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Short Communication

Mixed cropping of annual feed legumes with barley improves feed quantity and crude protein content under dry-land conditions

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Abstract: The objective of this research is to determine a suitable mixture of annual feed legumes and barley as a winter crop under dry-land conditions. Seeds of Hungarian vetch (cv. 2670), smooth vetch (cv. Maragheh), and local varieties of grass pea and field pea were mixed with barley (cv. Abidar) in a 1:1 ratio and were tested, along with related monoculture. All legumes in the mixture survived winter while legumes alone, except Hungarian vetch, did not survive in the cold areas. The maximum fresh and dry forage yields (56 and 15 ton ha^{-1} respectively) were obtained from a mixture of smooth vetch and barley in provinces with mild winter and more than 400 mm of rainfall. The mixture of barley and smooth vetch resulted in the highest mean crude protein content (17%). Autumn seeding of smooth vetch and barley in a 1:1 ratio produced more than 2 ton ha^{-1} of dry biomass with good quality in all studied areas and thus could serve as an alternative cropping system after wheat/barley in cold and semi-cold dry land.

Keywords: mixed cropping, field pea, grass pea, Hungarian vetch, smooth vetch, barley

INTRODUCTION

Dry land occupies about 6.2 million ha across Iran. It is mainly used for wheat and food legume production while about 2-3 million ha of arable land is left fallow each year, mainly due to the lack of suitable cold-tolerant varieties in rotation with cereals [1]. The resource base of dry-land agriculture is experiencing increasing pressure due to rapidly growing human population and demands for livestock. Considerable variation in herbage and grain yields of improved vetches (*Vicia* spp.) and grass pea (*Lathyrus* spp.) under rainfed conditions in different environments has been reported. Rainfall and temperature dictate the relative importance of feed legume species. Introduction of annual feed legumes in dry-land cropping systems that are dominated by cereals

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could reduce the risk of pests and diseases and increase sustainable productivity [2]. Mixed cropping of cereals with forage legumes can improve the quantity and quality of fodder compared to a pure cereal crop [3, 4].

Lithourgidis et al. [5] evaluated the forage yield of common vetch mixed with oat and triticale in Greece and reported that mixtures of annual feed legumes and winter cereals have great potential for forage production in rainfed conditions and a mixture of common vetch and oat at a ratio of 2:1 gave the highest forage yield. In highlands with harsh winter conditions there are more limitations. Pure stands of most feed legumes in autumn planting under cold dry-land conditions of Iran are damaged because of freezing temperature during winter [6]. The problem becomes more serious when monoculture of feed legumes as a spring crop does not provide remarkable results for forage production in highlands because of a short growing season. On the other hand, winter cereals provide high yields in terms of dry weight but they produce forage with low protein. Moreover, the forage quality is generally lower than that required to meet production goals for many classes of livestock [2]. In a legume-cereal mixture, the companion cereal provides structural support for the legume, improve light interception and facilitate mechanical harvest while the legume in mixture improves forage quality [3]. Other benefits of the mixture include greater uptake of water and nutrients, enhanced weed suppression and increased soil conservation [7].

Competition between component species in a mixture may affect the yield and quality of forage produced [8]. Competition normally reduces yield of the mixture compared with cereal monoculture [9], although higher yields have been reported when competition between the two species of a mixture is lower than competition within the same species [2]. Cereal and legume species that are used in a mixture have different levels of competition and interaction. Caballero and Goicoechea [9] and Thomson et al. [10] reported that the most suitable cereal for a mixture with common vetch is oat (*Avena sativa* L.), whereas Thomson et al. [11] and Roberts et al. [8] reported that barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.) are the most suitable cereals for mixtures. Seeding ratio is another factor that affects the competition between two species of a mixture [12]. Although competition is a factor that can affect forage yield and quality, there have been no reports on the effect of different cereals and different seeding ratios on the growth rate of legume-cereal mixtures. Competition can also have a significant effect on the growth rate of different species used in a mixture [5].

The objective of the present work is to evaluate biomass yield and protein content in mixtures of barley and different varieties of annual feed legumes, viz. Hungarian vetch, smooth vetch, grass pea and field pea at 1:1 seeding ratio. Barley serves as the winter crop under rainfed conditions.

MATERIALS AND METHODS

Seeds of Hungarian vetch (*Vicia panonica* L., cv. 2671), smooth vetch (*Vicia dasycarpa* L., cv. Maragheh), grass pea (*Lathyrus sativus* L., cv. Naghadeh) and local field pea (*Pisum sativum* L., cv. Zanjan) were mixed with barley (*Hordeum vulgare* L., cv. Abidar) at 1:1 ratio. Since seeding rate for the mixture was proportional to the pure stand seeding rate, we used 125 legume seeds and 200 barley seeds to make 1:1 mixture for each square metre. Experimental fields were prepared by chisel-ploughing followed by surface cultivation at the end of September. Appropriate N-P fertiliser (40 kg ha^{-1} N + 20 kg ha^{-1} P_2O_5) was applied uniformly to the soil just before seeding. Five different mixtures of barley and feed legumes, along with related monoculture, were planted in a randomised complete block design with three replications in mid-October under rainfed condition. The same

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experiment was performed in Golestan province in the north and Kermanshah province in the west, considered to be typical semi-cold areas, and in the north-west (East Azarbaijan, Zanjan and Kurdestan provinces), considered to be typical cold highlands of Iran. Each plot size was 10 m^2. Hay was harvested when the legumes initiated pod formation, which coincided with the milky stage of barley. At that time, samples from a randomly selected 1-m^2 area of each plot were cut to the ground level. Sub-samples (0.3 kg biomass from each plot) were dried at 70°C for 48 hr to determine dry matter yield. Crude protein, crude fibre and crude ash were then determined. The nitrogen content of hay was determined by the micro-Kjeldahl procedure described by Nelson and Sommers [13] while the crude protein concentration was calculated as N×6.25. AOAC [14] methods were used to determine crude fibre and crude ash.

SPSS (version 10) software [15] was used for analysis of variance (ANOVA). Treatment mean differences were separated by the least significant difference (LSD) test at 0.05 probability level.

RESULTS AND DISCUSSION

All legumes in the mixtures survived winter successfully. However, pure stands of feed legumes except Hungarian vetch were damaged by severe frost (-20°C or lower) in the cold north-west areas. Low rainfall in early fall and rapidly decreasing temperature along with severe cold in winter restrict the planting of many crops in the Iranian cold drylands [6]. Planting legumes as monoculture is possible as a spring crop in cold dry land but optimal plant growth is hampered by many problems such as short growth season in the highlands, difficulty in soil preparation, missing early spring precipitation and soil compaction [6]. Mixed cropping makes use of environmental resources better than monoculture and competition between component crops is not high [16, 17].

The ANOVAs for forage yield indicate that there were significant differences among treatments and location interactions ($P \leq 0.01$). A mixture of smooth vetch and barley produced more biomass at all sites since the climbing nature of smooth vetch produced more condensed forage. Precipitation and temperature during the vegetative growth period were higher in Golestan province than in other areas, resulting in higher yields. Maximum fresh (56.9 ton ha^{-1}) and dry (15 ton ha^{-1}) forage yields were obtained from a mixture of smooth vetch and barley in Golestan and Kermanshah provinces with a mild winter and high rainfall. Results in East Azarbaijan (harsh winter with more than 90 days of freezing temperature) show that a mixed cultivation of smooth vetch and Hungarian vetch with barley was superior, with a mean of 9 ton ha^{-1} of fresh forage yield. The mixture of barley and field pea was superior in Kurdestan and Zanjan provinces, although significant differences ($P \leq 0.05$) of the mixture of barley and smooth vetch were lacking (Table 1). Differences may have arisen from environmental conditions such as favourable precipitation and temperature during the vegetative growth phase of each location. Karadag and Buyukburc [18] recommended 50% Hungarian vetch and 50% triticale mixture for optimal dry matter yield in the rainfed condition of north-east Turkey.

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Table 1. Mean fresh and dry biomass yield (ton ha^{-1}) of different mixtures of feed legumes and barley (1:1 ratio)

	Smooth vetch + barley		Field pea+ barley		Hungarian vetch + barley		Grass pea + barley		Pure Hungarian vetch		Pure barley		LSD 5%	
	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry	Fresh	Dry
Maragheh	9.1	4.4	8.7	4.7	9.1	5.1	8.6	4.3	7.3	3.4	10.1	5.2	0.5	0.4
Golestan	56.9	15.4	51.1	13.1	45.1	12.7	44.8	10.6	29.5	9.21	55.3	15.4	3.2	1.9
Kurdestan	8.1	2.1	9.8	3.1	4	1.1	3.9	1.2	3.5	0.97	5.5	2.53	2.1	1.6
Kermanshah	13.7	4.4	13.6	6.4	13.1	4.2	14.3	7.4	11.2	5.7	13.1	3.9	0.6	0.5
Zanjan	5.8	1.8	6.8	1.9	5.5	1.8	5.3	1.8	4.7	0.9	7.5	2.6	1.1	0.6

Nutritional analysis shows that the mixture of barley and smooth vetch had the highest crude protein content (17%) followed by Hungarian vetch and barley (15%) (Table 2). In contrast, barley monoculture had the lowest crude protein content (11%). The crude protein content of forage is one of the most important criteria for evaluating forage quality [19]. In all mixtures, the crude protein content was at least 20% more than that of the barley monoculture (Table 2). These results are in agreement with those reported by Giacomini et al. [20]. In addition, Jannink et al. [21] found that a vetch mixture had much higher crude protein content than pea and oat alone.

Table 2. Mean protein and other quality indices of different mixtures of feed legumes and barley (1:1 ratio)

Mix	Crude protein (%)	Fibre (%)	Ash (%)
Smooth vetch + barley	16.87	24.27	12.85
Hungarian vetch + barley	15.38	24.09	10.25
Field pea+ barley	13.63	24.88	11.54
Grass pea + barley	13.88	27.65	10.55
Pure Hungarian vetch	24.32	7.10	3.20
Pure barley	11.25	28.83	12.97

CONCLUSIONS

Autumn seeding of smooth vetch (cv. Maragheh) and barley (cv. Abidar) in 1:1 ratio produces considerable forage in terms of quantity and quality. The mixture could thus be a suitable alternative crop after wheat or barley in cold and semi-cold dry land.

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