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Differences among potato (*Solanum tuberosum* L.) cultivars in northern India in performance of diffuse light stored seed potatoes

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Summary

Diffuse light storage (DLS) of potato seed tubers was evaluated in the Punjab, India. Seed tubers of seven cultivars were stored in a nylon mesh covered thatch-roofed DLS and their behaviour in store and subsequent performance in the field was compared with that of tubers stored traditionally in a refrigerated cold store (RCS). DLS of seed from March to October resulted in 34–82 % loss by weight due to high temperature and low humidity compared to 6–8 % in RCS. When the DLS seeds were planted in replicated field trials, they showed reduced germination, germination rate index, plant height and final yield (up to 37 %) compared to seeds from RCS. However, in cvs. Kufri Lalima and Phulwa yields were not significantly reduced following DLS.

Introduction

In the north Indian plains, seed tubers have to be stored from February to October, a period of eight months that includes the hot summer months when temperatures rise to 45 °C. The seed tubers are usually stored in refrigerated cold store (RCS) which is expensive and there may also be losses due to transportation. However, storage under ambient conditions results in high losses due to excessive sprouting, moisture loss and attack by pests and diseases. Exposure of tubers to diffuse light has physiological effects similar to those of low temperature, resulting in reduced sprout growth and a reduction in apical dominance (Dinkel, 1963). The use of diffuse light as a preplanting technique to induce green sprouts is widely practised particularly in Europe (Rastovski et al., 1981). Although diffuse light storage (DLS) under ambient conditions in the tropics and sub-tropics is increasingly common, it was not well described until recently (Booth & Shaw, 1981). Various modifications of the technique have been recommended by the International Potato Centre in Peru for use by potato farmers in a wide range of environments in developing countries and it has proved useful for storing seed in the Philippines (Potts, 1983; Potts et al., 1983) and in Vietnam (Ho et al., 1983).

To evaluate DLS in the north Indian plains, a nylon mesh covered DLS with a thatched roof (International Potato Centre, 1977) and a capacity of 7 t was built at Central Potato Research Station, Jalandhar (Long 75°4 E, Lat 31°2 N and altitude 250 m) in 1984. The behaviour of cultivars in this store and their subsequent field performance was examined in 1984 and in 1985 and compared to that of the same cultivars stored in RCS to see if seed potatoes can be satisfactorily stored without refrigeration.

Materials and methods

Uniform size (40–50 g) seed tubers of seven potato cultivars, Kufri Chandramukhi, Kufri Jyoti, Kufri Sindhuri, Kufri Lalima, Kufri Badshah, Kufri Lauvkar and Phulwa were selected from breeders' seed stocks raised at the station. Breeder's seed of cv. Phulwa was not available in 1984 so apparently healthy seed from another source was used.

In 1984 and 1985 seed tubers were stored from March until October in 20 kg capacity wooden crates in DLS and in hessian bags in RCS (2–4 °C). During 1985, a thatched shade was built on one side of the DLS to exclude direct sunlight and the seed tubers were stored about 20 days earlier than 1984. Maximum and minimum temperatures and relative humidity inside the DLS were recorded twice daily at 08.00 h and 15.30 h and light intensity was measured daily at 12.00 h. Fortnightly observations on total loss and losses due to tuber rots were recorded in four replications of 20 kg each in both the stores throughout the storage season. In September, towards the end of storage, rotted tubers were discarded and apparently healthy tubers, even though shrivelled were selected for planting. The number of sprouts per tuber for 100 tubers of each cultivar was recorded at the time of planting.

Tubers were planted in a split plot design with four replications (plot size – 4.2 × 3.0 m) with cultivars in the main plots which were split for the two methods of storage, i) tubers from RCS pre-sprouted for 10 days in diffuse light (traditional method) and ii) tubers from DLS. 'Kufri Lauvkar' could not be planted in 1984 due to excessive rotting in DLS. Cultural practices recommended for the region were followed. Germination counts commenced 10 days after planting (DAP) on alternate days and germination rate index (GRI) was calculated by dividing mean germination by final germination. Plant height and the number of stem per hill was recorded fortnightly up to 65 DAP on ten plants per plot. The crop was harvested at maturity and final yields recorded.

Results and discussion

Storage conditions. Maximum and minimum temperatures and relative humidity ranged from 29.0 to 44.0 °C, 17.3 to 29.8 °C and 13.5 to 87.4 %, respectively in DLS in 1984 and 1985. Temperatures and relative humidity inside the RCS ranged between 2 and 4 °C and 90 and 95 %, respectively. The light intensity within the DLS during storage ranged between 950 and 3500 lux.

Storage losses. Weight losses increased with time in both the stores. After 7 months, the total losses were high in DLS ranging from 34.2 % (1985, cv. Phulwa) to 82.0 % (1984, cv. Kufri Jyoti) compared to 6.0 and 8.0 % in RCS (Table 1). Modifying the DLS in 1985 by shading and storing the tubers therein early, led to delayed sprouting and reduced losses.

High cumulative losses in DLS were due to high temperature and low relative humidity which are reported to increase respiration rate (Burton, 1966), evaporation (Schippers, 1971), sprouting (Burton, 1973) and rotting (Hingorani & Addy, 1973), the processes that are reduced in cold storage due to low temperature and high humidity.

There were cultivar differences in percentage weight losses in DLS, and when averaged over both years cvs. Kufri Lalima (46.0 %) and Phulwa (48.4 %) had the lowest and cvs. Kufri Jyoti (75.5 %) and Kufri Lauvkar (74.1 %) the highest losses. The num-

Table 1. Total losses (as % by weight) in seed tubers during 7 months storage in cold storage and diffuse light store. Figures within parenthesis are the percentages of rotted tubers.

Cultivars	Diffuse light store		Cold store
	1984	1985	
Kufri Chandramukhi	68.6 (29.7)	56.9 (17.1)	6.1
Kufri Jyoti	82.0 (55.2)	69.1 (17.0)	6.5
Kufri Sindhuri	73.4 (44.2)	63.8 (25.1)	6.0
Kufri Badshah	76.2 (43.0)	66.5 (18.3)	8.0
Kufri Lalima	49.0 (15.3)	43.0 (15.7)	7.0
Phulwa	62.6 (41.0)	34.2 (3.1)	6.9
Kufri Lauvkar	80.3 (52.6)	67.9 (18.8)	7.5

ber of rotted tubers averaged over the two years also varied with a minimum of 15.5 % values in 'Kufri Lalima' and a maximum of 36.1 % in 'Kufri Jyoti' (Table 1). There was no rotting in the tubers in RCS.

Field evaluation. Sprouts that formed on tubers in DLS were green and sturdy as reported by Potts (1983). The mean number of sprouts per tuber ranged between 4.9 and 7.5. The number of sprouts per tuber at planting was not affected by storage conditions because all tubers were induced to sprout in diffuse light following both storage treatments. The sprouts on DLS tubers were, however, longer than those from RCS. The maximum length on DLS tubers ranged from 2.0 to 3.7 cm compared to 0.5 to 1.0 cm on RCS tubers.

In the field trials, the mean GRI of RCS tubers was 0.85 compared to 0.73 for tubers from DLS (Table 2) and overall GRI was 14.1 % lower from DLS tubers. There were, however, marked cultivar differences and in 1985 tubers of cv. Phulwa from DLS had as high a GRI (0.92) as the highest cultivar, Kufri Lalima, from RCS.

Mean germination of tubers from RCS over the two years was 94.8 % compared to 73.4 % for DLS, the lower figure probably can be attributed to loss of vigour caused by physiological ageing. However, all cultivars did not react similarly; storage conditions did not affect the germination of 'Kufri Lalima' in 1984 nor of 'Phulwa' in 1985.

The patterns of plant height and number of stems per hill were similar from 35 to 65 DAP, so only the 65 DAP values are given in Table 2. The mean plant height from RCS tubers was 62.5 cm compared to 49.1 cm from DLS tubers. Again, the cultivar reaction was not uniform and in 1985 the plant heights of cv. Kufri Lalima were unaffected by storage conditions and those of cvs. Phulwa and Kufri Lauvkar were highest following DLS.

The GRI and plant height of two cultivars, Kufri Lalima and Phulwa, both with

Table 2. Effect of storing seed tubers in cold store and diffuse light store on their growth and yield.

Treatments	Germination rate index		Germination %		Plant height (cm) (65 DAP)		No. of stems/hill (65 DAP)		Yield tonnes/ha	
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
Cold Storage										
1. Kufri Chandramukhi	0.82	0.91	88.7	100.0	33.8	58.3	3.3	4.1	22.6	32.1
2. Kufri Jyoti	0.82	0.88	96.3	99.7	42.8	59.4	3.8	4.7	30.2	43.9
3. Kufri Sindhuri	0.83	0.82	88.5	97.7	65.3	87.3	3.4	4.9	28.7	40.8
4. Kufri Badshah	0.83	0.88	93.2	99.0	61.6	84.2	3.5	4.4	31.3	45.3
5. Kufri Lalima	0.83	0.92	90.4	98.0	54.9	71.8	3.6	5.2	32.4	42.5
6. Phulwa	0.73	0.85	86.4	98.7	65.1	91.4	21.7	14.2	18.9	22.9
7. Kufri Lauvkar	–	0.89	–	100.0	–	45.4	–	3.3	–	37.7
Mean	0.82	0.88	90.6	99.0	53.8	71.1	6.6	6.8	27.3	37.9
Diffuse light store										
1. Kufri Chandramukhi	0.71	0.61	56.4	84.8	21.2	40.9	2.8	4.4	9.2	21.5
2. Kufri Jyoti	0.59	0.79	28.8	69.7	17.0	41.1	2.8	3.5	5.1	27.8
3. Kufri Sindhuri	0.71	0.80	21.9	82.7	44.6	73.2	4.8	5.4	21.2	32.3
4. Kufri Badshah	0.63	0.75	41.0	81.4	27.2	55.5	3.5	3.7	9.4	28.9
5. Kufri Lalima	0.79	0.85	88.5	98.7	46.3	71.6	5.1	7.3	26.7	40.8
6. Phulwa	0.69	0.92	72.8	99.0	61.4	95.6	24.9	16.9	16.8	21.5
7. Kufri Lauvkar	–	0.64	–	92.4	–	55.2	–	5.6	–	30.7
Mean	0.69	0.77	59.9	86.9	36.3	61.8	7.3	6.7	14.8	29.1
CD (0.05) for store	0.05	0.04	5.0	2.5	4.1	3.3	0.6	0.5	1.0	2.3
CD (0.05) for cultivar	0.06	0.07	8.2	4.7	6.8	6.9	1.3	0.7	1.9	4.2
CD (0.05) for store × cultivar	N.S.	0.10	11.9	6.6	9.8	9.2	1.6	1.2	2.5	5.9

CD = Critical differences according to Panse & Sukhatme (1967).

long dormancy, was improved by DLS because the physiological age of the seed was more nearly optimum at the time of planting. These improvements were less marked in cv. Phulwa in 1984 perhaps because of the poor quality of the seed used.

The number of stems per hill is usually correlated to the number of sprouts per tuber. We found that the number of sprouts per tuber had not been affected by storage conditions. Nevertheless, tubers in DLS grew 12.9 % more stems per hill than those from RCS (Table 2). This apparently anomalous result may be explained by the reimposition of apical dominance following planting tubers with sprouts <1 mm long (Morris, 1967; Goodwin et al., 1969); the sprouts on RCS tubers were 1 to 2.7 cm shorter than those on tubers from DLS and some may have been affected by the reimposition of apical dominance that did not affect the longer sprouts from DLS.

Mean tuber yield over the two years was 22.0 tonnes ha^{-1} from DLS seed compared to 32.60 tonnes ha^{-1} from RCS seed (Table 2). The high temperature and low humidity for 7 months in DLS resulted in physiologically old seed that yielded significantly less than RCS seed except for cvs. Kufri Lalima and Phulwa in 1985. The percent yield reductions from DLS seed compared to RCS seed in 1984 ranged from 11.0 ('Phulwa') to 83.1 ('Kufri Jyoti'), but the corresponding extremes in 1985 were 4.0 ('Kufri Lalima') and 36.7 % ('Kufri Jyoti') following modifications to the store and other precautions. The patterns of losses during storage were reflected in the yield reductions and comparing the mean yields over the two years in t ha^{-1}, the reductions following DLS were a maximum of 55.6 % with cv. Kufri Jyoti with lowest figures of 9.9 and 8.4% for 'Kufri Lalima' and 'Phulwa', respectively. Although the general pattern of loss during storage and field performance was similar during the two years, the proportional losses were less and germination, plant growth and yields were better from DLS tubers in 1985 compared to 1984. The results agree with the negative effects reported by Severian et al. (1986) from New Caledonia. The mean yield of only 27.3 t ha^{-1} from RCS tubers in 1984 compared to 37.9 in 1985 were probably due to unfavourable weather and the effects of late blight.

Our results do not agree with other reports from tropical countries: Potts et al. (1983) and Richarte et al. (1986) have shown that DLS can serve as a low cost alternative to expensive RCS, performing better than either traditional dark stores or RCS which are not within the financial reach of the farmer and moreover, are often associated with high damage levels due to transportation needs. However, their studies were made under conditions of relatively low temperature and high humidity.

Our results show that even with high storage losses such as 43.0 and 34.2 % in 'Kufri Lalima' and 'Phulwa' in DLS, yields comparable to those from RCS tubers were obtained with reductions of only 4.2 and 6.1 %, respectively in 1985. A key factor is the number of seed tubers available for planting and we found that the number lost due to rotting during seven months in DLS was only 15.7 and 3.1 % of the number stored of cvs. Kufri Lalima and Phulwa, respectively (Table 1).

The cultivars we examined varied greatly in their response to DLS and in their subsequent performance. These findings emphasize the need to testing cultivar performance in a given region before adopting DLS technology. The variability also suggests that it may be possible to develop cultivars through a directed breeding programme which may not need either traditional or expensive RCS technology.

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