AARHUS
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Tools for minimising laborious hand-weeding in row crops

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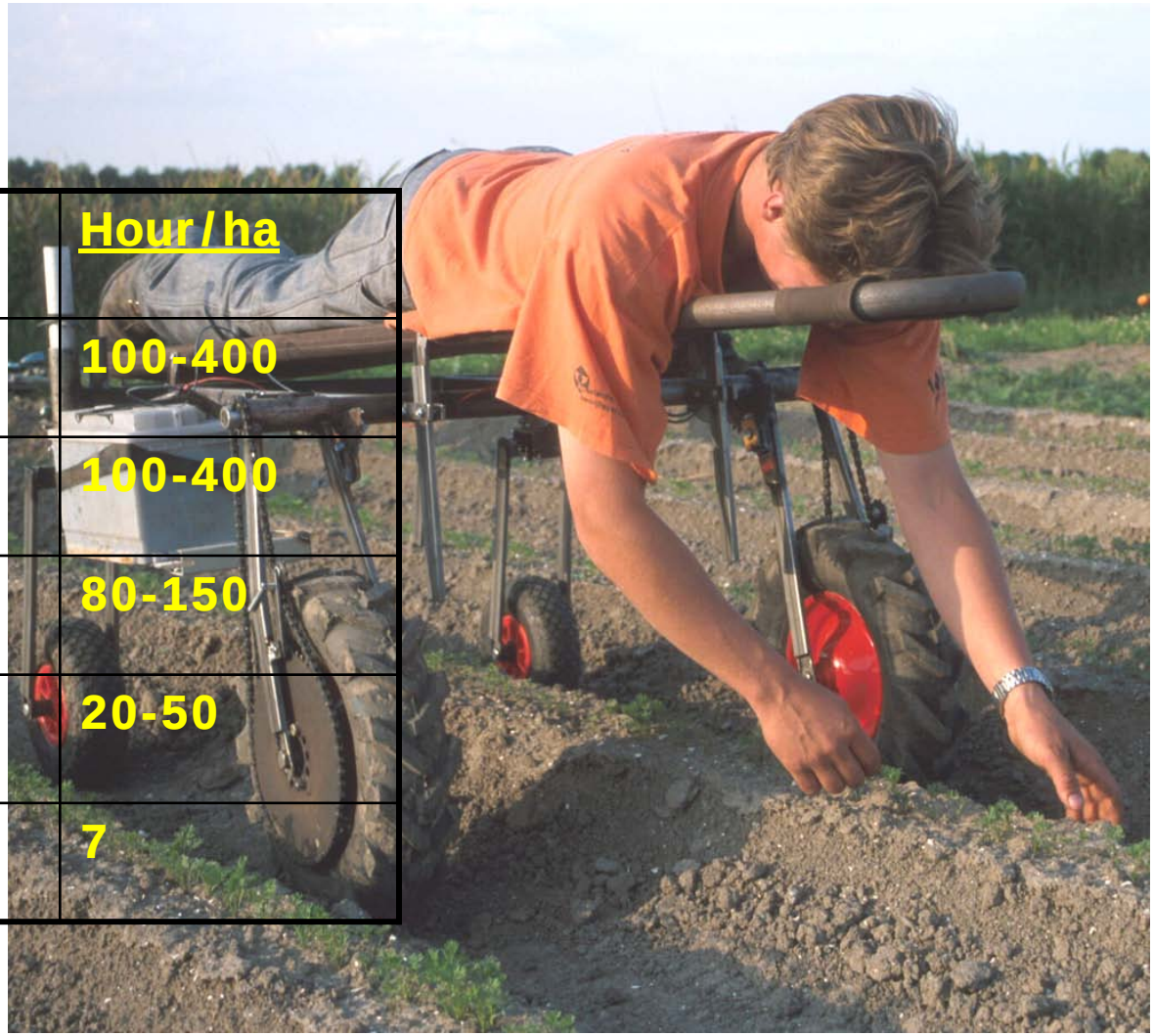
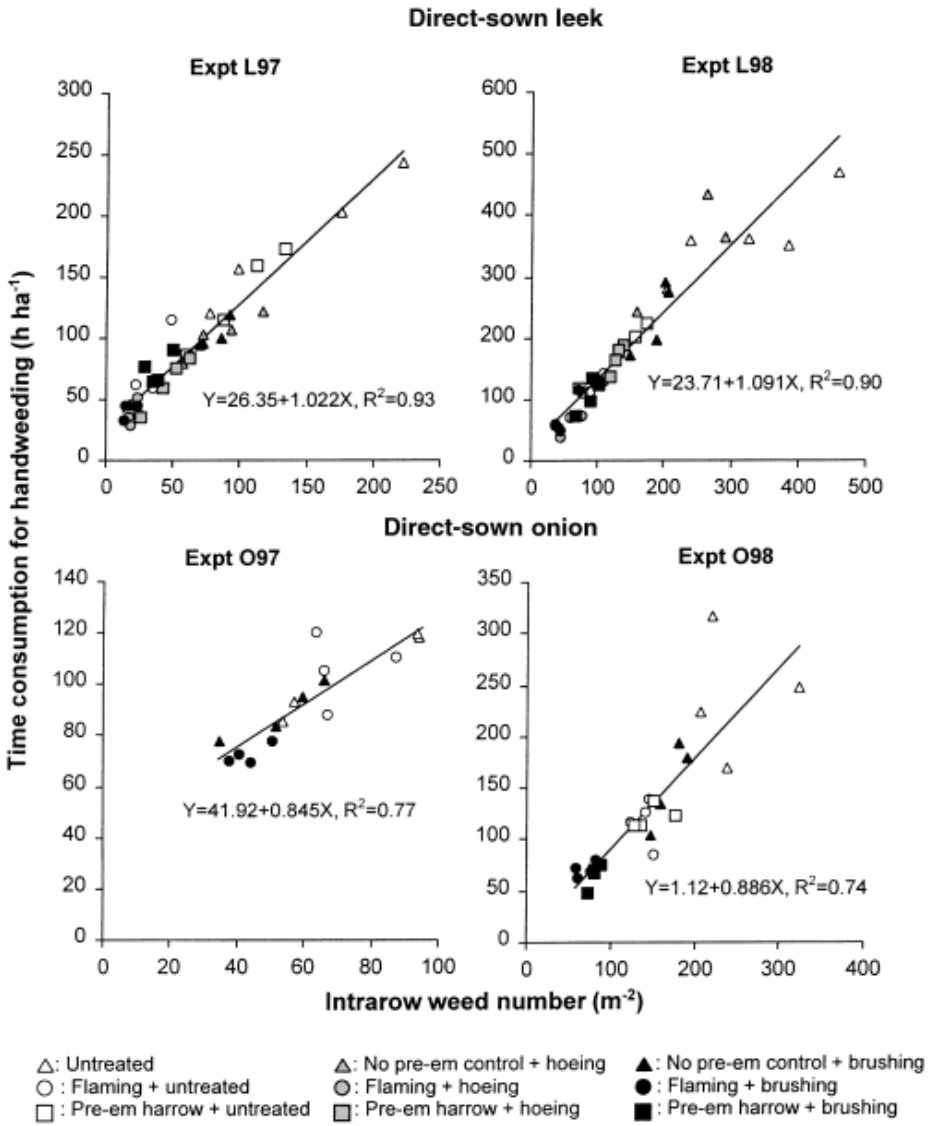
Intra-row

Hand weeding intra-row weeds

Time consumption for hand weeding

Crop		Hour / ha
Onion	sown	100-400
Carrot	sown	100-400
Sugarbeet	sown	80-150
Transplants		20-50
Cereals	sown	7





[From Melander & Rasmussen (2001). Weed Research 41, 491-508]

Current mechanical methods

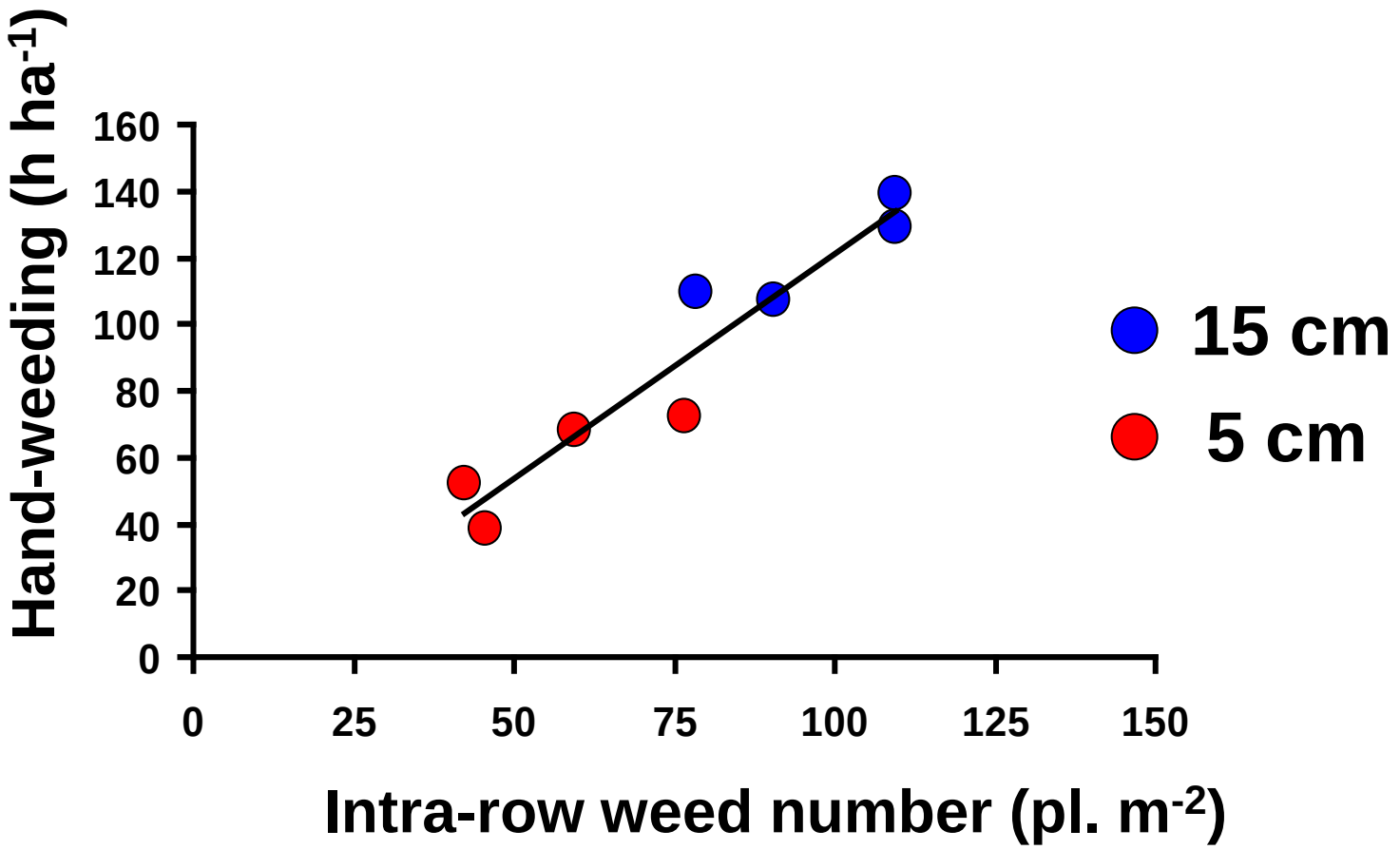
- Weed harrowing
- Brush weeding
- Torsion weeding
- Rake weeder
- Rotary tine weeder
- Ridging
- Hoeing close to the row

Current thermal methods

- Flame weeding
- Steaming
- (Hot water)
- (Hot foam)

Hoeing close to the row

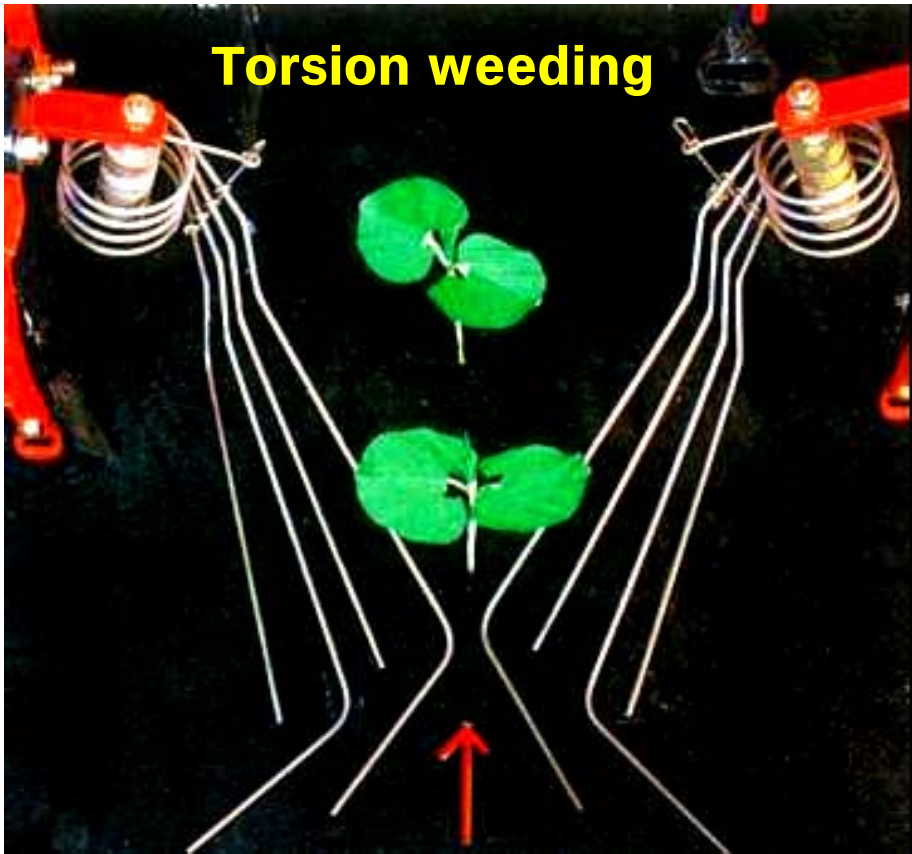
Hoeing close to the row



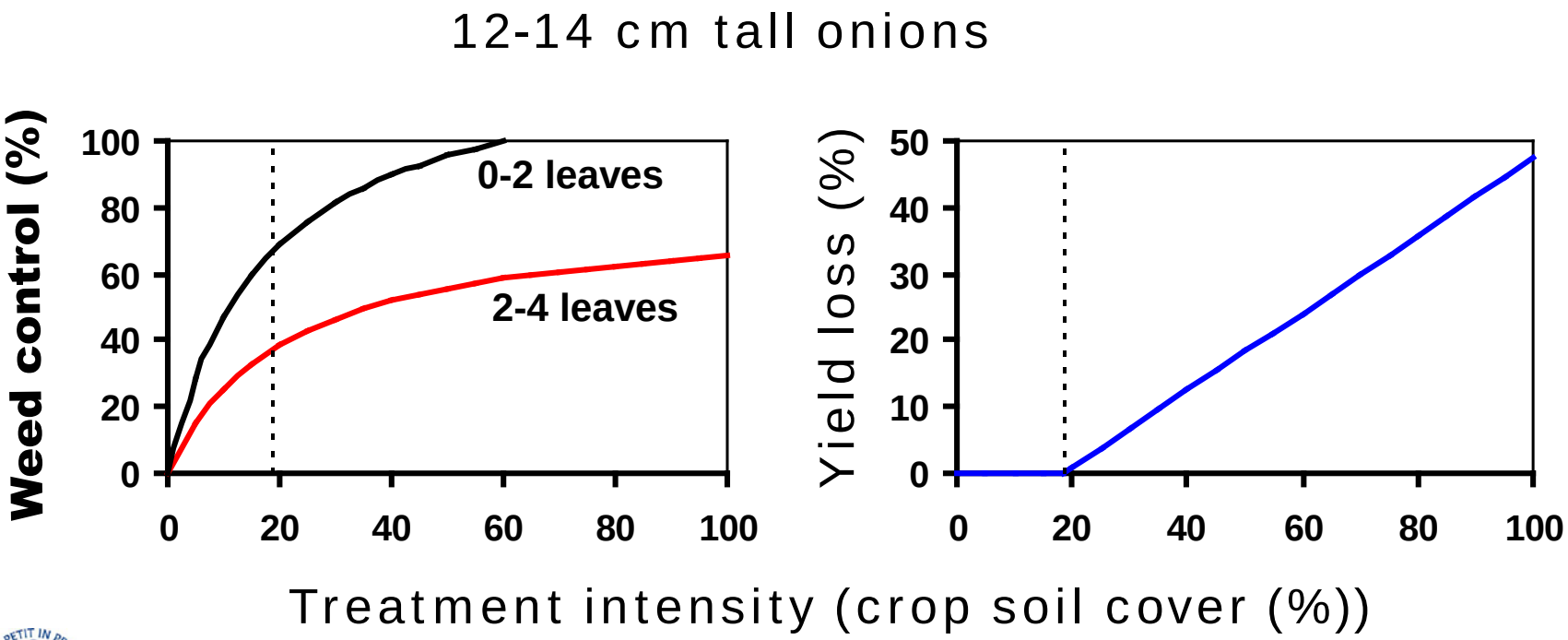
[From Melander & Rasmussen (2001). Weed Research 41, 491-508]


Brush weeding


Finger weeding

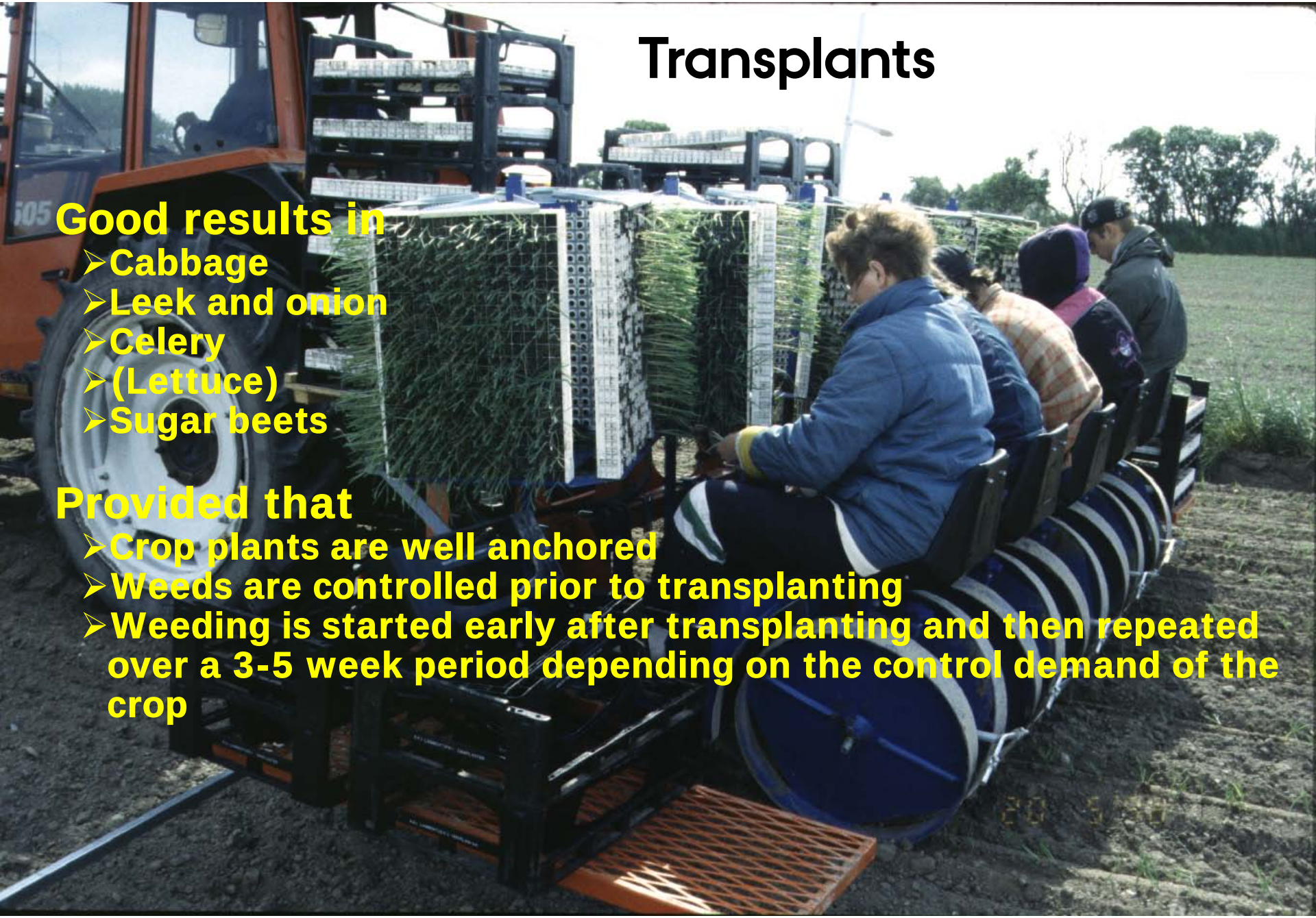

Torsion weeding

Post-emergence brush weeding and selectivity



[Adapted from Melander (1997). Journal of Agricultural Engineering Research 68, 39-50]

Transplants



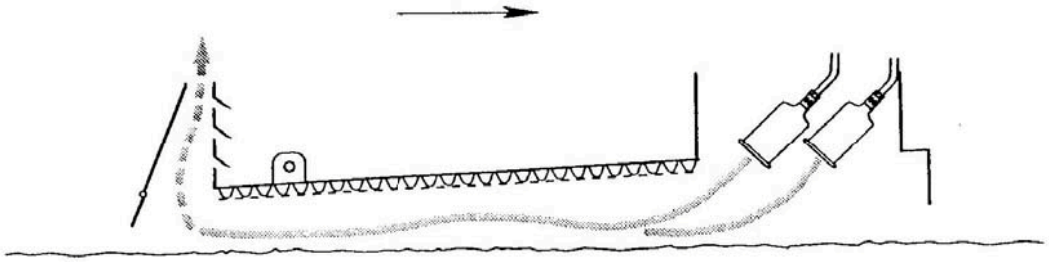
Good results in

- Cabbage
- Leek and onion
- Celery
- (Lettuce)
- Sugar beets

Provided that

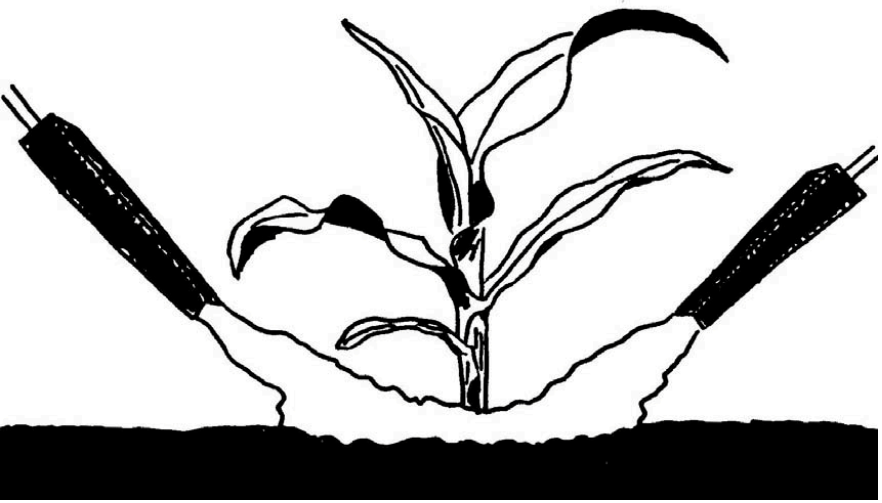
- Crop plants are well anchored
- Weeds are controlled prior to transplanting
- Weeding is started early after transplanting and then repeated over a 3-5 week period depending on the control demand of the crop

Pre-emergence flame weeding



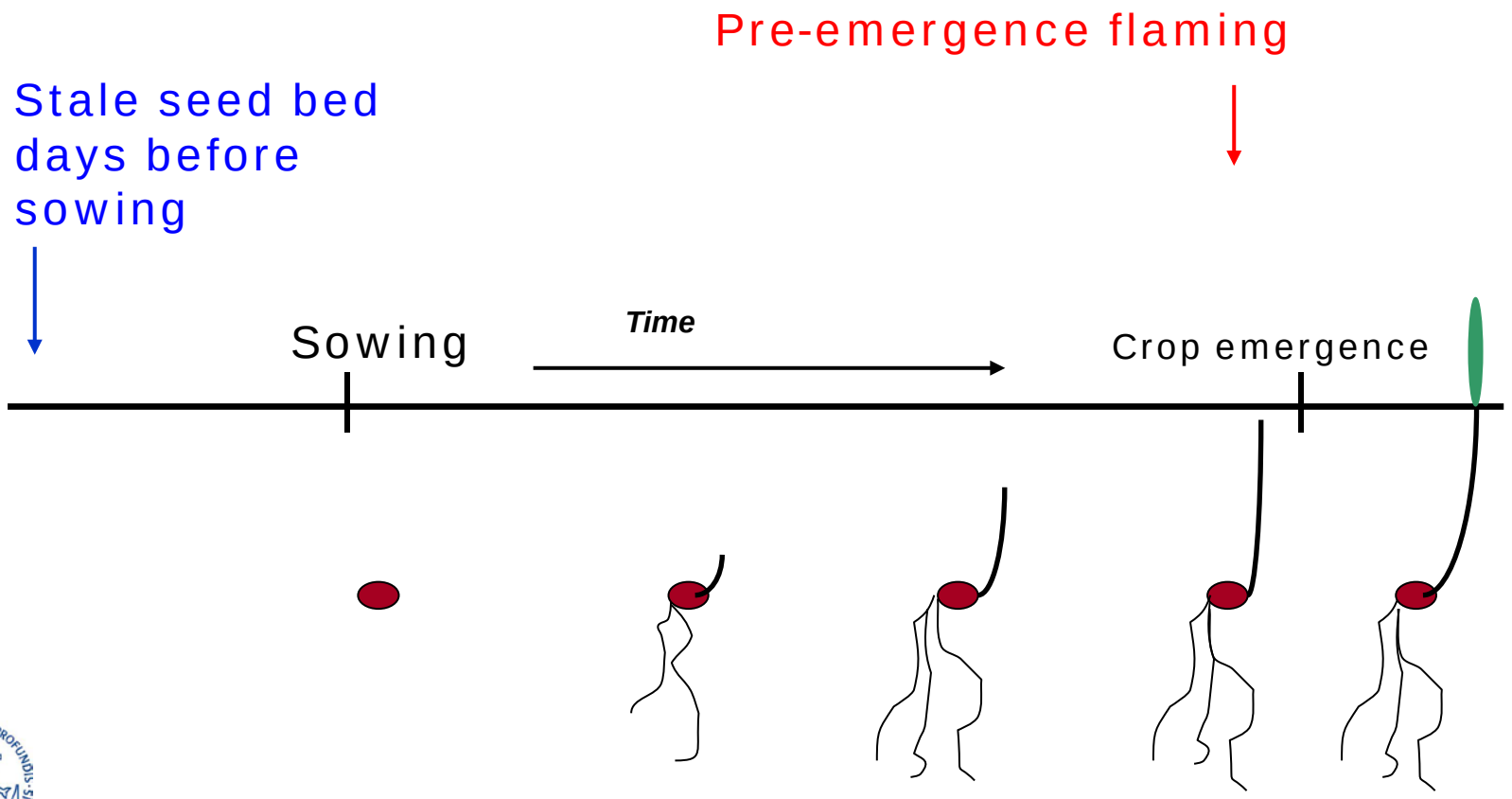
Selective post-emergence flame weeding

Maize

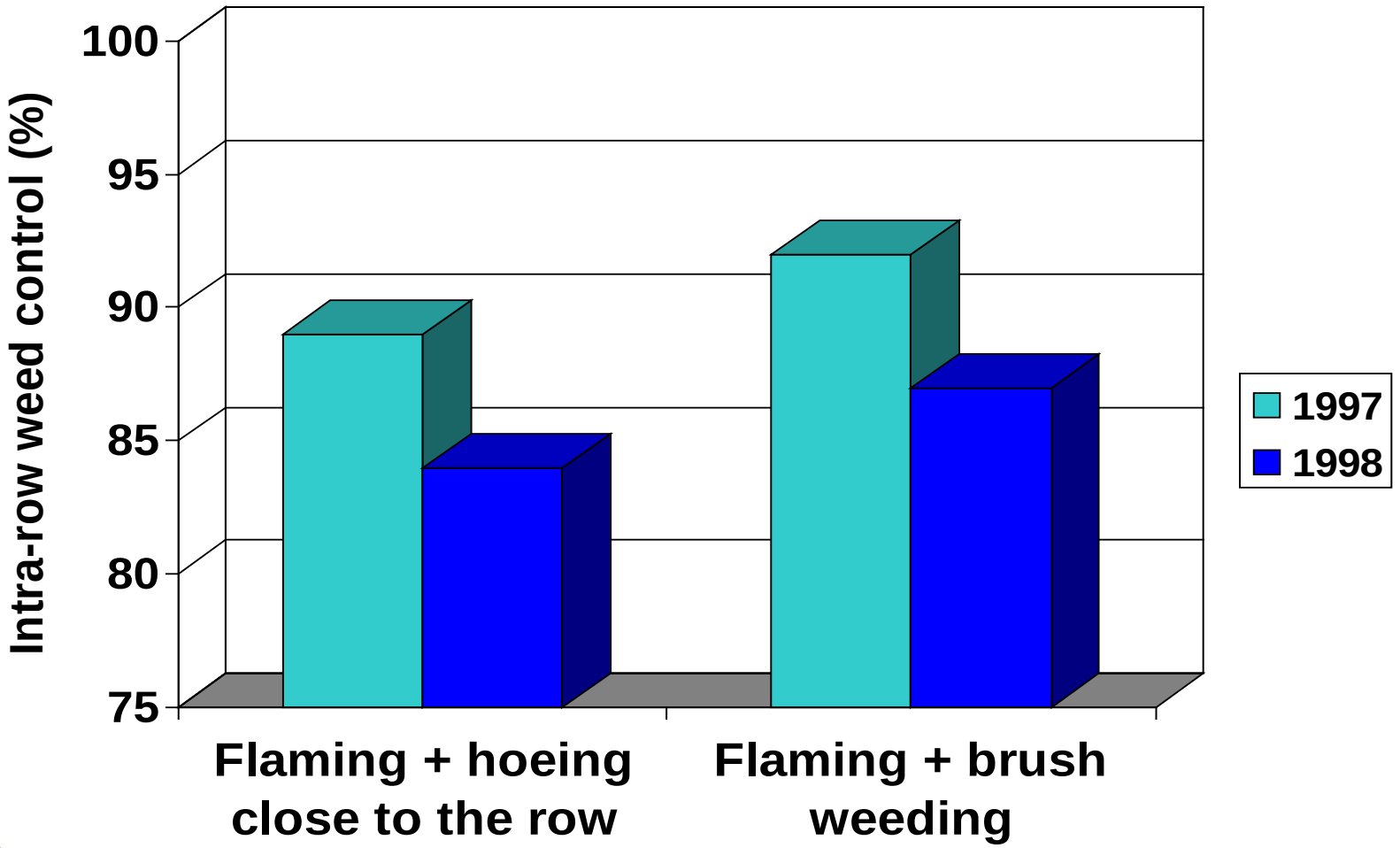


Onion

Stale seed bed and pre-emergence flaming



Direct-sown leek



[From Melander & Rasmussen (2001), Weed Research 41, 491-508]

Solutions for small-hold farmers

Conclusions on current tools

Advantages

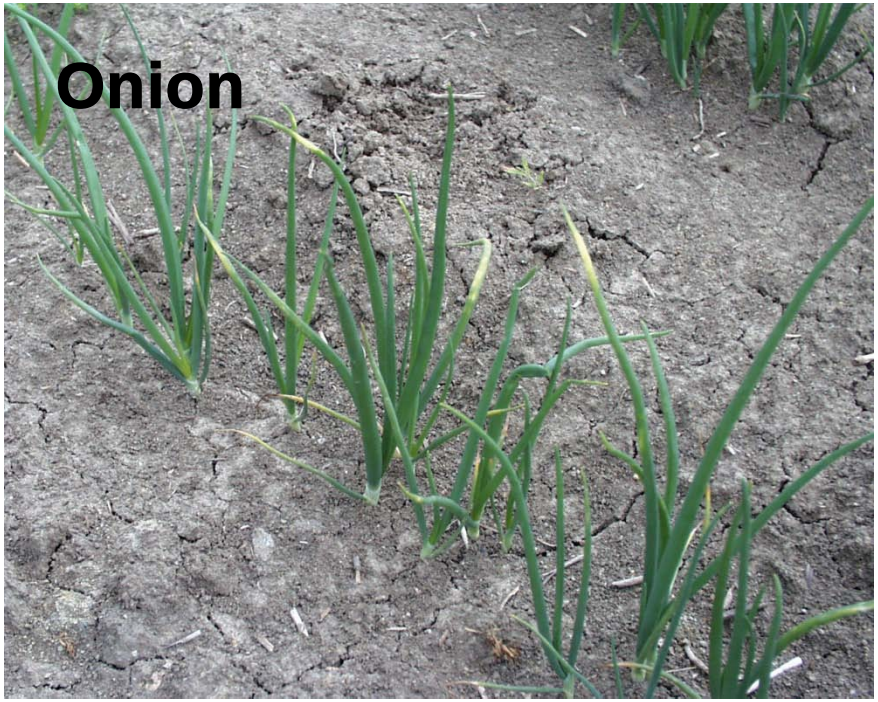
- Simple technology
- Relatively low purchase costs
- High effectiveness possible when combined
- Both tractor-born and hand-born versions

Disadvantages

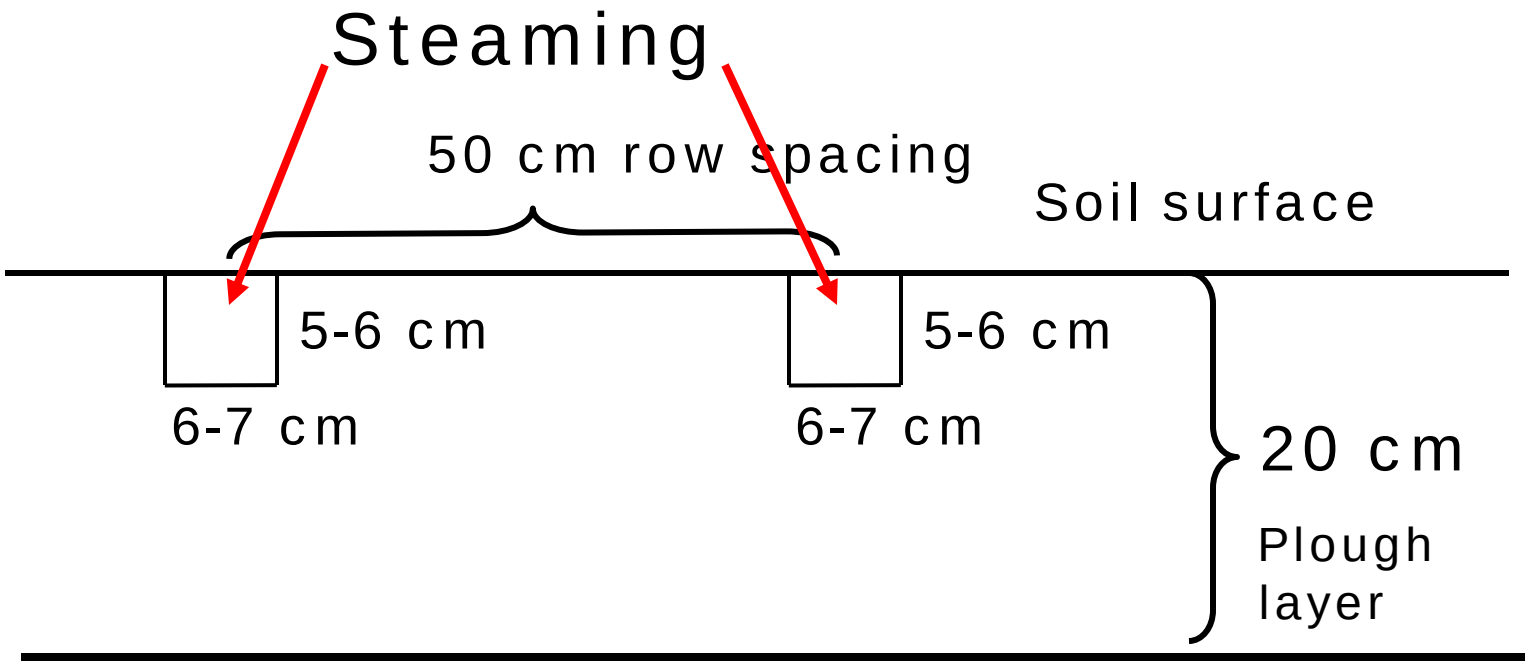
- Low selectivity
- Weather dependent
- Unworkable soils
- Training required

New technologies

- Robotic weeding
- Band-steaming

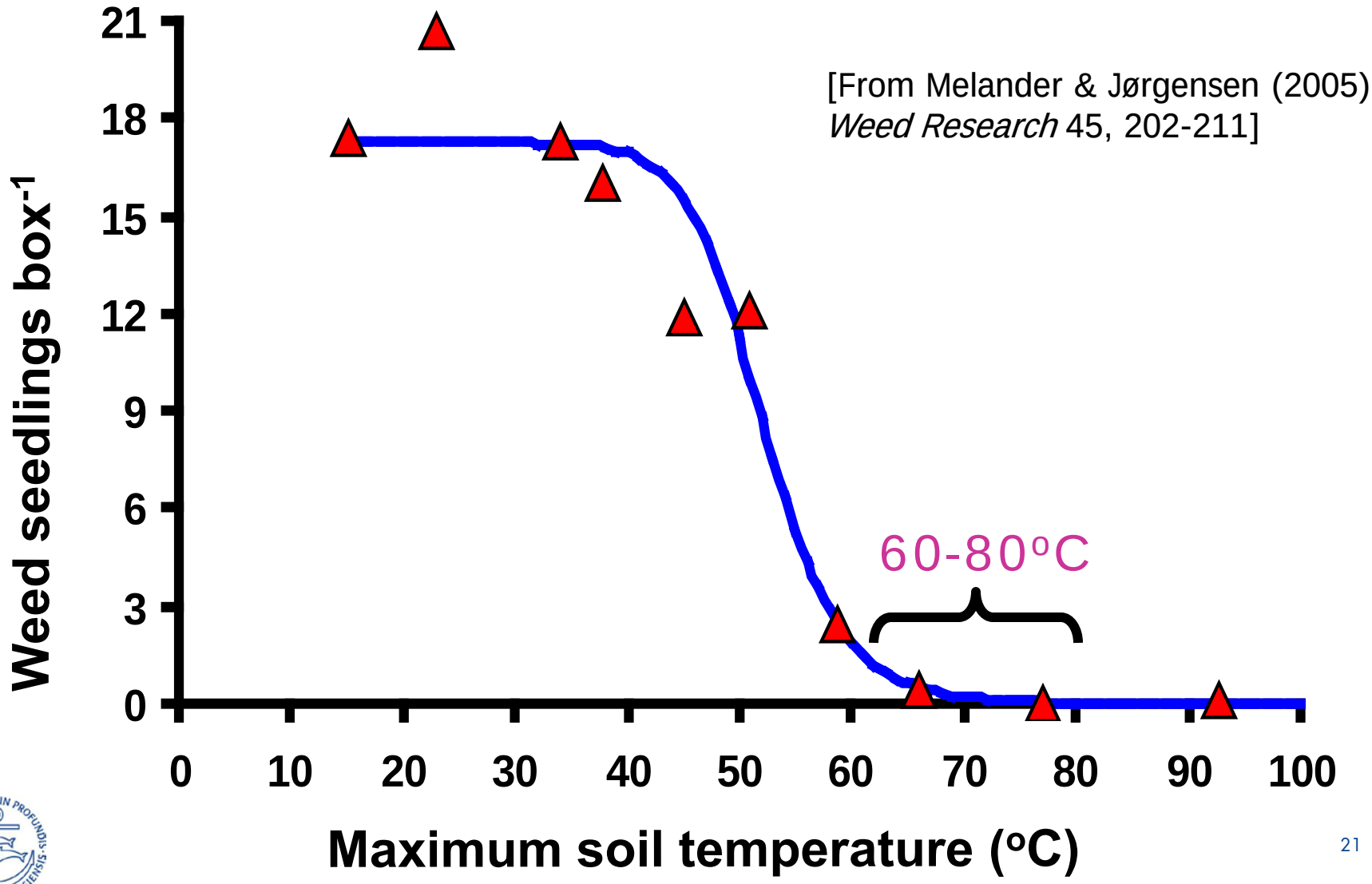


Steaming in narrow bands



Our vision: 1) Band-steaming for intra-row control

2) Hoeing with an automatic steering system for inter-row control



[From Melander & Jørgensen (2005)
Weed Research 45, 202-211]

Band steaming before carrot sowing

- 9 rows, 3 rows per bed
- 14 cm band width and 5 cm soil depth
- 600 litre oil and 7000 litre water ha^{-1}
- 0.2 km h^{-1}, capacity 0.112 ha h^{-1}

Temperature profiles on sand, target max. 80°C

0.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	38	55	53	58	49	52	53	52	51
1 cm	58	64	66	56	68	65	67	67	63
2 cm	64	60	71	69	63	67	70	66	63
3 cm	59	73	75	75	74	74	73	60	60
4 cm	42	69	74	76	75	73	69	61	27
5 cm	34	65	71	73	74	73	67	33	27
6 cm	17	48	62	68	67	63	45	24	16

1.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	39	38	46	51	44	46	44	46	44
1 cm	52	59	55	52	60	58	60	58	49
2 cm	57	51	66	68	67	67	67	58	45
3 cm	58	69	74	74	73	72	69	55	47
4 cm	53	67	73	75	74	71	64	57	27
5 cm	42	62	70	72	71	68	61	30	24
6 cm	33	55	62	65	65	60	43	24	15

2.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	37	42	42	48	40	42	44	43	37
1 cm	50	51	53	48	56	53	55	53	43
2 cm	55	52	65	64	62	61	62	54	46
3 cm	60	68	71	71	69	68	63	52	43
4 cm	56	67	71	72	70	67	58	52	31
5 cm	51	64	67	68	68	63	51	30	29
6 cm	41	56	62	62	59	52	40	24	16

3.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	35	37	38	43	38	39	40	39	35
1 cm	44	50	53	45	52	49	52	49	40
2 cm	55	49	61	60	61	58	58	52	43
3 cm	56	65	69	68	66	65	61	53	36
4 cm	51	62	69	70	68	63	59	50	33
5 cm	49	61	62	64	64	59	50	36	31
6 cm	35	51	58	63	56	50	43	29	16

4.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	29	37	35	41	39	38	36	37	34
1 cm	38	44	50	41	50	48	49	46	42
2 cm	45	43	55	58	59	54	56	52	42
3 cm	46	58	64	60	63	61	60	54	38
4 cm	39	53	63	65	64	62	59	54	37
5 cm	36	50	57	62	62	60	56	42	35
6 cm	28	43	51	58	54	52	47	38	21

5.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	30	33	35	36	37	37	34	32	30
1 cm	36	45	42	38	48	46	47	43	35
2 cm	44	37	54	55	55	54	54	49	38
3 cm	41	52	61	62	61	60	58	53	36
4 cm	37	49	60	64	63	59	57	52	38
5 cm	34	47	54	59	60	58	53	44	37
6 cm	27	40	49	56	53	50	48	38	22

6.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	29	33	34	35	36	36	33	34	30
1 cm	35	38	42	36	47	44	42	42	36
2 cm	36	36	51	51	49	50	50	47	39
3 cm	38	49	56	59	57	57	55	50	34
4 cm	35	46	56	60	59	56	55	50	35
5 cm	30	43	51	55	56	54	51	42	34
6 cm	26	38	45	51	50	48	44	37	23

7.5 min	0 cm	2 cm	4 cm	6 cm	8 cm	10 cm	12 cm	14 cm	16 cm
0 cm	29	31	31	35	33	33	31	30	25
1 cm	35	39	41	34	41	40	39	36	31
2 cm	39	36	49	51	50	47	47	42	32
3 cm	41	51	56	56	54	54	51	45	32
4 cm	40	50	55	57	56	54	50	45	33
5 cm	35	46	53	55	55	52	47	37	33
6 cm	32	42	48	51	50	47	41	33	21

Band-steaming on a sand soil in 2009 and 2010

Year	Max temp. (°C)	% effect	Stderr	Significance *P* - value
2009 Ca. 500 pl. m^{-2}	60-65°C	**71**	3.6	*P* = 0.55
	75-80°C	**78**	9.5	
2010 Ca. 280 pl. m^{-2}	60-65°C	**79**	3.7	*P* = 0.008**
	75-80°C	**89**	1.9	

Band steaming in beetroot

Band steaming in carrot

Preliminary conclusions on bandsteaming

Advantages

- High weeding effects
- Tendency for higher yield in some crops
- Pest and disease control
- Substantial savings in labour for manual weeding
- Release of manpower

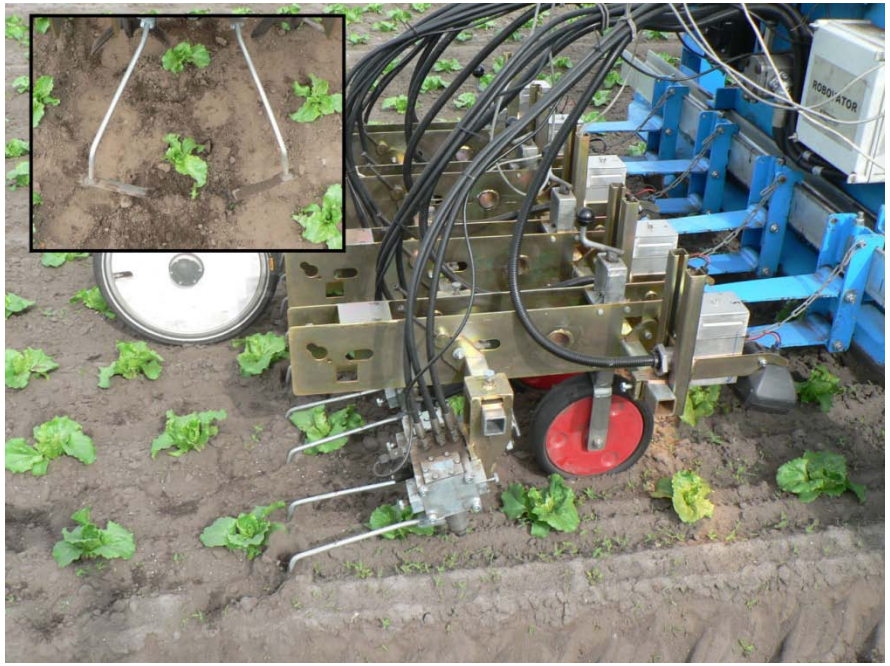
Disadvantages

- High fuel and water consumption
- Low work rates
- Sterilizes the soil

Robotic weeding in transplants

Robocrop

Robovator



Robocrop


Vision Guided In-row
Cultivation
Tillett and Hague Technology Ltd

Robovator

Preliminary experiences with robotic weeding

Advantages

- Selective weeding
- Less sensitive to weed growth stage
- High work rates
- Easy to operate
- Application for most transplants

Disadvantages

- High purchase costs
- No application for direct-sown crops
- Simpler tools may provide equal weeding effectiveness
- Repairs
- Closeness to the crop