Original Scientific paper
10.7251/AGRENG2302111G
UDC 633.1/.3

YIELD AND PROTEIN CONTENT OF GRAINLEGUMES INTERCROPPING WITH CEREALS IN TWO SPATIAL ARRANGEMENTS

Theodoros GALITSAS, Fokion PAPATHANASIOU, Theano B. LAZARIDOU*

University of Western Macedonia - Florina, School of Agricultural Sciences 53100 Florina, Greece
*Corresponding author:, tlazaridou@uowm.gr

ABSTRACT

Intercropping of two or more species in the same field was a common practice in the past, butisstill followed by many growers in our days as well. The purpose of this research was to study the effect of two different spatial arrangements on yield after intercropping grain legumes with cereals. The experiment was established at the farm of the School of Agricultural Sciences, in Florina (Greece). For this to be done, two varieties of lentils (Elpida and Thessalia) were used as grain legumes, and bread wheat (cultivar Yekora) and oat (cultivar Kassandra) were used as cereals, which were planted individually as well as intercropped in two sowing systems (1:1 alternating rows and mixed rows in a 50:50 sowing ratio). In each experimental plot, six rows five meters long were sown, while the four inner were harvested. During the growing season, the following morphological traits were measured: the blooming, as well as the grain yield, and the protein content of the seeds. The protein content was determined by using the NIR (Near - infared - spectroscopy spectrometer). Differences were found between treatments regarding yield and protein content. The bread wheat variety Yekora and the oat variety Kassandra yielded better intercropped with the lentil variety Thessalia and Elpida respectively. Lentil variety Thessalia was not affected by the intercropping with Yekora in alternating rows, while it was damaged intercropped with Yekora in mixed sowing. The lentil cultivar Elpida was not affected by the intercropping with Yekora and Kassandra in either of the sowing systems. Regarding the protein content, the bread wheat variety Yekora was not affected by the intercropping with either of the lentil varieties in either of thespatial arrangements. The oat variety Kassandra wasfavored by intercropping with the lentil variety Elpida (mixed rows). However, Elpida was damaged intercropped with oat variety Kassandra (mixed rows).

Key words: *intercropping, grain yield, spatial arrangement.*

INTRODUCTION

Winter cereals are crops of great importance due to their ability to exploit poor, barren and mountainous lands, where no other crop would be economically viable (Papakosta, 2008).On the other hand, lentil (*Lens culinaris*) intended for human consumption, is a very important crop as well, because it is a rich source of proteins, minerals and vitamins for humans and animals' nutrition.Lentil has the ability to fix atmospheric nitrogen, so that its cultivation improves the concentration of nitrogen, carbon and organic matter in the soil, so that it is possible to integrate it into sustainable crop production systems (Sharker and Erskine, 2006; Vlachostergios et al. 2011).

Intercropping, a sustainable agricultural practice, is considered a promising solution to face the growing problems of food security and resource efficiency. Intercropping of cereals and legumes has numerous potential benefits, including enhanced resource utilization, increased biodiversity, effective competition with weeds, reduction of effects from enemies and diseases and improved overall productivity (Banik et al., 2006, Malezieux et al., 2009, Jensen 2020). However, there are some disadvantages of intercropping such as the competition for light, water and nutrients (Lithourgidis et al., 2008; Lithourgidis et al., 2011; Menbere et al., 2015). So, the selection of appropriate crop or varieties combination, the sowing system and the sowing ratio are crucial in order to minimize competition and to achieve the maximum yield (Sahoo et al.,2023). One critical aspect to be investigated is the influence of spatial arrangement on the intercropping outcome. Understanding how different patterns of crop arrangement, such as alternate rows, mixed rows, strip intercropping, or relay intercropping can affect grain yield and overall crop performance is an issue that needs to be investigated.

This research was undertaken to study the effect of two different spatial arrangements on yield and protein content after intercropping grain legumes, especially lentil, with cereals (bread wheat and oat) grown under low-input conditions and the possibility to apply these systems in modern farming.

MATERIALS AND METHODS

During the growing period 2020-2021, an experiment was installed at the farm of the University of Western Macedonia in Florina (Greece). The plant material used was cereals and grain legumes, which were cultivated in monocropping and intercropping. Particularly, cereals (greek bread wheat cultivarYekora, and oat variety Kassandra), were intercropped with two lentil varieties (Thessaly and Elpida). A completely randomized design with three replications was used. The 3 different species were cropped either as a monocropping or in a cereal-legume intercropping. So, a total of 30 experimental blocks were created. The above-mentioned cultivars of the three species (wheat, oat, and lentil) were intercropped in two sowing systems (1:1 alternate rows and mixed rows of the two species (wheat+lentil and oat+lentil) in a sowing ratio 50:50. Before sowing, basic fertilization was applied with the addition of diammonium phosphate (20-10-0), so that 80 kg and 40 kg ha^{-1} of nitrogen (N_2) and phosphorus pentoxide (P_2O_5) were

added to the soil. In each experimental plot, 6 rows five meters long were sown, of which the four inner were harvested. The sowing distances between rows were 25 cm and a two-meter corridor was left between replications.The crop was kept free of weeds by hand hoeing when necessary.

The harvest of the four inner rows was carried out in July by combine harvester. During the growing season, the following morphological traits were measured: the blooming, as well as the grain yield, and the protein content of the seeds. The protein content was determined by using the NIR (Near - infared - spectroscopy spectrometer). Data were evaluated by analysis of variance (ANOVA) and the means were compared according to LSD test atp<0.05.

RESULTS AND DISCUSSION

Significant differences were recorded between the cultivars studied in seed protein content (significant differences at p=5%, Table 1). The % protein content, ranged from 5.34% for Kassandra intercropped with Elpida (alternative rows) to 31.1% for Thessalia (monocrop) (Table 1). Thessalia intercropped with Yekora (both spatial arrangements), Elpida intercropped with Yekora (mixed rows) and Kassandra (alternate rows) respectively, showed high protein content as well. Bread wheat variety Yekora showed the highest protein content both when it was grown in monocropping and in intercropping, in both sowing systems. On the contrary, oat variety Kassandra was favored by the intercropping with lentil variety Elpida (mixed rows).

Table 1.Seed protein content % in the 10 different treatments

Genotype	**Cereals**	**Legumes**
Yekora + Thessalia(alternative rows)	12.78*e	30.47ab
Yekora + Thessalia(mixture)	13.26e	30.17abc
Elpida		29.45bcd
Thessalia		31.1a
Yekora	13.08e	
Kassandra	5.4g	
Yekora +Elpida(alternative rows)	13.34e	28.96cd
Yekora +Elpida (mixture)	13.16e	29.95abc
Kassandra +Elpida (alternative rows)	5.34g	30.22ab
Kassandra +Elpida (mixture)	6.66f	28.6d

*Means followed by the same letter are not statistically significantly different for p<0.05

Statistically significant differences were observed between the genotypes studied in terms of yield (significant differences at p=5%, Table 2). The yield of cereals ranged from1064 kg /ha for oat variety Kassandra (monoculture) to 2504.0 kg/ha for Yekora (bread wheat), intercropped with lentil variety Thessaly in mixed rows. Regarding the lentil the yield ranged from 414kg/ha for Elpida intercropped with Yekora in mixed rows to 1465.0kg/ha for the mono-culture of Thessalia (lentil) (Table 2). Bread wheat variety Yekora was favored by intercropping with Thessaly (lentil) only in mixed rows. In all other combinations and sowing systems Yekora´yield was not affected. Oat variety Kassandra was favored by intercropping with Elpida (lentil) in mixed rows. This means that the intercropping on the same row had a positive effect on grain yield of both Yekora and Kassandra. On the contrary lentil variety Thessalia was damaged by its intercropping with Yekora in mixed sowing, while it yielded well and was not affected by the intercropping in alternating rows. Elpida showed the highest yield in monocropping, while it was damaged by its intercropping with bread wheat (Yekora variety) and oat (Kassandra variety) in both sowing systems. However, this reduction was not statistically significant. Apparently, from the two intercropped species (bread wheat-lentil, oat-lentil) the lentil is the least competitive species.The above results suggest that intercropping did not affect the seed protein content of cereals and grain legumes except the oat variety Kassandra intercropped with Elpida in mixed rows, which was favored by this sowing system and lentil variety Elpida intercropped with Yekora in mixed rows that was damaged from this system.

Table 2.Grain yield of cereals and legumes grown in monocropping and intercropping in two different spatial arrangements

Genotype	**Grain Yield kg** ha^{-1} **(cereals)**	**Grain Yield kg** ha^{-1} **(lentil)**
Yekora + Thessalia(alternative rows)	1859.0bc	1443.0*cde
Yekora + Thessalia(mixture)	2504.0a	592.6gh
Elpida	-	801.9fgh
Thessalia	-	1465.0cde
Yekora	1287.0cdef	
Kassandra	1064.0efg	
Yekora +Elpida(alternative rows)	1504.0cde	516.0h
Yekora +Elpida (mixture)	1609.0cd	414.0h
Kassandra +Elpida (alternative rows)	1217.0def	597.0gh
Kassandra +Elpida (mixture)	2260.0ab	562.8gh

*Means followed by the same letter are not statistically significantly different for $p<0.05$

The superiority of the sowing in the same row compared to alternate ones, emerged from the data. This is in disagreement with Cheriere et al. (2020) who reported increased soybean production in alternate-row intercropping compared to mixed intercropping, between soybean and buckwheat, lentil, sorghum and sunflower. On

the other hand Gennatos and Lazaridou (2021) reported that the grain yield of barley increased intercropped with forage pea only in mixed rows, but common vetch intercropped with barley was favored in alternate- row intercropping (Gennatos and Lazaridou 2021). Additionally Addo-Quaye (2011) reported that spatial arrangement greatly affected soybean growth in a maize-soybean intercropping system. In this study the variety Yekora (bread wheat) and Kassandra (oat) were favored by intercropping with the lentil variety Thessalia and Elpida respectively both in mixed rows. The increased yield of oat intercropped with lentil in mixed rows reported by Galitsas and Lazaridou (2020) as well. Lentil variety Thessalia was not affected by intercropping with Yekora in alternating rows, while it was damaged when intercropped with Yekora in mixed rows. Lentil variety Elpida was not affected by its intercropping with both Yekora and Kassandra in either of the seeding systems. In most cases, a higher yield was observed in the intercropping of the two species in mixed sowing rows compared to alternate rows. The above results suggest that there was a positive effect of intercropping concerning the cereals grain yield.

CONCLUSION

It was concluded that concerning the % protein content of the seeds, the lentil variety Thessalia contains the highest percentage of protein in all treatments.Intercropping did not affect the seed protein content of grain legumes except the oat variety Kassandra intercropped with Elpida in mixed rows, that was favored by this sowing system and lentil variety Elpida intercropped with Yekora in mixed rows that was damaged by this system.

Concerning the grain yield, the variety Yekora (bread wheat) and Kassandra (oat) were favored by intercropping with the lentil variety Thessalia and Elpida respectively both in mixed rows. Lentil variety Thessalia was not affected by intercropping with Yekora in alternating rows, while it was damaged when intercropped with Yekora in mixed rows. In most cases, a higher yield was observed in the intercropping of the two species in mixed sowing rows compared to alternate rows.There was a positive effect of intercropping concerning the cereals grain yield and it seemed that the cereals involved in the intercropping system had a better behavior when they were sowed as a mixture in the rows.

A first estimate of these results leads to the conclusion that sowing in the same row has a positive effect in the protein content seed production. However further research, including several seeding ratio and different cultivars, is needed to confirm the results of the present study.

REFERENCES

Addo-QuayeA.A., Darkwa A.A, Ocloo G.K. (2011). Growth analysis of component crops in a maize-soybean intercropping system as affected by time of planting and spatial arrangement. Journal of Agricultural and Biological Sciences 6(6) pp. 34-44.

Banik P., Midya A., Sarkar B., Ghose S. (2006). Wheat and chickpea intercropping systems in an additive series experiment: Advantages and weed smothering European. Journal of Agronomy. 24 pp. 325-332.

Cheriere T., Lorin M.,Corre-Hellou G. (2020) Species choice and spatial arrangement in soybean-based intercropping: Levers that drive yield and weed control Field Crop Research 256 https://doi.org/10.1016/j.fcr.2020.107923

Gennatos K.**,** Lazaridou T.B. **(**2021). Silage Yield and protein content of forage legumes intercropping with cereals in two spatial arrangements. AGROFOR.Volume 6, Issue 3; ISSN 2490-3434.

Galitsas T.**,** LazaridouT.B.(2020). Yield of grain legumes intercropping with cereals in the Florina area in Greece AGROFOR Vol. 5, Issue No. 3, pp. 100-104

Jensen E.S., Carlsson G., Hauggaard-Nielsen H. (2020). Intercropping of grain legumes and cereals improves the use of soil N resources and reduces the requirement for synthetic fertilizer N: A global-scale analysis Agronomy for Sustainable Development. 40 pp.5

Lithourgidis, A.S., Dordas C.A., Lazaridou T.B., I., Papadopoulos I. (2008). Silage yield and protein content of common bean intercropped with corn in two row-replacements. Proceedings of the 10th European Society of Agronomy (ESA) Congress, 15-19 September 2008, Bologna, Italy, pp. 217-218.

Lithourgidis A., Dordas C., Damalas C., Vlachostergios D. (2011). "Annual intercrops:an alternative pathway for sustainable agriculture", AustralianJournal of Crop Science vol 5, pp 397-401.

Malezieux, E., Crozat, Y., Dupraz, C., Laurans, M., Makowski, D., Ozier-Lafontaine, H., Rapidel, B., de Tourdonnet, S., Valantin-Morison, M. (2009). Mixing plant species in cropping systems: Concepts, tools and models. A review. Agronomy for Sustainable Development 29. pp. 43–62.

Menbere S., Dejene M., Abreha S. (2015). Dry matter yield and agronomic performance of herbaceous legumes intercropped with napier grass (*Pennisetum purpureum)* in the semi-arid areas of eastern amhara region. International Journal of Recent Research in Life Sciences 2 (1) pp. 7-14.

Papakosta-Tasopoulou D. (2012). Cereals and Legumes Eds. Synchrony Paideia Thessaloniki, pp. 113-117, 134. In Greek Language

SahooU., Maitra S., Dey S., Karthi K., Vishnupriya H., Sairam M., Sagar L. (2023).Unveiling the potential of maize-legume intercropping system for agricultural sustainability: A review Farm. Manage. 8 (1) pp. 1-13

Sarker A., Erskine, W. (2006). Recent progress in the ancient lentil. Journal of Agricultural Sciences 2006, 144 pp. 19–29, doi:10.1017/S0021859605005800.

Vlachostergios D.N., Lithourgidis A.S., Roupakias D.G. (2011). Adaptability to organic farming of lentil (*Lens culinaris* Medik.) varieties developed from conventional breeding programmes. J Agr Sci 149 pp. 85-93.