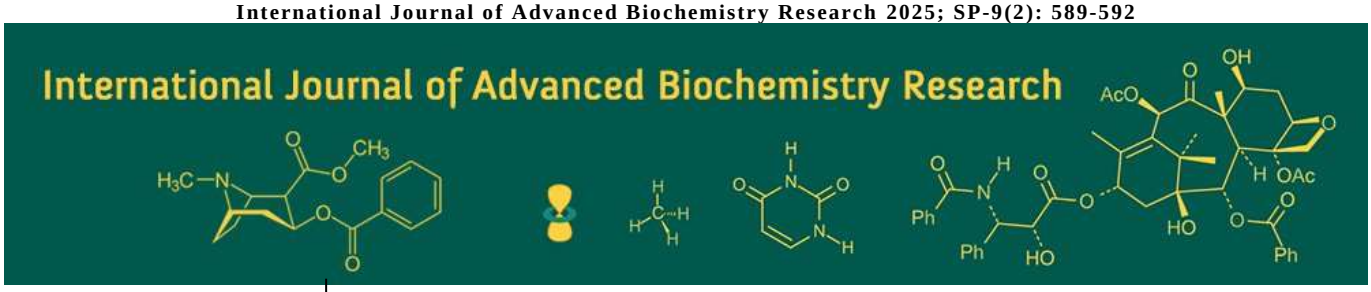

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Impact of storage containers on moisture content and germination of Indian mustard

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Abstract
The present investigation was carried out to evaluate the mustard seed quality under different storage conditions. Indian mustard (*Brassica juncea* L.) variety BIO-902 seed stored for eighteen months in tin container, aluminium foil, polythene bag and cloth bag at room temperature. The initial moisture content of the seed was 10.16% but after eighteen months (540 days) it was increased with moisture and humidity with time period in tin container, aluminium foil, polythene bag, cloth bag 15.33%, 16.52%, 17.26%, 17.37%. The initial standard germination percentage in seed was 88.23% however, after storage for eighteen months in tin container, aluminium foil, polythene bag and cloth bag it was declined to 20.00%, 15.00%, 12.23%, 10.77%. The initial speed of germination index percentage in seed was 53.00% however, after storage for eighteen months in tin container, aluminium foil, polythene bag and cloth bag it was declined to 15.77%, 10.23%, 8.23% and 6.77% respectively. Storage condition affects the moisture content and normal germination. The study revealed that for seed storage tin container was better significant than aluminium foil, polythene bag, cloth bag for mustard seeds.

Keywords: BIO-902, germination, mustard, seed quality, tin

Introduction
The oilseed plant of Brassica species is also called as rapeseed-mustard, which is the most important Rabi oilseed crop in agriculture. Mustard seeds play as crucial edible oilseed crops in worldwide. The term 'Rape' is derived from the Latin word 'rapum,' signifying turnip and the term 'Mustard' originates from the Latin 'must' or 'mustum,' denoting unfermented grape juice, and 'ardens,' meaning hot and burning (Ahlawat, 2008) [1]. Indian mustard (*Brassica juncia* L.) is belongs to the family of Cruciferae (Brassicaceae). The family Brassicaceae are containing about 350 genera and 3500 species. It is one of the ten most economically important plant families with a wide range in agriculture production. Brassica is the important oilseed plant. In India Brassica species have been cultivated since Vedic times. Mustard seeds are being used for many purposes, that is, edible oil, vegetable, condiments, medicine, fodder preparation and seasoning of food articles, and so forth. They have also been used as medicine and condiments (Suma A. *et al*., 2013) [18]. In any agriculture field the seed quality is significantly impacts crop yield and productivity. The high quality of seeds are essential inputs that contribute to increased productivity and greater financial returns per unit area (Dutta, 2017; Hemming *et al*., 2018) [8, 10]. Seeds require favourable as suitable storage due to the temporal gap of six months or longer, between harvesting and subsequent sowing. The quality of seed as well as preservation during storage is crucial role for maintaining acceptable levels of seed germination and vigour until sowing. The study of highlighted the influence of storage containers on quality of seed over time (Bortey *et al*., 2016; Moharana *et al*., 2017) [5, 13]. In any agriculture field seed quality and the natural seed deterioration of stored seeds poses a significant scientific challenge of global concern. Various biotic and abiotic factors, including crop genotype, initial seed quality, storage containers, and storage conditions, contribute to seed deterioration under improper storage conditions. Among these factors, storage temperature and moisture content are pivotal, with moisture content usually exerting a more pronounced influence than temperature (Ray and Bordolui, 2022) [16]. For seed viability and seedling vigour significantly affect packaging container as well as storage (Rao *et al*., 2006; Chakraborty *et al*., 2020) [15, 6].

During storage period maintenance of seed quality is important as well as the crop production in throughout the year but also for the maintenance integrity of the seeds because of their constant threat and of genetic erosion. In agriculture farmers face many problems regarding to storing seed. So, the present study was undertaken to identify the best storage container for storing mustard seed, (*Brassica juncea* L.) variety BIO-902.

Materials and Methods

The present experiment was conducted at the laboratories of Department of Botany, RTMNU, Nagpur and Govt. seed testing lab, Nagpur. This study was conducted during the period from Jan 2023 to June 2024 and evaluate the mustard seed quality under different storage conditions. The seed of Indian mustard (*Brassica juncea* L.) variety BIO-902 which was stored in four different storage condition i.e. tin container (C1), aluminium foil (C2), polythene bag (C3), and cloth bag (C4) and period of storage T_1 (0 day), T_2 (90 days), T_3 (180 days), T_4 (270 days), T_5 (360 days), T_6 (450 days) and T_7 (540 days) at the room temperature for 180 months (540 days) at room temperature. Seeds were collected from Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Nagpur. Seeds were used for the moisture content, standard germination percentage and speed of germination. The experiment was statistically analyzed by using factorial design CRD (Completely Randomized Design). The standard errors and critical differences between the parameters like mustard seed variety, container and storage period were worked out at five percent significance. During the storage period, seed samples were taken after three months (90 days) from each container for physiological observation of three parameters determination of moisture content, determination standard germination test percentage and speed of germination.

Determination moisture percentage

The standard method for determining moisture in seed was followed using hot air oven. The mustard seeds were finely ground was used for moisture determination. 5 gm of sample was weighed directly into the container. After weighing, the container with seeds (lid kept separately) was placed in the oven which has already been heated to the drying temperature. In this experiment the "low constant temperature method" was followed involving drying at 103 °C for 17 hours. The oven drops in temperature when the sample is placed in it and hence the drying period was counted from the moment only when oven regained the required temperature. At the end of drying period the container along with the lid was allowed to cool 30 to 45 minutes in desiccator and then it was weighed again. The moisture content in percentage was calculated as follows.

$$M.C.\% = \frac{M2\text{-}M3}{M2\text{-}M1} \times 100 \text{ (Nema, 1986) [14]}$$

Where
M1 = Weight of empty container with lid
M2 = Weight of container with lid and seed before drying
M3 = Weight of container with lid and seed after drying and cooling.

Determination of germination percentage

Standard germination procedure as described in the International Seed Testing Association Rules (Anonymous, 1985) [3], were followed seeds varieties. Four replications of 100 seeds of respective kinds were kept between the folded moist towel papers. These were then placed in a tray positioned at a 45° inclination at constant temperature of 25±0.5 °C and 85±3% relative humidity in germination chamber. The first count was noted on 5th day and final on 8th day of germination. Only normal seedlings having characteristics laid down in I.S.T.A. (International Seed Testing Association) rules for testing seeds were taken in to account and abnormal and dead seedling were excluded. The percentage of germination was calculated by counting the number of normal seedlings to the total number of seeds put for germination.

Speed of Germination (Vigour index)

The speed of germination was calculated as per the procedure laid down in standard germination test on 1st, 2nd, 3rd, 4th and 5th day. The result of Seedling count was taken from second day onwards until completion of the test. Seeds with radicle and plumule protruding were counted and removed from the towel paper before the latter were returned to the seed germination. This practice of removing the germinated seedlings from towel papers was continued up to the end of that particular test. At the end of the test, the germination index was calculated. The number of germinated seedlings counted each day was divided by number of days to that count. The values obtained at each count are summed up to obtain the germination index (Maguire, 1962) [12].

$$\frac{n1}{1} + \frac{n2}{2} + \frac{n3}{3} - - - - - = N\ (GI)$$

n_1, n_2, n_3, are number of seeds germinated in 1st, 2nd and 3rd days
N-Germination Index

Results and Discussion

In the present study moisture contents of mustard seed stored in different containers have presented in table 1. The result showed that moisture percentage increased with increase in time period and seed moisture appeared significant difference after 540 days of storage. The initial moisture content of the seed was (10.16%) but after 18 months (540 days) it was increased with time period. In mustard variety BIO-902, Tin container, Aluminium foil, Polythene bag and Cloth bag showed fluctuations in moisture content of seeds during storage according to temperature and relative humidity of the atmosphere. A significant minimum fluctuation of moisture content was observed in Tin container. Seed stored in Tin container showed significantly lower moisture content (15.33%) as compared to those stored in Aluminium foil (16.52%), Polythene bag (17.26%) and Cloth bag (17.37%) up to 540 days (T_7) days of the storage. Among the containers Tin container showed significantly lower mean moisture content (13.29%) as compared to Aluminium foil (14.19%), Polythene bag (14.49%) and Cloth bag (15.09%) throughout the storage period. Similar findings were reported by Tithi *et al*., (2010) [19] in mustard seeds. Doijode (1997) [7] reported similar kind of findings in Okra.

The standard germination percentage of mustard seed stored in different containers have presented in table 2. In mustard variety BIO-902, the standard germination significantly

decreased with increase in storage period. The rate of loss in standard germination varied with the type of container used. The initial standard germination test of the seed was (88.23%) but after the storage 18 months (540 days) in tin container, aluminium foil, polythene bag, cloth bag it was declined. Seeds stored in Tin showed significantly higher standard germination (20.00%) as compared to those stored in Aluminium foil (15.00%), Polythene bag (12.23%) and Cloth bag (10.77%) up to 540 days (T_7) days of the storage. Among the containers Tin showed significantly higher mean of standard germination (63.86%) as compared to Aluminium foil (61.71%), Polythene bag (57.81%) and Cloth bag (54.39%) throughout the storage period. Similar findings were reported by Guha *et al*., (2012) [9] in okra seeds. Saisantosh and Patil (2018) [17] also observed a continuous decrease in the germination percentage in onion seeds with a progressive extension in storage duration.

The speed of germination index percentage of mustard seed stored in different containers have presented in table 3. In mustard variety BIO-902, the speed of germination index significantly decreased with increase in storage period. The rate of loss in speed of germination index varied with the type of container used. The initial speed of germination index test of the seed was (53.00%) but after the storage 18 months (540 days) in tin container, aluminium foil, polythene bag, cloth bag it was declined. Seeds stored in Tin showed significantly higher speed of germination index (15.77%) as compared to those stored in Aluminium foil (10.23%), Polythene bag (8.23%) and Cloth bag (6.77%) up to 540 days (T_7) days of the storage. Among the containers Tin showed significantly higher mean of speed of germination index (35.17%) as compared to Aluminium foil (31.20%), Polythene bag (29.17%) and Cloth bag (26.42%) throughout the storage period. Basavegowda *et al*., (2013) [4] reported that, commercial storage at 5-7 °C and 65% relative humidity exhibited the highest seed vigour, while working on chickpea. So, the present study was revealed that tin container better storage for seeds as compared to aluminium foil, polythene bag and cloth bag.

Table 1: Moisture content (%) of mustard seeds stored in different containers.

Storage Period	Different Containers			
	Tin container	Aluminium foil	Polythene bag	Cloth bag
T_1	10.16	10.16	10.16	10.16
T_2	11.62	12.35	12.62	13.52
T_3	12.84	13.88	14.12	14.62
T_4	13.82	14.72	14.82	16.22
T_5	14.44	15.61	15.92	16.63
T_6	14.86	16.10	16.53	17.12
T_7	15.33	16.52	17.26	17.37
Mean	13.29	14.19	14.49	15.09
SE (m)	0.549	0.546	0.541	0.611
CD (P=5%)	1.666	1.656	1.641	1.853

Table 2: Standard Germination (%) of mustard seeds stored in different containers.

Storage Period	Different Containers			
	Tin container	Aluminium foil	Polythene bag	Cloth bag
T_1	88.23	88.23	88.23	88.23
T_2	82.23	80.77	78.00	72.77
T_3	77.00	74.77	70.77	66.00
T_4	72.77	70.00	65.23	58.77
T_5	66.77	65.00	60.23	55.00
T_6	40.00	38.23	30.00	29.23
T_7	20.00	15.00	12.23	10.77
Mean	63.86	61.71	57.81	54.39
SE (m)	1.194	1.304	1.126	1.145
CD (P=5%)	3.623	3.957	3.417	3.475

Table 3: Germination Index (speed of germination) (%) of mustard seeds stored in different containers.

Storage Period	Different Containers			
	Tin container	Aluminium foil	Polythene bag	Cloth bag
T_1	53.00	53.00	53.00	53.00
T_2	51.23	45.23	43.23	41.00
T_3	43.00	38.00	36.23	32.23
T_4	35.23	30.23	28.00	25.00
T_5	28.77	25.77	22.77	17.00
T_6	19.23	16.00	12.77	10.00
T_7	15.77	10.23	8.23	6.77
Mean	35.17	31.20	29.17	26.42
SE (m)	1.186	1.049	1.097	1.048
CD (P=5%)	3.597	3.182	3.329	3.178

Conclusion

The present study was concluded that moisture content, standard germination and speed of germination index rates were better significant in seeds stored in air tight tin container as compared to aluminium foil, polythene bag and cloth bag. Storage condition affects the production of normal germination and dead seedlings, and the study revealed that for seed storage in air tin container was better than aluminium foil, polythene bag, cloth bag for mustard seed.

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