SHORT COMMUNICATION

Effect of CO_2 treatment on dormancy duration, sprout growth and sugar content in two potato cultivars

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ABSTRACT: Dormant tubers of two potato cultivars Kufri Jyoti and Kufri Chandramukhi were treated for 7 days with 5, 10, 15 and 20% CO_2 concentrations at 18 ± 1°C and 90–95% RH, and compared with GA treated tubers and with untreated tubers serving as control. During subsequent storage at the same temperature and RH, dormancy duration was reduced by 20 days with CO_2 treatment and by 35 days with GA treatment. In Kufri Jyoti, GA treatment caused 2.6 fold increase in the concentration of reducing sugars and 0.8 fold increase in total sugars in the apical half of the tubers leading to early release of dormancy in apical buds but this increase in sugar content was not observed in the basal half where the buds remained dormant.

Keywords: potatoes; dormancy breaking; CO_2 concentration; sprout length; weight loss; reducing sugars; total sugars

Generally, only one potato crop is grown in tropical and sub-tropical countries during winter and in temperate countries during summer. Therefore, there is a sufficient time gap between two crops and there is no need to break dormancy since it is naturally broken in storage. However, there are localities like Punjab and Tamil Nadu in India where two successive crops are raised with a time gap of 2–3 weeks between them and the seed for the second crop comes from the harvest of the preceding crop. In such cases, dormancy breaking is essential. Several chemicals like gibberellic acid, thiourea, carbon-di-sulphide and rindite are used for breaking tuber dormancy (Reust, Gugerli 1984). GA treatment is commonly used in countries like India for breaking tuber dormancy since it is not toxic, unlike rindite. An increase in CO_2 concentration in the storage atmosphere is reported to shorten the dormancy period of potato tubers (Burton 1968). Treatment with 20% CO_2 for 7 days was found to be as efficient as rindite treatment for breaking tuber dormancy (Reust, Gugerli 1984). Enhanced dormancy release was observed with a 7-day treatment with 20% CO_2 by Coleman and McInerney (1997). The ability of higher concentrations of CO_2 to break dormancy has resulted in the exploration of a possibility of using this as an alternative to chemical treatment. The aim of this investigation was to see how effective CO_2 treatment is in releasing the dormancy of two popular Indian cultivars and to compare its efficacy with that of GA treatment, commonly used in India for breaking tuber dormancy.

MATERIAL AND METHODS

Potato tubers of two cultivars Kufri Chandramukhi (early duration [70–80 days] variety with large, oval, slightly flattened white tubers having fleet eyes) and Kufri Jyoti (medium duration [90–100 days] variety with large, oval white tubers having fleet eyes) were grown at the Central Potato Research Institute, Shimla, India, during 2002. Seed tubers weighing 50–75 g were planted on 19th of April and the crop was raised following the recommended package of practices. Haulms were cut on 5th of September and 10 days were allowed for the setting of skin. Tubers harvested on 15th of September were cured at 18–20°C for one week and well-cured tubers were exposed to different CO_2 concentrations for 7 days by storing in CO_2 incubators (WTB Binder, Tuttingen, Germany) maintained at 5, 10, 15 and 20% CO_2 concentrations. The temperature of CO_2 incubators was maintained at 18–20°C and at RH 90–95%. After 7 days, the tubers were taken out of CO_2 incuba-

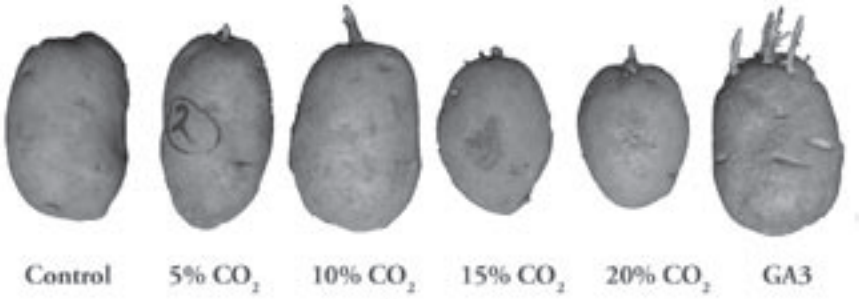

Fig. 1. Effect of CO_2 treatment on dormancy of potato tubers of cultivar Kufri Jyoti

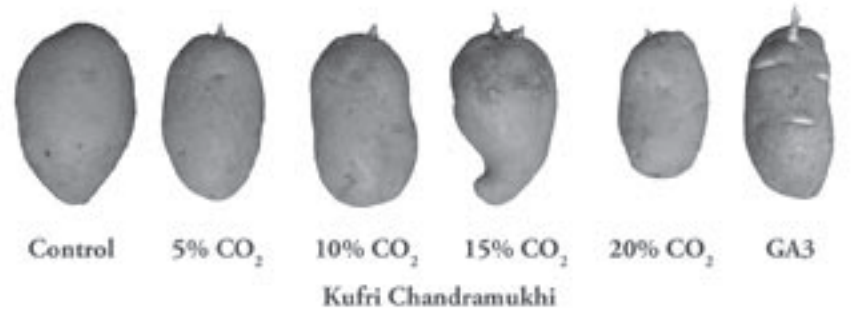

Fig. 2. Effect of CO_2 treatment on dormancy of potato tubers of cultivar Kufri Chandramukhi

tors and stored in a BOD incubator with humidity control, maintained at 18–20°C and 90–95% RH. For comparison with gibberellic acid (GA) treatment, tubers were treated with 1 ppm GA_3 for 1 h, after making 3–4 cuts of about 2 mm deep on each tuber. The treated tubers were dried at room temperature and stored in a BOD incubator with humidity control. All the above treatments were replicated thrice and each replication consisted of 30 tubers. Tubers were stored in egg trays and placed in such a manner that the rose end was facing upward. Observations were recorded on number of sprouts per tuber, length of the longest sprout and mean sprout length. Tubers were checked for the appearance of sprouts on alternate days and the appeared sprouts were measured daily until the length of the longest sprout reached 2 mm. Dormancy period was counted from the day of haulm cutting and was considered as released when 80% of the tubers had at least one sprout longer than 2 mm (Van Ittersum, Scholte 1992). For studying the effect of CO_2 treatment on sprout growth and sugar content, observations were started when the tubers had 0.5–0.9 cm long sprout (0 day) and thereafter observations were recorded after 7, 15 and 30 days during storage at 18–20°C and 90–95% RH. Reducing sugar content was determined by the method of Nelson (1944) and total sugars were determined by the Anthrone method (Van Handel 1968). Statistical analysis was done using MSTAT (4.0 C) package.

RESULTS

The dormancy duration was 97 days in control tubers of Kufri Jyoti (Table 1) and it was reduced to 62 days with GA treatment. While treatment with 5% CO_2 had a low effect on dormancy duration, 10, 15 and 20% CO_2 treatments reduced it to 77 days. In control tubers of Kufri Chandramukhi, dormancy duration was 97 days and it was reduced to 68 days with GA treatment. Treatments with 5, 10 and 15% CO_2 concentrations had low effects on the dormancy duration of Kufri Chandramukhi but treatment with 20% CO_2 reduced it to 77 days. Treatments with different CO_2 concentrations had no significant effect on the number of sprouts per tuber in Kufri Jyoti but in Kufri Chandramukhi, treatment with 20% CO_2 increased the number of sprouts significantly in 30 days after dormancy release (Table 1). GA treatment increased the number of sprouts significantly in Kufri Jyoti but not in Kufri Chandramukhi (Figs. 1 and 2). Kufri Jyoti had a significantly higher number of sprouts than Kufri Chandramukhi. The longest sprout was longer in tubers treated with 5 and 10% CO_2 for one week as compared to 15 and 20% (Table 1). However, there was no significant difference between 5 and 10% CO_2 treatments, and between 15 and 20% CO_2 treatments. No significant difference in sprout length was observed in 30 days. The sprout length was significantly higher with GA treatment and Kufri Jyoti had longer sprouts than Kufri Chandramukhi. The mean sprout length was significantly

Table 1. Effect of treating dormant potato tubers with different concentrations of CO_2 on dormancy period, number and length of sprouts, and weight loss in two potato cultivars

Variety/ Treatment	Dormancy duration (days)	Days of storage after dormancy release												Weight loss (%)		
		No. of sprouts/tuber				length of the longest sprout (cm)				mean sprout length (cm)				7 days after treatment	until dormancy release	30 days after dormancy release
		0	7	15	30	0	7	15	30	0	7	15	30			
Kufri Jyoti																
Control	97	2.3	3.8	3.9	4.4	0.7	1.1	1.3	2.7	0.6	0.6	0.7	1.7	0.7	2.6	3.6
GA_3	62	3.4	4.7	5.4	7.7	0.9	1.4	2.0	2.5	0.6	0.9	1.5	1.7	4.3	2.2	3.9
5% CO_2	95	1.1	2.5	3.0	3.9	0.8	1.0	1.3	3.2	0.8	0.9	1.2	2.4	0.2	3.3	3.5
10% CO_2	77	3.7	4.0	4.2	4.5	0.9	1.2	1.4	2.1	0.2	0.5	0.8	1.5	0.2	2.5	3.5
15% CO_2	77	3.8	4.0	4.0	4.7	0.7	0.8	0.9	2.6	0.5	0.6	0.7	0.9	0.1	2.2	4.2
20% CO_2	77	3.1	3.5	3.9	4.2	0.7	0.9	1.2	2.0	0.3	0.4	0.6	0.9	0.1	1.6	3.8
Kufri Chandramukhi																
Control	97	1.2	1.5	1.6	1.7	0.5	0.9	1.0	1.8	0.5	0.8	0.9	1.3	0.8	2.5	2.0
GA_3	68	1.2	1.5	1.9	2.0	0.7	1.4	1.6	2.0	0.6	1.4	1.5	1.8	3.9	2.2	2.6
5% CO_2	95	1.0	1.0	1.0	1.0	0.8	1.1	1.2	2.1	0.8	1.1	1.2	2.1	0.1	3.3	2.3
10% CO_2	95	1.3	1.7	2.0	2.0	0.6	0.8	1.2	2.4	0.4	0.7	0.9	1.6	0.1	2.5	2.2
15% CO_2	95	1.1	1.1	1.1	1.2	0.5	0.5	0.7	1.9	0.4	0.4	0.6	1.2	0.1	2.2	2.4
20% CO_2	77	2.7	2.9	2.9	3.9	0.5	0.5	0.6	1.3	0.3	0.4	0.4	0.7	0.1	1.6	2.7
$LSD_{0.05}$																
Treatment		NS	NS	NS	1.4	NS	0.2	0.5	NS	0.2	0.4	0.5	0.7	0.8	0.7	NS
Variety		0.4	0.7	0.7	0.8	0.1	NS	0.3	0.5	NS	NS	NS	NS	NS	NS	0.4
Interaction		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Effect of treating dormant potato tubers with different concentrations of CO_2 on reducing and total sugars (mg/100 g fresh weight) in two potato cultivars

Variety/ Treatment	Reducing sugars (mg/100 g f. wt)					Total sugars (mg/100 g f. wt)				
	before storage	7 days after treatment		at the release of dormancy		before storage	7 days after treatment		at the release of dormancy	
		apical half	basal half	apical half	basal half		apical half	basal half	apical half	basal half
Kufri Jyoti										
Control	41	37	102	132	103	73	141	172	239	192
GA_3		171	68	104	61		249	146	227	125
5% CO_2		58	63	139	66		106	109	213	110
10% CO_2		39	47	58	37		65	96	142	109
15% CO_2		56	65	77	45		130	96	143	119
20% CO_2		40	55	75	47		112	101	134	114
Kufri Chandramukhi										
Control	44	37	50	126	100	87	52	70	248	220
GA_3		69	39	99	61		128	83	132	138
5% CO_2		37	38	101	61		93	87	140	131
10% CO_2		34	43	97	66		43	62	144	156
15% CO_2		42	36	114	55		114	59	155	125
20% CO_2		67	58	103	45		103	81	153	117
$LSD_{0.05}$										
Treatment		17.0	NS	11.1	16.4		23.6	20.0	7.3	16.1
Variety		9.8	14.7	6.4	NS		13.6	NS	NS	3.5
Interaction		24.1	NS	15.7	NS		33.4	28.3	10.4	8.6

higher with 5% CO_2 as compared to other treatments (Table 1). There was no difference in weight loss in tubers treated with different concentrations of CO_2, 7 days after the treatment but in GA treated tubers the weight loss was significantly higher (Table 1). The higher weight loss in GA treated tubers in the first 7 days after treatment could be attributed to the incisions made to facilitate the entry of GA. However, after the wound healing, there was no difference in the weight loss between control and GA treated tubers. The weight loss was higher in tubers treated with 5% CO_2 until dormancy release but 30 days after the dormancy release, there was no significant difference in weight loss (Table 1).

Reducing and total sugars were determined in the apical and basal halves of the treated tubers. The reducing sugar content in the apical half of GA treated tubers was significantly higher than that in other treatments, 7 days after the treatment (Table 2). There was no significant difference between treatments in the basal half of the tubers. At the release of dormancy, the reducing sugar levels were higher in the apical half of the tubers in control, GA treatment and 5% CO_2 treatment, as compared to treatments with the other three CO_2 concentrations. The reducing sugar level was slightly higher in tubers treated with 15% CO_2 as compared to the other three CO_2 concentrations. However, the sugar levels in CO_2 treated tubers were lower than those in control. Total sugars were also maximum in the apical half with GA treatment, 7 days after treatment. Among the CO_2 treatments, it was higher with higher CO_2 concentrations. In the basal half, it was higher in GA treated and control tubers in Kufri Jyoti, but no large difference was observed in Kufri Chandramukhi. At dormancy release, the total sugar content in Kufri Jyoti was higher in control and GA treated tubers.

DISCUSSION

Treatment with 20% CO_2 was effective in hastening dormancy release in both the cultivars but was less efficient compared to GA treatment. Reust and Gugerli (1984) found that 20% CO_2 treatment was as efficient as rindite treatment and Coleman and McInerney (1997) observed that in the presence of ethylene, the effectiveness of 20% CO_2 was comparable to Bromoethane in enhancing dormancy release. But we observed that GA treatment was more effective than 20% CO_2 in hastening dormancy release. In addition, it also increased the number and length of sprouts. CO_2 treatment for 7 days had no effect on sprout number indicating that short-term treatment does not affect sprout number whereas in an earlier experiment we observed an increase in sprout number when tubers were treated with 5% CO_2 for 60 days (Singh, Ezekiel 2001). Treatment with 15 and 20% CO_2 reduced the length of the longest sprout. Coleman (1998) also observed a reduction in the length of the longest sprout with 20% CO_2. Inhibition of sprout growth was reported when tubers were stored at 5°C with 9.4% CO_2 (Khanbari, Thomson 1996) and at 10°C with 15 and 20% CO_2 (Burton 1989). Mean sprout length was stimulated by 5% CO_2 treatment but inhibited by 10, 15 and 20% CO_2 treatments. It was reported that at a storage temperature of 10°C, continuous exposure for 16 weeks to 5% CO_2 stimulated sprout growth, 10% CO_2 decreased sprout growth and 15 and 20% CO_2 inhibited sprout growth (Burton 1989).

GA treatment resulted in 3.8 fold increase in reducing sugar and 0.8 fold increase in total sugar content in the apical half of tubers leading to early release of dormancy in buds located in the apical half but this increase was not observed in the basal half, where the buds remained dormant. But in CO_2 treated tubers a considerable increase was observed only in 20% CO_2 treatment in Kufri Chandramukhi while in the other treatments there was a small change in the reducing sugar level. Coleman (1998) observed increased levels of glucose and fructose with 60% CO_2 treatment but not with 20% CO_2. However, 20% CO_2 treatment resulted in a slight increase in sucrose content. Increased sugar levels may not be the cause of dormancy release (Emilsson, Lindblom 1963) but the increased availability of sugars is essential for subsequent sprout growth. GA treatment resulted in the accumulation of sugars which were utilized by growing sprouts at the release of dormancy and this was reflected in the low level of reducing sugars in the apical half of GA treated tubers at the release of dormancy.

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Vliv ošetření CO_2 na délku dormance, růst klíčků a obsah cukrů u dvou kultivarů brambor

ABSTRAKT: Hlízy dvou kultivarů brambor Kufri Jyoti a Kufri Chandramukhi jsme ve fázi dormance ošetřovali po dobu sedmi dnů 5, 10, 15 a 20% koncentrací CO_2 při teplotě 18 ± 1 °C a 90–95% relativní vlhkosti. Tyto hlízy jsme porovnávali s hlízami ošetřenými GA a s neošetřenými hlízami, které sloužily jako kontrola. V průběhu následného skladování při stejné teplotě a relativní vlhkosti se délka doby dormance zkrátila o 20 dnů při ošetření CO_2 a o 35 dnů při ošetření GA. U kultivaru Kufri Jyoti ošetření GA způsobilo 2,6násobné zvýšení obsahu redukujících cukrů a 0,8násobné zvýšení obsahu celkových cukrů v apikální části hlíz. Toto zvýšení obsahu cukrů ve vrcholovém očku mělo za následek dřívější ukončení dormance. Naproti tomu žádné zvýšení obsahu cukrů jsme nepozorovali v bazální části hlíz, kde očka neklíčila.

Klíčová slova: brambory; ovlivnění dormance; koncentrace CO_2; délka klíčků; hmotnostní ztráta; redukující cukry; celkové cukry

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