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STANDARDIZATION OF PRE-SOWING ORGANIC SEED ENCRUSTATION TREATMENTS ON SEEDLING PARAMETERS OF CHILLI (*CAPSICUM ANNUM* L.) UNDER AMBIENT CONDITIONS OF STORAGE

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ABSTRACT

Encrustation is an important seed quality enhancement technique aiming at increasing the weight and size of seeds without altering its original shape is adopted for small seeded crop to ensure precision planting and to promote uniform crop establishment. To evaluate the efficacy of botanicals as pre sowing seed encrustation treatments on seedling parameters of Chilli under ambient conditions of storage a laboratory experiment was performed, in which the seeds were encrusted with various botanical leaf extract solutions *viz.* moringa (*Moringa oliefera*) (2, 4 and 6%), tulsi (*Ocimum sanctum*) (3, 5, 10%), arappu (*Albizia amara*) (25, 30 and 50g/kg) and vasambu (*Acorus calamus*) (10, 25 and 50g/kg) in three different concentrations and packed in C_1 aluminium pouches and C_2 air tight containers and stored for a period of 4,8 and 12 weeks under ambient conditions. The experiment was conducted in factorial CRD with 4 replications. The experimental results clearly revealed that seeds encrusted with arappu leaf powder (30g/kg) recorded maximum germination percentage (82.00), germination rate (3.16), shoot length (4.66), root length (7.56 cm), seedling length (12.22 cm), seedling growth rate (0.125), seedling fresh weight (0.072 g/10 seedlings), seedling dry weight (0.039 g/10 seedlings), seedling vigour I (1014.638) and seedling vigour II (3.27) over control. Packaging materials also showed significant influence on seedling growth parameters as the seed stored in air tight containers performed better with respect to seed quality parameters with less quantitative losses in comparison to seeds stored in aluminium foil pouches for 12 weeks of storage under ambient conditions. Among the botanicals tested, arappu leaf powder @30g/kg is found to be better in retaining seed viability and vigour up to 12 weeks of storage.
Keywords **:** Packing materials, encrustation, botanicals, seedling parameters, chilli, storage

Introduction

Chilli (*Capsicum annuum* L.) is an indispensable vegetable crop belonging to the family Solanaceae having diploid species with mostly 2n=24 chromosomes, but wild species with 2n=26 chromosomes have also been reported. (Pickersgill, 1991). Chilli crop shares its origin to South America and was introduced to India during 17th century by Portuguese (Raju and Luckrose 1991 and Ezhilkumar and Dinesh, 2016). India took lead in chilli production with 17.64 lakh tonnes followed by China (3.21 lakh tonnes), Ethiopia (2.94 lakh tonnes), Thailand (2.47 lakh tonnes) and Pakistan (1.48 lakh tonnes) in 2018-19. Source: www.indiastat.com, *2nd Advance Estimates). The need for organic farming elaborates the necessity for environmentally friendly seed augmentation strategies to increase the lifespan of seeds while they are being stored. Encrustation is a pioneering method of seed enhancement that includes applying a thick coating all around the seed, significantly adding buildup to increase weight and volume while maintaining its natural shape (Pedrini *et al.,* 2017 and Gregg and Billups 2010). Encrusting is a hybrid of film coating and pelleting which aims at physical modification of seed to improve handling and palatability through standardization of seed weight and size. (Taylor *et al.,* 1998, Halmer, 2008 and Avelar *et al*., 2012). This provides seeds a fine surface treatment with a blend of ingredients to create an inert organic and, as well as insecticides, colours and adhesives. Encrusting with botanicals are cheap and non-toxic and provide protection from pests and diseases during germination and early crop growth (Kumar *et al.,* 2015). Botanical seed treatments are derived from naturally available sources that has synergistic influence on early and uniform seed emergence as well as increased resistance to pests and diseases in the early stages of crop development. The active components in leaf extracts including

Moringa (*Moringa oleifera*) leaf powder, Tulsi (*Ocimum sanctum*) leaf powder, Arrappu (*Albizia amara*) leaf powder and Vasambu or Sweet Flag (*Acorus calamus*) rhizome powder, and act as antifungal, antibacterial, and seed-growth-promoting agents. Since the exogenous application of leaf powder of medicinal plants offers the only opportunities of sealing the development of plants and altering the physiological processes in the plant to increase seed quality, the leaf powders and plant extracts have been acknowledged as the main source to influence the plant performance. The plant-derived botanicals provide antioxidants, beneficial nutrients, and antifungal and antibacterial activities. Loss of seed quality, viability, and vigour as a result of harmful environmental variables is known as seed degradation (Kapoor *et al.,* 2010). It is a negative aspect of agriculture, and production failure is primarily caused by losses from detoriation. The process has been acknowledged as cumulative, irreversible, degenerative and inexorable process (Kapoor *et al.,* 2011). Declination in germination potential occurs because of non-starchy nature of endosperm in chilli seeds which functions as a mechanical barrier to developing embryo (Andreoli and Khan, 1999). To maintain lucrative outputs, chilli production requires high germination and uniform stand establishment (Ezhilkumar and Dinesh 2016). Several techniques, such as treating seeds with the appropriate organic or plant products and keeping them in secure containers, are being used to prevent the quantitative and qualitative losses caused by various biotic and abiotic variables during storage (Abdul-Baki and Anderson, 1973 and Chormule *et al.,* 2018).

The type of packaging material is the deciding factor for seed longevity in terms of seed storage. In open and pervious containers, seed moisture content is determined by RH of the surrounding atmosphere and temperature of the storage environment. Roberts (1961) said that seeds stored in ambient conditions loose their viability and vigour very fast due to changes in storage conditions of temperature and relative humidity. Using moisture proof containers to store the seeds can help in maintaining viability of the seeds in the long run (Mersal *et al*., 2018). For the farming community and the seed industry, comprehensive and relevant knowledge about how to store seeds with least amount of quality losses for at least one or more seasons was extremely helpful. Therefore the present investigation was planned to examine the effects of pre-sowing organic seed encrustation treatment on the quality of seed as well as the storability life of chilli seeds ambient condition.

Materials and Methods

A laboratory experiment was performed during March 2022 to June 2022 at Department of Genetics and Plant Breeding, SHUATS, Prayagraj (U.P) India in which the seeds were encrusted with various botanical leaf extract solutions *viz.* moringa (*Moringa oliefera*) (2, 4 and 6%), tulsi (*Ocimum sanctum*) (3, 5, 10%),arappu (*Albizia amara*) (25, 30 and 50g/kg) and vasambu (*Acorus calamus*) (10, 25 and 50g/kg) in three different concentrations and packed in C_1 aluminium pouches and C_2 air tight containers and stored for a period of 4,8 and 12 weeks under ambient conditions. The experiment was conducted in factorial concept CRD with 4 replications.

Preparation of botanicals (leaf extract) for seed encrustation treatment

Fresh leaves of moringa (*Moringa oleifera*), tulsi *(Ocimum sanctum*) and arrappu (*Albizia amara*) were collected from in and around the campus of Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh. Vasambu or Sweet Flag powder was purchased online. The leaves were cleaned thoroughly using tap water chopped into small pieces and were shade dried. The dried leaves were pulverized into powder using an electronic mixer grinder and sieved to get fine powder. The dried leaves were finely ground into fine powder and were used as seed treatment formulations for encrusting the seeds. Semi-liquid extract was used as seed dresser (coating). For making aqueous extracts of leaves of Moringa, Tulsi, Arrappu and Vasambu the required quantity of powders were made and soaked in 100 ml of sterile distilled water and kept for 6 hours and then passed through the muslin cloth. The powder extract solution were further prepared in three different concentrations for each treatment take under consideration in the present study.

Method of seed treatment (encrustation) and storage

The seeds to be encrusted were moistened with distilled water using a hand sprayer and were coated with binder solution (corn flour)followed by alternate application of leaf powder extract solution and sprinkling of leaf powders as fillers and were manually shaken in a pan for effective and uniform coating. The seeds were allowed to sit in the powdery slurry solution for proper coverage. The binder liquid was prepared and used on the same day .The formulation for seed incrustation binds with seeds after drying. After being coated on the seeds the product builds up a membrane that binds the seed dressing treatments as excess water evaporates after seeds are subjected to drying. Coated seeds are left to dry for 24 hours and dried back to their original moisture content at 7 percent and were packed in aluminium foil pouches and air tight containers. The packaging containers were then stored under ambient condition with 25 ± 3°C temperature with 95% RH (Relative Humidity) in Seed Testing Laboratory (Notified under Uttar Pradesh), Department of Genetics and Plant Breeding, SHUATS, Prayagraj (U.P.). Seed samples were drawn at an interval of four, eight and twelve weeks to assess the physiological parameters of Chilli (*Capsicum annum*) seeds. Observations on germination (%) by ISTA (2014), germination rate by Maguire (1962), shoot length (cm), root length (cm),seedling length (cm),seedling growth rate by Copeland (1976), seedling fresh weight (g/10 seedlings), seedling dry weight (g/10 seedlings), seedling vigour index (I) and seedling vigour index (II) by Abdul-Baki and Anderson (1973).

Statistical analysis

The observed data was statistically analysed with Factorial concept (FCRD) as suggested by Steel and Torrie (1960). The standard error of mean (S.Em.) and Critical difference (CD) at 5 % level of probability were worked out and presented in respective tables for interpretation of the results. The data were analyzed by of variance using OPSTAT statistical software.

Results and Discussion

Analysis of variance

The analyses of variance for different characters are presented in tables 1, 2 and 3 respectively. The mean sum of squares due to containers showed significant difference for all seedling growth parameters. The mean sum of squares due to treatment showed significant differences for all seedling growth parameters. The mean sum of squares due to interaction between containers and treatments showed significant differences for all seedling growth parameters except seedling growth rate at the 4^{th} , 8^{th}, and 12^{th}weeks at 5% level of significance.

1. Effect of packaging materials on seedling quality parameters of Chilli (*Capsicum annum*) seeds

In the present study, two packaging materials namely C_1 aluminium pouches and C_2 air tight container were used and

C_2 air tight container was observed to be significantly superior in maintaining higher seed quality standard throughout the storage period compared to C_1 aluminium pouches. The data of seedling quality parametersas influenced by containers at different weeks of storage periods are illustrated in table 1, 2 and 3. The difference in seedling parameters varied significantly throughout the storage period for air tight container. Variation in seedling parameters could be due to the quality of container. The maximum germination percentage (79.69), germination rate (3.07), shoot length (4.52 cm), root length (6.78 cm), seedling length (11.30 cm),seedling growth rate (0.113), seedling fresh weight (0.070g/10 seedlings), seedling dry weight (0.038 g/10 seedlings), seedling vigour I (909.412) and seedling vigour II (3.084) was recorded in air tight container stored seeds at the end of 12^{th} weeks of storage period.The superiority of the seed lots stored in air tight containers was due to the impervious nature of air tight containers that maintained low humidity resulting in lower respiration rate, reduced metabolic activity and high vigour retention during storage period. These findings are in accordance to the findings of Barua *et al.* (2009) inchilli, Peter *et al.* (2014) in tomato, Mollah *et al.* (2015) in onion, Gupta *et al.* (2016) in pearl millet, Sultana *et al.* (2016) in okra, Ningana *et al.* (2018) in chilli and Negi *et al.* (2020) in lentils. Germination percentage and germination rate showed declining trend as the storage period advanced. This is attributed to ageing effect that led to depletion of food reserves, decrease in synthetic activity of embryo and loss in viability (Tekrony *et al.,* 1993). Tame and Elam (2015); Nataraj and Jayaramegowda (2017) have also reported similar results for soybean. The seed stored in steel container (airtight) for 3 months had longer shoot and root length as compared to 6 and 9 months. Kandhare (2018) have also reported similar findings in black gram seeds due to airtight nature of tin box. The observations made in different crops stored in different packaging material, airtight containers proved to be the best.

2. Effect of pre sowing organic seed encrustation treatments on seedling quality parameters of chilli (*Capsicum annum*) seeds

The effect of pre sowing organic seed encrustation treatments *viz.,* moringa (*Moringa oliefera*), tulsi (*Ocimum sanctum*), arappu (*Albizia amara*) and vasambu (*Acorus calamus*) on seedling quality parameters studies of Chilli (*Capsicum annum*) seeds are presented in table 1, 2 and 3.Among the different organic seed encrustation treatments, the seeds treated with T_8 (arappu leaf powder 30g/kg) recorded significantly higher germination percentage (82.00), germination rate (3.16), shoot length (4.66 cm), root length (7.56 cm), seedling length (12.22cm), seedling growth rate (0.125), seedling fresh weight (0.072 g/10 seedlings), seedling dry weight (0.039 g/10 seedlings), seedling vigour I (1014.638) and seedling vigour II (3.27) and the least germination percentage (64.50), germination rate (2.49), shoot length (2.70 cm), root length (3.34 cm), seedling length (6.03cm), seedling growth rate of (0.056), seedling fresh weight (0.037g),seedling dry weight (0.010g),seedling vigour I of (389.948) and seedling vigour II of (0.65) was recorded in T_0 (Control) at the end of 12^{th} weeks of storage. The encrusted seeds showed significantly higher germination percentage in comparison to the control under laboratory condition. The encrustation further increased the vigour index computed on basis of germination and seedling length. The present study findings are in sync with findings of (Yadav, 2018) in mustard, and Patil *et al.,* (2019) in onion. The prime reason for enhancement in germination might be that the arappu leaf powder acting as a wick modified and regulated the soil moisture availability, thus increasing the seed to soil ratio. Arappu leaf powder contributes to the formation of auxin and ethylene thus positively affecting seed germination. The findings are similar to the findings of Kavitha *et al.* (2009) in chilli, Raikar *et al.* (2011) in rice, Ezhilkumar and Dinesh (2016)in chilli Narayanan *et al.* (2019) in sesame and Girase *et al.* (2019) in okra. A decline in germination rate was observed in all the treatments with advancement in storage period. This might be due to the phenomenon of ageing, depletion of seed reserves and degradation of seed coat resulting in leaching of its constituents as reported by Chandrasenan (1996) in chilli, Joeraj (2000) in sunflower and Gowda and Reddy (2008) in groundnut. The increased shoot length and root length in seeds treated with botanical leaf powder may be attributed to cell wall extension and increased metabolic activities and efficient transport of nutrients from seeds to heterotrophic primary seedlings. The physiological seed deterioration is reduced through its antifungal and antioxidant effects. Arappu leaf powders contains an active compound “saponin” having profound effects on seedling parameters which acts as precursor of GA_3 plant hormones responsible for enhanced root length. The botanical contains micro nutrients which are conducive for seed. The finding of Raikar *et al.* (2011) in rice and Kumar and Muthukrishnan (2015) in okra and chilli and Girase *et al.* (2019) in okra also corroborated with the results of present study.

The enhancement in dry weight, root length ,shoot length and germination percentage with botanicals treatment led to faster growth and development of seedlings and superlative hike in seedling vigour indices.An increase in seed quality parameters noticed may be due to the physiologically active substances present in the arappu leaf powder extract which might have triggered the embryo leading to cell elongation proliferation and other associated structure leading to development of stronger and efficient root system and higher vigour indices. The effect of arappu leaf powder treatments in enhancing vigour of seedlings is in line with the observations of Raikar *et al.* (2011) and Prakash *et al.* (2013) in riceAnanthi *et al.* (2015) in red gram, Sathishkumar *et al.* (2014) in brinjal, Kumar and Muthukrishna (2015) in okra and chilli seeds Ezhilkumar and Dinesh (2016) in chilli and Georgin Ophelia (2017) in black gram, Girase *et al.* (2019) in okra Thirusendura *et al.* (2019) in bitter gourd.

3. Interaction effect of packaging materials and organic seed encrustation treatments on seedling parameters of Chilli (*Capsicum annum*)

The data of table 1, 2, 3 revealed that the interaction effect between packaging materials and organic seed encrustation treatment when subjected to assessment of seedling growth parameters varied significantly up to 12^{th} weeks of storage. However the seedling growth rate varied non significantly throughout the storage period. The result revealed that the combination effect of arrappu leaf powder @30g/kg with air tight container on seedling growth parameters viz., germination percentage, germination rate, shoot length, root length, seedling length, seedling growth rate, seedling fresh weight, seedling dry weight, seedling vigour I and seedling vigour II out performed all treatment combinations used in the present study.

Conclusion

The conclusion drawn from the present investigation illustrates that seeds encrusted with arappu leaf powder @30g/kg helped to maintain higher seed quality standards and increasing the longevity of seeds. Encrusted seeds stored in air tight containers performed better in all aspects of seedling quality parameters as compared to the seeds stored in aluminium pouches. Encrusting seeds with arappu leaf powder extract @30g/kg and storing them in airtight/sealed containers could be commercially used to enhance the storability of chilli seeds under ambient conditions of storage. The findings are supported by experimental studies based on 12 weeks of storage period.

Table 1: Standardization of pre-sowing organic seed encrustation treatments on seedling parameters of Chilli (*Capsicum annum* L.) under ambient conditions of storage

Containers	Germination (%)			Germination rate			Shoot length (cm)			Root length (cm)		
	4 Weeks	8 Weeks	12 Weeks	4 Weeks	8 Weeks	12 Weeks	4 Weeks	8 Weeks	12 Weeks	4 Weeks	8 Weeks	12 Weeks
C_1	73.69	72.62	71.92	2.84	2.80	2.77	3.88	3.67	3.45	5.04	4.89	4.72
C_2	81.85	80.85	79.69	3.16	3.12	3.07	4.97	4.74	4.52	6.88	6.74	6.78
Grand	**77.77**	**76.73**	**75.81**	**3.00**	**2.96**	**2.92**	**4.42**	**4.20**	**3.99**	**5.96**	**5.81**	**5.75**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	S	S	S
C.D. at 5%	**1.437**	**1.372**	**1.413**	**0.055**	**0.053**	**0.053**	**0.030**	**0.087**	**0.039**	**0.116**	**0.115**	**0.126**
S.Ed. (+)	**0.720**	**0.688**	**0.708**	**0.028**	**0.027**	**0.026**	**0.015**	**0.044**	**0.020**	**0.058**	**0.057**	**0.063**
S.Em	**0.509**	**0.487**	**0.501**	**0.018**	**0.019**	**0.019**	**0.011**	**0.031**	**0.014**	**0.041**	**0.041**	**0.045**
Treatments												
T_0	67.00	65.75	64.50	2.58	2.53	2.49	3.21	2.95	2.70	3.80	3.66	3.34
T_1	82.25	81.50	81.00	3.17	3.14	3.12	5.00	4.79	4.58	7.25	7.09	6.93
T_2	81.00	80.25	79.75	3.12	3.09	3.07	4.84	4.62	4.40	6.87	6.70	6.54
T_3	77.75	77.00	76.25	3.00	2.97	2.94	4.53	4.31	4.09	5.96	5.81	5.70
T_4	75.50	74.00	73.75	2.91	2.85	2.85	4.18	3.96	3.74	5.39	5.28	5.09
T_5	75.25	73.75	72.75	2.90	2.84	2.81	3.68	3.50	3.33	5.33	5.12	5.11
T_6	74.50	73.25	72.50	2.87	2.82	2.80	4.10	3.90	3.70	4.29	4.16	5.06
T_7	81.00	80.50	79.75	3.12	3.10	3.07	4.92	4.70	4.49	7.04	6.89	6.74
T_8	83.75	82.75	82.00	3.23	3.19	3.16	5.07	4.86	4.66	7.84	7.70	7.56
T_9	77.25	76.50	75.50	2.98	2.95	2.91	4.32	4.10	3.88	5.88	5.75	5.64
T_{10}	79.75	79.00	77.00	3.08	3.05	2.96	4.76	4.51	4.26	6.16	6.01	5.86
T_{11}	78.75	77.75	76.75	3.04	3.00	2.97	4.65	4.43	4.21	6.07	5.90	5.77
T_{12}	77.25	75.50	74.00	2.98	2.91	2.85	4.25	4.03	3.80	5.64	5.51	5.38
Grand	**77.77**	**76.73**	**75.81**	**3.00**	**2.96**	**2.92**	**4.42**	**4.20**	**3.99**	**5.96**	**5.81**	**5.75**
Maximum	**83.75**	**82.75**	**82.00**	**3.23**	**3.19**	**3.16**	**5.07**	**4.86**	**4.66**	**7.84**	**7.70**	**7.56**
Minimum	**67.00**	**65.75**	**64.50**	**2.58**	**2.53**	**2.49**	**3.21**	**2.95**	**2.70**	**3.80**	**3.66**	**3.34**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**3.663**	**3.499**	**3.601**	**0.140**	**0.135**	**0.134**	**0.076**	**0.222**	**0.100**	**0.295**	**0.292**	**0.321**
S.Ed. (+)	**1.836**	**1.754**	**1.805**	**0.070**	**0.068**	**0.067**	**0.038**	**0.111**	**0.050**	**0.148**	**0.146**	**0.161**
S.Em	**1.298**	**1.240**	**1.277**	**0.050**	**0.048**	**0.048**	**0.027**	**0.0279**	**0.035**	**0.104**	**0.103**	**0.114**
Interaction (T x C)												
T_0xC_1	66.00	64.00	63.00	2.54	2.47	2.43	2.78	2.50	2.22	3.76	3.63	3.15
T_1xC_1	76.50	75.50	75.00	2.95	2.91	2.89	4.36	4.15	3.94	6.69	6.53	6.37
T_2xC_1	75.50	74.50	74.00	2.91	2.87	2.85	4.20	3.99	3.78	6.41	6.23	6.05
T_3xC_1	74.00	73.50	73.00	2.85	2.83	2.81	4.08	3.86	3.64	4.74	4.61	4.48
T_4xC_1	73.00	71.50	72.00	2.81	2.76	2.78	3.77	3.55	3.33	3.94	3.83	3.53
T_5xC_1	73.00	71.50	70.50	2.81	2.76	2.72	2.85	2.73	2.61	3.92	3.62	3.72
T_6xC_1	72.00	71.00	70.00	2.78	2.74	2.70	3.72	3.55	3.38	3.85	3.72	3.61
T_7xC_1	74.50	74.00	73.50	2.87	2.85	2.83	4.25	4.05	3.85	6.64	6.46	6.28
T_8xC_1	76.50	76.00	75.00	2.95	2.93	2.89	4.43	4.22	4.01	6.74	6.60	6.46
T_9xC_1	73.50	73.00	72.00	2.83	2.81	2.78	3.89	3.67	3.45	4.68	4.57	4.46
$T_{10}xC_1$	75.00	74.50	73.50	2.89	2.87	2.83	4.14	3.89	3.64	5.04	4.88	4.72
$T_{11}xC_1$	75.00	74.00	73.50	2.89	2.85	2.83	4.12	3.89	3.66	4.86	4.70	4.54
$T_{12}xC_1$	73.50	71.00	70.00	2.83	2.74	2.70	3.83	3.61	3.39	4.32	4.21	3.96
T_0xC_2	68.00	67.50	66.00	2.62	2.60	2.54	3.63	3.40	3.17	3.83	3.69	3.53
T_1xC_2	88.00	87.50	87.00	3.39	3.37	3.35	5.63	5.42	5.21	7.80	7.64	7.48
T_2xC_2	86.50	86.00	85.50	3.34	3.32	3.30	5.48	5.25	5.02	7.33	7.16	7.02
T_3xC_2	81.50	80.50	79.50	3.14	3.10	3.07	4.99	4.77	4.55	7.19	7.01	6.93
T_4xC_2	78.00	76.50	75.50	3.01	2.95	2.93	4.59	4.37	4.15	6.84	6.73	6.65
T_5xC_2	77.50	76.00	75.00	2.99	2.93	2.89	4.51	4.28	4.05	6.74	6.63	6.50
T_6xC_2	77.00	75.50	75.00	2.97	2.91	2.89	4.47	4.24	4.01	4.74	4.60	6.52
T_7xC_2	87.50	87.00	86.00	3.37	3.35	3.32	5.59	5.36	5.13	7.44	7.32	7.20
T_8xC_2	91.00	89.50	89.00	3.51	3.45	3.43	5.72	5.51	5.30	8.95	8.81	8.67
T_9xC_2	81.00	80.00	79.00	3.12	3.08	3.05	4.75	4.53	4.31	7.08	6.94	6.83
$T_{10}xC_2$	84.50	83.50	80.50	3.26	3.22	3.09	5.38	5.13	4.88	7.29	7.15	6.99
$T_{11}xC_2$	82.50	81.50	80.00	3.18	3.14	3.10	5.18	4.97	4.76	7.28	7.11	6.99
$T_{12}xC_2$	81.00	80.00	78.00	3.12	3.08	3.01	4.68	4.45	4.22	6.97	6.81	6.80
Mean	**77.77**	**76.73**	**75.81**	**3.00**	**2.96**	**2.92**	**4.42**	**4.20**	**3.99**	**5.96**	**5.81**	**5.75**
Maximum	**91.00**	**89.50**	**89.00**	**3.51**	**3.45**	**3.43**	**5.72**	**5.51**	**5.30**	**8.95**	**8.81**	**8.67**
Minimum	**66.00**	**64.00**	**63.00**	**2.54**	**2.47**	**2.43**	**2.78**	**2.50**	**2.22**	**3.76**	**3.62**	**3.15**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**5.180**	**4.948**	**5.093**	**0.198**	**0.192**	**0.190**	**0.107**	**0.314**	**0.141**	**0.417**	**0.413**	**0.454**
S.Ed. (+)	**2.597**	**2.481**	**2.553**	**0.099**	**0.096**	**0.095**	**0.054**	**0.157**	**0.071**	**0.209**	**0.207**	**0.227**
S.Em	**1.836**	**1.754**	**1.805**	**0.070**	**0.068**	**0.067**	**0.038**	**0.111**	**0.050**	**0.148**	**0.146**	**0.161**

Table 2: Standardization of pre-sowing organic seed encrustation treatments on seedling parameters of Chilli (*Capsicum annum* L.) under ambient conditions of storage

Containers	Seedling length (cm)			Seedling growth rate			Seedling Fresh weight (g/10seedlings)			Seedling Dry weight (g/10seedlings)		
	4 Weeks	8 Weeks	12 Weeks	4 Weeks	8 Weeks	12 Weeks	4 Weeks	8 Weeks	12 Weeks	4 Weeks	8 Weeks	12 Weeks
C_1	8.92	8.56	8.17	0.083	0.079	0.075	0.054	0.050	0.048	0.024	0.022	0.020
C_2	11.85	11.48	11.30	0.119	0.115	0.113	0.074	0.072	0.070	0.044	0.041	0.038
Grand	**10.39**	**10.02**	**9.73**	**0.101**	**0.097**	**0.094**	**0.064**	**0.061**	**0.059**	**0.034**	**0.032**	**0.029**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**0.121**	**0.143**	**0.130**	**0.008**	**0.008**	**0.007**	**0.003**	**0.003**	**0.003**	**0.002**	**0.002**	**0.002**
S.Ed. (+)	**0.061**	**0.073**	**0.065**	**0.004**	**0.004**	**0.004**	**0.001**	**0.002**	**0.002**	**0.001**	**0.001**	**0.001**
S.Em	**0.043**	**0.051**	**0.046**	**0.003**	**0.003**	**0.003**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
Treatments												
T_0	7.00	6.61	6.03	0.061	0.059	0.056	0.044	0.040	0.037	0.012	0.011	0.010
T_1	12.24	11.87	11.50	0.126	0.121	0.116	0.075	0.073	0.071	0.044	0.043	0.038
T_2	11.71	11.32	10.94	0.115	0.110	0.105	0.070	0.067	0.065	0.041	0.039	0.036
T_3	10.50	10.12	9.80	0.098	0.092	0.089	0.065	0.062	0.060	0.035	0.031	0.029
T_4	9.56	9.23	8.83	0.086	0.083	0.081	0.058	0.055	0.053	0.029	0.027	0.026
T_5	9.01	8.63	8.44	0.081	0.076	0.074	0.056	0.053	0.051	0.028	0.026	0.023
T_6	8.39	8.06	8.76	0.073	0.068	0.076	0.055	0.051	0.048	0.025	0.024	0.021
T_7	11.96	11.59	11.23	0.124	0.118	0.114	0.075	0.071	0.068	0.042	0.041	0.037
T_8	12.92	12.57	12.22	0.134	0.130	0.125	0.078	0.075	0.072	0.045	0.044	0.039
T_9	10.20	9.85	9.52	0.102	0.097	0.093	0.064	0.061	0.059	0.032	0.029	0.029
T_{10}	10.92	10.52	10.11	0.107	0.103	0.097	0.067	0.064	0.062	0.038	0.037	0.034
T_{11}	10.72	10.33	9.98	0.110	0.104	0.100	0.066	0.064	0.061	0.036	0.034	0.031
T_{12}	9.90	9.53	9.19	0.100	0.096	0.091	0.061	0.058	0.056	0.030	0.027	0.026
Grand	**10.39**	**10.02**	**9.73**	**0.101**	**0.097**	**0.094**	**0.064**	**0.061**	**0.059**	**0.034**	**0.032**	**0.029**
Maximum	**12.92**	**12.57**	**12.22**	**0.134**	**0.130**	**0.125**	**0.078**	**0.075**	**0.072**	**0.045**	**0.044**	**0.039**
Minimum	**7.00**	**6.61**	**6.03**	**0.061**	**0.059**	**0.056**	**0.044**	**0.040**	**0.037**	**0.012**	**0.011**	**0.010**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**0.310**	**0.366**	**0.331**	**0.020**	**0.0020**	**0.019**	**0.007**	**0.008**	**0.008**	**0.004**	**0.004**	**0.005**
S.Ed. (+)	**0.155**	**0.183**	**0.166**	**0.010**	**0.010**	**0.009**	**0.003**	**0.004**	**0.004**	**0.002**	**0.002**	**0.003**
S.Em	**0.110**	**0.130**	**0.117**	**0.007**	**0.007**	**0.007**	**0.002**	**0.003**	**0.003**	**0.001**	**0.003**	**0.003**
Interaction (T x C)												
T_0xC_1	6.55	6.13	5.37	0.054	0.053	0.051	0.043	0.038	0.035	0.012	0.011	0.010
T_1xC_1	11.05	10.68	10.31	0.106	0.101	0.096	0.060	0.058	0.055	0.034	0.033	0.028
T_2xC_1	10.62	10.23	9.84	0.102	0.097	0.092	0.057	0.054	0.051	0.033	0.030	0.028
T_3xC_1	8.81	8.46	8.11	0.075	0.071	0.066	0.055	0.052	0.050	0.022	0.021	0.020
T_4xC_1	7.70	7.37	6.86	0.060	0.059	0.058	0.052	0.048	0.046	0.018	0.016	0.015
T_5xC_1	6.77	6.35	6.32	0.056	0.052	0.051	0.048	0.045	0.042	0.016	0.015	0.014
T_6xC_1	7.57	7.27	6.99	0.068	0.062	0.059	0.047	0.043	0.038	0.014	0.013	0.012
T_7xC_1	10.89	10.51	10.13	0.112	0.105	0.101	0.059	0.054	0.051	0.033	0.032	0.028
T_8xC_1	11.17	10.82	10.47	0.110	0.105	0.101	0.061	0.058	0.055	0.035	0.034	0.030
T_9xC_1	8.57	8.24	7.91	0.080	0.076	0.072	0.054	0.052	0.050	0.020	0.019	0.018
$T_{10}xC_1$	9.18	8.77	8.36	0.085	0.080	0.075	0.056	0.053	0.051	0.028	0.026	0.024
$T_{11}xC_1$	8.98	8.59	8.20	0.091	0.086	0.081	0.055	0.053	0.051	0.025	0.022	0.021
$T_{12}xC_1$	8.15	7.81	7.35	0.079	0.076	0.070	0.054	0.049	0.046	0.019	0.018	0.017
T_0xC_2	7.46	7.08	6.70	0.068	0.064	0.060	0.044	0.041	0.039	0.013	0.012	0.011
T_1xC_2	13.43	13.06	12.69	0.146	0.141	0.136	0.091	0.089	0.088	0.054	0.053	0.047
T_2xC_2	12.81	12.41	12.04	0.128	0.123	0.119	0.082	0.081	0.079	0.050	0.049	0.044
T_3xC_2	12.19	11.78	11.48	0.120	0.113	0.111	0.075	0.072	0.070	0.047	0.042	0.039
T_4xC_2	11.43	11.10	10.79	0.112	0.107	0.103	0.064	0.062	0.060	0.039	0.038	0.037
T_5xC_2	11.25	10.91	10.55	0.105	0.101	0.098	0.064	0.061	0.059	0.039	0.037	0.033
T_6xC_2	9.22	8.85	10.53	0.078	0.073	0.094	0.063	0.060	0.058	0.037	0.035	0.030
T_7xC_2	13.03	12.68	12.33	0.136	0.132	0.127	0.090	0.088	0.085	0.051	0.050	0.046
T_8xC_2	14.67	14.32	13.98	0.159	0.155	0.150	0.095	0.092	0.090	0.055	0.054	0.049
T_9xC_2	11.83	11.47	11.14	0.124	0.119	0.115	0.074	0.071	0.067	0.045	0.040	0.039
$T_{10}xC_2$	12.66	12.28	11.87	0.129	0.125	0.120	0.079	0.076	0.074	0.049	0.047	0.044
$T_{11}xC_2$	12.46	12.08	11.75	0.128	0.122	0.119	0.078	0.075	0.072	0.048	0.046	0.042
$T_{12}xC_2$	11.65	11.26	11.02	0.120	0.115	0.112	0.069	0.067	0.067	0.040	0.037	0.035
Mean	**10.39**	**10.02**	**9.73**	**0.101**	**0.097**	**0.094**	**0.064**	**0.061**	**0.059**	**0.034**	**0.032**	**0.029**
Maximum	**14.67**	**14.32**	**13.98**	**0.159**	**0.155**	**0.150**	**0.095**	**0.092**	**0.090**	**0.055**	**0.054**	**0.049**
Minimum	**6.55**	**6.13**	**5.37**	**0.054**	**0.052**	**0.051**	**0.043**	**0.038**	**0.035**	**0.012**	**0.011**	**0.010**
F-Test	**S**	**S**	**S**	**NS**	**NS**	**NS**	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**0.438**	**0.517**	**0.468**	**-**	**-**	**-**	**0.010**	**0.012**	**0.011**	**0.006**	**0.007**	**0.006**
S.Ed. (+)	**0.219**	**0.259**	**0.235**	**0.014**	**0.014**	**0.013**	**0.005**	**0.006**	**0.005**	**0.003**	**0.004**	**0.003**
S.Em	**0.155**	**0.183**	**0.166**	**0.010**	**0.010**	**0.009**	**0.003**	**0.004**	**0.004**	**0.002**	**0.003**	**0.002**

Table 3: Standardization of pre-sowing organic seed encrustation treatments on seedling parameters of Chilli (*Capsicum annum* L.) under ambient conditions of storage

Containers	Seedling vigour index I			Seedling vigour index II		
	4 Weeks	8 Weeks	12 Weeks	4 Weeks	8 Weeks	12 Weeks
C_1	660.704	624.777	591.654	1.757	1.630	1.473
C_2	979.653	937.854	909.412	3.624	3.399	3.084
Grand	**820.179**	**781.315**	**750.533**	**2.691**	**2.514**	**2.278**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**17.005**	**16.112**	**16.3739**	**0.139**	**0.158**	**0.148**
S.Ed. (+)	**8.550**	**8.077**	**8.392**	**0.070**	**0.079**	**0.074**
S.Em	**6.046**	**5.712**	**5.934**	**0.049**	**0.056**	**0.052**
Treatments						
T_0	469.324	435.034	389.948	0.81	0.72	0.65
T_1	1013.593	974.734	938.698	3.66	3.55	3.10
T_2	954.670	914.495	878.060	3.40	3.21	2.93
T_3	822.540	784.273	752.343	2.74	2.45	2.27
T_4	726.560	688.303	654.420	2.21	2.01	1.96
T_5	682.975	641.213	618.838	2.11	1.93	1.70
T_6	627.354	591.630	639.000	1.92	1.75	1.51
T_7	975.380	939.663	902.035	3.47	3.33	2.99
T_8	1094.635	1051.828	1014.638	3.83	3.69	3.27
T_9	793.788	759.150	724.959	2.52	2.29	2.19
T_{10}	879.393	838.891	784.673	3.11	2.93	2.65
T_{11}	850.743	810.453	771.098	2.88	2.71	2.43
T_{12}	771.368	727.435	688.223	2.32	2.11	1.98
Grand	**820.179**	**781.315**	**750.533**	**2.69**	**2.51**	**2.28**
Maximum	**1094.635**	**1051.828**	**1014.638**	**3.83**	**3.69**	**3.27**
Minimum	**469.324**	**435.034**	**389.948**	**0.81**	**0.72**	**0.65**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**43.482**	**41.078**	**42.676**	**0.354**	**0.403**	**0.377**
S.Ed. (+)	**21.799**	**20.594**	**21.395**	**0.177**	**0.202**	**0.189**
S.Em	**15.414**	**14.562**	**15.128**	**0.125**	**0.143**	**0.134**
Interaction (T x C)						
T_0xC_1	431.868	392.418	338.045	0.777	0.672	0.599
T_1xC_1	845.195	806.458	772.990	2.604	2.474	2.115
T_2xC_1	801.655	762.060	727.400	2.489	2.203	2.066
T_3xC_1	651.990	621.410	592.000	1.628	1.517	1.440
T_4xC_1	562.365	526.845	494.150	1.339	1.148	1.099
T_5xC_1	494.025	453.920	446.350	1.187	1.072	0.965
T_6xC_1	545.250	515.540	488.520	0.988	0.905	0.804
T_7xC_1	811.275	776.705	744.440	2.449	2.365	2.046
T_8xC_1	854.505	822.195	785.395	2.640	2.603	2.210
T_9xC_1	629.540	600.975	570.003	1.432	1.368	1.314
$T_{10}xC_1$	688.195	652.948	613.625	2.067	1.939	1.751
$T_{11}xC_1$	673.885	636.005	601.865	1.841	1.646	1.538
$T_{12}xC_1$	599.405	554.625	516.725	1.400	1.282	1.207
T_0xC_2	506.780	477.650	441.850	0.850	0.777	0.707
T_1xC_2	1181.992	1143.011	1104.407	4.725	4.617	4.078
T_2xC_2	1107.685	1066.930	1028.720	4.311	4.210	3.791
T_3xC_2	993.090	947.135	912.685	3.845	3.387	3.095
T_4xC_2	890.755	849.760	814.690	3.074	2.869	2.814
T_5xC_2	871.925	828.505	791.325	3.041	2.793	2.442
T_6xC_2	709.458	667.720	789.480	2.849	2.602	2.214
T_7xC_2	1139.485	1102.620	1059.630	4.485	4.298	3.931
T_8xC_2	1334.765	1281.460	1243.880	5.024	4.785	4.322
T_9xC_2	958.035	917.325	879.915	3.605	3.209	3.058
$T_{10}xC_2$	1070.590	1024.835	955.720	4.162	3.927	3.553
$T_{11}xC_2$	1027.600	984.900	940.330	3.915	3.767	3.331
$T_{12}xC_2$	943.330	900.245	859.720	3.235	2.943	2.752
Mean	**820.179**	**781.315**	**750.533**	**2.691**	**2.514**	**2.278**
Maximum	**1334.77**	**1281.46**	**1243.88**	**5.02**	**4.79**	**4.32**
Minimum	**431.87**	**392.42**	**338.05**	**0.85**	**0.78**	**0.71**
F-Test	**S**	**S**	**S**	**S**	**S**	**S**
C.D. at 5%	**61.493**	**42.676**	**60.353**	**0.500**	**0.569**	**0.533**
S.Ed. (+)	**30.828**	**21.395**	**30.257**	**0.251**	**0.285**	**0.267**
S.Em	**21.799**	**15.128**	**21.395**	**0.177**	**0.202**	**0.189**

Conflict of interests

Authors declare that they have no conflict of interest to disclose.

Author's contribution

The authors conceived and planned the present study. Sumana Ahsan performed the laboratory experiments, recorded and analyzed the data for various parameters and drafted the manuscript. Prashant Kumar Rai contributed to manuscript reviews and feedback and approved the final version of the script.

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