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Weed Population and Income of Potato (*Solanum Tuberosum* L.) Affected By Vinegar Application

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***Abstract* – The aims of this study were to evaluate the effects of integrated weed management treatments on weed population, biological yield and income of potato (Solanum tuberosum L.). The field experiment was conducted at the field of Ardebil Agricultural Research Center, Ardebil Iran in 2011. This study was arranged based on randomized complete block design with eight treatments and three replications. The experimental treatments were different integrated weed management strategies including chemical - mechanical, natural - mechanical – cultural, cultural-mechanical–natural, natural–mechanical, cultural-chemical–mechanical, cultural–mechanical, hand weeding and weed infested treatment during entire growing season. Results showed that weed management treatments had significant effect on weed population and biological yield of potato. The biological yield of potato per unite area at chemical – mechanical, cultural – chemical-mechanical and cultural-mechanical managements were not significantly different with hand weeding treatment. In comparison with weed-infested treatment, the natural-mechanical-cultural and cultural- chemical-mechanical managements showed the highest reduction percentage (13.3%) in weed species population. The highest net income was observed in cultural - mechanical and cultural - chemical-mechanical managements. The cultural weed management increased the potato biological yield and income. The weed management treatment that began with cultural weed management had the highest net income. Application of common vinegar for weed management in potato should be integrated with mulch application and used at the end of the potato growth season.**

***Keywords* – Hilling, Integrated Weed Management, Mulch, Potato, Vinegar.**

I. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important crops that after wheat and rice are the main resource for nutrients. In 2008 the cultivated area of the potato was 153995 ha with 4107616 tones potato tuber production (Rashed-Mohassel *et al*., 2011). Growth and yield of potato 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. 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; Mohammaddost *et al*., 2011). 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*., 2012a, b). These techniques are expensive, time consuming and they are not always successful or cost-effective (Ngouajio *et al*., 1997). Rashed-Mohassel *et al*., (2011) reported that in integrated weed management treatment the weed control percentage, weed biomass and potato yield was not significantly different with broadcast herbicide treatment. 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). 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). 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).

Vinegar has herbicidal effects on broadleaf and grass weeds 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 (*Vicia villosa* L.) and several abundant broadleaf weeds were evaluated (Moran and Greenberg, 2008). Mohammaddost *et al.,* (2011) observed that plant residues of wheat, canola and barley reduced the emergence and growth of weed species in potato field. In the absence of chemical herbicides, vinegar applications could kill cover crops before beginning of crop growth and reduce the need for frequent cultivation and hand-weeding during growth period. Therefore the objectives of this research were to evaluate the effects of integrated weed management treatments including vinegar application on weed population, biological yield and net income of potato production system.

II. MATERIALS AND METHODS

In order to investigate the efficacy of vinegar in combination with mulch and other integrated weed management treatments in potato, a field experiment was conducted at the field of Ardebil Agricultural Research Center in 2011. In this experiment the potato of cultivar Agria (*Solanum tuberosum*) was used which was obtained commercially from Agricultural Research Center of Ardabil. The common (red vinegar of Varda) and wood vinegar at concentration of 5.1% acetic acid were used for experiment. 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 in rate of 3500 kg/ha between rows of the potato. The paraquat (Gramoxone SL 20% Saveh Co.) was applied in rate of 3 L/ha as chemical weed control treatment.

This study was arranged based on randomized complete block design with 8 treatments and three replications. The experimental treatments were included different integrated weed management treatments 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.

At the end of growth season at physiological maturity stage the shoot and 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 as potato biological yield. At the growth season the weed species in each plot was indentified and the numbers of species were recorded at different weed management treatments. Also the dominant weed species in the potato field were identified.

The gross and net income of potato was calculated based on the expenses for different weed management treatments and application of common vinegar. The expenses for weed management treatment were considered based on conventional system of potato production system in Ardebil province and vinegar price. The data were tested for normality and homogeneity of variance and no data transformation was needed. 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 $p \leq 0.05$.

III. Results and Discussion

Biological yields:

Analysis of variance (Table 1) showed that the effect of weed management treatment was significant on biological yield of potato ($P \leq 0.05$). The biological yield of potato in cultural – chemical – mechanical, cultural – chemical and hand weeding management treatments was higher than those for other management treatments (Figure 1). The natural – mechanical and weed-infested management treatments had the lowest biological yield but they were not significantly different with chemical –mechanical, natural – mechanical – cultural and cultural – mechanical – natural treatments. The biological yield of potato per unite area at chemical – mechanical, cultural – chemical – mechanical and cultural – mechanical managements were not significantly different with hand weeding treatment. This result indicates the good performance of these management treatments in suppressing the weeds and finally high biological yield of potato (Figure 1).

Table 1: Analysis of variance of potato biological yield and weed population (Number of weed species in plots). (ns, * and **, respectively, non-significant, significant at $p \leq 0.05$ and $p \leq 0.01$).

S.O.V	df	Biological yield	Weed population
Block	2	2242709.5^{ns}	2.167**
Management treatment	7	508621.6*	6.357*
Error	14	192399.6	1.786
CV (%)		17.26	12.11

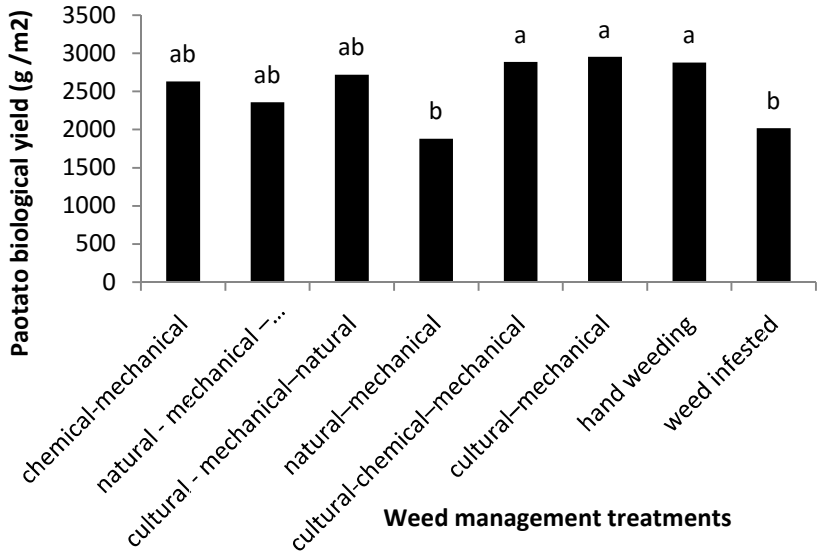

Fig.1. Biological yield of potato (g/m2) at different integrated weed management treatments including chemical, mechanical, natural and cultural managements. The means with the same letters are not significantly different at P≤0.05.

The results of changes in potato biological yield in comparison with hand weeding treatment indicated that the highest increase in biological yield of potato was observed in cultural–mechanical and cultural–chemical - mechanical managements(Figure 2). Therefore these two management treatments had the highest efficiency in weed suppression that could be attributed to the wheat straw mulch application that caused to save the soil moisture and decline temperature that finally increased the grow and dry matter accumulation in potato. Midmore *et al*., (1988) also reported that the shadow created in tuber bulking stage caused reduction in evaporation, increased the relative humidity, reduced the temperature and respiration and ultimately increased the potato biological and tuber yield. Sotoudenejad *et al.,* (2009) also observed that the effect of integrated weed management treatments on potato yield was significant and the treatment of herbicide + cultivator had the highest yield. Abutalebian and Mazaheri (2011) reported that using living mulch of barley (*Hordeum vulgare* L.) + reduced dose of herbicide produced the yield equivalent to conventional potato cropping system.

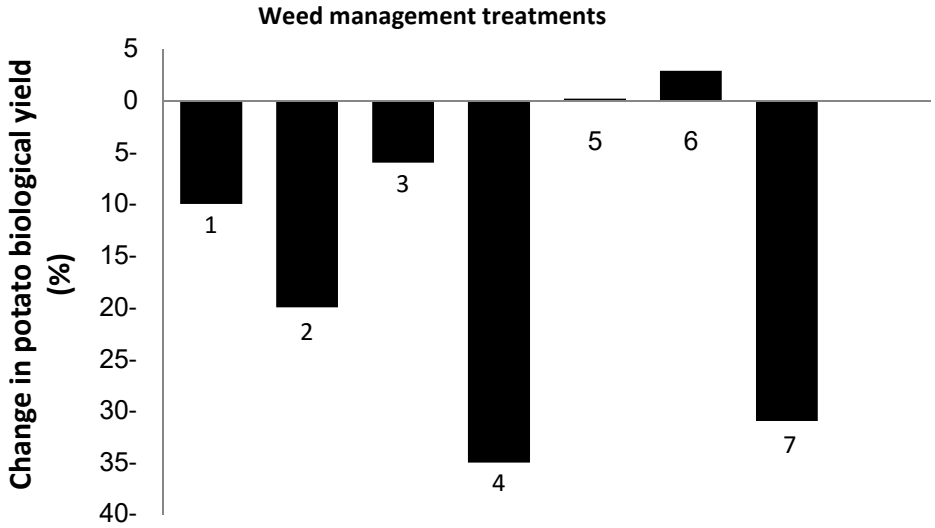

Fig.2. Changes for potato biological yield per unit area in comparison with hand weeding treatment (%) at different weed management treatments. 1- Chemical – mechanical management; 2- Natural – mechanical – cultural management; 3- Cultural – mechanical – natural management; 4- Natural – mechanical management; 5- Cultural – chemical – mechanical management; 6- Cultural – mechanical management; 7- Weed infested.

Weed population

The results of analysis of variance indicated that effect of weed management treatment was significant on weed species diversity ($P \leq 0.05$). The hand weeding and chemical-mechanical management had the lowest weed diversity (weed species number per unit area) and the other management treatments had the highest weed diversity (Figure 3). In comparison with weed-infested treatment, the natural – mechanical – cultural and cultural-chemical-mechanical managements showed the highest reduction percentage (13.3%) in weed species population (Figure 4). Also in weed management treatment of natural-mechanical and cultural-mechanical management treatments the reduction percentages in weed species population were 20 and 26.6%, respectively. In other word the management treatment that were including natural method (application of common vinegar), had the lowest weed diversity in comparison with other treatments. These results imply that using the vinegar in potato field could be effective strategy for reduction of the weed population. The cultural- chemical-mechanical management strategy caused 13.3% reduction in weed diversity and therefore indicates that application of wheat straw mulch early in the growing season followed by hilling at the next growing stages could be an alternative for vinegar application for reduction of weed species population in the field. The scientific name and life cycle of dominant weed species in the studied potato field was presented in Table 2.

Table 2: The systematic characteristics of dominant weed species in the potato field.

No.	*Scientific name*	*Common name*	*Family*	*Life cycle*
1	*Cirsium arvense* (L.) Scop.	Canada thistle	Asteraceae	Perennial
2	***Convolvulus arvensis* L.**	Field bindweed	**Convolvulaceae**	Perennial
3	***Chenopodium album* L.**	Lamb's-quarters	Chenopodiaceae	Annual
4	*Polygonum avicular* L.	Prostrate knotweed	Polygonaceae	Annual
5	*Sonchus oleraceus* L.	Common sowthistle	Asteraceae	Annual

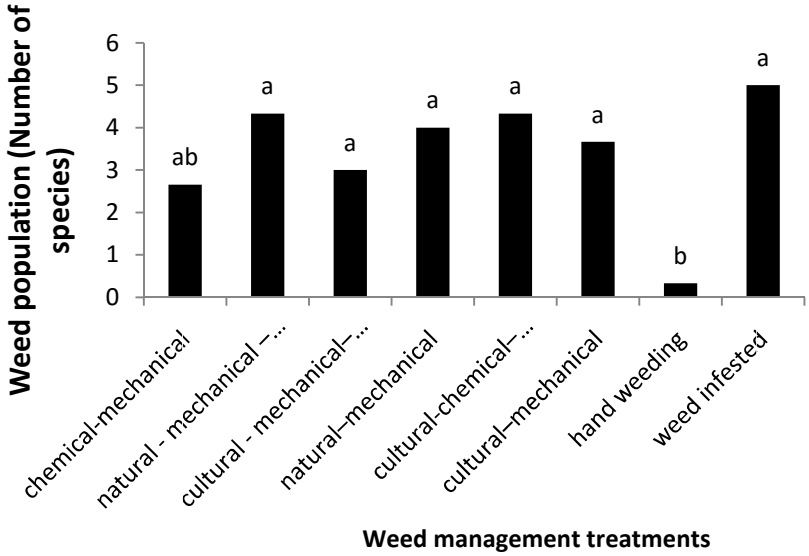

Fig.3. Effect of different weed management treatments in potato on weed population (the number of weed species) in the field.

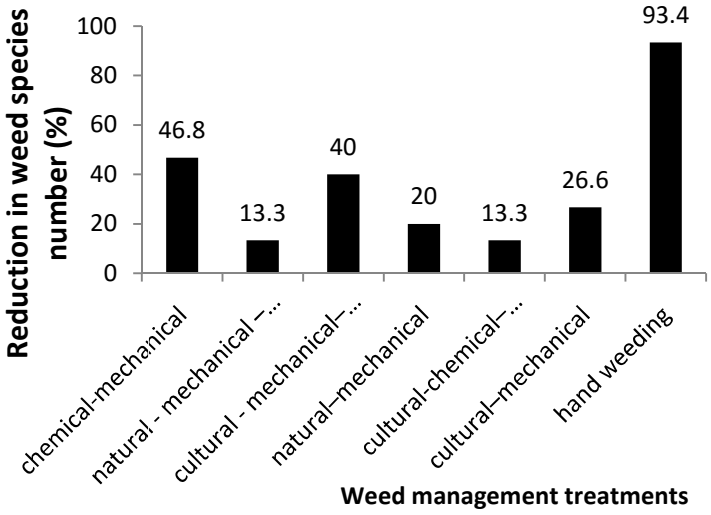

Fig.4. Reduction (%) in weed species number compared with weed-infested treatment at different management treatments.

Golzardi *et al*., (2007) found that by increasing the weed control period in potato the weed biomass was reduced significantly. Using the allelopathic cover crops such as canola (*Brassica napus* L.), hairy vetch and rye (*Secale cereale* L.) in potato production system, reduced the weeds fresh weight and density significantly (Jahedi, 2005). Therefore, herbicide application in potato could be replaced with cover crop plants. Application of living mulches (barley and clover) and hilling in potato had not significant effect on weed density but reduced weed biomass significantly (Abutalebian and Mazaheri, 2011). The application of metribuzin + plant residues reduced the plant density of redroot pigweed (*Amaranthus retroflexus* L.), lambsquarters (*Chenopodium album* L.) and common Purslane (*Portulaca oleracea* L.) (Mohammaddost *et al*., 2011).

Gross and net income of potato production

The results indicated that the hand weeding and natural–mechanical weed management had the highest (7800 Rails) and lowest (630 Rails) weed control cost among weed management treatments, respectively (Table 3). Among the weed management treatment included natural management, the natural - mechanical – cultural (1110 Rails) and natural – mechanical (630 Rails) had the highest and lowest weed control costs. Among the weed management treatments, the highest gross income (potato yield multiplied by the price of potato) was owned in cultural- mechanical management and after that was belong to the cultural – chemical – mechanical management and hand weeding during entire growing season (Table 3). The natural- mechanical treatment had the lowest (9000 Rails) gross income among the weed managements. The highest net income (deducting the cost of weed control) was observed in cultural -mechanical (12920 Rails) and cultural - chemical-mechanical (12880 Rails) managements (Table 3).

Table 3: The weed control costs, gross and net income /m^2 of potato at different integrated weed management treatments for application of common vinegar as natural weed management.

Management treatments	Weed control costs (Rails/m^2)	Gross income (Rails/m^2)	Net income (Rails/m^2)
Chemical – mechanical	2770	12500	9730
Natural - mechanical – cultural	1110	11000	9890
Cultural - mechanical–natural	900	13000	12100
Natural–mechanical	630	9000	8370
Cultural-chemical–mechanical	1070	13950	12880
Cultural–mechanical	1380	14300	12920
Hand weeding	7800	13900	6100
Weed- infested	0	9650	9650

The hand weeding management treatment had the lowest net income (6100 Rails) that it was due to the high cost of labor for weed hoeing (7800 Rails) throughout the growing season. In hand weeding treatment the gross income is high but its net income was lower than those for all other management treatments. In this study, the common household vinegar with 5% acidity was used. Common household vinegar usually has been used in businesses home use in comparison with wood vinegar, which is cheaper than common vinegar and the acidity of about 60 %. In order to prepare the spray solution for application at the farm level the wood vinegar should be diluted 12 times more with water in comparison with the amount used for common vinegar to obtain a solution with the same concentration. In order to prepare the wood vinegar solution for spraying, because of high acidity it can cause irritation and therefore it should be carefully used such as chemical herbicides.

It should be considered that among the weed management treatments, the highest net income was observed at cultural – mechanical, cultural–chemical–mechanical and cultural- mechanical–natural management. The application of common vinegar for weed management as natural management significantly increased the net income of potato when it was applied at the end of the growth period (cultural- mechanical–natural management). But by application of the common vinegar early in the growth season the net income of the potato was decreased (9890 and 8370 Rails /m^2 for natural -mechanical– cultural and natural –mechanical management). Generally we can conclude that the cultural weed management (use of wheat straw mulch) suppressed the weeds growth and increased the potato biological yield and income. Therefore the weed management that began with cultural weed management had the highest net income. Also application of common vinegar for weed management in potato should be integrated with mulch application (cultural management) and used at the end of the potato growth season. Integrated application of wheat straw mulch and common vinegar for weed management help us to suppress weed growth and also reduce chemical herbicide application in potato production. These non-chemical and integrated weed management strategies are along with organic and sustainable agriculture.

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REFERENCES

[1] M. A. Abutalebian and D. Mazaheri. 2011. Effect of hilling and living mulch on weed control and potato yield. J. Iranian Field Crop Res. 42: 255-264.

[2] A. Eftekhari, A.H. Shiranirad, A. Rezaei, H. Salehian and M.R. Ardekani. 2005. Determination of critical period of weed control in soybeans in Surrey. J. Agric. Sci. 7: 295-309.

[3] M. Ghaffari, G. Ahmadvand, M. Ardakani, A. Nadali and F. Elahipanah. 2012a. Cover crop residue effects on weed control, physiological parameters, yield and yield components of potato (*Solanum tuberosum* L.). Iranian J. Crops Sci. 43: 295-309.

[4] M. Ghaffari, G. Ahmadvand, M. Ardakani, A. Nadali and F. Elahipanah. 2012b. Ecological weed management by cover crops: Effect on winter weeds and establishment of summer weeds in potato cropping. Iranian J. Field Crops Res. 10: 247-25.

[5] F. Golzardi, F. Mandany, G. Ahmadvand, A. Sepehri and A. Jahed. 2007. Duration of weed interference on absorption and light use efficiency of canopy density in both seed and commercial potatoes Agria (*Solanum tuberosum*). Agric. Res. Water, Soil and Plant Agric. 7: 25-41.

[6] G.H. Habibi. 2009. Comparing the use of chemical herbicides whit mulch on weed control in potato fields. Msc. Thesis, Faculty of Agriculture, University of Mohaghegh Ardabili. Pp. 84.

[7] A. Jahedi. 2005. Allelopathic weed control in potato production. New Agric. Achiev. 1: 1-11.

[8] R.J. Kremer. 2002. Bio-herbicides: potential successful strategies for weed control. In: Microbial biopesticides (Eds.: G. Koul and D. haliwal). Taylor and Francis, London. pp. 307-32.

[9] R. Labrada. 2006. Weed management: a basic component of modern crop production. In: Handbook of sustainable weed management. (Eds.: H.P. Singh, D.R. Batish, and R.K. Kohli). Food Products Press, New York, NY. pp. 21-49.

[10] D.J. Midmore, J. Roca and D. Berrios. 1988. Potato (*Solanum* spp.) in the hot tropics. IV. Intercropping with maize and the influence of shade on potato microenvironment and crop growth. Field Crop Res. 18: 141-157.

[11] B. Mirshekari, A. Dabbagh Mohammadi Nasab and M. Puryusef. 2007. Economic damage threshold of red root pigweed (*Amaranthus retroflexus* L.) in the field of cowpea (*Vigna unguiculata* L.). J. Agric. Sci. 1: 55-6.

[12] H.R. Mohammaddost, A. Asghari, G.R. Habibi and B. Pourmorad. 2011. Effects of herbicides and plant residues on integrated weed control of potato. J Crop Prod. 4: 171-185.

[13] C.L. Mohler. 2001. Weed life history: identifying vulnerabilities. In: Ecological management of agricultural weeds (Eds.: M. Liebman, C.L. Mohler, and C.P. Stayer). Cambridge University Press, Cambridge, UK. pp. 40-98.

[14] P.J. Moran and S.M. Greenberg. 2008. Winter cover crops and vinegar for early-season weed control in sustainable cotton. J. Sustain. Agri. 32: 483-506.

[15] M. Ngouajio, J. Foko and D. Fouejio. 1997. The critical period of weed control in common bean (*Phaseolus vulgaris* L.) in Cameroon. Crop Prot. 16: 127–133.

[16] L.R. Oliver. 1988. Principles of weed threshold research. Weed Technol. 2: 398-403.

[17] M. Ozores-Hampton, T.A. Obreza, P.J. Stoffella and G. Fitzpatrick. 2002. Immature compost suppresses weed growth under greenhouse conditions. Compost Sci. Util. 10: 105-1.

[18] D. Papamichail, I. Eleftherohorinos, R. Froud-Williams and F. Gravanis. 2002. Critical periods of weed competition in cotton in Greece. Phytoparasitica. 30: 105–111.

[19] M.H. Rashed-Mohassel, K. Haj-Mohammad-Nia and S.A. Hosseini. 2011. Evaluating the effect of chemical and mechanical weed control methods with reduced herbicide dose in potato (*Solanum tuberosum* L.) production. J. Plant Prot. 25; 227-236.

[20] M. Sotoudenejad, M, Safari and L. Alimoradi. 2009. Evaluating the efficacy of integrated weed management of potato in Bardsir. J. Weed Ecol. 1: 41-55.