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Optimizing rotary hoe weed control in field bean crop at transition to organic agriculture in Dobrudzha. I. Crop injuries.

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Abstract. *The weed control is a basic problem in organic agriculture. Most often it leads by multiple mechanical treatments, which except significant weed destruction show certain positive as well as some negative influence on the crop. In this investigation the influence of rotary hoe working rate and number of treatments on field bean crop at transition to organic agriculture in Dobrudzha. The hoeing speed, the working depth and the number of hoeing were factors in the trial. The crop density, the number of injured plants per ha, crop height, pod placement height, 1000 grain weight, moisture content at harvesting and the bean yield were measured. The increase of working speed and hoeing depth, as well as the number of treatment leads to proved decrease of crop density, but did not decrease the yield. At most aggressive treatments the crop height and lowest pod height were lowered. There is no significant influence of rotary hoe working rate and number of treatments on the 1000 grain weight and on the moisture content at harvesting.*

Keywords: organic farming, weeds, rotary hoe, dry bean, injuries

Introduction

Weed control plays a key role in organic farming. In organic crops the diversity of weed species is greater than in conventional ones, but if the weed density is greater this is still a debatable question (Roschewitz et al., 2005; Deveikyte et al., 2009). After applying the first herbicides on conventional crops, either soil or vegetative ones, the weedness stays lower than in organic crops by number as well as by biomass. The weed control in organic crops starts by cultural methods – rational crop rotations, selecting proper cultivars and hybrids, schemes and dates of sowing, cover crops and other prophylactic measures, especially useful for crops with lower competitive power as bean, soy-bean and peas (Mcdonald, 2003). At later stages of crop growing the weed control continues by mechanical cultivations, one of the most widespread of which because of its many advantages, is hoeing by rotary hoe (Cloutier and Leblanc, 2004; Boyd and Brennan, 2006). The lower the competitiveness of the crop than the weeds, the higher the aggressiveness of hoeing demanded to destroy them. The high hoeing aggressiveness supposes higher working speeds, working depths and number of hoeing at different stages of vegetation. The higher the aggressiveness of hoeing the bigger the injuries on the crop expressed by lower population, lower height and placement of plant fruit-bearing organs, lower yield (Papazov, 1995; Ben Yahia, 1999; Leblanc and Cloutier, 2001; Place et al., 2009).

The aim of this study was to investigate the influence of parameters of the working regime and number of hoeing by rotary hoe on characteristics of dry bean crop at transition to organic farming in Dobrudzha.

Material and methods

The trial was led in the Dobrudzha Agricultural Institute Experimental field during 2008 – 2010 year, at 5-field crop-rotation on 10 hectares at transition to organic farming. Alfalfa, barley, dry bean, sunflower and maize were grown. The soil in the field is slightly leeched chernozem by middle content of humus in the working layer (3.30% by Turin) and slightly acid reaction (pH_{KCl} - 5.48). The three year period of study includes diverse meteorological conditions. The mean data of the study were proper for formulating conclusions representative for the region.

Dry bean cultivar Dobrudzhansky was sown with mean weight of 1000 seeds 388 g at mean germination of 94%. The sowing was made in the beginning of May, by row crop seeder Nodet Gougy at inter-row spacing 70 cm and seed rate of about 33 seeds per m^2. Predecessor in the crop-rotation was winter barley, after harvesting of which the soil was ploughed deeply to 28 cm. Pre-sowing tillage of the soil include three cultivations, starting at first possibility in the spring and last cultivation on 5–8 May, aiming provocation and destroying of greater number of weeds and creation of conditions for fast initial development of the crop. The sowing was performed immediately after the last cultivation of the field. Twenty four to twenty seven plants per square meter were yielded.

The weed control was performed by rotary hoe ISOMEC (s.r.l.) of ISORELLA (BS) Italy, type AT 3060. It consists of 17 sections of two working wheels Ø500 with 16 scarifying teeth (Figure 1). The trial was led according to the long plot method (2.8x100 m). Factors in the trial were as follows:

- Factor A – working speed; A1 – 5,0 km/h; A2 – 7,5 km/h and A3 – 10,0 km/h.
- Factor B – number of hoeing; B1 – one blind hoeing in phase "Germination" (V0), 5 – 8 days after planting, before shooting of the bean; B2 – B1 plus second hoeing in phase "Primary leaves" (V2) and B3 – B2 plus third hoeing in phase "1-3 trifoliate leaves" (V3) of the bean. In the variants with B2 and B3 the first and the second hoeing were executed at the middle level of the working speed.
- Factor C – working depth; C1 – 4 cm; C2 – 6 cm. The second depth was ensured by increase of the teeth's specific weight, putting additional concrete weights on the frame of the hoe.

In the middle of the experimental crop, across the whole width of

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Figure 1. Rotary hoe ISOMEC

the field, 15 m wide control was left. This surface was divided into three plots 5 m wide, parallel to the width of the trial. The middle one was neither hoed nor earthed-up. Half of it was the absolute control in which no mechanized or manual cultivations were executed and there the development of weed vegetation was studied without mechanical or chemical control (Control 0). The other half was only hand-weeded (Control 1). The other two plots of the control, to the sides of blocks C1 and C2, were not only hoed but additionally hand weeded. In this article bean biological data are presented, collected in these hoed and hand weeded, free of weeds plots. These data were compared to data from Control 1.

In the trial the following parameters were observed: crop density from squares of 0,25 m^2 in six replications, p/ha; number of injured or covered by soil plants per hectare, from squares of 1 m^2 in six replications, p/ha; crop height, of 10 plants in six replications in phase "Physiological maturity" (R9), cm; mean height of the lowest three pods, from the soil surface to the middle of the pod, on 5 plants in phase "Physiological maturity" (R9) in six replications, cm; moisture content at harvesting, %; yield, in phase "Farm maturity" (R10), from squares of 1 m^2 in six replications, kg/ha; weight of 1000 grains, g; losses at mowing, from squares of 0,25 m^2 in six replications, kg/ha.

The data were statistically processed by SPSS – 13.0.

Results and discussion

The peculiarities of the region, including soil-climatic conditions, crops grown, the level of knowledge about agriculture etc., create great diversity of the system crop-weeds and often make the scientific conclusions unusable for crops, 100 km away from their experimental fields. Because of this the agroecosystem sustainability suggests locally adapted systems of organic farming.

In Table 1 are presented data of the crop density, number of injured plants, weight of 1000 grains, moisture content at harvesting and yield per hectare of dry bean crop at transition to organic farming, after one-, two- and tree-fold hoeing by rotary hoe at two depths and three working speeds. Crop density provenly decreased at increased aggressiveness of hoeing. At blind cultivation, led 5 – 8

Table 1. Crop density, number of injured plants, weight of 1000 seeds, moisture content at harvesting and yield of bean crop, tilled by rotary hoe, 2008-2010 year.

Hoeing	Depth, cm	Speed, km/h	Density, p/ha	Injured plants, p/ha	Weight of 1000 seeds, g	Moisture content, %	Yield, kg/ha
Control 0			258 200	0	384	15.2	680
Control 1			263 200	0	420	16.0	1280
Blind hoeing	4	5.0	259 200	0	421	15.3	1320
		7.5	260 150	0	418	16.7	1200
		10.0	260 700	0	415	16.2	1250
	6	5.0	255 200	0	418	15.8	1330
		7.5	256 150	0	420	16.9	1210
		10.0	257 300	0	419	16.0	1230
Blind hoeing + 1st pair of leaves hoeing	4	5.0	256 200	400	416	15.8	1310
		7.5	257 100	480	420	16.6	1280
		10.0	257 200	510	421	16.3	1320
	6	5.0	254 200*	420	414	15.7	1250
		7.5	253 300*	460	409	17.1	1300
		10.0	253 400*	560	417	15.9	1280
Blind hoeing + 1st pair of leaves + 1-3 trifoliate lea-ves hoeing	4	5.0	253 150*	510	422	16.4	1260
		7.5	253 050*	620	416	16.9	1280
		10.0	252 000*	680	421	16.1	1290
	6	5.0	246 400**	620	419	16.7	1310
		7.5	246 200**	700	418	15.7	1270
		10.0	245 250**	760	414	17.0	1320

* P<0.05; ** P< 0.01

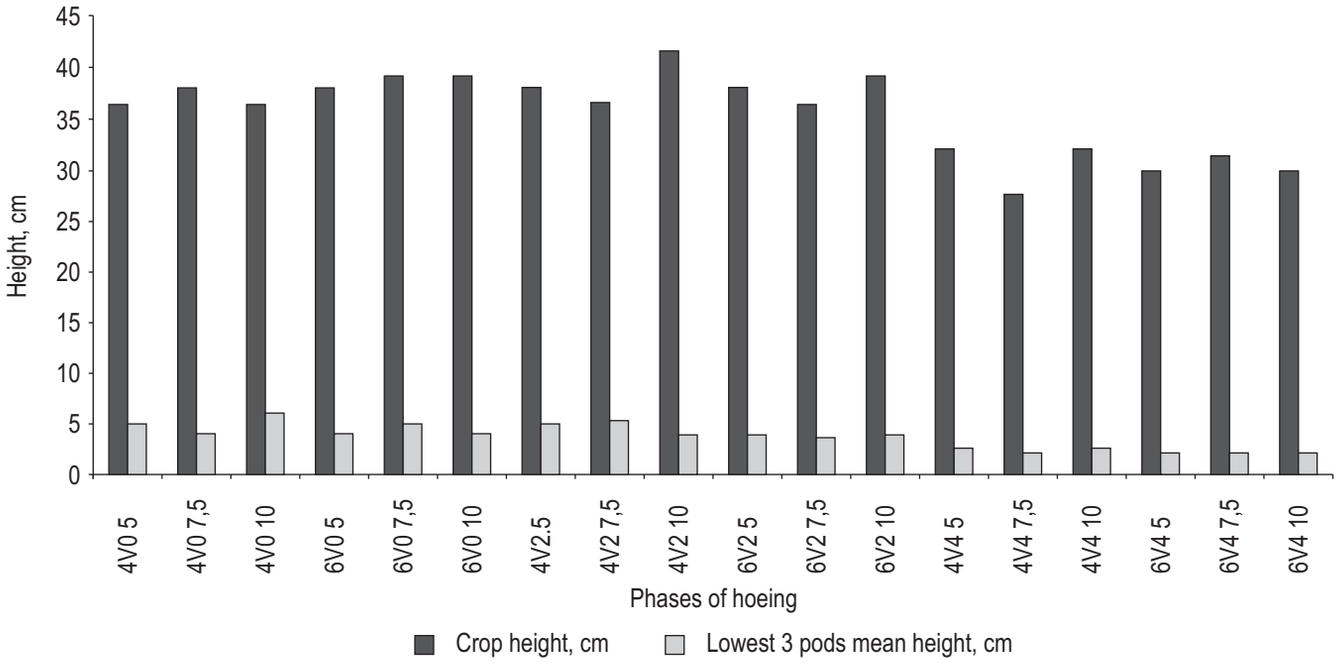

Figure 2. Crop height H and lowest three pod mean height h at phase "Physiological maturity" (R9), 2008–2010 year; 4V0.10 – hoeing in phase V0 at working speed of 10 km/h and working depth of 4 cm

days after planting, depending mostly on the meteorological conditions, bean grains were in phase "Germination" (V0). Crop density decrease appeared especially because of killing of early grown germs by the rotary hoe teeth. The increase of the working speed leads to some decrease of the working depth and as a consequence in the variants, hoed by 10 km/h there were more yielded plants than in the variants, hoed by lower working speeds. This effect at the second hoeing was compensated by the extracting force appeared at the direct contact between the hoe teeth and the stems of the plants, which were still not well rooted at the second hoeing in the phase "Primary leaves" (V2). The working depth increase in double hoed variants provenly decreased the number of plants per hectare. In all triple hoed variants the number of plants per hectare is proven lower than in control 1 variant. Although the plants were well rooted in this phase ("1-3 trifoliate leaves"), they contact the tool teeth at greater surface and the anchorage force, transferred to the plant especially at higher working speeds, was great enough to kill certain number of them. Except of the killed plants, the number of injured or partially buried plants increased too. A big percentage of them - 62÷78% were restored and yielded.

The change of the working speed and depth at hoeing as well as the number of cultivations didn't lead to some proven difference in 1000 grain weight, bean moisture content at harvesting and yield (Table 1). Since the data were for weed-free crop, it has to be supposed that the decreased density and other crop injures were compensated by the beneficial effect of rotary hoe tillage. It is expressed in breaking the soil crust, improving root aeration, moisture conservation, intensification of tuber-formation and nitrogen fixation.

As a result of the stress of the hoeing the mean crop height decreased, as well as the mean height of the lowest three pods – Figure 2. The pods disposal by height directly influenced the losses at harvesting, especially in the first phase – the mowing of the crop. Because of the hoeing the mean height of the lowest three pods was decreased by 2,1÷2,6 cm and it caused an increase of losses by 1,5÷1,8%, or 19.5÷23.4 kg/ha (Figure 3). For the lower mean pod

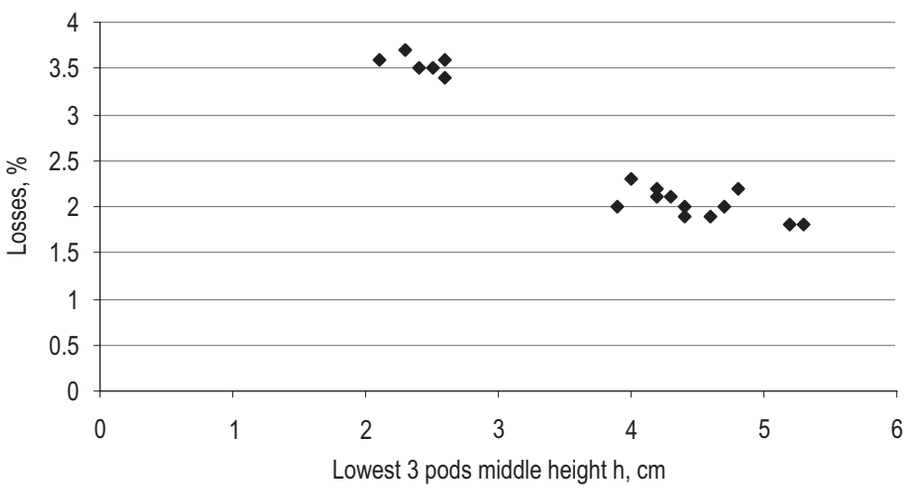

Figure 3. Losses at mowing, depending on lowest three pods mean height h, 2008-2010 year, %

height decrease contributed the effect of multiple hoeing soil compaction and leveling of the soil surface.

Conclusion

The increase of the rotary hoe working speed and working depth, as well as the number of hoeing in the studied limit provenly decreased crop density, but didn't decrease the yield. At most aggressive cultivations the height of the crop and the mean height of the lowest three pods were lowered, which led to proven increase of the losses at mowing. The weight of 1000 grains and their moisture content at harvesting were not essentially influenced by the rotary hoe working regime and by the number of cultivations.

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CONTENTS **1 / 3**

CONTENTS **2 / 3**

CONTENTS **3 / 3**

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