Environmental factors affecting bleaching in Marrowfat peas

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Abstract

Marrowfat peas (*Pisum sativum*) are a high value crop commonly grown in New Zealand. Uses include mushy peas, canning, and global niche food markets. Seed colour is a key quality factor when grading for the marketplace, and poor colour is generally caused by environmental conditions near harvest or during storage. Understanding how environmental conditions influence the quality of peas and designing management practices to improve quality is important for growers. The objective of this study was to assess the impact of shading and rainfall exclusion on bleaching of peas. A plot trial was conducted in the 2012-13 growing season at the Foundation for Arable Research site near Chertsey, Canterbury. Treatments included rain exclusion, light shade, heavy shade, and a control (exposure to rain and full sun). Treatments were applied at mid-pod fill and at yellowing of pods. At harvest, peas were evaluated for percentage of pea bleaching per plot using a photographic technique. Shading decreased ($P<0.05$) the amount of bleaching compared with the control by 17 and 59% for light and heavy shade, respectively. Cumulative radiation on the pea plants from mid pod fill to harvest promoted ($P=0.001$, $r^2=0.70$) the colour degradation of pea seeds. The key period when bleaching occurred was between pod yellowing and harvest. Neither rain exclusion nor the timing of treatment application affected bleaching. Practical whole field approaches for reducing radiation exposure need to be developed for grower application.

Additional keywords: shading, rainfall, seed quality, radiation, chlorophyll degradation

Introduction

The production of marrowfat peas (*Pisum sativum* L.) in New Zealand is almost exclusively for export to international markets (PIDG, 2008). Seed colour (including seed coat and cotyledon) is the most important quality factor in the marketing of marrowfat peas, though colour is graded subjectively (Coles, 1997). Subjective techniques continue to be used despite the increased consistency and repeatability created by advancements in machine methods over the last two decades (Coles, 1997; Davey 2007).

Chlorophyll is the pigment most responsible for the greenness of pea seed, and degradation of chlorophyll results in a bleached appearance that is not desirable. Field peas should be harvested when seed moisture is between 16 and 20%. The longer seed moisture remains above 20%, the greater the degree of bleaching (Riehle and Muehlbauer, 1975). Environmental conditions during maturation and storage have been shown to affect chlorophyll degradation of peas. Hosnedl (1974) found that rainfall accelerated the bleaching process, and irrigation has been shown to enhance bleaching (Riehle, 1974). Rainfall patterns including the duration of rainfall events are likely to be important considerations when assessing the effect of moisture on bleaching (Gubbels, 1977). Few studies have assessed the effect of light on bleaching of peas, specifically, but Cheng *et al*. (2004) reported greater chlorophyll degradation in peas soaked in water than those exposed to light post-harvest. Bleaching was also increased with light exposure compared with darkness (Riehle and Muehlbauer, 1975).

A preliminary study conducted by the Foundation for Arable Research (FAR) indicated that light exclusion was significantly more effective at reducing bleaching than rain exclusion. The objective of the present study was to compare the effects of different shading densities and rain exposure during pre-harvest seed drying on the bleaching of marrowfat peas. Results of this study may be used as a base for further research into applied production methods for improving market quality.

There is no recognised threshold for bleaching for acceptance in international markets. This is because there is no objective method currently in use. This paper outlines a method that could be used by the industry.

Materials and Methods

Marrowfat peas (cv. 22-5; Cates Grain & Seed Ltd, Canterbury New Zealand) were sown at the FAR Arable Site in Chertsey (43° 47’ 37’’ S, 171° 57’ 45’’ E) on 16 October 2012. ‘22-5’ is semi-leafless cultivar developed in New Zealand for higher yield potential and good colour retention. The soil at the trial site is a Chertsey silt loam and is moderately well drained. Weather data collected for the site was obtained from the Chertsey CWS NIWA station on-site, and included monitored daily rainfall, radiation, and temperature. The whole trial was maintained as a single block until pod set when treatments were applied in a split-plot design consisting of four replicated blocks, each with two ‘main plot’ treatments and four ‘sub plot’ treatments within the main plots. Treatments were applied at two timings (mid-pod fill and at yellowing of pods), making time of treatment implementation the main plot in the experimental design. Mid-pod fill (approximately 50% seed moisture content) treatments were applied on 31 January 2013, and yellowing of pod treatments (approximately 35% seed moisture content) on 11 February 2013. Subplots were designed to assess the effect of environmental conditions on pea seed colour. This included rain exclusion, light shade (10% light exclusion), heavy shade (60% light exclusion), and a control with full exposure to sunlight and rainfall. A cloche system was used to provide exclusion of sunlight or rainfall. Rain exclusion was achieved with clear plastic (50 µm thick), light shade with two layers of white bird netting (mesh size 16 mm), and heavy shade with green knitted shade cloth (240 g/m^2). All materials were sourced from Redpath Pacific Ltd. Light exclusion percentages were determined using a ceptometer and are based on photosynthetically active radiation (PAR) readings at canopy level under the cloche materials. The ceptometer used does not differentiate between wavelengths, so any light quality differences under the materials are not known. The cloches were left on the plots until harvest on 27 February 2013.

Peas were field-dried and 50 pods were hand harvested from each plot when seeds could no longer be dented with fingernail pressure (16-20% moisture). The peas were then shelled and stored in plastic bags in a dark environment. Colouration of the peas was determined using the gimp image manipulation program (GIMP 2.8.2, 2012; http://www.gimp.org/downloads/). The aim was to objectively calculate the percentage of peas bleached. To determine this, three photos were taken of all peas of the 50 pods from each plot on a dark solid backdrop. The photos were then uploaded into the software from where bleached areas could be selected and the percentage of the bleached area calculated. The calculation process involves the user altering the photo so that only three primary colours are represented (red=background, green=green pea, blue=bleached pea); by selecting each desired component in the photo and taking percentiles generated by the software for each portion. The formula used to determine the bleaching percentage was:

Percentage bleached = blue/(blue + green) x 100

The bleaching percentage for each plot was calculated as an average over the three photos per plot. Analysis of variance was performed on the bleaching percentage data, and the least significant difference (LSD) (α=0.05) test was used for means separation using Statistix 9.0 (Analytical Software, Tallahassee, Florida, United States). A response curve of bleaching percentage to radiation was generated using regression analysis in Sigma Plot 12.5 (Systat, Point Richmond, California, United States).

Results

The total rainfall was 21.2 mm over the duration of the trial, with only 2.2 mm of the total falling after pod yellowing. Cumulative radiation, as a sum of daily radiation calculated from the on-site weather data, from mid-pod fill through to harvest for fully exposed plots was 586 MJ/m^2. Total radiation at canopy level under the 10% shading and 60% shading treatments of the mid-pod fill timing was 528 and 234 MJ/m^2, respectively. Radiation under the shading treatments indicate likely radiation levels as radiation was not measured directly through the trial period under the given treatments, but was calculated as a percentage based on ceptometer readings above and below the shade materials. All plots of the pod yellowing application timing were exposed to full sunlight for 11 days longer than those sheltered in the mid-pod fill treatment timing. Therefore, total radiation likely reaching pea plants for the 10 and 60% shading treatments set up at pod yellowing was 554 and 391 MJ/m^2. The cumulative amount of radiation at canopy level of the various shading and timing treatments strongly correlated to the final bleaching percentage of pea seeds (P=0.001, r^2=0.70) (Figure 1).

Overall, timing of treatment application had no effect (P<0.05) on pea colouration, and there were no timing x treatment interactions, therefore results are averaged over both timings (Figure 2). Shading had a significant effect on pea colouration. Both the light and heavy shading treatments resulted in a lower (P<0.05) final percentage bleaching than those exposed to full sunlight in the control and rain exclusion treatments (Figure 3). Shading decreased the amount of bleaching compared to the control by 17 and 59% for light and heavy shade, respectively. The heavily shaded peas had a lower (P<0.05) percentage of bleached peas harvested (16.9%) than the lightly shaded (34.6%). The presence or absence of rain did not affect pea colouration.

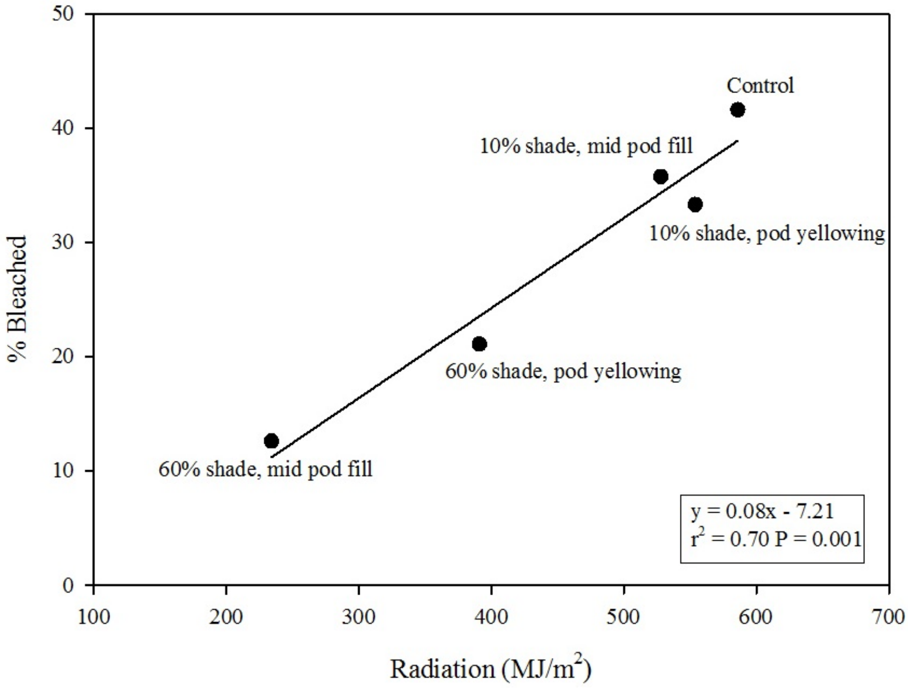

Figure 1: Percentage of marrowfat peas bleached in relation to approximate total radiation reaching pea plants fully exposed to sunlight or with 10% or 60% shading implemented at either mid-pod fill or at pod yellowing. A linear regression line was fit using data from all four replicates, and points on the graph show the average bleaching percentage for each treatment.

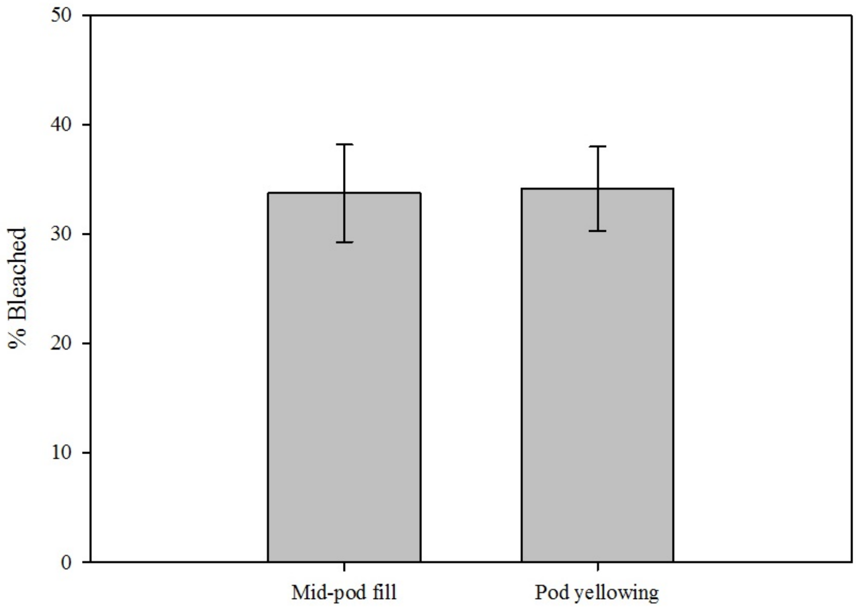

Figure 2: Percentage of marrowfat peas bleached as an average of all environmental treatments (full sun and rain exposure, 10% shade, 60% shade, rain exclusion) implemented at mid-pod fill and at pod yellowing. Verticals bars are standard errors for each implementation timing. Timing had no effect ($P>0.05$) on bleaching.

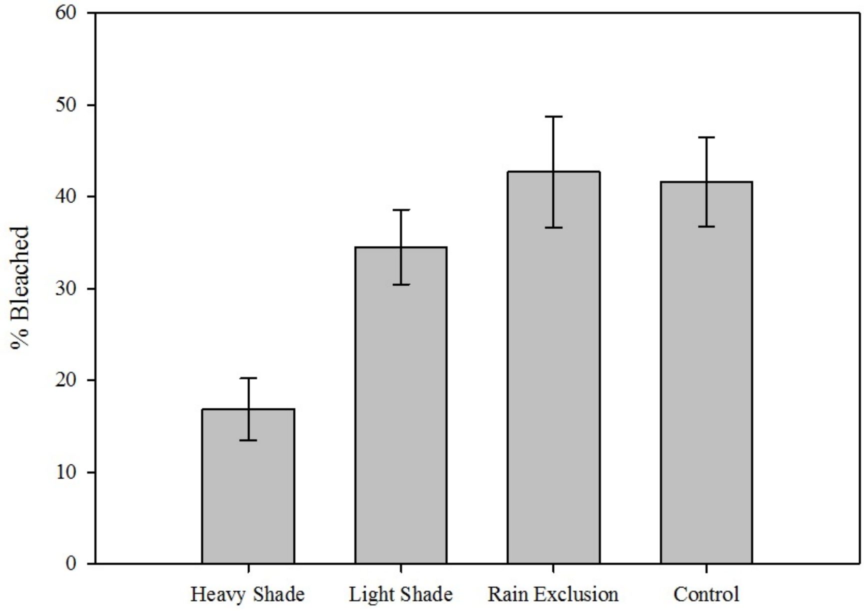

Figure 3: Percentage of marrowfat peas bleached following exposure to four environmental conditions (full sun and rain exposure control, 10% shade, 60% shade, rain exclusion) averaged over both mid pod fill and pod yellowing implementation timings. Vertical bars are standard errors for each environmental treatment. LSD (α=0.05) = 6.86.

Discussion and Conclusions

Environmental Effects

There was no effect on bleaching by timing of treatment application or any timing x treatment interaction, indicating that the key period affecting colour degradation occurred after the pod yellowing treatment application. Unlike previous studies (Hosnedl, 1974; Riehle, 1974; Maguire *et al*., 1973), rainfall did not affect bleaching. Gubbels and Ali-Khan (1990) suggests that short periods of wetness may not cause substantial bleaching, as would have been the case during this experiment in the period from mid-pod fill to harvest. Gubbels (1977) also indicates that severe bleaching may occur when seeds endure several consecutive days of high humidity and dampness. Results from this experiment show that shading provides environmental conditions favourable for reduced bleaching of marrowfat peas. This supports previous FAR research and the study by Riehle and Muehlbauer (1975) where the rate of colour degradation of harvested peas was greater in light than in dark conditions. It is possible that the reduction in bleaching was related to lower temperature under the shade cloth as well as reduced radiation. However, Kowalewska and Szymczak (2001) suggest that chlorophyll pigments are sensitive to light and not to temperatures below 25°C. Also, the strong relationship between radiation and bleaching percentage seen in this trial suggests that radiation is the primary environmental factor responsible for bleaching.

Reducing the radiation reaching the pea plants from mid pod fill to harvest will reduce colour degradation. Therefore, it may be possible to adjust the degree and duration of light exposure to achieve the same effect in the field. This could be achieved by shading or by increasing the rate of seed drying.

Practical whole field practices for reducing light exposure need to be developed for grower application. Shade cloth will not be economical for large scale pea production. Therefore, further research is required to determine other methods which may be sufficient and economical for creating enough shade to minimise bleaching or to speed up the drying process.

Image Analysis

The subjectivity of the grading process in marrowfat peas continues to be a concern for growers. An objective scoring method has been developed in New Zealand using image analysis (Coles, 1997), but is not currently being used on a commercial scale despite being at least twice as accurate as subjective methods. The Acurum® machine (DuPont™) has been tested, with some success, for its ability to measure seed coat colour for quality analysis of lentils in Canada (Davey, 2007). The image manipulation technique used in this study allowed for quantitative analysis and could be useful in developing a consistent and repeatable grading method. Because marrowfat peas are primarily an export crop, it is important that the method be internationally accepted by the importers of New Zealand peas. Therefore, the creation of a reliable objective scoring system will not be useful until international buyers adopt the technology.

References

Cheng, M., McPhee, K.E. and Baik, B.-K. 2004. Bleaching of green peas and changes in enzyme activities of seeds under simulated climatic conditions. *Journal of Food Science* 69: 511-518.

Coles, G.D. 1997. An objective dry pea 'colour' scoring system for commercial and plant breeding applications. *Journal of the Science of Food and Agriculture* 74: 435-440.

Davey, B.F. 2007. Green seed coat colour retention in lentil (*Lens culinaris*). M.S. Thesis, University of Saskatchewan, Saskatoon, Saskatchewan. 92 pp.

Gubbels, G.H. 1977. Quality, yield and weight per seed of green field peas as affected by sowing and harvest dates. *Canadian Journal of Plant Science* 57: 1029-1032.

Gubbels, G.H. and Ali-Khan, S.T. 1990. Screening green field pea genotypes for resistance to color loss. *Canadian Journal of Plant Science* 70: 45-49.

Hosnedl, V. 1974. The effect of harvesting and post-harvest treatment on color uniformity and quality in peas. I. The effect of harvest time and method. *Rostlinna Vyroba* 20: 1173-1182.

Kowalewska, G. and Szymczak, M. 2001. Influence of selected abiotic factors on the decomposition of chlorophylls. *Oceanologia* 43: 315-328.

Maguire, J.D., Kropf, J.P. and Steen, K.M. 1973. Pea seed viability in relation to bleaching. *Proceedings of the Association of Official Seed Analysts* 63: 51-58.

PIDG (Pea Industry Development Group) 2008. Making Peas Pay. Foundation for Arable Research. Lincoln, Canterbury. 68pp.

Riehle, W.G. 1974. Physiological aspects during bleaching of pea seeds. M.S. Thesis, Washington State University, Pullman, Washington. 42 pp.

Riehle, W.G. and Muehlbauer, G.J. 1975. Laboratory techniques for bleaching pea seeds. *Crop Science* 15: 853-855.