Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada



SUSTAINABLE CROP PROTECTION

Results from the *Pesticide Risk Reduction Program*

Carrot production on raised beds

Reduced risk weed control strategies

Carrots in many regions of Canada are produced on raised beds. Such practice requires high levels of herbicide inputs in order to achieve adequate weed control over raised beds. Weed control is primarily dependant on broadcast applications of mainly three broad spectrum soil herbicides (linuron, trifluralin and prometryn) as carrots are considered poor competitors. Resistance to linuron has been documented in Quebec and Ontario for two major weeds: green pigweed and common ragweed. This can limit the control options available to growers for effective weed management in carrots.

Introduction

Technological advances in physical weed control may allow the adaptation of practices such as stale seedbed, shallow tillage or propane flaming as means to reduce herbicide inputs in carrot production on raised beds and delaying resistance development.

In general, cultural and physical weed control practices do not provide high levels of control individually but combinations of methods can provide economically viable weed control. Each practice has its advantage within a crop production (Table 1).

Research was conducted in 2007 and 2008 at the *Harrington Research Farm, which is part of Agriculture and Agri-Food Canada's Crops and Livestock Research Centre* in Prince Edward Island, with the financial support of the *Pest Management Centre's Pesticide Risk Reduction Program*.

Trials, conducted on mineral soils, compared weed control and crop yield under recommended broadcast linuron applications with different combinations of banded chemical sprays and propane flaming or shallow cultivation in either stale seedbed or direct seeded situations. These combinations are summarized in Table 2. The stale seedbeds received one pass of the basket weeder just prior to planting to loosen soil which may have crusted and for weed control.

Canada

Table 1. Cultivation practice, intended use and impact

Cultivation practice	Technique	Target use in carrot	Purpose
Stale seedbed in combination with basket weeder		• Control weeds prior to planting crop • Break soil crust	Replace linuron applied pre-emergence
Banded linuron		• Applied pre and/or post crop emergence • Control weeds in a narrow band over crop row	Reduce amount of linuron applied
Banded flaming		• Applied preplanting or pre-emergence to crop or both to control weeds	Replace linuron applied pre-emergence
Banded acetic acid		• Applied post emergence to weeds and pre-emergence to crop • Control weeds over crop rows	Replace linuron applied pre-emergence
Tillage with side knifes		• Applied post-emergence to weeds • Control weeds on sides of raised bed	Complements cultivation
Tillage using S-tines with or without duckfoot		• Applied post emergence to weeds • Control weeds in-between carrot bed	Complements cultivation

Table 2. Treatment combinations, the number of equipment passes associated with each technique and respective costs

No.	Treatment Combination	Bed preparation[1]	No. passes for weed control	No. passes for cultivation	Cost ($/ha)[2]	Cost ($/T)[6]
1	Weedy Check	Planting	---	---	51.87	4.46
2	Broadcast Linuron[3] pre & post-emerge	Planting	2	---	327.43	5.36
3	Banded Linuron pre & post-emerge + cultivation[4]	Planting	2	2	365.81	6.53
4	Banded Linuron pre & post-emerge + side knifes & S-tine with duckfoot	Planting	2	2	400.43	7.96
5	Flaming pre-emerge + cultivation	Planting	1	1	293.56	13.29
6	Flaming pre-emerge + side knifes & S-tine with duckfoot	Planting	1	1	310.92	13.85
7	Weedy Check	Stale seedbed	---	---	59.84	13.51
8	Broadcast Linuron pre & post-emerge	Stale seedbed	2	---	335.40	5.80
9	Banded Acetic acid[5] pre-emerge + cult.	Stale seedbed	1	1	1179.14	51.31
10	Banded Acetic acid pre-emerge + side knifes & S-tine with duckfoot	Stale seedbed	1	1	1196.50	40.45
11	Flaming preplant & pre-emerge + cultivation	Stale seedbed	2	2	543.22	22.26
12	Flaming preplant & pre-emerge + side knifes & S-tine with duckfoot	Stale seedbed	2	2	577.94	24.81

1 Planting = beds shaped just prior to planting; Stale seedbed = beds shaped 2 wks prior to planting.

2 Estimation according to "Machinerie, Coûts d'utilisation et taux à forfait suggérés, AGDEX 740/825, Avril 2006, Corrigé Septembre 2006, section 7,2" (*Centre de Référence en Agriculture et Agroalimentaire du Québec*). The estimates are based on yearly use level, 15 years economic life, 300 hours of utilization per year, Tractor 14,4kW + operator (15$/h), negligible cost for weeders (small unit) width of work corrected to effective width of application, adjusted with fuel cost of 0,95$/L and adjusted with propane cost according to trial conditions and actual price (0,8414$/L, propane, March 8 2009).

3 Linuron broadcast PRE at 600 and POST at 1185 g ai/ha when carrots were 8-15 cm tall; linuron banded PRE and POST at same rates; banded width over the rows in all cases was 30 cm. Propane consumption was 120L/ha applied at 4 km/hr.

4 Cultivation = S-tine cultivation; tillage with side-knives was done on the sides of the hills with 1 pass at 2 km/h 2.5 cm from the carrot row followed by a second pass at 10km/h 10cm from the carrot row.

5 Acetic acid applied at 6.25%.

6 Treatment cost per marketable yield.

Results

Overall, stale seedbed practice combined with raised beds had more weeds on the top than beds prepared at planting (Figure 1). Linuron or acetic acid banded over the top of the bed reduced weed biomass comparable to linuron applied broadcast (commercial standard). Banded linuron gave the highest weed control and carrot yield (Figure 2). Propane flaming was not as effective as the herbicides in weed biomass reduction on top of the bed primarily because it had no residual activity. Cultivation with side knifes was effective at weed removal only on the side of beds but it was less favoured over cultivation with tines because tines allowed for faster field operation. Banding treatments reduced the cost for both herbicides (linuron or acetic acid) and flaming use. The large volume of acetic acid applied makes this treatment uneconomical. Similarly, pre-emergence flaming resulted in a low carrot yield. More precise application with better crop safety is required before pre-emergence flaming or acetic acid is to be recommended.

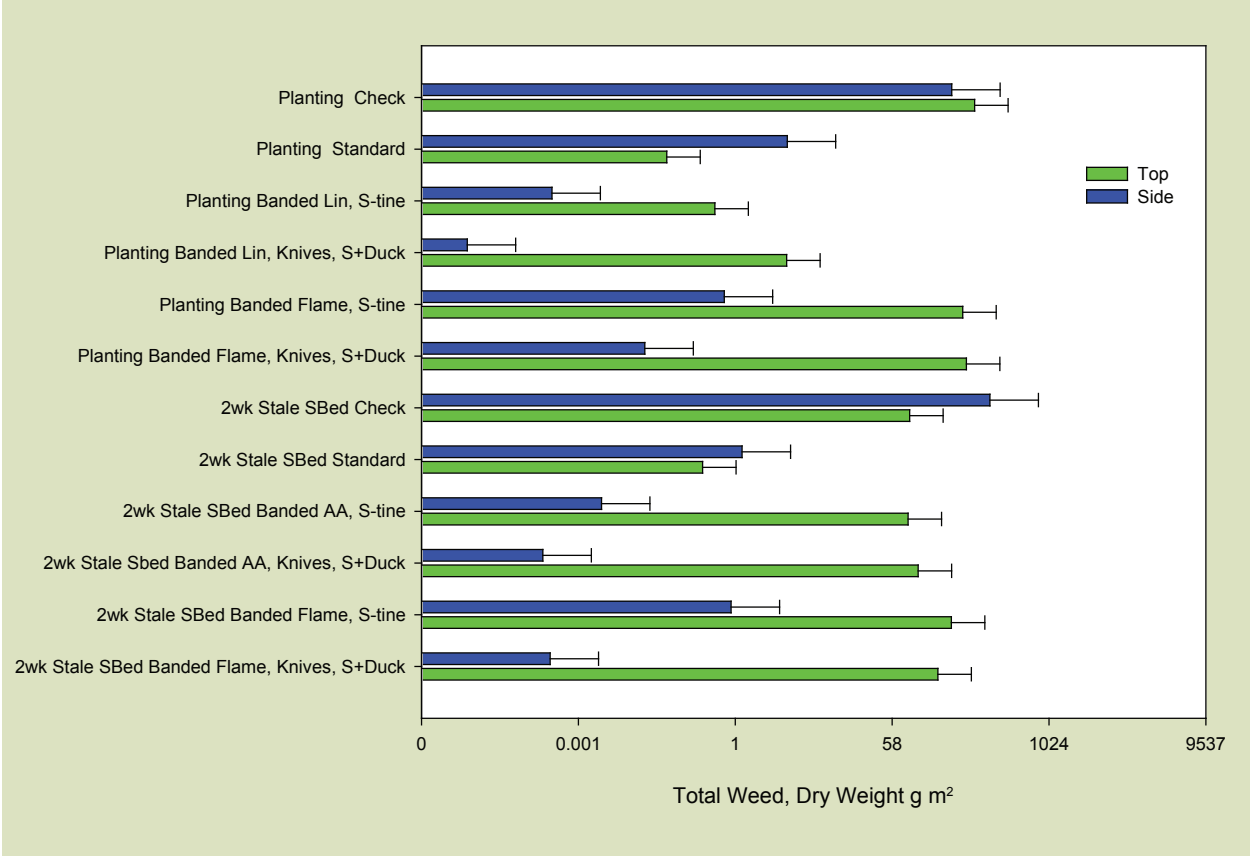

Figure 1. **Effect of reduced risk weed control practices on weed control on the top and sides of the carrot bed in July (mean of 2007 and 2008).**
Standard = broadcast linuron; **Banded** = herbicide applied in 30 cm wide band directly over the carrot row; **Knives** = side knives; **Lin** = linuron; **S+Duck** = S-tine + duckfoot; **2wk Stale SBed** = 2 weeks old stale seedbed; **AA** = acetic acid.

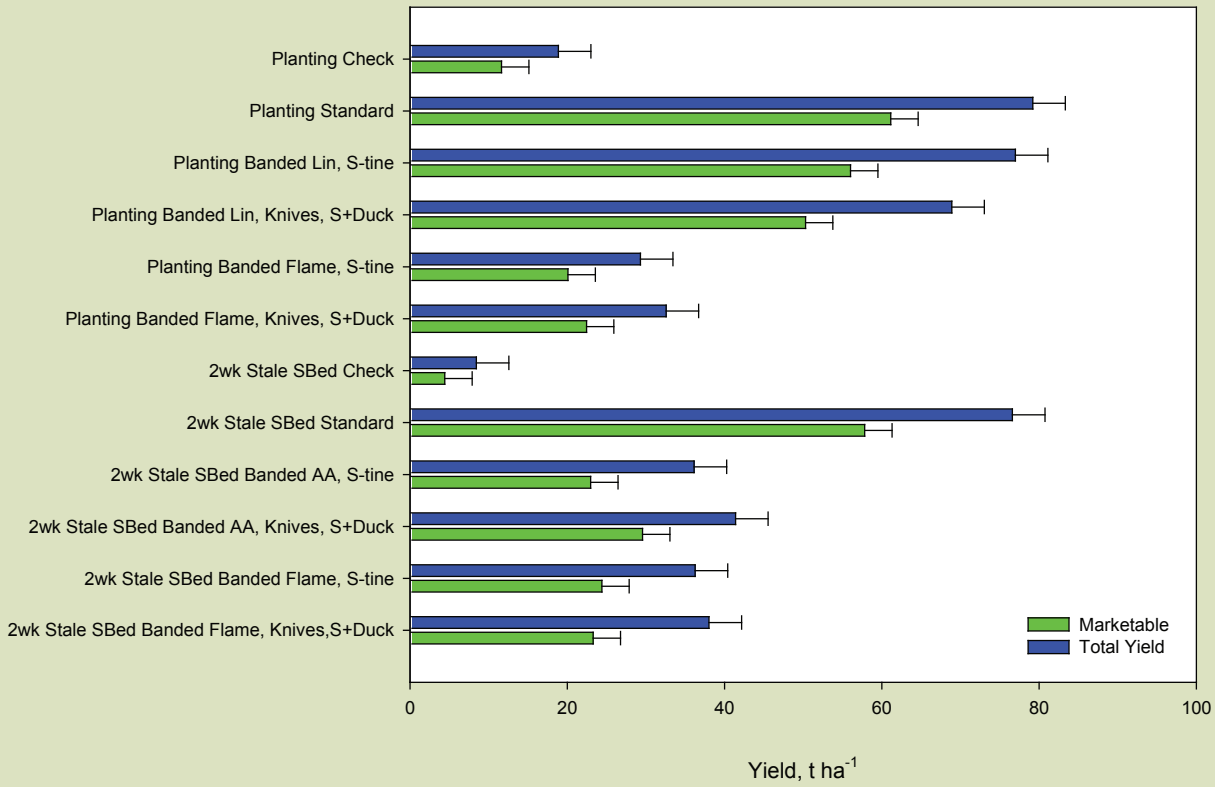

Figure 2. **Effect of reduced risk weed control practices on carrot yield (mean of 2007 and 2008).**
(**Marketable** = carrot diameter >19 mm).
Standard = broadcast linuron; **Banded** = herbicide applied in 30 cm wide band directly over the carrot row;
Knives = side knives; **Lin** = linuron; **S+Duck** = S-tine + duckfoot; **2wk Stale SBed** = 2 weeks old stale seedbed;
AA = acetic acid.

Summary

The weed control alternative with the greatest potential in reducing the amount of herbicide used while providing acceptable control efficacy and yields is the one where banded application of linuron over the carrot bed is combined with mechanical cultivation using side knives and duckfoot cultivators between the raised beds. The cost difference between the proposed practice and the commercial standard is negligible but the environmental benefits are of major importance. Banding herbicide on top of the bed reduced herbicide use by 66%, thereby reducing environmental impact. This helps reduce the herbicide load in the environment especially on sandy loam soils, low in organic matter, on which most of the carrots are produced.

About the *Pesticide Risk Reduction Program* at *Agriculture and Agri-Food Canada*

The Pesticide Risk Reduction Program delivers viable solutions for Canadian growers to reduce pesticide risks in the agricultural and agri-food industry. In partnership with the Pest Management Regulatory Agency of Health Canada (PMRA), the Program achieves this goal by coordinating and funding integrated pest management strategies developed through consultation with stakeholders and pest management experts.

The Pesticide Risk Reduction Program is actively pursuing the development and implementation of strategies which are key to reducing pesticide risks in the agricultural environment. To view Program's current priorities and the issues being addressed, visit www.agr.gc.ca/prrmup

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