

Management of Clubroot of Asian Brassica Crops Grown on Organic Soils

M.R. McDonald, B. Kornatowska and A.W. McKeown
Department of Plant Agriculture, University of Guelph
Guelph, Ontario, Canada

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Abstract

Clubroot of crucifers (*Plasmodiophora brassicae* Woronin) is endemic in most organic soils in Ontario, Canada. Production of cole crops on these soils is limited, but production of Asian Brassica crops has increased markedly and clubroot has become an important limiting factor. Applications of lime are recommended for disease management, but results have been variable. Field trials were conducted from 1999 to 2001 to evaluate the efficacy of calcium cyanamide (Perlka, 50% calcium oxide, 19.8 % nitrogen, 1.5 % magnesium oxide) for the management of clubroot on muck soil (60% organic matter, pH 6.4). Shanghai pak choy (*Brassica rapa* subsp. *chinensis* var. *communis*) and flowering Chinese cabbage (*B. rapa* subsp. *chinensis* var. *utilis*) were direct seeded in June and August of each year, along with Chinese broccoli (*B. oleracea* var. *alboglabra*) in 1999 and 2000. Perlka at 1000, 500 and 333 (banded) kg/ha, and calcitic lime (4.9 tonnes/ha, 1999 or 8 tonnes/ha, 2000, 2001) were incorporated 14 days before seeding, or in the fall of 2000, prior to seeding in 2001. The untreated check received 200 kg/ha N. In 2000 and 2001, a treatment of 1000 kg/ha Perlka, applied 7 days before seeding, and an additional check with 100 kg/ha N, were included. In the trials seeded in June, all rates of Perlka reduced clubroot incidence (average 16%) compared to the untreated check (43%) and lime treatments (33%). Shanghai pak choy had a consistently higher incidence of clubroot than flowering Chinese cabbage. Clubroot incidence was much lower in the trials seeded in August (5.8 % disease in 2000) and no significant differences were detected. Under high disease pressure, clubroot incidence was effectively reduced by Perlka soil amendments. Application of lime was less effective. Crop selection and timing of seeding can also be used to manage clubroot.

INTRODUCTION

Clubroot (*Plasmodiophora brassicae* Woronin) is a soil borne disease which causes considerable economic loss in the production of Brassica crops in Ontario. The main recommendation for disease management is the application of calcitic lime to achieve a soil pH of 7.2 (Myers et al., 1985; OMAFRA, 2000). Other cultural controls that are recommended are crop rotations of 5 to 7 years, the production of seedlings or transplants in disease-free soil and avoiding production in wet, poorly drained soils. Chemical control of clubroot is inconsistent (OMAFRA, 2000).

Production of cole crops on organic (muck) soil is low, possibly because of the high incidence of clubroot, but the area of Asian vegetables, and especially Asian Brassica crops has increased in the past 15 years. There are approximately 1200 ha of Asian vegetables grown in Ontario. Of these, 450 ha are Chinese cabbage (napa) which is grown primarily on mineral soils, and 500 ha are on organic soils. The majority of these vegetables are Brassica crops. These organic soils tend to have relatively low pH (5.5-6.5) and are highly buffered, so require large amounts of lime to raise the pH. Much of the vegetable production is done on rented land, so growers do not always have the opportunity to follow long rotations, or to apply lime the previous fall, or over several years, to adjust the soil pH.

PerlkaTM, a granulated slow release fertilizer consisting of calcium cyanamide (50 % calcium oxide, 19.8 % nitrogen and 1.5 % magnesium) has been available in Ontario since 1998. This material has been shown to suppress clubroot in crops grown on

mineral soils (Klasse, 1996). The possible effects of calcium cyanamide in managing clubroot on crops grown on organic soils are not known. The recommended rate for mineral soils is 1000 kg/ha (Humpherson-Jones et al., 1992). However, Perlka is relatively expensive, and if it was effective at lower rates, it would be more attractive for general use. The recommended application method for mineral soils is to broadcast and incorporate Perlka 14 days before seeding, and to ensure that the soil moisture is in the range required for seed germination. Soil moisture is required to activate the calcium cyanamide. The waiting period is to reduce the risk of phytotoxicity to germinating seeds. Asian Brassica crops mature within 30 – 40 days, and growers try for 3 or 4 consecutive seedings on a field. Waiting for 14 days from harvest to reseeding is not consistent with current production practices. Decreasing the time from application to seeding would increase the options for use.

At least nine different species and varieties of Asian Brassica crops are grown in Ontario. Growers have observed differences in susceptibility to clubroot, but these have not been well documented.

This study was conducted to identify improved methods of managing clubroot on Asian Brassica crops grown on organic soils. The specific objectives were: to determine the efficacy of Perlka as a soil amendment in the management of clubroot and compare the efficacy to the recommended application of lime; to assess the effects of reduced time from application to seeding and reduced rates of Perlka on efficacy; and to identify differences in crop susceptibility to clubroot.

MATERIALS AND METHODS

Two Asian Brassica cultivars were used in all the trials: Shanghai pak choy (*B. rapa* L. ssp. *chinensis* (Rupr.) Olson var. *communis* Tsen and Lee) and flowering Chinese cabbage (also called flowering edible rape, *B. rapa* L. ssp. *chinensis* (Rupr.) Olson var. *utilis* Tsen and Lee). Other crops used in susceptibility trials were Chinese broccoli (*Brassica alboglabra* Bailey) and big leaf mustard (*Brassica juncea* L. Coss. var. *foliosa* Bailey). The seeds were provided by a local grower and were from Chan Man Hop Seed Co., Hong Kong, China.

Field Techniques

Field trials were conducted on organic (muck) soil, a hemic histosol, at the University of Guelph Muck Crops Research Station (44°15'N 77°90'W), naturally infested with the clubroot pathogen, in 1999, 2000 and 2001. Mean soil moisture was approximately 30% w/w. Field sites were irrigated following application of Perlka, if required, to provide adequate moisture for seed germination and activity of the calcium cyanamide. The crops were mainly rain fed during the period of observation. A randomized block design was used (3 replications in the 3 year efficacy trial and 4 replications per treatment in all other trials). Each replicate plot was 3.4 x 5 m². The cultivars were direct seeded with a Stan Hay precision seeder (4 cm spacing; rows approximately 40 cm apart). Plots were seeded on 1 June, 1999, 12 June, 2000 and 31 May, 2001. Another trial with 4 Asian Brassica crops was seeded 24 August, 2000. Crop management procedures followed standard cultivation practices recommended by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA, 2000).

Application of Treatments

The treatments included PERLKA (19.8 % N, SKW Torsberg, Germany) at 3 rates of 1000, or 500 kg ha⁻¹ broadcast or 333 kg ha⁻¹ in a 20 cm band. Calcitic lime (Ca CO₃, 22% Ca, 3% Mg, Cargill Ltd., Canada) was incorporated into the soil at a rate recommended to increase the pH to 7.2, based on soil tests; 8.4 tonnes ha⁻¹ in the fall of 2000, and 4.9 tonnes ha⁻¹ incorporated 14 days before seeding in the spring of 1999 and 2001. The check plots received calcium ammonium nitrate, (27.5% N, Cargill Ltd., Canada) at 100 kg ha⁻¹ N, the recommended rate, and 200 kg ha⁻¹ N, the N rate equivalent to 1000 kg ha⁻¹ of Perlka. If needed, the recommended rates of potassium and phosphorus

were applied. All these treatments were broadcast by hand onto measured areas to ensure the uniformity of application and incorporated to a depth of approximately 10 cm 14 days before seeding, and in 2000 and 2001, a further treatment of 1000 kg ha Perlka was applied 7 days before seeding.

At harvest, yield samples (30 heads per replication) were graded for clubroot incidence (% of infected plants). Disease severity was visually assessed using a scale from zero to three: zero (0) - no clubbing, one (1) - < 25 % of root system clubbed, two (2) - 25 to 50 % of root system clubbed and three (3) - > 50 % root system clubbed (Humpherson-Jones, 1989). Root and head weights were recorded for all yield samples assessed for clubroot infection.

Data were analyzed with General AOV and Mean Separation Tests (Fisher Protected LSD) using Linear Models section of Statistix 7 (Analytical Software, 2000, U.S.A.)

RESULTS

Significant differences in the incidence and severity of clubroot was found among the treatments, years and crops grown. There were no interactions, except crop by year. Perlka effectively reduced the incidence of clubroot on the two Asian Brassica vegetables over the three years of trials on muck soils (Fig. 1). Applications of lime at the recommended rate also reduced clubroot compared to the check (200 kg ha CAN), but was not as effective as Perlka. There were no differences in efficacy among the rates of Perlka tested. The mean incidence of clubroot was greater in 1999 (35%) than in 2000 (24%) or 2001 (14%).

When simple effects were examined, there were no differences in the incidence of clubroot at the two different rates of nitrogen (Table 1) or when the full rate (1000 kg ha) was applied 7 or 14 days prior to seeding (Table 1). The results were similar when the trial was repeated in August (Table 2) however, the incidence and severity of clubroot was so low that there was no significant effect of any treatment.

Differences were found in the incidence of clubroot at harvest among the Brassica crops tested. In the three year efficacy trial, the incidence of clubroot was higher on Shanghai pak choy than flowering Chinese cabbage in 1999 and 2000 (52% vs. 13% in 1999 and 37% vs. 11% in 2000) but there were no differences in 2001 (18% vs. 11%). Similarly, when four crops were grown in 2000, Shanghai pak choy had a higher incidence of clubroot than the other three crops (Table 3). No differences in disease incidence were found among the crops when they were seeded in August, but the levels of clubroot were very low.

DISCUSSION

The granular fertilizer, Perlka, was effective as a soil amendment for the suppression of clubroot on Asian Brassica crops grown on organic soils. The rate recommended for disease management on mineral soils (1000 kg ha⁻¹) was also effective on organic soils, but results indicate that lower rates or a banded application can be equally effective. Calcitic lime also suppressed clubroot but was not as effective as Perlka. Timing of the Perlka application 14 or 7 days before seeding did not appear to reduce the effectiveness of the treatments.

The results of this study led to the following recommendations for the management of clubroot on Asian Brassica crops grown on organic soils in Ontario:

- (a) Where clubroot is known to be a problem, avoid susceptible crops such as Shanghai pak choy and grow less susceptible crops such as flowering Chinese cabbage, big leaf mustard or Chinese broccoli.
- (b) To reduce the incidence of clubroot, apply Perlka 7 to 14 days before seeding. Rates of 500 kg ha⁻¹ or a banded application of 333 kg ha⁻¹ should be effective.
- (c) There is no need to select crops or treat soil for crops seeded in August.

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Tables

Table 1. Main effects of treatment on clubroot incidence and disease index in four Asian crucifer crops, seeded June 2000.

Treatments (days before seeding) ¹	Rate kg/ha	Clubroot Incidence	Disease Index
Check (7)	100 (N)	26.0 cd	14.6 c
High Nitrogen Check (14)	200 (N)	33.5 d	20.1 c
PERLKA (14)	1000	11.7 ab	7.8 a
PERLKA (7)	1000	9.6 a	5.4 a
PERLKA (7)	500	18.5 abc	12.0 bc
PERLKA banded (7)	1000	14.6 abc	9.0 ab
Calcitic Lime (7)	8 t/ha	22.1 bcd	13.1 bc

¹ the numbers in brackets indicate application timing (days prior to seeding)

² the numbers in the columns followed by the same letter are not significantly different at P=0.05 (Fisher's Protected LSD test)

Table 2. Main effects of treatment on clubroot incidence and disease index in four Asian crucifer crops seeded August, 2000.

Treatments (days before seeding) ¹	Rate kg/ha	Clubroot Incidence	Disease Index
Check (7)	100 (N)	1.5 NS*	0.6 NS
High Nitrogen Check (14)	200 (N)	5.2	2.6
PERLKA (14)	1000	2.3	1.1
PERLKA (7)	1000	1.0	0.3
PERLKA (7)	500	2.3	1.0
PERLKA banded (7)	1000	1.9	0.9

¹ the numbers in brackets indicate application timing (days prior to seeding)

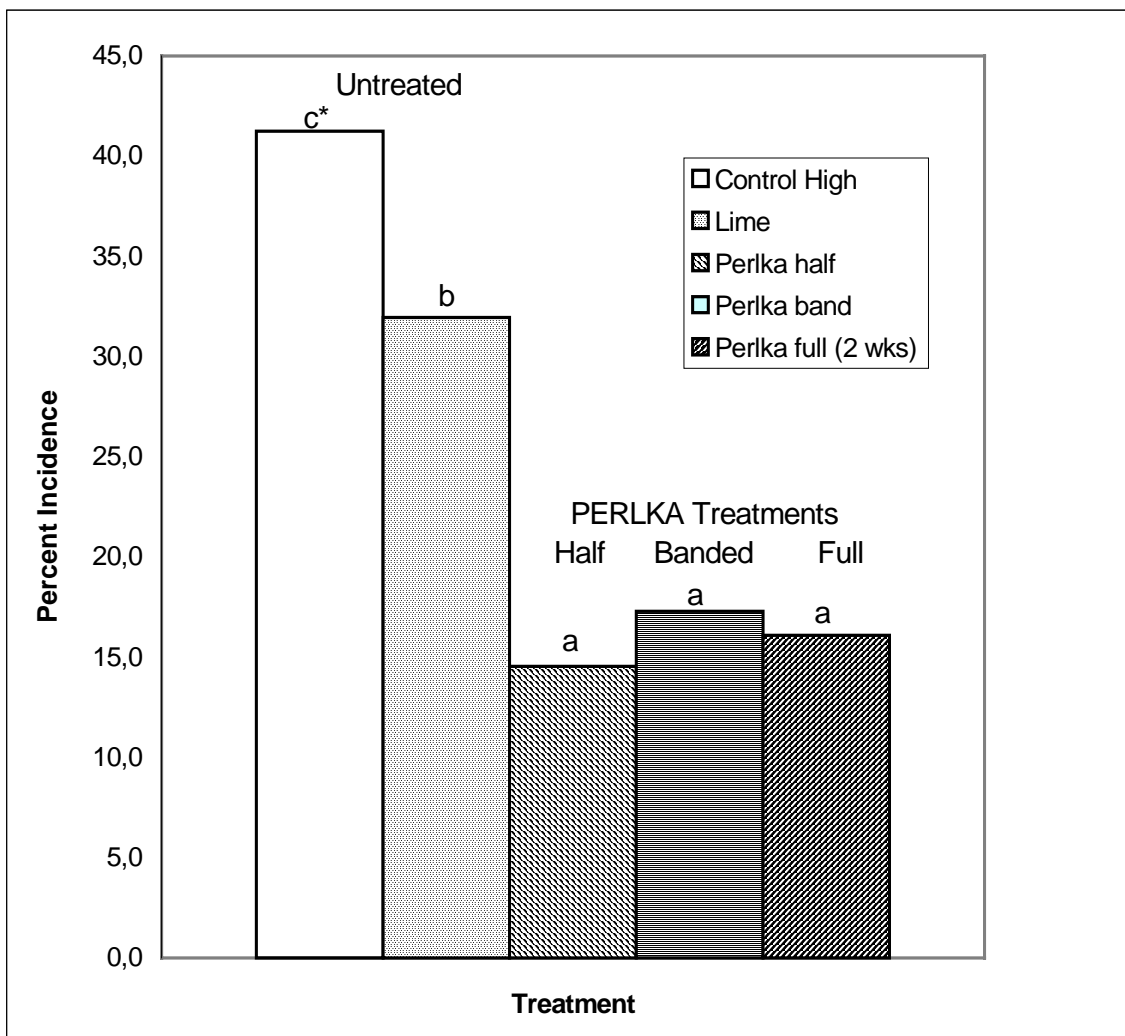
* NS are not significantly different at P<0.05

Table 3. Main effects of crop on clubroot incidence in four Asian crucifer crops seeded in June and August, 2000.

Crop	Clubroot Incidence (%)	
	June	August
Chinese broccoli	15.3 a ¹	2.9 NS*
Flowering Cabbage	18.1 a	1.1
Shanghai pak choy	33.3 b	3.1
Leaf mustard	13.5 a	0.8

¹ The numbers in a column followed by the same letter are not significantly different at P=0.05 (Fisher's Protected LSD test), * NS are not significantly different at P<0.05

Figures



*Columns with the same letter are not significantly different at $P < 0,05$

Fig. 1. The effect of three rates of Perlka and lime on the incidence of clubroot on two Asian vegetables grown on muck soils over three years, 1999- 2001.