Research Journal of Applied Sciences, Engineering and Technology 4(19): 3628-3636, 2012
ISSN: 2040-7467

Submitted: February 10, 2012 Accepted: March 24, 2012 Published: October 01, 2012

Investigating the Effect of Phosphorus, Potassium and Weed Management on Forage and Seed Yield of Alfalfa Ecotypes (*Medicago sativa* L.)

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Abstract: In order to investigate fertilizing and weed management effects on forage and seed yield of alfalfa ecotypes, a field trial was conducted during 2008-2009 growing season at Khorasan Agricultural and Natural Resource Research Center, Mashhad-Iran. Alfalfa ecotypes including (Ghareghozlo, Hoakmabad, Malekkandi, Kozre, Faminin, Galebani, Rahnani, Shorkat, Chaleshtar, Ghareaghaj, Gharoghlogh, Ordobad, Sedighan, Silvana, Sahandava, Ghahavand, Mohajerankaraj and Mashhad) were allocated to main plots; sub plots consisted of two levels of none fertilizing and fertilization treatments using simultaneous application of potassium sulphate and phosphate triple at rates of 150 and 350 K/ha, respectively and sub-sub plots were allocated to weeding and none weeding treatments based on a complete randomized block design in a split-split-plot scheme with three replicates. Results showed that the effect of ecotype on forage yield was not significant. Gharoghlogh and Silvana produced the highest (18270 kg/ha) and the lowest (14630 kg/ha) green forage yield, respectively at both cuttings (first and second cuts). The interaction of fertilization and weeding on forage yield was significant ($p<0.01$). On the other hand, with application of fertilizer, forage yield 11.74% was increased and it was enhanced 26.93% by manual weeding. Furthermore, results revealed that ecotype fertilizer interaction was significant ($p<0.05$) for weed dry weight. Ecotype weeding interaction was significant ($p<0.05$) for number of seed per pod and seed weight ($p<0.01$). In addition, fertilizer weeding interaction was significant ($p<0.05$) for number of seed per plant. Among the treatments, highest number of seed per plant was produced by fertilizer and weeding treatment (2734) and the lowest one was obtained by non-fertilizer and non-weeding treatment (559.5).

Keywords: Alfalfa, fertilization, manual weeding, weed competition, yield

INTRODUCTION

Weed control has been recognized as an essential practice in every crop production system. The presence of weeds in cropped fields is associated with a number of undesired incidents such as reduced quality and quantity of crop yield, increased harvesting costs and afflicted on-farm beneficial insect population (Gesimba and Langat, 2005). Weeds reduce crop yields via overlapping and shading crop canopy, decreasing the amount of light absorption and producing inhibitory allelopathic substances (Loux *et al*., 2009). The most negative impact of weed on crop is the competition for the limited sources (Patterson, 1995). Competition capability is not just a measurable and inherent feature but it is related to other plant characteristics. The higher amounts of food reserves stored in plant organs, greater root and stem systems (Kruepl *et al*., 2006), faster canopy expansion (Callaway, 1992), increased plant height (Vollmann *et al*., 2010), higher rate of leaf surface expansion (Gomes *et al*., 2007) are of crucial factors determining competitively dominant plant species and can provide a higher level of crop competitive ability against weeds. Dominant weed species in the competition are those that have rapid seedling growth (Storkey, 2004), short vegetative phase (Bakker *et al*., 2009) and higher Relative Growth Rate (RGR) (Menalled *et al*., 2005). The above-mentioned factors are highly important in terms of forage management, especially in perennial legumes such as alfalfa, which is subjected to frequent cuttings.

Of the management approaches that can help to minimize the competition between weeds and agronomic crops is manual weeding. It is considered to be an effective form of weed control, especially in less developed countries, where farmers can not afford to purchase chemical herbicides or farming is done on small scale. Manual weeding can contribute substantially to suppress weed growth and increase crop yield (Tawaha *et al*., 2002; Abusuwar and Bakri, 2009).

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One of the most important factors in crop-weed competition is period of competition. So that, the drastic reductions in crop yield occur when the period of competition is prolonged.

Alfalfa is not able to compete with turf grass weeds for the uptake of nutrients, especially divalent ions. Therefore, timely application of phosphorus and potassium fertilizers as well as weed removal is critical to prevent weeds from obtaining these elements and enhance the competitive ability of alfalfa.

Phosphorus and potassium are key elements for alfalfa establishment and can increase the ability of alfalfa stand to outcompete weeds (Malhi and Goerzen, 2010). Furthermore, adequate phosphorus levels are essential to achieving optimum alfalfa seed yields (Berg *et al*., 2003; López-Bucio *et al*., 2003). Liebman and Davis (2000) stated that weeds can accumulate mineral nutrients in their tissues faster and more effectively than crops. Although, apparently nutrients promote crop growth, they may result in increased weed growth instead of increased crop yield (Bettmann *et al*., 2006). Weed infestations can weaken young alfalfa seedlings, retard growth, reduce plant stands, delay the first cutting of alfalfa and reduce forage quality in the first and second cutting.

Weeds compete with alfalfa for water, nutrients and light (Lillak *et al*., 2005). Alfalfa is most sensitive to weed interference during seedling establishment stage, thus, the weed occurrence at early growth stages of alfalfa could lead to severe yield losses (Canevari *et al*., 2007). Summer annual weeds such as foxtail (*Setaria* spp.), pigweed (*Amaranthus* spp.) and lambsquarter (*Chenopodium* album) or perennial weeds such as field bindweed (*Convolvulus arvensis* L.), curly dock (*Rumex crispus* L.) and dandelion (*Taraxacum officinale* Wigg.) are the most troublesome weed species found in many alfalfa fields. Having a rapid growth rate, these weeds can significantly reduce alfalfa stand establishment (Canevari *et al*., 2007). A strategy for management of these weeds during alfalfa establishment is highly important, due to the fact that alfalfa seedlings are slow establishers and poor competitors for the limited sources. Weed control in alfalfa is more critical up to 60 days after sowing, during which weeds should be removed.

The weed species that emerge after this period do not significantly affect alfalfa forage yield. Therefore, the best way of weed control in alfalfa is to obtain healthy and vigorous stands through adequate fertilization program, harvest management and pest control. Dillehay *et al*. (2011) showed that weed control during establishment period of alfalfa stands increased seedling weight, leaf number and forage crop yield. Different alfalfa ecotypes may respond differently to weed competition and utilization of nutrients during the competition. Little work, however, has been done to evaluate these competitive aspects of alfalfa ecotypes against weeds in Iran.

Table 1: Soil test result

K (ava.) p.p.m	P (ava.) p.p.m	Total N	Soil depth (cm)	O.C
195	15.6	0.056	0.40	0-30
125	8.8	0.046	0.30	30-60

The aim of this research was to investigate fertilizing and weed management influences on forage and seed yield of eighteen alfalfa cultivars.

MATERIALS AND METHODS

The study was carried out during the 2008-2009 growing seasons at Khorasan Agricultural and Natural Resource Research Center (36º13′ 11 N latitude, 59º 38′19 E longitude and an altitude of 1029 m above sea level) located in Mashhad, Iran. Eighteen different ecotypes of alfalfa including Ghareghozlo, Hoakmabad, Malekkandi, Kozre, Faminin, Galebani, Rahnani, Shorkat, Chaleshtar, Ghareaghaj, Gharoghlogh, Ordobad, Sedighan, Silvana, Sahandava, Ghahavand, Mohajerankaraj and Mashhad were used in the study. The experiment was laid out in a randomized complete block design with split-split plot arrangement having three replicates. Alfalfa ecotypes were assigned to the main plots, whereas no-fertilizer treatment and a simultaneous application of potassium sulphate and triple phosphate were allocated to subplots and non-weeding or hand weeding was allocated to sub-sub plots. Field preparation was done according to typical practices in Research Station, which involved primary and secondary tillage operations such as disc plowing and leveling in summer-fallow field. At first year the young growing plants were well-established and based on soil test result (Table 1), 150 kg potassium sulphate and 350 kg triple phosphate per hectare were simultaneously applied on November 19 2008 and 20 July 2009 to evaluate fertilizer effectiveness on forage yield and seed production. The fertilizers were applied at a depth of 5 cm below the soil surface and a distance of 10 cm away from the plant stands. Alfalfa ecotypes were irrigated at 7-9 day intervals, depending on growth stage. In order to measure the biomass, number and diversity of weed species, a four-stage weed sampling was done. The weed samples were identified and then collected from each sub-sub plot prior to the application of fertilizer treatments, before the first and second cutting of alfalfa and at the end of growing season when alfalfa ecotypes were seeded. To determine the dry matter production of weed species, the collected samples were put into separate pockets and dried in an oven at 72ºC for 48 h to constant weight and weighed. The net sub-sub plot (4 m^2) was harvested after removing the border rows. At every cutting stage, a 250 g sample of harvested alfalfa ecotypes from each plot was analyzed for determination of forage dry weight. Three guarded plants were randomly selected from each sub-sub plot to estimate the following growth traits and yield components; weight and number of pods per plant, 1000-

seed weight, number of seeds per pod and number of pods per plant. Statistical analysis was conducted using the MSTAT-C statistical package. Microsoft Excel was used to make graphs of the collected data. Duncan's Multiple Rang Test (DMRT) at the 0.05 probability level was applied to compare treatment means.

RESULTS AND DISCUSSION

Forage green yield: Analysis of variance showed that the effects of fertilizer and weeding on forage yield were significant ($p<0.01$) (Table 2). However, there was no significant difference among alfalfa ecotypes but mean comparison showed that Gharoghlogh ecotype produced the maximum yield (18270 kg/ha) and the minimum yield was obtained by Silvana ecotype (14630 kg/ha) (Table 3). The differences among the alfalfa ecotypes can be attributed to the canopy structure (higher, leaf area index, the position of leaves and branches, stems density) and also differences in physiological characteristics of each ecotype. Altinok and Karakaya (2002) stated that among the alfalfa ecotypes, there is significant genetic variation for forage green yield production. Forage yield in fertilizer treatment was 11.74% higher than in non-fertilizer treatment (Table 4). In addition, forage yield in weeding treatment increased by 26.93% compared to non-weeding treatment (Table 5). These results revealed that there was genetic variation for forage green yield among the ecotypes. Santos *et al.* (1997) showed that P is relatively immobile in the soil. Therefore, plants with extensive root system may absorb P more efficiently than weeds. Ecotype fertilizer interaction indicated that application of both P and K fertilizers resulted in higher forage yield than when the nutrients were added separately, which was consistent with other findings (Berg *et al*., 2007). They also found that cultivars with the genetic potential to produce large shoots (low leaf-to-stem ratios) would be more responsive to P and K fertilizer applications and have high yield under well-fertilized conditions. Berg *et al.* (2005) reported that the highest forage yields were obtained with application of both P and K fertilizer rather than single application of the nutrients. Genotypic differences in efficiency of K uptake have been reported in many crops such as alfalfa (James *et al*., 1995). Allelopathic potential of older alfalfa stands can negatively affect the growth and subsequent yield of newly established stands. Jennings and Nelson (2002) reported that autotoxicity from an established plant may create a zone of influence around them that can lead to reduction in growth of the new alfalfa stands. *Berg et al*. (2003) showed that when alfalfa stand densities decline, due to fall dormancy, phosphorus application can enhance the number of shoots per plant and finally produce more yield. Weed control is more critical during the first year than any other period of forage production. Forage seedlings growth slightly and are easily out-competed by fast growing weeds. Some broadleaf weed seedlings are capable of growing five-fold faster than legume seedlings.

Pod per plant: The data presented in Table 2 indicated that fertilizer application and weeding had a significant effect ($p<0.01$) on the number of pods per plant. Mean comparison showed that Kozre ecotype surpassed other ecotypes in number of pods/plant (390.5) which was not statistically different with other ecotype and the lowest number of pods/plant was obtained by Silvana ecotype (169.2) (Table 3). The number of pods/plant was 45.20% higher in fertilizer treatment than non-fertilizer treatment (Table 4). In addition, with weeding application, number of pod per plant was enhanced to (411.4) which were considerably higher than non-weeding treatment (189.1) (Table 5). It seems that the investigated trait responds differently to the applied treatments, depending on cultivar or agronomic crop. Whereas Roshdy *et al*. (2008) on canola showed that pod/plant increased by weeding, Odeleye *et al*. (2007) found that varying weeding regimes had no significant effect on number of pods/plant in soybean cultivars. Shabani *et al*. (2011) on annual medic (*Medicago scutellata* cv. Robinson) indicated that fertilizer application resulted in an increase in number of pods/plant. Singh *et al*. (1990) on chickpea found that larger pods/plant is expected to be produced in ecotypes with higher yield strength. It appears that genetic variation is one of the most important factors that determine number of pods/plant in many crops. It is not clear what relationship exists between yield components of alfalfa and greater forage yield and how phosphorus and potassium fertilizers contribute to alfalfa yield and its components while alfalfa population is declined as alfalfa stands age.

Seed per plant: The data presented in Table 2 showed that fertilizer application and weeding had a significant effect ($p<0.01$) on seed number per plant. Mean comparison showed that Kozre ecotype surpassed other ecotypes in number of seed per plant (2118) and the minimum seed number was obtained by Silvana ecotype (881.1) (Table 3). Fertilizer weeding interaction was significant ($p<0.05$) (Table 2). The highest number of seed per plant was recorded by fertilizer and weeding treatment (2734) and the lowest one was observed in non-fertilizer and non-weeding treatment (559.5) (Fig. 1). Seed number in fertilizer treatment increased by 63.90% compared to non-fertilizer treatment (Table 4). In addition, with weeding application, number of seed per plant was enhanced to (2249) which were noticeably higher than non-weeding treatment (816.5) (Table 5). Rashid *et al*. (2007) on rapeseed reported that weeding application resulted in enhanced seed yield. Our results revealed that the eighteen ecotypes did not respond similarly to the weeding in terms of seed per plant (Table 2). Genetic diversity in alfalfa varieties is a

Table 2: Analysis of variation of forage yield and yield components

Source of variation	df	Forage yield	Pod/plant	Seed/plant	Seed/pod
Mean squares					
Replication	2	100481261.574*	12399.542ns	1541221.207ns	3.716ns
Ecotype	17	20278616.588ns	54679.441ns	1488697.248ns	2.695ns
Error	34	27871212.544	57882.748	1769794.255	1.757
Fertilizer	1	165900416.667**	661122.685**	29757500.573**	21.825**
E*F	17	558137.255ns	5903.999ns	188543.444ns	0.060ns
Error	36	506145.833	5532.940	229692.769	0.057
Weeding	1	760125185.185**	2669778.685**	110812440.343**	68.907**
E*W	17	880454.793ns	18456.783ns	586798.635ns	0.307*
F*W	1	3325185.185ns	16328.167ns	2814514.177*	0.248ns
E*F*W	17	576043.028ns	3713.873ns	94155.277ns	0.124ns
Error	72	1550648.148	13397.292	490136.216	0.190
Total	215	1082053307	3519196.155	149773494.18	99.886

**: Significant at 1%; *: Significant at 5%; ns: non significant

Table 3: Mean comparison for forage yield and yield components

Treatment	Forage yield (kg/ha)	Pod/ plant	Seed/ plant	Seed/ pod	Pod weight (kg/ha)	Seed weight (kg/ha)	1000 grain weight (gr)	Weed dry weight (kg/ha)
Ghareghozlo	17600a	355.9a	1621.4a	4.556bc	1608a	1260a	2.017ab	44.22a
Hokmabad	16540a	283.5a	1141.9a	4.028c	1521ab	1209ab	2.092ab	51.72a
Malekkandi	14920a	380.8a	1809.1a	4.751abc	1482abc	1094abc	2.042ab	44.22a
Kozre	17310a	390.5a	1941.5a	4.972abc	1343abcd	1017abc	2.125ab	53.38a
Faminin	14670a	233.6a	1168a	5.000abc	1302abcd	1007abc	2.008ab	48.38a
Galebani	17100a	273.3a	1639.8a	6.000a	1384abcd	1037abc	2.142ab	69.22a
Rahnani	15770a	381.0a	1905a	5.000abc	1291abcd	974.8abc	2.342a	69.22a
Shorkat	15500a	297.1a	1600.7a	5.388ab	1264abcd	961.8bc	1.992ab	85.05a
Chaleshtar	14170a	374.0a	1735.3a	4.640bc	1364abcd	1026abc	2.242ab	50.05a
Ghareaghaj	15250a	324.2a	1558.1a	4.806abc	1189bcd	919.1bc	1.958b	45.88a
Gharoghlogh	18270a	248.3a	1034.9a	4.168bc	1191bcd	918.9bc	1.925b	50.05a
Ordobad	13920a	236.1a	1017.9a	4.222bc	1076d	850.5c	2.075ab	50.05a
Sedighan	15980a	312.4a	1518.5a	4.861abc	1143cd	842.1c	1.958b	71.72a
Silvana	13630a	169.2a	1353.5a	5.028abc	1272abcd	964.8bc	2.092ab	99.22a
Sahandava	16060a	212.5a	1145.3a	5.390ab	1189bcd	915.8bc	2.042ab	64.22a
Ghahavand	15400a	317.5a	1429.0a	4.501bc	1258abcd	897.7c	2.225ab	49.22a
Mohajerankaraj	14770a	241.7a	1174.9a	4.861abc	1277abcd	977.3abc	1.992ab	70.88a
Mashhad	16250a	378.3a	1765.5a	4.667bc	1339abcd	1004ab	c2.042ab	55.88a

Means, in each column, following similar letter(s) are not significantly different at the 5% level of probability-using Duncan's Multiple Range Test

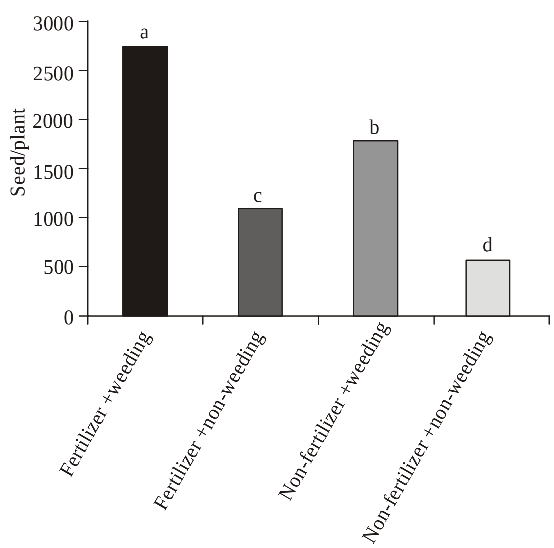

Fig. 1: Fertilizer × weeding interaction for seed/plant

determining factor in seed yield and yield formation which could be affected by agronomical management such as weeding. Liatukiene *et al*. (2009) and Sengul (2006) stated that seed yield in alfalfa is affected by pollen fertility, ovule fertility and ease of tripping. These factors differ genetically among alfalfa ecotypes. In addition, some external factors such as weather condition and the practices conducted by growers have great influence on seed yield. Pedersen and Lauer (2004) on soybean found that seed number was influenced by weather condition throughout flowering and pod set stages. As a result of an increase in number of pods per plant, seed number is increased and, thus assimilates are supplied to more seeds. In present study, seed yield reduction in Hokmabad and Malekkandi ecotypes can be attributed to more partitioning of assimilates to vegetative parts rather than productive parts.

Seed per pod: Fertilizer application and weeding had a significant effect (p<0.01) on Seed/pod (Table 2). Mean comparison showed that among alfalfa ecotypes there was a significant variation and Galebani (6) and Hokmabad (4.02) produced highest and lowest seed per pod, respectively (Table 3). Seed/pod in fertilizer treatment increased by 13.33% as compared to non-fertilizer treatment (Table 4). Furthermore, Seed/pod in weeding treatment increased by 25.58% as compared to non-

Table 4: The effect of fertilizer on forage yield, seed yield and yield components

Treatment	Forage yield (kg/ha)	Pod/ Plant	Seed/ plant	Seed/ pod	Pod weight (kg/ha)	Seed weight (kg/ha)	1000 grain weight (gr)	Weed dry weight (kg/ha)
Fertilizer	16550.7a	355.6a	1903.9a	5.1a	1361.5a	996.6a	2.2a	62a
Non-fertilizer	14811.4b	244.9b	1161.6b	4.5b	1249b	840.5b	2b	57b

Means, in each column, following similar letter are not significantly different at the 5% level of probability-using Duncan's Multiple Range Test

Table 5: The effect of weeding on forage yield and yield components

Treatment	Forage yield (kg/ha)	Pod/ Plant	Seed/ plant	Seed/ pod	Pod weight (kg/ha)	Seed weight (kg/ha)	1000 grain weight (gr)	Weed dry weight (kg/ha)
Weeding	17542.8a	411.4a	2249.0a	5.4a	1391.7a	1005.4a	2.2a	10b
Non-weeding	13820.3b	189.1b	816.5b	4.3b	1218.8b	980.7b	1.9b	45a

Means, in each column, following similar letter are not significantly different at the 5% level of probability-using Duncan's Multiple Range Test

Table 6: Ecotype × weeding interaction for seed/pod and seed weight and ecotyp × efertilizer interaction for weed dry weight

Treatment	Ecotypeseed/pod	seed weight (kg/ha)	Treatmentweed		dry weight (kg/ha)
Weeding	Ghareghozlo	5.612b-e	1301a	Fertilizer	51.72cde
	Hokmabad	4.000l-o	1219b4		8.38cde
	Malekkandi	4.500h-i1	238b		53.38cde
	Kozre3.890	m-o11	80c		60.05be
	Faminin	5.390d-f	1109d		40.05cde
	Galebani	4.112k-o	1079e		70.05a-e
	Rahnani	5.612b-e	1035fg		71.72a-e
	Shorkat	4.333i-m	998.2hi		90.05a-d
	Chaleshtar	5.833b-d	1024fg		76.72a-e
	Ghareaghaj	4.445h-m	990.2hij		121.7a
	Gharoghlogh	6.555a	1045f		93.38abc
	Ordobad	5.445d-f	1029fg		45.05cde
	Sedighan	5.500c-f	982.8ijk		58.38b-e
	Silvana	4.500h-I	966.7jk		l80.08a-e
	Sahandava	6.055abc	983.7ijk		108.4ab
	Ghahavand	4.772g-j	971.0jk		l93.38abc
	Mohajerankaraj	5.335d-f	1041f		61.79b-e
	Mashhad	4.333i-m	1011gh		66.72b-e
Non-weeding				Non-fertilizer	
	Ghareghozlo	5.167e-g	924.8m		40.05cde
	Hokmabad	3.945l-o	913.3mn		40.05cde
	Malekkandi	4.445h-m	926.7m		40.05cde
	Kozre	3.555o	911.2mn		50.05cde
	Faminin	4.772g-j	856.0o		30.05e
	Galebani	3.723n-o	845.0o		48.38cde
	Rahnani	5.388d-f	849.0o		53.38cde
	Shorkat	4.333i-m	835.2o		35.05de
	Chaleshtar	5.612b-e	971.8ijk		l40.05cde
	Ghareaghaj	4.167j-n	957.7k		l56.72b-e
	Gharoghlogh	6.113ab	923.0m		90.05a-d
	Ordobad	4.667g-k	908.7mn		38.38cde
	Sedighan	4.778g-I	903.8mn		31.72e
	Silvana	4.223i-n	891.5n		66.72b-e
	Sahandava	5.388d-f	970.2jkl		48.38cde
	Ghahavand	4.333i-m	935.5l		61.72b-e
	Mohajerankaraj	5.000f-h	1014gh		61.72b-e
	Mashhad	3.945l-o	993.2hij		33.38e

Means, in each column, following similar letter(s) are not significantly different at the 5% level of probability-using Duncan's Multiple Range Test

weeding treatment (Table 5). Ecotype weeding interaction was significant ($p<0.05$) (Table 2). In weeding treatment, Gharoghlogh ecotype (6.5) and in non-weeding treatment Kozre ecotype (3.5) produced highest and lowest number of seed per pod, respectively (Table 6). Our results are in line with Mir *et al*. (2010) on mustard and Amjad *et al*. (2001) on okra who found that P fertilizer increased seed/pod. Keramati *et al*. (2008) on soybean reported that weed competition did not influence seed/pod. Alfalfa ecotypes differences in seed/pod could be due to the genetic variation. Wang *et al*. (2011) indicated that seed number per pod is considerably affected by genetic structure of alfalfa varieties. Sengul (2006) noticed that self-compatibility along with large seed/pod is the most important factors for larger seed yield. Furthermore, seed/pod reduction is greatly affected by defoliation. To reach the highest value of seed yield, it is suggested that tripping and phosphorus and potassium application should be done at the same time (Shebl *et al*., 2009). Therefore, tripping greatly influence seed formation in alfalfa plants.

Pod weight: The results showed that alfalfa ecotype ($p<0.05$), fertilizer application and weeding had a significant effect ($p<0.01$) on pod weight (Table 7). Mean comparison showed that highest pod weight was produced

Table 7: Analysis of variation of pod weigh, seed weight, 1000 grain weight and weed dry weight

Source of variation	df	Pod weight	Seed weight	1000 grain weight	Weed dry weight
Mean squares					
Replication	2	8972411.241**	8782249.38**	0.143ns	137.463*
Ecotype	17	216433.112*	143527.895**	0.144ns	28.100ns
Error	34	127191.834	89875.698	0.129	35.630
Fertilizer	1	684225.227**	9295.782**	2.344**	16.667ns
E*F	17	3945.492ns	311.890ns	0.015ns	33.304*
Error	36	3502.394	257.356	0.0141	5.241
Weeding	1	1614263.560**	33078.375**	4.363**	7643.608**
E*W	17	3488.629ns	1057.012**	0.024ns	28.100ns
F*W	1	8226.338ns	1.338ns	0.024ns	16.667ns
E*F*W	1	75152.975ns	39.384ns	0.011ns	33.304ns
Error	72	3824.838	420.065	0.021	28.264
Total	2151	1642664.64	9060114.769	7.232	8016.348

**: Significant at 1%; *: Significant at 5%; ns: non significant

by Ghareghozlo ecotype (1608 kg/ha) and the lowest pod weight was obtained by Ordobad ecotype (1076 kg/ha) (Table 3). Pod weight in fertilizer treatment increased by 9% as compared to non-fertilizer treatment (Table 4). In addition, pod weight in weeding treatment was 14.18% higher than non-weeding treatment (Table 5).

Seed weight: Analysis of variance showed that ecotype, fertilizer application and weeding had a significant effect ($p<0.01$) on seed weight (Table 7). Mean comparison showed that the highest seed weight was produced by Ghareghozlo ecotype (1260 kg/ha) and the lowest seed weight was obtained by Sedighan ecotype (842.1 kg/ha) (Table 3). Ecotype weeding interaction was significant ($p<0.01$) (Table 7). The interaction of ecotype weeding revealed that the highest seed weight was produced by Ghareghozlo ecotype (1301 kg/ha) in weeding treatment and the lowest seed weight was produced by Shorkat ecotype in non-weeding treatment (835.2 kg/ha) (Table 6). With fertilizer application, seed weight was enhanced to 996.6 kg/ha (Table 4). Furthermore, seed weight in weeding treatment increased by 1005.4 kg/ha in comparison to non-weeding treatment (980.7 kg/ha) (Table 5). Increase in pod/plant and seed/plant lead to enhancement of seed weight (Singh *et al*., 1990).

1000 grain weight: Analysis of variance showed that fertilizer application and weeding had a significant effect ($p<0.01$) on 1000 grain weight (Table 7). Alfalfa ecotypes showed significant variation on 1000 seed weight (Table 3). The highest 1000 seed weight (2.34 gr) was obtained by Rahnani ecotype and the lowest 1000 seed weight (1.92 gr) was obtained by Gharoghlogh ecotype (Table 3). Table 4 indicated that 1000 seed weight in fertilizer treatment increased by 10% when compared to non-fertilizer treatment. In addition, 1000 seed weight in weeding treatment increased by 15.78% when compared to non-weeding treatment (Table 5). These results revealed that the size of seed is controlled by genetic variation and seed growth and development are affected by seed sheath. Ruhul Amin *et al*. (2009) observed that there is genetic variation for this trait among soybean cultivars. Hand-weeding reduces weed density by which utilization of available nutrients is improved during photosynthesis. Consequently, higher amounts of assimilates will be stored in seeds, which will give rise to more 1000-grain weight.

Table 8: Common weeds associated with alfalfa production

Common name	Scientific name	Class	Life cycle*
Downy brome	Bromus tectorum	Grass	WA
London rocket	Sisymbrium irio	Broadleaf	WA
Creeping thistle	Circium arvense	Broadleaf	CP
Yellow goats-beard	Tragopogon dubius	Grass	SP
Field bindweed	Convolvulus arvensis	Broadleaf	CP
Bermudagrass	Cynodon dactylon	Grass	CP
Foxtail barely	Hordeum jubatum	Grass	SA
Dandelion	Taraxacum officinale	Broadleaf	SP
Quackgrass	Agropyron repence	Grass	CP
Russian knapweed	Acroptilon repens	Broadleaf	CP
lambsquarters	Chenopodium album	Broadleaf	SA
Plantain	Plantago spp.	Broadleaf	SP
Italian ryegrass	Lolium multiflorum	Grass	SA
Green foxtail	Setaria viridis	Grass	SA
Barnyardgrass	Echinicloa cruss-galli	Grass	SA

*WA: Winter annual; SP: Simple perennial; SA: Summer annual; CP: Creeping perennial

Weed dry weight: Analysis of variation revealed that weeding had a significant effect ($p<0.01$) on weed dry weight (Table 7). Mean comparison showed that the highest dry weight of weeds was found in Silvana ecotype (99.22 kg/ha) and the lowest dry weight of weeds was recorded for Malekkandi ecotype (44.22 kg/ha) (Table 3). The interaction of ecotype fertilizer was significant on weed dry weight ($p<0.05$) (Table 7). The interaction of ecotype fertilizer showed that the highest weed dry weight was produced by Ghareaghaj ecotype (121.7 kg/ha) in fertilizer treatment and the lowest weed dry weight was produced by Faminin ecotype (30.05 kg/ha) in non-fertilizer treatment (Table 6). Table 4 indicated that weed dry weight in fertilizer treatment increased by 8.77% as compared to non-fertilizer treatment. Also, weed dry weight in non-weeding treatment enhanced by 83.07% in comparison to weeding treatment (Table 5). These results revealed that Silvana ecotype is a poor competitor and Malekkandi ecotype is a strong competitor against weeds (Table 3). Kazinczi *et al*. (2007) found that

Table 9: Alfalfa weed species, average density and cover percentage

Weed species	Min	Max	Average density (Plants -2)	Cover (%)		
				1st weeding	2nd weeding	3rd weeding
Bromus tectorum	0	10	2.5	0.30	0.39	-
Sisymbrium irio	0	9	0.69	2.55	-	-
Circium arvense	2	21	1.49	6.65	2.65	-
Tragopogon dubius	1	4	0.66	0.61	0.26	-
Convolvulus arvensis	10	151	3.98	53.55	12.28	-
Cynodon dactylon	5	51	1.56	35.88	-	-
Hordeum jubatum	0	5	0.78	0.22	0.53	-
Taraxacum spp.	0	3	0.41	-	0.41	-
Agropyron repence	6	57	2.93	-	45.15	-
Acroptilon repens	0	6	0.62	-	0.99	-
Chenopodium album	2	83	2.51	-	28.15	8.21
Plantago spp.	0	1	0.25	-	0.79	-
Lolium multiflorum	0	16	1.68	-	1.79	-
Setaria viridis	3	57	3.96	-	6.30	85
Echinicloa cruss-galli	0	8	0.64	-	-	6.5

Min: Minimum; Max: Maximum

weed intra-specific competition is more severe as compared to crop and weed inter-specific competition. Nadeem and Tanveer (2006) reported that application of phosphorus and potassium resulted in increasing dry weight and density of weeds, due to the fact that weeds were more efficient absorber of nutrients than crop. Based on findings of Baker *et al*. (2006), weeds may accumulate larger amounts of NPK compared to crops, which can lead to their superiority in competition with crops. In addition, Ullah *et al*. (2009) stated that weed management along with fertilizer application can reduce competitiveness of weeds against crops and increase the effectiveness of fertilizers. Blackshaw *et al*. (2002) observed that weeds vary greatly in response to phosphorus and potassium application. Some of them exhibit rapid growth and a substantial increase in biomass when phosphorus fertilizer is applied. Shrefler *et al*. (1994) reported that a luxurious absorption of NPK by several weed species caused inhibition of crop growth.

Some of the morphological features of alfalfa such as plant height make it capable of suppressing weed growth and development. Perpetual weeds increase their competitive advantage against crops through releasing allelopathic chemicals. Canevari *et al*. (2007) stated that *Chenopodium album*, *Cynodon dactylon* and *Agropyron repense* are species which release chemical substances in alfalfa fields.

The types of weeds which were found in this experiment identified and the percentage of each species was recorded (Table 8 and 9). Annual and perennial weeds of both broadleaves and grasses were prevalent in the area. However, *Convolvulus arvensis*, *Cynodon dactylon*, *Agropyron repenc*, *Chenopodium album* and *Setaria viridis* were the most commonly occurring species, dominating the weed population in the experimental site (Table 9). The share of weed biomass in the total biomass differed between the weed species. In the first weeding *Convolvulus arvensis* accounted for 53.55% of the total weed number but decreased to 12.28% in the second weeding. *Chenopodium album* accounted for 28.15% of the total weed number which later declined to 8.21%.

CONCLUSION

The results presented in this study for cold region of Iran Alfalfa ecotypes, in agreement with what has been mainly reported in the literature for other regions specially in the arid and semi-arid regions. Our results revealed that the ecotypes did not respond similarly to the weeding and fertilizer application in terms of green forage, seed yield and yield components. Genetic diversity in alfalfa varieties is a determining factor in forage, seed yield and yield formation which could be affected by agronomical management such as weeding and fertilizer application .In the present study, Forage and seed yield in fertilizer treatment was higher than in non-fertilizer treatment, in addition, in weeding treatment increased compared to non-weeding treatment. Ecotype fertilizer interaction indicated that application of both P and K fertilizers resulted in higher forage yield than when the nutrients were added separately. These results revealed that there was genetic variation for forage green yield among the ecotypes. Therefore, plants with extensive root system may absorb P and k more efficiently than weeds. Fertilizer weeding interaction had a significant effect on seed number per plant. The highest number of seed per plant was recorded by fertilizer and weeding treatment and the lowest one was observed in non-fertilizer and non-weeding treatment. Seed number per plant in fertilizer treatment increased by 63.90% compared to non-fertilizer treatment. In addition, with weeding application, number of seed per plant was noticeably higher than non-weeding treatment (three folder) and therefore increase in pod/plant, 1000 seed weight and seed/plant lead to enhancement of seed weight. In present study, seed yield reduction in some ecotypes can be attributed to more partitioning of assimilates to vegetative parts rather than productive parts. Results of our study revealed that application of phosphorus and potassium resulted in increasing dry weight and density of weeds, due to the fact that weeds were more efficient absorber of nutrients than alfalfa, which can lead to their superiority in competition with this crop. In addition weed management along with fertilizer application can reduce competitiveness of weeds against crops and increase the effectiveness of fertilizers.

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