Plant Archives Vol. 26, No. 1, 2026 pp. 1793-1802 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.1.247

STANDARDIZATION OF PHYSICAL SEED TREATMENT PROTOCOLS FOR ENHANCING SEED QUALITY IN GREENGRAM (*VIGNA RADIATA* L.) UNDER *IN VITRO* CONDITIONS

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(Date of Receiving : 13-12-2025; Date of Revision : 31-01-2026; Date of Acceptance : 20-02-2026)

ABSTRACT

The present investigation was undertaken to standardize physical seed treatment protocols for enhancing seed quality in greengram (*Vigna radiata* L.) under *in vitro* conditions and to compare their effectiveness with conventional fungicidal and insecticidal seed treatments. Seeds of greengram variety MGG-385 were subjected to fourteen treatments comprising cold plasma treatment at 10, 15 and 20 kV for 15 and 20 minutes, opto-hydro-ionization treatment for 5, 10 and 15 minutes, neutral silica treatment at 3000 ppm (3g kg^{-1} seed), chemical seed treatments including deltamethrin 2.8 EC at 1 ml kg^{-1} seed, carbendazim at 2 g kg^{-1} seed, penflufen 13.28% w/w + trifloxystrobin 13.28% w/w FS at 1.5 ml kg^{-1} seed, along with an untreated control. Treated seeds were evaluated for physiological, seed health and biochemical parameters under laboratory conditions. Analysis of variance revealed significant differences among treatments for seedling dry weight, seedling vigour index-II, field emergence, seed moisture content, seed damage percentage, dehydrogenase activity and phenolic content, while germination percentage remained non-significant. Opto-hydro-ionization treatment for 5 minutes recorded the highest seedling dry weight, seedling vigour index-II and phenolic content, whereas, cold plasma treatments, particularly cold plasma treatment at 10 kV for 20 minutes(T2) and 15 kV for 15 minutes(T3), significantly enhanced dehydrogenase activity. Neutral silica treatment at 3000 ppm(T10) effectively reduced seed damage, performing on par with deltamethrin treatment. Overall, physical seed treatments performed comparably or superiorly to fungicidal and insecticidal treatments in improving seedling vigour and biochemical activity without adversely affecting seed viability, indicating their potential as eco-friendly alternatives for seed quality enhancement in greengram under *in vitro* conditions.

***Keywords* :** Greengram, Cold plasma, Ozonation, N silica, Insecticide and Fungicide.

Introduction

Greengram (*Vigna radiata*) is an important short-duration pulse crop in India, commonly grown as a fallow crop in rice-based cropping systems. It is a rich source of high-quality protein, vitamins (B6, B9 and K) and essential minerals, supplying dietary protein to a large vegetarian population (Panchal, 2015). India contributes over 70 per cent of global greengram production, with major producing states including Rajasthan, Madhya Pradesh, Karnataka and

Maharashtra. In Telangana, greengram is cultivated extensively in districts such as Sangareddy, Khammam and Kamareddy (Green gram Outlook, July 2025)

Post-harvest storage of greengram seeds is critical, as significant losses occur due to biotic stresses such as insect pests and seed-borne diseases. Storage losses may range from 10 to 50 per cent, with pulse beetle (*Callosobruchus chinensis*) causing severe damage by feeding on seed contents, leading to reduced seed weight, quality and germination (Roja *et al*., 2021). Seed-borne fungi further deteriorate seed quality and may produce harmful mycotoxins. (Lee and Ryu, 2017)

Although synthetic insecticides are commonly used for storage pest management, their high cost, persistence, environmental hazards and health risks necessitate the development of safer alternatives. Eco-friendly physical seed treatments such as cold plasma, ozonation and amorphous silica dusts have emerged as promising substitutes. Cold plasma (Saberi *et al*., 2018) and ozone treatments (Isikber *et al*., 2007; Subramanyam *et al*., 2014) effectively control storage pests and pathogens, improve seed germination and reduce mycotoxin contamination, while amorphous silica dusts provide safe and effective insect control through desiccation (Mesbah *etal.* 2017). These approaches offer sustainable, environmentally benign solutions for protecting greengram seeds during storage.

Materials and Methods

Experimental location and seed material

The study was conducted during 2024-25 at the Department of Seed Science and Technology, Seed Research and Technology Centre (SRTC), Rajendranagar, Hyderabad, Telangana. Greengram seeds of variety MGG-385 were procured from the Agricultural Research Station, Madhira, Khammam district, Telangana.

Rearing of pulse beetle

(for the purpose of calculating Seed damage percentage based on the proportion of beetle-damaged seeds)

The pulse beetle (*Callosobruchus chinensis* L.) culture was maintained in the Seed Entomology Laboratory, SRTC, Rajendranagar. The stock culture was reared on healthy greengram seeds under controlled conditions of 28 ± 1 °C temperature and 70 ± 5% relative humidity. Approximately 75 adult beetles were released into plastic containers containing 1 kg of disinfested greengram seeds. After a seven-day oviposition period, parent adults were removed to obtain a uniform-aged population for experimental use. Hosamani *et al*. (2018).

Seed treatments

Greengram seeds were subjected to different treatments comprising physical as well as chemical treatments which include cold plasma**,** opto-hydro-ionization**,** insecticide**,** fungicide. Cold plasma treatments were imposed at three voltage levels (10, 15, and 20 kV) with two exposure durations (15 and 20 min). Opto-hydro-ionization treatments were applied for 5, 10, and 15 min. Chemical treatments included neutral silica (3000 ppm), deltamethrin 2.8 EC (1 ml kg^{-1} seed), carbendazim (2 g kg^{-1} seed), and penflufen 13.28% + trifloxystrobin 13.28% FS (1.5 ml kg^{-1} seed). Untreated seeds served as control. Treated seeds were evaluated for physiological, seed health and biochemical parameters under laboratory conditions.

Table 1 : List ofdifferent treatments used in greengram

Sl No.	Treatments
1	T1: 10 kV Cold plasma for 15 min
2	T2: 10 kV Cold plasma for 20 min
3	T3: 15 kV Cold plasma for 15 min
4	T4: 15 kV Cold plasma for 20 min
5	T5: 20 kV Cold plasma for 15 min
6	T6: 20 kV Cold plasma for 20 min
7	T7: Opto –hydro –ionization Process for 5 min
8	T8: Opto –hydro –ionization Processfor 10 min
9	T9: Opto –hydro –ionization Process for 15min
10	T10: N Silica 3000 ppm (3g/kg seed)
11	T11: Deltamethrin 2.8 EC (1ml/kg seed)
12	T12: Carbendazim (2gm/kg seed)
13	T13: Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS(1.5ml/kg seed)
14	T14: Untreated control

Cold plasma treatment

Cold plasma treatment was carried out using a low-pressure glow discharge plasma system with a bell-jar configuration. The reactor consisted of a Pyrex glass chamber fitted with parallel aluminum electrodes connected to a radio-frequency power supply operating at 13.56 MHz. Seeds were evenly spread on a stainless-steel mesh inside the chamber. The chamber pressure was initially reduced to 0.05 mbar, with a working pressure of 0.5 mbar during treatment. Plasma exposure was applied at the specified voltages and durations to evaluate their effect on seed quality and insect control (Liu *et al*., 2019).

Opto-hydro-ionization treatment

Opto-hydro-ionization treatment was performed in an enclosed chamber combining UV radiation (254 nm) with ionized water vapour to generate reactive oxygen species. Seeds (1000 g per batch) were exposed for 5, 10 and 15 min under controlled conditions of 25°C temperature and 60% relative humidity. Treated seeds were stored under ambient conditions for further evaluation (Lin *et al.*, 2025)

Silica treatment

Seeds were treated with plant-derived neutral silica at 3000 ppm (3 g kg^{-1} seed) using a mechanical seed coater to ensure uniform coating. Treated seeds were stored in airtight containers under ambient conditions (Yashavanth*et al.*, 2023).

Deltamethrin treatment

Deltamethrin 2.8 EC was applied at 1 ml kg^{-1} seed, diluted in water and uniformly mixed with the seeds. After treatment, seeds were shade-dried and stored in airtight containers.

Fungicidal treatments

Carbendazim was applied at 2 g kg^{-1} seed to protect seeds from storage fungi. Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS was applied at 1.5 ml kg^{-1} seed to manage seed-borne and soil-borne pathogens and to maintain seed quality during storage.

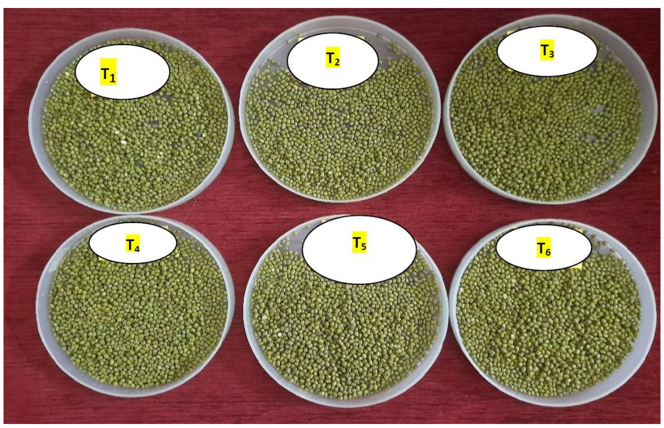

Plate 1 : Different treatments of greengram seed T_1-10 kV Cold plasma for 15 min, T_2- 10 kV Cold plasma for 20 min, T_3- 15 kV Cold plasma for 15 min,T_4- 15 kV Cold plasma for 20 min, T_5- 20 kV Cold plasma for 15 min and T_6- 20 kV Cold plasma for 20 min

Plate 2 : T_7-Opto –hydro –ionization Process for 5 min, T_8-Opto –hydro –ionization Process for 10 min and T9-Opto –hydro –ionization Process for 15 min

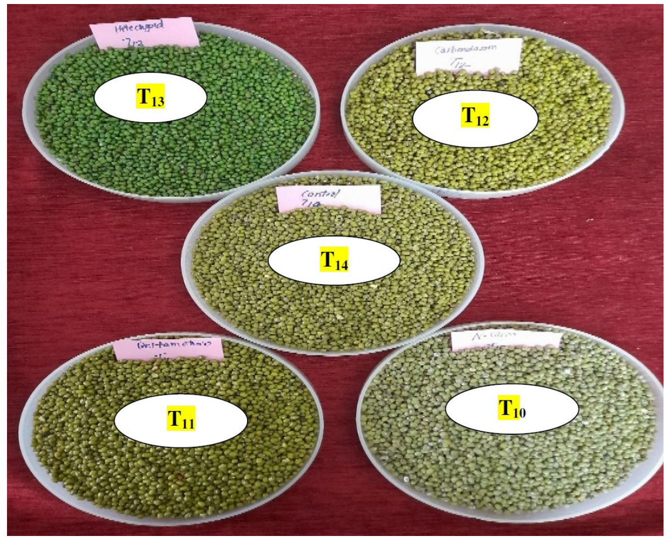

Plate 3 : T_{10}- N Silica 3000 ppm (3gms / kg seed) T_{11} - Deltamethrin 2.8 EC (1ml/kg seed) T_{12}- Carbendazim (2gm/kg seed) T_{13} - Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS (1.5ml/kg seed) T_{14} - Untreated control

Experimental evaluation

Treated and untreated greengram seeds were stored under ambient conditions and periodically evaluated for seed quality parameters. Germination percentage was determined by the paper towel method, while seedling dry weight and seedling vigour index-II were assessed using standard seedling evaluation procedures. Seed moisture content was estimated by the hot air oven method. Field emergence was recorded through seed bed sowing under natural conditions. Seed damage percentage was calculated based on the proportion of beetle-damaged seeds, and seed infection percentage was assessed using the blotter paper method. Dehydrogenase activity was estimated by the tetrazolium reduction method, and phenol content was quantified using the Folin–Ciocalteu reagent method. All estimations were carried out following ISTA rules and standard biochemical protocols. The experiment was laid out in a one-factorial Completely Randomized Design (CRD) and the data were subjected to statistical analysis to assess the significance of main effects and interactions.

Results and Discussions

Analysis of Variance

The analysis of variance revealed highly significant differences ($p \leq 0.01$) among physical seed treatments for major seed physiological, health, and biochemical parameters, including seedling dry weight, seed vigour index-II, field emergence, seed moisture content, seed damage percentage, dehydrogenase activity, and total phenolic content. However, germination percentage exhibited non-significant variation among treatments, indicating that most treatments preserved baseline seed viability (Table 2-4).

1. Seed germination %

Seed germination (%) of greengram seeds did not differ significantly among the treatments, with values ranging from 93% in the T14 (untreated control) to 98% in T7 (opto-hydro-ionization for 5 min). Treatments T4(15 kV Cold plasma for 20 min), T5(20 kV Cold plasma for 15 min) and T11(Deltamethrin 2.8 EC (1ml/kg seed)) also recorded high germination (96%), indicating that most physical seed treatments were effective in maintaining seed viability (Table 5). Although numerical differences were evident, the overall variation was narrow, suggesting uniformly high germination across treatments. This could be attributed to the use of freshly harvested seeds possessing high initial viability, intact cellular membranes and minimal physiological deterioration, which may have masked treatment-induced effects at the germination level. The present results are in line with Avdeeva *et al*. (2018), who reported improved germination and vigour in wheat following ozone-air treatments, and Ahmed and Hayashi (2024), who observed enhanced germination performance in mung bean due to cold plasma treatment.

2. Seedling dry weight (mg)

Seedling dry weight showed significant variation among the treatments, with values ranging from 166.00 mg in the T14(untreated control) to 210.00 mg in T7(opto-hydro-ionization for 5 min) (Table 5). The maximum seedling dry weight was recorded in T7(opto-hydro-ionization for 5 min), followed by T10(N Silica 3000 ppm (3g/kg seed)) (207.00 mg) and T2(10 kV Cold plasma for 20 min) (204.00 mg), indicating that these treatments effectively enhanced seedling biomass accumulation. In contrast, the lowest dry weight was observed in the control, highlighting the beneficial influence of seed treatments on early seedling growth. Notably, all treated seed lots produced seedlings with higher dry weight compared to the untreated control, suggesting improved metabolic activity, efficient mobilization of seed reserves and enhanced seedling robustness imparted by the treatments. These results are in agreement with Kumar *et al*. (2019), who reported increased seedling dry weight in okra under cold plasma treatment, emphasizing the role of physical seed treatments in improving seedling vigour.

3. Seedling vigour index (SVI-II)

Seedling vigour index-II differed highly significantly among the treatments, with values ranging from 1616 to 2052 (Table 5). The highest seedling vigour index-II was recorded in T7 (opto-hydro-ionization for 5 min) (2052), followed by T10 (N Silica 3000 ppm (3g/kg seed)) (1973) and T2(10 kV Cold plasma for 20 min) (1918), indicating superior seedling performance under these treatments. In contrast, the lowest seedling vigour index-II was observed in T8 (Opto –hydro –ionization Processfor 10 min) (1616) and theT14(untreated control) (1678), reflecting comparatively reduced seedling growth potential in the absence of seed treatment. The consistently higher vigour index-II in treated seeds, particularly under opto-hydro-ionization, nano-silica and cold plasma treatments, suggests improved seedling dry matter accumulation and overall vigour due to enhanced physiological activity. These findings are in agreement with Starodubtseva*et al*. (2007), who reported improved germination and early seedling development in soybean following optimized ozone treatment, and Ling *et al*. (2014), who documented a significant enhancement of seedling vigour indices in soybean seeds subjected to cold plasma treatment.

4. Field Emergence (%)

Field emergence (%) showed significant variation among the treatments, with values ranging from 86% in the untreated control to 97% in T2(10 kV Cold plasma for 20 min) (Table 5). The highest field emergence was recorded in T2 (10 kV Cold plasma for 20 min), followed by T6(20 kV Cold plasma for 20 min), T7 (opto-hydro-ionization for 5 min)and T13(Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS(1.5ml/kg seed)) (94%), indicating the positive influence of seed treatments on field establishment. The comparatively lower emergence observed in the control reflects inferior field performance due to the absence of seed enhancement measures. In contrast, the improved field emergence under treated seeds, particularly with cold plasma, opto-hydro-ionization and chemical seed treatments, may be attributed to enhanced seed vigour, improved membrane integrity and greater physiological readiness of the seeds, which collectively facilitated better seedling establishment under field conditions. These findings are in agreement with Kishk *et al*. (2024), who reported that moderate cold plasma exposure significantly enhanced field emergence, especially in freshly harvested seeds.

5. Seed moisture content (%)

Seed moisture content varied significantly among the treatments, with values ranging from 6.77 to 7.83 per cent (Table 5). The lowest moisture content was recorded in T6(20 kV Cold plasma for 20 min) (6.77%) and T13(Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS(1.5ml/kg seed))

(7.00%), whereas the highest moisture content was observed in T9 (Opto –hydro –ionization Process for 15min) (7.83%). The comparatively higher moisture content in opto-hydro-ionization (ozonation) treated seeds may be attributed to the hydration phase involved in the treatment process, which promotes temporary water uptake by seed tissues. Similarly, cold plasma–treated seeds also exhibited relatively higher moisture content compared to the untreated control, possibly due to plasma-induced surface etching and increased seed coat wettability, which enhance moisture adsorption. These changes in seed surface properties facilitate improved water exchange and may influence subsequent physiological responses. The present findings are in agreement with Harshaprada *et al*. (2023), who reported that factors influencing seed moisture content significantly affect seed quality and storability. Further support is provided by Ling *et al*. (2014), who observed improved wettability, water absorption and vigour indices in plasma-treated soybean seeds, and by Filatova *et al.* (2011), who demonstrated that plasma-induced modifications in seed coat microstructure play a crucial role in regulating water exchange.

Seed health parameters

1. Seed damage (%)

Seed damage varied among treatments, ranging from 0.35% to 1.43%. The lowest damage was recorded in T10 (N-silica @ 3000 ppm; 0.35%), followed by T2 (10 kV Cold plasma for 20 min) (0.62%) and T7 (opto-hydro-ionization for 5 min) (0.76%), whereas the highest damage occurred in T8(opto-hydro-ionization for 10 min) (1.43%) and the T14(untreated control) (1.18%) (Table 6). The comparatively higher damage in the control indicates greater susceptibility to deterioration in the absence of protective treatments. The significant reduction in seed damage under N-silica treatment may be attributed to the formation of a protective silica layer on the seed surface, which enhances mechanical strength, stabilizes moisture levels, and restricts microbial invasion, thereby maintaining seed integrity during storage. These findings align with Arumugam *et al*. (2016), who reported that hydrophobic silica nanoparticles effectively reduced oviposition, adult emergence and seed damage in pulses, with maximum efficacy observed at higher concentrations.

2. Seed infection %

Seed infection (%) was completely absent across all fourteen treatments, with each recording 0%, indicating no fungal or microbial contamination in the fresh greengram seed samples. This uniformity confirms that none of the applied treatments adversely affected seed health and that all were equally effective in maintaining pathogen-free seeds at the initial stage. The results highlight the inherent quality of freshly harvested seeds and the safety of the applied physical and chemical treatments in preserving seed health.

Seed Biochemical Parameters

1. Dehydrogenase activity (OD Value)

Dehydrogenase activity varied among treatments, ranging from 3.14 to 4.39 OD units. The highest activity was observed in T2(10 kV Cold plasma for 20 min) (4.39), followed by T1(10 kV Cold plasma for 15min) (4.26) and T5(20 kV Cold plasma for 15 min) (4.03), all of which involved cold plasma treatments, whereas the lowest activity was recorded in the untreated control (T14) (3.14)(Table 6). The reduced enzyme activity in the control indicates lower respiratory efficiency and metabolic activity in the absence of stimulatory treatments. In contrast, the enhanced dehydrogenase activity in cold plasma–treated seeds may be attributed to plasma-induced activation of respiratory enzymes and improved membrane permeability, which facilitate efficient substrate utilization. Similarly, opto-hydro-ionization (ozonation) treatments showed higher dehydrogenase activity than the control, suggesting metabolic stimulation through oxidative priming and improved oxygen availability. The elevated dehydrogenase activity in treated seeds reflects enhanced respiratory metabolism, contributing to superior seedling vigour and early seedling performance. These observations are consistent with Harish *et al*. (2024), who reported increased dehydrogenase activity in mustard seeds following cold plasma treatment, with maximal enzymatic response at optimized voltage and exposure duration.

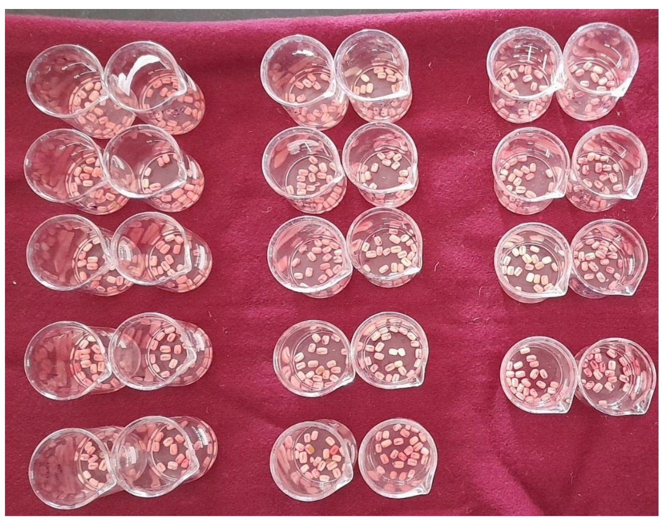

Plate 4 : Experimental setup Dehydrogenase estimation.

2. Phenols (µmol g^{-1})

Phenolic content differed significantly among treatments, ranging from 1.51 µmol g^{-1} in the untreated control(T14) to 2.15 µmol g^{-1} in opto-hydro-ionization for 5 min(T7) (Table 6). Elevated phenolic levels in opto-hydro-ionization and N-silica–treated seeds suggest enhanced antioxidant defense, improved stress tolerance, and better metabolic regulation, whereas the lower content in the control reflects weaker protective capacity. These findings are consistent with Dwivedi *et al*. (2019), who highlighted the importance of phenolic compounds in seed defense, antioxidant activity, and storability. Additionally, plasma-based treatments have been shown to maintain higher phenolic content during storage, demonstrating their effectiveness in enhancing seed biochemical quality and resilience

Plate 5: Germination%: T7-Opto hydro ionization process@ 5mins,T14-Untreated control


Plate 6 : Seed infection%

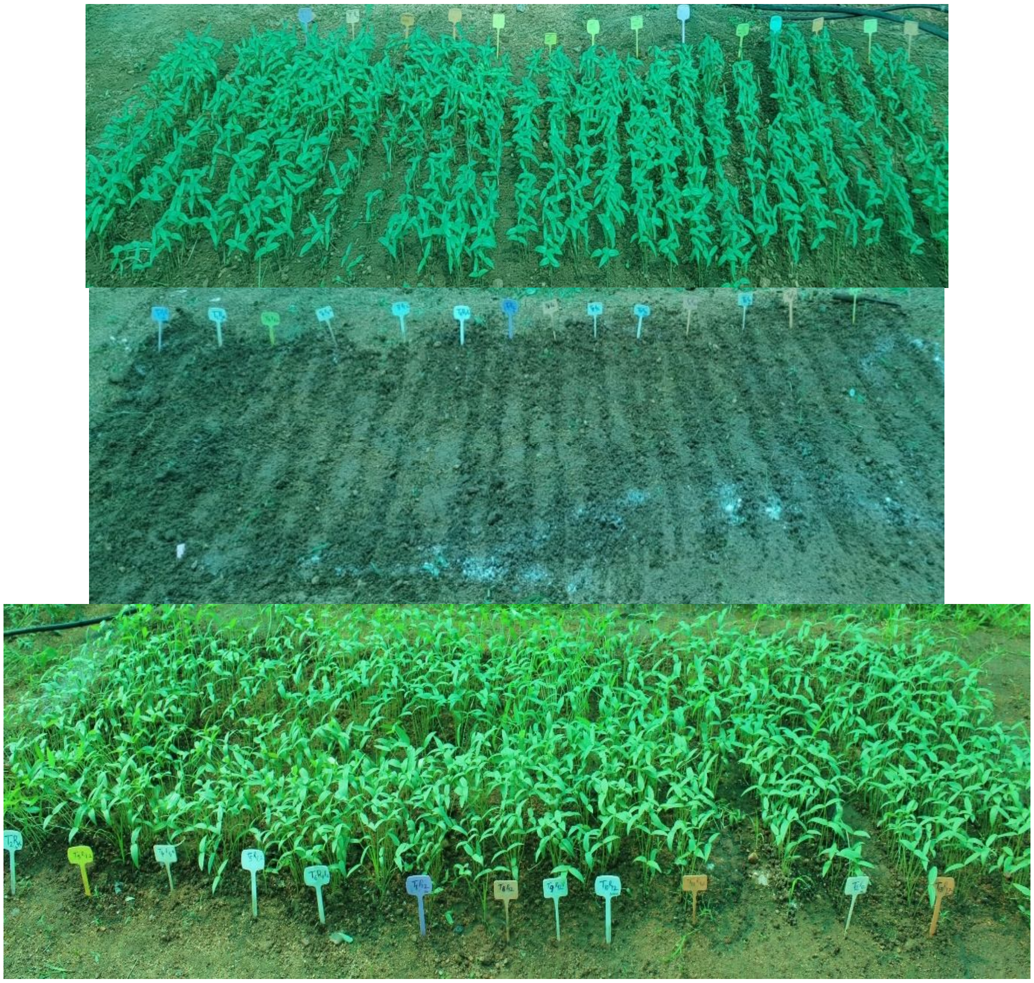

Plate 7 : Field emergence%

Conclusion

The present study conclusively demonstrates that physical seed treatments significantly influence seed quality attributes of greengram under *in vitro* conditions and are comparable or superior to conventional fungicidal and insecticidal seed treatments. Although germination percentage was not significantly affected due to the high initial viability of the seed lot, substantial improvements were observed in seedling dry weight, seed vigour index-II and field emergence following physical seed treatments. Opto-hydro-ionization treatment for 5 minutes (T7) proved most effective in enhancing seed vigour and phenolic content, indicating improved physiological efficiency and antioxidant potential. Cold plasma treatments, particularly cold plasma treatment at 10 kV for 20 minutes (T2) and 15 kV for 15 minutes (T3), significantly enhanced dehydrogenase activity, reflecting improved respiratory metabolism and biochemical activation. Neutral silica treatment at 3000 ppm (T10) effectively minimized seed damage and performed on par with deltamethrin insecticidal treatment, while avoiding chemical residues. Fungicidal seed treatments ensured seed health but did not consistently improve vigour and biochemical parameters to the extent achieved by physical treatments. Hence, opto-hydro-ionization and cold plasma treatments can be standardized as safe, non-chemical and environmentally sustainable seed treatment protocols for improving seed quality in greengram under laboratory conditions.

Table 2 : ANOVA of seed physiological parameters

Source of variation	df	Seed germination %	Seedling dry weight (mg)	Seedling vigour index-II	Field emergence test (%)	Moisture content (%)
Treatments	13	4.36	478.60***	50314***	20.96***	0.25***
Error	28	2.83	62.73	6861	4.11	0.04
Total	41	3.31	194.59	20639	9.46	0.11

Table 3 : ANOVA of seed health parameters

Source of variation	df	Seed damage (%)	Seed infection %
Treatments	13	0.23***	0
Error	28	0.01	0
Total	41	0.07	0

Table 4 : ANOVA of seed biochemical parameters

Source of variation	df	Dehydrogenase activity	Phenols (µmol g-1)
Treatments	13	0.36***	0.15***
Error	28	0.01	0.00
Total	41	0.12	0.04

Note: ***- Significant at 0.1% level probability; df- Degrees of freedom

Table 5 : Effect of different treatments on seed physiological parameters in greengram.

Treatments	Germin-ation %	Seedling dry weight (mg.)	Seed vigour index-II/ Seedling	Field emergence %	Seed moisture %
T_1 - 10 kV Cold plasma for 15 min	94	195.67	1846	90	7.23
T_2 - 10 kV Cold plasma for 20 min	94	204.00	1918	97	7.27
T_3 - 15 kV Cold plasma for 15 min	94	177.00	1670	93	7.50
T_4 - 15 kV Cold plasma for 20 min	96	190.33	1820	91	7.07
T_5 - 20 kV Cold plasma for 15 min	96	180.33	1737	92	7.47
T_6 - 20 kV Cold plasma for 20 min	95	184.00	1754	94	6.77
T_7 - Opto –hydro –ionization Process for 5 min	98	210.00	2052	94	7.60
T_8 - Opto –hydro –ionization Process for 10 min	94	172.00	1616	91	7.67
T_9 - Opto –hydro –ionization Process for 15min	94	189.33	1785	90	7.83
T_{10}- N Silica 3000 ppm (3gms / kg seed)	95	207.00	1973	93	7.57
T_{11} - Deltamethrin 2.8 EC (1ml/kg seed)	96	177.33	1708	91	7.33
T_{12}- Carbendazim (2gm/kg seed)	95	173.00	1637	92	7.17
T_{13} - Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS(1.5ml/kg seed)	95	195.67	1853	94	7.00
T_{14} - Untreated control	93	166.00	1678	86	7.17
C.D.	2.81	13.08***	139.25***	3.41***	0.37***
SE(m)	0.97	4.49	47.82	1.17	0.13
C.V.	1.77	4.15	4.63	2.21	2.98

Note: ***- Significant at 0.1% level probability

Table 6 : Effect of different treatments on seed health and biochemical parameters in greengram

Treatments	Seed damage (%)	Dehydrogenase activity– OD value	Phenols (µmol g^{-1})
T1: 10 kV Cold plasma for 15 min	0.92	4.26	1.61
T2: 10 kV Cold plasma for 20 min	0.62	4.39	1.59
T3: 15 kV Cold plasma for 15 min	1.04	3.40	1.57
T4: 15 kV Cold plasma for 20 min	1.08	3.54	1.82
T5: 20 kV Cold plasma for 15 min	0.88	4.03	1.89
T6: 20 kV Cold plasma for 20 min	1.32	3.71	1.56
T7: Opto –hydro –ionization Process for 5 min	0.76	3.46	2.15
T8: Opto –hydro –ionization Process for 10 min	1.43	3.20	2.07
T9: Opto –hydro –ionization Process for 15min	0.82	3.36	1.92
T10: N Silica 3000 ppm (3g/kg seed)	0.35	3.72	2.10
T11: Deltamethrin 2.8 EC (1ml/kg seed)	0.79	3.44	1.96
T12: Carbendazim (2gm/kg seed)	0.86	3.51	1.78
T13: Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS(1.5ml/kg seed)	0.77	3.89	1.58
T14: Untreated control	1.18	3.14	1.51
C.D.	0.15***	0.14***	0.05***
SE(m)	0.05	0.05	0.02
C.V.	10.10	2.32	1.63

Note: ***- Significant at 0.1% level probability

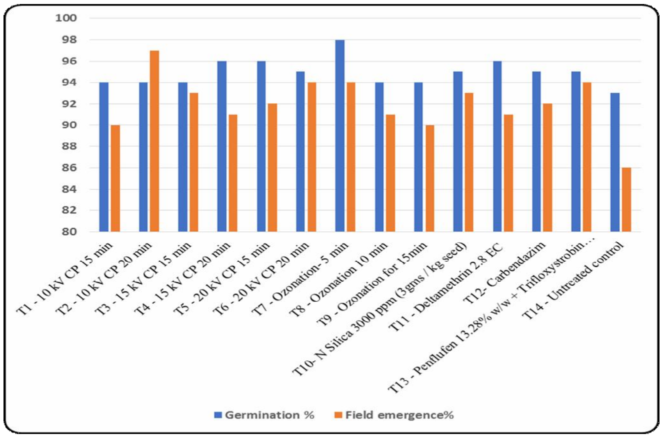

Fig. 1 : Graphical representation of effect of different treatments on germination% and field emergence % of greengram seed

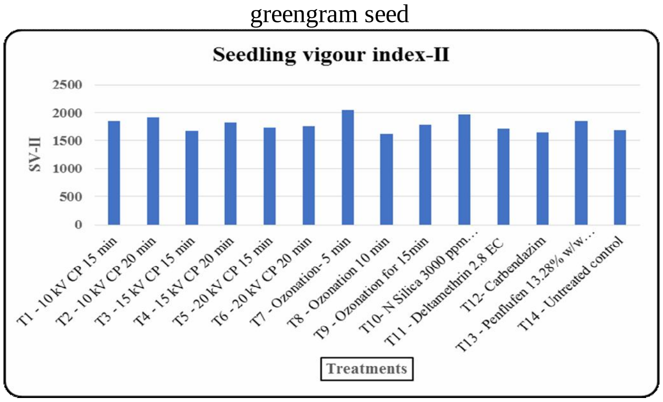

Fig. 2 : Graphical representation of effect of different treatments on Seedling vigour index-II of greengram seed

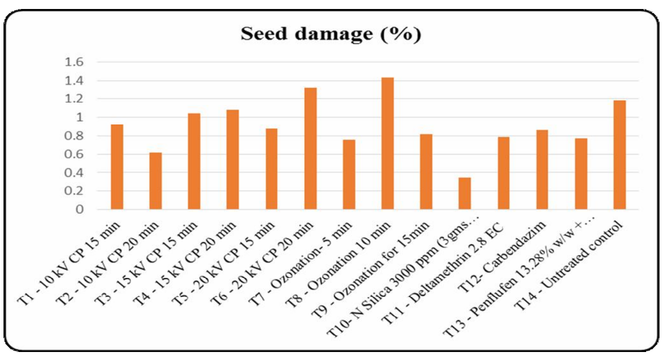

Fig. 3 : Graphical representation of effect of different treatments on Seed damage% of greengram seed

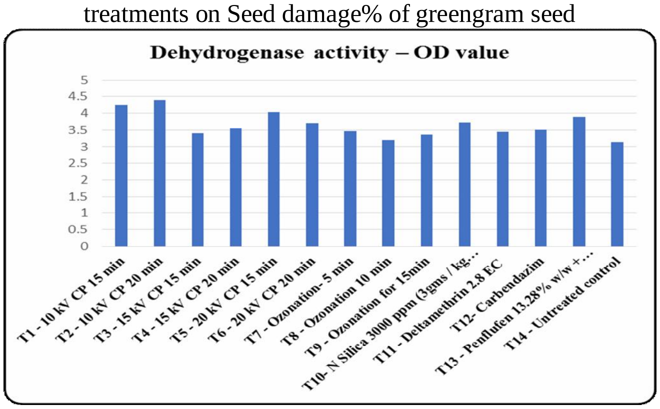

Fig. 4 : Graphical representation of effect of different treatments on Dehydrogenase activity of greengram seed

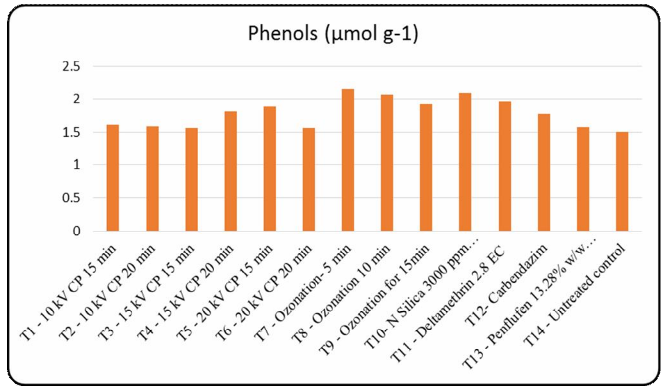

Fig. 5 : Graphical representation of effect of different treatments on phenols of greengram seed

Acknowledgements

The Author expressessincere gratitude to Head of the Department, College of Agriculture, Rajendranagar, PJTAU, Hyderabad and to Agricultural Research Station, Madhira, Khammam district, Telangana as well as to the Scientists and Professors for their constant support and guidance in conducting the experiment.

Competing Interests: None

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