Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 925-932
Received: 17-06-2020
Accepted: 24-07-2020

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Appraisal of storage potential of onion cv. CO (On) 5 seeds under carbon dioxide and ambient storage condition

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DOI: https://doi.org/10.22271/phyto.2020.v9.i5m.12351

Abstract
The laboratory experiment was conducted to study the storage potential of onion seeds under ambient and carbon dioxide (CO_2) conditions. The onion seeds were given with different treatments such as T_1-Control, T_2-Seed coating formulation-I (SCF-I)-10g/kg, T_3-Seed coating formulation-II (SCF-II)-10g/kg and stored in cloth bag under ambient condition and plastic container under CO_2 condition (30% CO_2) for six months. The seed samples were drawn at monthly intervals and evaluated for the seed and seedling quality parameters. The result revealed that, seeds coated with SCF-II and stored under CO_2 condition recorded the highest germination rate and seedling vigour; dehydrogenase, α-amylase, catalase and peroxidase activity; protein and oil content; lowest electrical conductivity and pathogen infection after six months of storage compared to other treatments and ambient storage. It can be used effectively to enhance the seed quality and particularly beneficial in the absence of cold storage facility and in addition it can be used for maintaining seed quality for long period.

Keywords: Onion, seed coating formulation, storage condition, seed storage, seed quality

1. Introduction

Good seed is a basic input in vegetable production. The production of vegetable seeds is a costly venture and the possibilities of carrying over the left over stock for more than one season possess a serious problem, because seeds deteriorate during storage. Wastage of seeds is highly regrettable because of their high economic value. Prolonging the shelf life of stored seeds is always a profitable and can be adopted if the procedure is cheap and easy to follow. Seed production in onion is very specific with season; it necessitated the storage of seeds until used for sowing. In order to prevent the quantitative and qualitative losses due to biotic and abiotic factors during storage, several seed enhancement techniques are being adopted.

Seed coating is an effective enhancement technique results in uniform deposition of an extremely thin film on the seed surface, multiple coatings of various ingredients are also possible (John *et al*., 2005) [1]. Seed coating formulations may contain plasticizers, colorants and other ingredients that are commercially available in aqueous suspensions. The benefits of film coating include uniform placement of protective materials very precise amounts and with a minimal impact on the environment (Baudet & Peres, 2004) [2], enhanced appearance due to the addition of pigments and an excellent delivery for seed treatment chemicals (Taylor *et al*., 2001) [3]. Film coating is routinely performed by the seed industry on high-value seeds such as vegetables and flowers. Seed coating protects the seed from various stress imposed during storage including fungal invasion.

Onion seeds are very poor in storage (Nagaveni, 2005) [4]. It loses its viability and vigour more rapidly after harvest than the seeds of other crops unless special precautions are taken in its storage. It is well known fact that the choice of materials for seed treatment, containers selected for storing the seeds and storage environment exert a positive effect on the viability and vigour of seeds in storage. CO_2 storage is modified atmospheric storage condition in which carbon dioxide is added to a storage container of seeds in an effort to replace oxygen with the carbon dioxide. The idea is that the lack of oxygen will increase the seed storability by slowing down the respiration rate of the seeds, allowing them to remain dormant longer. Carbon dioxide is heavier than oxygen, so introducing it into a container replaces the oxygen by gravity. This may also have the additional advantage of killing any insect pests which may be present, as the insects also require oxygen to respire and survive (but at a greater quantity than seeds).

Hence, an attempt was made to know the effect of seed treatment and storage condition on seed quality parameters of small onion cv. CO (On) [5].

2. Material and Methods

The storage experiment was conducted at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore during 2017-2018 to study the effect of seed treatment on storage potential of onion seeds under ambient and CO_2 storage conditions. The onion seeds were given with following treatments and stored under ambient and CO_2 condition (30 % CO_2) for 6 months.

T_1 - Control
T_2 - Seed coating formulation I (SCF-I)
T_3 - Seed coating formulation II (SCF-II)

2.1 Ambient storage

300 g seeds from each treatment were packed in gada cloth bag (Fig. 1) stored for six months. The seed filled cloth bags were kept in a room under ambient condition (Fig. 6). Every month 50 g seeds were drawn from each treatment for assessing seed quality.

2.2 CO_2 storage

500 ml plastic bottles with air tight cap were taken to fill CO_2 gas and store the seeds. The bottles were fitted with two ports, one inlet port and one outlet port (made of silicone tube) in one side of bottle. The bottles were made air tight using M-seal (Fig. 2). CO_2 gas from CO_2 gas cylinder (Fig. 4) was introduced through inlet port and displaced gas came out through outlet port. The CO_2 gas was flushed into bottles at 30 % concentration. The concentration of CO_2 gas inside the container was checked by using gas analyzer (Fig. 5). After checking the gas concentration, the two ports were plugged with rubber septum. The containers were kept in a room under ambient condition up to six months (Fig. 6). Every week the gas concentration was checked to know the any gas leakage in the container. Six times of 50 g seeds from each treatment were stored in separate container for six months. Every month's one container from each treatment was taken for seed quality assessment.

Fig 1. Seeds stored in cloth bag

Fig 2. CO_2 storage container

Fig 3. Seeds stored in plastic container with CO_2

Fig 4. CO_2 gas cylinder

Fig 5. CO_2 gas analyzer

Fig 6. Packed seeds stored under ambient condition

2.3 Design of the experiment

The laboratory experiment was conducted in the completely randomized block design with two factorial concepts and replicated four times.

2.4 Preparation of seed coating formulations

The components of the formulations are described below.

Components of seed coating formulation I (1000 g)	
1. Kamcryll 2074 Polymer	800 g
2. Pigment	200 g
3. CMC (Carboxyl methyl cellulose)	10 g
4. GA3	250 ppm (250 mg)
5. Ethanol	5 ml

Components of seed coating formulation II (1000 g)	
1.Kamcryll 2074 Polymer	800 g
2.Pigment (Red)	200 g
3.CMC (Carboxyl methyl cellulose)	10 g
4.Brassinosteroid (0.04 % of w/w)	0.1 ppm (0.1 µl)
5.Ethanol	5ml

2.5 Observations

At monthly intervals stored seed were evaluated by adopting standard procedures. The observations such as germination percentage (ISTA, 2013) [5], seedling length, dry matter production, vigour index (Abdul-Baki & Anderson, 1973) [6], electrical conductivity (Presley, 1958) [7], dehydrogenase (Kittock & Law, 1968) [8] and α- amylase activity (Simpson and Naylor, 1962) [9], catalase (Povolotskaya & Sedenka, 1956) [10] and peroxidase activity (Singh *et al.*, 1980) [11], protein (Ali-Khan & Youngs, 1973) [12] and oil content (AOSA, 1961) [13], and pathogen infection (ISTA, 2013) [5] were assessed under the laboratory conditions.

3. Results and Discussion

3.1 Effect of seed treatment and storage condition on seed physiological parameters during storage

The result revealed that the, seed germination significantly influenced by seed treatments, storage condition and periods of storage. The seeds treated with SCF-II and stored under CO_2 condition maintained the germination at higher level

(83%) at end of storage period of six month than the seeds treated with SCF-I (81%) and control seeds (76%). The percentage improvement in germination was 2.5 and 9.2 higher than the seeds treated with SCF-I and control respectively under CO_2 storage condition (Table 1) (Fig. 7).

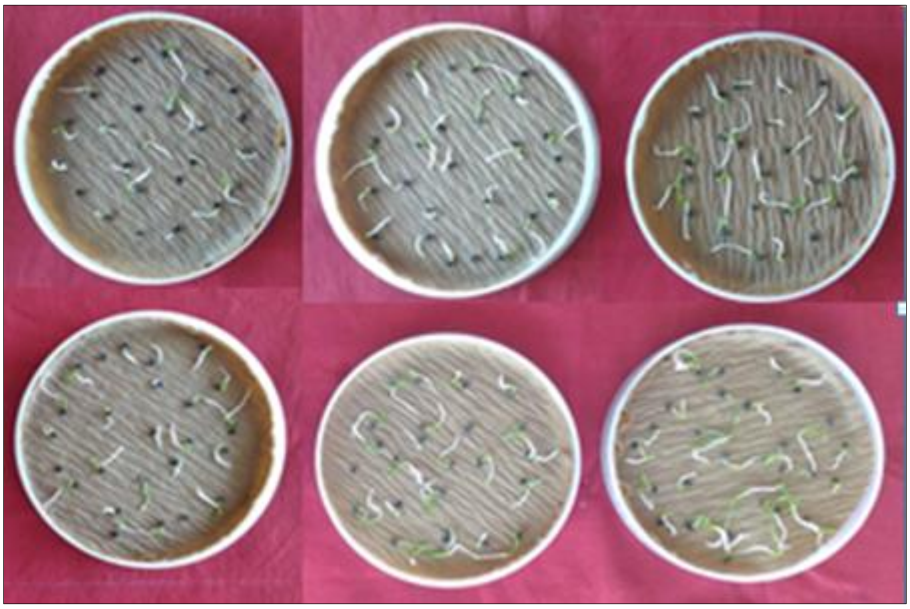

Fig 7: 5th day germination of six months stored seeds

The seedling length and dry matter production over a period of storage decreased in all the treatments and significant differences among treatments, storage condition, periods of storage and interaction between storage condition and period of storage (C X P) were observed. Seedling length is the best indicator of seed vigour. The relative length of root and shoot of seedlings would predict their subsequent growth and performance. Among the treatments, the seeds treated with SCF-II recorded a maximum seedling length and dry matter production of 14.8 cm and 15.2 mg than the seeds treated with SCF-I (4.1 cm and 15.0 mg) and untreated control (11.4 cm and 14.7 mg) at the end of storage period of six months. Between the storage conditions the seeds stored under CO_2 storage condition recorded higher value of 14.0 cm and 15.5 mg than the seeds stored under ambient condition (12.8 cm and 14.4 mg) at the end of six months of storage (Table 1).

Seedling vigour is usually characterized by weight of the seedlings after a period of growth (Dasgupta and Austenson, 1973) [14] and this is essentially a physiological phenomenon influenced by the reserve metabolites, enzyme activities and growth regulators. In the present investigation, the vigour index over a period of storage decreased in all the treatments and significant differences among treatments, storage condition, periods of storage, interaction between treatment and period of storage (T X P), storage condition and periods of storage (C X P) were observed. It was maximum for seed treated with SCF-II (1200) compared with SCF-I (1109) and untreated control (809) at six months after storage. The seeds coated with SCF-II recorded a minimal decrease in vigour index with 48 per cent increase over untreated control seed at sixth month of storage. The synergetic effect of polymers might have contributed for better germination, vigour index and slow down the process of deterioration (Rao *et al*., 2015) [15]. The seeds stored in CO_2 storage condition recorded higher value of vigour index (1240) than the ambient condition (1080) at the end of storage (Table 1) (Fig. 8).

Table 1: Effect of seed treatments and storage conditions on seed physiological parameters

Treatment (T)	Storage condition (C)	Germination (%)		Seedling length (cm)		Dry matter production (mg seedling^{-10})		Vigour index	
		P_0	P_6	P_0	P_6	P_0	P_6	P_0	P_6
T_1	C_1	89 (70.63)	70 (56.79)	14.9	10.6	16.3	14.0	1326	742
	C_2	92 (73.57)	76 (60.67)	15	12	16.3	15.3	1350	876
	Mean	91 (72.54)	73 (58.70)	15	11.4	16.3	14.7	1338	809
T_2	C_1	92 (73.57)	76 (60.67)	16.4	13.5	16.5	14.4	1509	1026
	C_2	92 (73.57)	81 (64.16)	16.4	14.7	16.5	15.5	1509	1191
	Mean	92 (73.57)	79 (62.73)	16.4	14.1	16.5	15.0	1509	1109
T_3	C_1	94 (75.52)	79 (62.73)	17.1	14.3	16.6	14.7	1607	1130
	C_2	94 (75.82)	83 (65.65)	17.2	15.3	16.6	15.7	1617	1270
	Mean	94 (75.82)	81 (64.16)	17.2	14.8	16.6	15.2	1612	1200
Treatment mean	C_1	92 (73.57)	75 (60.00)	16.1	12.8	16.5	14.4	1481	1481
	C_2	93 (74.66)	80 (63.44)	16.2	14	16.5	15.5	1492	1112
	Mean	92 (73.57)	78 (62.03)	16.2	13.4	16.5	14.9	1486	1297

(Figures in parenthesis indicate arcsine values); P_0- Before storage, P_6- Six months after storage; C_1- Ambient storage, C_2- CO_2 storage

Parameters		C	T	P	C X T	T X P	C X P	C X T X P
Germination (%)	SE d	0.365	0.447	0.683	NS	1.183	0.966	NS
	CD(0.05)	0.726	0.889	1.358	NS	2.353	1.921	NS
Seedling length (cm)	SE d	0.028	0.035	0.053	NS	NS	0.175	NS
	CD(0.05)	0.056	0.069	0.105	NS	NS	0.348	NS
Dry matter production	SE d	0.076	0.093	0.141	NS	NS	0.200	NS
	CD(0.05)	0.150	0.184	0.281	NS	NS	0.397	NS
Vigour index	SE d	5.466	6.694	10.23	NS	17.71	14.46	NS
	CD(0.05)	10.87	13.31	20.34	NS	35.22	28.76	NS

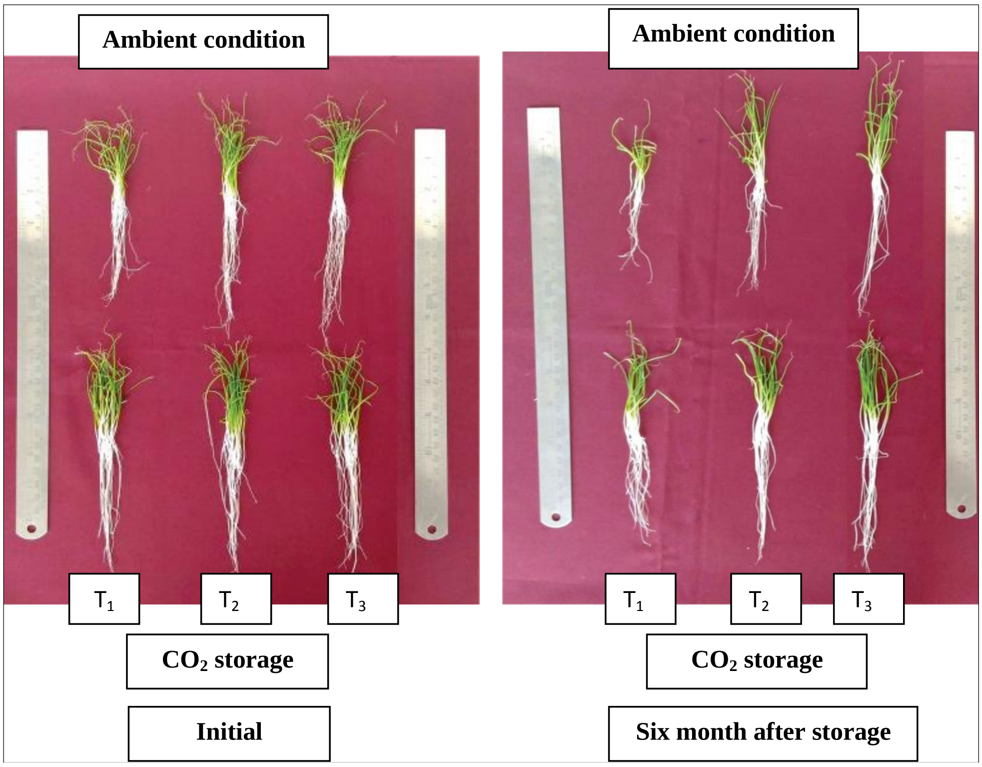

Fig 8: Seedling vigour before and after six months of storage under ambient and CO_2 condition

The present study clearly indicated that seeds treated with SCF-II and stored under CO_2 condition maintained the seed physiological parameters at higher level. The enhanced effect of SCF-II might be due to hormone (brassinosteroid) present in the formulation. The findings of the present study are in line with Leelavathi, (2018) [16] who studied the effect of seed coating formulation (contains brassinosteroid) in different crops like maize, black gram and cotton on their storage potential and confirmed that all the seed quality parameters *viz.*, germination, seedling length, vigour index and drymatter production were found to be maximum for the treated seeds than the untreated control. Brassinosteroid (BR) application has been reported to enhance germination of certain parasitic angiosperms (Takeuchi *et al*., 1995) [17], cereals (Yamaguchi *et al*., 1987) [18], Arabidopsis (Steber & McCourt, 2001) [19] and tobacco (Leubner-Metzger, 2001) [20]. Pretreatment with brassinolide stimulates the germination and seedling emergence of aged rice seeds (Yamaguchi *et al*., 1987) [18]. BR seed treatment has enhanced the germination, seedling length, seedling fresh and dry weight in radish and *Brassica juncea* (Raghu *et al*., 2014; Sharma & Bhardwaj, 2007) [21, 22]. Application of brassinosteroids to soybean seed improves both its germination and vigour (Prochazka *et al*., 2015) [23]. Seed treatment with BR has improved the seed germination and germination energy in several tree species such as red pine (*Pinus tabuliformis*), ailanthus (*Ailanthus altissima*) and black locust (*Robinia pseudoacacia*) (Li *et al*., 2002) [24]; sycamore (*Acer pseudoplatanus* L.) and ash (*Fraxinus excelsior* L.) (Prochazka *et al*., 2015) [23].

CO_2 storage of seeds showed retention of higher seed viability and vigour. This might be due to low oxygen under CO_2 storage leads to reduced catabolic activity of seeds, so it maintain viability and vigour for long period. Seeds stored under CO_2 rich condition maintained its physiological parameters during storage (Bera *et al*., 2004 in wheat; Bera *et al*., 2008 in paddy; Shehata *et al*., 2009 in cowpea; Vasudevan *et al*., 2014 in groundnut) [25-28]. Groundnut and Kabuli chickpea seeds stored under modified atmospheric storage particularly with carbon dioxide and vacuum conditions well preserved its viability and vigour (Vasudevan *et al*., 2014; Shinde & Hunje, 2019) [28, 29].

3.2 Effect of seed treatment and storage condition on seed physical parameter during storage

During early years it self, Hibbard & Miller (1928) [30] opined that loss of membrane permeability is one of the prime biochemical vigour character in any seed in storage and this could be measured as electrical conductivity (Agarwal & Dadlani, 1995) [31] in seed steep water, as the inner content of seed oozes out due to the loss of seed coat semi-permeability (Delouche & Baskin, 1973) [32] and dissolved in water and thereby enhances the conductivity of water used for soaking. The significant differences were obtained among the seed treatments, storage condition, periods of storage and interaction between treatments and periods of storage (T X P), storage condition and periods of storage. The electrical conductivity was minimum for seed treated with SCF-II (0.348 dSm^{-1}) compared with untreated control (0.411 dSm^{-1}) at six months after storage. At sixth month of storage, the seeds coated with SCF-II recorded a minimal increase in electrical conductivity and however, 15% decrease over untreated control seed. Between the storage conditions, seeds stored in ambient conditions recorded the higher value of electrical conductivity (0.439 dSm^{-1}) and the seeds stored in CO_2 storage conditions registered lower value (0.308 dSm^{-1}**)** of electrical conductivity (Table 2).

Table 2: Effect of seed treatments and storage conditions on seed physical and biochemical parameters

Treatment (T)	Storage condition (C)	Electrical conductivity (dSm^{-1})		Dehydrogenase activity (OD value)		α-amylase (mg maltose min^{-1})		Catalase activity (µg H_2O_2 mg^{-1} min^{-1})	
		P_0	P_6	P_0	P_6	P_0	P_6	P_0	P_6
T_1	C_1	0.228	0.485	0.074	0.042	0.545	0.304	1.47	0.94
	C_2	0.226	0.337	0.075	0.056	0.546	0.407	1.46	1.19
	Mean	0.227	0.411	0.075	0.049	0.546	0.356	1.47	1.07
T_2	C_1	0.226	0.423	0.076	0.051	0.546	0.347	1.45	1.10
	C_2	0.226	0.299	0.077	0.061	0.546	0.425	1.47	1.30
	Mean	0.226	0.361	0.077	0.056	0.546	0.386	1.46	1.20
T_3	C_1	0.227	0.409	0.076	0.055	0.544	0.368	1.46	1.14
	C_2	0.227	0.287	0.078	0.065	0.545	0.442	1.47	1.32
	Mean	0.227	0.348	0.077	0.060	0.545	0.405	1.47	1.23
Treatment mean	C_1	0.227	0.439	0.075	0.049	0.545	0.340	1.46	1.06
	C_2	0.226	0.308	0.077	0.061	0.546	0.425	1.47	1.27
	Mean	0.227	0.373	0.076	0.055	0.545	0.382	1.46	1.17

P_0- Before storage, P_6- Six months after storage; C_1- Ambient storage, C_2- CO_2 storage

Parameters		C	T	P	C X T	T X P	C X P	C X T X P
Electrical conductivity	SE d	0.001	0.002	0.003	NS	0.004	0.004	NS
	CD(0.05)	0.003	0.003	0.005	NS	0.009	0.007	NS
Dehydrogenase activity	SE d	0.0003	0.0004	0.0006	NS	0.0010	0.0008	NS
	CD(0.05)	0.0006	0.0008	0.0012	NS	0.0021	0.0017	NS
α-amylase	SE d	0.002	0.003	0.004	0.004	0.007	0.006	NS
	CD(0.05)	0.005	0.006	0.008	0.008	0.015	0.012	NS
Catalase	SE d	0.006	0.007	0.011	0.010	0.019	0.015	NS
	CD(0.05)	0.012	0.014	0.022	0.020	0.038	0.031	NS

Result indicates that SCF-II and CO_2 gas maintains the seed membrane integrity during storage. Brassinosteroid support the membrane stability and osmoregulation (Anuradha & Rao, 2007) [33]. Well known fact that malondialdehyde (MDA) levels are quantitative indices of lipid peroxidation and the consequential membrane damage and electrolyte leakage. The application of brassinosteroid reduced the MDA content in radish when compared to control (Raghu *et al*., 2014) [21]. Under low O_2 atmosphere might decrease the initiation of free radicals, which should extend seed longevity by reducing lipid peroxidation and generation of additional damaging compounds. Free radicals degrade the seed membrane integrity. Swapna kumari, 2013 [34] found that soybean seeds stored under modified atmosphere (80% CO_2+5% O_2+15% N_2) recorded less EC compared to control.

3.3 Effect of seed treatment and storage condition on seed biochemical parameters during storage

The dehydrogenase activity over a period of storage has decreased in all the treatments and significant differences among treatments, storage condition, periods of storage, interaction between treatment and period of storage (T X P), storage condition and periods of storage (C X P) were observed. On advancement of storage period, the dehydrogenase activity was reduced. It was drastically reduced at the end of storage period. The dehydrogenase activity was maximum for seed treated with SCF-II (0.060 OD value) compared with untreated control (0.049 OD value) at the end of storage. The seeds coated with SCF-II recorded a minimal decrease in dehydrogenase activity however; it was 22% increase over untreated control. Between the storage conditions, the seeds stored in CO_2 storage conditions recorded higher value of dehydrogenase activity (0.061 OD value) and the seed stored in ambient condition registered lower value of dehydrogenase activity (0.049 OD value) (Table 2).

In onion seeds, the development of α-amylase activity constitutes an important event in germination. It was drastically reduced at the end of storage period. Seed treatments, storage condition, periods of storage and interaction between storage condition and treatment (C X T), treatment and period of storage (T X P), storage condition and period of storage (C X P) had significant influence on α-amylase activity. It was maximum for seed treated with SCF-II (0.405 mg maltose min^{-1}) compared with untreated control (0.356 mg maltose min^{-1}). The seeds coated with SCF-II recorded a minimal decrease in α-amylase activity and however, 14% increase over untreated control at six months after storage. Seeds stored in CO_2 storage condition maintain the α-amylase activity at higher level (0.425 mg maltose min^{-1}) than the ambient condition (0.340 mg maltose min^{-1}) after six months of storage (Table 2).

The protein and oil content over a period of storage has decreased in all the treatments and significant differences among treatments, storage condition and periods of storage and interaction between storage condition and period of storage (C X P) were observed. Among the seed treatments, seeds treated with SCF-II recorded the maximum protein and oil content (17.91% and 11.15%) followed by SCF-I (17.77% and 10.71%) and the minimum (17.39% and 10.30%) was recorded in the control. Between the storage conditions, seeds stored in CO_2 storage condition recorded higher value

(18.32% and 11.49%) and the seeds stored in ambient condition recorded lower value (17.06% and 9.94%) of protein and oil content at the end of storage (Table 3).

Table 3: Effect of seed treatments and storage conditions on seed biochemical parameters and seed health

Treatment (T)	Storage condition (C)	Peroxidase activity (ΔOD 430 mg^{-1} min^{-1})		Protein content (%)		Oil content (%)		Pathogen infection (%)	
		P_0	P_6	P_0	P_6	P_0	P_6	P_0	P_6
T_1	C_1	1.37	0.74	19.33	16.64	14.28	9.36	0.00	4.23
	C_2	1.37	1.12	19.32	18.14	14.27	11.24	0.00	2.11
	Mean	1.37	0.93	19.33	17.39	14.28	10.30	0.00	3.17
T_2	C_1	1.36	1.05	19.31	17.21	14.25	9.94	0.00	3.37
	C_2	1.38	1.17	19.33	18.32	14.25	11.47	0.00	1.94
	Mean	1.37	1.11	19.32	17.77	14.25	10.71	0.00	2.66
T_3	C_1	1.38	1.09	19.32	17.33	14.27	10.53	0.00	3.26
	C_2	1.39	1.22	19.32	18.49	14.28	11.76	0.00	1.72
	Mean	1.39	1.16	19.32	17.91	14.28	11.15	0.00	2.49
Treatment mean	C_1	1.37	0.96	19.32	17.06	14.27	9.94	0.00	3.62
	C_2	1.38	1.17	19.32	18.32	14.27	11.49	0.00	1.92
	Mean	1.38	1.07	19.32	17.69	14.27	10.72	0.00	2.77

P_0- Before storage, P_6- Six months after storage; C_1- Ambient storage, C_2- CO_2 storage

Parameters		C	T	P	C X T	T X P	C X P	C X T X P
peroxidase activity	SE d	0.006	0.007	0.011	0.010	0.019	0.016	0.027
	CD(0.05)	0.012	0.015	0.022	0.021	0.039	0.031	0.055
protein content	SE d	0.080	0.098	0.149	NS	NS	0.211	NS
	CD(0.05)	0.159	0.194	0.297	NS	NS	0.420	NS
oil content	SE d	0.052	0.064	0.097	0.090	NS	0.138	NS
	CD(0.05)	0.103	0.127	0.193	0.179	NS	0.274	NS
pathogen infection	SE d	0.010	0.013	0.019	0.018	0.033	0.027	0.047
	CD(0.05)	0.021	0.025	0.038	0.036	0.067	0.054	0.094

The catalase and peroxidase activity over a period of storage was decreased. Seed treatments, storage condition, periods of storage and interaction between storage condition and treatment (C X T), treatment and period of storage (T X P), storage condition and period of storage (C X P) had significant influence on catalase and peroxidase activity. Among the seed treatments, SCF-II recorded the maximum catalase and peroxidase activity (1.23 µg H_2O_2 mg^{-1} min^{-1} and 1.16 OD value) than SCF-I (1.20 µg H_2O_2 mg^{-1} min^{-1} and 1.11 OD value) and control (1.07 µg H_2O_2 mg^{-1} min^{-1} and 0.93 OD value). Between the storage condition, seeds stored in CO_2 storage condition recorded higher value (1.27 µg H_2O_2 mg^{-1} min^{-1} 1.17 OD value) and the seeds stored in ambient condition recorded lower value (1.06 µg H_2O_2 mg^{-1} min^{-1} and 0.96 OD value) of catalase and peroxidase activity (Table 2 & 3).

The present study insists that seed treated with SCF-II and stored under CO_2 condition maintains its biochemical parameters during storage. This might be due to the hormone brassinosteroid present in the SCF-II reduces the rate of seed deterioration. This result is similar with findings of many authors. Seed treatment with brassinosteroid has decreased the malondialdehyde content and increased the soluble proteins, catalase, superoxide dismutase, peroxidase activity compared to control in radish (Raghu *et al*., 2014) [21]. Wheat seeds supplemented with brassinolide increased the carbohydrates and total soluble protein, and it also increased the hydrolytic enzymes activity such as α- amylase and protease (El-Feky & Abo-Hamad, 2014) [35]. Seed priming with BR increased the protein, lipid, sugar, vitamin E, C and provitamin A content in pea and lupine seeds (Janeczko *et al*., 2015) [36]. It indicates that BRs stimulates the seedlings metabolic activity; and enhances the seed nutritional value; it may help in vigorous seed production.

In general, ageing is manifested by the decrease of metabolic activity and an increase of catabolic processes (Gorecki *et al*., 1996) [37]. In particular, an oxidative stress might be reduced in O_2 free storage atmospheres (Justice & Bass, 1978; Wilson & McDonald, 1990; Gorecki *et al*., 1996) [38, 39, 37]. It should be noted that seed deterioration during storage could result in marked changes in the content and activity of enzymes capable for regarding the stored reserves (Prestley, 1986; Smith & Berjak, 1995; Walters, 1998) [40, 41, 42]. In the present investigation it was observed that the all biochemical activity in the seed was maximum due to, better maintenance of seed quality in modified atmospheric storage condition as compared to control (Vasudevan *et al*., 2014; Manjunatha *et al*., 2016; Feng *et al*., 1989) [28, 43, 44].

3.4 Effect of seed treatment and storage condition on seed health during storage

Seed health is a major consideration in any seed production programme next to vigour and viability of seeds. Seed health is always associated with seed quality. Significant differences were obtained among the seed treatments, storage condition, periods of storage and their interactions. The seeds coated with SCF-II recorded minimum percent of pathogen infection (2.49%) compared with untreated control (3.17%) at the end of six months of storage period. In the present study fungal infection increased with the advancement of storage period and it was more in untreated control seeds. It might be due to increased moisture absorption by the bare seed without seed coating. West *et al*. (1985) [45] reported that mycelia growth was significantly less for the polymer coated soybean seeds and the polymer coat itself provides protection from fungal (Robani, 1994) [46]. Between the storage conditions, seeds stored in ambient condition registered the maximum pathogen infection (3.62%) and the minimum pathogen infection was registered by seeds stored in CO_2 storage condition (1.92%) (Table 3). It might be due to CO_2 gas inhibits the fungal spores present in the seeds. Hocking (1998) [47] reported that 20% CO_2 was having inhibitory effect on fungal growth.

4. Conclusion

The results of the study revealed that onion cv. CO (On) 5 seeds coated with seed coating formulation II and stored under CO_2 storage condition maintained storage potential by recording higher germination percentage, vigour index, dehydrogenase, catalase, peroxidase and α- amylase activity, protein and oil content with minimum electrical conductivity and pathogen infestation after six months of storage. Further, this technology can be used effectively to enhance the seed quality and particularly beneficial in the absence of cold storage facility and in addition it can be used for maintaining seed quality for long period.

5. Acknowledgement

I sincerely thanks to Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore, for providing the facilities to complete this work. I am also thankful to my friends for their constant help and support.

6. References

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