Effect of weed management strategies on the risk of enteric pathogen transfer into the food chain and lettuce quality

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Abstract

The hygienic quality of raw edible vegetables such as lettuce may be influenced by pathogen transfer from soil to plant, which might occur during weed control by hoeing or as splash-effects during rainfall. The hygienic quality is often discussed when farmyard manures are applied during production, as e.g. in organic farming systems. In a field experiment, the effects of weed control on pathogen transfer from soil fertilised with farmyard manure to lettuce (Lactuca sativa, var. *capitata) were evaluated. First results do not confirm pathogen transfer by mechanical weeding or splash effects during rainfall.*

Introduction

For raw edible products like lettuces, a high hygienic quality is required. Potential risks are seen in organic farming systems where use of well rotted or composted farmyard manure (FYM) is common. Cattle manure contains among others *Enterobacteriaceae*, in our investigations differentiated into coliforms, *Escherichia coli* and *salmonellae*. *E. coli* is a group of bacteria that to an unknown but presumably small degree includes human pathogenic strains that may cause severe disease especially to immuno-repressive persons. Thus, it is used as an indicator of potential health risks. *E. coli* can survive in the soil, depending upon various factors like soil type, moisture content, etc., for up to 100 or even more days after manure application (Ingham, 2004). Hence, field production of lettuce and other raw consumed vegetables that grow close to soil surface might entail health risks for consumers. Besides splash effects during rainfall events or overhead irrigation which has been shown to have no risk effect (Rattler et al., 2006) another possible way of transmittance is given by soil particles that can be transported into lettuce heads during mechanical weeding. This hypothesis was studied in field experiments. First results are given by this paper.

Materials and methods

Two field trials on *Lactuca sativa* var. *capitata*, variety *Estelle*, were conducted at the organic research farm “Wiesengut” in North-Rhine Westphalia, Germany (50°48´N, 7°17´E) in 2006. Two further field experiments will follow in 2007. The farm is located 65 m above sea level with 846 mm precipitation per year and an average annual temperature of 10.2°C. The treatments used were based on former experiments from Rattler et al. (2006) as potentially resulting in the highest risk of pathogen transfer. The statistical design of the field trials was a latin square with 6 treatments and 6 replications. Lettuces were planted on 5th May 2006 (9 plants m^{-1}). As the conditions were relatively dry after planting, additional overhead irrigation was used. All treatments were adjusted to a mineral nitrogen content of the upper soil layer (0-30 cm) of 170 kg N_{min} ha^{-1} using manure. Between 21st and 29th June lettuce was harvested treatment-wise because of heterogenic development. Weed management treatments varied from hoeing over flame weeding to mulching by using straw and plastic weed mats (Table1) and were evaluated in their effectiveness of reducing the

transmittance of enteric pathogens from soil to lettuce heads by microbiological analyses.

Six lettuce samples per treatment, each one a pool sample from 6 heads, were analysed directly after harvest and a first wash in running tap water of controlled quality for total aerobic bacterial counts, *Enterobacteriaceae*, coliforms, *E. coli* and *salmonellae* by standard cultivation methods (LFGB, 2006). Results were statistically evaluated by ANOVA followed by Tukey's test.

Tab. 1: Treatments

Treatment	Manure Incorporation	Manure Type
Mechanical 1	rotary tiller	fresh FYM
Mechanical 2	plough	fresh FYM
Mechanical 3	all rotary tiller	composted FYM
Flame weeding		fresh FYM
Plastic mulch		
Straw layer		

Results

Salmonellae were not detected in any sample of soil or lettuce. As to the soil samples, in none of the microbial parameters significant differences were observed between treatments (Table 2). Positive samples of *E. coli* were found, but the level was quite low (>10<100 CFU/g). The *E. coli* counts did not differ significantly (Fisher´s Exact Test) either.

Tab. 2: Total aerobic bacterial count and level of *Enterobacteriaceae*, coliform bacteria and number of *E. coli*-positive samples in soil after harvest and in lettuce in spring 2006. Significant differences between means are indicated by different letters at p<0.05 (Tukey - test).

	Total aerobic bacterial count		*Enterobac-teriaceae*		Coliform bacteria		*E. coli*	
	log_{10} CFU/g		log_{10} CFU/g		log_{10} CFU/g		positive samples (total number = 6)	
Treatment	soil	lettuce	soil	lettuce	soil	lettuce	soil	lettuce
Mechanical 1	7.07	6.17	5.26	6.11	4.44	4.94 b	2	1
Mechanical 2	7.51	6.19	5.25	5.78	5.02	4.84 b	3	1
Mechanical 3	7.23	6.23	5.27	5.21	5.14	4.77 b	5	0
Flame weeding	7.21	6.49	5.54	5.34	4.61	4.82 b	2	2
Plastic mulch	7.23	6.32	5.39	5.84	4.85	5.34 a	3	4
Straw layer	6.96	6.52	5.52	5.78	4.69	5.31 a	2	1
Mean	7.20	6.32	5.37	5.68	4.79	5.00		

In lettuce, total aerobic bacterial counts and *Enterobacteriaceae* showed no significant differences between the treatments (Table 2). For *Enterobacteriaceae*, a slightly higher contamination of treatment mechanical 1 was observed, but the difference was not significant. Coliform counts were significantly higher in the treatments plastic mulch and straw layer. *E. coli* was isolated in low levels (>10<100 CFU/g) in all treatments with fresh FYM applied, but not in the composted FYM treatment. The highest number of positive samples was determined in the plastic mulch treatment (p), but the occurrence did not differ significantly from the other treatments (Fisher´s Exact Test).

Discussion

In soil, bacterial counts did not differ significantly (Table 2), indicating that manure application to the upper soil layer independent whether fresh or composted does not create higher hygienic problems compared to manure application that was ploughed into deeper soil layers (30 cm soil depth) (mechanical 2).

Concerning bacterial counts in lettuce, no differences for total aerobic bacterial counts and *Enterobacteriaceae* were observed. Counts of coliform bacteria were significantly higher in the treatments plastic mulch and straw layer, and *E. coli* counts show also an increasing, although not significantly, number of positive samples for plastic mulch (Table 2). This means, *E. coli* were detected (positive sample), but always only in very small amounts (>10<100 CFU/g) slightly above the detection limit (10 CFU/g).

It can not be excluded that a pre-contamination of the mulching materials plastic mulch and straw might have caused these results. *E. coli* was observed in only some cases in our experiments, and if so, in amounts slightly above the detection limit of 10 CFU/g.

In accordance with the results presented here a similar extent of bacteria transfer has been shown for systems using mineral fertiliser (Rattler et al., 2006). No decline of bacterial counts in lettuce was caused by washing (Rattler et al., 2006). Bacterial pathogens have been detected in the leaf tissue e.g. in several other investigations and were not affected by washing and probably entering the plant over the root system (Solomon et al., 2002). Thus, based on the results of our field experiment even enhanced risks scenarios i.e. FYM in the upper soil layer do not create evident hygienic problems.

Conclusions

The different weed control treatments neither had an effect on soil bacterial counts nor on pathogen transfer of *Enterobacteriaceae* and *E. coli* into lettuce. *E. coli* was only detected in lettuce in low levels near the detection limit of 10 CFU/g. Coliform counts in lettuce were significantly higher in the straw layer treatment or plastic mulch, but these findings were not confirmed by a corresponding number of positive *E. coli* samples suggesting that the coliform counts are not a reliable indicator for potential contamination with *E. coli*. The determination of further causes of lettuce contamination with *E. coli* such as root uptake and insect transfer still require further research efforts.

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