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SILAGE YIELD AND PROTEIN CONTENT OF FORAGE LEGUMES INTERCROPPING WITH CEREALS IN TWO SPATIAL ARRANGEMENTS

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ABSTRACT

Intercropping of most annual legumes with winter cereals is a very common practice for forage production in many countries. The aim of this study was to determine the effect of different spatial arrangements of intercropping cereals with forage legumes on silage yield and protein content. The completely randomized design was applied with three replications. Particularly, common vetch and forage pea were used as forage legumes, and barley, and triticale were used as cereals, which were grown individually as well as intercropped with each other in mixed rows in a sowing ratio 65:35 or in alternate rows. The plants were harvested when the legumes were at the end of the flowering period and were separated by hand to determine the weight of fresh matter for each species. Samples of 100 g of hay from each experimental plot were used to calculate the dry matter and to determine the total N and subsequently the total protein content using the Kjeldahl method. In most cases differences were found between the treatments concerning the dry matter and the protein content. Regarding the fresh weight the mixtures triticale+ common vetch (alternate rows), barley + common vetch (alternate rows) and barley+ forage pea (alternate rows) showed the higher yield. The forage pea gave the higher yield among the nonocrops. Regarding the dry weight the mixtures barley+ forage pea (alternate rows) and triticale+ common vetch (alternate rows) showed the higher yield. Additionally, significant differences were recorded between the examined genotypes in grain yield. The barley intercropped with forage pea (mixed rows) gave the higher yield. Regarding the grain yield of legumes, common vetch intercropped with barley (alternate rows) and forage pea intercropped with barley (both cases) gave the higher yield. In all cases the forage yield (weight of dry matter) was higher in separated lines compared to mixed lines. However, concerning the grain yield the mixed rows were probably more productive.

Key words: *intercropping, dry matter, protein content, spatial arrangement.*

INTRODUCTION

Intercropping is the cultivation of two or more species simultaneously in the same field during the same growing season and depending on the design, there are mixed intercropping, row intercropping, strip intercropping and relay intercropping. Intercropping of most annual legumes with winter cereals is a very common practice for forage production in many countries. Intercropping of cereals and legumes can provide high biological value protein animal feed and additionally it is suitable for agricultural systems with low inputs (Lithourgidis et al., 2008, Lithourgidis and Dordas 2010, Dordas et al., 2012, Tang et al., 2021). This may be due to some of the potential benefits for intercropping systems such as high productivity, improvement of soil fertility, reduction of soil erosion, most effective competition with weeds, reduction of effects from enemies and diseases and improvement of forage quality (Banik et al., 2006, Vasilakoglou et al., 2008, Malezieux et al., 2009). The ecological advantages of intercropping are also under consideration (Mohammed et al., 2008) because according to Jensen et al. (2020) the intercropping of legumes and cereals can reduce the nitrogen fertilization by 26%. However, there are some disadvantages of intercropping such as the competition for light, water and nutrients that can reduce yields compared to monoculture (Lithourgidis et al., 2008, Lithourgidis and Dordas 2010, Menbere et al., 2015, Iqbal et al., 2019). So, careful considerations are needed in order to optimize spatial arrangements in intercropping systems to achieve maximum productivity.

The objective of this study was to determine the effect of intercropping cereals with forage legumes on silage yield and protein content in two spatial arrangements (1:1 alternate rows, and mixed forage legume and cereal in the same row) in the special climatic conditions of the Florina area. The forage yield and the quality characteristics of the hay and the yield of produced seed were studied as well.

MATERIALS AND METHODS

The experiment was carried out in the farm of the University of Western Macedonia in Florina, during the vegetation period 2020-2021. The cultivars were sown in early November 2020 in a field at the University of Western Macedonia Farm in Florina Greece (40°46′ N, 21°22′E, 707 m asl), in a sandy loam soil with pH 6.3, organic matter content14.0 g kg^{-1}, N-NO3 100 mg kg^{-1}, P (Olsen) 50.3 mg kg^{-1} and K 308 mg kg^{-1} and water holding capacity 21.8% (0 to 30 cm depth). Greek winter varieties of forage legumes and cereals were intercropped in two different ways: in mixed rows in a sowing ratio 65: 35 (cereals: legumes) and in alternate rows. Particularly, common vetch (cv. Leonidas), and forage pea (cv. Olymbos) were used as forage legumes, and barley (cv. Triptolemos) and triticale (cv. Niovi), were used as cereals, which were grown individually as well as intercropped with each other. Thus 10 different treatments were created (4 treatments for monocrops and 6 treatments for intercrops = 2 spatial arrangements x 3 mixtures). The plots consisted of six rows five meters long of which the four inner were harvested. The distances between rows were 0.25m. The completely

randomized design with three replications was used. The field was fertilized only with basic fertilization and all the cultivation practices used by farmers were applied. The crop was kept free of weeds by hand hoeing when necessary. The fresh biomass of the two inner rows was harvested at the end of the legume flowering period (early June) and dried naturally to form hay. The plants were separated by hand to determine the fresh weight of each species. The other two rows were harvested when the seeds were mature and the yield was calculated. Samples of 100 g of hay from each experimental plot were placed at 65° C for 96h to calculate the dry matter, and in addition to determine the total N using the Kjeldahl method and subsequently the total protein content. Data were evaluated by analysis of variance (ANOVA) and the means were compared according to LSD test at $p<0.05$.

RESULTS AND DISCUSSION

Significant differences were recorded between the examined cultivars in fresh and dry weight (significant differences at p=5%, Table 1). Fresh weight ranged from 6400 kg/ha in barley (monocropping) to 31190Kg/ha in mixture triticale+ common vetch (alternate rows) (Table 1).The mixtures barley + common vetch (alternate rows) and barley+ forage pea (alternate rows) showed high yield as well. The forage pea gave the higher yield among the nonocrops. Additionally, the superiority of the sowing in different and distinct rows compared to mixed ones, emerged from the data. The same was reported by Cheriere et al (2020) who intercropped soybean with buckwheat, lentil, sorghum and sunflower and found that alternate-row intercropping helped to increase soybean production. Spatial arrangement did not significantly affect the growth of maize plants in a maize-soybean intercropping system, whereas, soybean growth was greatly affected by spatial arrangement (Addo-Quaye et al., 2011). Dry weight ranged from 3500 kg/ha in common vetch (monocropping) to137578 Kg/ha in mixture barley+ forage pea. So concerning the dry matter, the mixture barley+ forage pea (alternate rows) is still more productive. The above results suggest that the intercrops may have higher dry matter yield than the respective monocrops. The same was reported by Galanopoulou et al. (2019), when they studied the effect of various spatial arrangements in faba bean and barley intercropping systems on the growth rates of the two species. In an experiment of intercropping barley with vetch Lithourgidis et al., (2007) found that, in two different sowing ratios (55% / 45% and 65% / 35%), biomass production was increased by 29.9% and 13.3% respectively compared to vetch monocrop, but reduced by 12.2% and 23.4% respectively compared to barley monocrop.

Table 1. The fresh weight, the weight of dry matter, the grain yield of intercropping crops and monocropping

Genotype	Fresh Weight Kg/ha	Dry Weight Kg/ha	Grain yield Kg/ ha (for cereals)	Grain yield Kg/ha (for legumes)
Triticale	10130de	5117d	1068.2c	
Common vetch	9100de	3500e		257.7c
Forage pea	13860d	3960e		326.3c
Barley	6400e	3879e	1658bc	
Triticale +Vetch mixture	20133c	8346c	1376 bc	328.6c
Triticale+Vetch alt. rows	31190a	12475a	1056 c	340.9c
Barley+ Vetch mixture	23467bc	11174b	1852.9b	294.4c
Barley+Vetch alt. rows	28533ab	11413b	1297.4bc	866.9a
Barley+forage pea mixture	21867c	7289c	2961.5a	607.3b
Barley+forage pea alt.rows	28800a	13758a	1529.2bc	572.6b

Means in columns followed by different letters are significantly different at $p<0.05$ by LSD test.

Intercropping had significant effects on grain yield. Specifically, significant differences were recorded between the examined genotypes in yield (significant differences at $p<5\%$, Table 1). Yield ranged from 1056 Kg/ ha in triticale intercropped with vetch (alternate rows) to 2961.5 Kg/ha in barley intercropped with forage pea (mixed rows). The barley intercropped with forage pea (mixed rows) gave the higher yield. These results indicated that the intercropping increased the yield of barley intercropped with forage pea only in mixed rows. Regarding the yield of legumes, common vetch intercropped with barley (alternate rows) and forage pea intercropped with barley (both cases) performed the higher yield. These results were in disagreement with those of other researchers who reported that the yield of sole crops was higher compared to their intercrops (Dușa and Stan 2013).

The above results suggest that there was a positive effect of intercropping concerning the silage yield and it seemed that the species involved in the intercropping system had a better behavior when they were sowing in different rows. However, this was not the case concerning the grain yield. In this case the mixed rows were probably more productive.

Preliminary data of this study showed that the mixtures had higher protein content than the monocrops (data not presented).

CONCLUSION

It was concluded that concerning the dry matter the mixture triticale + common vetch (alternate rows) and barley+ common vetch (alternate rows) are more productive followed by the mixtures of barley intercropped with common vetch

(different rows and mixed rows). Barley intercropped with forage pea in mixed rows have higher grain yield compared to other monocrops and the mixtures. Among the legumes common vetch intercropped with barley (alternate rows) and forage pea intercropped with barley (both spatial arrangements) gave the higher grain yield. A first estimate of these results leads to the conclusion that the sowing in alternate rows results in promising mixtures for production of high quality forage. However further research, including several seeding ratio and different cultivars, is needed to confirm the results of the present study.

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