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Effect of Storage Containers on Seed Quality of Barley (*Hordeum vulgare* L.) during Storage

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ABSTRACT: The study was conducted on seeds of three two-rowed varieties *viz.* BH 885, DWRB 92, DWRB 101 and three six-rowed rowed barley varieties *viz.* BH 946, BH 393, BH 902 at CCS HAU, Hisar, Haryana (India) during 2020-21. The seeds of all barley varieties were stored in ordinary (Cloth bags) and moisture-proof (Polythene bags>700gauge thickness) containers under ambient conditions and observations were recorded on seed quality parameters upto 9 months at three months. The results revealed that maximum test weight (48.71g), dry seedling weight (234.00mg), and vigour index-II (20608) were recorded in DWRB 92. Variety BH 393 recorded maximum seedling length (27.83cm) and minimum test weight (26.64g), and germination (94.33%). Variety DWRB 101 recorded maximum germination (97.67%) and vigour index-I (2488) while this variety recorded minimum seedling dry weight (161.50mg) and vigour index-II (14946) after 9 months of storage. Variety BH 902 recorded maximum electrical conductivity (196.64 µS/cm/seed) and BH 885 recorded minimum (148.24 µS/cm/seed).The highest value of field emergence (8.90) index was observed in BH 393, while the lowest (6.07) was in BH 946. Topseedling establishment(89.83%) was observed in BH 393, whileminimum (85.83%) was in BH 885.Polythene bag recorded more test weight (39.08g), germination (94.61%), seedling length (28.70cm), seedling dry weight (193.72mg), vigour index-I (2599), vigour index-II (17523), field emergenceindex (8.13),seedling establishment(87.78%)and minimum electrical conductivity (160.79 µS/cm/seed) as compared to cloth bag which registered less test weight (38.82g), germination (94.61%), seedling length (25.16cm), seedling dry weight (185.67mg), vigour index-I (2165), vigour index-II (15911)field emergenceindex (7.00), seedling establishment (86.11%) and maximum electrical conductivity (179.45µS/cm/seed). It was concluded from the study thatBarley seed quality can be maintained in polythene bags under ambient conditions for a longer period as compared to cloth bags when stored with optimum moisture content. Among six-rowed barley varieties, BH 393 performed better in all the quality parameters while in the case of two-rowed barley varieties DWRB 101 performed best. These varieties can be used in further breeding programmes.

Keywords: Seed quality, two-rowed and six-rowed barley, storage container

Barley (*Hordeum vulgare* L.) is one of the major cerealsand ranks fourth among grains with the production of 156.12 million tonnes after maize, rice and wheat in India and the world. Russia ranks first in barley production, which contributes about 14 per cent of the world,while India contributes 1.12 per cent in barley production, which was 1.75 million tonnes[3]. Nutritionally, barley is an essentialsource of carbohydrates (77.7%), protein (9.9%), fat (1.2g) and, vitamins like niacin and pyridoxine, and minerals like calcium, iron and manganese. The crop is also used as animal fodder, as a source of fermentable material for beer and certain distilled beverages and as a component of various health foods. Barley grains are commonly made into malt in a traditional and ancient preparation method. In general, barley is mainly classified as six-rowed and two-rowed barleys based on the arrangement of kernels. Six-rowed barley contains more protein and enzymes than two-rowed barley, which makes six-rowed barley famous for brewing purposes. Barley grown for malt purposes is called malting barley instead of feeding barley.

Seed is an essentialessential component, and the quality seed plays a vital role in agricultural production and the national economy. Seed deterioration starts once the seed attains physiological maturity in the field. Seed deterioration will lead to some the physiological changes like a drop ingerminability, a decrease in mean germination time and loss of vigour. Storage containers or packaging materials primarily influence the seed longevity during storage. Using proper storage containers during storage is most important for maintaining seed quality until the next cropping season. The container properties greatly influence the interaction of the seed with the surrounding environment. The rate of entry and exit of moisture content from the storage container will influence the seed longevity [17]. Since the seed is hygroscopic will absorb moisture when it is stored in humid storage conditions until it reaches the equilibrium moisture content. High temperature and moisture content increase the rate of seed deterioration [14]. To overcome these factors, it is essential to store the seeds in moisture-proof containers such as polythene bags with or without desiccating agents to maintain the seed quality [16]. The storage container's better barrier properties will maintain seed germination for longer durations [7]. Very little information was available on the effect of containers on seed quality of two and six-rowed barley during storage. Therefore, the present study was planned to assess the effect of containers on seed quality in barley during storage.

MATERIALS AND METHODS

The study was conducted on seeds of three two-rowed varieties *viz.* BH 885, DWRB 92, DWRB 101 and three six-rowed rowed barley varieties *viz.* BH 946, BH 393, BH 902 were procured from the Department of Genetics and Plant Breeding, CCS HAU, Hisar during 2020-21.The seed was stored with an initial moisture level (8%) in ordinary (Cloth bags) and moisture-proof (Polythene bags>700gauge thickness) containers under ambient conditions. The observations on seed quality parameters *viz.*, test weight (g), germination (%), seedling length (cm), dry seedling weight (mg), vigour indices, electrical conductivity, field emergence index and seedling establishment (%) were recorded at three months interval up to nine months.Test weight was measured by usingone thousand seeds from each variety in three replications were counted, and weighed by using an electronic balance and the average seed weight was determined in grams.For the germination testhundred seeds from each variety with 3 replications were placed between sufficient moistened germination papers (BP) and kept at 20°C in a seed germinator. The final count was taken on the 8th day and only normal seedlings were considered for per cent germination as per International Seed Testing Association rules [8].Ten normal seedlings were randomly selected from each replication of all six barley varieties at the time of the germination test's final count. The average seedling length was calculated and expressed in centimetres. After measuring the seedling length, ten seedlings from each replication were dried in a hot air oven for 48 hrs at 70±1°C and each variety's average seedling dry weight. Each variety's average seedling dry weight was calculated in milligrams.Seedling vigour indices were calculated according to the method given by Abdul-Baki and Anderson [1]:

Vigour index-I = Germination (%) x Average seedling length (cm)

Vigour index-II = Germination (%) x Average seedling dry weight (g)

Electrical conductivity was computed as per AOSA [4]. Fifty healthy and undamaged seeds from each treatment in three replications were soaked in 75 ml of distilled water in 100 ml beakers. Seeds were soaked entirely in distilled water and covered with parafilm to reduce evaporation. A control beaker, one per replicate, was also kept containing distilled water without seeds. After that, these samples were held at 25°C for 24 hrs. The electrical conductivity of the seed leachates was obtained through a direct reading of the conductivity meter and expressed in µS/cm/seed.

Field emergence index: On each day, the number of seedlings that emerged wascounted until the seedling establishment was completed. The field emergence index (speed of emergence) was calculated by the method described by Maguire [9].

$$\text{Field emergence index} = \frac{\text{No. of seedling emerged}}{\text{First day of sowing}} + \ldots + \frac{\text{No. of seedling emerged}}{\text{last day of count}}$$

When the seedling emergence was accomplished and no further increase in total seedling emergence, the seedling establishment was evaluated by counting the total number of seedlings that emerged.

Statistical Analysis: The experiments were conducted in a randomized block design (RBD) anda completely randomized design (CRD) for field and laboratory parameters, respectively. The data obtained from an experiment conducted in RBD and CRD were analyzed as per the standard method suggested by [11] and using the online statistical tool (OPSTAT) developed by [15].

RESULTS AND DISCUSSION

Results revealed no significant differencebetween the test weights of seeds stored in both containers. However, a

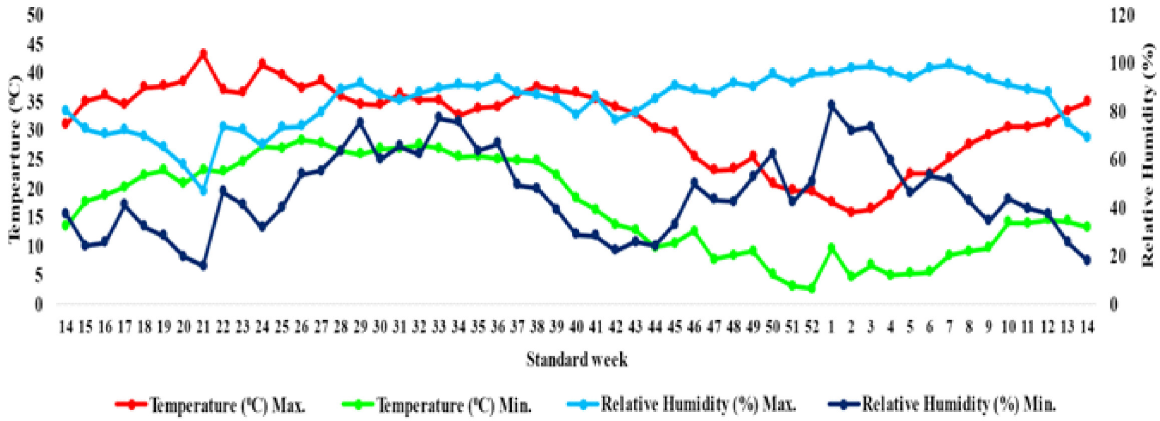

Figure 1. Average weather data of Hisar during the storage period (2020-21)

significant difference was recorded among varieties and storage periods. Maximum test weight (48.71g) was recorded in DWRB 92, while minimum test weight (26.64g) was in BH 393. Polythene bag recorded more test weight (39.08g) as compared to cloth bag (38.82g) after 9 months of storage (Table 1). Seed is hygroscopic. The variation in the test weight may be due to changes in the relative humidity during storage and the cloth bag's porous nature, which lead to fluctuations in seed moisture content. The results obtained are in accordance with [12] reported that the polythene bag significantly decreased the thousand seed weight during 9 months of storage. The germination percentage was decreased with an increase in storage period in both polythene and cloth bag.Maximum germination (97.67%) was recorded in DWRB 101 and minimum (94.33%) in BH 393. Polythene bags recorded more germination (94.61%) as compared to cloth bags (85.89%). Cloth bag recorded the minimum germination percentage as compared to polythene bag, this is probably associated with the porous nature of cloth which allows more moisture and oxygen exchange between seed and environment. These two factors are majorly responsible for seed deterioration during storage. At high-temperature conditions, oxygen concentration enhances the respiration rate which in turn causes the seed deterioration. Similar results were observed in the studies undertaken by [3] in cowpea, [5] in wheat, and 12] in barley reported that the seeds stored in the high-density polythene bag maintained the germination percentage as compared to gunny bag stored seeds.Maximum seedling length (27.83cm) was recorded in BH 393 and minimum (25.44cm) in BH 885. Polythene bag recorded more seedling length (28.70cm) as compared to cloth bag (25.16cm). Polythene bag recorded significantly more seedling dry weight (193.72mg) as compared to cloth bag (185.67mg). DWRB 92 recorded maximum seedling dry weight (234.00mg) while minimum (161.50mg)was recorded in DWRB 101 (Table 4). Maximum vigour index-I (2488) was recorded in DWRB 101 and minimum (2094) in BH 885. Polythene bag recorded a significantly higher (2599) vigour index-I as compared to cloth bag (2165).Maximumvigour index-

Table 1. Effect of containers on test weight(g) of different barley varieties during storage

Varieties(V)	Storage period (Months)									
	Initial	3			6			9		
		Cloth	Polythene	Mean	Cloth	Polythene	Mean	Cloth	Polythene	Mean
BH 946	39.60	39.05	39.33	39.19	37.87	38.06	37.97	36.56	36.74	36.65
BH 902	42.94	43.25	42.84	43.05	41.63	41.57	41.60	41.27	41.51	41.39
BH 393	33.20	32.24	32.82	32.53	32.75	32.62	32.69	21.82	31.46	26.64
BH 885	39.97	39.85	39.92	39.89	39.32	39.40	39.36	38.47	38.85	38.66
DWRB 101	47.08	47.60	46.67	47.14	46.62	46.68	46.65	46.40	46.55	46.48
DWRB 92	51.51	50.71	51.11	50.91	49.41	49.70	49.56	48.39	49.02	48.71
Mean	42.38	42.12	42.12	42.12	41.27	41.34	41.30	38.82	39.08	38.95
C.D (p=0.05)	M=1.308, C=NS, MxC= NS, V=1.849, MxV=NS, CxV=NS, MxCxV=NS									

II (20608) was recorded in DWRB 92 and minimum (14946) in DWRB 101. Polythene bag recorded a significantly higher (17523) vigour index-II as compared to cloth bag (15911).The polythene bag seeds hadmaximum seedling length, dry weight and vigour indices as compared to cloth bag which may be due to a higher rate of seed deterioration in a cloth bag. Fluctuations in seed moisture content during storage and an increased respiration rate in cloth bag causes more deterioration, resulting in the lowest seedling growth and vigour attributes. The seedling length and vigour indices dependon the initial test weight. According to [13] higher the test weight highest will be the seedling's growth and vigour. This may be due to the metabolism of a large amountof food reserves in the seed,givingrise to more energy which supports the seedling's growth in turn vigour. [6] also reported similar findings as reported in the present study. The seeds of barley stored in a gunny bag showed comparatively less seedling length, seedling dry weight and vigour indices as compared to polypropylene containers and polythene lined containers. Similar results were found in the barley studies of [13].

The cloth bag recorded significantly more electrical conductivity(179.45µS/cm/seed) as compared polythene bag (160.79 µS/cm/seed) after nine months of storage. Variety BH 902 recorded maximum electrical conductivity (196.64 µS/cm/seed) and minimum (148.24 µS/cm/seed) was recorded in BH 885.The increase in electrical conductivity may be due to the loss of membrane integrity. The increase in the lipid peroxidation process over the period affected the membrane characteristics of the seed

Table 2. Effect of containers on germination (%) of different barley varieties during storage

Varieties (V)	Storage period (Months)									
	Initial	3			6			9		
		Cloth	Polythene	Mean	Cloth	Polythene	Mean	Cloth	Polythene	Mean
BH 946	96.67	96.67	96.67	96.67	96.67	96.67	96.67	90.00	96.67	96.67
	(79.49)	(79.4)	(79.47)	(79.4)	(79.47)	(77.09)	(78.28)	(71.55)	(79.47)	(79.47)
BH 902	97.33	96.67	97.00	96.84	97.33	96.67	97.00	83.33	96.67	97.00
	(80.60)	(79.47)	(80.09)	(79.78)	(76.63)	(77.97)	(77.30)	(65.88)	(79.47)	(80.09)
BH 393	94.67	94.00	94.33	94.17	94.67	94.00	94.34	87.33	94.00	94.33
	(76.65)	(75.82)	(76.21)	(76.02)	(74.65)	(76.21)	(75.43)	(69.13)	(75.82)	(76.21)
BH 885	98.00	93.33	95.67	94.50	98.00	93.33	95.67	78.67	93.33	95.67
	(81.87)	(75.02)	(77.97)	(76.49)	(67.73)	(72.86)	(70.29)	(62.47)	(75.02)	(77.97)
DWRB 101	98.00	97.33	97.67	97.50	98.00	97.33	97.67	91.33	97.33	97.67
	(81.87)	(80.61)	(81.22)	(80.92)	(79.47)	(78.95)	(79.21)	(72.86)	(80.61)	(81.22)
DWRB 92	99.33	89.67	95.00	92.34	99.33	89.67	94.50	84.67	89.67	95.00
	(85.30)	(71.23)	(77.09)	(74.16)	(74.65)	(75.40)	(75.03)	(66.92)	(71.23)	(77.09)
Mean	97.33	94.61	96.06	95.33	97.33	94.61	95.97	85.89	94.61	96.06
	(80.60)	(76.94)	(78.68)	(77.81)	(75.44)	(76.41)	(75.92)	(68.13)	(76.94)	(78.68)
C.D.(P=0.05)	M=1.141, C=0.932, MxC=1.614, V=1.614, MxV=2.796, CxV=2.283, MxCxV=NS									

Figures in parenthesis are angular transformed values

Table 3. Effect of containers on seedling length(cm) of different barley varieties during storage

Varieties(V)	Storage period (Months)									
	Initial	3			6			9		
		Cloth	Polythene	Mean	Cloth	Polythene	mean	Cloth	Polythene	Mean
BH 946	35.75	34.97	35.24	35.11	26.3	32.52	29.41	24.28	28.48	26.38
BH 902	35.71	34.92	35.39	35.16	29.38	34.51	31.95	25.45	29.32	27.39
BH 393	33.62	32.57	33.14	32.86	28.3	31.1	29.7	26.23	29.43	27.83
BH 885	35.71	34.33	35.15	34.74	27.73	31.41	29.57	23.67	27.21	25.44
DWRB101	33.69	33.05	33.42	33.24	29.16	32.05	30.61	25.22	28.52	26.87
DWRB 92	34.21	33.92	34.3	34.11	31.01	32.85	31.93	26.12	29.22	27.67
Mean	34.78	33.96	34.44	34.2	28.65	32.41	30.53	25.16	28.7	26.93
C.D.(P=0.05)	M=1.052, C=0.859, MxC=1.488, V=NS, MxV=NS, CxV=NS, MxCxV=NS									

Table 4. Effect of containers on seedling dry weight(mg) of different barley varieties during storage

Varieties (V)	Storage period (Months)									
	Initial	3			6			9		
		Cloth	Polythene	Mean	Cloth	Polythene	Mean	Cloth	Polythene	Mean
BH 946	255.33	240.33	246.66	243.50	225.33	230.67	228.00	174.00	182.00	178.00
BH 902	277.00	264.66	270.66	267.66	230.00	236.67	233.34	172.67	183.00	177.84
BH 393	229.33	211.66	225.00	218.33	209.66	216.33	213.00	191.33	195.33	193.33
BH 885	283.67	265.33	273.66	269.50	256.00	260.67	258.34	189.00	198.00	193.50
DWRB 101	276.00	271.66	273.66	272.66	239.33	244.67	242.00	156.67	166.33	161.50
DWRB 92	337.00	313.00	324.66	318.83	273.00	279.66	276.33	230.33	237.67	234.00
Mean	276.39	261.11	269.05	265.08	238.89	244.78	241.83	185.67	193.72	189.69
C.D.(P=0.05)	M=5.71, C=4.662, MxC=NS, V=8.074, MxV=13.985, CxV=NS, MxCxV=NS									

Table 5. Effect of containers on Vigour index-I of different barley varieties during storage

Varieties (V)	Storage period (Months)									
	Initial	3			6			9		
		Cloth	Polythene	Mean	Cloth	Polythene	Mean	Cloth	Polythene	Mean
BH 946	3452	3379	3408	3393	2542	3092	2817	2184	2599	2392
BH 902	3476	3373	3427	3400	2780	3299	3039	2122	2675	2399
BH 393	3182	3063	3128	3095	2632	2928	2780	2290	2669	2480
BH 885	3501	3204	3365	3284	2376	2870	2623	1878	2310	2094
DWRB 101	3301	3217	3263	3240	2819	3087	2953	2303	2673	2488
DWRB 92	3398	3039	3259	3149	2885	3079	2982	2213	2666	2439
Mean	3385	3212	3308	3260	2672	3059	2866	2165	2599	2382
C.D.(P=0.05)	M=99.12, C=80.931, MxC=140.177, V=140.177, MxV=242.793, CxV=NS, MxCxV=NS									

Table 6. Effect of containers on Vigour index-II of different barley varieties during storage

Varieties (V)	Storage period (Months)									
	Initial	3			6			9		
		Cloth	Polythene	mean	Cloth	Polythene	mean	Cloth	Polythene	mean
BH 946	24655	23237	23846	21775	21920	3092	12506	15652	16615	16134
BH 902	26954	25560	26292	21799	22634	3299	12967	14401	16693	15547
BH 393	21688	19901	21229	19497	20379	2928	11653	16703	17702	17203
BH 885	27803	24770	26174	21937	23802	2870	13336	14896	16828	15862
DWRB 101	27047	26441	26726	23123	23533	3087	13310	14315	15577	14946
DWRB 92	33490	28052	30846	25387	26205	3079	14642	19495	21721	20608
Mean	26939	24660	25852	22253	23079	3059	13069	15911	17523	16717
C.D.(P=0.05)	M=574.937, C=469.434, MxC=NS, V=813.083, MxV=1,408.30, CxV=NS, MxCxV=NS									

Table 7. Effect of containers on electrical conductivity (µS/m/seed) of different barley varieties during storage

Varieties (V)	Storage period (Months)									
	Initial	3			6			9		
		Cloth	Polythene	Mean	Cloth	Polythene	mean	Cloth	Polythene	Mean
BH 946	162.37	165.87	164.27	165.07	175.53	170.20	172.87	180.53	173.27	176.90
BH 902	183.80	184.47	183.40	183.94	199.60	183.70	191.65	206.57	186.70	196.64
BH 393	121.53	129.63	125.47	127.55	148.27	134.10	141.19	158.17	140.10	149.14
BH 885	143.93	148.13	146.73	147.43	156.37	120.87	138.62	165.57	130.90	148.24
DWRB101	148.90	150.07	149.57	149.82	162.13	153.70	157.92	169.63	156.77	163.20
DWRB 92	149.83	154.47	152.63	153.55	182.37	172.93	177.65	196.20	176.97	186.59
Mean	151.73	155.44	153.68	154.56	170.71	155.92	163.31	179.45	160.79	170.12
C.D.(P=0.05)	M=3.315, C=2.706, MxC=4.687, V=4.687, MxV=8.119, CxV=6.629, MxCxV=NS									

Table 8. Effect of containers on test field emergence index of different barley varieties during storage

Container(C)	Varieties (V)						
	BH 946	BH902	BH393	BH885	DWRB 101	DWRB 92	Mean
Cloth	5.72	6.71	8.59	7.32	6.72	6.90	7.00
Polythene	6.41	8.49	9.21	8.72	7.89	8.07	8.13
Mean	6.07	7.60	8.90	8.02	7.31	7.49	
C.D.(P=0.05)	C=0.437, V=0.757, CxV=NS						

Table 9. Effect of containers on seedling establishment (%) of different barley varieties during storage

Container(C)	Varieties (V)						
	BH 946	BH 902	BH 393	BH 885	DWRB 101	DWRB 92	Mean
Cloth	86.00	85.33	89.00	84.33	86.00	86.00	86.11
	(68.03)	(67.48)	(70.63)	(66.68)	(68.03)	(68.03)	(68.12)
Polythene	88.33	86.67	90.67	87.33	87.33	86.33	87.78
	(70.02)	(68.59)	(72.21)	(69.15)	(69.15)	(68.30)	(69.54)
Mean	87.17	86.00	89.83	85.83	86.67	86.17	
	(69.01)	(68.03)	(71.40)	(67.89)	(68.59)	(68.17)	
C.D.(P=0.05)	C=1.388, V=2.405, CxV=NS						

Figures in parenthesis are angular transformed values

which results in the seed deterioration. Cloth bag stored seeds showedmore electrical conductivity thanpolythene bag due to less deterioration in a polythene bag. [10] found more electrical conductivity of seed leachates in a plastic container while the aluminium containers had lowered the electrical conductivity during the storage period in sorghum.The highest value of field emergence (8.90) index was observed in BH 393, while the lowest (6.07) was in BH 946.In the polythene bag, the highest field emergence index (9.21) was found in BH 393 and the lowest was in BH 946 (6.41). Polythene bags recorded a significantly higher field emergence index (8.13) than cloth bags (7.00).The highest value of seedling establishment(89.83%) was observed in the variety BH 393, while the lowest (85.83%) was in BH 885.Polythene bags recorded significantly higher seedling establishment (87.78%)than cloth bags (86.11%).The reduced seedling establishment and FEI in cloth bag seeds may be due to more loss of vigour which was the ultimate effect of increased deterioration in cloth bag stored seeds. Among six varieties, the highest field emergence index and the seedling establishment were observed in BH 393 which may be due to various genetic factors of variety. [6] alsoreported similar findings as reported in the present study. The barley seeds stored in gunny bag showed comparatively less field emergence index and seedling emergence than polypropylene containers and polythene lined containers. No significant effect of containers and storage period was observed between six-rowed and two-rowed barley varieties. Among six-rowed barley varieties, BH 393 performed better in all the quality parameters, while in the case of two-rowed barley varieties, DWRB 101 performed best. The variation in variety's performance may be attributed to genetic makeup, environmental influence and other management factors.

CONCLUSION

Barley seed quality can be in moisture-proof (Polythene bags>700gauge thickness) containers under ambient conditions for a more extendedperiod as compared to cloth bags (ordinary containers) when stored with optimum moisture content. Among six-rowed barley varieties, BH 946 performed better in all the quality parameters; in the case of two-rowed barley varieties, DWRB 101 performed best. These varieties can be used in further breeding programmes.

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