Elimination of weed influence through fruit thinning and fertilisation in apple tree plantings

V. FALTA, M. PRAŽÁK, M. HUDSKÝ

Research and Breeding Institute of Pomology, Holovousy, Czech Republic

ABSTRACT: The objective of this research is to study the effect of two measures (fruit thinning and additional fertilisation – 222 kg calcium nitrate/hectare) compensating the negative influence of weeds (yield loss and reduction of growth) in plantings of Idared cv. In addition, the yield response of two other apple cultivars (Melrose, Gloster) to the exclusion of chemical weed control is discussed in this paper. The obtained results have shown that the differences between yields of individual variants of Idared cv. were smaller and not significant in the first year (2000) of experiment. In the second year (2001), the significant ($\alpha = 0.05$) yield loss (40%) was observed in the case of variant with mowing of weeds and fruit thinning compared with variant with herbicide treatments and additional fertilisation. The influence of measures on Idared cv. growth was not significant. The absence of herbicides has led to yield reduction (27%) of Idared cv. in 2001 in comparison with yield in 2000. However, the difference was not significant ($\alpha > 0.1$), probably due to the relatively short period of trials. On the contrary, the yield of Gloster cv. observed in 2001 was significantly higher ($\alpha = 0.01$) than in 2000 even though herbicides were excluded.

Keywords: apples; weeds; weed control; herbicides; fertilisation; fruit thinning; yield loss

Herbicide treatments are considered as one of the most effective ways of weed control in intensive orchards (HARRINGTON 1993; RABCEWICZ et al. 1998). Despite the fact that ecotoxicological properties of all legalised herbicides correspond to required norms, their careless use can bring about some risks, such as occurrence of residues on the soil surface followed by contamination of groundwater (VERSTRAETEN et al. 1995; BUSINELLI et al. 2000), phytotoxicity effect on the crop (MATSCHKE, AMENDA 1995; WÓCIOR 1999), serious changes in weed composition (DASTGHEIB, FRAMPTON 2000), induction of weed resistance (BULCKE, CALLENS 1998) and others.

For this reason the system of integrated weed control in fruit crop production should involve practices enabling proportional applications or complete exclusion of chemicals, e.g. alternative treatments (MANTINGER, GASSER 1993; RABCEWICZ et al. 1998), selective spray (DORUCHOWSKI et al. 1998) or establishment of low growing ground cover species (HARRINGTON 1993). However, the sound practical integration of these methods is currently lacking.

This contribution is focussed on the evaluation of the effect of some compensation measures (coupled with exclusion of herbicide applications) on the growth and yield of apple trees in orchards situated on permanent research plots in Research and Breeding Institute of Pomology (RBIP) at Holovousy. The effect of these measures (additional fertilisation, fruit thinning) was related to herbicide treatments in tree strips and to untreated control (mowing of weeds in summer).

MATERIAL AND METHODS

The experiments were performed during the period 2000–2001 in apple tree plantings (planted in 1986, spacing 4.5 × 1.8 m, cv. Idared/M9) in RBIP Holovousy (altitude 290 m, average temperature 8.14°C, amount of precipitation 654 mm). The following 5 variants (4 replications in randomised blocks) were compared: (1) herbicide applications; (2) mowing of weeds (2000 – May 25, August 2; 2001 – May 22, June 28, August 8) + fruit thinning; (3) mowing of weeds (the same dates as in var. 2) + additional fertilisation (222 kg calcium nitrate/hectare; 2000 – May 17, 2001 – April 25); (4) herbicides (as var. 1) + fruit thinning (thinning performed manually on the following dates: June 2, 2000; June 6, 2001) + additional fertilisation (222 kg calcium nitrate/hectare 2000 – May 17, 2001 – April 25); (5) mowing of weeds (the same days as in var. 2).

On the same location the two parallel trials were evaluated (Melrose/M9 and Gloster/M9 planted in 1986, spacing 4.5 × 1.8 m). Here the yield and the tree growth of herbicide treated plots were compared with the untreated control (mowing of weeds – May 25, 2000; August 2, 2000; May 22, 2001; June 28, 2001; August 8, 2001).

In variants 1 and 4 of trials in Idared cv. and in the herbicide treated variants in the Melrose and Gloster cvs., the following preparations were applied: May 3, 2000 – Starane 250 EC + Gallant Super (2.0 + 1.5 l/ha); May 24, 2000 – Basta (6 l/ha); May 3, 2001 – Folar 525 FW + Rondup Biaktiv (5 + 2 l/ha); June 28, 2001 – Basta (6 l/ha).

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Table 1. Weed coverages (expressed in percentage of total soil surface area in tree strips) observed in plantings of Idared cv. in spring 2001

Variant	Weed coverage (%)					
	STEME*	TAROF*	AGRRE*	Other weed	Perennials**	Total**
1	28.8	13.0	15.3	17.8	28.3	74.8
2	0.0	36.3	46.3	1.0	82.5	83.5
3	0.0	30.0	61.3	0.0	91.3	91.3
4	19.4	8.3	31.5	2.1	39.8	61.3
5	18.8	22.5	45.0	2.5	67.5	88.8

Explanation:
*STEME – Chickweed (*Stellaria media* L. Will.)
*TAROF – Dandelion (*Taraxacum oficinale* Webb.)
*AGRRE – Quackgrass (*Agropyron repens* L. Beauv.)
**Diferences between variants are not significant

During the experiment the standard agrotechnics (pruning, mowing, fertilisation) and plant protection were performed (all variants without irrigation).

The following aspects were studied:

1. Weed spectrum and coverage of individual weed species and total weed coverage were observed in spring 2001 (Idared). The coverages of individual weed species were evaluated as a percentage of the soil surface area (two-meter wide tree strips considered) covered by above-ground biomass of species; the total weed coverage was expressed as a sum of coverages of individual weed species.
2. Yield in autumn 2000 and 2001(Idared, Melrose, Gloster).
3. Two-year (2000–2002) increment of trunk cross section area in plantings of Idared cv. Trunk cross section area (S) was calculated as $S = O^2/4\pi$ (where O is a trunk girth measured 30 cm above the soil surface), in spring 2000 and 2002.

Differences between 5 variants in Idared cv. were tested by ANOVA (Tukey's test; values of weed coverage after transformation $y' = \arcsin\sqrt{y}/100$); for the comparison of yields in untreated variants in Melrose, Gloster and Idared cvs. (compared values observed in 2000 with yield in 2001), *t*-test was used.

RESULTS

1. *Influence of different treatments in Idared cv. on weed occurrence*: After the first vegetation period (2000), the reduction of total weed coverage (by 10–30%) and also of coverage of perennial weeds (by 30–60%) in the case of common herbicide applications (i.e. of variants 1 and 4) was observed (comparing to alternative measures – variants 2, 3, 5). However, the differences were not significant (Table 1).
2. *Influence of different treatments in Idared cv. on the yield:* The highest yield was observed both in 2000 and in 2001 in the case of herbicide treatments coupled with additional fertilisation (var. 4). The most visible difference (14%) appears to be between variant 4 and variant 2 (mowing of weeds + fruit thinning) in 2001 (significant at $\alpha = 0.05$), and to some degree (not significant) also the difference between var. 2 and variants 1 (herbicides) and 3 (weed mowing + additional fertilisation) (Fig. 1).
3. *Influence of different treatments of tree strips in Idared cv. on the two-year increment of trunk cross section area:* After two years, the highest trunk cross section increment (Fig. 1) was observed in the case of var. 1 (herbicide weed control) and of var. 4 (herbici-

Table 2. Yield of Idared, Melrose and Gloster cvs. in 2000 and 2001 in variants with and without herbicides (mowing of weeds)

Cultivar	Year	Yield (t/ha)		S_H	S_M
		Herbicides	Mowing		
Idared	2000	15.81	17.26	> 0.10	0.10
	2001	17.88	12.59		
Melrose	2000	20.23	13.18	0.10	> 0.10
	2001	26.61	20.51		
Gloster	2000	10.96	8.54	0.10	0.01
	2001	20.13	17.81		

Explanation:
S_H – significance level of differences between yields in 2000 and 2001 in the case of herbicide treatments
S_M – significance level of differences between yields in 2000 and 2001 in the case of weed mowing

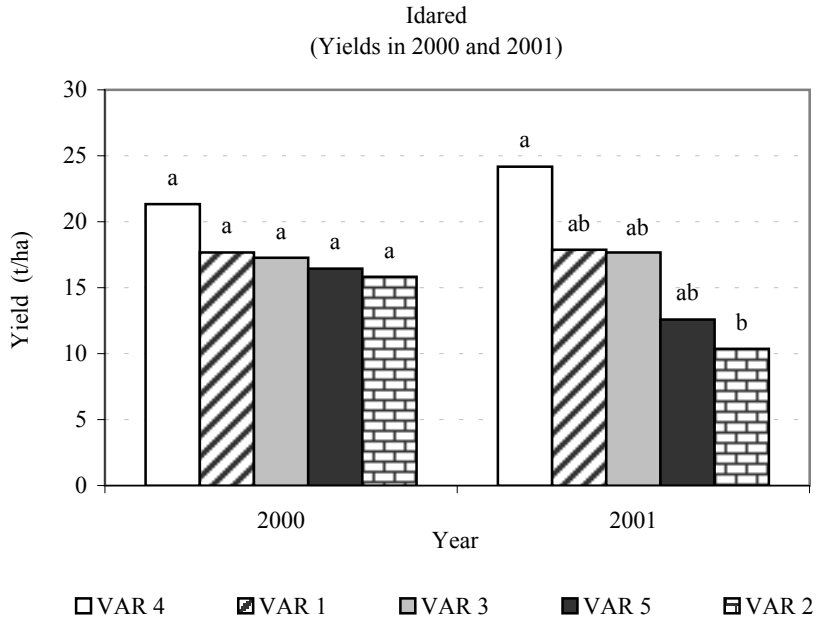

Fig. 1. Yield of Idared cv. in t/ha observed in 2000 and 2001
Explanation:
VAR 4 = Herbicides + fruit thinning + additional fertilisation
VAR 1 = Herbicides
VAR 3 = Mowing of weeds + additional fertilisation
VAR 5 = Mowing of weeds without compensation measure
VAR 2 = Mowing of weeds + fruit thinning
The same letters above columns = differences not significant

des + fertilisation). The observed differences ranged from 11 to 25% (not significant) (Fig. 2).

4. *Influence of exclusion of herbicide treatments on the reduction of yield in Idared, Melrose and Gloster cvs.:* The most sensitive reaction to the absence of chemical weed control (in the second vegetation season the yield was reduced by 30%) was displayed by Idared cv. in 2001 ($\alpha = 0.1$). On the contrary, the other cultivars (Melrose, Gloster) had significantly higher ($\alpha = 0.01$) yield in 2001 than in 2000 even in variants without herbicides (Table 2).

DISCUSSION AND CONCLUSIONS

Application of alternative methods of weed control in orchard, esp. of those without herbicide treatments, can lead to a lower or higher increase of weed coverage. In some cases, their total aboveground biomass can reach to 6 kg per square meter during one vegetation season (SILAJEVA 1999). However, the role of weeds in orchard has not been clear yet and much remains to be known concerning the relationships between plant populations and a crop (influence upon both the yield and growth).

The hitherto studies (STANĚK, NOVOTNÁ 1995; MIKA et al. 1998; MANTINGER, GASSER 1993) suggest that the complex of weed influence (first of all competition for nutrients and water) mostly results in remarkable yield loss. On the contrary, the observations of tree growth reaction (mostly shoot increment, trunk diameter or root dry weight evaluated) refer to contradictory effects. In some studies (STANĚK, NOVOTNÁ 1995; MANTINGER, GASSER 1993; MIKA et al. 1998; PARK et al. 2000), the growth reduction is presented whereas

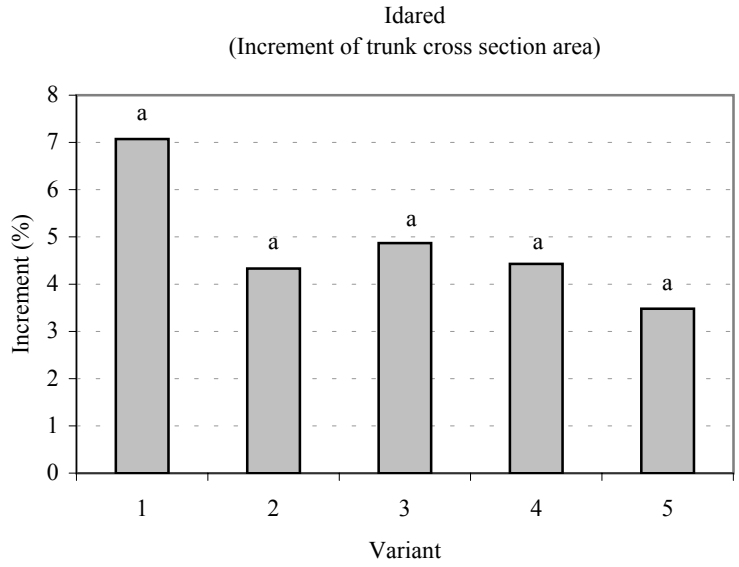

Fig. 2. Two year increment of trunk cross section area of Idared cv. observed during the period 2000–2002
Explanation:
VAR 1 = Herbicides
VAR 2 = Mowing of weeds + fruit thinning
VAR 3 = Mowing of weeds + additional fertilisation
VAR 4 = Herbicides + fruit thinning + additional fertilisation
VAR 5 = Mowing of weeds without compensation measure
The same letters above columns = differences not significant

other authors (PEDERSEN 1999; WÓCIOR et al. 1999) recorded strong tree growth in spite of a relatively poor weed control. In this research, the higher occurrence of weeds resulted in a growth reduction. In some cases, the increment of a trunk cross section area was lowered nearly by 25%, which corresponds to the experience of MANTINGER and GASSER (1993). However, the differences between means were not significant (probably due to data variability).

The presented study suggests that lower risks of yield reduction can be expected in intensively growing cultivars, such as Gloster and alternatively Melrose (both cultivars grafted on M9 rootstock), when herbicides are excluded. On the other hand, in less vigorously growing cultivars (e.g. Idared/M9), the significant yield loss (30%) may be expected already in the second year after exclusion or reduction of herbicide use. Reduction of yield recorded in the presented study may be higher in subsequent years due to the expected expansion of dominant perennial weeds (dandelion, quackgrass).

This experience corresponds to long-term studies performed in Holovousy in the years 1988–1993 (STANĚK, NOVOTNÁ 1995) where the yield loss of Idared cv. was 45% (in adequate trial conditions). Similar results were also obtained in trials performed in Poland from 1990 to 1992 (MIKA et al. 1998). In this case, the yield loss (Idared cv. /M26) also reached considerably high values already in the second year of experiments (20%). Similar results were presented by MANTINGER and GASSER (1993), who observed the yield loss of 20–25% in Golden Smooth cv. (M9) on the plots with two-year herbicide exclusion (clover as an alternative crop applied in the third year of trials).

As a relatively positive measure appears to be the increase of fertiliser use (222 kg calcium nitrate/hectare), whereas simple fruit thinning did not generate any compensatory effect.

It can be concluded on the basis of presented results that even short term (1–2 years) absence of herbicide application is not recommended in moderately growing apple cultivars (grafted on dwarfed rootstocks).

On the contrary, in plantings of vigorously growing cultivars the herbicides can be replaced by a compensatory measure (e.g. by increased fertiliser use). The question remains what the consequences of the expansion of perennial weeds can be expected in untreated variants in the third and subsequent years. For this reason, these studies would require long-term observations to obtain more exact information about future yield and growth development.

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Eliminace vlivu plevelů probírkou plodů a hnojením ve výsadbách jabloní

ABSTRAKT: Příspěvek je zaměřen na sledování vlivu dvou kompenzačních opatření (probírky plodů a doplňkového hnojení ledkem amonno-vápenatým v dávce 222 kg/ha) na výnos a růst odrůdy Idared. Kromě toho je diskutována reakce dvou dalších odrůd jabloní (Melrose, Gloster) na vyloučení herbicidních ošetření. Z výsledků vyplývá, že rozdíly mezi výnosy z jednotlivých variant odrůdy Idared nebyly v prvním roce (2000) průkazné. Ve druhém roce však došlo k signifikantnímu ($\alpha = 0,05$) snížení výnosu (o 40 %) u varianty se sežínáním plevelů a s probírkou plodů ve srovnání s variantou s herbicidními aplikacemi a s kompenzačním hnojením. Vliv zásahů na růst stromů byl po dvou letech pokusů neprůkazný. Absence herbicidních ošetření vedla u odrůdy Idared ke snížení výnosu v roce 2001 proti roku 2000 (o 27 %). Rozdíl však nebyl průkazný ($\alpha > 0,1$), a to pravděpodobně díky relativně krátkému období sledování. Naopak u odrůdy Gloster byl výnos i u neošetřené varianty v roce 2001 signifikantně vyšší proti roku 2000 ($\alpha = 0,01$).

Klíčová slova: jabloně; plevele; regulace plevelů; herbicidy; hnojení; probírky plodů; sklizňové ztráty

Corresponding author:

Ing. VLADAN FALTA, Výzkumný a šlechtitelský ústav ovocnářský Holovousy, s.r.o., Holovousy 1, 508 01 Hořice v Podkrkonoší, Česká republika
tel.: + 420 493 692 821–5, fax: + 420 493 692 833, e-mail: falta@vsuo.cz