79)
T_5: Foliar spray of maleic hydrazide @ 2500 ppm	26.92 (31.24)	8.51	5.91	69.45 (56.42)	39.20	95 (77.05)
T_6: Foliar spray of maleic hydrazide @ 3000 ppm	24.64 (29.75)	9.35	6.67	71.47 (57.69)	39.65	96 (78.43)
T_7: Foliar spray of maleic hydrazide @ 3500 ppm	25.02 (30.00)	9.03	6.07	67.43 (55.18)	39.53	94 (75.79)
T_8: Foliar spray of maleic hydrazide @ 4000 ppm	25.60 (30.38)	8.59	5.85	68.72 (55.97)	39.35	92 (73.54)
T_9: Foliar spray of maleic hydrazide @ 4500 ppm	25.10 (30.07)	8.70	5.77	66.21 (54.44)	39.47	93 (74.63)
T_{10}: Foliar spray of maleic hydrazide @ 5000 ppm	25.65 (30.47)	8.69	5.65	64.80 (53.59)	39.40	91 (72.251)
Mean	**30.57**	**8.01**	**5.38**	**67.05**	**38.81**	**92.55**
S.E.m ±	**0.941**	**0.210**	**0.173**	**1.673**	**0.980**	**4.372**
CD @ 5 %	**2.777**	**0.621**	**0.511**	**4.935**	**2.893**	**12.822**
CV	**15.99**	**13.67**	**16.71**	**15.82**	**13.09**	**13.50**

*Figures in the parentheses are arcsine transformed values.

IG : *in situ* germination
KY/P : Kernel yield per plant
HSW : Hundred seed weight
PY/P : Pod yield per plant
SP : Shelling percentage
SMK : Sound mature kernel

Table 2. Effect of maleic hydrazide foliar application on seed quality parameters in groundnut (cv. Dh 86).

Treatments	G (%)	SL (cm)	RL (cm)	MSL (cm)	SDW (mg)	SVI I	SVI II
T_0: Un sprayed control	86 (68.00)	12.05	15.73	27.77	397	2388	34142
T_1: Foliar spray of maleic hydrazide @ 500 ppm	80 (63.41)	10.71	14.99	25.70	383	2056	30640
T_2: Foliar spray of maleic hydrazide @ 1000 ppm	77 (61.32)	10.28	14.81	25.09	369	1933	28413
T_3: Foliar spray of maleic hydrazide @ 1500 ppm	76 (60.64)	9.32	14.51	23.83	357	1811	27132
T_4: Foliar spray of maleic hydrazide @ 2000 ppm	74 (59.32)	9.17	14.31	23.48	349	1738	25826
T_5: Foliar spray of maleic hydrazide @ 2500 ppm	71 (57.39)	8.93	13.98	22.90	337	1626	23927
T_6: Foliar spray of maleic hydrazide @ 3000 ppm	66 (54.31)	8.13	13.50	21.63	332	1428	21912
T_7: Foliar spray of maleic hydrazide @ 3500 ppm	68 (55.53)	8.30	13.67	21.97	335	1494	22780
T_8: Foliar spray of maleic hydrazide @ 4000 ppm	69 (56.14)	8.44	13.80	22.24	334	1534	23046
T_9: Foliar spray of maleic hydrazide @ 4500 ppm	67 (54.92)	8.35	13.90	22.25	333	1491	22311
T_{10}: Foliar spray of maleic hydrazide @ 5000 ppm	67 (54.92)	8.26	13.87	22.13	336	1482	22512
Mean	**72.82**	**9.27**	**14.28**	**23.54**	**351.09**	**1725**	**25695**
S.E.m ±	**1.000**	**0.167**	**0.256**	**0.334**	**1.670**	**35.897**	**369.052**
CD @ 1%	**3.986**	**0.665**	**1.019**	**1.330**	**6.656**	**143.095**	**1471.162**
CV	**2.379**	**3.100**	**3.102**	**2.455**	**0.824**	**3.603**	**2.488**

*Figures in the parentheses are arcsine transformed values

G : Germination
SL : Shoot length
RL : Root Length
SVI II Seedling vigour index II
MSL : Mean seedling length
SDW : Seedling dry weight
SVI I : Seedling vigour index I

The results of the study on the effect of maleic hydrazide (MH) foliar application on seed quality parameters in groundnut (cv. Dh 86) are presented in Table 2. The data shows negative correlation between maleic hydrazide concentration and germination percentage. The unsprayed control treatment (T_0) showed the highest germination (86%), while the lowest (66%) was recorded in the treatment where foliar spray of maleic hydrazide at 3000 ppm (T_6) was applied. The maleic hydrazide inhibit mitosis in the meristematic region (Appleton *et al*., 1981). This reduction of germination percentage aligns with earlier findings that maleic hydrazide can inhibit cell division and elongation, leading to decreased germination (Nooden, 1969).

Studies conducted by Naylor and Davis (1950) showed that maleic hydrazide's growth inhibiting effects extend to both root and shoot portions of the plants. Both seedling length and root length followed a similar trend to germination percentage, with the highest values observed in the unsprayed control (12.05 cm and 15.73 cm, respectively) and the lowest in T_6 i.e. foliar spray of maleic hydrazide at 3000 ppm (8.13 cm and 13.50 cm, respectively). Application of maleic hydrazide is a growth inhibitor, known to cause inhibition of seedling growth by inhibiting mitotic cell division in the developing seeds (Zukel, 1950**).** The present findings are in line with earlier findings that the maleic hydrazide reduces corn root length by disrupting cell division, despite not inhibiting the enlargement of individual cells (Nooden, 1969) and also demonstrated that maleic hydrazide suppresses root growth by interfering with auxin transport, leading to reduced root elongation. According to Singh *et al*. (2020), application of maleic inhibits shoot bud growth by modifying the expression of several gene types those involved in meristem development, DNA repair and recombination, cell division, and hormone signaling pathways in tobacco. These findings also align with previous research studies on rice (Soganna *et al*., 2012), Poonguzhali and Kanagarasu (2016) and Mishra and Swain (2019) in groundnut.

Seedling dry weight showed a gradual decline from 397 mg per seedling in the unsprayed control (T_0) to 333 mg per seedling in foliar spray of maleic hydrazide at 3000 ppm (T_6), mirroring the trend seen with seedling and root lengths. Reduced seedling dry weight suggests limited nutrient uptake and utilization, likely due to the inhibitory effects of maleic hydrazide on root development, as described by Nooden (1969). Inhibition of root growth leads to reduced water and nutrient absorption, which in turn impacts overall seedling biomass.

Seedling Vigor Index I and II both showed significant declines with increasing concentrations of maleic hydrazide. The unsprayed control (T_0) displayed the highest (2388 and 34142) vigour indices, while foliar spray of maleic hydrazide at 3000 ppm (T_6) recorded the lowest (1428 and 21912) vigour indices respectively. This reduction in vigour indices is indicative of the overall weakening of seedling performance as maleic hydrazide concentrations increased. The decline in seedling vigour index could be due to less germination as result of maleic hydrazide spray and it was in conformity with previous results Jayadeva, (2008) and Poonguzhali and Kanagarasu (2016) in ground nut.

Further increase in MH concentrations after 3000 ppm (T_6), there was no significant reduction in the *in situ* germination, seed quality parameters and in the yield attributes among treatments T_7 to T_{10} as compared to foliar spray of maleic hydrazide @ 3000 ppm (T_6). It might be due to higher concentrations may lead to adverse effects on plants. Excessive use of maleic hydrazide may disrupt normal plant physiological processes, undesirable changes in plant metabolism. Therefore, careful management of its concentration is crucial to avoid negative impacts on plant health and development.

CONCLUSION

Maleic hydrazide, a known growth inhibitor, was applied to induce seed dormancy and prevent premature germination. In this study, the use of growth regulators, particularly maleic hydrazide at 3000 ppm as a foliar spray (T_6), effectively reduced *in situ* germination in groundnut, thereby enhancing seed dormancy and yield parameters under field conditions. The findings suggest that incorporating growth regulators, such as maleic hydrazide and abscisic acid, could be an effective strategy for managing groundnut seed production, especially in regions prone to high humidity or prolonged field exposure post-maturity. This approach offers a viable method for enhancing crop resilience, ultimately contributing to higher-quality yields and improved post-harvest seed management.

REFERENCE

Abdul B A and Anderson J D, 1973, Vigour determination of soybean. *Crop Science*, 13: 630-633.

Anonymous, 2010, International Rules for Seed Testing. *Seed Science and Technology*, 24:1-335.

Anonymous, 2015, International Rules for Seed Testing (ISTA). *Seed Science and Technology,* 24: 1-335

Anonymous, 2023, *FAOSTAT*, Food and Agricultural Organization of the United Nations, Rome, Italy.

Anonymous,2010, International Rules for Seed Testing. *Seed Science and Technology*, 24: 1-335.

Appleton M D, Haab W, Eisenstadi M L and Thomos R, 1981, Incorporation of maleic hydrazide into ribonucleic acid of *Saccharomyces cerensiae*. *Journal of Agricultural and Food Chemistry,* 29: 986-89.

Gowda K S, Siddaraju R, Narayanaswamy K C, Manjunath H and Mahesh H M, 2015, Induction of dormancy in non-dormant groundnut cv. KCG 2. *Journal Trends in Biosciences,* 8(22): 6289-6294.

Jagatap P B, 2000, Physiological maturity and seed dormancy studies in bunch type groundnut (*Arachis hypogaea* L.), *M.Sc. (Agri.) thesis*, PGI, MPKV, Rahuri, 1-85.

Jayadeva B, 2008, Induction of dormancy in summer groundnut (*Arachis hypogaea* L.), *M. Sc (Agric) Thesis*, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India.

Jyotirmayee M, Prekshya D, Mohapatra and Sudhansu S B, 2022, Effect of foliar spray of maleic hydrazide on biochemical traits of groundnut seeds. *The Pharma Innovation Journal,* 11(11): 547-552

Ketring D L, 1973, Germination inhibitors. *Seed Science and Technology*, 1:305-324.

Mishra J and Swain S K, 2019, Application of MH to prevent pre-harvest sprouting of seeds in groundnut. *International Journal of Current Microbiology and Applied Sciences*, 8, (9): 15-25.

Nagarjun P and Radder G D, 1983, Studies on induction of seed dormancy in bunch type groundnut. *Seed Research,*11 (1): 24.

Nagarjun S S and Gopalkrishnan S, 1958, Root inducing substances in groundnut seed. *Current Science,* 27: 29-30.

Nautiyal P C, 2004, Issues related to maintenance of seed viability and regulation of dormancy in groundnut, *Groundnut Research in India*, 321-338.

Naylor A W and Davis E A, 1950, Maleic hydrazide as a plant growth inhibitor. *Botanical Gazette*, 112(1): 112-126.

Nelson S K, Kanno Y, Seo M and Steber C M, 2023, Seed dormancy loss from dry after-ripening is associated with increasing gibberellin hormone levels in Arabidopsis thaliana. *Frontiers in Plant Science*, 14: 1145414.

Noodén L D, 1969, The mode of action of maleic hydrazide: inhibition of growth. *Physiologia Plantarum*, 22 (2): 260-270.

Poonguzhali S and Kanagarasu S, 2016, Influence of Growth Retardant on the Seed Quality of Bunch Groundnut Cultivars. *Advances in Life Sciences*, 5(16): 6449-6455.

Pushp S and Virender S, 2012, Effect of growth-regulating substances on the chlorophyll, nitrate reductase, leghaemoglobin content, and yield in groundnut (*Arachis hypogaea*). *An International Quarterly Journal of Life Sciences*, 7(1): 13-17.

Pushp S, Virender S and Sukhvinder S K, 2013, Dry matter partitioning and source-sink relationship as influenced by foliar sprays in groundnut. *The Bioscanning*, 8(4): 1171-1176.

Singh S K, Richmond M D, Pearce R C, Bailey W A, Hou X, Pattanaik S and Yuan L, 2020, Maleic hydrazide elicits global transcriptomic changes in chemically topped tobacco to influence shoot bud development. *Planta*, 252: 1-17.

Sooganna L S, Babu P K, Chaitanya U and Keshavulu K, 2012, Effect of maleic hydrazide on induction of seed dormancy and seed quality parameters in rice. *Seed Science Research*, 40(2): 24-133.

Zhu Y, Li X, Gao X, Sun J, Ji X, Feng G, Shen G, Xiang B and Wang Y, 2021, Molecular mechanism underlying the effect of maleic hydrazide treatment on starch accumulation in *S. polyrrhiza. Biotechnology for Biofuels*, 14: 1-14.

Zukel J W, 1950, Use of maleic hydrazide as a plant growth inhibitor. *Agricultural Chemistry*, 5: 35-36.

Gupta J P, Pandey B K, Modi S, Kumar R and Rathore M, 2024, Chemical solutions for seed dormancy: a comprehensive review on strategy to combat pre-harvest sprouting in mung bean. *Agricultural Science Digest*. Doi: 10.18805/ag.