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Vicia panonica: A Suitable Cover Crop for Winter Fallow in Cold Regions of Iran

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ABSTRACT

In order to compare the yield potential of three cover crops, namely wheat (*Triticum aestivum* cv. 'Alvand'), barley (*Hordeum vulgare* cv. 'Makoeie') and Hungarian vetch (*Vicia panonica* cv. 'Vp-2670'), an investigation was carried out over two years (2006-2008) at the Kheyrabad Agricultural Research Station, Zanjan, Iran. Cover crops were planted under irrigated conditions in late September. The amount of dry matter (DM), crude protein (CP), and percentage of nitrogen (N), phosphorus (P) and potassium (K) in DM were determined when vetch reached the 50% flowering stage, coinciding with the milky stages of wheat and barley. A combined analysis showed that the main effect of year and cover crop on DM, CP and the percentage of N and P was significant ($P < 0.01$); wheat and vetch produced the highest and least amount of DM, 9.72 and 5.49 t/ha, respectively. Crops reacted similarly to environmental conditions. Mean performance of CP in vetch (897 kg/ha) differed significantly from the cereal cover crops which could be attributed to the highest N content (2.6%) detected in its DM. Due to its higher potential N and CP performance, Hungarian vetch is a recommended winter fallow crop for cold areas.

Keywords: barley, Hungarian vetch, wheat, winter crop

INTRODUCTION

Recent economic and environmental concerns have fueled a resurgence in the use of cover crops, which, before the development of synthetic fertilizers, were commonly used to improve soil structure and productivity. Nowadays, these crops are the most practical option to face limited grazing area and foraging resources the world over; cover crops enhance the level of soil organic matter, soil aggregation, infiltration and bulk density as well as improve soil structure while increasing soil biotic activity (Daniel *et al.* 1999). Cover crops provide many benefits, but they are not do-it-all wonder crops (Clark 2007). Each cover crop has a niche or special purpose. Cover crops also increase nitrogen (N) production and reduce its leaching (Badaruddin and Meyer 1994; Beckie *et al.* 1997; Daniel *et al.* 1999; Rao *et al.* 2005, 2007). They reduce soil compaction while increasing water percolation and retention (McVay *et al.* 1989). Anwar *et al.* (2010) evaluated the performance of non-traditional legumes with and without oats to ensure the supply of nutritional fodder for livestock under rainfed conditions of Pothowar, Pakistan, and its subsequent effect on soil health. The most common grass species are rye, wheat, triticale, barley and oat among which, winter annual cereals such as wheat and barley are the most common winter-hardy cover crops in Iran. These crops must be planted in September/October to allow the production of enough biomass and absorption of excess nitrate from the soil. The main benefits of wheat and barley as cover crops would be the improvement of soil structure, soil protection in winter, reduction in nitrate leaching and an increase in organic matter. Barley provides, to some extent, erosion control and weed suppression in light soils distributed in semi-arid regions; meanwhile, it can fill short rotation niches or serve as a topsoil-protecting crop during drought conditions in any region due to its fast-growing nature. Barley can also produce more biomass in a shorter period of time than any other cereal. Wheat, typically grown as a grain crop, is also an ideal fall cover crop that can provide most of the cover crop benefits of cereal crops, as well as a grazing option before stem tiller elongation in spring.

Annual legumes, compared with cereal hay, are more important sources of protein in livestock feeding (Karadag and Buyukburc 2003). Legume cover crops include hairy vetch, Hungarian vetch, crimson clover, red clover and field peas, among the winter legumes, Hungarian vetch being native to Eastern Europe and the Caucasus and well adapted to severe winter cold. It can also be cultivated in fallow years even in environments where the average annual precipitation is < 400 mm (Durutan *et al.* 1988; Kurt *et al.* 1989). In Turkey, the cultivation of this species is expanding rapidly, replacing less productive vetches (Francis *et al.* 1999). Hungarian vetch has several advantages as a rotation crop because of its cold tolerance, high hay quality, adaptability to poor farming conditions and acceptable amount of yield. It can grow in poorly drained soils better than other vetches (Kurt *et al.* 1989). Hungarian vetch is well recognized as a plant with the potential of increasing soil nitrogen (N) levels. Although a preliminary study on the feed quality of Hungarian vetch revealed to have 25% crude protein (CP), 18% natural detergent fiber, 4% ash, 68% digestible dry matter, 63% digestible organic matter, 7.9 mg/kg Cu, 359 mg/kg Fe, 59 mg/kg Zn and 0.4 mg/kg Mn in above-ground dry matter (Lamei, unpublished data), sufficient knowledge regarding the performance of legume cover crops (including Hungarian vetch) in cold conditions is lacking.

The objectives of this study were to compare some selected winter annual cover crops for biomass production, accumulation of some essential elements and the yield of CP to identify the most adaptable crop to be cultivated in the region as well as in similar cold areas around the country.

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Table 1 Some properties of experiment field soils in depth (0-30 cm) during 2006-2008.

Year	Soil texture			pH	O.C	EC ×10^3	P	K	Mn	Fe	Cu	Zn
	Clay %	Silt %	Sand %		%		mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg
2006-2007	36	32	32	8.01	0.82	0.53	11.3	568	7.9	3.9	2.5	2.2
2007-2008	32	30	38	7.91	0.97	0.63	11.2	580	10.6	5	2.4	1.5

MATERIALS AND METHODS

Experiments were conducted during 2006-2007 and 2007-2008 growing seasons at Kheyrabad Agricultural Research Station, Zanjan, Iran (48° 47′ E, 36° 31′ N). The research area, located in the North-west of Iran, is generally exposed to low humidity, cold and snowy winters and dry summers. Details of the soil of the experimental field are shown in **Table 1**. A randomized complete block design (RCBD) layout with six replications was used. The three treatments, corresponding to the three cover crops, namely wheat (*Triticum aestivum* cv. 'Alvand'), barley (*Hordeum vulgare* cv. 'Makoeie') and Hungarian vetch (*Vicia panonica* cv. 'Vp-2670') were sown on the 20th and 30th October, 2006 and 2007. Inter-row spacing was 20 cm and the seed rate of wheat, barley and Hungarian vetch was 200, 200 and 80 kg/ha, respectively. Each plot size was 10 m × 9.6 m. Harvest, which took place at the 50% flowering stage for Hungarian vetch, coincided with the milky stage of cereals. Biomass samples (0.50 kg) taken from each plot of each crop species were dried at 72°C for 48 h to determine relative water content; the N concentration of hay was detected by the micro–Kjeldahl procedure described by Nelson and Sommers (1973); applying the formula of N × 6.25, CP concentration was estimated and this value was multiplied by dry matter yield to calculate the CP yield.

Data was subjected to analysis of variance (ANOVA) using MSTAT-C software (1988). Percentage data was arcsine transformed prior to ANOVA.

RESULTS

Total precipitation in both years was 370 and 176 mm, respectively, equivalent to 146 and 70% of the long-term average of the region which is 252 mm according to annual local meteorological data (unpublished data, 2010). Mean air temperature from sowing to harvesting was 5.3 and 5.7°C in the first and second year, respectively. Differences in biomass yield and CP were mainly induced by climatic changes. Less precipitation (176 mm) with higher temperature in the second year would explain lower production of green forage, dry matter, CP and accumulation of NPK in the second year (**Table 3**). Moreover, the mean green forage yield of all three crops was higher in the first year (**Table 4**).

No significant differences were found for green forage production among the studied cover crops (**Table 2**). Combined ANOVA revealed a significant difference between the two years of study (**Table 3**). Green forage yield varied from 25 to 28 t/ha in the first year, and from 14 to 17 t/ha in the second year (**Table 4**). Average green forage yield for Hungarian vetch was 20 t/ha and for winter wheat it was 22 t/ha. The difference in dry matter yield was significant ($P <$ 0.01) in both years (**Table 4**). In 2006-2007, the lowest dry matter yield (7 t/ha) was obtained from Hungarian vetch, while the highest yield (11.7 t/ha) was obtained from winter wheat. In 2007-2008 dry matter yield varied from 4 t/ha for Hungarian vetch to 7.8 t/ha for winter wheat.

There were significant differences in N accumulations among the three cover cops in the first year but not in the second year of study. Mean N accumulation in the first year was 30% higher than in the second year. In combined analysis, Hungarian vetch accumulated the highest amount of N (144 kg/ha) followed by winter wheat (124 kg/ha), while barley produced the lowest value (102 kg/ha). The mean N content in dry matter of Hungarian vetch was 2.6% while these levels in wheat and barley were 1.3 and 1.2%, respectively. The interaction between year × cover crops was not significant in combined analysis of N accumulations data (**Table 2**).

Significant differences were observed among cover crops in terms of CP in the first year but not in the second year (**Table 5**). CP yield ranged from 711 to 1032 kg/ha in the first year and from 477 to 762 kg/ha in the second year. Based on the results of two years, highest CP yield was achieved in Hungarian vetch (897 kg/ha) and the lowest in barley (598 kg/ha) (**Table 5**). The year × cover crop interaction was not significant in combined analysis of CP yield data (**Table 2**).

There were no significant differences in potassium (K) accumulation of cover crops in both years (**Table 5**); in the first year, the highest K accumulation (190 kg/ha) was obtained in wheat and the lowest in barley (166 kg/ha). In the second year, K accumulation ranged from 68 kg/ha for barley and 107 kg/ha for winter wheat. Regarding the average results of two years, highest K accumulation was achieved in wheat (148 kg/ha) and the lowest in barley (117 kg/ha).

A significant difference (P < 0.01) was found in the amount of phosphorous (P) accumulation by cover crops in the first year; the highest P accumulation (22.4 kg/ha) was obtained in barley followed by winter wheat (19.9 kg/ha). There were no significant differences between cover crops in the second year regarding P accumulation.

DISCUSSION

The least mean dry matter yield in two years (5.49 t/ha) was observed in Hungarian vetch whereas the highest dry matter yield (9.73 t/ha) was observed in winter wheat but was not significantly different to barley. These results confirm the findings of Lithourgidis *et al*. (2007), who reported 10.7, 10.5 and 7.1 t/ha dry matter yield for wheat, barley and common vetch, respectively. In the comparison of winter cereal and legume crops in Pakistan (Nadeem *et al*. 2010) maximum green fodder yield was recorded in oats crop followed by barley, wheat and vetch. In this study, vetch produced the least dry matter yield, confirming the same result as in earlier reports (Lithourgidis *et al*. 2007; Nadeem *et al*.

Table 2 Analyses of variance for forage, dry mater, N yield, crude protein, phosphorous and potassium yield during 2006-2008 in Zanjan, Iran.

Source	Degrees of freedom	Mean square					
		Green forage yield	Dry matter yield	Nitrogen yield	Crude protein yield	Phosphorous yield	Potassium yield
Year	1	1008.38**	148.67**	9496.02**	343510.1**	79275.1**	199.1**
Error	10	13.063	2.602	444.25	15198.7	482.79	12.023
Cover crop	2	5.055^{ns}	57.73**	5197.91**	277100.3**	3093.97**	129.86^{ns}
Year × Cover crop	2	23.835^{ns}	3.69^{ns}	759.33^{ns}	29501.4^{ns}	283.08^{ns}	79.06^{ns}
Error	20	15.75	2.36	658	23612.3	564.75	12.72
CV	-	18.82	19.36	20.82	20.81	17.67	21.42

* Significant at 5%; ** Significant at 1%; ^{ns} not significant using the F-test

Table 3 The effect of different year on green forage yield, dry matter yield, crude protein yield, nitrogen, phosphorous and potassium accumulation during 2006-2008 in Zanjan, Iran.

Year	Green forage yield (t/ha)	Dry matter yield (t/ha)	Nitrogen accumulation (kg/ha)	Crude protein yield (kg/ha)	Phosphorous accumulation (kg/ha)	Potassium accumulation (kg/ha)
2006-2007	26.38 a	9.97 a	139.4 a	835.9 a	19.0 a	181.4 a
2007-2008	15.79 b	5.90 b	107.0 b	640.6 b	14.3 b	87.6 b

Values with the same letters within a column do not differ significantly ($P < 0.01$) according to Duncan's multiple range test.

Table 4 Mean green forage yield, dry matter yield, and nitrogen accumulation in three cover crops under winter fallow sowing during 2006-2008 in Zanjan, Iran.

Cover Crops	Green forage yield (t/ha)			Dry matter yield (t/ha)			Nitrogen accumulation (kg/ha)		
	2006-2007	2007-2008	Mean	2006-2007	2007-2008	Mean	2006-2007	2007-2008	Mean
Hungarian vetch	24.9 a	15.86 a	20.38 a	7.00 b	3.99 b	5.49 b	165.1 a	122.00 a	143.54 a
Winter barley	28.15 a	14.31 a	21.33 a	11.20 a	5.98 ab	8.58 a	122.0 b	81.85 a	101.94 b
Winter wheat	26.1 a	17.22 a	21.65 a	11.71 a	7.75 a	9.73 a	131.2 b	117.00 a	124.10 ab

Values with the same letters within a column do not differ significantly ($P < 0.01$) according to Duncan's multiple range test.

Table 5 Means crude protein yield, phosphorous and potassium accumulation in three cover crops under winter fallow sowing during 2006-2008 in Zanjan, Iran.

Cover crop	Crude protein yield (kg/ha)			Phosphorous accumulation (kg/ha)			Potassium accumulation (kg/ha))		
	2006-2007	2007-2008	Mean	2006-2007	2007-2008	Mean	2006-2007	2007-2008	Mean
Hungarian vetch	1031.8 a	762.4 a	897.11 a	14.7 b	11.6 a	13.13 b	188.9 a	87.7 a	128.30 ab
Winter barley	711.3 b	477.2 a	594.28 b	22.4 a	11.9 a	17.17 ab	165.7 a	68.1 a	116.90 b
Winter wheat	764.8 b	682.1 a	723.43 ab	19.9 a	19.4 a	19.64 a	189.8 a	106.9 a	148.34 a

Values with the same letters within a column do not differ significantly ($P < 0.01$) according to Duncan's multiple range test.

2010). This increase in cereal dry matter yield may be the result of more efficient utilization of natural resources by cereals plants than by legumes through the production of more tillers and leaves and greater plant height. However, legume crops maintain their advantage over cereal crops in so far as protein yield is concerned. Uzun *et al.* (2004) showed that the dry matter yield of four Hungarian vetch lines ranged from 3.9 to 4.25 t/ha in Turkey. The main reason for this difference may be differences in the climatic conditions of the experimental locations.

N accumulation is a measure of how much N is taken up and accumulated by the crop and also how much is removed from the field at harvest time (Lithourgidis *et al.* 2007). Although dry matter yield in Hungarian vetch was lower than that of winter wheat and barley, high N accumulation in Hungarian vetch is likely to be because of a higher N concentration in above-ground matter in Hungarian vetch. Lithourgidis *et al.* (2007) reported that wheat, barley and common vetch accumulated 134, 151 and 160 kg/ha N, respectively. These differences can be attributed to cereal variety, vetch species and environmental conditions.

In both years, the highest and lowest CP yields were obtained in Hungarian vetch and barley due to the higher and lower N content level, respectively. Although there was no significant difference between the average CP yield of barley and wheat, the CP yield in wheat was 22% higher than in barley due to higher dry matter yield and N content. Significant differences were found between years regarding K accumulation. The highest K accumulation (181 kg/ha) was obtained in the first year due to higher precipitation and high dry matter production in the first year. The average results of two years showed that the highest mean P accumulation over two years was recorded in wheat (19.6 kg/ha) while the lowest P accumulation was recorded in Hungarian vetch (13.1 kg/ha). Badrzadeh *et al.* (2008) reported that vetch accumulated less P than reported by Ranjbari *et al.* (1998), who studied the mineral status of 11 range plants covering the Graminae, Leguminosae, Apiaceae and Chenopodiaceae. They reported that P content for all species was lower than the critical P content required for grazing ruminants.

CONCLUSIONS

Hungarian vetch has the potential to provide greater biomass and nutritive value to livestock from May to June, the forage-deficit period in cold regions of Iran. Planting Hungarian vetch as the second crop during fallow in winter may control soil erosion, supply parts of forage needs, provide proper spring weed management and may recycle the shedding grains of wheat and barley, all of which are future investigations. When using these crops as green manure, soil fertility can be improved and part of the N requirement of the next crop may be provided. Furthermore, agronomic practices such as planting date, seed rate and mixed cropping with cereals for growing this little known legume (Hungarian vetch) in cold regions should be described to capture its potential benefits.

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