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Araştırma Makalesi/Research Article

Effects of Mixture Types and Ratios in Hungarian Vetch-Cereal Intercropping System on Plant Development and Soil C/N Ratios

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Abstract

The study has been conducted in order to investigate the effects of Hungarian vetch and cereals on plant development and soil properties depending on different mixture types and ratios. This study was carried out between the years 2009–2011 in Çanakkale Province of Turkey. The study has been established according to the randomized complete block design using a total of 3 replications. Anadolu Pembesi variety of Hungarian vetch (V) (*Vicia pannonica*), Agile variety of barley (B) (*Hordeum vulgare*), Renan variety of wheat (W) (*Triticum aestivum*), Servente variety of oat (O) (*Avena sativa*) and Mikham-2002 variety of triticale (T) (*Triticosecale* Wittm. Triticale) were used as materials in the experiment. In the study, the crops have been cultivated with both single as well as mixed cropping (3:1, 2:2, 1:3 Hungarian vetch: cereals) systems with cereals using different amounts of Hungarian vetch. The number of seedlings, seedling ratio, upper and subsoil biomass ratios, leaf area index, land use efficiency and C/N ratios of soils were investigated in this research work. Consequently, the highest seedling ratios have been determined in Hungarian vetch mixing with barley and triticale. The leaf area index did not show a significant change as compared to other applied factors. The highest total mass amount was the lowest in the Hungarian vetch ratio which determined in 1V3T treatments. 2V2O treatments were found prominent in terms of land use efficiency. The C/N contents of soils increased in the second year and reached to its highest ratio level in 2V2B treatments. According to the overall results, the most suitable cropping mixture in terms of the studied parameters is the mixture of Hungarian vetch with barley and oats by using the lowest proportion of the mixtures.
Keywords: Cereals, İntercropping system, Leaf area index, Rations, Total biomass**.**

Macar Fiği-Tahıllar Karışık Ekim Sisteminde Farklı Karışım Şekli ve Oranlarının Bitki Gelişimi ve Toprağın C/N İçeriklerine Etkileri

Öz

Macar fiği ile tahılların farklı karışım şekli ve oranlarına bağlı olarak toprak altı ve toprak üstü gelişimlerine etkilerini belirlemek amacıyla planlanan bu çalışma 2010-2011 yıllarında (2 yıl) Çanakkale ili ekolojik şartlarında yürütülmüştür. Araştırma tesadüf blokları deneme desenine göre 3 tekerrürlü olarak kurulmuştur. Denemede materyal olarak Macar fiğinin (*Vicia pannonica*) Anadolu Pembesi, arpanın (*Hordeum vulgare*) Agile, buğdayın Renan (*Triticum aestivum)*, yulafın (*Avena sativa*) Servente ve Tritikalenin (*Triticosecale* Wittm. Triticale) Mikham-2002 çeşitleri kullanılmıştır. Çalışmada bitkiler hem yalın hem de Macar fiği ile farklı oranlarda oluşturduğu karışımlar (3:1, 2:2, 1:3 Macar fiği: Tahıllar) şeklinde yetiştirilmiştir. Araştırmada fide sayısı, fide oranı, toprak altı ve toprak üstü biomas oranı ve miktarı, yaprak alan indeksi, arazi kullanım etkinliği ve toprakların C/N oranları incelenmiştir. Çalışmanın sonuçlarına göre en yüksek fide oranına Macar fiğinin arpa ve tritikale ile olan ekimlerinde tespit edilmiştir. Uygulanan faktörlere göre yaprak alan indekslerinde önemli farklılıklar bulunmamıştır. En yüksek toplam biomas üretimi Macar fiğinin en düşük oranlarının bulunduğu 1Fiğ+3Tritikale parsellerinde belirlenmiştir. Arazi kullanım etkinlikleri bakımından en uygun karışım şekli ve oranı 2Fiğ+2Yulaf olmuştur. Toprağın C/N içerikleri araştırmanın ikinci yılında daha yüksek bulunmuş ve en uygun karışım oranı ise 2Fiğ+2Buğday parsellerinde tespit edilmiştir. Yürütülen bu araştırmanın sonunda incelenen parametrelere göre en uygun karışık ekimin en düşük Macar fiği oranının arpa ve yulaf ile oluşturulan yetiştiricilik uygulamaları olduğu sonucuna varılmıştır.
Anahtar Kelimeler: Tahıllar, Karışık ekim sistemi, Yaprak alan indeksi, Oranlar, Toplam biomas.

Introduction

In Turkey, livestock production is largely depending on rangelands grazing. Rangelands herb species and fodder crops grown in agricultural lands are not sufficient to meet the fodder needs of

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livestock. Such needs are met through only supplementary sources of fodder crops and grass having low quality straw, hay or husk-like plant residues (Gökkuş, 1994). However, for a profitable and efficient livestock production, animals should be fed with quality feed sources (Gökkuş and Koç, 1996). Agricultural lands of Turkey are gradually decreasing and about 1/5 of already available lands are followed each year. Thus, the only way to have sufficient feed source is to get maximum yields per unit area. Fertilization and irrigation are among the best practices used to increase per acre yield of especially fodder crop lands. However, intercropping systems including different fodder crops may also improve yield and quality in such areas. About 15-20% of world food production comes from multi-cropping or intercropping systems (Altieri, 1999). Intercropping is defined as to grow two or more crop species within the same growing season under the same natural conditions in the same field (Zhang and Li, 2003), generally, without applying any fertilizer, thus in a low-cost and environment-friendly fashions (Bakoğlu, 2004). The most efficient use of available sources is the greatest advantage of intercropping system (Dhima et al., 2007; Agegnehu et al., 2008).

Carbon sources of the earth are composed of atmosphere, terrestrial biotopes, soil and oceans. Every year, 120 million tons of carbon passed from atmosphere to soil through photosynthesis and about half of it is released back to atmosphere through respiration. About 30% of terrestrial carbon sources reside in pastures and savannas. Vegetation diversity may have great contributions to soil organic carbon and nitrogen quantities with great impacts on soil quality. The greater the number of species in vegetation cover, the greater the organic matter to be left in soils will be. Therefore, pasture soils generally have greater carbon and nitrogen quantities (Steinbeiss et al., 2008; Cong et al., 2014). There is a continuous carbon cycle in agricultural fields. There are about 3 million tons of carbon in agricultural lands. Such a quantity constitutes about 12% of carbon stocks of the earth (Janzen, 2005; Bambrick, 2009). Carbon exists in organic matter of the soil. Soil organic carbon quantities largely depend on plant and animal residues incorporated into soil, available moisture, pH and oxygen (Li and Chen, 2004).

In this study, Hungarian vetch and some cereal crops have been sown by using intercropping system at different ratios, and determined the effects of intercropping systems on plant development and soil C/N ratios.

Materials and Methods

Experiments have been conducted in the experimental field of ÇOMÜ Dardanos Campus in 2009-10 and 2010-11 growing seasons. Average monthly temperatures in the years 2009 and 2010 (15.9 and 16.4^{o}C) were observed higher than the long-term average (15.5^{o}C), but the average monthly temperature in the year 2011 (13.8^{o}C) has been recorded lower than that of its long-term average. Similarly, precipitation level in 2009 and 2010 (685.6 and 933.6 mm) were found higher, but the precipitation in 2011 (548.6 mm) was lower than that of the long-term average (559.1 mm). Soil analyses revealed that experimental soils were clay-loam in texture with moderate lime, insufficient nitrogen and phosphorus, sufficient potassium and insufficient organic matter levels. Anadolu pembesi variety of Hungarian vetch (*Vicia pannonica*), Agile variety of barley (*Hordeum vulgare*), Renan variety of wheat (*Triticum aestivum*), Servente variety of oat (*Avena sativa*), and Mikham-2002 variety of triticale (x *Triticosecale* Wittm.) have been used as plant materials in this research work. Seed sowing has been done in the month of November in each year (2009 and 2010). Experimental materials i.e., Hungarian vetch, barley, wheat, oat and triticale were sown in both pure-sown and sown in Hungarian vetch-cereal intercropping system (3:1, 2:2, 1:3 Hungarian vetch:cereal). Experimental trials have been conducted according randomized completer block design with 3 replications. Overall means of data were compared by using Duncan's multiple range test of SAS statistical software programe (Düzgüneş et al., 1987).

Each block had 17 plots and 2 m spacing was provided between the blocks. Each plot had a size of 1 m (0,2 m row spacing x 5 rows) x 6 m = 6 m^2 and total experimental site area was 750 m^2. Amount of pure alive seed (PAS) to be sown to each plot was calculated based on mixture ratio, number of pure alive seeds of mixture materials, thousand-seed weight (g), purity and germination ratio (%) (Altın et al., 2005). Soil samples were taken right after the harvest of the plots and nitrogen and carbon content of soil samples were determined with the aid of CN-Analysis device (Elementar Vario EL). Following the harvest of the plots, randomly 40 x 20 cm sections as to cover two rows were selected and 20 cm (as to include effective root depth) soil profile was removed without creating

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any damages on roots (Synman and Fouche, 1993). Soil profiles were initially placed into water in pots to soften the clods, then washed to separate the roots from the soil. Fresh root samples were dried in an oven at 70ºC for 24 hours to get dry root weights.

Results and Discussion

Number of seedlings: As the average of two years, number of seedlings emerged from sown alive seeds is provided in Table 1. In pure sowings, while the other species had close emergence ratios to each other, barley had relatively low emergence ratios. However, the greatest seedling formation from the sown seeds were observed in Hungarian vetch (42.5%). Seedling formation ratios of the other species varied between 21.4-27.3%. In intercropping systems, both the number of emerged seedlings and seedling formation ratios were greater than the pure sowings. As the average of intercropping systems, 150.3 seedlings per square meter were counted and such a value corresponded to an emergence ratio of 38.0%. Without considering the mixture ratios, the greatest seedling emergence ratios were obtained from the Hungarian vetch intercropping systems with barley (166.5 seedling/m^2) and triticale (156.3 seedling/m^2). Correspondingly, the greatest seedling emergence ratios (41.7 and 39.2%) were observed in intercropping systems with these two plant species. Significant differences were observed in number of seedlings with the vetch ratio of the mixtures. Based on Hungarian vetch ratios in mixtures, number of emerged seedlings varied between 148.1-152.0 seedling/m^2. Seedling formation ratios decreased with decreasing vetch ratios of the mixtures.While 42.3% of the seeds formed seedlings in mixtures with 3Vetch, average 33.6% formed seedlings in 1Vetch mixtures(Table 1).

Table 1. Number of seedlings emerged from the sown seeds (seedling/m^2) and seedling formation ratios (%)

Plant Groups	Number of seedling	Seedling ratio	Number of vetch	Number of cereal
Hungarian vetch (V)	127.5 a-d	42.5 ab	127.5 a	-
Barley (B)	107.0 d	21.4 f	-	107.0 bcd
Wheat (W)	136.5 a-d	27.3 ef	-	136.5 a
Oat (O)	129.5 a-d	25.9 ef	-	129.5 ab
Triticale (T)	136.0 a-d	27.2 ef	-	136.0 a
3V:1B	176.5 a	50.5 a	113.5 a	63.0 gh
2V:2B	169.5 ab	42.4 ab	63.6 d	105.9 def
1V:3B	153.5 a-d	34.1 b-e	25.6 g	127.9 abc
3V:1W	117.5 cd	33.6 b-e	75.5 cd	42.0 h
2V:2W	155.5 abc	38.9 bcd	58.3 de	97.2 ef
1V:3W	130.0 a-d	28.9 def	21.7 g	108.3 cde
3V:1O	143.5 a-d	41.0 abc	92.3 bc	51.3 gh
2V:2O	121.5 bcd	30.4 c-f	45.6 ef	75.9 fg
1V:3O	167.5 ab	37.2 b-e	27.9 fg	139.6 ab
3V:1T	155.0 abc	44.3 ab	99.6 ab	55.4 gh
2V:2T	161.5 abc	40.4 abc	60.6 de	100.9 def
1V:3T	152.5 a-d	33.9 b-e	25.4 g	127.1 abc
Pure sowing mean	127.3	28.9	25.5	101.8
Intercropping mean	150.3	38.0	59.1	91.2
General mean	**143.6**	**35.3**	**60.51**	**94.3**
Type of mixture				
VB	166.5 a	41.7 a	67.6 a	98.9
VW	134.3 b	33.7 b	51.8 b	82.5
VO	144.2 ab	36.2 ab	55.3 b	88.9
VT	156.3 ab	39.2 a	61.9 a	94.5
Vetch ratios				
3V	148.1	42.3 a	95.2 a	52.9 c
2V	152.0	38.1 ab	57.0 b	95.0 b
1V	150.9	33.6 bc	25.2 c	125.7 a

For number of seedlings: $P_{plant\ group}$; 0.021. $P_{type\ of\ mixture}$; 0.045. $P_{vetch\ ratio}$; 0.920
For seedling ratio: $P_{plant\ group}$; 0.0001. $P_{type\ of\ mixture}$; 0.0001. $P_{vetch\ ratio}$; 0.0359
For number of vetch seedlings: $P_{plant\ group}$; 0.0001. $P_{type\ of\ mixture}$; 0.0086. $P_{vetch\ ratio}$; 0.0001
For number of cereal seedlings: $P_{plant\ group}$; 0.0001. $P_{type\ of\ mixture}$; 0.5974. $P_{vetch\ ratio}$; 0.0001

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Seeds were sown in autumn and seedlings were counted in spring. Besides the seed characteristics, several other factors including sowing depth, competition among the species, pest damages, soil and climate conditions influence seedling formation (Avcı and Gökkuş, 1997). Despite insignificant differences, intercropping systems had greater seedling emergence ratios than the pure sowings. Such a case was attributed to less legume-cereal competition than intra-species competition. In intra-species competition, there is an aggravated competition among the species with the same genetic potential. However, since the growing ambient was better utilized in legume-graminae mixtures (Tan and Çomaklı, 2009), inter-species competition was weak. In previous studies conducted with pure sowings and legume-cereal intercropping systems with different sowing ratios, number of seedlings was reported as between 101.1-230,3 (Gökkuş et al., 1996), between 69.2-112.9 (Avcı and Gökkuş, 1997) and between 102.7-169,3 (Bakoğlu and Memiş, 2002).

Leaf area index (LAI): In present experiments, leaf areas have been measured only in 2010. The differences in LAI values of plant groups were not found to be significant. In pure sowings, the highest LAI (2.27) was obtained from Hungarian vetch and the lowest LAI (1.15) was obtained from wheat. Average LAI of intercropping systems was measured as 2,05. The greatest LAI values (2.77 and 2.75) were respectively obtained from 3:1 vetch:barley and 2:2 vetch:triticale mixtures. On the other hand, the lowest LAI values (1.48 and 1.62) were respectively obtained from 1:3 vetch:triticale and 1:3 vetch:wheat mixtures. As the average of the mixture ratios, vetch-barley mixture had the highest LAI (2.39) and it was respectively followed by vetch:triticale (2.16), vetch:wheat (1,92) and vetch:oat (1,72) mixtures. LAI values of 3:1, 2:2 and 1:3 vetch ratios were respectively calculated as 2.10, 2.20 and 1.84 (Table 2).

LAI values of the plots with greater Hungarian vetch ratios were higher than the other plots. Such a case was attributed to greater leaf/shoot ratios of the legumes (Miller, 1984). Lodging or semi-lodging development, compounded leaf structure, larger leaf blades and greater branching of legumes resulted in greater LAI values for legumes than for graminae. Increasing leaf/shoot ratios of intercropping systems (Yisehak, 2008) also allowed the mixtures to have greater LAI values than the pure-sowings.

Table 2. Leaf area index values of single and mixed cropping plots in Hungarian vetch-cereal

Plant groups	**LAI**		**LAI**
Hungarian vetch (V)	2.27	**Type of mixture**	
Barley (B)	1.56	VB	2.39
Wheat (W)	1.15	VW	1.92
Oat (O)	1.19	VO	1.72
Triticale (T)	1.80	VT	2.16
3V:1B	2.77	**Vetch ratio**	
2V:2B	2.16		
1V:3B	2.24	3V	2.10
3V:1W	1.87	2V	2.20
2V:2W	2.27	1V	1.84
1V:3W	1.62		
3V:1O	1.51		
2V:2O	1.63		
1V:3O	2.00		
3V:1T	2.24		
2V:2T	2.75		
1V:3T	1.48		
Pure sowing mean	1.59		
Intercropping mean	2.05		
General mean	**1.91**		

$P_{plant\ group}$; 0.095. $P_{type\ of\ mixture}$; 0.002. $P_{vetch\ ratio}$; 0.009

Total biomass: Total biomass values of single and mixed cropping systems were presented as the average of two years. The highest sub-soil biomass (301.7 kg/da) was obtained from 3V1O treatment and the highest top-soil biomass (832.0 kg/da) was obtained from single sowing triticale.

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Triticale had also the second highest sub-soil biomass (269.3 kg/da). There is an inverse effect in case of oat experimental trials. Higher top-soil biomass of oat allowed it to have the greatest total biomass. Both below and above-ground biomass values of Hungarian vetch, barley and wheat attained quite low levels. Root biomass of triticale and oat mixtures (232.4 and 248.0 kg/da) were greater than barley and wheat mixtures (209.0 and 209.2 kg/da). Triticale and oat maintained their high above-ground biomass values in intercropping systems. Thus, total biomass values of the mixtures including these two species (973.3 and 953.1 kg/da) were also greater than the others. Since the mixture with the least vetch ratio (1F) had the greatest root and above-ground biomass (236.5 and 687.8 kg/da), this treatment had also the greatest total biomass (924.3 kg/da).

Table 3. Biomass value of single and Hungarian vetch-cereal mixed cropping systems (kg/da)

Plant groups	**Below-ground**	**Above-ground**	**Total biomass**
Hungarian vetch (V)	202.9 c-f	442.3 e	645.6 g
Barley (B)	150.8 f	549.9 de	700.7 fg
Wheat (W)	180.4 ef	684.1 bcd	864.5 cd
Oat (O)	190.5 def	817.3 ab	1007.8 ab
Triticale (T)	269.3 ab	832.0 a	1001.3 ab
3V:1B	189.6 def	535.4 cde	725.0 cde
2V:2B	197.0 c-f	559.1 cde	756.1 cde
1V:3B	240.4 b-e	566.4 cde	806.8 cde
3V:1W	207.6 c-f	586.7 cde	794.3 cde
2V:2W	187.6 def	580.9 cde	768.5 cde
1V:3W	232.4 b-e	670.8 bcd	903.2 bc
3V:1O	301.7 a	755.8 bc	1057.5 ab
2V:2O	210.9 b-f	736.0 bc	946.9 bc
1V:3O	231.3 a-d	684.3 bcd	915.6 bc
3V:1T	202.1 c-f	645.1 b-e	847.2 bcd
2V:2T	253.0 abc	687.6 bcd	940.6 bc
1V:3T	242.0 bcd	829.5 ab	1071.5 a
Pure sowing mean	198.8	665.1	863.9
Intercropping mean	224.6	653.1	877.8
General mean	**217.0**	**656.7**	**873.7**
	Type of mixture		
VB	209.0 b	553.6 b	762.6 b
VW	209.2 b	612.8 b	822.0 ab
VO	248.0 a	725.4 a	973.3 a
VT	232.4 a	720.7 a	953.1 a
	Vetch ratios		
3V	225.3 ab	630.8 ab	856.0 b
2V	212.1 ab	640.9 ab	853.0 b
1V	236.5 a	687.8 a	924.3 a

For below-ground biomass; $P_{plant\ group}$: 0.0001. $P_{type\ of\ mixture}$: 0.0450. $P_{vetch\ ratio}$: 0.0006
For below-ground biomass; $P_{plant\ group}$: 0.0001. $P_{type\ of\ mixture}$: 0.0001. $P_{vetch\ ratio}$: 0.0041
For total biomass; $P_{plant\ group}$: 0.0001. $P_{type\ of\ mixture}$: 0.0001. $P_{vetch\ ratio}$: 0.0002

There is always a competition among the plants and plants mostly compete for light, soil water and nutrients. The species with well-developed below-ground parts have higher competitive power. The species in mixtures benefit from different depths of soil profile through the roots, thus competition among the mixture species is less and they developed more roots. Therefore, in present study, intercropping systems had greater root biomass values than the pure-sowings. Legumes have taproot and cereals have diffuse roots and mixture species use different segments of soil profile, thus competition among them was reduced and they developed greater quantities of root biomass. Legumes fixate atmospheric nitrogen into the soil through rhizobium bacteria and graminae respond this nitrogen the best, therefore, in such intercropping systems, both above and below-ground yields of graminae species increase (Whitehead, 1995). In compatible legume-graminae mixtures, the land is better utilized (Mariotti et al., 2006; Erkovan et al., 2008; Geren et al., 2008). In this case, above-soil biomass (dry herbage yield) increases. Cereals generally have greater competitive and production

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power (Tan and Serin, 1996; Rakeih et al., 2010), thus the mixtures with the greatest cereal ratios generally have the greatest above-ground biomass.

Land use efficiency (LUE): It is a prominent indicator for the compatibility of mixing species. There were significant differences in LUE values of each year. Increasing LUE values were observed with increasing Hungarian vetch ratios of the mixtures. The greatest LUE (2.44) was obtained from 2:2 vetch:oat treatment of 2009/10 growing season and the lowest LUE (0.93) was obtained from 2:2 vetch:wheat treatment of 2010/11 growing season. Average of all plots was calculated as 1.34 (Table 3).

In intercropping systems, a LUE value above 1,00 indicates the advantage of the system and a LUE value below 1,00 indicates disadvantage of the system (Caballero et al., 1995; Runkulatile et al., 1998; Dhima et al., 2007). In present study, only 50-50% vetch-cereal mixture had a LUE value below 1,00 and the rest had values above 1,00. Since the nutrient needs and root structures of mixture species are different and they use different layers of soil profile, the land is more efficiently used in intercropping systems and thus they usually have greater LUE values. Also in proper mixtures, plants get higher light exposures (Hay and Walker, 1989), amount of nitrogen fixated to soil by the legumes will increase, thus yield levels are expected to increase under these available micro-environments (Şengül, 2003). It is also known that legumes in mixtures may have positive contributions to development of graminae species (Banik, 1996). Similar findings were also reported by the other studies (Bakoğlu, 2004; Yisehak, 2008; Oseni, 2010).

Table 4. Land use efficiency for Hungarian vetch-cereal intercropping systems

Plant groups	**2009/10**	**2010/11**	**Mean**
3V:1B	1.43	1.19	1.31 ab
2V:2B	1.56	1.00	1.28 ab
1V:3B	1.44	1.24	1.34 ab
3V:1W	1.13	1.07	1.10 b
2V:2W	1.05	0.93	0.99 b
1V:3W	1.57	0.97	1.27 ab
3V:1O	2.08	1.04	1.56 ab
2V:2O	2.44	1.15	1.80 a
1V:3O	1.70	1.30	1.50 ab
3V:1T	1.48	1.04	1.26 ab
2V:2T	1.62	0.99	1.30 ab
1V:3T	1.63	1.12	1.38 ab
Mean	**1.59 a**	**1.09 b**	**1.34**

Between the years: P_{year}; <.0001. $P_{plant\ group}$; 0.440. $P_{year*plant\ group}$; 0.675

Soil C/N ratio: With regard to soil C/N ratios, years, plant groups and year x plant group interactions were found to be significant, but type of mixture and vetch ratios of the mixtures were not found to be significant. The greatest C/N ratio (26.85) was obtained from pure-sown wheat plots and the lowest C/N ratio (22.56) was obtained from triticale plots. In intercropping systems, the greatest C/N ratio (32.62) was obtained from 2:2 vetch:barley plots and the lowest C/N ratio (20.22) was obtained from 2:2 vetch:triticale plots. As the average of the years and mixture ratios, vetch:oat and vetch:barley plots had greater C/N ratios (26.47 and 27.46) than the other mixtures. Considering the vetch ratios of the mixtures, C/N ratios of 3, 2 and 1 vetch ratios were respectively calculated as 27.67, 25.16 and 24.66. In general, legumes are rich in protein (nitrogen) and graminae species are rich in cellulosic compounds (Bakoğlu et al., 1999). Since total carbon and total nitrogen ratios are high in mixture plots, C/N ratios of these plots were also high (Domínguez et al., 2009; Verma and Yadav, 2014).

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Table 5. C/N ratios of pure-sowings and Hungarian vetch-cereal intercropping systems

Plant groups	**2009-2010**	**2010-2011**	**Mean**
Hungarian vetch (V)	18.39 **bc**	27.54 **b**	22.97
Barley (B)	29.12 **a**	24.14 **b**	26.63
Wheat (W)	22.82 **abc**	30.87 **ab**	26.85
Oat (O)	25.41 **ab**	21.00 **b**	23.21
Triticale (T)	23.47 **abc**	21.64 **b**	22.56
3V:1B	26.57 ab	21.52 **b**	24.05
2V:2B	23.28 **abc**	41.95 **a**	32.62
1V:3B	25.03 **ab**	26.37 **b**	25.70
3V:1W	27.44 **a**	29.00 **b**	28.22
2V:2W	24.16 **abc**	23.38 **b**	23.77
1V:3W	23.76 **abc**	24.38 **b**	24.07
3V:1O	28.63 **a**	30.31 **ab**	29.47
2V:2O	21.67 **abc**	26.40 **b**	24.04
1V:3O	28.24 **a**	23.58 **b**	25.91
3V:1T	24.71 **abc**	33.17 **ab**	28.94
2V:2T	18.06 **bc**	22.37 **b**	20.22
1V:3T	23.33 **abc**	22.59 **b**	22.96
Pure sowing mean	23.84	25.04	24.44
Intercropping mean	24.57	27.09	25.83
General mean	**24.36 b**	**26.48 a**	**25.42**
Type of mixture			
VB	24.96	29.95	27.46
VW	25.12	25.59	25.35
VO	26.18	26.76	26.47
VT	22.03	26.04	24.04
Vetch ratios			
3V	26.84	28.50	27.67
2V	21.79	28.53	25.16
1V	25.09	24.23	24.66

Between the years: P_{year} 0.003. $P_{plant\ group}$; 0.014. $P_{year*plant\ group}$; 0.047. For years: $P_{plant\ group}$; 0.072.
General: P_{year}; 0.053. $P_{vetch\ ratio}$; 0.683. $P_{type\ of\ mixture}$; 0.776. $P_{year*vetch\ ratio}$; 0.318. $P_{year*type\ of\ mixture}$; 0.185.

Conclusion

This study was conducted to determine the effects of single cropping and Hungarian vetch–cereal (barley, wheat, oat and triticale) mixed cropping systems with different mixture ratios on plant development and soil characteristics. The best values for seedling characteristics have been obtained in Hungarian vetch–barley and triticale mixtures and number of seedlings and ratios increased with increasing vetch ratios of the mixtures. Top and sub-soil and total biomass values increased by 8.0% with increasing vetch ratios of mixed cropping system. The highest biomass values have been obtained from Hungarian vetch–oat and triticale mixtures. While leaf area index (LAI) values did not change significantly with present treatment plots, the highest land use efficiency (LUE) has been recorded from the mixtures of 2:2 vetch:oat ratio. Soil C/N ratios varied significantly only with the years and increased by 8.7% in the forthcoming year. Present findings showed that the seedling, biomass and soil parameters significantly changed with Hungarian vetch–cereal mixed cropping systems and the mixtures of barley, oat and triticale have been found to be more prominent with regard to these parameters. In conclusion, it is recommended for similar ecological conditions that Hungarian vetch should be done by using mixed cropping with these cereals at equal ratios.

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