RESEARCH ARTICLE

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Effect of alfalfa cultivation on the damage by *Otiorhynchus ligustici* Linnaeus (Coleoptera, Curculionidae)

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ABSTRACT

The effect of cultivation of alfalfa – alone and in mixtures with grass components (awnless bromegrass, cocksfoot, and combination with both components) on the degree of root damage by *Otiorrhynchus ligustici* Linnaeus (Coleoptera, Curculionidae) and the productivity of dry aboveground and root biomass of crops was studied. The study was conducted at the Institute of Forage Crops - Pleven, Bulgaria, and covers the period 2018-2020. It was found that mixed cultivation of alfalfa with grass components has been shown to reduce root damage by *O. ligustici* compared to alfalfa pure crop. The least preferred, with the lowest degree of damage was a mixture of alfalfa with cocksfoot (50:50%), where the number of gnawed furrows and holes, and the length of the furrows decreased by 70.5, 71.4, and 23.1%, respectively, followed by a mixture of alfalfa with awnless bromegrass (50:50%). The mixed cultivation of legumes and grasses has a positive effect on the development of grass components compared to their pure cultivation, as the values of stem height, the number of stems, and root length have been shown to increase in mixtures. Cocksfoot in mixture with alfalfa has the highest values on all three indicators studied. Thus, the mixed cultivation of alfalfa with grass components significantly increased the productivity of dry aboveground and root biomass of the individual components in the mixtures and ensures yield stability over the years.

Key words: forage, mixtures, *Otiorrhynchus ligustici*, productivity, aboveground biomass, root biomass

Introduction

Agrocenoses can regulate the change patterns of diversity and ecological processes between plants and pests through, primarily trophic and behavioral regulation (Karp et al., 2018; Snyder, 2019; Wan et al., 2019). Throughout the world, monoculture (single species) cropping is the most simplified cultivation method and its aim is to maximize yield and net profit. However, the monoculture system is associated with serious problems: monocultures are more susceptible to pests, diseases, and weeds.

Insect pest control in monocultures is associated primarily with the use of chemical products of different pesticide generations (Ratnadass et al., 2012; Zhao et al., 2014). An alternative approach to growing some crop species is inter-species intercropping. Such crops are subjected to less pest pressure and can therefore be controlled without the intervention of chemical agents (Lai et al., 2011a).

Yu et al. (2015) reported that different species in mixed crops, due to being able to make better use of the habitat's resources, resulted in increased plant productivity and total yield. Mixed crops can also better counteract soil erosion and organic matter degradation, contributing to an increase in the content of organic carbon and soil nitrogen (Cong et al., 2012; Feike et al., 2015; Zhang et al., 2019).

Considering the spatial distribution of different plant species and taking into account the length of time that they co-occur, one of the frequent types of multi-cropping system is intercrops (mixed crops): two or more plant species are cultivated simultaneously. In this instance, the developmental process overlaps in space and time, for example, a mixture of wheat and alfalfa (Ma et al., 2007).

Intercropping is essential in controlling many pest species and protecting useful insects, which plays an important role in enhancing biodiversity in agroecosystems (Eskandari et al., 2010; Konar et al., 2010; Vaiyapuri & Amanullah, 2010). The results of many studies suggest that intercropping can considerably improve both pest management and disease (Iqbal, et al., 2018). For example, Hassan (2009) found that the intercropping of cowpea *Vigna unguiculata* (L.) and sorghum significantly reduced the *Aphis craccivora* Koch population compared with the sole crops of these species. The effects of grape–tobacco intercropping on populations of *Viteus* *vitifoliae* (Fitch), were evaluated in a field. It was reported that grape phylloxera populations in the intercropping systems were lower compared with the monoculture model and *Viteus* vitifoliae decreased each year (Powell et al., 2013). Straub et al. (2014) reported that the damage caused by some main sucking insect pests such as *Acyrthosiphon pisum* Harris and *Empoasca fabae* Harris in alfalfa monoculture is significantly greater than in the intercropping system. According to Andrews (1972), a sudden increase in the pest population occurred when individual species were easily capable of locating food and favourable conditions for reproduction. Mixtures reducing the population of host plants changed the design and physiognomy of the cultivation and had a negative effect on the microclimate of specialized pest species. The increased stability of the agrocenosis and, as a practical benefit, the reduction in pest populations is based on diversified or multispecies cultivation systems (Willey, 1979).

The aim of the present study was to determine the effect of the alfalfa cultivation system (alone and in mixtures with grasses) on the *Otiorhynchus ligustici* L. damage and productivity of dry aboveground and root biomass.

Materials and Methods

The experiment was performed in 2018-2020 in the experimental field of the Institute of Forage Crops – Pleven, Bulgaria. The characteristics of the individual perennial and grass-legume mixtures, as well as the applied ratios in the mixtures, are presented in Table 1. The size of the experimental plot was 5 m^2, with a row spacing of 12.5 cm and 4 replications of each variant. Sowing was done manually on 19 October 2017.

Table 1. *Experiment design.*

	Variants	Ratio,%	Sowing rate, kg/da
1	Awnless bromegrass (*Bromus inermis* Leys.), Nika cv.	100	3.00
2	Cocksfoot (*Dactylis glomerata* L.), Dabrava cv.	100	3.00
3	Alfalfa (*Medicago sativa* L.), Dara cv.	100	2.5
4	Alfalfa + Awnless bromegrass	50:50	1.25 + 1.50
5	Alfalfa + Cocksfoot	50:50	1.25 + 1.50
6	Alfalfa + Awnless bromegrass + Cocksfoot	50:25:25	1.25 + 0.75 + 0.75

In the stage of flowering - the beginning of pod formation in the second cut of alfalfa, soil monoliths measuring 20 x 50 x 40 cm were taken. After washing the plants with water, indicators characterizing the degree of damage by *Otiorrhynchus ligustici* (Coleoptera, Curculionidae) were measured: number of spiral furrow per root, number of holes per root, furrows length (cm) spacing of the furrows from the root cervix (cm). The root length indicator does not take into account the entire length of the alfalfa root system. The height (cm) and the number of plant stems were also measured. For grass components, height (cm), number of stems, and root length (cm) were recorded. The area of damage (cm^2) was calculated as a multiplication between the length (cm) and width (cm) of each gnawed furrow of root per plant.

The data of the productivity of dry aboveground and root biomass were processed statistically using ANOVA for a one-factor case, the mean being compared by a Tukey test for 5% significance ($p \leq 0.05$).

Results and Discussion

The degree of damage by *Otiorhynchus ligustici* to the roots of alfalfa was affected by the method of cultivation - pure or mixed cultivation with grass components. According to Seni (2018), one of the major challenges in choosing the right intercrop combination for pest control was determining which combinations successfully reduced pest abundance since all combinations of crops did not produce the desired effect. So, intercrop can be used as a sole approach to pest management or combined with other pest management strategies such as host-plant resistance, rising biological control, and chemical control. The results of Table 2 clearly showed that the enemy causes damage in both pure and mixed crops, but with a pronounced preference for pure alfalfa crops.

In pure alfalfa, the significant highest degree of damage, expressed by the number of gnawed furrows and holes, as well as the length of the furrows was found. Some deviation was observed in the first year (2018), where the statistical significance of differences was lacking between the alfalfa pure sown and triple mixture, and alfalfa with cocksfoot mixture in terms of the number and spacing of the furrows from the root cervix. No significance was found regarding the number of gnawed holes.

In the second year of cultivation, the values of the studied indicators in the mixtures were significantly lower than the corresponding ones in the legume crop, but the degree of damage decreases to a different degree. The cultivation of alfalfa with cocksfoot was associated with significantly the largest reduction in the number of gnawed furrows on the roots of plants (by 84.8% compared to pure alfalfa sowing), followed by the triple combination (by 76.7%) and the mixture of alfalfa with awnless bromegrass (by 66.4%). The number of holes was significantly lowest in the triple mixture and was reduced by 80.0% compared to pure alfalfa. In the other two mixtures, a significant reduction was found in the range of 70.9 - 74.0%. The triple mixture and the mixture of alfalfa with cocksfoot stand out with the smallest length of furrows and reduction of 27.5 and 22.4%, as the differences between the two variants have not been statistically significant.

Table 2. *Degree of damage by Otiorhynchus ligustici Linnaeus in perennial pure crops and grass-legume mixtures.*

V	Perennial legumes							Perennial grasses		
	Height, cm	Number of stems/ Plant	Number of spiral furrow/root	Number of holes/root	Furrows length, cm	Spacing of the furrows from the root cervix, cm	Root length, cm	Height, cm	Number of stems/plant	Root length, cm
2018										
	-	-	-	-	-	-	-	25.4 a	1.5 ab	10.2 a
	-	-	-	-	-	-	-	45.9 b	1.3 a	14.8 bc
	67.6 a*	2.8 b	1.3 c	0.8 ab	2.0 c	4.1 b	24.0 a	-	-	-
	83.8 c	2.9 b	0.5 a	1.0 b	1.7 b	2.8 a	26.3 c	54.1 c	1.6 b	12.1 b
	72.1 b	2.5 a	0.8 b	0.7 a	1.6 b	4.8 bc	25.1 b	70.6 d	3.2 c	15.9 c
	71.6 b	3.0 b	1.2 c	0.9 ab	1.4 a	5.2 c	24.4 a	40.9AB 58.4CF	1.5AB 1.5CF	11.2AB 15.0CF
x	**73.8**	**2.8**	**1.0**	**0.9**	**1.7**	**4.2**	**25.0**	b c	ab b	b bc
2019										
	-	-	-	-	-	-	-	40.8 a	4.8 a	12.5 a
	-	-	-	-	-	-	-	39.6 a	4.5 a	17.8 bc
	77.6 a	7.5 c	4.6 d	5.0 c	2.3 c	8.9 c	25.6 a	-	-	-
	82.4 b	3.7 a	1.5 c	1.5 b	1.9 b	2.5 a	31.0 c	49.2 c	5.9 b	15.1 b
	84.1 b	4.7 b	0.7 a	1.3 b	1.8 ab	4.2 b	27.0 b	47.4 b	9.3 c	19.9 c
	82.0 b	4.7 b	1.1 b	1.0 a	1.7 a	4.6 b	26.6 ab	50.6AB 59. 2CF	5.5AB 4.6CF	13.9AB 18.7CF
x	**81.5**	**5.2**	**2.0**	**2.2**	**1.9**	**5.0**	**27.6**	c d	ab a	a bc
2020										
	-	-	-	-	-	-	-	20.0 a	12.7 c	19.8 a
	-	-	-	-	-	-	-	22.7 a	12.6 c	25.4 c
	79.4 a	8.3 d	4.5 c	4.7 d	5.4 c	4.8 a	37.5 a	-	-	-
	85.5 b	5.8 a	4.3 c	3.3 c	5.2 c	4.9 a	42.6 b	27.7 b	13.3 d	26.8 d
	93.0 c	7.5 c	1.6 a	1.0 a	4.0 b	4.4 a	44.0 b	39.8 c	16.0 e	29.7 e
	82.6 ab	6.9 b	3.0 b	2.7 b	3.5 a	4.4 a	38.3 a	$38.0^{AB}39.3^{Cf}$	11^{AB} 8.7^{Cf}	24.9^{AB} 23.2^{Cf}
x	**85.1**	**7.1**	**3.3**	**2.9**	**4.5**	**4.7**	**40.6**	c c	b a	c b
Average for the period										
	-	-	-	-	-	-	-	28.7 a	6.3 bc	14.2 a
	-	-	-	-	-	-	-	36.1 b	6.1 b	19.3 d
	74.9 a	6.2 c	3.5 c	3.5 c	3.2 b	5.9 c	29.0 a	-	-	-
	83.9 c	4.1 a	2.1 b	1.9 b	2.9 ab	3.4 a	33.3 b	43.7 c	6.9 c	18.0 c
	83.1 c	4.9 b	1.0 a	1.0 a	2.5 a	4.5 b	32.0 b	52.6 d	8.9 d	21.8 e
	78.7 b	4.9 b	1.8 b	1.5 b	2.2 a	4.7 b	29.8 a	$43.2^{AB}52.3^{Cf}$	$6.0^{AB}4.9^{Cf}$	16.7^{AB} 19.0Cf
x	**80.1**	**5.0**	**2.1**	**2.0**	**2.7**	**4.6**	**31.0**	c d	b a	b d

Legend: *V – variants; 1. Awnless bromegrass (100%); 2. Cocksfoot (100%); 3. Alfalfa (100%); 4. Alfalfa + Awnless bromegrass (50:50%); 5. Alfalfa + Cocksfoot (50:50%); 6. Alfalfa + Awnless bromegrass + Cocksfoot (50:25:25%); x–average value; ^{AB} - Awnless bromegrass ; ^{Cf} - Cocksfoot; x – average; * The values in the columns with identical letters are not statistically significant, p <0.05.*

The spacing of spiral furrows from the root cervix significantly decreased in mixtures, with the lowest value being distinguished by the sowing of the alfalfa mixture with awnless bromegrass (decrease of 71.6% compared to the pure sown legume).

Mixed cultivation of alfalfa with grass components has a positive effect on plant height, which significantly increased in the range of 5.7 - 8.4% compared to pure sowing, as well as on the root length, increasing from 4.0 (triple mixture) to 21.2% (mixture of alfalfa with awnless bromegrass).

The tendency for a favourable effect of mixed cultivation on the development of plants and suppression of damage by the enemy was preserved also in the third year of the experiment. In the case of mixtures, a decrease in the values of the damage-reporting indicators compared to the alfalfa crop was established. With the most reliable and largest reduction in the number of furrows and holes, the cultivation of alfalfa with cocksfoot stands out (reduction by 64.4 and 78.7%, respectively), followed by the triple mixture. In the mixtures, there were more favourable conditions for both vegetative and generative development and a significant increase in plant height, root length, and the number of stems (except triple mixture in terms of the number of stems, and cocksfoot from the triple mixture in terms of root length). On average for the period, the cultivation of alfalfa with grass components was associated with a significant reduction in the damage to the roots of alfalfa from the larva of *Otiorrhynchus ligustici* compared to the pure crop, and this was mostly found in the mixed crop with cocksfoot. In the mixture, the damage expressed as the amount of gnawed furrows and holes, and the length of the furrows, decreased by 70.5, 71.4, and 23.1%, respectively. There was a significant decrease in the triple mixture, by 49.8, 56.5, and 31.6%, respectively. Despite the shorter length of the furrows in the triple mixture compared to the alfalfa-cocksfoot mixture, no significant differences were found.

The mixed cultivation of legumes and grasses had a positive effect on the development of grass components compared to their pure cultivation, as the values of stem height, the number of stems, and root length significantly increased in mixtures. On average for the period of mixed cultivation of cocksfoot with alfalfa, the cocksfoot was characterized by significantly the largest number of formed stems and an increase of 45.4% compared to pure grass crop, and the mixture with awnless bromegrass - with the largest increase in stem height (by 52.1%) and the length of the root (26.8%) compared to the pure crop. The alfalfa – cocksfoot mixture showed the highest values on all three indicators studied.

In themselves, the indicators number and length of the spiral furrow do not give a clear idea of the degree of damage, but their joint analysis and their inclusion in the calculation of the area of damage to the root system helps to accurately determine the damage or preference of *O. ligustici* to certain crops.

The results in Table 3 show that over the years and on average for the period a significantly smaller area of damage was found in all three mixed crops compared to the pure alfalfa crop, but the decrease was different depending on the grass component. In 2018, significantly the lowest value of the damaged area was reported in the cultivation of alfalfa with awnless bromegrass (damage reduction by 67.3%). This was due to the reported longer length of the gnawed furrows, despite the fact that their number was less than the corresponding one in the mixture with cocksfoot. The decrease was also significant in the mixture of alfalfa with cocksfoot (a decrease of 50.8% compared to the variant with alfalfa). In 2019 and 2020, they are more pronounced with an increase in damage to plant roots, as well as the preference of the enemy. The sowing of alfalfa with cocksfoot showed a significant smallest area of damage and reduction by 88.3 and 73.6% compared to the pure sowing. There was a significant decrease in the triple mixture - by 83.2 and 56.7%, respectively.

Table 3. *Area of damage to the root system of alfalfa (in pure and in mixed crops with grass components) by Otiorhynchus ligustici Linnaeus.*

Variants	Area of damage, cm^2			
	2018	**2019**	**2020**	**Average**
Alfalfa	2.60 c*	10.66 d	24.26 d	12.51 d
Alfalfa+Awnless bromegrass	0.85 a	2.94 c	22.02 c	8.60 c
Alfalfa+ Cocksfoot	1.28 b	1.25 a	6.40 a	2.98 a
Alfalfa+AB+Cf	1.68 b	1.79 b	10.50 b	4.66 b
Average	**1.60**	**4.16**	**15.79**	**7.18**

* *The values in the columns with identical letters are not statistically significant, p <0.05*

On average for the three years, the mixed cultivation of alfalfa with cocksfoot stands out with significantly the smallest area of damage and reduction by 76.2%, followed by the triple mixture - by 62.8% and the mixture with awnless bromegrass - decrease by 31.3% compared to alfalfa.

A number of authors have found that mixed cultivation of legumes and grasses results in higher yields and well-balanced feed in terms of nutrition compared to pure grown crops (Sanderson, 2010; Woodward et al., 2013). This was due to the more intensive absorption of nutrients and moisture from the soil, better use of heat and light (Zhuchenko, 1994). The application of multicultural farming models was also an important cultural practice for pest control. These models are based on the principle of reducing enemy density by increasing species diversity (Moonen & Bàrberi, 2008; Tooker and Frank, 2012). Moorhouse et al. (2008) found that growing vines undercover with blueberries was associated with a significant reduction in the number of adult individuals of *Otiorrhynchus sulcatus* and reduced damage by the enemy.

Similar results for the control of *O. ligustici* were reported by Bailey (2015), where the mixed cultivation of alfalfa and cocksfoot in a ratio of 12:2 reduced the damage and density by 48.0%, while in the mixture with tall fescue (10:4), the decrease was 50.2%. Svensson (2006), in another mixed cultivation system, found that *O. sulcatus* avoids mixtures of strawberries with parsley and/or spruce as plants and prefers to feed and propagate in pure strawberry plantations. Barnes and De Barro (2009) report that a mixture of alfalfa and ryegrass was associated with high larval mortality, the interaction between component crops makes mixtures more complex systems and reduces the attack of pests as a result of interspecific diversity and increased efficiency of natural enemies.

Table 4. *Productivity of dry aboveground biomass of perennial pure crops and grass-legume mixtures, kg/da.*

Variants	2018	SD	2019	SD	2020	SD	Average	SD
Awnless bromegrass	192.29 a*	5.156	423.21 a	7.754	161.69 a	4.681	259.06 a	7.976
Cocksfoot	269.05 b	7.407	462.20 b	6.345	261.48 b	5.091	330.91 b	6.272
Alfalfa	909.39 c	8.213	980.91 c	5.624	849.03 c	4.200	913.11 c	8.160
Alfalfa + Awnless bromegrass	1084.38 e	6.705	1103.89 e	6.915	1186.83 e	1.442	1125.03 e	2.276
Alfalfa + Cocksfoot	1178.67 f	5.028	1306.45 f	3.207	1371.41 g	2.885	1285.51 g	5.345
Alfalfa + Awnless bromegrass + Cocksfoot	952.06 d	6.149	1068.98 d	4.342	1043.78 d	2.008	1021.61 d	5.395

Legend: *SD – standard deviation; * The values in the columns with identical letters are not statistically significant, p <0.05.*

Ma et al. (2007) found that the strip cropping of wheat and alfalfa improved the biological control of the cereal aphid, Sitobion avenae (Fabr.) by the mite, *Allothrombium berlese* (Acari: Trombidiidae). The productivity of dry aboveground biomass of perennial grass-legume mixtures over the years and on average for the period exceeds the respective pure perennial crops and the differences were significant (Table 4). In 2018, the productivity of dry biomass from alfalfa in a mixture with awnless bromegrass was 19.2% higher than the alfalfa crop alone. The highest productivity of dry aboveground biomass was shown by the mixture of alfalfa with cocksfoot (an increase of 29.6% compared to pure sowing), but for the triple combination (alfalfa with awnless bromegrass and cocksfoot) the productivity of alfalfa was only 4.7% higher than that of the pure crop. A similar tendency was observed for pure grass crops, whose productivity has been shown to be lower compared to the respective mixtures ($F_{5,2} = 22.455$; $p < 0.024$).

In 2019, the productivity of pure grass crops was twice as high as in the first year of cultivation. This was a result of the realization of their productive potential, as well as a larger and more even distribution of the amount of precipitation compared to 2018 (the amount of precipitation during the development of the second cut in 2019 was 30.5 mm higher than in 2018). The tendency for higher productivity in the mixtures compared to the pure crops was preserved as the increase in alfalfa and awnless bromegrass mixture was by 12.5%, for alfalfa with cocksfoot - by 33.2%, and for the triple mixture - by 9.0% compared to the pure crop of alfalfa. The differences between all variants were significant ($F_{5,2}$ = 25.018; $p < 0.001$).

In the third year of the study, the cultivation of alfalfa with cocksfoot was associated with significantly higher productivity ($F_{5,2} = 11.303$; $p < 0.008$), exceeding that of alfalfa by 61.5%. In the case of mixtures with awnless bromegrass and the triple mixture, the increase was by 39.8 and 22.9%, respectively.

The mixed cultivation of alfalfa with cocksfoot on average for the period was associated with significantly the largest increase in productivity by 40.8% compared to the pure cultivation of legumes ($F_{5,2} = 15.570$; p <0.016). The mixture with awnless bromegrass occupied an intermediate position (by a 23.2% increase), and the weakest increase was found in the triple mixture (an increase of 11.9%).

The productivity of the root biomass over the years and on average for the period was significant higher in the mixtures compared to the respective pure crops (2018-$F_{5,2} = 12.768$; $p < 0.034$; 2019- $F_{5,2} = 26.690$; $p < 0.001$; 2020- $F_{5,2} = 1.559$; $p < 0.010$; mean- $F_{5,2} = 13.064$; $p < 0.026$) (Table 5). The values for the mixtures of alfalfa with awnless bromegrass, cocksfoot, and the combination of legumes with the two grass components increased on average by 11.2, 26.2, and 7.7% compared to the pure alfalfa crop. The differences over the years and the average for the period in the mixtures were found significant.

Table 5. *Productivity of dry root biomass of perennial pure crops and grass-legume mixtures, kg/da.*

Variants	2018	SD	2019	SD	2020	SD	Average	SD
Awnless bromegrass	147.62 a*	7.608	332.33 a	7.311	353.50 a	0.707	277.82 a	5.211
Cocksfoot	188.26 b	6.986	542.50 b	12.020	571.75 b	0.919	434.17 b	6.646
Alfalfa	732.65 c	3.733	839.05 c	11.943	860.00 c	0.565	810.56 c	5.409
Alfalfa + Awnless bromegrass	773.14 d	5.282	956.93 e	8.662	973.00 e	0.282	901.02 e	4.744
Alfalfa + Cocksfoot	830.36 f	3.429	1078.99 f	4.551	1159.38 f	0.678	1022.91 f	2.885
Alfalfa + Awnless bromegrass + Cocksfoot	798.36 d	1.753	893.97 d	16.659	927.66 d	0.480	873.33 d	6.293

Legend: *SD – standard deviation; * The values in the columns with identical letters are not statistically significant, p <0.05.*

Intercropping or diverse field margins were intensively applied for many centuries and, to date, are well approved as one of the most promising practices to maintain ecosystem biodiversity. Moreover, diversification practices may increase productivity in widely utilized agricultural systems (Lithourgidis et al., 2011).

Lai et al. (2011b, c) reported that the greater the differentiation degree in agroecosystems, the more stable the systems that regulate pest populations become when compared with monocultures and productivity is not as compromised. Intercropping should be introduced as often as possible into crop production systems to provide crop yield stability and to decrease the risk of crop failure (Raseduzzaman & Jensen, 2017).

Many studies have been conducted and selected the best intercropping practice with their associated crop that provided successful pest management and high crop yield that can maximize the production per unit of land. For example, Rao et al. (2012) founded a significant positive effect of *Coriandrum sativum* L. intercropping with the *Vicia faba* L. varieties, as it caused significant decreases in aphid's population of *Aphis craccivora* Koch., significant increases in the numbers of associated predators and increases in the seed yields. Results showed a significant negative correlation between seed yield/plant and the mean number of aphid/tiller. The field study on the effect of intercropping on population dynamics of major insect pests and vectors of potato as well as on the productivity revealed that Potato + Onion in alternative rows (1:1), and Potato + Garlic in alternative rows (1:1) were statistically superior and significant compared with the sole crops of these species (Konar et al., 2010). Shalaby and Fouad (2016) reported that intercropping of faba bean *Vicia faba* L. with fenugreek *Trigonella foenum-graecum* L. reduced populations of *A. craccivora* and increased the seed yield of faba bean crop. Intercropping of cotton with alfalfa resulted in the reduction of insect damage and increased production (Vaiyapuri & Amanullah, 2010).

Intercropping of grass with legumes is an alternative practicable solution that decreased insect pest infestation, providing successful plant protection and high and stable crop yield.

Conclusion

The mixed cultivation of alfalfa with grass components (cocksfoot, awnless bromegrass) has been shown to reduce root damage by *Otiorrhynchus ligustici* compared to alfalfa pure crop. The least preferred, with the lowest degree of damage was a mixture of alfalfa with cocksfoot (50:50%), where the number of gnawed furrows and holes, and the length of the furrows decreased by 70.5, 71.4, and 23.1%, respectively, followed by mixture with awnless bromegrass (50:50%).

The mixed cultivation of legumes and grasses has a positive effect on the development of grass components compared to their pure cultivation, as the values of stem height, the number of stems, and root length have been shown to increase in mixtures. Cocksfoot in mixture with alfalfa has the highest values on all three indicators studied.

Mixed cultivation of alfalfa with grass components significantly increased both dry aboveground and dry root biomass productivity of the individual components in the mixtures.

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