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Effects of integrated weed management treatments on some growth parameters of potato (*Solanum tuberosum* L.) and weed density

Adel Dabbagh Mohammadi Nassab*, Sanam Ghorbani Faal, Rouhollah Amini

Department of Plant Eco-physiology, Faculty of Agriculture, University of Tabriz, Tabriz, Iran

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Abstract

In order to evaluate the effects of integrated weed management treatments on some growth parameters of potato (*Solanum tuberosum* L.), a field experiment was conducted at the field of Ardebil Agricultural Research Center in 2011. This study was arranged based on randomized complete block design with 8 treatments and 3 replications. The experimental treatments were including 6 integrated weed management treatments, hand weeding and weed-infested treatment during entire growth season. Weed management treatments had significant effect on stems number per plant, tuber dry weight and weed density. The highest and lowest tuber weight was observed in cultural-mechanical and natural-mechanical management, respectively. The lowest weed density was observed in chemical-mechanical weed management that had no significant difference with hand weeding treatment that shows this management is useful for reducing the weed density. Regarding to the potato tuber dry weight and weed density the cultural-mechanical, cultural-chemical-mechanical and cultural-mechanical-natural managements are recommended. Also vinegar application in combination with cultural and mechanical control could be an alternative for herbicide application.

* **Corresponding Author:** Adel Dabbagh Mohammadi Nassab ✉ adeldabb@yahoo.com

Introduction

Growth and yield of potato (*Solanum tuberosum* L.) are substantially reduced by weed competition for nutrients, water and light. Application of pre-emergence or pre-planting herbicides is quite common for weed control in potato-growing areas. However, after crop emergence, machine or hand hoeing techniques are commonly used for the control of weeds by potato growers. Iranian farmers commonly use metribuzine at 0.75-1 kg ha^{-1} (pre-emergence herbicide) about 7 days after planting and remove weeds once more with inter-row cultivation or hand hoeing, when potato plants are at 15–25 cm height (Ghaffari *et al.*, 2012). These techniques are expensive, time consuming and they are not always successful or cost-effective (Ngouajio *et al.*, 1997). Since a considerable cost of production is allocated to weed control, production techniques should be designed in ways that reduce herbicide applications in order to guide against weed resistance and environmental damage (Oliver, 1988). Yield reduction depends on weed species, population density, and relative time of emergence and distribution as well as on the soil type, soil moisture, pH and fertility (Papamichail *et al.,* 2002).

Sustainable agriculture encompasses a wide range of physical, cultural, biological, and chemical weed control techniques and seeks to minimize off-farm inputs mall phases of crop production (Labrada, 2006). Many crop production techniques are compatible with sustainable and organic weed control, including various tillage regimes (Mohler, 2001), inter-row cultivation, mulching, weed flaming, the coating of seed with deleterious *Rhizobacteria* (Kremer, 2002), the application of plant pathogenic fungi as bio-herbicides, crop rotation, and cover cropping (Ortiz-Ribbing and Williams, 2006).

A limited number of chemical substances, including vinegar (Webber *et al.*, 2005) have been approved for specific uses inorganic production under the USDA National Organic Program (OMRI, 2007). Vinegar has herbicidal effects on broadleaf and grass weeds (Webber *et al.,* 2005), and the high acetic acid content of immature mulches contributes to weed control (Ozores-Hampton *et al.* 2002). The effects of vinegar on hairy vetch and several abundant broadleaf weeds were evaluated (Moran and Greenberg, 2008). In the absence of synthetic herbicides, vinegar applications could kill cover crops before crop production begins, and reduce the need for frequent cultivation and hand-weeding during production. Increasing the herbicide application for weed control caused to develop herbicide resistant in weed species and environmental problems. In these conditions the application of straw mulch and vinegar as non-chemical methods for weed control could be effective for reduction in herbicide application. Therefore, the objective of this study was to evaluate the effects of integrated weed management strategies on weed density and some growth parameters of potato.

Materials and methods

Site description and materials

In order to evaluate the performance of vinegar and mulch in integrated weed management of potato, a field experiment was conducted at the field of Ardebil Agricultural Research Center in 2011. In this experiment potato cv. Agria (*Solanum tuberosum*) was used which was obtained from Agricultural Research Center of Ardabil. Household vinegar (red vinegar of Varda) at concentration of 5.1% acetic acid was used. Vinegar and water were mixed in a ratio of 1:4 and sprayed by 20 L hand sprayer between rows that did not contact with potato shoot. Wheat straw mulch (non-living) was applied (3500 kg/ha) between rows of the potato. The paraquat (Gramoxone SL 20% Saveh Co.) was applied in rate of 3 L/ha.

Experimental design and field practice

This study was arranged based on randomized complete block design with 8 treatments and three replications. The experimental treatments were different integrated weed management strategies including chemical - mechanical (paraquat application, hilling after 20 days, hand weeding after

20 days, the second hand weeding after 20 days), natural-mechanical-cultural control (spraying of vinegar, re-application of vinegar after 15 days, hilling after 15 days and immediately mulch application), cultural-mechanical-natural control (mulch application, hilling after 30 days, spraying vinegar after 15 days), natural–mechanical control (spraying vinegar, re-spraying vinegar after 15 days, hilling after 15 days and spraying vinegar after 15 days), cultural-chemical–mechanical control (mulch application, paraquat application after 30 days, hilling after 15 days and vinegar spraying after 15 days), cultural-mechanical control (mulch application, hilling after 30 days and immediately mulch application), hand weeding and weed infested treatment during entire growing season.

Data collection

At the end of growth season at physiological maturity stage, the number of stems per plant of potato and weeds density at unit area was recorded. The tubers in 1 m^{-2} of each plot was harvested and placed in oven with 80°C for 72 h and then the tuber dry weight was measured.

Statistical analysis

The data subjected to analysis of variance after testing for normality and homogeneity of variance, using MSTATC and SAS. The means were compared using Duncan's multiple range test at p≤0.05.

Results and discussion

Number of stems per plant

The results indicated that the number of stems per potato was not affected by different weed management treatments (Table 1). The highest and lowest number of stems per plant was belonged to the cultural-mechanical and hand weeding through the growing season, respectively. These management treatments were not significantly different with others (Table 2). With increasing duration of weed interference, the number of potato stems decline that finally potato yield significantly decreased (Mandany *et al.*, 2007).

Table 1. Analysis of variance of potato growth parameters and weed density (ns, * and **, respectively, non-significant, significant at p≤0.05 and p≤ 0.01).

S.O.V	df	umber of stems per plant	Tuber dry weight	Weed density
Block	2	0.445^{ns}	22427.475^{ns}	22.799^{ns}
Manage me treatmen ts	7	0.116^{ns}	508621.610^{*}	656.874^{**}
Error	14	0.644	192399.581	93.258
CV (%)		3.37	4.52	2.98

With increasing periods of weed competition with soybeans, the amount of environmental resources witch allocated to vegetative buds reduced and collateral growth capacity decreased subsidiaries (Eftekhari *et al.*, 2005). Being a dominant plant in competitive depends on features such as of plant height and number of branches (Tollenaar and Dwyer, 1999).

Table 2. The means comparison of number of stems per plant of potato at different weed managements (The means with same letters are not significantly different at p≤0.05).

Management treatments	Number of stems per plant
Chemical – mechanical	3.42a
Natural - mechanical – cultural	3.22a
Cultural - mechanical– natural	3.39a
Natural–mechanical	3.00 a
Cultural-chemical– mechanical	3.33a
Cultural–mechanical	3.44a
Hand weeding	2.92a
Weed- infested	3.33a

Redroot pigweed due to high competition, especially with short legs and early plants such as cowpea can be effective yield loss, such as the number of sub-branches (Mirshekari *et al.*, 2007). Chemical control of safflower was instrumental in increasing the number of branches, while hand weeding resulted in a significant increase in the number of safflower

branches (Hatami *et al.*, 2006). Chemical control and two times hand weeding of soybean increased number of branches have been reported by Abdelhamid and El-Metwally (2008).

Potato tuber dry weight

Results showed that the effect of weed management treatments was significant on potato tuber dry weight ($p \leq 0.05$) (Table 1). The lowest potato tuber dry weight was observed in natural-mechanical management which showed no significant difference with weed infested treatment. Management treatments of cultural-chemical-mechanical, cultural - mechanical and hand weeding in the whole growth season compare were significantly different with weed infested and natural– mechanical management (Fig. 1).

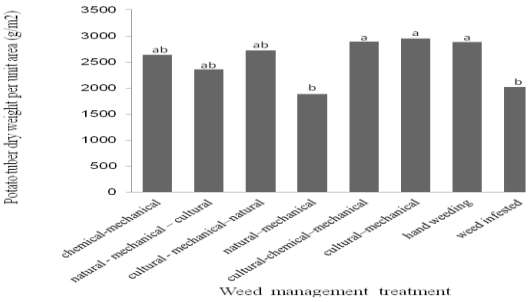

Fig. 1. Potato tuber dry weight (g/m^2) in the different weeds management treatments (the means with same letters are not significantly different at $p \leq 0.05$).

Potato tuber dry weight at chemical-mechanical, natural-mechanical-cultural, cultural-mechanical-natural, cultural-chemical-mechanical and cultural-mechanical were not significantly different with hand weeding treatment. Pourazar and Qadiri (2001) stated that with increasing the density of wild oats in the wheat, biological yield of wheat was significantly reduced. Cudney *et al.*, (1991) observe that when wild oat density increased the wheat grain dry weight was decreased. Semers and Froud (2001) noted that competition between roots of maize and pea decreased the biological function of corn and pea by 41 and 47%, respectively. In general, due to the competitive effects, this result shows the superiority of the competitive effects of two plant roots than shoot competition.

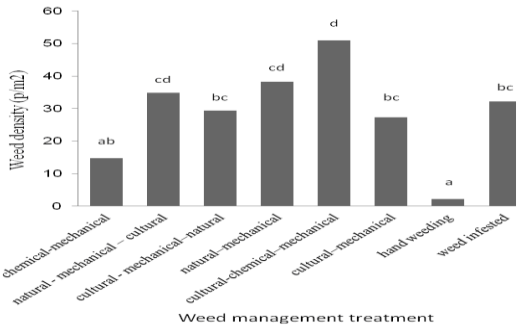

Fig. 2. Effect of different weed management treatments on weeds density (the means with same letters are not significantly different at $p \leq 0.05$).

Sedghi (2006) stated that the proportion of dry matter and harvest index in increasing the final yield of soybean was 81.7 and 18.3%, respectively. In other words, the increasing the soybean yield in weed-free treatments compared with weed-infested treatment was attributed to the increase in biomass production. These results suggested that weeds caused to reduction in soybean biomass production trough reduction in net photosynthesis rate because of competition for light interception. Finally this competition reduced the proportion of assimilates used for soybean grain filling (Sedghi, 2006).

Weed density

Weed density was significantly influenced by different weed managements (Table 1). The lowest weed density was observed in the chemical-mechanical treatment that was not significantly different with hand weeding treatment that indicating this management is appropriate for reduction in weed density. The highest weed density was observed in cultural-chemical-mechanical management (Fig. 2). The weed density at all management treatments except cultural-chemical-mechanical and hand weeding was not significantly different with that of weed-infested treatment.

Habibi (2009) reported that herbicide application compared with the control (no herbicide) reduced weed density at the flowering stage of potato. Also application of mulch compared with no mulch treatment reduced the total density of weeds in

potato flowering stage. The results showed that the use of the residues of wheat, barley and canola reduced the total density of weeds compared with no-residue treatment. The highest weeds density (51p/m²) was observed in plots without residues. These results demonstrate the inhibitory effects of plant residues on germination and early growth of weed species at flowering stage of potato (Habibi, 2009).

Ghaffari *et al.*, (2012) found that cover crops of canola (*Brassica napus* L.) and rye (*Secale cereal* L.) and chemical control caused 36, 35 and 35% reduction in weeds density, respectively. Average weed density and dry weight had significant negative correlation with potato tuber yield because of reduction in germination and emergence of weed species.

Conclusion

The cultural-chemical-mechanical and cultural-mechanical managements had the highest tuber dry weight that indicated cultural management (application of wheat mulch) could be effective for weed control, probably by preventing weed germination. The potato tuber dry weight was the lowest in natural-mechanical management that indicate the application of vinegar at early growth season was not suitable for weed control.

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