NOUN Jour. of Agric. Res. & Dev. Vol. 1, No.2, Page 120 - 124

p-ISSN: 1595-1405

NOUN Journal of Agricultural Research and Development (NJARD)

The Official Journal of the Faculty of Agricultural Sciences, National Open University of Nigeria, Kaduna Campus

Journal homepage: https://journal.agric.nou.edu.ng

Original Article

Viability and Vigour Qualities of Bell Pepper (*Capsicum annuum)* Seeds influenced By Seed Dressing Chemicals.

OPEN ACCESS

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Editor: *Dr. Sunday N. Obasi*
National Open University of Nigeria

Received: *July 8, 2025*
Accepted: *August 30, 2025*
Published online: *September 5, 2025*
Peer-review: Externally peer-reviewed

Conflict of Interest: *The authors have no conflicts of interest to declare*

Financial Disclosure: *The authors declared that this study has received no financial support*

ABSTRACT

Seed dressing chemicals play a critical role in enhancing seed quality and protecting against seed–borne pathogens with varying effects on germination and seedling growth. This study evaluated the impact of different seed dressing treatments on germination and early growth parameters. A variety of bell peppers and three seed dressing chemicals (Imidacloprid 20% + Metalaxyl –M 20% + Tebuconazole 2% WS, Imidacloprid 20% + Metalaxyl 20% and Imidacloprid 10% + Thiram 10%) were tested. Final germination percentage, mean germination time, germination rate index, germination energy, germination index, and seedling growth parameters were investigated to determine the effectiveness of the seed dressing chemicals. Results showed that the control, Imidacloprid 20% + Metalaxyl 20% and Imidacloprid 10% + Thiram 10% treatments maintained relatively high germination performance. However, Imidacloprid 20% + Metalaxyl –M 20% + Tebuconazole 2% WS drastically reduced germination (5.00%) and all other germination indices, indicating severe toxicity. Similarly, Imidacloprid 20% + Metalaxyl –M 20% + Tebuconazole 2% WS had the most detrimental effects on seedling growth, resulting in a significantly reduced plumule length (0.04 cm), radicle length (0.98 cm), and SVI (15.25). Conversely, Imidacloprid 20% + Metalaxyl 20% exhibited comparable performance to the control in both germination and seedling vigour, while Imidacloprid 10% + Thiram 10% showed moderate inhibitory effects on root and shoot development. Conclusively, these findings suggest that Imidacloprid 20% + Metalaxyl 20% is a promising seed dressing chemical, while Imidacloprid 20% + Metalaxyl –M 20% + Tebuconazole 2% WS has a strong inhibitory effect and should be avoided or reformulated.

Keywords: *Viability, Vigour, Bell pepper, Seed Dressing Chemicals*

INTRODUCTION

Bell pepper (*Capsicum annum* Linnaeus.) belongs to the family *Solanaecea,* genus Capsicum (Abbas *et al*., 2020). It is Nigeria's third most cultivated vegetable (Abu *et al*., 2020). Bell peppers are used in food and industrial applications (Liliana *et al*., 2023). High-quality seeds are essential for optimal germination, seedling establishment, and subsequent crop productivity. However, seed-borne pathogens, soil-borne diseases, and environmental stresses can significantly reduce seed viability and vigour, leading to poor crop performance (Bewley and Black, 2013; Liliana *et al.,* 2023). It is reported that the seeds of bell peppers are passive input carriers of seed-borne pathogens such as bacteria, fungi, nematodes, and viruses (Chigoziri *et al*., 2013). According to FAO (2018), bell peppers are susceptible to seed–borne and air-borne diseases, which affect the seed germination rate and seedling vigour to a greater extent, hence leading to yield reduction.

Seed dressing chemicals, including fungicides, insecticides, and bio-stimulants, are commonly used to protect seeds from pathogens and pests while enhancing germination and early seedling growth (Nault *et al*., 2020). These chemicals can influence physiological and biochemical processes in seeds, affecting their viability and vigour (Marcos-Filho, 2015).

While seed treatments can improve plant health and yield, some chemicals may have phytotoxic effects, impairing seed germination and seedling development (Pedrini *et al.,* 2017). The balance between pathogen control and seed physiological integrity is crucial for sustainable agriculture. Therefore, evaluating the impact of different seed dressing chemicals on the viability and vigour of bell pepper seeds is essential for optimising seed treatment protocols.

This study was conducted to investigate how various seed dressing chemicals influence the germination potential, seedling vigour, and overall quality of bell pepper seeds. The findings will contribute to improved seed treatment strategies, ensuring better crop establishment and productivity in bell pepper cultivation.

MATERIALS AND METHODS

This experiment was conducted at the Federal University of Technology, Minna, Crop Production Department Laboratory (Latitude 9° 41´N Longitude 6° 31´E) in September 2024.

The experiment consisted of 2.5gram powder of four different seed dressing chemicals (fungicide), Control (T1), Imidacloprid 10% + thiram 10% (T2), Imidacloprid 20% + Metalxyl 20% (T3) and Imidacloprid 20% + Metalaxyl – M 20% + Tebunconazole 2% (T4). Bell pepper seeds (*Capsicum annuum* Linnaeus, cv California wonder) were obtained from certified seed supplier in Minna, Niger State, Nigeria. The seeds were surface sterilized with 1% Sodium hypochloride (NaOCl) for two minutes, then rinsed with distilled water, and air- dried at room temperature (25 ± 2°C) before treatment.

Each chemical treatment was applied as a seed coating by mixing seeds with the respective suspensions. The treated seeds were air – dried for 24 hours in a shaded, well-ventilated area before testing. The dried treated seeds were packed in plastic bags and labelled.

Seeds treated with the above-mentioned fungicides once, and untreated seeds were used as controls. Fifty seeds in each treatment were placed in 12 cm glass Petri dishes on a layer of filter paper (Whatman No. 4) separately. Distilled water was added as required. The petri dishes were maintained in a seed germinator at (25 ± 1°C). The experiment was conducted in CRD with four replications for both treated and normal samples.

Seed germination was recorded daily until day 13 after the experiment started. A seed was considered germinated when a radical emerged about 2 mm in length.

DATA COLLECTION

The following data were collected: (i) final germination percentage (%) (Number of germinated seeds / Total number of seeds × 100); (ii) germination energy (%) (Number of germinating seeds / Number of total seeds per treatment after germination for three days × 100) (Hernández-Herrera *et al*., 2014); (iii) mean germination time (d) [$\Sigma(D \times n)/\Sigma n$], where D is the number of days from the start of the trial and n is the number of seeds germinated on day D) (Ellis and Roberts, 1981); (iv) germination rate index (seed per day) [$\Sigma^{k}_{i=1} n_i / t_i$], where n_i is the percentage of seeds germinating on the i^{th} day and t_i is the number of days counted from the start of the experiment (i) to k, the last day on which seeds germinated (Hellal *et al*., 2018); (v) root length (cm); (vi) shoot length (cm); and (vii) seedling vigour index [(Mean root length + Mean shoot length) × Final germination percentage] (Hellal *et al*., 2018).

Data obtained were subjected to analysis of variance (ANOVA) using the Statistical Analysis System (SAS). Means were separated using least significant difference (LSD) to compare treatments and determine significant differences among the treatments. Data in percentages were transformed using arcsin before analysis.

RESULTS AND DISCUSSION

RESULTS

Effect of Seed Dressing Chemicals on the Germination parameters of Bell Pepper

Table 1 shows a significant difference ($p<0.05$) among the seeds of bell pepper treated with different seed dressing chemicals prior to sowing on the germination parameters.

Final Germination Percentage (FGP)

Significant difference was observed among the different seed dressing chemicals ($p<0.05$) for the final germination percentage. The highest final germination percentage (75.5%) was recorded in the untreated seed, while the lowest (0.5%) final germination percentage was recorded in seed treated with T2 (Imidacloprid 20% + Metalaxyl-M 20% + Tebuconazole 2% WS).

Mean Germination Time

There was no significant difference ($p<0.05$) observed among the various seed dressing chemicals for the mean germination time.

Germination Energy

There was no significant difference ($p<0.05$) observed among the various seed dressing chemicals for the germination energy.

Germination Rate Index

A significant difference ($p<0.05$) was in the Germination rate index. The untreated seeds recorded the highest germination rate index (49.40%), while the lowest germination rate index (2.22%) was recorded in seeds treated with T2 (Imidacloprid 20% + Metalaxyl-M 20% + Tebuconazole 2% WS).

Germination Index

A significant difference ($p<0.05$) was observed in the Germination index (GI). Seeds of bell pepper treated with T3 (Imidacloprid 20% + Metalyxyl 20%) had the highest germination index (198.00), while the lowest germination index (18.25) was observed in seeds treated with T2 (Imidacloprid 20% + Metalaxyl-M 20% + Tebuconazole 2% WS).

Table 1: Effect of Seed Dressing Chemicals on Germination Parameters of Bell Pepper

Treatments	FGP	MGT	GI	GE	GRI
T1	75.05a	9.34a	183.00a	10.56a	49.39a
T2	5.00b	5.02a	18.25b	6.63a	2.22b
T3	70.00a	9.65a	198.00a	10.97a	38.25a
T4	68.00a	9.29a	176.00a	10.34a	42.93a
±SEM	7.69	0.82	19.45	0.97	5.13

Effect of Seed Dressing Chemicals on the Seedling Vigour of Bell Pepper

Table 2 presents the effects of different seed dressing treatments on Plumule length (PL), Radicle length (RL), and Seedling Vigour Index (SVI) of bell pepper seedlings.

Plumule length (PL)

A significant difference ($p<0.05$) was observed in the plumule length of the bell pepper seeds treated with different seed dressing chemicals in the plumule length. The untreated seeds (control) had the highest (4.05 cm) plumule length, while the lowest (0.04 cm) plumule length was observed in seeds treated with Imidacloprid 20% + Metalaxyl- M 20% + Tebuconazole 2% WS.

Radicle length (RL)

A significant difference ($p<0.05$) was observed among the different seed dressing chemicals in the radicle length. The untreated seeds and seeds treated with Imidacloprid 20% + Metalaxyl 20% had the longest (3.40 cm each) radicle length, while seeds treated with Imidacloprid 10% + Thiram 10% had the shortest (0.60 cm) radicle length.

Seedling Vigour Index (SVI)

A significant difference ($p<0.05$) was observed among the different seed dressing chemicals in the seedling vigour index (SVI). The untreated seeds had the highest (574.10) SVI, which was statistically similar to seeds treated with Imidacloprid 20% + Metalaxyl 20% (471.15), while seeds treated with Imidacloprid 20% + Metalaxyl – M 20% + Tebuconazole 2% WS had the lowest (15.25) SVI.

Table2: Effect of Seed dressing chemical on seedling growth parameters of bell pepper.

Treatments	PL (cm)	RL (cm)	SVI
T1	4.05a	3.40a	574.10a
T2	0.04d	0.98b	15.25b
T3	3.38b	3.40a	471.15a
T4	1.38c	0.60b	133.70b
± SEM	0.39	0.38	63.35

Any two means within each column not sharing a letter differ significantly from each other at 5 % probability level. ±SEM = standard error for the mean, PL = plumule length, RL = radicle length and SVI = seedling vigour index

DISCUSSION

Final Germination Percentage (FGP)

The high germination percentages observed in the untreated seeds, and those treated with Imidacloprid 20% + Metalaxyl 20% and Imidacloprid 10% + Thiram 10% indicated that these treatments did not significantly hinder seed viability. However, the extremely low final germination percentage observed in seeds treated with Imidacloprid 20% + Metalaxyl – M 20% + Tebuconazole 2% WS suggested that the chemical used in this treatment may have had a toxic effect on seed germination. The drastic reduction implies that this seed dressing chemical could have inhibited seed water uptake, enzyme activity, or overall seed viability. Similar results were reported by Ergin *et al*. (2021), in seeds of Safflower treated with macozeb, Khairmar *et al*. (2013) and Choudhary *et al*. (2013) also found that germination rates in control (untreated) seeds were 76 – 84%; while it reached up to 91 – 95% in seeds treated with fungicides. Gill and Tuteja (2010), also reported that high concentrations of Imidacloprid and triazole fungicides like tebuconazole can induce oxidation stress by elevating reactive oxygen species (ROS) production. Tebuconazole, in particular, inhibits cytochrome P450 enzymes, which are crucial for detoxification (Zhu *et al*., 2016). This may lead to lipid peroxidation and membrane damage, impairing seed imbibition and radicle emergence.

Mean Germination Time

Mean germination time (MGT) values remained statistically similar across the treatments, ranging from 5.02 to 9.65 days. It therefore implies that once the germination occurred, the seed took approximately the same amount of time to complete germination. Moreover, the lowest MGT (5.02 days) observed in seeds treated with Imidacloprid 20% + Metalaxyl – M 20% + Tebuconazole 2% WS may indicate that while very few seeds germinated, those that did emerged quickly. This could be due to the selection of only highly viable seeds overcoming the negative effects of the treatment. Ergin *et al.*(2021) observed a shorter mean germination time in Safflower seeds treated with thiram and metalaxyl of 1.17 days and longer MGT in seeds treated with macozeb and captan. Gawade *et al.*(2016) also obtained a similar trend in soybeans treated with fungicide.

Germination Index (GI)
The highest germination index (GI) observed in seeds treated with Imidacloprid 20% + Metalaxyl 20% and control indicated an efficient germination. Conversely, the lowest GI observed in seeds treated with Imidacloprid 20% + Metalaxyl – M 20% + Tebuconazole 2% WS, further confirmed its adverse effect on seed germination capacity. This result is consistent with the report of Abbas *et al.*(2020) in *Capsicum annuum* treated with two fungicides and Ergin *et al*. (2021) in Safflower seeds.

Germination Energy (GE) and Germination Rate Index (GRI)
The germination energy (GE) and germination rate index (GRI) followed the same trend as FGP and GI, where the untreated seeds had the GE and GI, maintaining a relatively high value, suggesting that the seed vigour was highly preserved. However, the extreme low values observed in GE and GI for seeds treated with Imidacloprid 20% + Metalaxyl – M 20% + Tebuconazole 2% WS reinforced the conclusion that this treatment significantly suppressed seed germination performance. Similar trend was reported by Ergin *et al*. (2021), Abbas *et al*. (2020), Gawade *et al*. (2016).

Plumule Length (PL)
The control (untreated seeds) exhibited the longest plumule length (PL) indicating healthy shoot development. Seeds treated with Imidacloprid 20% + Metalaxyl 20% had a slightly shorter but statistically significant shoot length compared to the control, suggesting that the seed dressing chemical in this treatment did not severely impact shoot growth. Seeds treated with Imidacloprid 10% + Thiram 10% showed a drastic reduction in shoot growth length, indicating that the chemical used in this treatment negatively affected shoot elongation. Seeds treated with Imidacloprid 20% + Metalaxyl – M 20% + Tebuconazole 2% WS had an almost negligible shoot length confirming that the treatment severely hindered shoot growth, likely due to toxicity. Similar trends was reported by Ergin *et al*. (2021) in Safflower seeds treated Metalaxyl and Thiram, Choudhary *et al.*(2013) reported longer PL in seeds treated with Thiram and shorter PL in Captan. Costa *et al*. (2019) reported similar results in soybean seeds treated with Metalaxyl –M +fludioxonil.

Radicle Length (RL)
The untreated seeds and seeds treated with Imidacloprid 20% + Metalaxyl 20% had the longest radicle length which implies that these treatments did not negatively impact on root elongation. However, seeds treated with Imidacloprid 20% + Metalaxyl – M 20% + Tebuconazole 2% WS and Imidacloprid 10% + Thiram 10% had significantly shorter radicles, indicating that these seed dressing chemicals restricted root development. A shorter radicle length can affect the plants ability to absorb water and nutrients, ultimately reducing its survival rate and overall growth potential. The results are in line with the findings of Ergin *et al*.(2021) in Safflower seeds treated with Mancozed. Sultema and Ghaffar (2010) that fungi adversely affect seedling growth and healthy seedling growth can be achieved with fungicidal application.

Seedling Vigour Index (SVI)
The highest seedling vigour index (SVI) observed in the untreated seeds (control) and seeds treated with Imidacloprid 20% + Metalaxyl 20% indicated strong seedling vigour and good establishment potential. The lowest SVI observed in seeds treated with Imidacloprid 20% + Metalaxyl- M 20% + Tebuconazole 2% WS implied that the treatment drastically reduced seedling growth and viability. The results are in line with the findings of Ergin *et al*. (2021) in Safflower seeds, Islam *et al*. (2015) in Wheat, Addrah *et al*. (2020) in Sunflower and Ellis *et al*. (2011) in Egg plant. According to Gisi and Sierotzki (2008), Metalaxyl – M and tebuconazole may impair mitochondrial functions, reducing ATP production necessary for seedling growth. Imidacloprid can further disrupt energy metabolism by interfering with acetylcholine – mediated signalling in plants (Ford and Casida, 2006). The combined effect may suppress amylase and protease activity, limiting starch and protein mobilization required for seedling vigour (Pedrini *et al*., 2017).

Conclusion
Based on the results of this study, Imidacloprid 20% + Metalaxyl 20% is a promising seed dressing chemical for bell pepper seeds, while Imidacloprid 20% + Metalaxyl- M 20% + Tebuconazole 2% WS showed a strong inhibitory effect on the germination and seedling growth of the bell pepper. Its phytotoxic effects on bell pepper seeds may likely result from oxidative stress, hormonal imbalance, and metabolic inhibition. Further studies should be conducted both in field conditions and with other variables to optimise dosage and formulation to minimise adverse effects while maintaining pest and disease control efficacy.

Recommendation
Imidacloprid 20% + Metalaxyl 20% is recommended for small-holder farmers who wish to carry out seed dressing treatment on their bell pepper seeds.
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