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Assessment the Effect of Nano-particles in Quality Parameters of Stored Seeds of Paddy (*Oryza sativa* L.)

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ABSTRACT: The present study was carried out on paddy variety Pusa Basmati 1509 at Indian Agricultural Research Institute, New Delhi during 2020-21 with the objective to study the effect of nanoparticles on seed storage potential. The seeds were dry dressed and infused with each of nano and bulk forms of Zinc oxide, Titanium oxide, Silicon dioxide @ 50, 100, 250, 500 and 750ppm. Along with the two controls i.e., untreated and treated with recommended PoP (Thiram treated @ 2g/Kg of seeds), seeds were stored in different packaging material i.e., Polythene and cloth bags under ambient conditions up to 6 months, to study the storage efficacy. The aim of this study is to draw a systematic and comprehensive picture of quality parameters on stored seed of paddy which inhance the production and productivity of paddy. Present data revealed that the highest germination percentage, seedling vigour index I and seedling vigour index II were recorded at initial month but after 6 month of storage highest germination percentage (86.8%) in (T3) Dry Bulk ZnO@50ppm, seedling vigour index I (5306) in (T5) Dry Bulk ZnO@250ppm and seedling vigour index II (18.75) in (T7) Dry Bulk ZnO@750ppm were recorded in polythene bag then cloth bag as compared to both the controls. Significant highest seedling emergence percentage were recorded at initial month but after 6 month of storage highest seedling emergence percentage (84.06%) in (T2) Thiram@2gm/kg recorded in polythene bag as compared to (control 1). Lowest moisture content was recorded at initial month but after 6 month of storage lowest moisture content (8.3%) in (T8) Dry Bulk ZnO@50ppm recorded in polythene bag as compared to both the controls.

Keywords: Paddy, nanoparticle, germination, emergence, seedling vigour and storage.

INTRODUCTION

Rice, *Oryza sativa* (2n = 24) (Poaceae; subfamily Oryzoides), is the nourishment for half of the world's population and accounts for nearly 20% of all cereal-growing land. Rice bran is used in baked goods such as pizza, chips, cookies, and biscuits. Parboiled rice is used to make parched rice, which is quickly digestible. Rice husk is used as a fuel, as well as in the production of board and paper, packaging and construction materials, and as an insulator. It has a wide range of applications and is second only to wheat in terms of area and production. India and China account for 48% of total land area and 53.4 per cent of global rice production (FAO, 2019). Total production of rice during 2019-2020 is estimated at record 117.94 million tonnes (DAC&FW, 2019-2020). West Bengal, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, and Karnataka are the India's most important rice producing states. It is classified as a semi-aquatic annual grass crop.

Low and uncertain income, degraded natural resource base, growing labour and energy shortages and threats of climate change are making Indian agriculture highly vulnerable and unsustainable (Pathak *et al.,* 2018). Environmentally safe and economically viable disposal of rice straw is another challenge of rice farming in many, particularly the north-western part of the country. Indian rice farming thus seems to be in a cross-road once again. Producing enough rice for the increasing Population against the backdrop of reducing natural resource base is, therefore, the primary task of Indian rice sector.

Excessive use of pesticides and even fertilizers in rice farming pollutes water and creates health hazards. Conventional fertilizers help increase yield in many crops, but they have a negative impact on the environment by causing eutrophication and contaminating water bodies. There is little knowledge about the mode of action of nanoparticles in relation to plant systems. Thus, before using the nanomaterials in the field, the phytotoxic behavior of nanomaterials must be fully understood (Gokhade, 2010). Nanoparticles, according to IUPAC, are "particles of any form with a dimension in the range of 10^{-9} to 10^{-7}, and possessing distinct physical, chemical and biological properties''. Carbon-based nanoparticles, metallic nanoparticles, metal oxide nanoparticles, polymeric nanoparticles, and lipid-based nanoparticles are the most commonly used nanoparticles in agriculture.

Metals and metal oxides (e.g., TiO_2, SiO_2, Fe ZnO, Al_2O_3, CeO_2, Cu, and Ag), carbon nanotubes, nano clay composites, and graphenes are the most common engineered nano materials (Keller & Lazareva 2014). Zn is absorbed by higher plants as a divalent cation (Zn^{2+}), which serves as a metal part of enzymes as well as a functional structural or regulatory co-factor in a wide range of enzymes (Khan *et al.,* 2004; Hafeez *et al.,* 2013). Another commonly used metal oxide nanoparticle is SiO_2, which is used in photo catalysis, cosmetics, fertilizers, cancer treatment, and bio-imaging (Cheng *et al.,* 2010; Slowing *et al.,* 2008; Rosenholm *et al.,* 2010). Nano titanium oxide particles could be used in agriculturally valuable crops as a weapon. The impact of titanium nanoparticles differs between species and doses (Mattiello, 2018).

MATERIAL AND METHODS

A. Germination percentage

Germination percentage was recorded by the using rolled towel paper method. From each treatment combination 100 seeds were placed in three replications on moist towel paper, rolled appropriately and kept for germination at constant temperature (25±1ºC) and 90% relative humidity. The first and final counts were recorded on 5th and 14th day. The seedlings were evaluated for normal seedlings, abnormal seedlings, fresh un-germinated (FUG) and dead seeds. Total numbers of normal seedlings counted were considered for calculation of germination and were expressed in percentage (ISTA, 2019) (Table 1).

Table 1: Enlisted treatments were used for above different observations.

Treatments	Remarks	Treatments	Remarks
T1	Control	T32	Dry Nano SiO_2@750ppm
T2	Thiram@2g/kg(recommended PoP: control2)	T33	Wet Bulk SiO_2@50ppm
T3	Dry Bulk Zno @50ppm	T34	Wet Bulk SiO_2@ 100ppm
T4	Dry Bulk Zno @100ppm	T35	Wet Bulk SiO_2@250ppm
T5	Dry Bulk Zno@250ppm	T36	Wet Bulk SiO_2@500ppm
T6	Dry Bulk Zno@500ppm	T37	Wet Bulk SiO_2@750ppm
T7	Dry Bulk Zno@750ppm	T38	Wet Nano SiO_2@50ppm
T8	Dry Nano Zno@50ppm	T39	Wet Nano SiO_2@100ppm
T9	Dry Nano Zno@ 100ppm	T40	Wet Nano SiO_2@250ppm
T10	Dry Nano Zno@250ppm	T41	Wet Nano SiO_2@500ppm
T11	Dry Nano Zno@500ppm	T42	Wet Nano SiO_2@750ppm
T12	Dry Nano Zno@750ppm	T43	Dry Bulk TiO_2@50ppm
T13	Wet Bulk Zno@50ppm	T44	Dry Bulk TiO_2@100ppm
T14	Wet Bulk Zno@100ppm	T45	Dry Bulk TiO_2@250ppm
T15	Wet Bulk Zno@250ppm	T46	Dry Bulk TiO_2@500ppm
T16	Wet Bulk Zno@500ppm	T47	Dry Bulk TiO_2 @750ppm
T17	Wet Bulk Zno@750ppm	T48	Dry Nano TiO_2@50ppm
T18	Wet Nano Zno@50ppm	T49	Dry Nano TiO_2@ 100ppm
T19	Wet Nano Zno@100ppm	T50	Dry Nano TiO_2@250ppm
T20	Wet Nano Zno@250ppm	T51	Dry Nano TiO_2@500ppm
T21	Wet Nano Zno@500ppm	T52	Dry Nano TiO_2@750ppm
T22	Wet Nano Zno@750ppm	T53	Wet Bulk TiO_2@50ppm
T23	Dry Bulk SiO2@50ppm	T54	Wet Bulk TiO_2@100ppm
T24	Dry Bulk SiO2@100ppm	T55	Wet Bulk TiO_2@250ppm
T25	Dry BulkSiO2@250ppm	T56	Wet Bulk TiO_2@500ppm
T26	Dry Bulk SiO2@500ppm	T57	Wet Bulk TiO_2@750ppm
T27	Dry Bulk SiO2@750ppm	T58	Wet Nano TiO_2@50ppm
T28	Dry Nano SiO2@50ppm	T59	Wet Nano TiO_2@100ppm
T29	Dry Nano SiO2@100ppm	T60	Wet Nano TiO_2 @250ppm
T30	Dry Nano SiO2@250ppm	T61	Wet Nano TiO_2@500ppm
T31	Dry Nano SiO2@500ppm	T62	Wet Nano TiO_2@750ppm

$$\text{Germination (\%)} = \frac{\text{Number of normal seedling}}{\text{Total number of seeds}} \times 100$$

B. Abnormal seedlings (%)

From the germination test, those seedlings which did not showed the capacity of continued development into normal plants under favourable conditions were counted and expressed in percentage (Table 1).

$$\text{Abnormal seedlings (\%)} = \frac{\text{No. of abnormal seedlings}}{\text{Total number of seeds}} \times 100$$

C. Fresh un-germinated seeds (%)

From the germination test, those seeds which at the end of the test period, were fresh and have not produced the seedlings are counted and expressed in percentage (Table 1).

$$\text{Fresh un} - \text{germinated seeds (\%)} = \frac{\text{No. of fresh ungerminated}}{\text{Total number of seeds}} \times 100$$

D. Dead seeds (%)

From the germination test, those seeds which at the end of the test period, were neither hard nor fresh and have not produced the seedlings are counted and expressed in percentage (Table 1).

$$\text{Dead seeds (\%)} = \frac{\text{No. of dead seeds}}{\text{Total number of seeds}} \times 100$$

E. Root, shoot and total length of seedlings (cm)

Ten random seedlings from each replication were used for measuring root, shoot and total lengths of seedlings by scale and expressed in centimeters (cm) (Table 1).

F. Seedling dry weight

Those ten seedlings that were used for recording seedling length were dried in hot air oven at 80±1℃ for 17 hrs. Seedling dry weight was taken after cooling them for half an hour in desiccator and weight was expressed as mg/10 seedlings (Table 1).

G. Seedling vigor index

Seedling vigour indices were estimated (Table 1) following the procedure suggested by the Abdul-Baki and Anderson (1973) with the using of following formula:

Seedling vigour index I = Germination (%) × Mean Seedling length

Seedling vigour index II= Germination (%) × Mean seedling dry weight

Where; Seedling length (cm) = Shoot length (cm) + Root length (cm)

H. Seedling emergence (%)

The initial month of seedling emergence was takan in field and 3, 6 month of seedling emergence experiment were taken in laboratory. Seeds were sown in 5" deep trays filled with moist soil in four replications of 100 seeds each from each treatment combination. The trays were placed in walk in germination chamber set at 25±1℃ and 90 ± 2% relative humidity. The number of seedlings emerged were recorded on 21st day after sowing and the mean seedling emergence was expressed in percentage (Table 1).

RESULTS AND DISCUSSION

Storage of seeds at least till the next planting season is an integral part of agricultural production system. Moreover, seed treatments particularly for enhancing the planting value is becoming more common now-a-days. Various types of seed quality enhancement treatments, including treatment with nanoparticles are available to alleviate the ill effects of biotic and abiotic stresses on seed germination and plant stand establishment. But there are reports that the quality enhanced seeds had poor storability. Seed treatment with nanoparticles is also an upcoming area of interests in seed technology research. Therefore, the nanoparticle treated paddy seeds were also stored under ambient conditions for 6 months and evaluated for various seed quality parameters. The NP treated seeds of paddy variety Pusa Basmati 1509 were stored in the cloth and polyethylene bags and data on quality parameters were recorded quarterly. The results obtained on effect of seed treatments with different NPs, packaging materials and periods of storage under this experiment have been given here.

A. Germination percentage

The germination percentage was found to be significantly affected by the treatments (T), periods of storage and materials in which the treated seeds were packed. The interaction effects between packaging materials (PM) and storage periods (SP), packaging materials (PM) and treatments (T), storage periods (SP) and treatments (T) also significantly affected the percent germination in the storage. Data on effects of different nanoparticle seed treatments, packaging materials and periods of storage on germination percentage of paddy variety Pusa Basmati 1509 has been presented (Table 2).

The germination percentage at initial period (0 month) was found to be significantly higher (85.3%) than the germination percentage after 3 months (70.3%) and 6 months (55.4%) of storage in seeds treated with various nanoparticles. Significantly higher germination percentage after 6 months of storage under ambient conditions was noticed in seeds packed in polyethylene bags (81.1%) than the seeds and packed in cloth bags (70.5%). The mean values of germination percentage in 62 treatments were found to be divided in eight homogeneous subsets based upon the significance (p-0.05). The NP seed treatment, T8 exhibited significantly higher values of germination percentage (86.8%) than untreated control (77.3%) and recommended PoP: control (78.6%), however it was found to be at par with treatments; T9 (86.4%), T10 (85.6%), T11 (84.6%) and T12 (83.8%) after 6 months of storage. In addition to these, NP treatments; T3 (78.2%) recorded significantly higher germination percentage than untreated control. Significantly lower germination percentage was detected in T60 (71.7%), however it was found to be at par with treatments; T31 (72.1%), T62 (72.3%), T21 (72.4%), T43 (72.6%), T44 (73.4%), T39 (73.7%), T47 (73.8%), T38 (73.8%), and T23 (73.8%) after 6 months of storage. In total there were 54 treatments that resulted in significantly lower germination percentage than both the controls. The interactions between PM and SP revealed significantly higher germination percentage in seeds packed in polyethylene bags and stored for 3 months (81.6%) followed by seeds packed in cloth bags and stored for 3 months (70.7%) and similar patterns were revealed after 6 months of storage. However, the interaction effects between packaging materials and storage periods and treatments were found to have non-significant effects on the germination percentage during the storage for 6 months under ambient storage conditions. Amongst all the combinations of treatments, packaging materials and storage periods numerically highest values of germination (94.7%) were witnessed in T8 treated seeds at initial period in which was followed by T9 (92.3%) whereas, numerically lowest values of germination (43.7%) were observed in T60 and T62 at 6-month storage period in cloth bag.

Similar results were supported by Pasquini *et al.* (2012) and concluded that the higher germination percentage in polyethylene bags could be linked to the lower gaseous exchanges and water vapors thereby help in maintaining the metabolic activity at low levels. The deleterious effects of nano particles on germination could be due to the higher doses and specific metal oxides binding to the genomic DNA of germinating seeds. The argument could be supported by the findings in Pennycress (Khalifa, 2018). In view of the above we may deduce that the paddy seeds treated with nanoparticles are therefore recommended to be stored at vacuum or low RH or low temperature condition to ensure good quality of seeds for better crop establishment.

Table 2: Effect of different nanoparticle seed treatments and packaging materials on germination percentage of paddy variety Pusa Basmati 1509 at different periods of storage.

Treatments (Trt)	Packaging material (PM)								G. Mean
	Cloth (1)				Polythene (2)				
	Storage period (SP)			Mean	Storage period (SP)			Mean	
	0m	3m	6m		0m	3m	6 m		
T1	85.0 (67.31)*	74.7 (59.81)	57.0 (49.05)	**72.2 (58.73)**	85.0 (67.31)	82.3 (65.24)	79.7 (63.25)	**82.3 (65.27)**	**77.3 (62.00)**
T2	87.3 (69.25)	71.3 (57.67)	56.0 (48.47)	**71.6 (58.46)**	87.3 (69.25)	86.3 (68.36)	83.0 (65.69)	**85.6 (67.77)**	**78.6 (63.12)**
T3	94.7 (76.77)	80.3 (63.80)	68.3 (55.83)	**81.1 (65.47)**	94.7 (76.77)	92.3 (74.02)	90.3 (71.93)	**92.4 (74.24)**	**86.8 (68.71)**
T4	92.3 (74.11)	82.0 (64.97)	76.3 (60.94)	**83.6 (66.67)**	92.3 (74.11)	89.0 (70.76)	86.3 (68.37)	**89.2 (71.08)**	**86.4 (68.45)**
T5	90.7 (72.32)	84.0 (66.48)	74.0 (59.39)	**82.9 (66.06)**	90.7 (72.32)	88.0 (69.80)	86.3 (68.43)	**88.3 (70.19)**	**85.6 (67.85)**
T6	91.0 (72.83)	83.3 (65.95)	72.7 (58.51)	**82.3 (65.77)**	91.0 (72.83)	86.7 (68.80)	83.0 (65.69)	**86.9 (69.11)**	**84.6 (66.85)**
T7	90.0 (71.66)	81.7 (64.69)	72.0 (58.10)	**81.2 (64.82)**	90.0 (71.66)	86.0 (68.09)	83.0 (65.72)	**86.3 (68.49)**	**83.8 (66.45)**
T8	86.3 (68.36)	74.7 (59.82)	56.0 (48.47)	**72.3 (58.88)**	86.3 (68.36)	83.3 (65.95)	82.7 (65.46)	**84.1 (66.59)**	**78.2 (62.74)**
T9	86.3 (68.36)	72.7 (58.52)	57.7 (49.44)	**72.2 (58.77)**	86.3 (68.36)	81.7 (64.68)	77.3 (61.63)	**81.8 (64.89)**	**77.0 (61.83)**
T10	84.7 (67.01)	72.3 (58.32)	54.3 (47.52)	**70.4 (57.62)**	84.7 (67.01)	76.3 (60.93)	77.3 (61.62)	**79.4 (63.19)**	**74.9 (60.40)**
T11	85.0 (67.25)	74.0 (59.38)	52.0 (46.17)	**70.3 (57.60)**	85.0 (67.25)	81.7 (64.71)	76.0 (60.71)	**80.9 (64.23)**	**75.6 (60.91)**
T12	86.0 (68.14)	76.0 (60.75)	48.3 (44.07)	**70.1 (57.65)**	86.0 (68.14)	85.0 (67.34)	75.0 (60.07)	**82.0 (65.18)**	**76.1 (61.42)**
T13	82.3 (65.19)	73.3 (58.95)	58.0 (49.63)	**71.2 (57.92)**	82.3 (65.19)	81.0 (64.20)	77.7 (61.84)	**80.3 (63.74)**	**75.8 (60.83)**
T14	85.0 (67.40)	68.3 (55.81)	56.0 (48.47)	**69.8 (57.23)**	85.0 (67.40)	81.0 (64.20)	73.0 (58.73)	**79.7 (63.44)**	**74.7 (60.33)**
T15	81.7 (64.69)	75.3 (60.34)	54.3 (47.51)	**70.4 (57.51)**	81.7 (64.69)	80.7 (63.98)	75.3 (60.25)	**79.2 (62.97)**	**74.8 (60.24)**
T16	82.7 (65.44)	75.7 (60.49)	56.3 (48.67)	**71.6 (58.20)**	82.7 (65.44)	82.3 (65.19)	77.3 (61.63)	**80.8 (64.09)**	**76.2 (61.14)**
T17	84.7 (67.00)	69.3 (56.44)	56.0 (48.48)	**70.0 (57.31)**	84.7 (67.00)	84.0 (66.48)	75.0 (60.03)	**81.2 (64.50)**	**75.6 (60.91)**
T18	82.7 (65.46)	70.3 (57.09)	55.7 (48.29)	**69.6 (56.94)**	82.7 (65.46)	83.7 (66.21)	75.0 (60.06)	**80.4 (63.91)**	**75.0 (60.43)**
T19	86.7 (68.63)	74.3 (59.66)	58.0 (49.63)	**73.0 (59.31)**	86.7 (68.63)	82.3 (65.19)	76.0 (60.72)	**81.7 (64.85)**	**(77.3) 62.08**
T20	82.3 (65.19)	73.7 (59.17)	55.0 (47.90)	**70.3 (57.42)**	82.3 (65.19)	79.3 (63.00)	77.0 (61.38)	**79.6 (63.19)**	**74.9 (60.31)**
T21	82.0 (64.97)	68.0 (55.61)	53.0 (46.75)	**67.7 (55.77)**	82.0 (64.97)	77.7 (61.84)	71.7 (57.89)	**77.1 (61.57)**	**72.4 (58.67)**
T22	82.7 (65.46)	72.0 (58.10)	56.7 (48.86)	**70.4 (57.47)**	82.7 (65.46)	82.3 (65.19)	74.3 (59.60)	**79.8 (63.41)**	**75.1 (60.44)**
T23	83.3 (65.98)	69.3 (56.56)	55.7 (48.28)	**69.4 (56.94)**	83.3 (65.98)	83.3 (66.01)	68.0 (55.58)	**78.2 (62.52)**	**73.8 (59.73)**
T24	86.3 (68.39)	67.0 (55.14)	55.7 (48.28)	**69.7 (57.27)**	86.3 (68.39)	83.0 (65.69)	68.0 (55.58)	**79.1 (63.22)**	**74.4 (60.25)**
T25	86.0 (68.07)	70.7 (57.41)	56.0 (48.47)	**70.9 (57.98)**	86.0 (68.07)	77.7 (61.84)	69.7 (56.62)	**77.8 (62.18)**	**74.3 (60.08)**
T26	88.0 (69.84)	64.3 (53.42)	54.0 (47.33)	**68.8 (56.86)**	88.0 (69.84)	80.7 (63.97)	73.3 (58.95)	**80.7 (64.25)**	**74.7 (60.56)**
T27	85.0 (67.28)	70.3 (57.11)	52.7 (46.56)	**69.3 (56.98)**	85.0 (67.28)	78.3 (62.40)	75.7 (60.49)	**79.7 (63.39)**	**74.5 (60.19)**
T28	85.0 (67.31)	66.0 (54.39)	54.0 (47.33)	**68.3 (56.34)**	85.0 (67.31)	79.3 (63.21)	77.7 (61.84)	**80.7 (64.12)**	**74.5 (60.23)**
T29	86.0 (68.09)	69.7 (56.67)	54.0 (47.32)	**69.9 (57.36)**	86.0 (68.09)	79.7 (63.27)	75.0 (60.03)	**80.2 (63.80)**	**75.1 (60.58)**
T30	87.0	72.0	45.3	**68.1**	87.0	75.7	77.0	**79.9**	**74.0**

	(69.07)	(58.28)	(42.34)	**(56.56)**	(69.07)	(60.50)	(61.40)	**(63.65)**	**(60.11)**
T31	82.0 (64.95)	68.0 (55.64)	47.7 (43.68)	**65.9 (54.76)**	82.0 (64.95)	78.7 (62.57)	74.0 (59.39)	**78.2 (62.30)**	**72.1 (58.53)**
T32	83.3 (65.98)	67.3 (55.25)	58.0 (49.63)	**69.6 (56.95)**	83.3 (65.98)	82.3 (65.22)	77.7) (61.84)	**81.1 (64.35)**	**75.3 (60.65)**
T33	88.0 (70.05)	70.3 (57.07)	58.0 (49.63)	**72.1 (58.92)**	88.0 (70.05)	80.7 (63.96)	73.0) (58.73)	**80.6 (64.24)**	**76.3 (61.58)**
T34	84.7 (67.00)	67.0 (55.08)	54.3 (47.52)	**68.7 (56.53)**	84.7 (67.00)	81.0 (64.20)	77.0 (61.40)	**80.9 (64.20)**	**74.8 (60.36)**
T35	86.3 (68.43)	70.3 (57.12)	55.3 (48.09)	**70.7 (57.88)**	86.3 (68.43)	82.7 (65.48)	81.0 (64.30)	**83.3 (66.04)**	**77.0 (61.96)**
T36	86.7 (68.66)	67.3 (55.23)	52.0 (46.17)	**68.7 (56.69)**	86.7 (68.66)	81.7 (64.69)	78.7 (62.56)	**82.3 (65.30)**	**75.5 (60.99)**
T37	82.7 (65.46)	67.7 (55.42)	55.7 (48.28)	**68.7 (56.38)**	82.7 (65.46)	81.0 (64.24)	78.0 (62.08)	**80.6 (63.93)**	**74.6 (60.16)**
T38	81.0 (64.21)	68.7 (56.03)	55.7 (48.28)	**68.4 (56.17)**	81.0 (64.21)	79.7 (63.23)	77.0 (61.38)	**79.2 (62.94)**	**73.8 (59.56)**
T39	83.0 (65.71)	71.7 (57.89)	56.0 (48.47)	**70.2 (57.36)**	83.0 (65.71)	76.0 (60.72)	72.7 (58.52)	**77.2 (61.65)**	**73.7 (59.50)**
T40	86.0 (68.20)	70.0 (56.86)	54.0 (47.33)	**70.0 (57.46)**	86.0 (68.20)	81.7 (64.71)	78.3 (62.33)	**82.0 (65.08)**	**76.0 (61.27)**
T41	84.7 (67.00)	72.7 (58.53)	52.7 (46.56)	**70.0 (57.36)**	84.7 (67.00)	81.3 (64.47)	79.3 (63.00)	**81.8 (64.82)**	**75.9 (61.09)**
T42	85.7 (66.12)	61.3 (51.58)	54.0 (47.33)	**67.0 (55.62)**	85.7 (66.12)	83.0 (65.70)	78.7 (62.54)	**82.4 (65.40)**	**74.7 (60.51)**
T43	80.3 (67.95)	66.3 (54.63)	54.7 (47.70)	**67.1 (55.35)**	80.3 (67.95)	80.0 (63.47)	73.7 (59.18)	**78.0 (62.12)**	**72.6 (58.73)**
T44	82.0 (63.71)	61.0 (51.38)	58.3 (49.82)	**67.1 (55.38)**	82.0 (63.71)	81.3 (64.45)	76.0 (60.72)	**79.8 (63.37)**	**73.4 (59.38)**
T45	83.3 (64.95)	69.3 (56.41)	49.7 (44.84)	**67.4 (55.73)**	83.3 (64.95)	82.3 (65.19)	77.7 (61.85)	**81.1 (64.33)**	**74.3 (60.03)**
T46	85.0 (65.94)	67.7 (55.40)	55.0 (47.90)	**69.2 (56.85)**	85.0 (65.94)	77.0 (61.40)	75.0 (60.03)	**79.0 (62.89)**	**74.1 (59.87)**
T47	82.7 (67.25)	69.0 (56.26)	53.3 (46.94)	**68.3 (56.21)**	82.7 (67.25)	78.7 (62.57)	76.3 (60.97)	**79.2 (62.99)**	**73.8 (59.60)**
T48	87.3 (65.44)	66.3 (54.58)	57.3 (49.24)	**70.3 (57.68)**	87.3 (65.44)	82.3 (65.22)	76.0 (60.72)	**81.9 (65.06)**	**76.1 (61.37)**
T49	86.3 (69.23)	72.3 (58.52)	55.3 (48.09)	**71.3 (58.35)**	86.3 (69.23)	80.7 (63.96)	74.3 (59.61)	**80.4 (64.01)**	**75.9 (61.18)**
T50	88.7 (68.45)	71.3 (57.66)	57.0 (49.05)	**72.3 (59.17)**	88.7 (68.45)	82.3 (65.21)	72.7 (58.53)	**81.2 (64.85)**	**76.8 (62.01)**
T51	89.0 (70.80)	75.3 (60.33)	49.7 (44.84)	**71.3 (58.62)**	89.0 (70.80)	82.3 (65.21)	73.0 (58.75)	**81.4 (64.88)**	**76.4 (61.75)**
T52	82.0 (64.95)	69.3 (56.47)	54.7 (47.71)	**68.7 (56.38)**	82.0 (64.95)	81.7 (64.69)	74.3 (59.60)	**79.3 (63.08)**	**74.0 (59.73)**
T53	86.0 (68.33)	68.7 (56.02)	55.7 (48.29)	**70.1 (57.54)**	86.0 (68.33)	81.7 (64.70)	72.7 (58.51)	**80.1 (63.85)**	**75.1 (60.70)**
T54	83.0 (65.71)	65.3 (53.96)	55.0 (47.90)	**67.8 (55.86)**	83.0 (65.71)	82.0 (64.93)	77.3 (61.62)	**80.8 (64.09)**	**74.3 (59.97)**
T55	85.0 (67.35)	66.7 (54.79)	54.0 (47.33)	**68.6 (56.49)**	85.0 (67.35)	78.0 (62.08)	77.3 (61.62)	**80.1 (63.85)**	**74.3 (60.09)**
T56	88.3 (70.54)	67.7 (55.39)	52.7 (46.56)	**69.6 (57.50)**	88.3 (70.54)	83.3 (65.96)	75.0 (60.03)	**82.2 (65.51)**	**75.9 (61.50)**
T57	85.3 (67.59)	69.0 (56.20)	54.0 (47.33)	**69.4 (57.04)**	85.3 (67.59)	78.7 (62.57)	72.7 (58.51)	**78.9 (62.89)**	**74.2 (59.96)**
T58	82.7 (65.49)	71.3 (57.72)	53.0 (46.75)	**69.0 (56.65)**	82.7 (65.49)	79.7 (63.24)	76.7 (61.16)	**79.7 (63.30)**	**74.3 (59.97)**
T59	85.7 (67.87)	66.0 (54.46)	53.3 (46.94)	**68.3 (56.42)**	85.7 (67.87)	81.7 (64.70)	69.7 (56.62)	**79.0 (63.06)**	**73.7 (59.74)**
T60	82.7 (65.46)	68.0 (55.73)	43.7 (41.38)	**64.8 (54.19)**	82.7 (65.46)	82.0 (64.95)	71.3 (57.66)	**78.7 (62.69)**	**71.7 (58.44)**
T61	88.0 (69.81)	70.7 (57.34)	48.0 (43.88)	**68.9 (57.01)**	88.0 (69.81)	83.0 (65.69)	77.3 (61.62)	**82.8 (65.71)**	**75.8 (61.36)**
T62	84.7 (67.24)	63.3 (52.76)	43.7 (41.38)	**63.9 (53.80)**	84.7 (67.24)	82.7 (65.49)	75.0 (60.03)	**80.8 (64.25)**	**72.3 (59.02)**
Mean	**85.3 (67.59)**	**70.7 (57.40)**	**55.5 (48.24)**	**70.5 (57.78)**	**85.3 (67.59)**	**81.6 (65.1)**	**76.4 (61.07)**	**81.1 (64.51)**	**75.8 (61.15)**
CD (p= 0.05)	**PM= 0.27; SP= 0.33; Trt= 1.52; PM×SP= 0.47; PM×Trt= 2.15; SP×Trt= 2.63; PM×SP×Trt= NS.**								

*Figures in parentheses are square root transformed values

B. Abnormal seedlings (%)

The abnormal seedlings percentage was found to be significantly affected by the treatments (T) and periods of storage. The interaction effects between packaging materials (PM) and storage periods (SP) also significantly affected the percent abnormal seedlings in the storage. Data on effects of different nanoparticle seed treatments, packaging materials and periods of storage on abnormal seedlings percentage of paddy variety Pusa Basmati 1509 has been presented (Table 3).

Table 3: Effect of different nanoparticle seed treatments and packaging materials on abnormal seedling percentage of paddy variety Pusa Basmati 1509 at different periods of storage.

Treatments (Trt)	Packaging material (PM)								G. Mean
	Cloth (1)				Polythene (2)				
	Storage period (SP)			Mean	Storage period (SP)			Mean	
	0 m	3m	6m		0m	3m	6m		
T1	3.67	5.33	9.00	**6.00**	3.67	4.67	6.00	**4.78**	**5.39**
T2	4.67	5.00	9.00	**6.22**	4.67	6.33	7.33	**6.11**	**6.17**
T3	2.33	6.67	10.00	**6.33**	2.33	5.67	7.00	**5.00**	**5.67**
T4	3.00	5.00	15.00	**7.67**	3.00	2.33	4.33	**3.22**	**5.44**
T5	2.33	5.33	15.33	**7.67**	2.33	7.00	8.00	**5.78**	**6.72**
T6	5.00	7.67	11.67	**8.11**	5.00	5.33	8.67	**6.33**	**7.22**
T7	3.33	5.67	9.67	**6.22**	3.33	6.33	7.00	**5.56**	**5.89**
T8	4.00	6.67	11.00	**7.22**	4.00	4.67	6.67	**5.11**	**6.17**
T9	4.33	7.00	15.00	**8.78**	4.33	4.33	6.33	**5.00**	**6.89**
T10	6.67	9.33	8.00	**8.00**	6.67	3.67	5.33	**5.22**	**6.61**
T11	6.67	7.33	6.67	**6.89**	6.67	8.00	9.33	**8.00**	**7.44**
T12	4.00	7.33	6.33	**5.89**	4.00	6.67	8.67	**6.44**	**6.17**
T13	10.33	4.33	11.33	**8.67**	10.33	6.00	8.00	**8.11**	**8.39**
T14	8.67	6.33	11.67	**8.89**	8.67	6.33	8.67	**7.89**	**8.39**
T15	9.67	7.67	9.67	**9.00**	9.67	4.33	6.33	**6.78**	**7.89**
T16	7.00	6.00	8.00	**7.00**	7.00	5.00	6.67	**6.22**	**6.61**
T17	7.67	7.00	7.67	**7.44**	7.67	8.33	9.00	**8.33**	**7.89**
T18	10.00	6.67	7.67	**8.11**	10.00	6.33	9.67	**8.67**	**8.39**
T19	7.67	8.00	9.00	**8.22**	7.67	3.00	5.67	**5.44**	**6.83**
T20	11.67	4.00	8.33	**8.00**	11.67	5.00	7.67	**8.11**	**8.06**
T21	8.67	5.67	9.33	**7.89**	8.67	4.33	6.67	**6.56**	**7.22**
T22	7.00	4.67	10.67	**7.44**	7.00	4.33	7.33	**6.22**	**6.83**
T23	6.67	8.33	7.67	**7.56**	6.67	6.67	6.67	**6.67**	**7.11**
T24	3.67	6.33	7.67	**5.89**	3.67	3.67	5.33	**4.22**	**5.06**
T25	5.33	6.00	10.67	**7.33**	5.33	5.33	7.67	**6.11**	**6.72**
T26	5.67	4.67	11.33	**7.22**	5.67	5.67	8.00	**6.44**	**6.83**
T27	6.00	9.67	13.33	**9.67**	6.00	6.00	5.67	**5.89**	**7.78**
T28	4.67	7.33	10.33	**7.44**	4.67	5.00	8.33	**6.00**	**6.72**
T29	4.33	5.33	14.00	**7.89**	4.33	5.00	8.00	**5.78**	**6.83**
T30	3.67	3.33	7.33	**4.78**	3.67	8.00	8.33	**6.67**	**5.72**
T31	8.00	6.67	9.67	**8.11**	8.00	6.33	8.00	**7.44**	**7.78**
T32	6.67	6.67	8.00	**7.11**	6.67	7.00	8.33	**7.33**	**7.22**
T33	5.00	4.67	7.67	**5.78**	5.00	7.33	9.33	**7.22**	**6.50**
T34	3.00	4.33	7.67	**5.00**	3.00	5.33	5.67	**4.67**	**4.83**
T35	5.00	3.67	7.00	**5.22**	5.00	3.33	7.67	**5.33**	**5.28**
T36	4.33	8.00	8.00	**6.78**	4.33	6.67	6.00	**5.67**	**6.22**
T37	4.33	6.67	7.67	**6.22**	4.33	6.67	10.67	**7.22**	**6.72**
T38	10.33	6.33	8.67	**8.44**	10.33	8.33	9.67	**9.44**	**8.94**
T39	6.33	3.00	7.67	**5.67**	6.33	6.33	8.33	**7.00**	**6.33**
T40	6.67	5.00	7.67	**6.44**	6.67	7.33	9.67	**7.89**	**7.17**
T41	7.00	4.33	9.00	**6.78**	7.00	4.67	7.00	**6.22**	**6.50**
T42	9.33	4.33	10.00	**7.89**	9.33	9.67	10.00	**9.67**	**8.78**
T43	8.33	6.67	9.33	**8.11**	8.33	6.67	9.33	**8.11**	**8.11**
T44	6.33	3.67	8.33	**6.11**	6.33	8.00	10.67	**8.33**	**7.22**
T45	7.33	5.33	7.67	**6.78**	7.33	4.00	8.00	**6.44**	**6.61**
T46	4.67	5.67	8.67	**6.33**	4.67	5.67	9.00	**6.44**	**6.39**
T47	10.67	6.00	8.00	**8.22**	10.67	4.67	9.00	**8.11**	**8.17**
T48	4.67	5.00	7.67	**5.78**	4.67	6.33	8.33	**6.44**	**6.11**
T49	6.33	5.00	8.00	**6.44**	6.33	7.00	9.00	**7.44**	**6.94**
T50	4.67	8.00	7.67	**6.78**	4.67	7.67	9.67	**7.33**	**7.06**
T51	2.33	6.33	9.67	**6.11**	2.33	6.00	9.67	**6.00**	**6.06**
T52	9.33	7.00	8.33	**8.22**	9.33	7.33	9.00	**8.56**	**8.39**
T53	5.33	6.00	8.00	**6.44**	5.33	6.67	9.00	**7.00**	**6.72**
T54	6.33	6.33	7.67	**6.78**	6.33	7.00	8.33	**7.22**	**7.00**
T55	6.67	4.33	6.67	**5.89**	6.67	9.33	10.00	**8.67**	**7.28**
T56	4.00	5.00	8.00	**5.67**	4.00	7.33	9.67	**7.00**	**6.33**
T57	3.67	8.33	7.67	**6.56**	3.67	7.33	9.00	**6.67**	**6.61**
T58	6.00	4.67	7.67	**6.11**	6.00	6.67	10.00	**7.56**	**6.83**
T59	6.33	6.33	8.67	**7.11**	6.33	5.00	8.33	**6.56**	**6.83**
T60	9.67	5.67	7.67	**7.67**	9.67	5.33	8.33	**7.78**	**7.72**
T61	5.00	2.33	7.67	**5.00**	5.00	8.67	9.33	**7.67**	**6.33**
T62	6.00	7.00	7.33	**6.78**	6.00	6.33	8.67	**7.00**	**6.89**
Mean	**6.10**	**5.94**	**9.05**	**7.03**	**6.10**	**6.05**	**8.08**	**6.74**	**6.89**
CD (p=0.05)	**PM= NS; SP= 0.42; Trt= 1.89; PM×SP= NS; PM×Trt= 2.67; SP×Trt= 3.27; PM×SP×Trt= NS.**								

*Figures in parentheses are square root transformed values

The abnormal seedling percentage at initial period (0 month) was found to be significantly (6.10%) than the abnormal seedlings percentage after 3 months (5.94%) and highest in 6 months (9.05%) of storage in seeds treated with various nanoparticles. Significantly lower abnormal seedlings percentage after 6 months of storage under ambient conditions was noticed in seeds packed in polyethylene bags (6.74%) than the seeds and packed in cloth bags (7.03%). The mean values of abnormal seedlings percentage in 62 treatments were found to be divided in six homogeneous subsets based upon the significance (p=0.05). The NP seed treatment, T34 exhibited significantly lower values of abnormal seedlings percentage (4.83%) than untreated control (5.39%) and recommended PoP: control (6.17%), however it was found to be at par with treatments; T24 (5.06%), T35 (5.39%), T1 (5.39%), T9 (5.44%), T8 (5.67%), T30 (5.72%), T12 (5.89%), T51 (6.06%), T48 (6.11%) , T7(6.17%), T3 (6.17%) and T2 (6.17%), T36 (6.22%), T39 (6.33%), T56 (6.33%), T61 (6.33%) and T46 (6.39%) after 6 months of storage. In addition to these, NP treatments; T38 (8.94%) recorded significantly higher abnormal seedlings percentage than untreated control however it was found to be at par with treatments; T42 (8.78%), T25 (8.39%), T13 (8.39%), T14 (8.39%), T18 (8.39%), T52 (8.39%), T47 (8.17%), T43 (8.11%) and T20 (8.06%) after 6 months of storage. In total there were 58 treatments that resulted in significantly higher abnormal seedlings percentage than both the controls. The interactions between PM and SP revealed significantly higher abnormal seedlings percentage in seeds packed in polyethylene bags and stored for 3 months (6.05%) followed by seeds packed in cloth bags and stored for 3 months (5.94%) and similar patterns were revealed after 6 months of storage. However, the interaction effects between packaging materials and storage periods and treatments were found to have non-significant effects on the abnormal seedlings percentage during the storage for 6 months under ambient storage conditions. Amongst all the combinations of treatments, packaging materials and storage periods numerically highest values of abnormal seedlings (15.33%) were witnessed in T10 treated seeds at 6-month storage period in cloth bag which was followed by T4 (15.00%) whereas, numerically lowest values of abnormal seedlings (2.33%) were observed in T4, T51 at 3 months of storage in cloth and polythene bag.

Similar finding were supported and reported that when ambient relative humidity and temperature changed, the seed moisture content fluctuated. Moisture content of seed increased as the storage period progressed and increased the fungal activity will consequence of higher abnormal seedling percentage and dead seed. Gradual degradation of the seed is caused by ageing, resulting to fatal damage and inability to germinate the similar findings was reported by (Bouteau *et al.,* 2011). Seed ageing associated with various alterations in macro and micro molecular structures result in decreased energy metabolism, impairment of RNA and protein synthesis and DNA degradation as reported by Kibinza *et al.* (2006).

C. Dead seeds (%)

The dead seeds percentage was found to be significantly affected by the periods of storage and materials in which the treated seeds were packed and not significantly affected by treatments (T). The interaction effects between packaging materials (PM) and storage periods (SP) also significantly affected the percent dead seeds in the storage. Data on effects of different nanoparticle seed treatments, packaging materials and periods of storage on dead seeds percentage of paddy variety Pusa Basmati 1509 has been presented (Table 4).

The dead seeds percentage at initial period (0 month) was found to be significantly lower (3.83%) than the dead seeds percentage after 3 month (4.22%) and 6 months (7.13%) of storage in seeds treated with various nanoparticles. Significantly lower dead seeds percentage after 6 month of storage under ambient conditions was noticed in seeds packed in polyethylene bags (4.06%) than the seeds and packed in cloth bags (5.06 %). The mean values of dead seeds percentage in 62 treatments were found to be divided in one homogeneous subset based upon the significance (p=0.05). The NP seed treatment, T18 exhibited significantly lower values of dead seeds percentage (3.39%) than untreated control (4.78%) and recommended PoP: control (5.28%), however it was found to be at par with treatments; T8 (3.44%), T5 (3.50%), T19 (3.61%), T20 (3.72%), T30 (3.72%), T22 (3.78%), T13 (3.78%), T33 (3.83%), T60 (3.83), T17 (3.89%), T47 (3.94%) and T11 (3.94%) after 6 months of storage. Significantly higher dead seeds percentage was detected in T23 (5.89%), however it was found to be at par with treatments; T10 (5.78%), T12 (5.72%), T61 (5.67%), T25 (5.61%), T39 (5.33%), T9 (5.33%), T40 (5.28%) after 6 months of storage. In total there were twenty treatments that resulted in significantly higher dead seeds percentage than both the controls. The interactions between PM and SP revealed significantly lower dead seeds percentage in seeds packed in cloth bag and stored for 3 months (4.22%) followed by seeds packed in polythene bags and stored for 3 months (7.13%) and opposite patterns were revealed after 6 months of storage. However, the interaction effects between packaging materials and treatments, packaging materials and storage periods and treatments were found to have non-significant effects on the dead seeds percentage during the storage for 6 months under ambient storage conditions. Amongst all the combinations of treatments, packaging materials and storage periods numerically lowest values of dead seeds (0.67%) were witnessed in T8 treated seeds at initial period which was followed by T18 (0.67%), T19(0.67%) and T20(0.67%) whereas, numerically highest values of dead seeds percentage (15.67%) was observed in T9 at 6 month of storage in cloth bag.

Kibinza *et al.,* (2006) reported and examined that when ambient relative humidity and temperature changed, the seed moisture content fluctuated. Moisture content of seed increased as the storage period progressed and increased the fungal activity will consequence of higher abnormal seedling percentage and dead seed. Seed ageing associated with various alterations in macro and micro molecular structures resulting in decreased energy metabolism, impairment of RNA and protein synthesis and DNA degradation.

Table 4: Effect of different nanoparticle seed treatments and packaging materials on dead seed percentage of paddy variety Pusa Basmati 1509 at different periods of storage.

Treatments (Trt)	Packaging material (PM)								G. Mean
	Cloth (1)				Polythene (2)				
	Storage period (SP)			Mean	Storage period (SP)			Mean	
	0 m	3 m	6 m		0 m	3 m	6 m		
T1	5.67	4.67	6.33	**5.56**	5.67	3.33	3.00	**4.00**	**4.78**
T2	4.00	6.33	6.00	**5.44**	4.00	4.67	6.67	**5.11**	**5.28**
T3	0.67	4.33	10.67	**5.22**	0.67	1.33	3.00	**1.67**	**3.44**
T4	2.00	2.33	15.67	**6.67**	2.00	5.67	4.33	**4.00**	**5.33**
T5	2.67	6.33	14.00	**7.67**	2.67	4.67	4.33	**3.89**	**5.78**
T6	1.00	3.67	12.33	**5.67**	1.00	4.67	4.33	**3.33**	**4.50**
T7	3.33	5.00	14.00	**7.44**	3.33	6.33	2.33	**4.00**	**5.72**
T8	4.67	4.00	6.00	**4.89**	4.67	4.67	3.00	**4.11**	**4.50**
T9	3.67	4.00	5.00	**4.22**	3.67	5.00	3.33	**4.00**	**4.11**
T10	2.33	4.00	5.33	**3.89**	2.33	3.33	3.67	**3.11**	**3.50**
T11	3.67	3.33	5.67	**4.22**	3.67	3.67	3.67	**3.67**	**3.94**
T12	3.67	1.67	8.00	**4.44**	3.67	4.67	3.33	**3.89**	**4.17**
T13	2.33	5.00	5.67	**4.33**	2.33	4.67	2.67	**3.22**	**3.78**
T14	3.00	4.33	7.33	**4.89**	3.00	4.00	5.67	**4.22**	**4.56**
T15	5.00	3.00	6.67	**4.89**	5.00	3.67	5.00	**4.56**	**4.72**
T16	4.33	5.33	7.00	**5.56**	4.33	6.33	2.67	**4.44**	**5.00**
T17	3.00	3.33	5.67	**4.00**	3.00	4.33	4.00	**3.78**	**3.89**
T18	0.67	2.33	7.67	**3.56**	0.67	2.33	6.67	**3.22**	**3.39**
T19	0.67	3.67	6.33	**3.56**	0.67	6.33	4.00	**3.67**	**3.61**
T20	.67	3.67	7.67	**4.00**	0.67	5.33	4.33	**3.44**	**3.72**
T21	3.33	5.33	6.67	**5.11**	3.33	4.00	5.00	**4.11**	**4.61**
T22	2.00	3.00	5.33	**3.44**	2.00	5.33	5.00	**4.11**	**3.78**
T23	5.67	5.00	7.67	**6.11**	5.67	5.67	5.67	**5.67**	**5.89**
T24	6.00	4.67	4.67	**5.11**	6.00	6.00	3.67	**5.22**	**5.17**
T25	5.67	5.67	5.33	**5.56**	5.67	5.67	5.67	**5.67**	**5.61**
T26	3.33	6.00	6.33	**5.22**	3.33	3.33	5.67	**4.11**	**4.67**
T27	3.67	3.00	8.00	**4.89**	3.67	3.67	6.00	**4.44**	**4.67**
T28	4.67	4.00	6.00	**4.89**	4.67	4.00	3.33	**4.00**	**4.44**
T29	5.00	3.33	5.00	**4.44**	5.00	2.67	3.33	**3.67**	**4.06**
T30	2.67	4.33	5.00	**4.00**	2.67	4.33	3.33	**3.44**	**3.72**
T31	3.67	4.33	8.00	**5.33**	3.67	3.67	2.67	**3.33**	**4.33**
T32	4.67	4.67	7.00	**5.44**	4.67	1.33	3.67	**3.22**	**4.33**
T33	2.33	4.67	5.00	**4.00**	2.33	4.00	4.67	**3.67**	**3.83**
T34	6.33	5.00	7.00	**6.11**	6.33	3.33	2.00	**3.89**	**5.00**
T35	4.00	3.33	8.33	**5.22**	4.00	4.33	3.33	**3.89**	**4.56**
T36	4.00	3.67	7.00	**4.89**	4.00	4.33	3.67	**4.00**	**4.44**
T37	5.33	4.67	5.00	**5.00**	5.33	4.67	4.33	**4.78**	**4.89**
T38	4.67	2.33	7.00	**4.67**	4.67	5.00	4.67	**4.78**	**4.72**
T39	5.00	6.33	7.00	**6.11**	5.00	4.67	4.00	**4.56**	**5.33**
T40	4.00	5.33	7.00	**5.44**	4.00	5.67	5.67	**5.11**	**5.28**
T41	4.00	4.00	8.00	**5.33**	4.00	6.00	4.33	**4.78**	**5.06**
T42	4.00	5.33	6.67	**5.33**	4.00	3.00	6.33	**4.44**	**4.89**
T43	5.00	5.67	6.67	**5.78**	5.00	2.33	5.33	**4.22**	**5.00**
T44	4.67	6.00	5.67	**5.44**	4.67	3.67	2.33	**3.56**	**4.50**
T45	5.67	5.67	6.67	**6.00**	5.67	3.67	3.33	**4.22**	**5.11**
T46	6.00	3.33	6.67	**5.33**	6.00	5.33	3.33	**4.89**	**5.11**
T47	3.67	3.67	5.67	**4.33**	3.67	3.00	4.00	**3.56**	**3.94**
T48	3.33	4.00	8.33	**5.22**	3.33	5.00	5.33	**4.56**	**4.89**
T49	4.00	2.67	7.00	**4.56**	4.00	4.33	4.00	**4.11**	**4.33**
T50	3.67	4.33	6.00	**4.67**	3.67	3.00	4.00	**3.56**	**4.11**
T51	4.67	3.67	7.33	**5.22**	4.67	7.33	3.67	**5.22**	**5.22**
T52	4.33	1.33	8.00	**4.56**	4.33	3.33	5.33	**4.33**	**4.44**
T53	4.67	4.67	5.00	**4.78**	4.67	4.00	5.00	**4.56**	**4.67**
T54	6.33	4.00	7.00	**5.78**	6.33	4.00	3.67	**4.67**	**5.22**
T55	4.33	3.67	8.33	**5.44**	4.33	4.00	4.67	**4.33**	**4.89**
T56	1.67	6.33	7.33	**5.11**	1.67	3.33	5.00	**3.33**	**4.22**
T57	2.67	4.33	7.00	**4.67**	2.67	1.67	1.33	**1.89**	**3.28**
T58	4.67	3.33	7.00	**5.00**	4.67	4.33	3.67	**4.22**	**4.61**
T59	4.00	4.67	6.00	**4.89**	4.00	2.33	3.33	**3.22**	**4.06**
T60	3.00	1.33	7.33	**3.89**	3.00	5.67	2.67	**3.78**	**3.83**
T61	6.33	5.67	7.00	**6.33**	6.33	3.67	5.00	**5.00**	**5.67**
T62	4.00	4.67	6.00	**4.89**	4.00	5.00	3.33	**4.11**	**4.50**
Mean	**3.83**	**4.22**	**7.13**	**5.06**	**3.83**	**4.24**	**4.10**	**4.06**	**4.56**
CD (p= 0.05)	PM= 0.42; SP= 0.51; Trt= NS; PM×SP= 0.72; PM×Trt= NS; SP×Trt= 3.29; PM×SP×Trt= NS.								

*Figures in parentheses are square root transformed values

D. Seedling vigour index I

The seedling vigour index I was found to be significantly affected by the treatments (T), periods of storage and materials in which the treated seeds were packed. The interaction effects between packaging materials (PM) and storage periods (SP), packaging materials (PM) and treatments (T), storage periods (SP) and treatments (T) also significantly affected seedling vigour index I in the storage. Data on effects of different nanoparticle seed treatments, packaging materials and periods of storage on seedling vigour index I of paddy variety Pusa Basmati 1509 has been presented (Table 5).

The seedling vigour index I at initial period (0 month) was found to be significantly higher (2710) than the seedling vigour index I after 3 months (2029) and 6 months (1356) of storage in seeds treated with various nanoparticles. Significantly higher seedling vigour index I after 6 month of storage under ambient conditions was noticed in seeds packed in polyethylene bags (2404) than the seeds and packed in cloth bags (2032). The mean values of seedling vigour index I in 62 treatments were found to be divided in sixteen homogeneous subsets based upon the significance (p=0.05). The NP seed treatment, T10 exhibited significantly higher values of seedling vigour index I (5306) than untreated control (2269) and recommended PoP: control (2459), however it was found to be at par with treatments; T9 (5146), T12 (4383), T11 (4143) and T8 (4119) after 6 months of storage. Significantly lower seedling vigour index I was detected in T25 (1202), however it was found to be at par with treatments; T27 (1214), T28 (1224), T24 (1266), T23 (1268), T29 (1314), T31 (1355) and T13 (1376) after 6 month of storage. In total there were 49 treatments that resulted in significantly lower seedling vigour index I than both the controls. The interactions between PM and SP revealed significantly higher seedling vigour index I in seeds packed in polyethylene bags and stored for 3 months (2383) followed by seeds packed in cloth bags and stored for 3 months (2029) and similar patterns were revealed after 6 months of storage. However, the interaction effects between packaging materials and storage periods and treatments were found to have non-significant effects on the seedling vigour index I during the storage for 6 months under ambient storage conditions. Amongst all the combinations of treatments, packaging materials and storage periods numerically highest values of seedling vigour index I (6130) were witnessed in T5 treated seeds at initial period in which was followed by T4 (5881) whereas, numerically lowest values of seedling vigour index I (807) were observed in T30 at 6-month storage period in cloth bag.

Similar results were reported and find that, when ambient relative humidity and temperature changed, the seed moisture content fluctuated. Moisture content of seed increased as the storage period progressed. When seeds are kept in a moisture pervious bag (cloth bag) compared to a moisture imperviouse bag (polyethene bag) the seeds may lose or acquire moisture depending on the ambient conditions and metabolic release of water during respiration. The difference of moisture content was significantly higher in uncoated seeds compated to NP coated seeds. This may be due to the NPs function as physical barrier, which is preventing the flow of water vapour in and out of the NP treated seeds and hence, reduced the moisture fluctuation during the storage. Similar observation was observed by Chandravathi (2008) in pearl millet and Hanegave (2009) in maize.

Table 5: Effect of different nanoparticle seed treatments and packaging materials on seedling vigour index I of paddy variety Pusa Basmati 1509 at different periods of storage.

Treatments (Trt)	Packaging material (PM)								G. Mean
	Cloth (1)				Polythene (2)				
	Storage period (SP)			Mean	Storage period (SP)			Mean	
	0 m	3 m	6 m		0 m	3 m	6 m		
T1	2671	2029	1456	**2052**	2671	2455	2334	**2487**	**2269**
T2	2859	2200	1662	**2240**	2859	2659	2514	**2677**	**2459**
T3	4891	3402	2478	**3590**	4891	4597	4452	**4647**	**4119**
T4	5881	4464	3398	**4581**	5881	5674	5575	**5710**	**5146**
T5	6130	4596	3455	**4727**	6130	5822	5705	**5886**	**5306**
T6	4752	3616	2889	**3752**	4752	4524	4324	**4533**	**4143**
T7	5076	3957	2812	**3948**	5076	4814	4566	**4819**	**4383**
T8	2864	2148	1489	**2167**	2864	2613	2420	**2632**	**2400**
T9	3185	2131	1433	**2250**	3185	2968	2765	**2973**	**2611**
T10	3251	2299	1343	**2298**	3251	2964	2720	**2978**	**2638**
T11	2960	2148	1285	**2131**	2960	2732	2536	**2743**	**2437**
T12	1765	1470	1074	**1436**	1765	1579	1431	**1592**	**1514**
T13	1682	1239	961	**1294**	1682	1406	1284	**1457**	**1376**
T14	1714	1295	1022	**1344**	1714	1507	1357	**1526**	**1435**
T15	1751	1201	960	**1304**	1751	1575	1327	**1551**	**1428**
T16	1726	1224	968	**1306**	1726	1373	1119	**1406**	**1356**
T17	1796	1233	991	**1340**	1796	1551	1327	**1558**	**1449**
T18	1839	1265	1009	**1371**	1839	1601	1313	**1584**	**1478**
T19	1729	1259	1010	**1333**	1729	1467	1223	**1473**	**1403**
T20	1747	1438	884	**1356**	1747	1445	1283	**1491**	**1424**
T21	1811	1371	1038	**1407**	1811	1490	1232	**1511**	**1459**
T22	1870	1266	916	**1351**	1870	1575	1305	**1583**	**1467**
T23	1599	1181	941	**1240**	1599	1214	1074	**1296**	**1268**

T24	1514	1190	972	**1225**	1514	1301	1104	**1306**	**1266**
T25	1459	1127	934	**1173**	1459	1173	1058	**1230**	**1202**
T26	1605	1171	881	**1219**	1605	1280	2121	**1669**	**1444**
T27	1531	1144	867	**1181**	1531	1167	1044	**1247**	**1214**
T28	1531	1130	844	**1168**	1531	1221	1090	**1281**	**1224**
T29	1662	1144	867	**1224**	1662	1390	1160	**1404**	**1314**
T30	2023	1407	807	**1412**	2023	1531	1310	**1621**	**1517**
T31	1689	1281	838	**1269**	1689	1469	1165	**1441**	**1355**
T32	2906	2109	1110	**2041**	2906	2498	2091	**2498**	**2270**
T33	2693	2061	1216	**1990**	2693	2356	1979	**2343**	**2166**
T34	2593	1856	1177	**1875**	2593	2231	1808	**2211**	**2043**
T35	2428	2879	1848	**2385**	2428	1989	1643	**2020**	**2203**
T36	2873	2118	1301	**2097**	2873	2579	2307	**2586**	**2342**
T37	2457	1882	1166	**1835**	2457	2115	1940	**2171**	**2003**
T38	2345	1816	1216	**1792**	2345	1888	1709	**1980**	**1886**
T39	2600	1985	1322	**1969**	2600	2127	1882	**2203**	**2086**
T40	2755	2061	1339	**2052**	2755	2556	2138	**2483**	**2267**
T41	2892	2171	1415	**2159**	2892	2648	2270	**2603**	**2381**
T42	2963	2122	1340	**2142**	2963	2521	2036	**2507**	**2324**
T43	2406	1898	1134	**1813**	2406	2104	1767	**2092**	**1953**
T44	2634	2421	1579	**2211**	2634	2272	1839	**2248**	**2230**
T45	2808	2143	1310	**2087**	2808	2307	1904	**2340**	**2213**
T46	3057	2176	1172	**2135**	3057	2651	2168	**2625**	**2380**
T47	2917	2214	1291	**2141**	2917	2501	1971	**2463**	**2302**
T48	2970	2165	1385	**2173**	2970	2601	2186	**2586**	**2380**
T49	3453	2372	1450	**2425**	3453	2965	2504	**2974**	**2700**
T50	3309	2475	1509	**2431**	3309	2995	2520	**2942**	**2686**
T51	3858	2980	2012	**2950**	3858	3416	2944	**3406**	**3178**
T52	2881	2151	1234	**2089**	2881	2387	2106	**2458**	**2273**
T53	3062	2297	1467	**2275**	3062	2733	2390	**2728**	**2502**
T54	3063	2264	1337	**2222**	3063	2734	2473	**2757**	**2489**
T55	2908	2141	1263	**2104**	2908	2422	2037	**2456**	**2280**
T56	2913	2006	1224	**2047**	2913	2420	2125	**2486**	**2267**
T57	2790	2095	1269	**2051**	2790	2298	1875	**2321**	**2186**
T58	2888	2186	1319	**2131**	2888	2636	2185	**2570**	**2350**
T59	3048	2164	1350	**2187**	3048	2829	2670	**2849**	**2518**
T60	2836	2052	1188	**2025**	2836	2430	2028	**2431**	**2228**
T61	3371	2451	1431	**2418**	3371	2987	2615	**2991**	**2704**
T62	2783	2045	1231	**2020**	2783	2431	2005	**2406**	**2213**
Mean	**2710**	**2029**	**1356**	**2032**	**2710**	**2383**	**2119**	**2404**	**2218**
CD (p=0.05)	**PM= 36.08; SP= 44.19; Trt= 200.89; PM×SP= 62.49; PM×Trt= 284.11; SP×Trt= 347.96; PM×SP×Trt= NS.**								

*Figures in parentheses are square root transformed values

E. Seedling vigour index II

The seedling vigour index II was found to be significantly affected by the treatments (T), periods of storage and materials in which the treated seeds were packed. The interaction effects between packaging materials (PM) and storage periods (SP), packaging materials (PM) and treatments (T), storage periods (SP) and treatments (T) also significantly affected seedling vigour index II in the storage. Data on effects of different nanoparticle seed treatments, packaging materials and periods of storage on seedling vigour index II of paddy variety Pusa Basmati 1509 has been presented (Table 6).

The seedling vigour index II at initial period (0 month) was found to be significantly higher (11.30) than the seedling vigour index II after 3 months (9.15) and 6 months (7.42) of storage in seeds treated with various nanoparticles. Significantly higher seedling vigour index II after 6 months of storage under ambient conditions was noticed in seeds packed in polyethylene bags (9.94) than the seeds and packed in cloth bags (9.29). The mean values of seedling vigour index II in 62 treatments were found to be divided in twenty-five homogeneous subsets based upon the significance (p=0.05). The NP seed treatment, T12 exhibited significantly higher values of seedling vigour index 2 (18.75) than untreated control (8.16) and recommended PoP: control (8.34), however it was found to be at par with treatments; T11 (18.34), T5 (18.05), T10 (15.62) and T8 (14.28) after 6 months of storage. Significantly lower seedling vigour index II was detected in T58 (6.61), however it was found to be at par with treatments; T43 (6.62), T62 (7.22), T54 (7.43), T44 (7.58), T52 (7.62), T61 (7.66), T60 (7.70) and T59 (7.89) after 6 months of storage. In total there were eleven treatments that resulted in significantly lower seedling vigour index II than both the controls. The interactions between PM and SP revealed significantly higher seedling vigour index II in seeds packed in polyethylene bags and stored for 3 months (9.77) followed by seeds packed in cloth bags and stored for 3 months (9.15) and similar patterns were revealed after 6 month of storage. However, the interaction effects between packaging materials and storage periods and treatments were found to have significant effects on the seedling vigour index II during the storage for 6 months under ambient storage conditions. Amongst all the combinations of treatments, packaging materials and storage periods numerically highest values of seedling vigour index II (23.42) were witnessed in T12 treated seeds at initial period in which was followed by T11 (22.92) whereas, numerically lowest values of seedling vigour index II (5.52) were observed in T62 at 6 month storage period in cloth bag.

Present finding were supported by Tamil Kumar *et al.,* 2016 concluded that in fresh seeds of tomato among the various concentration of ZnO tested both the 600mg and 800mg concentration recorded the highest vigour index. (1986) was observed in 600 mg followed by 800 mg over control. The accumulation of free radicals may be responsible for the reduction in seed vigour. Hong *et al.* (2005) reported that when seeds are pretreated before planting, the consequences of ageing are greatly reduced (Ramamoorthy and Basu, 1984). Nanoparticulate formulations have significant potential as improved characteristics with high specificity and better functionality. When aged seeds are exposed to nanoparticles, they can be activated to eliminate ROS by activating SOD, CAT, APX, and GPX, as well as other antioxidant enzymes.

Table 6: Effect of different nanoparticle seed treatments and packaging materials on seedling vigour index II of paddy variety Pusa Basmati 1509 at different periods of storage.

Treatments (Trt)	Packaging material (PM)								G. Mean
	Cloth (1)				Polythene (2)				
	Storage period (SP)			Mean	Storage period (SP)			Mean	
	0 m	3 m	6 m		0 m	3 m	6 m		
T1	9.62	8.30	6.31	**8.08**	9.62	8.24	6.85	**8.24**	**8.16**
T2	9.39	8.41	7.21	**8.34**	9.39	7.94	7.68	**8.34**	**8.34**
T3	17.55	12.36	10.05	**13.32**	17.55	15.07	13.09	**15.24**	**14.28**
T4	19.11	12.92	11.11	**14.38**	19.11	16.98	14.47	**16.85**	**15.62**
T5	22.32	15.00	11.86	**16.39**	22.32	19.66	17.16	**19.71**	**18.05**
T6	22.92	14.78	11.15	**16.28**	22.92	20.01	18.25	**20.39**	**18.34**
T7	23.42	14.79	10.47	**16.23**	23.42	21.48	18.94	**21.28**	**18.75**
T8	12.59	8.84	6.37	**9.27**	12.59	10.16	8.98	**10.58**	**9.92**
T9	10.80	8.65	6.97	**8.81**	10.80	9.55	7.94	**9.43**	**9.12**
T10	12.62	8.70	7.24	**9.52**	12.62	10.08	8.57	**10.42**	**9.97**
T11	12.95	9.48	6.90	**9.78**	12.95	10.90	10.42	**11.43**	**10.60**
T12	10.20	8.66	7.25	**8.70**	10.20	8.58	7.73	**8.84**	**8.77**
T13	11.16	8.27	6.56	**8.66**	11.16	9.98	8.77	**9.97**	**9.32**
T14	11.39	8.97	6.35	**8.90**	11.39	10.04	8.89	**10.11**	**9.51**
T15	11.12	8.25	6.99	**8.79**	11.12	10.12	9.42	**10.22**	**9.50**
T16	11.26	7.56	5.93	**8.25**	11.26	10.18	9.65	**10.37**	**9.31**
T17	11.29	8.69	6.54	**8.84**	11.29	9.87	8.23	**9.80**	**9.32**
T18	11.72	8.48	6.62	**8.94**	11.72	10.62	9.58	**10.64**	**9.79**
T19	11.47	8.92	6.41	**8.93**	11.47	10.39	9.23	**10.36**	**9.65**
T20	10.79	8.20	6.50	**8.50**	10.79	9.84	8.68	**9.77**	**9.13**
T21	10.70	7.83	6.04	**8.19**	10.70	9.83	9.19	**9.91**	**9.05**
T22	10.86	8.12	6.73	**8.57**	10.86	9.40	8.23	**9.49**	**9.03**
T23	10.25	8.55	9.27	**9.36**	10.25	9.27	8.48	**9.33**	**9.34**
T24	10.56	8.25	6.36	**8.39**	10.56	9.36	8.13	**9.35**	**8.87**
T25	11.57	9.55	8.67	**9.93**	11.57	9.58	8.49	**9.88**	**9.90**
T26	11.68	9.95	8.13	**9.92**	11.68	9.13	8.36	**9.72**	**9.82**
T27	11.14	9.73	8.56	**9.81**	11.14	9.55	8.46	**9.71**	**9.76**
T28	11.09	9.74	7.99	**9.61**	11.09	9.33	8.61	**9.68**	**9.64**
T29	11.44	10.05	7.40	**9.63**	11.44	9.40	8.27	**9.70**	**9.66**
T30	11.13	9.35	7.10	**9.19**	11.13	9.10	8.30	**9.51**	**9.35**
T31	11.49	10.88	8.32	**10.23**	11.49	9.62	8.50	**9.87**	**10.05**
T32	10.81	9.95	8.38	**9.71**	10.81	9.25	8.38	**9.48**	**9.60**
T33	11.54	9.39	7.72	**9.55**	11.54	10.12	9.35	**10.34**	**9.94**
T34	10.95	10.17	8.10	**9.74**	10.95	9.19	8.65	**9.60**	**9.67**
T35	11.42	10.58	8.85	**10.28**	11.42	9.93	8.60	**9.98**	**10.13**
T36	11.15	10.11	8.27	**9.85**	11.15	9.50	8.45	**9.70**	**9.77**
T37	10.86	9.44	7.85	**9.38**	10.86	9.73	8.70	**9.76**	**9.57**
T38	9.19	7.82	6.46	**7.82**	9.19	9.20	8.25	**8.88**	**8.35**
T39	9.96	7.95	6.06	**7.99**	9.96	9.31	8.05	**9.11**	**8.55**
T40	10.59	9.50	8.45	**9.51**	10.59	9.71	8.60	**9.63**	**9.57**
T41	10.43	8.64	7.14	**8.74**	10.43	9.49	8.24	**9.38**	**9.06**
T42	10.79	9.46	8.11	**9.45**	10.79	9.08	8.73	**9.53**	**9.49**
T43	8.08	6.59	5.72	**6.80**	8.08	5.72	5.51	**6.44**	**6.62**

T44	8.60	7.38	6.23	**7.40**	8.60	7.59	7.11	**7.77**	**7.58**
T45	9.45	8.15	6.95	**8.19**	9.45	9.36	8.45	**9.09**	**8.64**
T46	9.50	8.90	7.76	**8.72**	9.50	9.73	8.70	**9.31**	**9.01**
T47	9.40	7.78	5.88	**7.69**	9.40	9.20	8.25	**8.95**	**8.32**
T48	9.71	8.56	7.29	**8.52**	9.71	9.11	8.05	**8.95**	**8.74**
T49	10.09	8.75	6.85	**8.56**	10.09	9.37	8.60	**9.35**	**8.96**
T50	10.16	8.15	6.16	**8.15**	10.16	9.49	8.24	**9.29**	**8.72**
T51	10.60	9.53	6.74	**8.96**	10.60	9.30	8.81	**9.57**	**9.26**
T52	8.99	7.71	6.60	**7.77**	8.99	7.27	6.15	**7.47**	**7.62**
T53	9.58	8.85	6.71	**8.38**	9.58	7.04	6.52	**7.71**	**8.05**
T54	8.98	8.01	6.29	**7.76**	8.98	6.63	5.70	**7.10**	**7.43**
T55	9.76	8.84	7.62	**8.74**	9.76	8.28	7.17	**8.40**	**8.57**
T56	10.35	9.72	8.88	**9.65**	10.35	8.88	7.51	**8.91**	**9.28**
T57	9.58	8.71	7.95	**8.75**	9.58	7.95	7.71	**8.41**	**8.58**
T58	8.34	7.01	5.58	**6.98**	8.34	5.58	4.79	**6.24**	**6.61**
T59	9.27	8.56	7.11	**8.31**	9.27	7.11	6.05	**7.47**	**7.89**
T60	8.73	7.66	6.58	**7.66**	8.73	7.25	7.28	**7.75**	**7.70**
T61	9.25	7.74	6.71	**7.90**	9.25	6.71	6.28	**7.41**	**7.66**
T62	8.96	7.67	5.52	**7.38**	8.96	6.40	5.83	**7.06**	**7.22**
Mean	**11.30**	**9.15**	**7.42**	**9.29**	**11.30**	**9.77**	**8.75**	**9.94**	**9.61**
CD (p=0.05)	**PM= 0.09; SP= 0.11; Trt= 0.50; PM×SP= 0.16; PM×Trt= 0.71; SP×Trt= 0.86; PM×SP×Trt= 1.22.**								

*Figures in parentheses are square root transformed values

F. Moisture content (%)

The moisture content was found to be significantly affected by the treatments (T), periods of storage and materials in which the treated seeds were packed. The interaction effects between packaging materials (PM) and storage periods (SP), significantly and also packaging materials (PM) and treatments (T), storage periods (SP) and treatments (T) not significantly affected in the storage. Data on effects of different nanoparticle seed treatments, packaging materials and periods of storage on moisture content of paddy variety Pusa Basmati 1509 has been presented (Table 7).

The moisture content at initial period (0 month) was found to be significantly lower (8.6%) than the moisture content after 3 months (9.4%) and 6 months (10.3%) of storage in seeds treated with various nanoparticles. Significantly higher Moisture content after 6 months of storage under ambient conditions was noticed in seeds packed in cloth bags (9.4%) than the seeds packed in polyethylene bags (8.8%). The mean values of moisture content in 62 treatments were found to be divided in eight homogeneous subsets based upon the significance (p=0.05). The NP seed treatment, T1 (control 1) exhibited significantly higher values of moisture content (9.5%) than recommended PoP: control (8.5%), however it was found to be at par with treatments; T56 (9.5%), T25 (9.5%), T58 (9.4%), T50 (9.4), T9 (9.3%), T18 (9.3%), T31 (9.3%), T43 (9.3%), T46 (9.3%), T51 (9.3%) and T52 (9.3%) after 6 months of storage. Significantly lower values of moisture content were detected in T7 (8.3%), however it was found to be at par with treatments; T23 (8.5%), T2 (8.5%), T28 (8.6%), T29 (8.6%), T59 (8.9%), T61 (8.8%) and T62 (8.9%) after 6 months of storage. In total there were eleven treatments that resulted in significantly lower moisture content than both the controls. The interactions between PM and SP revealed significantly higher moisture content in seeds packed in cloth bags and stored for 3 months (9.4%) followed by seeds packed in polythene bags and stored for 3 months (8.8%) and similar patterns were revealed after 6 month of storage. However, the interaction effects between packaging materials and treatments, storage periods and treatments, packaging materials and storage periods and treatments were found to have non-significant effects on the moisture content during the storage for 6 months under ambient storage conditions. Amongst all the combinations of treatments, packaging materials and storage periods numerically highest values of moisture content (10.9%) were witnessed in T10 treated seeds at 6 month storage period in which was followed by T16 (10.7%) whereas, numerically lowest values of moisture content (7.9%) were observed in T1at initial (0 month) storage period in cloth bag.

The argument could be supported by the findings (Meenakshi *et al.,* 2020) and concluded that the effect of metaloxide NPs on seed storability of sunflower seeds (COH3) under natural ageing. Dry dressing of sunflower seeds with ZnO, TiO_2 and CuO NPs @ 1000,750 and 1250 mg kg^{-1} performed well as compared to control during ageing. Significance difference observed among NPs seed treatments. Seeds treated with ZnO at 1000 mg kg-1 of seeds obtained higher germination (%), root length, shoot length and vigour indices. Krishnashyla *et al.,* 2016 examined that the equilibrium moisture content of the seed would depend upon the materials in which the seed was packed and stored. The outperformance of ZnO NPs in maintaining the viability under ambient environment conditions by quenching of free radicals by donating free electrons to pair with unpaired electrons that protect the cell membrane integrity and avoid cell collapse

Table 7: Effect of different nanoparticle seed treatments and packaging materials on moisture content (%) of paddy variety Pusa Basmati 1509 at different periods of storage.

Treatments (Trt)	Packaging material (PM)								G. Mean
	Cloth (1)				Polythene (2)				
	Storage period (SP)			Mean	Storage period (SP)			Mean	
	0 m	3 m	6 m		0 m	3 m	6 m		
T1	9.1	8.4	9.2	**8.5**	7.9	8.1	8.2	**8.0**	**9.6**
T2	8.1	8.7	9.3	**8.7**	8.1	8.2	8.3	**8.2**	**8.5**
T3	8.7	9.2	10.2	**9.4**	8.7	8.8	8.9	**8.8**	**9.1**
T4	8.7	9.4	10.1	**9.4**	8.7	8.9	9.0	**8.9**	**9.1**
T5	8.7	9.5	10.4	**9.5**	8.7	8.8	8.9	**8.8**	**9.1**
T6	8.6	9.3	10.4	**9.4**	8.6	8.7	8.9	**8.7**	**9.1**
T7	8.7	9.5	10.2	**9.5**	8.7	8.9	9.1	**8.9**	**8.3**
T8	8.6	9.4	10.2	**9.4**	8.6	8.8	8.9	**8.8**	**8.3**
T9	8.8	9.5	10.4	**9.5**	8.8	9.0	9.1	**9.0**	**9.3**
T10	8.9	9.9	10.9	**9.9**	8.9	9.1	9.2	**9.1**	**9.5**
T11	8.7	9.4	10.4	**9.5**	8.7	9.0	9.2	**9.0**	**9.2**
T12	8.6	9.2	10.4	**9.4**	8.6	8.8	8.9	**8.8**	**9.1**
T13	8.7	9.3	10.2	**9.4**	8.7	8.8	9.0	**8.8**	**9.1**
T14	8.7	9.5	10.6	**9.6**	8.7	8.8	8.9	**8.8**	**9.2**
T15	8.6	9.6	10.5	**9.6**	8.6	8.7	8.9	**8.7**	**9.1**
T16	8.6	9.4	10.7	**9.6**	8.6	8.9	9.0	**8.8**	**9.2**
T17	8.6	9.4	10.4	**9.5**	8.6	8.7	8.9	**8.7**	**9.1**
T18	8.8	9.7	10.5	**9.7**	8.8	9.0	9.1	**9.0**	**9.3**
T19	8.6	9.4	10.2	**9.4**	8.6	8.8	9.0	**8.8**	**9.1**
T20	8.7	9.5	10.3	**9.5**	8.7	8.9	9.1	**8.9**	**9.2**
T21	8.7	9.4	10.6	**9.6**	8.7	8.9	9.2	**8.9**	**9.2**
T22	8.7	9.5	10.4	**9.5**	8.7	8.9	9.0	**8.9**	**9.2**
T23	8.4	9.4	10.4	**9.4**	8.4	8.6	5.8	**7.6**	**8.5**
T24	8.5	8.9	10.2	**9.2**	8.5	8.6	8.8	**8.6**	**8.9**
T25	8.9	9.7	10.7	**9.8**	8.9	9.1	9.3	**9.1**	**9.4**
T26	8.7	9.7	10.6	**9.7**	8.7	8.8	9.0	**8.8**	**9.2**
T27	8.5	9.4	10.5	**9.5**	8.5	8.7	8.8	**8.6**	**9.1**
T28	8.1	8.8	10.2	**9.0**	8.1	8.2	8.5	**8.3**	**8.6**
T29	8.0	8.6	10.3	**8.9**	8.0	8.2	8.4	**8.2**	**8.6**
T30	8.8	9.4	9.9	**9.3**	8.8	8.9	9.3	**9.0**	**9.2**
T31	8.7	9.8	10.7	**9.7**	8.7	8.9	9.1	**8.9**	**9.3**
T32	8.7	9.5	10.6	**9.6**	8.7	8.9	9.1	**8.9**	**9.2**
T33	8.7	9.6	10.4	**9.6**	8.7	8.8	9.0	**8.8**	**9.2**
T34	8.6	9.6	10.4	**9.5**	8.6	8.9	9.1	**8.9**	**9.2**
T35	8.6	9.4	10.2	**9.4**	8.6	8.8	9.0	**8.8**	**9.1**
T36	8.7	9.4	10.1	**9.4**	8.7	8.8	9.0	**8.8**	**9.1**
T37	8.7	9.3	10.6	**9.5**	8.7	8.9	9.1	**8.9**	**9.2**
T38	8.6	9.2	10.4	**9.4**	8.6	8.8	9.0	**8.8**	**9.1**
T39	8.5	9.3	10.4	**9.4**	8.5	8.7	8.9	**8.7**	**9.0**
T40	8.6	9.4	10.2	**9.4**	8.6	8.7	9.0	**8.8**	**9.1**
T41	8.7	9.3	10.4	**9.5**	8.7	8.8	9.1	**8.9**	**9.2**
T42	8.6	9.3	10.5	**9.4**	8.6	8.7	9.0	**8.8**	**9.1**
T43	8.8	9.4	10.4	**9.5**	8.8	8.9	9.2	**9.0**	**9.3**
T44	8.6	9.6	10.4	**9.5**	8.6	8.8	9.1	**8.8**	**9.2**
T45	8.5	9.4	10.1	**9.4**	8.5	8.7	8.9	**8.7**	**9.0**
T46	8.9	9.5	10.1	**9.5**	8.9	9.0	9.4	**9.1**	**9.3**
T47	8.5	9.6	10.4	**9.5**	8.5	8.6	8.9	**8.7**	**9.1**
T48	8.8	9.4	10.3	**9.5**	8.8	9.0	9.2	**9.0**	**9.2**
T49	8.4	9.3	10.4	**9.4**	8.4	8.5	8.8	**8.5**	**9.0**
T50	9.0	9.7	10.3	**9.7**	9.0	9.1	9.4	**9.2**	**9.4**
T51	8.9	9.5	10.3	**9.6**	8.9	9.0	9.3	**9.1**	**9.3**
T52	8.7	9.7	10.4	**9.6**	8.7	8.9	9.2	**9.0**	**9.3**
T53	8.5	9.4	10.5	**9.5**	8.5	8.7	9.1	**8.8**	**9.1**
T54	8.6	9.5	10.3	**9.5**	8.6	8.8	9.0	**8.8**	**9.1**
T55	8.7	9.5	10.2	**9.4**	8.7	8.8	9.1	**8.9**	**9.2**
T56	9.0	9.7	10.5	**9.7**	9.0	9.2	9.3	**9.2**	**9.5**
T57	8.7	9.5	10.2	**9.4**	8.7	8.8	9.0	**8.8**	**9.1**
T58	7.9	9.7	10.2	**9.6**	9.1	9.2	9.2	**9.2**	**9.4**
T59	8.4	9.2	9.8	**9.2**	8.4	8.5	8.7	**8.6**	**8.9**
T60	8.6	9.3	9.9	**9.2**	8.6	8.7	9.0	**8.8**	**9.0**
T61	8.2	9.2	9.9	**9.1**	8.2	8.4	8.6	**8.4**	**8.8**
T62	8.3	9.5	10.3	**9.4**	8.3	8.4	8.6	**8.4**	**8.9**
Mean	**8.6**	**9.4**	**10.3**	**9.4**	**8.6**	**8.8**	**8.9**	**8.8**	**9.1**
CD (p=0.05)	**PM= 0.04; SP= 0.05; Trt= 0.24; PM×SP= 0.07; PM×Trt= NS; SP×Trt= NS; PM×SP×Trt= NS.**								

*Figures in parentheses are square root transformed values

G. Seedling emergence percentage

The Seedling emergence percentage was found to be significantly affected by the treatments (T), periods of storage and materials in which the treated seeds were packed. The interaction effects between packaging materials (PM) and storage periods (SP), packaging materials (PM) and treatments (T) significantly affected the seedling emergence percentage in the storage except storage periods (SP) and treatments (T) interaction effect. Data on effects of different nanoparticle seed treatments, packaging materials and periods of storage on Seedling emergence percentage of paddy variety Pusa Basmati 1509 has been presented (Table 8).

The Seedling emergence percentage at initial period (0 month) was found to be significantly higher (89.05%) than the germination percentage after 3 months (71.80%) and 6 months (55.89%) of storage in seeds treated with various nanoparticles. Significantly higher Seedling emergence percentage after 6 months of storage under ambient conditions was noticed in seeds packed in polyethylene bags (84.21%) than the seeds and packed in cloth bags (72.25%). The mean values of seedling emergence percentage in 62 treatments were found to be divided in fourteen homogeneous subsets based upon the significance (p=0.05). The NP seed treatment, T2 recommended PoP: control exhibited significantly higher values of seedling emergence percentage (84.06%) than untreated control (81.61%). However, it was found to be at par with treatments; T48 (83.72%), T10 (83.17%), T59 (82.83%), T6 (82.72%), T12 (82.50%), T25 (82.17%) and T5 (82.11%) after 6 months of storage. Significantly lower seedling emergence percentage was detected in T56 (73.22%), however it was found to be at par with treatments; T58 (74.22%), T17 (74.67%), T33 (74.72%) and T28 (74.94%) after 6 months of storage. In total there were 60 treatments that resulted in significantly lower seedling emergence percentage than both the controls. The interactions between PM and SP revealed significantly higher seedling emergence percentage in seeds packed in polyethylene bags and stored for 3 months (85.03%) followed by seeds packed in cloth bags and stored for 3 months (71.80%) and similar patterns were revealed after 6 month of storage. However, the interaction effects between packaging materials and storage periods and treatments were found to have non-significant effects on the seedling emergence percentage during the storage for 6 months under ambient storage conditions. Amongst all the combinations of treatments, packaging materials and storage periods numerically highest values of seedling emergence (97.3%) were witnessed in T10 treated seeds at initial period in which was followed by T2 (96.00%) whereas, numerically lowest values of germination (47.67%) were observed in T47 at 6 month storage period in cloth bag.

Similar results were find and concluded that seed treatment of chilli with Thiram enhanced emergence and untreated seeds showed lowest emergence after 10 months of storage (Koteshwar Rao *et al.,* 1962). The reduction in seedling emergence may be attributed to age-induced deteriorative alterations in cell and cell organells and germination capacity of seed under storage condition. The argument could be supported by the Vijaykumar (2005) who observed increase seedling emergence in cotton Parihar *et al.,* (2019) in okra and Kotia *et al.,* (2020) in radish seeds.

Table 8: Effect of different nanoparticle seed treatments and packaging material on seedling emergence percentage of paddy variety Pusa Basmati 1509 at different periods of storage

Treatments (Trt)	Packaging material (PM)								G. Mean
	Cloth (1)				Polythene (2)				
	Storage period (SP)			Mean	Storage period (SP)			Mean	
	0 m	3 m	6 m		0 m	3 m	6 m		
T1	84.25 (72.41)	73.00 (58.73)	65.67 (54.17)	**76.44 (61.77)**	84.25 (72.41)	86.67 (68.77)	83.00 (65.70)	**86.78 (68.96)**	**81.61 (65.36)**
T2	81.00 (78.76)	75.00 (60.09)	63.67 (52.96)	**78.22 (63.94)**	81.00 (78.76)	90.00 (71.66)	83.67 (66.21)	**89.89 (72.21)**	**84.06 (68.07)**
T3	89.33 (72.33)	75.67 (60.61)	68.00 (55.61)	**77.67 (62.85)**	89.33 (72.33)	83.67 (66.20)	79.33 (63.00)	**84.11 (67.17)**	**80.89 (65.01)**
T4	90.67 (72.51)	82.00 (64.93)	64.00 (53.17)	**78.89 (63.54)**	90.67 (72.51)	84.00 (66.47)	76.67 (61.16)	**83.78 (66.72)**	**81.33 (65.13)**
T5	88.22 (74.14)	81.67 (64.85)	64.67 (53.56)	**79.44 (64.18)**	88.22 (74.14)	85.33 (67.56)	77.00 (61.40)	**84.78 (67.70)**	**82.11 (65.94)**
T6	88.23 (76.19)	79.67 (63.44)	67.33 (55.18)	**79.44 (64.94)**	88.23 (76.19)	87.00 (69.19)	79.67 (63.23)	**86.00 (69.54)**	**82.72 (67.24)**
T7	88.67 (71.63)	73.00 (58.80)	66.00 (54.37)	**75.89 (61.60)**	88.67 (71.63)	86.00 (68.38)	78.00 (62.12)	**84.22 (67.38)**	**80.06 (64.49)**
T8	85.33 (67.71)	77.33 (61.74)	59.33 (50.41)	**74.00 (59.95)**	85.33 (67.71)	82.67 (65.49)	72.67 (58.52)	**80.22 (63.91)**	**77.11 (61.93)**
T9	84.67 (68.01)	68.67 (56.07)	54.33 (47.52)	**69.22 (57.20)**	84.67 (68.01)	83.00 (66.86)	78.33 (62.29)	**82.00 (65.72)**	**75.61 (61.46)**
T10	97.33 (82.61)	79.00 (62.83)	53.67 (47.13)	**76.67 (64.19)**	97.33 (82.61)	90.00 (71.66)	81.67 (65.09)	**89.67 (73.12)**	**83.17 (68.65)**
T11	89.33 (72.14)	77.33 (61.64)	57.67 (49.44)	**74.78 (61.07)**	89.33 (72.14)	84.67 (67.53)	81.00 (64.56)	**85.00 (72.76)**	**79.89 (64.57)**
T12	94.67 (77.13)	75.00 (60.03)	53.00 (46.74)	**74.22 (61.30)**	94.67 (77.13)	90.00 (71.66)	87.67 (69.50)	**90.78 (68.07)**	**82.50 (67.03)**
T13	84.00	74.33	58.00	**72.11**	84.00	80.00	74.33	**79.44**	**75.78**

	(66.63)	(59.64)	(49.63)	**(58.63)**	(66.63)	(63.59)	(59.60)	**(63.27)**	**(60.95)**
T14	84.67 (67.17)	75.33 (60.27)	54.33 (47.51)	**71.44 (58.32)**	84.67 (67.17)	79.67 (63.27)	74.67 (59.81)	**79.67 (63.42)**	**75.56 (60.87)**
T15	86.67 (69.09)	73.00 (58.75)	53.67 (47.13)	**71.11 (58.32)**	86.67 (69.09)	82.33 (65.39)	76.33 (60.95)	**81.78 (65.14)**	**76.44 (61.73)**
T16	94.00 (76.73)	72.00 (58.08)	56.33 (48.67)	**74.11 (61.16)**	94.00 (76.73)	89.33 (71.09)	82.67 (65.68)	**88.67 (71.17)**	**81.39 (66.16)**
T17	82.67 (65.53)	77.00 (61.40)	52.00 (46.17)	**70.56 (57.70)**	82.67 (65.53)	79.67 (63.24)	74.00 (59.38)	**78.78 (62.72)**	**74.67 (60.21)**
T18	90.00 (72.19)	67.00 (54.97)	57.00 (49.06)	**71.33 (58.74)**	90.00 (72.19)	86.00 (68.23)	77.67 (62.06)	**84.56 (67.49)**	**77.94 (63.12)**
T19	88.00 (69.94)	71.67 (57.90)	54.33 (47.52)	**71.33 (58.45)**	88.00 (69.94)	85.67 (67.87)	75.33 (60.37)	**83.00 (66.06)**	**77.17 (62.26)**
T20	88.67 (70.80)	68.33 (55.82)	52.00 (46.17)	**69.67 (57.60)**	88.67 (70.80)	85.67 (67.95)	82.00 (65.16)	**85.44 (67.97)**	**77.56 (62.78)**
T21	94.67 (77.13)	69.33 (56.41)	54.00 (47.32)	**72.67 (60.28)**	94.67 (77.13)	86.67 (68.89)	84.67 (67.20)	**88.67 (71.07)**	**80.67 65.68)**
T22	91.33 (73.02)	66.33 (54.60)	56.00 (48.48)	**71.22 (58.70)**	91.33 (73.02)	87.00 (68.91)	82.00 (64.95)	**86.78 (68.96)**	**79.00 (63.83)**
T23	90.00 (71.84)	69.00 (56.26)	54.67 (47.71)	**71.22 (58.60)**	90.00 (71.84)	87.67 (69.48)	82.00 (64.93)	**86.56 (68.75)**	**78.89 (63.68)**
T24	90.67 (73.32)	69.67 (56.64)	53.67 (47.13)	**71.33 (59.03)**	90.67 (73.32)	85.67 (67.99)	81.00 (64.40)	**85.78 (68.57)**	**78.56 (63.80)**
T25	92.00 (73.83)	77.33 (61.62)	57.67 (49.44)	**75.67 (61.63)**	92.00 (73.83)	89.00 (70.80)	85.00 (67.74)	**88.67 (70.79)**	**82.17 (66.21)**
T26	86.33 (68.43)	66.33 (54.62)	53.00 (46.74)	**68.56 (56.60)**	86.33 (68.43)	82.00 (64.95)	77.67 (61.84)	**82.00 (65.07)**	**75.28 (60.84)**
T27	88.00 (69.94)	68.00 (55.58)	58.00 (49.63)	**71.33 (58.38)**	88.00 (69.94)	84.00 (66.48)	76.67 (61.18)	**82.89 (65.87)**	**77.11 (62.13)**
T28	87.33 (69.24)	64.33 (53.36)	54.33 (47.51)	**68.67 (56.71)**	87.33 (69.24)	83.00 (65.71)	73.33 (58.95)	**81.22 (64.63)**	**74.94 (60.67)**
T29	85.67 (67.93)	73.00 (58.78)	53.67 (47.13)	**70.78 (57.94)**	85.67 (67.93)	82.00 (64.95)	77.00 (61.40)	**81.56 (64.76)**	**76.17 (61.35)**
T30	87.33 (69.96)	68.00 (55.65)	54.33 (47.52)	**69.89 (57.71)**	87.33 (69.96)	85.00 (67.58)	71.00 (57.45)	**81.11 (65.00)**	**75.50 (61.35)**
T31	87.33 (69.33)	65.33 (53.99)	55.33 (48.09)	**69.33 (57.15)**	87.33 (69.33)	82.33 (65.20)	77.67 (61.84)	**82.44 (65.47)**	**75.89 (61.31)**
T32	91.33 (73.08)	63.67 (52.97)	52.67 (46.55)	**69.22 (57.53)**	91.33 (73.08)	86.67 (68.89)	84.00 (66.82)	**87.33 (69.60)**	**78.28 (63.57)**
T33	87.33 (69.37)	68.00 (55.58)	53.00 (46.75)	**69.44 (57.23)**	87.33 (69.37)	79.67 (63.24)	73.00 (58.73)	**80.00 (63.78)**	**74.72 (60.51)**
T34	88.67 (70.55)	67.33 (55.22)	54.33 (47.52)	**70.11 (57.76)**	88.67 (70.55)	81.33 (64.46)	73.00 (58.73)	**81.00 (64.58)**	**75.56 (61.17)**
T35	87.33 (69.20)	77.67 (62.21)	57.67 (49.44)	**74.22 (60.28)**	87.33 (69.20)	84.33 (66.72)	73.67 (59.17)	**81.78 (65.03)**	**78.00 (62.65)**
T36	92.00 (73.69)	76.00 (60.75)	52.00 (46.17)	**73.33 (60.20)**	92.00 (73.69)	84.67 (67.09)	75.00 (60.03)	**83.89 (66.94)**	**78.61 (63.57)**
T37	91.33 (73.82)	72.67 (58.53)	53.00 (46.75)	**72.33 (59.70)**	91.33 (73.82)	85.00 (67.31)	72.67 (58.59)	**83.00 (66.57)**	**77.67 (63.14)**
T38	90.67 (72.41)	72.00 (58.08)	54.33 (47.52)	**72.33 (59.34)**	90.67 (72.41)	86.00 (68.09)	74.00 (59.38)	**83.56 (66.63)**	**77.94 (62.98)**
T39	86.00 (68.15)	73.67 (59.20)	55.33 (48.09)	**71.67 (58.48)**	86.00 (68.15)	83.67 (66.22)	73.00 (58.74)	**80.89 (64.37)**	**76.28 (61.43)**
T40	86.67 (69.08)	71.33 (57.66)	54.33 (47.51)	**70.78 (58.08)**	86.67 (69.08)	85.00 (67.25)	76.00 (60.72)	**82.56 (65.69)**	**76.67 (61.88)**
T41	87.33 (69.24)	74.00 (59.49)	56.33 (48.67)	**72.56 (59.13)**	87.33 (69.24)	85.33 (67.53)	77.33 (61.62)	**83.33 (66.13)**	**77.94 (62.63)**
T42	88.67 (70.66)	75.33 (60.26)	54.33 (47.52)	**72.78 (59.48)**	88.67 (70.66)	83.00 (65.69)	75.00 (60.03)	**82.22 (65.46)**	**77.50 (62.47)**
T43	90.00 (71.66)	76.00 (60.74)	55.33 (48.09)	**73.78 (60.16)**	90.00 (71.66)	83.00 (65.70)	77.33 (61.62)	**83.44 (66.33)**	**78.61 (63.24)**
T44	90.00 (71.84)	72.67 (58.57)	52.67 (46.55)	**71.78 (58.99)**	90.00 (71.84)	86.67 (68.71)	79.00 (62.99)	**85.22 (67.85)**	**78.50 (63.42)**
T45	88.67 (70.42)	67.33 (55.25)	57.67 (49.44)	**71.22 (58.37)**	88.67 (70.42)	86.67 (68.66)	78.00 (62.22)	**84.44 (67.10)**	**77.83 (62.73)**
T46	90.67 (72.51)	65.67 (54.16)	51.67 (45.98)	**69.33 (57.55)**	90.67 (72.51)	87.33 (69.27)	83.67 (66.31)	**87.22 (69.36)**	**78.28 (63.46)**
T47	91.33 (72.94)	74.33 (59.64)	47.67 (43.68)	**71.11 (58.75)**	91.33 (72.94)	89.33 (70.99)	89.00 (70.68)	**89.89 (71.54)**	**80.50 (65.15)**
T48	94.67 (77.13)	75.33 (60.27)	56.33 (48.67)	**75.44 (62.02)**	94.67 (77.13)	92.00 (73.90)	89.33 (71.12)	**92.00 (74.05)**	**83.72 (68.04)**
T49	93.33 (75.24)	64.67 (53.57)	54.33 (47.52)	**70.78 (58.78)**	93.33 (75.24)	90.33 (71.93)	89.00 (70.70)	**90.89 (72.62)**	**80.83 (65.70)**
T50	93.33 (75.32)	66.00 (54.38)	55.33 (48.09)	**71.56 (59.26)**	93.33 (75.32)	89.00 (70.88)	83.67 (66.21)	**88.67 (70.80)**	**80.11 (65.03)**

T51	87.33 (69.24)	66.67 (54.77)	55.00 (47.90)	**69.67 (57.30)**	87.33 (69.24)	82.67 (65.44)	78.33 (62.35)	**82.78 (65.68)**	**76.22 (61.49)**
T52	91.33 (73.86)	71.67 (57.97)	56.67 (48.86)	**73.22 (60.23)**	91.33 (73.86)	87.33 (69.96)	80.00 (64.13)	**86.22 (69.32)**	**79.72 (64.77)**
T53	91.33 (73.08)	69.33 (56.46)	53.33 (46.94)	**71.33 (58.83)**	91.33 (73.08)	90.00 (71.66)	81.33 (64.87)	**87.56 (69.87)**	**79.44 (64.35)**
T54	85.33 (67.71)	62.67 (52.39)	53.67 (47.13)	**67.22 (55.74)**	85.33 (67.71)	85.33 (67.71)	80.00 (63.52)	**83.56 (66.31)**	**75.39 (61.03)**
T55	86.00 (68.09)	66.33 (54.57)	56.33 (48.67)	**69.56 (57.11)**	86.00 (68.09)	84.00 (66.46)	73.67 (59.16)	**81.22 (64.57)**	**75.39 (60.84)**
T56	81.33 (64.53)	65.33 (53.98)	54.33 (47.52)	**67.00 (55.34)**	81.33 (64.53)	79.33 (63.03)	77.67 (61.84)	**79.44 (63.13)**	**73.22 (59.24)**
T57	86.00 (68.17)	76.33 (61.35)	55.33 (48.09)	**72.56 (59.20)**	86.00 (68.17)	81.00 (64.20)	71.00 (57.45)	**79.33 (63.27)**	**75.94 (61.24)**
T58	81.33 (64.53)	75.00 (60.11)	55.00 (47.90)	**70.44 (57.51)**	81.33 (64.53)	79.00 (62.99)	73.67 (59.18)	**78.00 (62.23)**	**74.22 (59.87)**
T59	93.33 (75.11)	72.67 (58.53)	56.67 (48.86)	**74.22 (60.83)**	93.33 (75.11)	91.67 (73.26)	89.33 (70.99)	**91.44 (73.12)**	**82.83 (66.98)**
T60	85.33 (67.53)	73.67 (59.17)	53.33 (46.94)	**70.78 (57.88)**	85.33 (67.53)	80.33 (63.71)	73.00 (58.74)	**79.56 (63.33)**	**75.17 (60.60)**
T61	86.67 (68.71)	73.00 (58.74)	54.00 (47.32)	**71.22 (58.26)**	86.67 (68.71)	82.67 (65.46)	74.67 (59.81)	**81.33 (64.66)**	**76.28 (61.46)**
T62	87.33 (69.38)	72.33 (58.32)	53.33 (46.94)	**71.00 (58.21)**	87.33 (69.38)	83.67 (66.46)	78.00 (62.15)	**83.00 (66.00)**	**77.00 (62.10)**
Mean	**89.05 (71.35)**	**71.80 (58.08)**	**55.89 (48.42)**	**72.25 (59.29)**	**89.05 (71.35)**	**85.03 (67.51)**	**78.55 (62.68)**	**84.21 (67.18)**	**78.23 (63.23)**
CD (p=0.05)	**PM= 0.42; SP= 0.52; Trt= 2.36; PM×SP= 0.74; PM×Trt= 3.34; SP×Trt= NS; PM×SP×Trt= NS.**								

*Figures in parentheses are square root transformed values

SUMMERY AND CONCLUSION

The highest germination percentage, seedling vigour index I and seedling vigour index II were recorded at initial month but after 6 month of storage highest germination percentage (86.8%) in (T3) Dry Bulk ZnO@50ppm, seedling vigour index I (5306) in (T5) Dry Bulk ZnO@250ppm and seedling vigour index II (18.75) in (T7) Dry Bulk ZnO@750ppm were recorded in polythene bag then cloth bag as compared to both the controls. Significant highest seedling emergence percentage were recorded at initial month but after 6 month of storage highest seedling emergence percentage (84.06%) in (T2) Thiram@2gm/kg recorded in polythene bag as compared to (control 1). Lowest moisture content was recorded at initial month but after 6 month of storage lowest moisture content (8.3%) in (T8) Dry Bulk ZnO@50ppm recorded in polythene bag as compared to both the controls. Significant lowest abnormal seedling and dead seed were recorded at initial month but after 6 month of storage lowest abnormal seedling (4.83%) in (T34) Wet Bulk SiO2@100ppm and dead seed percentage (3.39%) in (T18) Wet Nano Zno@50ppm were recorded in polythene bag as compared to both the controls.

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Conflict of Interest. None.

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