Effect of Storage Methods and Seed Rhizome Treatment on Field Performance of Ginger var. Humnabad

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ABSTRACT

An experiment was conducted to evaluate the effect of different storage methods and seed rhizome treatment on the field performance of ginger var. Humnabad. The study included four storage methods *viz.*, rhizomes kept in sand layers, 250 gauge polyethylene bag with 0.5% vents, Zero energy cool chamber (ZECC) either in open condition or in polyethylene bag with 0.5% vents. The seed rhizomes are treated with three different levels *viz.*, Ridomil MZ (3g/l), *Trichoderma harzianum* (5g/kg seed rhizome) and control (no seed treatment). Highest sprouting percentage (98.89%), plant height (52.3 cm), leaf area index (25.75), number of tillers per clump (19.7), pseudostem girth (3.41 cm) and fresh rhizome yield (22.35 t/ha) was recorded in rhizome stored in ZECC treated with *Trichoderma harzianum* whereas, the rhizome stored in sand layer with no seed treatment recorded the lowest germination percentage (75.56%), plant height (33.6 cm), leaf area index (9.73), number of tillers per clump (12.6), pseudostem girth (2.32 cm) and fresh rhizome yield (11.84 t/ha).

Keywords: Rhizome yield, *Trichoderma harzianum,* Zero energy cool chamber

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is among the important and widely used spice crops throughout the world (Hamza et al. 2013). In India it is grown on an area of 1.06 lakh hectares with annual production of about 3.76 lakh tonnes (NHB 2008). Ginger is an herbaceous perennial, rhizomatous spice crop containing volatile oil, fixed oil, pungent compounds, resins, starch, protein and minerals (Archana et al. 2013). The refreshing aroma and pungent taste make ginger an essential ingredient of food, *masala* or spice mixes and food processing industries worldwide. It is an also used as an ingredient in many Ayurvedic preparations and folk cure for many ailments including against asthma, cough, diarrhoea, flatulence, nausea and vomiting.

Ginger is propagated vegetatively using rhizome. Nearly 17 – 20 per cent of the produce is retained and stored annually for subsequent crop as seed rhizome. From the time of harvesting of rhizome (January-February) till subsequent planting (May-June), the seed rhizome are to be stored about 3 to 3½ months in healthy and viable condition. But during the storage period, seed rhizome is infested with several pest and diseases besides desiccation and sprouting. *In situ* storage (delayed harvest) method is prone to rhizome rot and harbor insect pests (Rai and Hossain 1998). Similarly, in pit storage method, about 25 – 30% rhizomes rot in the pit itself and 10 – 15% rhizome sprout during storage are rendered useless for sowing (Karuppaiyan et al., 2008). Furthermore, according to Rahman et al. (2007) storage of ginger in shaded places is economic however; drying of ginger is a major problem in this method. Thus, the recovery of healthy seed rhizome for planting in the coming season reduced considerable low, leading to poor crop's performance in the field. Hence the present investigation was undertaken to study the effect of storage methods and seed rhizome treatment on the growth and yield of ginger.

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MATERIALS AND METHODS

The experiment was carried out during 2009/10 at KRC College of Horticulture, Arabhavi, Gokak (Tq), Karnataka. Healthy and uniform size seed rhizomes of ginger var. Humnabad were used for the study. Seed rhizomes used for study was stored for 90 days in four different methods of storage and three different treatments of seed rhizome. The methods of storage included M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber (ZECC) and M_4, ZECC + polyethylene bag with 0.5% vents . The three different treatments of seed rhizome are S_1, Control (no seed treatment); S_2, Ridomil MZ (3 g/l water solution) and S_3, *Trichoderma harzianum* (5 g/kg seed rhizome). At the end of the storage period, thirty randomly selected rhizomes weighing 25 gm each from each treatment combination were planted on raised bed of size 3 m x 1 m x 15 cm at spacing of 30 x 20 cm. FYM @ 25 t/ha was applied to all the beds before planting and mixed well with the soil. The recommended dose of fertilizer (100, 50 and 50 kg NPK/ha) was applied in three splits. Full dose of phosphorus and potassium were applied as basal dose. Nitrogen was top dressed in equal splits after weeding at 30 days and 60 days of planting. The other cultural operations were carried out as per the recommended package of practices. Sunhemp was also sown along the border of each bed to provide partial shade during the initial establishment of the crop. Days to first sprouting was noted when the first rhizome in a bed have sprouted and taken as days to first germination. Sprouting percentage was calculated by the number of sprouts that emerged at 45^{th} day after planting divided by number of rhizome planted and multiplied with 100. Observations on growth attributes, *viz*., plant height, number of leaves per clump, number of tillers per clump, leaf area index and pseudostem girth were recorded at 150 days after planting. The experiment was laid out in 2 factorial completely randomized design (FCRD) with five replications for each treatment. The data on different parameters were analysed by using analysis of variance (ANOVA) based on factorial randomised block design (RBD) by using Statistical Package for Agricultural Workers (STAT OP Sheoran). Valid conclusions were drawn only on significant differences between the treatment mean at 0.05 level of probability.

RESULTS AND DISCUSSION

Sprouting percentage was significantly increase by different storage methods and seed treatments and their interaction (Table 1). Among storage methods, the rhizome stored under ZECC recorded highest germination (97.78%) followed by rhizome stored under 250 gauge polyethylene bag with 0.5 per cent vents (88.89%) compared to the lowest germination by rhizome stored under sand layer (83.70%). Chandrappa (1996) also recorded more than 80 per cent sprouting in ginger rhizomes stored in 100 gauge white polyethylene bags. Similar results were also obtained in turmeric by Kirankumar (2001); Vanamala (1994) where lower percentage of sprouting recorded in turmeric rhizomes stored in heap covered with sand under Bangalore conditions. Among seed rhizome treatments, maximum germination percentage was significantly recorded in the rhizome treated with *Trichoderma harzianum* (5 g/kg) (93.06%), while the lowest was observed in control with no seed treatment (84.17%). Among interaction of seed storage methods and seed rhizome treatments, ZECC + *Trichoderma harzianum* (5 g/kg) showed maximum germination percentage (98.89), followed by ZECC + Ridomil MZ (3 g/l) (97.78). Whereas, the rhizome stored in sand layer with no seed treatment recorded the lowest germination (75.56%). The seed rhizome treatment has significant influenced on the germination percentage in ginger which might be due to favourable effect of the bio-agent on germination of ginger. Similar results were obtained by Sharma et al. (1991) in ginger and Kirankumar (2001) in turmeric. Mukhtar (2008) reported that *Trichoderma harzianum* is highly effective in enhancing the germination percentage in okra seeds. Sharma et al. (1991) reported that *Trichoderma viride* in combination with Ridomil MZ gave a greater protection against rhizome rot and also gave higher yield, when given as a seed treatment.

The results obtained in plant height due to seed storage and treatments showed significant influenced in plant height (Table 2). Among seed storage methods, plant raised from seed rhizome stored under ZECC recorded significantly higher plant height (49.8 cm), followed by seed rhizome stored under 250 gauge polyethylene bags with 0.5 per cent vents (42.7 cm). Lowest plant height was observed with seed rhizome stored under sand layer

Table 1: Effect of storage methods and seed rhizome treatment on sprouting percentage at 45 days after planting in ginger var. Humnabad

Factors	M_1	M_2	M_3	M_4	Mean
S_1	75.56 (8.72)	84.44 (9.22)	96.67 (9.86)	80.00 (8.97)	84.17 (9.19)
S_2	85.56 (9.26)	88.89 (9.45)	97.78 (9.91)	80.00 (8.96)	88.06 (9.39)
S_3	90.00 (9.51)	93.33 (9.68)	98.89 (9.97)	90.00 (9.50)	93.06 (9.67)
Mean	83.70 (9.16)	88.89 (9.45)	97.78 (9.91)	83.33 (9.14)	
Factors	M	S	M x S		
S.Em±	0.11	0.10	0.20		
CD (0.05)	0.33	0.29	0.57		

Storage methods (M): M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber; M_4, ZECC + polyethylene bag with 0.5% vents.
Seed treatment (S): S_1, Control; S_2, Ridomil MZ (3 g/l); S_3, *Trichoderma harzianum* (5 g/kg seed rhizome).

Table 2: Effect of storage methods and seed rhizome treatment on plant height (cm) at 45 days after planting in ginger var. Humnabad

Factors	M_1	M_2	M_3	M_4	Mean
S_1	33.60	38.10	46.60	35.90	38.60
S_2	35.90	40.20	50.50	39.20	41.40
S_3	39.80	49.80	52.30	48.40	47.60
Mean	36.40	42.70	49.80	41.20	
Factors	M	S	M x S		
S.Em±	1.49	1.29	2.58		
CD (0.05%)	4.36	3.78	7.55		

Storage methods (M): M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber; M_4, ZECC + polyethylene bag with 0.5% vents.
Seed treatment (S): S_1, Control; S_2, Ridomil MZ (3 g/l); S_3, *Trichoderma harzianum* (5 g/kg seed rhizome).

(36.4 cm). Among treatments, seed rhizome treated with *Trichoderma harzianum* (5 g/kg) produced maximum plant height (47.6 cm), followed by the crop raised from seed rhizome treated with Ridomil MZ (3 g/l) (41.4 cm). The crop raised from seed rhizome without seed treatment recorded the lowest plant height (38.6 cm). Among interaction effect, treatment combination ZECC + *Trichoderma harzianum* (5 g/kg) recorded higher plant height (52.3 cm) and the lowest was recorded in sand layers + control (33.6 cm).

Data presented in Table 3 indicated that seed storage methods, seed treatments and their interactions showed significant effect on number of leaves per clump. Regarding storage methods, maximum number of leaves per clump was recorded in seed rhizome stored under ZECC (434.3) followed by seed rhizome stored under 250 gauge polyethylene bag with 0.5 per cent vents (358.0). The lowest number of leaves per clump was obtained in the seed rhizome stored under sand layer (302.7). Regarding seed treatments, seed rhizome treated with *Trichoderma harzianum* (5 g/kg) recorded maximum number of leaves per clump (399.7) followed by rhizome treated with 0.3 per cent Ridomil MZ (3 g/l) (360.2) and the lowest (316.1) was in the rhizome without seed rhizome treatment (control). Among the interaction effect, the number of leaves per clump was highest in ZECC + *Trichoderma harzianum* (5 g/kg) (492.6) closely followed by ZECC + Ridomil MZ (3 g/l) (418.5). The lowest number of leaves per clump was recorded in sand layers + control (252.7). The leaf area index at 150 days after planting in ginger var. Humnabad was significantly affected by seed storage methods and treatments and their

Table 3: Effect of storage methods and seed rhizome treatment on number of leaves per clump at 45 days after planting in ginger var. Humnabad

Factors	M_1	M_2	M_3	M_4	Mean
S_1	252.70	315.50	391.90	304.40	316.10
S_2	309.40	359.60	418.50	353.40	360.20
S_3	345.90	398.90	492.60	361.10	399.70
Mean	302.70	358.00	434.30	339.60	
Factors	M	S	M x S		
S.Em±	19.99	17.31	34.62		
CD (0.05%)	58.62	50.76	101.53		

Storage methods (M): M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber; M_4, ZECC + polyethylene bag with 0.5% vents.
Seed treatment (S): S_1, Control; S_2, Ridomil MZ (3 g/l); S_3, *Trichoderma harzianum* (5 g/kg seed rhizome).

interactions (Table 4). Maximum leaf area index was recorded in seed rhizome stored under ZECC (22.47) followed by rhizome stored under 250 gauge polyethylene bag with 0.5 per cent vents (16.26). Minimum leaf area index was recorded in seed rhizome stored under sand layer (12.67). Seed rhizome treated with *Trichoderma harzianum* (5 g/kg) recorded maximum leaf area index (20.09), while lowest (14.09) was recorded in crop without seed rhizome treatment. Similarly, the interaction effect showed highest leaf area index in ZECC + *Trichoderma harzianum* (5 g/kg) (25.75), followed by ZECC + Ridomil MZ (3g/l) (22.13) and lowest was obtained in sand layers + control (9.73).

Number of tillers per clump was also significantly affected effect by seed storage methods and treatments and their interactions (Table 5). Among seed storage, maximum number of tillers was recorded in seed rhizome stored under ZECC (18.2) followed by rhizome stored under 250 gauge polyethylene bag with 0.5 per cent vents (16.2). Minimum number of tillers per clump was obtained in seed rhizome stored under the sand layer (14.6). Among seed treatments, number of tillers per clump was highest in seed rhizome treated with *Trichoderma harzianum* (5 g/kg) (17.3) followed by rhizome treated with Ridomil MZ (3 g/l) (16.4). While lowest number of tillers per clump was produced in rhizome without seed treatment (15.1). Among the interaction effect, highest number of tillers per clump was recorded in ZECC + *Trichoderma harzianum* (5 g/kg) (19.7) followed by ZECC + Ridomil MZ (3 g/l) (17.6). Minimum number of tillers per clump was given by sand layers + control (12.6).

Table 4: Effect of storage methods and seed rhizome treatment on leaf area index at 150 days after planting in ginger var. Humnabad

Factors	M_1	M_2	M_3	M_4	Mean
S_1	9.73	13.69	19.53	13.42	14.09
S_2	12.07	14.72	22.13	15.54	16.12
S_3	15.01	20.37	25.75	19.25	20.09
Mean	12.27	16.26	22.47	16.07	
Factors	M	S	M x S		
S.Em±	1.51	1.00	1.99		
CD (0.05)	3.38	2.92	5.85		

Storage methods (M): M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber; M_4, ZECC + polyethylene bag with 0.5% vents.
Seed treatment (S): S_1, Control; S_2, Ridomil MZ (3 g/l); S_3, *Trichoderma harzianum* (5 g/kg seed rhizome).

Table 5: Effect of storage methods and seed rhizome treatment on number of tillers per clump at 150 days after planting in ginger var. Humnabad

Factors	M_1	M_2	M_3	M_4	Mean
S_1	12.60	15.50	17.20	15.20	15.10
S_2	15.30	16.30	17.60	16.30	16.40
S_3	15.90	16.90	19.70	16.50	17.30
Mean	14.60	16.20	18.20	16.00	
Factors	M	S	M x S		
S.Em±	0.61	0.53	1.06		
CD (0.05%)	1.80	1.56	3.12		

Storage methods (M): M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber; M_4, ZECC + polyethylene bag with 0.5% vents.
Seed treatment (S): S_1, Control; S_2, Ridomil MZ (3 g/l); S_3, *Trichoderma harzianum* (5 g/kg seed rhizome).

Data on pseudostem girth due to seed storage methods and seed treatments and their interaction are presented in table 6. Maximum pseudostem girth (3.14 cm) was recorded in seed rhizome stored under ZECC followed by rhizome stored under 250 gauge polyethylene bag with 0.5 per cent vents (2.79 cm). Minimum pseudostem girth (2.42 cm) was obtained in seed rhizome stored in sand layers. Regarding seed treatments, highest pseudostem girth (3.11 cm) was recorded in seed rhizome treated with *Trichoderma harzianum* (5 g/kg) followed by Ridomil MZ (3 g/l) treated rhizome (2.69 cm). The crop produced from untreated seed rhizome recorded the lowest pseudostem girth (2.54 cm). Among the interaction effects, pseudostem girth was highest in ZECC + *Trichoderma harzianum* (5 g/kg) (3.41 cm) whereas lowest was recorded in sand layers + control (2.32 cm).

Yield per hectare was also significantly influenced by seed storage methods, seed treatments and their interactions (Table 7). Regarding seed storage methods, maximum yield per hectare (20.54 t) was recorded in seed rhizome stored under ZECC which was on par with seed rhizome stored under 250 gauge polyethylene bag with 0.5 per cent vents (17.98 t). However, the seed rhizome stored under sand layer recorded significantly lowest yield (13.37 t/ha). Among seed treatments, *Trichoderma harzianum* (5 g/kg) treated rhizome recorded highest rhizome yield per hectare (18.84 t) which was on par with rhizome treated with Ridomil MZ (3 g/l) (16.70 t). Lowest yield per hectare (15.59 t) was recorded in seed rhizome without seed treatment. The interaction effect between storage methods and seed rhizome treatment produced significant results. Highest rhizome yield per

Table 6: Effect of storage methods and seed rhizome treatment on pseudostem girth (cm) at 150 days after planting in ginger var. Humnabad

Factors	M_1	M_2	M_3	M_4	Mean
S_1	2.32	2.51	2.84	2.46	2.54
S_2	2.38	2.62	3.16	2.59	2.69
S_3	2.57	3.24	3.41	3.20	3.11
Mean	2.42	2.79	3.14	2.75	
Factors	M	S	M x S		
S.Em±	0.08	0.07	0.13		
CD (0.05%)	0.22	0.19	0.38		

Storage methods (M): M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber; M_4, ZECC + polyethylene bag with 0.5% vents.
Seed treatment (S): S_1, Control; S_2, Ridomil MZ (3 g/l); S_3, *Trichoderma harzianum* (5 g/kg seed rhizome).

Table 7: Effect of storage methods and seed rhizome treatment on fresh rhizome yield (t/ha) at 150 days after planting in ginger var. Humnabad

Factors	M_1	M_2	M_3	M_4	Mean
S_1	11.84	15.94	19.21	15.36	15.59
S_2	13.49	17.51	20.07	15.75	16.70
S_3	14.77	20.48	22.35	17.78	18.84
Mean	13.37	17.98	20.54	16.29	
Factors	M	S	M x S		
S.Em±	0.90	0.78	1.56		
CD (0.05%)	2.64	2.28	4.56		

Storage methods (M): M_1, Sand layers; M_2, 250 gauge polyethylene bag with 0.5% vents; M_3, Zero energy cool chamber; M_4, ZECC + polyethylene bag with 0.5% vents.
Seed treatment (S): S_1, Control; S_2, Ridomil MZ (3 g/l); S_3, *Trichoderma harzianum* (5 g/kg seed rhizome).

hectare (22.35 t) was recorded in ZECC + *Trichoderma harzianum* (5 g/kg) followed by 250 gauge polyethylene bag with 0.5% vents + *Trichoderma harzianum* (5 g/kg) (20.48 t). Lowest rhizome yield per hectare was recorded in sand layers + control (11.84 t). The growth and yield characters of ginger was maximum in rhizome stored under ZECC treated with *Trichoderma harzianum* which may be due to the quicker and increase germination percentage of rhizome treated with the bio-agent under favourable storage conditions (Mukhtar 2008; Windham et al. 1986). The quicker and higher germination of rhizome resulting in optimum vegetative growth with more number of leaves and vigorous growth attributes of clump leading to higher photosynthesis, higher translocation of photosynthates to rhizome which ultimately increased the rhizome yield.

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