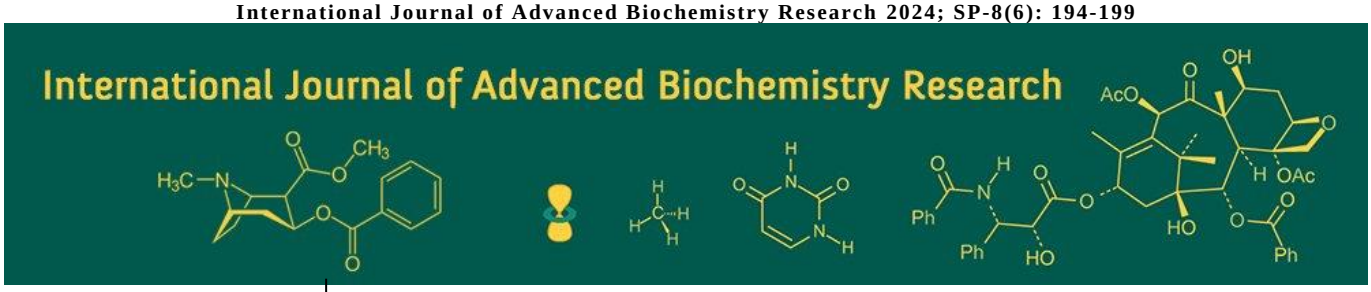

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Influence of modified atmospheric packaging on seed quality parameters during storage in onion seed (*Allium cepa* L.)

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Abstract
A lab experiment was conducted from June 2021 to Nov 2022 at NSP, Seed unit, UAS, Dharwad. The experimental design was completely randomised design having 3 replications and packed with different combination mixture of gases like N_2, CO_2, and O_2 stored for 18 months of period. Seed quality parameters like speed of germination, mean seedling length and mean germination time were evaluated at bimonthly intervals, the results revealed that the treatment with onion seeds packed in vacuum packaging (T_{22}= Vacuum)) gave good results at the end of the 18 months of storage period. Speed of germination (39.47), mean seedling length (17.62 cm) and mean germination time (1.42 days) respectively compared to other treatments stored in different combination of gases and followed by treatment (T_1= 70% CO_2: 05% O_2: 25% N_2) speed of germination (32.27), mean seedling length (15.88 cm) and mean germination time (1.50 days) respectively.

Keywords: Vacuum packaging, speed of germination, mean seedling length, mean germination time

1. Introduction
Onion (*Allium cepa* L.) is considered one of the important vegetables among bulb crops which comes under the family Amaryllidaceae. It occupies a major position in the world as it is cultivated in the majority of the countries and has a huge demand for its consumption. Seed is the basic and crucial input in agriculture. Seeds are practically worthless if, they fail to give healthy and vigorous plants upon planting. The successful production of any crop depends on the quality of the seeds used for sowing. Although seed quality is governed by genetic makeup, seed storage and retention of viability are important for seed vigour (Deepa *et al.*, 2013) [8].

Majorly the initial quality of seeds, moisture level, relative humidity (RH%) and storage conditions have considerable influence on seed storability. However, if the seeds are stored in controlled conditions it is suitable for maintenance of the seed quality for a longer duration. As onion seed is one of short lived compared to other crop species so seed sellers practice mixing old seeds with freshly harvested seeds to get more profits. This practice results in decreasing transplants required in the field. Prolong the storage period, especially in natural environments under tropical and subtropical areas, seed deterioration will be higher. Seed viability and vigour may decline due to deterioration processes as it is an inexorable and irreversible process, which leads to an increase in the free radicals and their chain elongation, modifications in the structure of proteins, food reserves depletion, increase in fat acidity, alterations in the activity of enzymes, membrane related damages, chromosomal aberrations and finally increase in the respiration rate of the seeds. Normally the extent of deterioration will increase when seed moisture levels and the temperature of the storage place increases. Moist seeds and increased storage temperatures cause injury to the seed (Ellis *et al*., 1981) [9]. Irrespective of initial seed quality, unfavourable storage conditions, and relative humidity, contribute to accelerating seed deterioration during storage. Hence, it is difficult to assess the effective storage period because the storability of the seed is a function of initial seed quality and the storage conditions and may vary among different seed types (Anfinrud, 1997; Fabrizius *et al*. 1999; Heatherly and Elmore, 2004) [2, 10, 11].

Modified atmosphere storage is one of the seed and food preservation methods that maintain the natural quality of seed and food products besides extending the storage of food products and activity or inactivity of insects or microorganisms in seeds and food products (Moltas *et al*., 2002) [14].
Disinfestations of stored seeds using modified atmospheric storage involves the alteration of natural gases such as N_2, CO_2 and O_2 to render the atmosphere in the atmosphere storage lethal to pests.

2. Materials and Methods
A lab experiment was conducted from June 2021 to Nov 2022 at NSP, Seed unit, UAS, Dharwad. The experimental design was completely randomised design having 3 replications and stored for 18 months of period in vacuum packed bags and seed quality parameters like speed of germination, mean seedling length and mean germination time were evaluated.
Arka Kalyan variety was selected for the study. The seed is obtained from University of horticultural sciences, Bagalkot. The readings were taken on a bimonthly basis.

2.1 Speed of germination
A hundred seeds of four replications were kept for germination on paper medium. The number of seeds germinated was recorded daily up to the day of the final count. The speed of germination was calculated by using the formula suggested by Maguire (1962) [13].

$$\text{Speed of germination} = \frac{G_1}{D_1} + \frac{G_2}{D_2} + \ldots\ldots\ldots + \frac{G_n}{D_n}$$

Where,
G_1, G_2, --- G_n are the number of seeds germinated on D_1, D_2, --- D_n day

2.2 Mean seedling length (cm)
Ten normal seedlings were randomly selected from each treatment and replication and then carefully separated from the wet paper towel of the germination test. The total length of the seedling was measured from the tip of the primary root to the tip of the primary leaf by using a measuring scale. The mean of ten seedlings from each treatment in each replication was calculated and is expressed in centimetres (Anon., 2010) [3].

2.3 Mean germination time (MGT, days)
Seeds were put for germination by following between paper method by placing 100 seeds. The numbers of seeds germinated were recorded on a daily basis. The mean germination time was calculated by following the formula as suggested by Azimi *et al*. (2013) [4].

$$\text{Mean germination time} = \frac{(n1 \times d1) + (n2 \times d2) + \ldots\ldots}{\text{Total number of seeds germinated}}$$

Where,
n: number of seeds germinated on each day
d: number of days

3. Results and discussion
3.1 Speed of germination
The results of speed of germination is given in table 1. Initially, the speed of germination was 47.36, as the storage period progressed the speed of germination got decreased from 46.58 in the second month to 39.47 at the 18th month of storage period. As the storage period progressed the speed of germination got decreased in all the months of storage period. But in the case of vacuum packed storage (T_{22}) there was seen a less decrease in the speed of germination compared to other treatments. Then it is followed by T_1 (70% CO_2: 05% O_2: 25% N_2). The more decrease was observed in T_{21} Atmospheric air (78% N_2: 21% O_2) (Control).

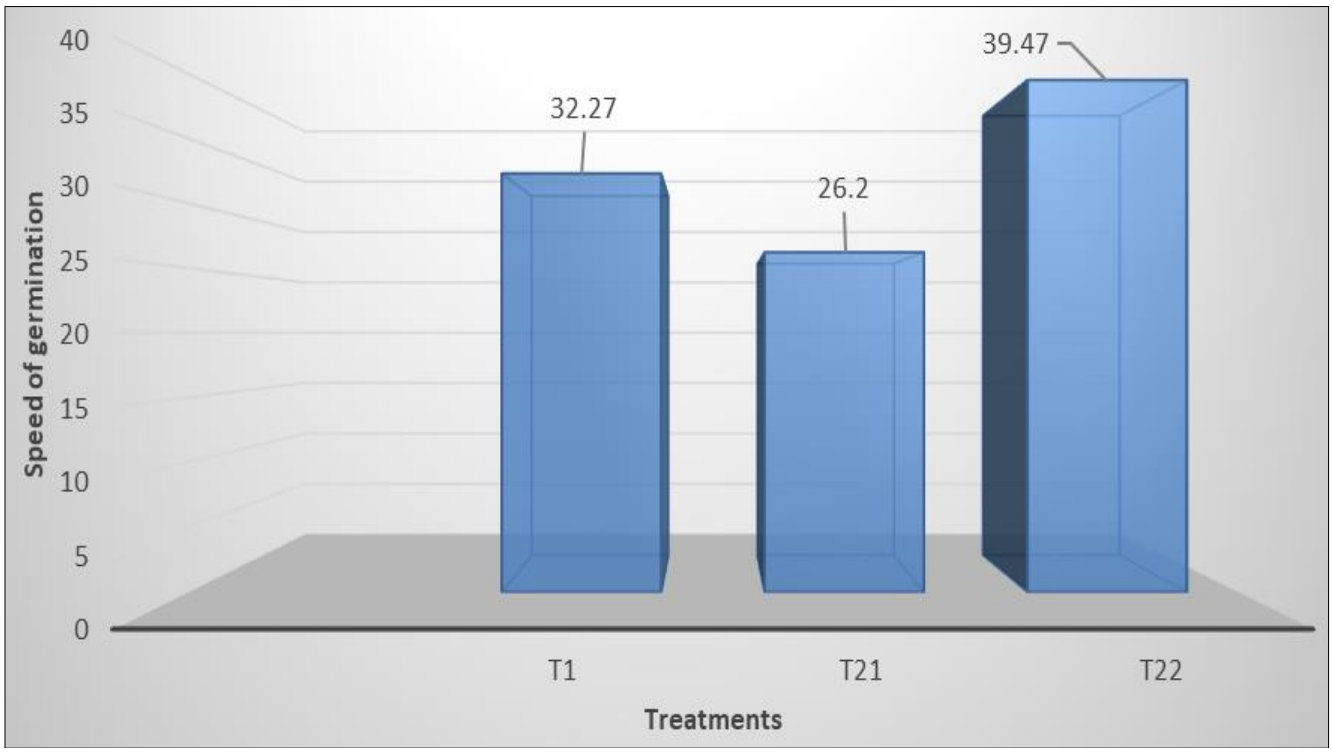

Fig 1: Effect of modified atmospheric storage on the speed of germination in onion seed after 18 months of storage

3.2 Mean seedling length (cm)

The results of mean seedling length are given in table 2. Initially, the mean seedling length was 20.80 cm, as the storage period progressed the mean seedling length got decreased from 20.55 cm in the second month to 17.62 at the end of the 18th month of storage period. As the storage period progressed the mean seedling length got decreased in all the months of storage period. In case of vacuum packed storage (T_{22}), there was seen a least decrease in mean seedling length compared to other treatments. Then it is followed by T_1 (70% CO_2: 05% O_2: 25% N_2). The more decrease was observed in T_{21} Atmospheric air (78% N_2: 21% O_2) (Control).

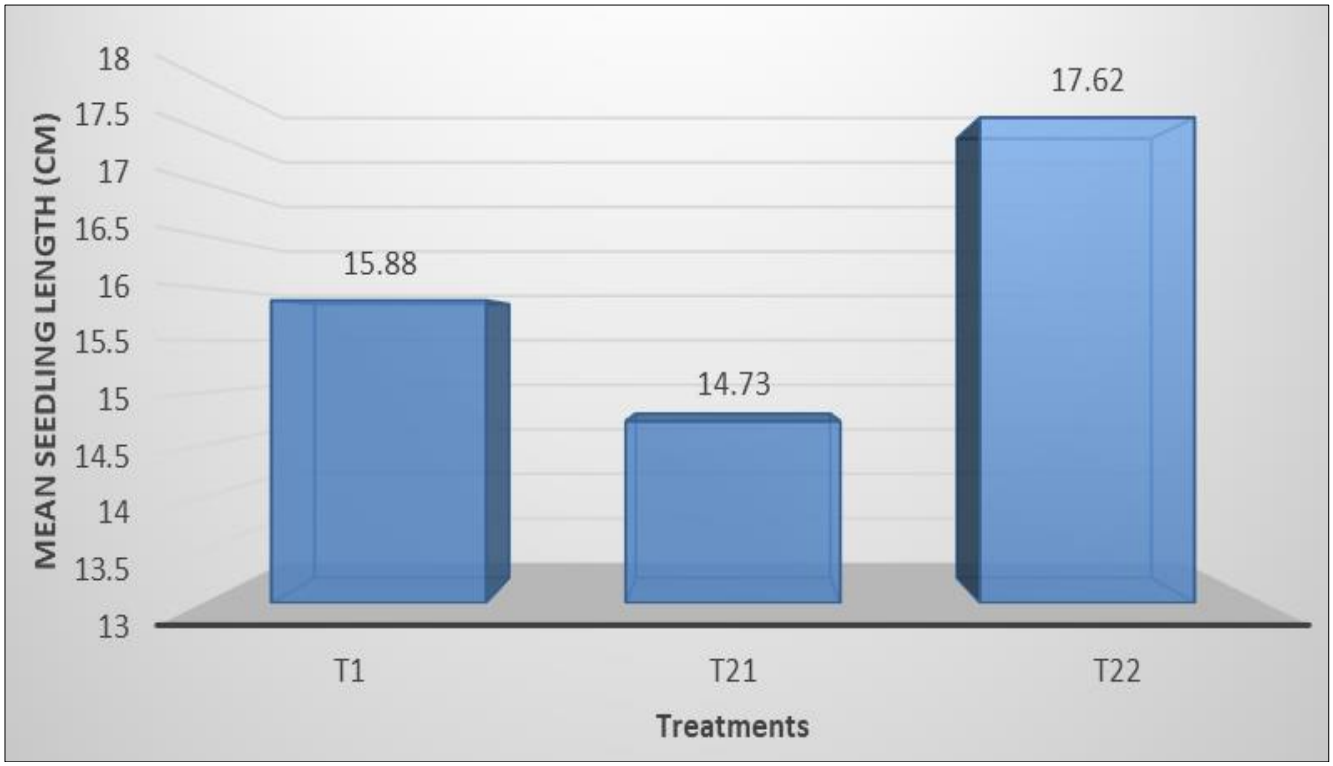

Fig 2: Effect of modified atmospheric storage on Mean seedling length in onion seed after 18 months of storage

3.3 Mean germination time (MGT, days)

The results of mean germination time are given in table 3. Initially, the mean germination time was 1 day, as the storage period progressed the mean germination time increased from 1.00 days in the second month to 1.42 days at the end of 18th month of storage period. As the storage period progressed the mean germination time got increased in all the months of the storage period. In case of vacuum packed storage (T_{22}), there was seen a least decrease in mean germination time compared to other treatments. Then it is followed by T_1 (70% CO_2: 05% O_2: 25% N_2). The more decrease was observed in T_{21} Atmospheric air (78% N_2: 21% O_2) (Control).

As the storage progressed the deterioration occurred due to the high respiration rate increased due to high moisture content. As the storage period advances the vigour of the seed declines due to catabolic activity going on in the seed and thus the seed though viable, yet fails to emerge. The decline in seed vigour depends on storage condition that is temperature, relative humidity and seed moisture contents. High temperature, relative humidity and moisture in the storage environment appear to be principle factors involved in the deterioration of seed quality. Speed of germination decreases as the storage prolongs due to high metabolic activity, high respiration, production of reactive oxygen species (ROS) and high electrolyte leachates from the seed surface. The variation in speed of germination among the storage materials implies that this might be due to differences in temperature, RH, and moisture content that each storage material has. These findings are in accordance with Cabrera and Lansakara (2002) [7]. Alhamdan *et al.*, (2011) [1] reported that seeds of onion stored at 5°C had the highest speed of germination. The mean seedling length of the seed decreases as the storage period progressed because of the reduction in the availability of food materials in the seed to grow and the dry matter of seed is also decreased with less mean seedling length. Similar findings were reported by Balesevic-Tubic *et al.*, (2010) [5] in oil seed crops, Khalequzzaman *et al.*, (2012) [12] in French bean, Basavegowda *et al.*, (2013) [6] in chickpea, Patel *et al.*, (2017) [15] in onion. Mean germination time in days increased due to loss of cell membrane integrity with the advancement in the storage period as membrane integrity of the seed has a greater influence on seed performance.

Table 1: Influence of modified atmospheric packaging on the speed of germination of onion seeds at different intervals of storage

Treatments	Storage (Months)								
	2	4	6	8	10	12	14	16	18
T_1 = 70% CO_2: 05% O_2: 25% N_2	46.15	45.50	44.68	42.16	40.25	39.21	37.04	34.70	32.27
T_2 = 65% CO_2: 05% O_2: 30% N_2	45.63	44.94	43.81	41.73	39.82	38.26	36.69	34.44	31.75
T_3 = 60% CO_2: 05% O_2: 35% N_2	45.24	44.33	43.46	41.38	39.64	37.91	36.09	34.35	31.32
T_4 = 55% CO_2: 05% O_2: 40% N_2	44.66	44.11	43.03	41.12	39.38	37.74	35.39	34.09	30.93
T_5= 50% CO_2: 05% O_2: 45% N_2	44.46	43.72	42.77	40.68	39.04	37.65	35.13	33.66	30.71
T_6= 65% CO_2: 10% O_2: 25% N_2	44.94	44.15	43.46	41.38	39.90	37.74	35.57	33.83	31.75
T_7= 60% CO_2: 10% O_2: 30% N_2	44.68	43.72	42.77	41.03	39.64	37.82	35.39	33.83	31.58
T_8= 55% CO_2: 10% O_2: 35% N_2	44.41	43.55	42.42	40.68	39.47	37.74	35.09	33.74	31.49
T_9= 50% CO_2: 10% O_2: 40% N_2	44.15	43.20	42.25	40.34	39.21	37.30	34.87	33.14	30.88
T_{10}= 45% CO_2: 10% O_2: 45% N_2	43.72	42.85	41.94	40.16	39.04	37.21	34.70	33.14	30.54
T_{11}= 60% CO_2: 15% O_2: 25% N_2	44.24	43.46	42.51	40.86	39.82	37.39	35.13	33.48	30.19
T_{12}= 55% CO_2: 15% O_2: 30% N_2	43.81	43.03	42.25	40.42	39.56	37.21	34.87	33.22	29.41
T_{13}= 50% CO_2: 15% O_2: 35% N_2	43.37	42.64	41.73	40.16	39.21	37.04	34.57	32.96	29.23
T_{14}= 45% CO_2: 15% O_2: 40% N_2	43.03	42.16	41.55	39.99	38.95	36.95	34.35	32.88	28.80
T_{15}= 40% CO_2: 15% O_2: 45% N_2	42.85	41.90	41.12	39.82	38.52	36.69	34.02	32.18	28.28
T_{16}= 55% CO_2: 20% O_2: 25% N_2	43.98	42.42	42.25	40.34	39.47	37.30	34.79	33.05	27.85
T_{17}= 50% CO_2: 20% O_2: 30% N_2	43.72	41.90	42.07	39.99	39.21	37.21	34.61	32.70	27.15
T_{18}= 45% CO_2: 20% O_2: 35% N_2	43.37	41.81	41.81	39.82	39.04	36.95	34.35	32.62	27.07
T_{19}= 40% CO_2: 20% O_2: 40% N_2	42.94	41.73	41.55	39.30	38.78	36.74	34.05	32.53	26.81
T_{20}= 35% CO_2: 20% O_2: 45% N_2	42.42	41.64	41.12	39.04	38.52	36.52	33.83	32.36	26.63
T_{21}= Atmospheric air (78% N_2: 21% O_2) (Control)	42.03	41.47	40.51	38.86	37.39	36.43	33.53	31.32	26.20
T_{22}=Vacuum	46.58	45.98	45.28	44.59	43.98	43.03	41.99	40.86	39.47
Mean	44.11	43.19	42.47	40.63	39.45	37.64	35.28	33.60	30.01
S. Em (±)	0.22	0.13	0.14	0.14	0.11	0.11	0.08	0.21	0.13
C. D. (1%)	0.86	0.52	0.56	0.55	0.42	0.42	0.32	0.79	0.52
C.V (%)	0.89	0.55	0.60	0.62	0.48	0.51	0.42	1.08	0.78

Table 2: Influence of modified atmospheric packaging on mean seedling length of onion seeds at different intervals of storage

Treatments	Storage (Months)								
	2	4	6	8	10	12	14	16	18
T_1 = 70% CO_2: 05% O_2: 25% N_2	19.85	19.65	19.34	18.87	18.35	17.99	17.42	16.72	15.88
T_2 = 65% CO_2: 05% O_2: 30% N_2	19.82	19.64	19.29	18.84	18.33	17.97	17.25	16.67	15.85
T_3 = 60% CO_2: 05% O_2: 35% N_2	19.80	19.60	19.24	18.80	18.30	17.95	17.23	16.60	15.84
T_4 = 55% CO_2: 05% O_2: 40% N_2	19.78	19.58	19.22	18.77	18.27	17.85	17.20	16.56	15.74
T_5= 50% CO_2: 05% O_2: 45% N_2	19.77	19.55	19.18	18.75	18.24	17.81	17.15	16.50	15.72
T_6= 65% CO_2: 10% O_2: 25% N_2	19.78	19.56	19.16	18.74	18.22	17.74	17.11	16.49	15.63
T_7= 60% CO_2: 10% O_2: 30% N_2	19.77	19.53	19.15	18.71	18.19	17.71	17.07	16.44	15.60
T_8= 55% CO_2: 10% O_2: 35% N_2	19.74	19.51	19.11	18.69	18.17	17.67	17.02	16.38	15.58
T_9= 50% CO_2: 10% O_2: 40% N_2	19.71	19.48	19.09	18.64	18.14	17.61	16.98	16.36	15.51
T_{10}= 45% CO_2: 10% O_2: 45% N_2	19.68	19.46	19.05	18.60	18.09	17.53	16.93	16.30	15.51
T_{11}= 60% CO_2: 15% O_2: 25% N_2	19.67	19.47	19.03	18.55	18.07	17.52	16.94	16.23	15.52
T_{12}= 55% CO_2: 15% O_2: 30% N_2	19.63	19.45	19.01	18.51	18.04	17.49	16.89	16.17	15.48
T_{13}= 50% CO_2: 15% O_2: 35% N_2	19.60	19.41	18.99	18.45	18.01	17.44	16.86	16.15	15.49
T_{14}= 45% CO_2: 15% O_2: 40% N_2	19.58	19.39	18.97	18.43	18.00	17.42	16.82	16.06	15.40
T_{15}= 40% CO_2: 15% O_2: 45% N_2	19.56	19.36	18.94	18.40	17.97	17.36	16.80	16.04	15.42
T_{16}= 55% CO_2: 20% O_2: 25% N_2	19.58	19.38	18.93	18.39	17.94	17.35	16.80	15.95	15.33
T_{17}= 50% CO_2: 20% O_2: 30% N_2	19.57	19.33	18.88	18.37	17.92	17.32	16.77	15.86	15.38
T_{18}= 45% CO_2: 20% O_2: 35% N_2	19.53	19.29	18.85	18.34	17.88	17.30	16.74	15.77	15.32
T_{19}= 40% CO_2: 20% O_2: 40% N_2	19.52	19.26	18.83	18.30	17.84	17.25	16.71	15.72	15.29
T_{20}= 35% CO_2: 20% O_2: 45% N_2	19.50	19.21	18.81	18.24	17.82	17.21	16.66	15.70	15.23
T_{21}= Atmospheric air (78% N_2: 21% O_2) (Control)	19.32	19.09	18.53	17.96	17.53	16.50	16.09	15.13	14.73
T_{22}=Vacuum	20.55	20.22	19.86	19.42	19.12	18.56	18.25	17.87	17.62
Mean	19.70	19.47	19.07	18.58	18.11	17.57	16.99	16.26	15.59
S. Em (±)	0.04	0.009	0.009	0.01	0.01	0.01	0.09	0.01	0.08
C. D. (1%)	0.16	0.03	0.03	0.04	0.05	0.06	0.35	0.06	0.32
C.V (%)	0.38	0.08	0.08	0.10	0.12	0.17	0.95	0.17	0.94

Table 3: Influence of modified atmospheric packaging on Mean germination time (days) of onion seeds at different intervals of storage

Treatments	Storage (Months)								
	2	4	6	8	10	12	14	16	18
T_1 = 70% CO_2: 05% O_2: 25% N_2	1.25	1.25	1.25	1.25	1.33	1.33	1.33	1.50	1.50
T_2 = 65% CO_2: 05% O_2: 30% N_2	1.17	1.17	1.17	1.25	1.17	1.33	1.33	1.50	1.50
T_3 = 60% CO_2: 05% O_2: 35% N_2	1.08	1.08	1.25	1.25	1.33	1.33	1.33	1.42	1.50
T_4 = 55% CO_2: 05% O_2: 40% N_2	1.17	1.25	1.25	1.25	1.42	1.42	1.42	1.42	1.50
T_5= 50% CO_2: 05% O_2: 45% N_2	1.17	1.25	1.25	1.25	1.42	1.42	1.42	1.42	1.50
T_6= 65% CO_2: 10% O_2: 25% N_2	1.17	1.17	1.17	1.25	1.17	1.33	1.42	1.42	1.50
T_7= 60% CO_2: 10% O_2: 30% N_2	1.25	1.25	1.25	1.25	1.42	1.42	1.42	1.50	1.50
T_8= 55% CO_2: 10% O_2: 35% N_2	1.25	1.25	1.33	1.33	1.42	1.42	1.42	1.42	1.50
T_9= 50% CO_2: 10% O_2: 40% N_2	1.25	1.25	1.25	1.25	1.33	1.42	1.42	1.42	1.50
T_{10}= 45% CO_2: 10% O_2: 45% N_2	1.17	1.17	1.17	1.25	1.33	1.42	1.42	1.42	1.50
T_{11}= 60% CO_2: 15% O_2: 25% N_2	1.17	1.17	1.25	1.25	1.33	1.42	1.42	1.50	1.50
T_{12}= 55% CO_2: 15% O_2: 30% N_2	1.17	1.17	1.17	1.25	1.33	1.42	1.42	1.50	1.50
T_{13}= 50% CO_2: 15% O_2: 35% N_2	1.17	1.17	1.25	1.25	1.33	1.42	1.42	1.50	1.50
T_{14}= 45% CO_2: 15% O_2: 40% N_2	1.25	1.25	1.25	1.25	1.33	1.42	1.42	1.50	1.50
T_{15}= 40% CO_2: 15% O_2: 45% N_2	1.17	1.17	1.17	1.25	1.33	1.42	1.42	1.50	1.50
T_{16}= 55% CO_2: 20% O_2: 25% N_2	1.17	1.17	1.25	1.25	1.33	1.42	1.42	1.50	1.50
T_{17}= 50% CO_2: 20% O_2: 30% N_2	1.17	1.17	1.17	1.17	1.42	1.42	1.42	1.50	1.50
T_{18}= 45% CO_2: 20% O_2: 35% N_2	1.17	1.17	1.25	1.25	1.42	1.42	1.42	1.50	1.50
T_{19}= 40% CO_2: 20% O_2: 40% N_2	1.17	1.17	1.17	1.17	1.42	1.42	1.50	1.50	1.50
T_{20}= 35% CO_2: 20% O_2: 45% N_2	1.17	1.17	1.17	1.17	1.42	1.42	1.50	1.50	1.50
T_{21}= Atmospheric air (78% N_2: 21% O_2) (Control)	1.25	1.33	1.42	1.50	1.58	1.58	1.58	1.58	1.67
T_{22}=Vacuum	1.00	1.08	1.08	1.17	1.25	1.33	1.33	1.42	1.42
Mean	1.19	1.20	1.22	1.25	1.36	1.41	1.42	1.47	1.50
S. Em (±)	0.07	0.07	0.05	0.03	0.08	0.08	0.08	0.05	0.02
C. D. (1%)	NS	NS	NS	0.15	NS	NS	NS	NS	0.09
C.V (%)	10.38	10.25	8.34	5.50	11.11	10.94	10.41	6.26	2.89

NS: Non Significant (Initial = 1.00 days)

4. Conclusion

It is concluded that the speed of germination and mean seedling length were highest in treatment T_{22} (vacuum packed storage) compared to all other treatments at end of the storage period (18 months). It will be useful for farmers as the seeds germinate and emerge within less period and favours early harvesting. The lowest mean germination time (MGT) was recorded in T_{22} (vacuum packed storage) as this also favours early germination and early harvesting.

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