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# Relationship between potato yield and the degree of weed infestation

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**Field experiment was carried out in the years 2002 to 2004 to study the effect of soil tillage methods and weed control techniques with herbicides. Potato yield and degree of weed infestation were investigated using correlation coefficients and linear regression analysis. High negative associations were found between the number of weeds, their fresh and air dry matter, and total potato tuber yield as well as marketable fraction tuber yield. The relationships were negative linear. A higher negative influence of weed infestation on potato yield was found before harvest, compared with early stage of crop growth before closing of potato rows. The presence of weeds was increasing by 1 ton of air weed dry matter per 1 ha furthermore it reduced the marketable fraction tubers yield by, respectively, 0.94 and 1.34 t per 1 ha when recorded before closing of potato rows, and by 2.62 and 3.76 t ha$^{-1}$ when recorded before potato harvest. To conclude, weeds can affect yield and harvesting of potatoes and may encourage certain pests and diseases. Consequently weed reduction by using two techniques, either mechanical or combination of mechanical and chemical weed control is surely required.**

**Key words:** Potato, weed infestation, yield, correlation coefficient, analysis of regression, herbicides.

## INTRODUCTION

Yield losses worldwide caused by pests are estimated at 43 to 85%, and worldwide use of herbicides reaches 47% of all pesticides (Aydin and Uzunören, 2006; Dowley et al., 2008; Tolman et al., 1986; Wilson et al., 1997). Potato crop losses due to weed infestation are estimated at 20 to 80% (Jaiswal and Lal, 1996; Jan et al., 2004; Knezevic et al., 1995; Souza and Eberlein, 1997). Ekeberg and Riley (1996) and Lisińska and Leszczyński (1989) found that potato uptake of nutrients supplied with fertilizers was as low as 20 to 30%, the remaining 70 to 80% being taken up by weeds as a result of reciprocal competition. According to Lehoczky et al. (2003) under conditions of substantial weed infestation, nutrient uptake of nitrogen, phosphorus, potassium and calcium, by potato was by: 10, 17, 22 and 30% lower, respectively. Radecki (1977) calculated that weed infestation of 2 t ha$^{-1}$ weed air-dry matter use approximately 115 NPK, which could give 10tonnes of potato yield. Moreover, weeds worsen yield structure and tuber quality, make harvest more difficult and reduce profitability of potato cultivation (Hashim et al., 2003; Eberlein et al., 1997; Gugała and Zarzecka, 2009). Thus the purpose of the study was to find out what losses of tuber total and commercial fraction of tubers yield result from the number and amount of weeds found in potato stands.

## MATERIALS AND METHODS

A field experiment was conducted at the University of Natural Sciences and Humanities Experimental farm in Zawady during the years 2002 to 2004. It was set up on a soil belonging to the rye very good complex, slightly acidic (pH=4, 8-5.2). The experiment was

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**Table 1.** Decrease weed infestation under the effect of herbicides (values negative – decrease, average for 3 years and tillage systems).

| Index of weed infestation | Control | Herbicides | | | | | | $LSD_{0.05}$ |
|---|---|---|---|---|---|---|---|---|
| | | Plateen | Plateen + Fusilade Forte | Plateen + Fusilade Forte + Atpolan | Barox | Barox + Fusilade Forte | Barox + Fusilade Forte + Atpolan | |
| Number of weeds per 1 $m^2$ before closing of potato rows | 21.7 | -11.7 | -12.4 | -13.6 | -9.2 | -10.7 | -12.3 | 3.8 |
| Number of weeds per 1 $m^2$ before harvest of tubers | 18.0 | -7.6 | -8.2 | -10.0 | -6.1 | -6.6 | -7.8 | 2.9 |
| Fresh matter of weeds before closing of potato rows, t $ha^{-1}$ | 0.91 | -0.46 | -0.74 | -0.76 | -0.38 | -0.52 | -0.56 | 0.17 |
| Fresh matter of weeds before harvest of tubers, t $ha^{-1}$ | 3.63 | -1.01 | -1.76 | -2.10 | -0.95 | -1.34 | -1.67 | 0.72 |
| Air-dry matter of weeds before closing of potato rows, t $ha^{-1}$ | 0.24 | -0.11 | -0.18 | -0.20 | -0.08 | -0.13 | -0.14 | 0.05 |
| Air-dry matter of weeds before harvest, t $ha^{-1}$ | 0.99 | -0.31 | -0.46 | -0.59 | -0.26 | -034 | -0.43 | 0.28 |

established as a randomised complete block in a split-plot arrangement with two soil tillage methods as a main plots and seven weed control technologies, design in three replications and it included the following factors:

(I) Two soil tillage methods – conventional farming system (skimming in September + fall ploughing in October + (harrowing + cultivating + harrowing in April) and simplified farming system (either skimming and cultivating in April),
(II) Seven weed control methods including an application of herbicides:

(1) Control – mechanical weed control prior to and following potato emergence,
(2) Plateen 41.5 WG (metribuzin + flufenacet) 2.0 kg $ha^{-1}$,
(3) Plateen 41.5 WG (metribuzin + flufenacet) 2.0 kg $ha^{-1}$ + Fusilade Forte 150 EC (fluazifop-P-butyl) 2.5 $dm^3$ $ha^{-1}$ (mixture),
(4) Plateen 41.5 WG (metribuzin + flufenacet) 1.6 kg $ha^{-1}$ + Fusilade Forte 150 EC (fluazifop-P-butyl) 2.0 $dm^3$ $ha^{-1}$ + adjuvant Atpolan 80 EC 1.5 $dm^3$ $ha^{-1}$ (mixture),
(5) Barox 460 SL (bentazone + MCPA) 3.0 $dm^3$ $ha^{-1}$,
(6) Barox 460 SL (bentazone + MCPA) 3.0 $dm^3$ $ha^{-1}$ + Fusilade Forte 150 EC (fluazifop-P-butyl) 2.5 $dm^3$ $ha^{-1}$ (mixture),
(7) Barox 460 SL (bentazone + MCPA) 2.4 $dm^3$ $ha^{-1}$ + Fusilade Forte 150 EC (fluazifop-P-butyl) 2.0 $dm^3$ $ha^{-1}$ + adjuvant Atpolan 80 EC 1.5 $dm^3$ $ha^{-1}$ (mixture).

Treatments 2 to 7 was used to performed pre-emergence mechanical weed control. Herbicides were applied just prior to potato emergence (Treatments 2, 3 and 4) and post-emergence to 10 to 15 cm of potato plant height (Treatments 5, 6 and 7). In the experiment, farmyard manure and mineral fertilizers were applied at the respective rates of 25 t/ha and 90 kg N, 90 kg $P_2O_5$, and 135 kg $K_2O$ per hectare. Potato tubers of Wiking cultivar were planted in the third decade of April at the spacing of 67.5 × 37 cm.

Weed infestation was determined by the square frame and gravimetrical method before closing of potato rows and before tubers harvest. There were determined number of weeds and their fresh and air dry matter per $m^2$. Large subsamples of 10 plants were taken from the produce of each plot, then graded to set sizes as follows: less than 30 mm, 30 to 40 mm, 40 to 50 mm, 50 to 60 mm and tubers greater than 60 mm, and subsequently weighted. The weight of tubers greater than 40 mm was counted to estimate the marketable fraction tubers yield. The yield of potato tubers data have been presented in the paper by Gugała and Zarzecka (2009).

A significant effect of weed control methods on weed infestation characteristics as well as potato yields stimulated us to calculate relationships of the number and amount of weeds with potato yields. In order to determine the relationships, correlation coefficients were calculated and linear regression equations were developed at the significance level p=0.05, the significance being checked by t-Student test. Statistical calculations were performed based on average values from three years of studies and means for soil tillage methods.

## RESULTS AND DISCUSSION

Application of herbicides and their mixtures in the experiment caused significantly lower number of weeds, fresh matter and air-dry matter of weeds determined at the beginning and towards the end of potato growth compared with the control object (Table 1). Correlation coefficients reflected a significant negative impact of weed infestation indicators (number, fresh and air dry matter of weeds) determined at the beginning and end of potato vegetation on tuber total and marketable fraction yield of tubers (Table 2). Fresh and air dry matters of weeds were more strongly correlated with tuber total and commercial fraction yields than the number of weeds. It indicates that the amount of weed mass threatens potato fields much more than number of weeds. Results observed by Pomykalska (1991) and Zarzecka (2004) support this inference. Also Chistaz and Nelson (1983) and Hashim et al. (2003) showed that correlation between tuber yield and air dry matter of weeds was significant and negative, and the correlation coefficient amounted to -0.970 and -0.498, respectively. Moreover, Hashim et al. (2003) found that tuber yield was positively

**Table 2.** Significant values of linear correlation coefficients between the weediness index and the total and marketable fraction of potato tubers yield (average for 3 years and tillage systems).

| Index of weed infestation | Total yield of tubers t ha$^{-1}$ | Marketable fraction of tubers yield t ha$^{-1}$ |
|---|---|---|
| Number of weeds per 1 m$^2$ before closing of potato rows | - 0.913* | - 0.935* |
| Number of weeds per 1 m$^2$ before harvest of tubers | - 0.959* | - 0.968* |
| Fresh matter of weeds before closing of potato rows, t ha$^{-1}$ | - 0.969* | - 0.976* |
| Fresh matter of weeds before harvest of tubers, t ha$^{-1}$ | - 0.981* | - 0.997* |
| Air-dry matter of weeds before closing of potato rows, t ha$^{-1}$ | - 0.981* | - 0.986* |
| Air-dry matter of weeds before harvest, t ha$^{-1}$ | - 0.995* | - 0.997* |

*Significant at P<0.05.

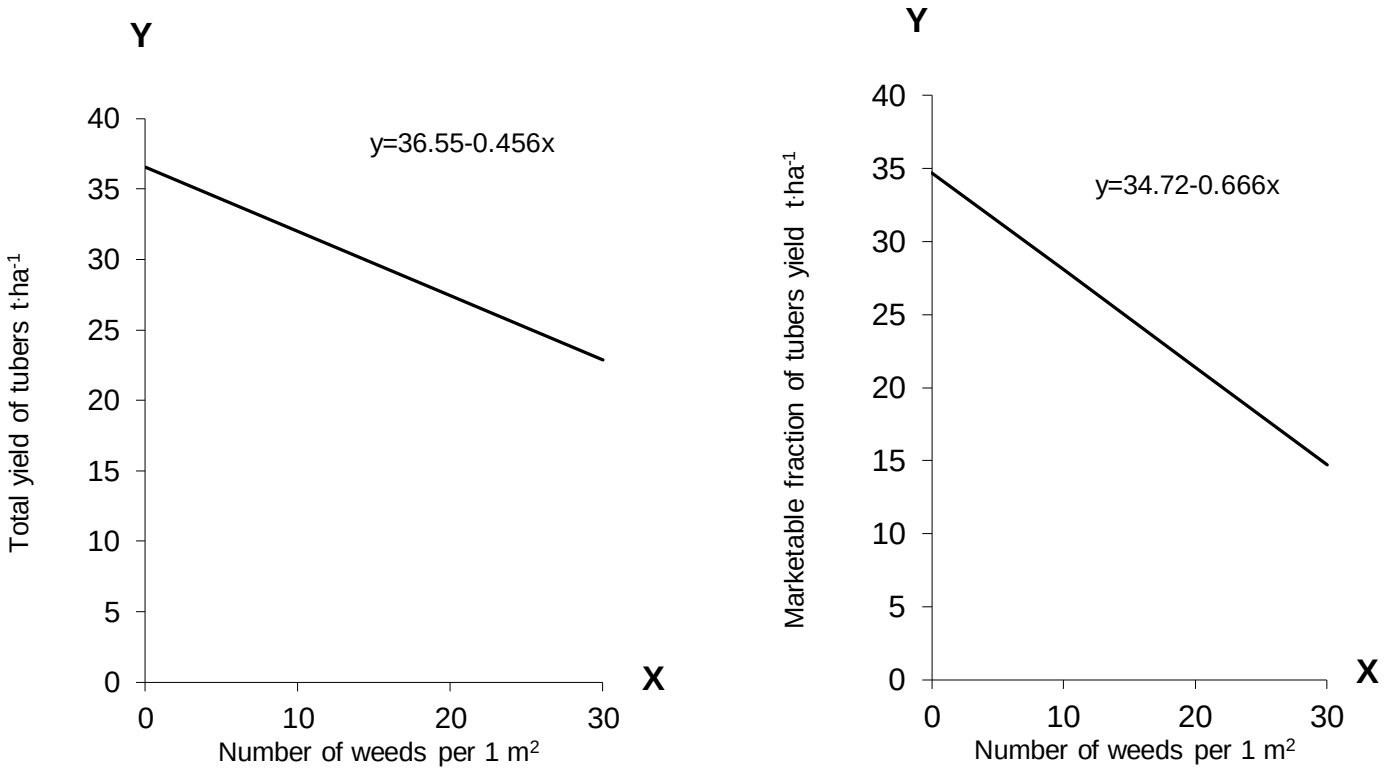


**Figure 1.** Relationship between total and marketable fraction yield of tubers and the number of weeds before closing of potato rows.

associated with potato plant height and number of tubers harvested from an area of 1 ha, but the differences were statistically insignificant. In turn, Mišovic et al. (1997) proved, on the basis of values of correlation coefficients, that of weeds biomass (r = 0.868) had less effect on yield of potato tubers than number of weed plants (r = 0.902).

In the present study it was also shown that, at the second date of weed infestation determination (before tubers harvest) potato tuber yields were more correlated with weed infestation indices (number of weeds, fresh and air dry matter of weeds) than at the beginning of vegetation (before closing of potato rows). Similar regression relationships between tuber yield and weed infestation were obtained by Pomykalska (1991) for potatoes grown on soil originating from sand and from loess.

An application of regression analysis revealed a linear negative relationship of total and marketable fraction yield of tubers with number of weeds, fresh and air dry matter of weeds determined both at the beginning at towards the end of vegetation (Figures 1 to 6). Increasing weed infestation by 1 plant per 1 m$^2$ reduced total and marketable fraction yields by, respectively, 0.46 and 0.67 t per 1 ha before closing of potato rows, and 0.54 and0.77 t per 1 ha before tuber harvest (Figures 1 and 2). In the studies by Pomykalska (1991) the reduction

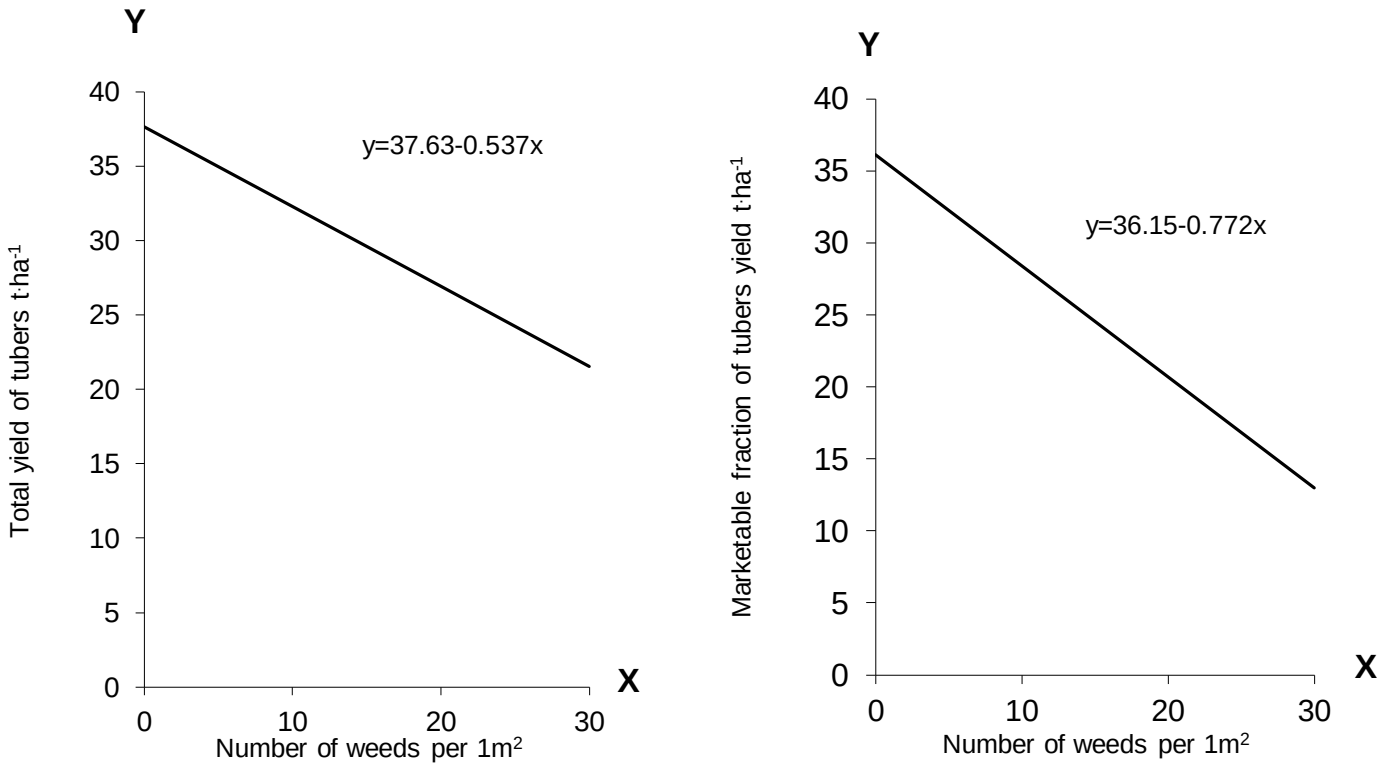


**Figure 2.** Relationship between total and marketable fraction yield of tubers and the number of weeds before harvest of tubers.

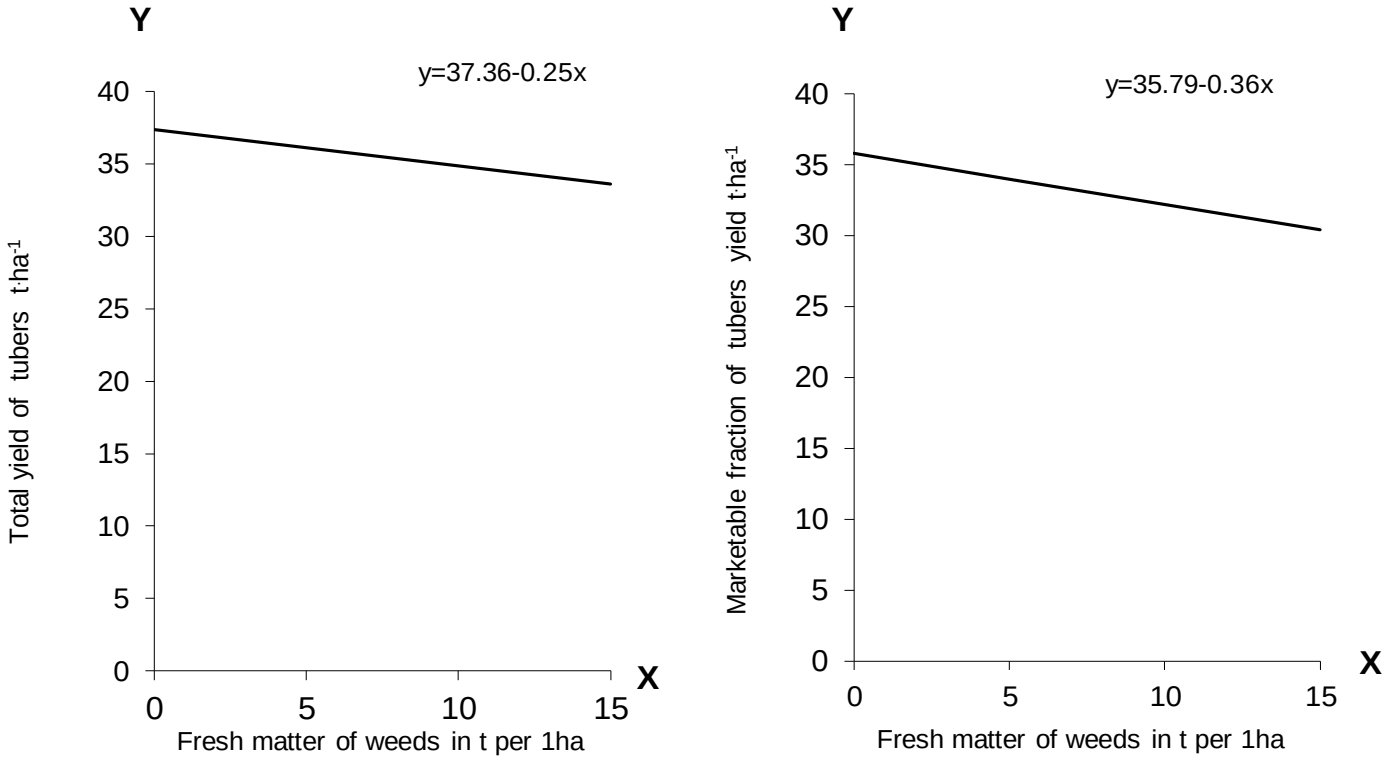


**Figure 3.** Relationship between total and marketable fraction yield of tubers and the fresh matter of weeds before closing of potato rows.

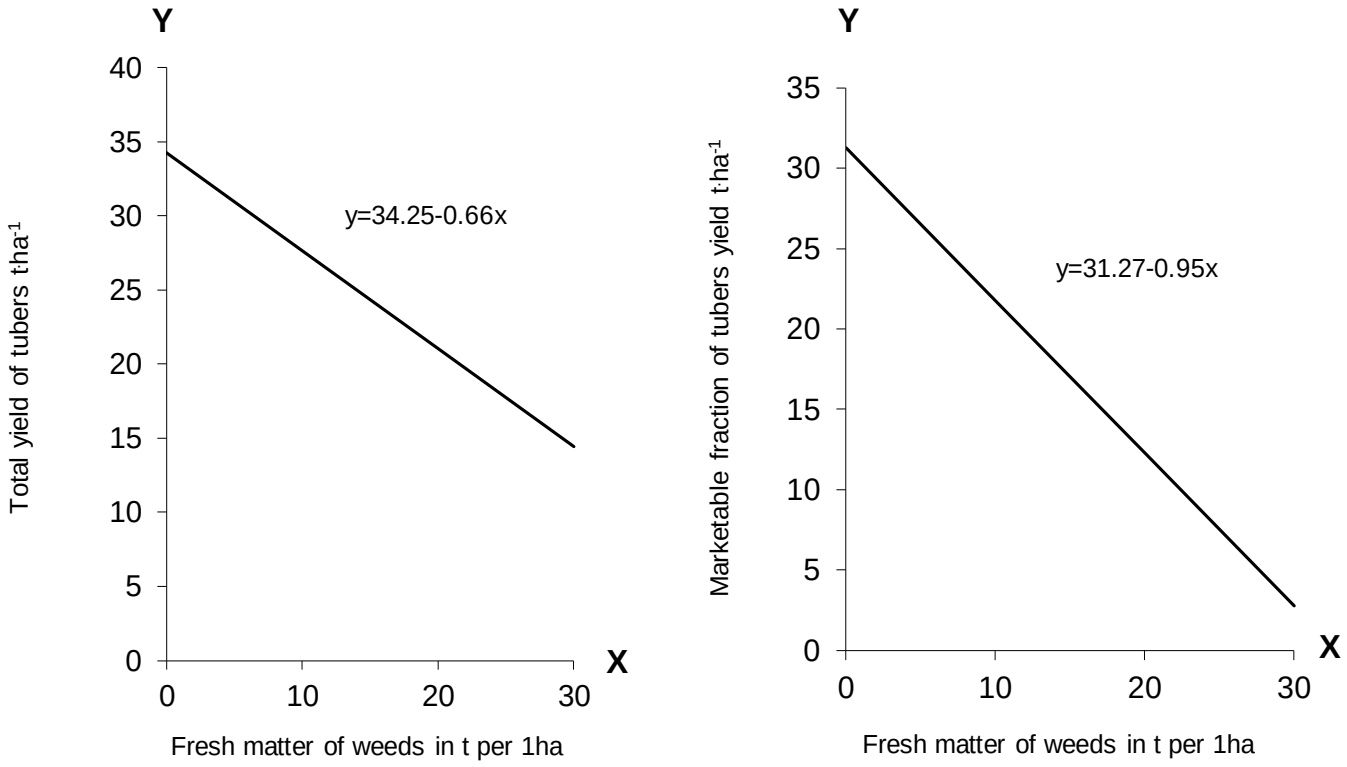


**Figure 4.** Relationship between total and marketable fraction yield of tubers and the fresh matter of weeds before harvest of tubers.

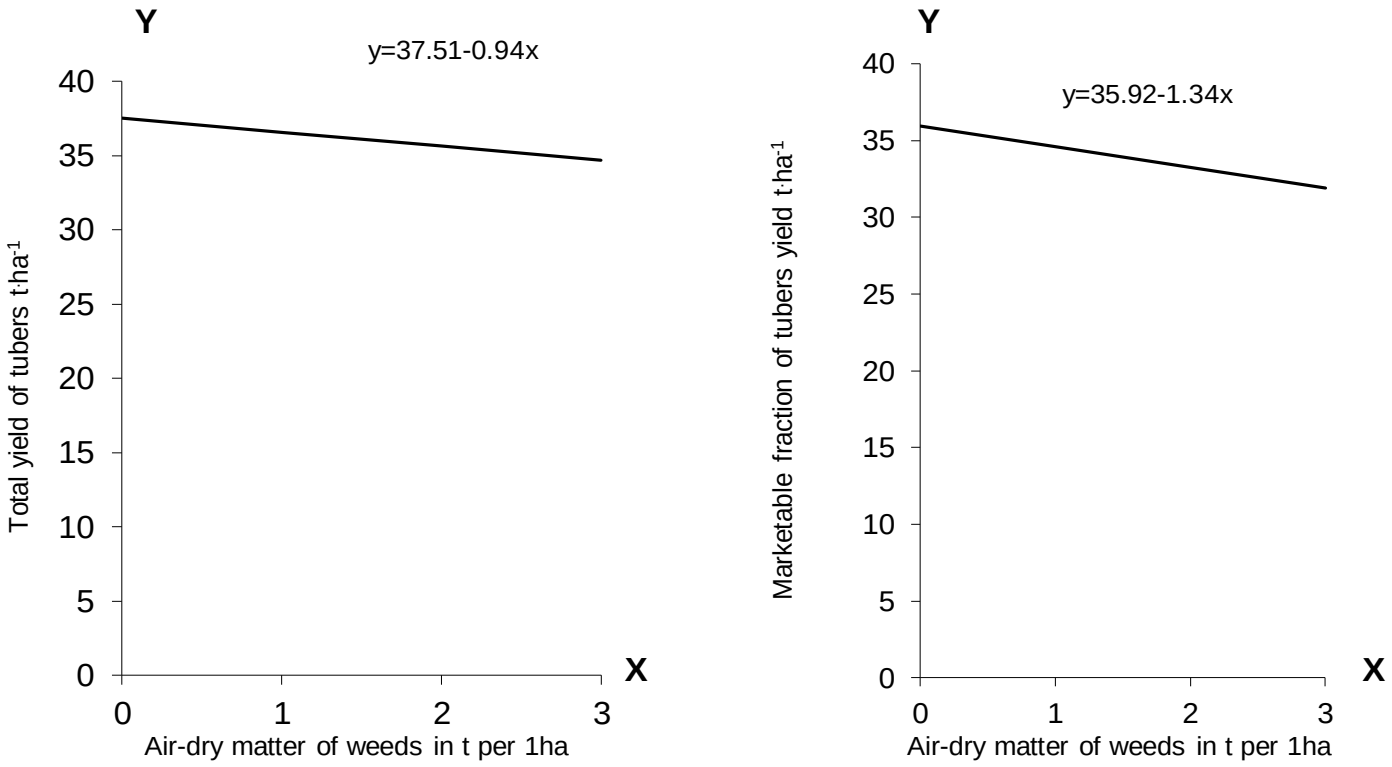


**Figure 5.** Relationship between total and marketable fraction yield of tubers and the air-dry matter of weeds before closing of potato rows.

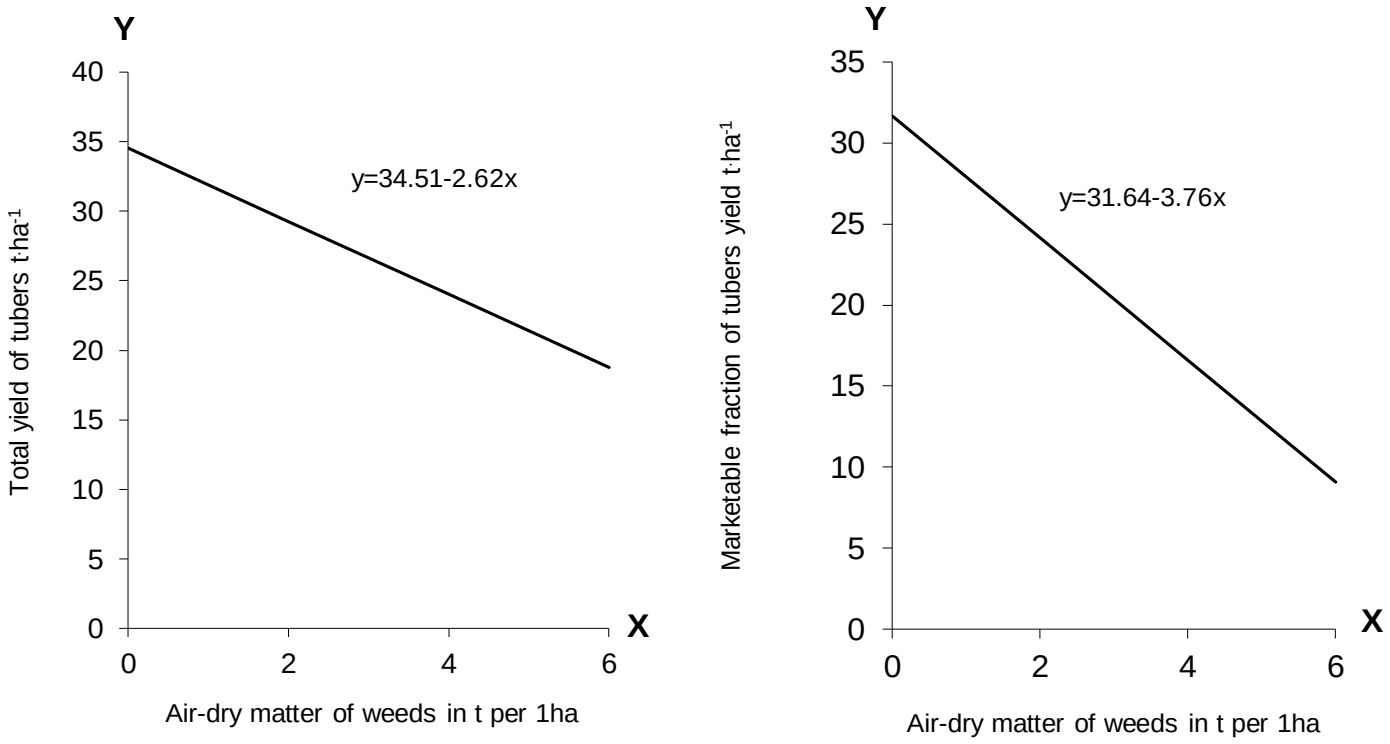


**Figure 6.** Relationship between total and marketable fraction yield of tubers and the air-dry matter of weeds before harvest of tubers.

amounted to 0.10 to 0.12 t $ha^{-1}$ for total yield, and Maykuhus (1988) says the respective total yield drops were 0.10-0.46 and 0.02-0.06 t $ha^{-1}$. In turn, Zarzecka (2004) recorded reductions in total and marketable fraction yields amounting to 0.23 and 0.28 t $ha^{-1}$, respectively.

Regression equations reflecting relationships between fresh matter of weeds and tuber yields indicate that tuber matter losses for total and marketable fraction yields amounted to, respectively, 0.25 and 0.36 t $ha^{-1}$ at the start of vegetation, and 0.66 and 0.95 t $ha^{-1}$ towards the end of vegetation (Figures 3 and 4).

The regression analysis indicated that an increase in weed infestation by 1 ton of air dry matter of weeds per 1 ha was followed by reductions in total and marketable fraction tubers yield by, respectively, 0.94 and 1.34 t per 1 ha when recorded before closing of potato rows, and by 2.62 and 3.76 t $ha^{-1}$ when recorded just before potato harvest (Figures 5 and 6). Pomykalska (1991) found that, depending on a type of soil on which the experiment was located, a 1-ton increase in air dry matter of weeds at the start of potato growth was followed by a 5.5 to 6.7 t $ha^{-1}$ decrease in total yield whereas at the end of vegetation the reduction amounted to 5.2 to 6.0 t $ha^{-1}$. According to Zarzecka (2004), an average total yield decrease per 1 ton of air-dry matter of weeds was 2.6 t $ha^{-1}$. Also Pomykalska (1991) and Radecki (1977) showed a linear negative association between yield and air dry matter of weeds, and found that 1 ton of weeds decreased tuber total yield by 5.0 to 7.0 t $ha^{-1}$. According to Pomykalska (1991), Radecki (1977), Boydston (2007), Buddoi et al. (1998) and Renner (1998) weed weight is a more precise and accurate indicator, than number of weeds of determining potato yield decrease. Moreover, the workers observed that the level of losses depended on species composition of weeds, as well as weather and soil conditions.

## Conclusions

The issue of relationship between weed infestation and potato yielding is of importance as far as agricultural practice is concerned because it reflects the degree to which the yield is at risk, and explains the purposefulness of applying mechanical-chemical weed control operations. A higher negative influence of weed infestation on potato yielding was found before tubers harvest, compared with the beginning of crop growth.

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