Effect of Time and Method of Harvest on Seed Vigour in Garden Peas (*Pisum sativum* L.)

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ABSTRACT

The quality of seed produced from two garden pea (*Pisum sativum* L.) cultivars following three times and three methods of harvest was determined. Seeds were harvested at 40, 25 and 15% seed moisture content (SMC) by hand harvesting and threshing (HHHT), windrowing and machine threshing (WMT) or direct threshing (DT). At 40% SMC hand harvested seeds of both cultivars had germinations of over 90% and were high in vigour, as indicated by low conductivity and hollow heart, and little loss of germination after controlled deterioration (CD). Both machine harvest methods significantly reduced quality by reducing germination and vigour. Machine harvesting at 25% SMC did not affect germination before or after controlled deterioration, although conductivity was significantly increased when compared to hand harvested seeds. However, there was no difference in conductivity between WMT and DT. Hollow heart was significantly lower in DT than the other two treatments. In cv. Pania, hollow heart was greatest at 15% SMC, nearly double that at 25% SMC. Hollow heart incidence in cv. Princess was generally lower and did not differ between seeds harvested at 15% and 25% SMC. Neither conductivity nor germination after CD at 15% SMC differed from that at 25% SMC in either cultivar, although conductivity was increased by machine harvesting. For DT seeds, expected field emergence did not differ between harvests at 25 and 15% SMC for cv. Pania, but was lower at 15% than 25% SMC for cv. Princess. These results suggest that the common New Zealand farmer practice of machine harvesting peas at around 15% SMC requires re-evaluation, particularly to determine whether seed quality could be improved by harvesting at a higher moisture content.

***Additional index words: Pisum sativum* L., garden pea, seed vigour, time and method of harvest, conductivity, controlled deterioration, germination, hollow heart.**

INTRODUCTION

Mechanical damage inflicted during harvesting can severely reduce the viability of some seeds, especially large seeded legumes. Injured or deeply bruised areas may serve as centres for infection and/or result in accelerated deterioration. Injuries close to vital parts of the embryonic axis or near the point of attachment of cotyledons to the axis usually bring about the most rapid losses of viability. It is therefore of the utmost importance to harvest and thresh seeds very carefully, making sure the drum speed is low and seeds are harvested at the right time (Matthews, 1973; Gane, Biddle, Knott and Eagle, 1984; Gane, 1985).

Climatic conditions during the post maturation pre-harvest period have a great influence on the quality of the seed harvested (Delouche, 1980; TeKrony, Egli and Balles, 1980). High temperatures during drying or drying too quickly or excessively, can also dramatically reduce viability (Bewley and Black, 1986) and vigour (Hampton, 1990). Adverse weather conditions during the pre-harvest period cause moderate to severe seed quality problems, commonly termed weathering damage (Delouche, 1974).

Gane *et al.* (1984) reported that harvesting pea seeds at around 25% SMC minimised harvest damage and produced higher quality seed than when harvested at 15% SMC. Similarly in maize (*Zea mays* L.) Mashauri, Coolbear and Hill (1992) recommend shelling at 20-24% SMC rather than at lower SMC's when using a small seed sheller. Most New Zealand pea seed crops are harvested at around 14-15% SMC (Logan, 1983) using direct combining or windrowing then combining. Whether the quality of New Zealand pea seed could be improved by harvesting at a higher seed moisture content, and what effect method of harvest has on seed quality was unknown. This study was therefore designed to investigate these factors in two New Zealand cultivars.

MATERIALS AND METHODS

Experimental design and method of sowing

Factorial experiments each with three methods and three times of harvest as factors were conducted separately for both cv. Pania and cv. Princess in the 1989-1990 season. Plots were arranged in a randomised complete block design with four replications. The plot size was 2 m x 8 m.

Seeds of both cv. Pania and cv. Princess were sown using a cone seeder (Seedmatic 6, F. Walter and H. Wintersteiger K.G., Austria), adjusted to a depth of 3 cm and to sow a distance of 8 m with 20 cm between rows. Each plot was sown to produce a population density of around 100 plants m^{-2} which was achieved by sowing 400 g seed per plot (250 kg seed ha^{-1}) on 3 November 1989.

The trial area was a Tokomaru silt loam soil classified as an aeric fragiaqualf (gleyed yellow-grey earth).

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Superphosphate (0-9-0-12) was applied at the rate of 20 kg ha^{-1} prior to sowing. MCPB herbicide was applied twelve days after sowing at the rate of 1.2 kg a.i. ha^{-1} (3 litres in 200 litres of water ha^{-1}) to control broad leaf weeds.

Seed moisture content determination and harvest timing

Seed development was monitored from 20 days after flowering up to maturity by randomly collecting five plants from each plot (but excluding border rows) every two days up to the last harvest for the determination of seed moisture content (SMC). All pods were removed from the five plants and seeds hand removed from the pods. Then 10 g seed sampled by the quartering method (ISTA, 1985) was ground and oven dried for one hour at 130°C for the determination of seed moisture content (ISTA, 1985). Samples for bulk seed quality and vigour assessment were then harvested when SMC's reached 40%, 25% and 15%.

Method of harvest

For the hand harvested, hand threshed (HHHT) treatment, the pea plants were cut at ground level and the seeds obtained by hand podding immediately after harvest. For direct threshing (DT), a combine harvester (Seedmaster Universal Hydrostatic combine-harvester) with a drum speed of 684 rpm and a rhomboid threshing concave set at 8 cm was used. For the windrow and machine threshing (WMT), the pea plants were cut at the base and allowed to dry in the field for three days before they were threshed by the same combine harvester used in DT.

After harvesting, seeds were immediately heated air dried to 12% SMC (Gane et al., 1984). After the drying of the last harvest, seeds from the WMT and DT treatments were cleaned using an air-screen cleaner (Clipper Inc., Bay City, Michigan, USA) with a 10 mm round perforation screen.

Seed quality

Seed quality was determined for all treatments using the appropriate ISTA methods (ISTA, 1985) or recommendations (ISTA, 1987) where available.

Germination was tested between paper, with four replicates of 50 seeds evaluated in each treatment. Hollow heart was evaluated from the normal seedlings from the germination test. The leachate conductivity was measured by soaking four replicates of 50 seeds of known weight each in 250 ml of deionised water for 24 h at 20°C and then determining conductivity using a CDM-83 Radiometer conductivity meter.

The controlled deterioration test was carried out according to ISTA (1987) with some modifications. For each treatment, four replicates of 20 g of seeds of known moisture content were placed in aluminium laminated foil packs for the controlled deterioration test. The moisture in each sample was raised to 20% (Wang and Hampton, 1991) and the packets were immediately heat sealed, allowed to equilibrate at 5°C for 24 h and then transferred to a germinator set at 40°C and left for two days. Immediately after removing the samples from the 40°C treatment, seed moisture content and germination were determined (ISTA, 1985).

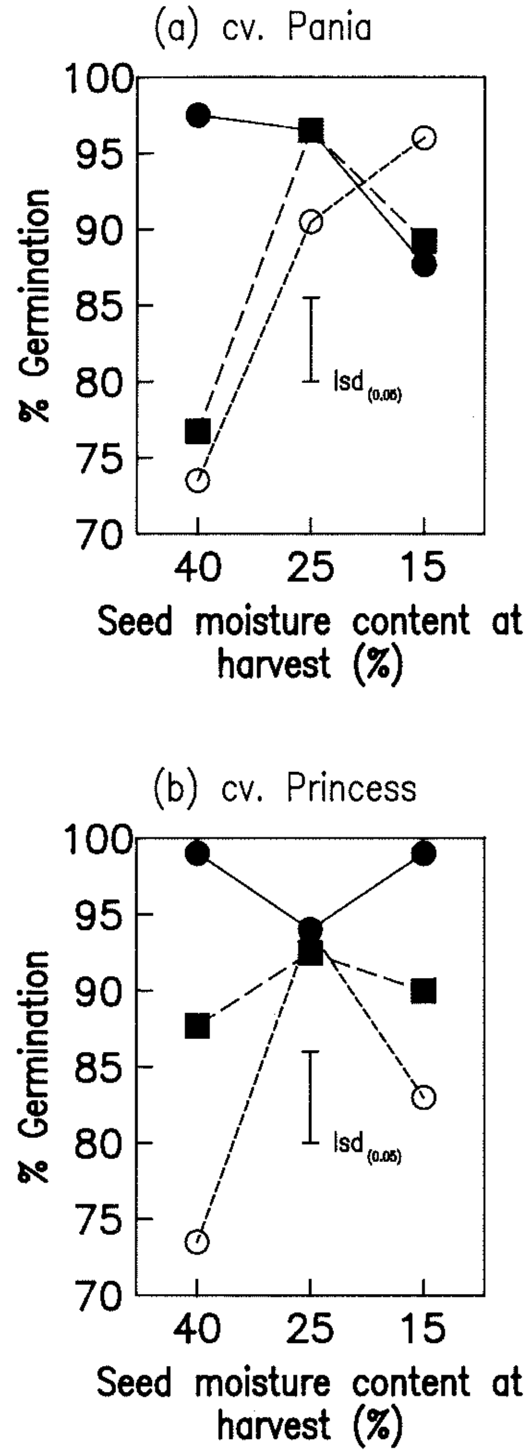

Figure 1.
Percent normal germination of garden pea seeds; (a) cv. Pania, (b) cv. Princess as affected by time and method of harvest. —— = HHHT, — — = WMT, - - - = DT.

RESULTS

Germination

The WMT and DT seeds of cv. Pania had a germination of around 75% when harvested at 40% SMC while that of HHHT seeds was 97% (Fig. 1a). DT germination increased as harvest was delayed, with the highest germination at the 15% SMC harvest, although this was not significantly different from the 25% SMC harvest. For the other two treatments the highest germination was attained at the 25% SMC harvest.

In cv. Princess the DT seeds had a 73% germination at the 40% SMC harvest, 94% at the 25% SMC harvest but only 83% at the 15% SMC harvest (Fig. 1b). Germination for the both the HHHT and WMT treatments was not affected by SMC at harvest.

Hollow heart

In cv. Pania significant differences in percent hollow heart were obtained depending on the time and method of harvest (Table 1) although there was no significant interaction between the two factors. Hollow heart increased significantly as harvest was delayed and was lowest for DT. In cv. Princess the highest hollow heart was at 25% SMC but no further increase was obtained at 15% SMC (Table 1).

Table 1. The effects of a) time and b) method of harvest on hollow heart incidence in cv. Pania and cv. Princess.

	cv. Pania	cv. Princess
a) **SMC at harvest**		
40% SMC	8.7	3.1
25% SMC	11.8	14.8
15% SMC	21.5	14.5
P level	**	**
LSD ($P < 0.05$)	1.64	1.69
CV	13.9	18.7
b) **Method of harvest**		
HHHT	14.2	
WMT	15.2	
DT	12.7	
P level	**	
LSD ($P < 0.05$)	1.64	
CV	13.9	

Conductivity

In cv. Pania, seeds harvested at 40% SMC had higher conductivity readings compared to seeds harvested at 25% and 15% SMC and the WMT and DT harvested seeds had a higher conductivity than the HHHT seeds (Table 2), but again there was no interaction between time and method of harvest.

For cv. Princess, the DT seeds harvested at 40% SMC had the highest solute leakage (Fig. 2). As the SMC decreased at harvest, the conductivity reading decreased regardless of the method of harvest used. However at the 15% SMC harvest, WMT and DT seeds had a higher conductivity than HHHT seeds.

Controlled deterioration

In cv. Pania (Fig. 3a), seeds from WMT and DT had lower germination than the HHHT seeds when harvested at 40% SMC after the 2 days controlled deterioration (CD) test. However, the 2 day CD germination of seed harvested

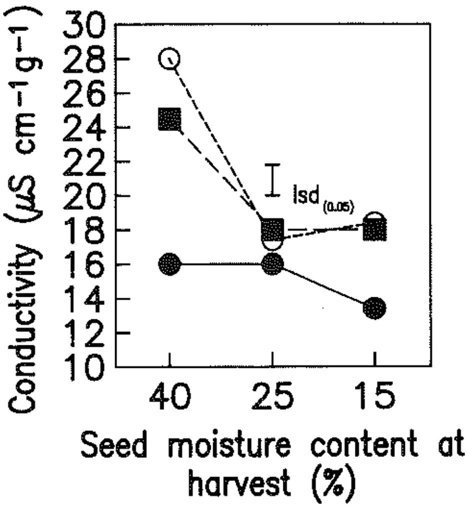

Figure 2.
The electroconductivity reading obtained from garden pea seeds (cv. Princess) as affected by time and method of harvest. —— = HHHT, – – = WMT, - - - = DT.

Table 2. The effects of time and method of harvest on electroconductivity in cv. Pania.

SMC at harvest	Conductivity µs cm^{-1} g^{-1}	Method of harvest	Conductivity µs cm^{-1} g^{-1}
40% SMC	27.1	HHHT	16.3
25% SMC	17.3	WMT	24.2
15% SMC	19.5	DT	23.3
P level	**		*
LSD (P < 0.05)	2.33		2.33
CV	13.0		13.0

at both 25% SMC and 15% SMC did not vary significantly among the methods of harvest. Similar results were obtained from cv. Princess (Fig. 3b), with the exception that at the 15% SMC harvest DT germination was significantly lower than HHHT germination.

DISCUSSION

Seed deterioration may begin as soon as seed development is complete, and its time course may range from a few days to many years depending on factors such as genetic constitution, the environment, seed moisture content and physical damage (Hampton and Hill, 1990). Deterioration involves changes in membrane integrity, solute leakage, enzyme activity, respiration and ATP content, protein and DNA synthesis, the chemical content of the seed, and genetic changes (Powell, 1988).

As expected, the use of machinery in either harvesting and or threshing of pea seeds at high SMC (40%) resulted in low germination. The seeds were prone to bruising and internal damage due to the high moisture content of the seed, and as a result, conductivity was high. As the SMC reduced to 25%, germination increased and conductivity decreased. This agrees with the findings of Moreira, Krutz and Foster (1981), who reported that at optimal seed moisture contents, seeds are dry enough to prevent rupture of cells and release of destructive hydrolytic enzymes upon impaction. A fall in the leachate conductivity during seed maturation is usually observed in peas (Bedford and Matthews, 1975), and a sharp fall in conductivity occurs as seeds develop the ability to withstand post-harvest drying without loss of viability (Bedford and Matthews, 1985; Powell, 1988).

Hollow heart incidence increased significantly in cv. Pania as harvest was delayed, but did not differ when seed was harvested at 25 and 15% SMC in cv. Princess. Increasing time of exposure to temperatures above 25°C is known to increase hollow heart incidence (Perry and Harrison, 1973, Halligan, 1986), and this effect was also evident in the hollow heart differences between the WMT and DT harvest methods. Presumably hollow heart was higher in the WMT treatment because seeds in the pods were exposed to three days of sun during the time between cutting and threshing,

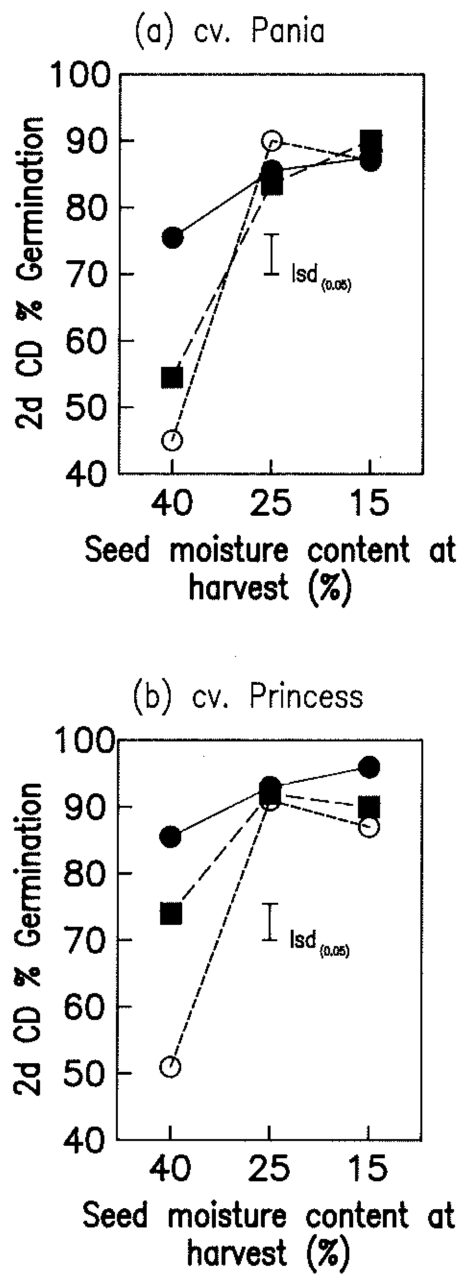

Figure 3.
Percent normal seedlings obtained from the 2 day controlled deterioration test of garden pea seeds; (a) cv. Pania, (b) cv. Princess as affected by time and method of harvest. —— = HHHT, — — = WMT, - - - = DT.

whereas direct threshed seeds did not have this exposure.

Seeds harvested at 40% SMC using WMT and DT also had lower vigour than seeds obtained from HHHT as revealed by the controlled deterioration test (Fig. 3). However when harvest was delayed to 25% and 15% SMC, germination after the CD test was comparable in all treatments except DT at 15% SMC in cv. Princess (Fig. 3a-b). This result and the conductivity test results for these two cultivars (Table 2 and Figure 2) imply that peas machine harvested at 25% SMC can withstand the impact of machine harvesting and are not damaged. Seed vigour as measured by controlled deterioration was comparable to that of the hand harvested peas, even though machinery was used in harvesting. When cv. Pania was machine harvested at 15% SMC, seeds had a higher hollow heart incidence than those harvested at 25% SMC, and although conductivity did not differ significantly between these two seed moistures (Table 2), Castillo (1992) found that in the previous season, conductivity of seeds of this cultivar harvested at 15% SMC was significantly greater than in those harvested at 25% SMC.

When the data for germination, conductivity and hollow heart following DT harvest at 25 and 15% SMC were included in the expected field emergence (EFE) equation used to provide an index of seed lot planting value (Hampton and Scott, 1982), EFE for cv. Pania did not differ with harvest time (both 83%), but the EFE for cv. Princess at the 25% SMC harvest was 84% compared with 76% at the 15% SMC harvest (as a result of a lower germination and increased conductivity). However, these data were collected from one site and in one season. Further work is required to determine whether machine harvesting of New Zealand pea seed crops at higher seed moisture contents than the 14-15% currently used will lead to improved seed quality by reducing the incidence of cell membrane damage as well as reducing the time for hollow heart to develop. If this is so, an investigation of the effects of drying on quality of seeds harvested at higher seed moisture contents will also become necessary (Hampton, 1992). Nevertheless, the results of this study tend to support the findings of Gane et al. (1984) who showed that damage can occur in pea seed harvested at 15% SMC or lower because the seeds become more brittle and cracking damage can occur during harvest.

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