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Research Article
Competitive Effect Between Black Oat (*Avena strigosa*) and Common Vetch (*Vicia sativa*) Plants in Consortium under Diverse Populational Densities

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Abstract

Objective: The goal of this study was to evaluate the in coexistence effects of black oat and common vetch plants subjected to diverse tillage densities (seeding densities). Dry mass and fresh mass of the stems, leaves and decomposed matter were evaluated in both species and the land efficient use rate (LER) of the consortia was assessed. **Methodology:** The experiment was performed in vases containing tillage soil where a black oat and common vetch plant was kept in coexistence for 35 days with 0, 1, 2, 3, 4 and 5 the common vetch and black oat plants. **Results:** The density hike that was observed for the common vetch caused a linear drop in biomass of the black oat plants although, it did not cause significant effects on the decomposed matter of the species. Likewise, the increase in the number of black oat plants led to a diminution of the biomass in a quadratic fashion of the vetch plants and also resulting in a linear increase in the mass of the decomposed matter. **Conclusion:** The LER values were meaningfully affected in a crescent manner, because of the density of both species. The use of the consortium between the two species should be cautious relations of densities and ideally 50% of each species.

Key words: Winter crops, additive method, LER

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Brazil's Southern region, many swaths of land are cultivated intensively and without their handling (operations) having been done adequately which may lead to a reduction in the amounts of organic matter in the soils and to favoring erosion processes[1,2].

In aiming to ensure sustainability of a production system under such conditions, it is necessary to adopt different techniques other than the conventional agricultural methods, taking heed of the need to utilize techniques such as direct drilling associated with a rotation and succession system of diverse cultivars. Also, seeking to produce a crops residues on the soil surface adequately which consequently is to bring about advantages to the stability for grains yields, a break in plagues and diseases cycle, a reduction of harmful weeds and maintenance or improvement of the physical traits of the soil[3,4].

The use of canopy plants during the winter has been known to be a technique capable of enhancing grains yield without increasing production costs by means of augmentation of the capability to fix and/or recycle nutrients and soil protection[3]. Black oat and the vetch plants stand out as prime options for soil coverage, black oat because it is a grassy and has an elevated capability of producing phytomass and presenting a satisfactory resilience to rust, upon the impacts of greenflies and hydro-deficiency, whereas the common vetch differs mostly for being leguminous, it is capable of fixing atmospheric nitrogen and therefore, it contributes to a betterment of the nitrogen balance in the soil and providing benefits for the succession cultivars[5].

Thus, the consortium of these two species has shown to be efficient also in terms of the pasture tillages along the critical period in Southern Brazil[6]. Black oat is one of the yearly grassy plants most widely employed in supplying for fodder during the winter as a rustic and resilient species in drought periods having a fine capability for outlining and producing green mass[1].

In contrast, the use of the vetch in the consortium may result in positive outcomes towards animal performance since, the nitrogen provided by the leguminous plant is enough for supporting fodder production and broadening the pastures lifecycle as well as for its high protein value, the leguminous plant contributes to animal production owing to the change in the diet's quantitative and qualitative profiles with a remarkable effect on animal performance[7].

Nonetheless, they are two species of different families, both presenting physiological differences, it is a complex task to cultivate and handle pastures in a consortium, a reason these systems are normally in seldom occurrence in the country[8].

Because of the relevance of the use of black oat and the vetch during the winter in Southern Brazil, be it as canopy for the soil or as pastures and for the need for studies that seek to understand the behaviors of both species in consortium.

When mixing two different species, they are shown competitive potential existing between both such as allelopathic effects or competition for light, water and soil nutrients which can mean that there is predominance of a species about other. The competition between species vegetables can alter the morphology, reducing stolons, tillers, leaf area, leaf number height, dry matter and other characteristics than affect the pasture performance.

This study aimed at evaluating the effects of coexistence of black oat and common vetch plants as they are subjected to different seeding densities, this is know the density good of seeds to not have competition between species.

MATERIALS AND METHODS

The experiment was developed from April to May 2015 in a greenhouse that belongs to the experimental station of the Federal Technological University of Paraná, Campus Dois Vizinhos, Southwest in the state of Paraná.

The experimental units were comprised of vases with an area of 0.018 m^2 and capacity for 2 L containing dystroferric Red Nitosol (NVdf) taken from the surface at a depth from 0-20 cm of a seeding area priorly cultivated with soybeans. Treatments entailed black oat (*Avena strigosa*) cv IAPAR 61 in consortium with common vetch (*Vicia sativa*) cv. Amethyst plants over different levels of density, making an entirely casual design/outline with four repetitions.

Firstly, black oat and common vetch were seeded in trays that contained a commercial substratum, wherein this seeding took place so that germination of both species would occur on the same day that both would settle in consortium with the same development stage after germination. Seven days after germination, transplantation was made with the two species, when one black oat plant was placed in the center of each experimental unit and a variable number of common vetch plants (0, 1, 2, 3, 4 and 5) inside the embroideries. The same procedure was done by placing a common vetch plant in the center of the vase and the variable number of black oat plants (0, 1, 2, 3, 4 and 5) inside the embroideries. Each plant at the edges stayed 5 cm away from the central plant and the distance between the plants on the brim varied according to

the treatment. The densities and usage of equidistant spacing follow the methodology from the additive experiments employed for evaluating the competition among plants[9].

Irrigation was done on a daily basis in the afternoon portion of the day with the application of the same volume of water for all the vases and control of the weed plants was performed manually as necessary, not any manuring taking place so that the competition effect would occur among the plants.

The plants developed in consortium during 35 days after transplantation, when they were singled out being aligned with the floor so that then fresh mass of the leaves could be verified as well as stem and decomposed matter which were all weighed on an analytical scales, separately. Next, they were transferred to paper bags and put to dry up inside an air-forced stove with circulation at 58°C during 72 h, when the samples were weighed again for ascertaining the dry phytomass in the plant's constituents.

Building on the dry matter values, the land efficient use rate (LER) was tallied, pursuant to the methodology described by Mead and Willey[10] with the use of the LER formula:

$$LER = (I_{oat}/S_{oat})+(I_{vetch}/S_{vetch})$$

where, I and S are the productivity of the consortium and of the singly cultivar of each species, accordingly.

The data obtained was subjected to variance analysis by the F-test at 5% of likelihood and when meaningful, regression analysis was performed by the method of orthogonal polynomials by means of the statistical software program ASSISTAT[11].

RESULTS AND DISCUSSION

Black oat biomass production under different common vetch densities: The variables stem's fresh mass (SFM) and stem dry mass (SDM) of black oat fit a linear regression model, making it feasible to observe a decrease in these values as there would be an increase in the number of the common vetch plants in the consortium (Fig. 1). In the treatment under which it was kept, only the isolated black oat presented a greater value for both variables, since in this treatment there was not any competition between the plants and thus, the black oat plant growth was not affected. In contrast, in the treatment wherein the black oat plant was kept in consortium with five common vetch plants, it was noted that there was a reduction of roughly 57.95% in the production of fresh stem mass and roughly 76.77% in the production of stem dry mass in relation to the isolated black oat.

Likewise, there was a diminution in the production of leaves fresh mass (LFM) and leaves dry mass (LDM) of the black oat plants as an increase occurred in the participation of common vetch plants in the consortium, where the greatest value in the treatment was for the isolated black oat and the lowest value in the treatment where black oat was kept in consortium with five common vetch plants (Fig. 2). Additionally, these reductions were at 58.38% for leaves fresh mass and 60.46% for leaves dry mass.

In relation to the fresh and dry masses of the decomposed matter a meaningful effect ($p>0.05$) was not observed among the treatment strands which means the increase in the number of the common vetch plants does not affect meaningfully the black oat tissues degradation.

The augmentation in the number of plants per vase lead to a diminution of the available area for the development of black oat plants which consequently affected its adoptability capabilities. De Abreu *et al.*[6] occurred the observation that the biomass per white black oat plant dropped in a linear fashion according to the augmentation in the number of plants per meter square, showing the reduction in the capacity of adoptability and therefore, the dwindling of biomass per plant. Likewise, Heinrichs *et al.*[5] observed that the phytomass production of black oat dropped as the proportion of common vetch plants increased in the consortium by evaluating the dry mass of black oats and common vetch in different proportions with the application of the replacement (substitutive) method.

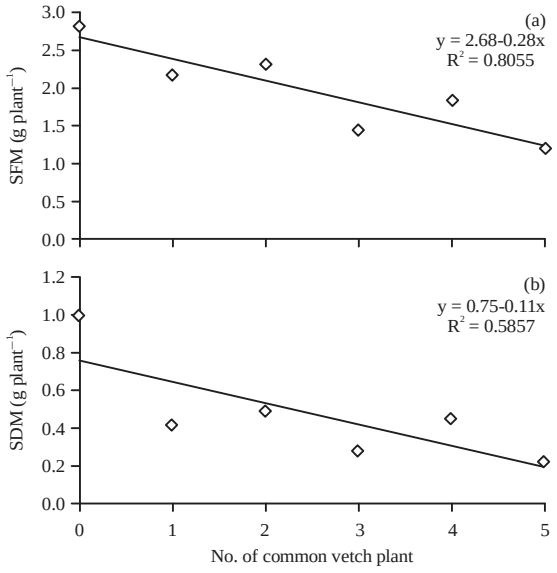

Fig. 1(a-b): Production of (a) Stem's fresh mass and (b) Stem's dry mass per black oat plant under different densities of common vetch plants, UTFPR-Dois Vizinhos, 2015

However, in assessing the performance of different winter species under an isolated cultivar and in consortiums. Balbinot *et al.*[12] noted that the dry mass of the section of black oat was lower than the black oat+common vetch dry mass.

Noting the changes in the variables of Fig. 1 and 2, it is possible to observe that the ideal proportion of plants per pot is 2/1 that will be 111 plants vetch to 55 oat plants per meter square. With the proportion of plants there would be non-significant losses of cover or forage production of the species.

Biomass production of common vetch under different black oat densities: The production of stem's fresh mass (SFM) and stem's dry mass (SDM) of common vetch fit into the model of quadratic regression, with a dwindling in these values as there occurred an augmentation in the number of black oat plants in the consortium (Fig. 3). In the treatment in which the isolated common vetch was possible to observe a greater value for both variables, since in this treatment, the common vetch plant was capable of developing without the need for other plant's inference in the resource competition. Thus, the growth of the same was not hindered. In another extreme case in the treatment in which the common vetch plant was subjected to the consortium of five black oat plants, it was feasible to observe a decline of roughly 87.87% in the production of stem's fresh mass and 82.35% in the production of stem's dry mass in relation to the common vetch in an isolated cultivar fashion.

Likewise, a decline in the production of leaves fresh mass (LFM) was seen and in the production of leaves dry mass (LDM) of common vetch plants, as there was an augmentation in the number of black oat plants in the consortium, wherein the greatest value was registered for the treatment with the isolated common vetch and the lowest value for the treatment in which the common vetch was kept in consortium with five black oat plants (Fig. 4) and these declines were 91.27% for the leaves fresh mass and 89.30% for the leaves dry mass.

As for the values obtained for the fresh and dry masses of decomposed matter (DFM and DDM) an augmentation was seen in a linear manner as the participation of black oat plants would increase, per vase. It was feasible to observe that the common vetch plants in isolated cultivars did not present decomposed matter mass, whereas the plants in consortium with atleast one black oat plant already showed a trend to the occurrence of tissues degradation during the coexistence period between the species (Fig. 5).

The results obtained resemble those encountered by Heinrichs *et al.*[5] and Bortolini *et al.*[13], wherein the same were able to observe a greater phytomass production of isolated common vetch with a sensitive trend to a dwindling as the participation of black oat in the consortium increased which reveals the low competition capability of this leguminous item as in consortium with black oats. In assessing different

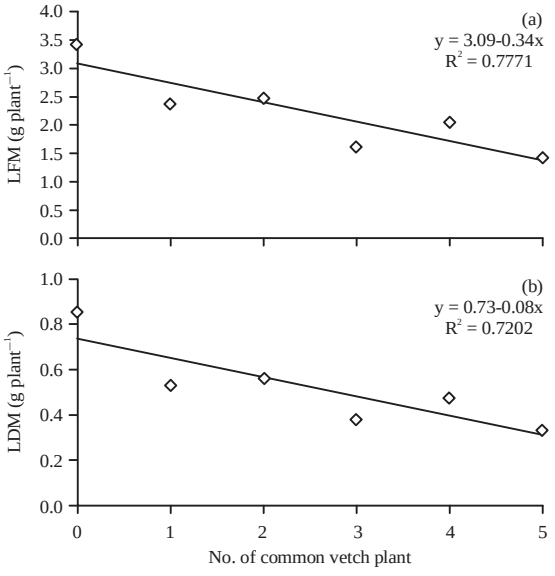

Fig. 2(a-b): Production of (a) Leaves fresh mass and (b) Leaves dry mass per black oat plant under different densities of the common vetch, UTFPR-Dois Vizinhos, 2015

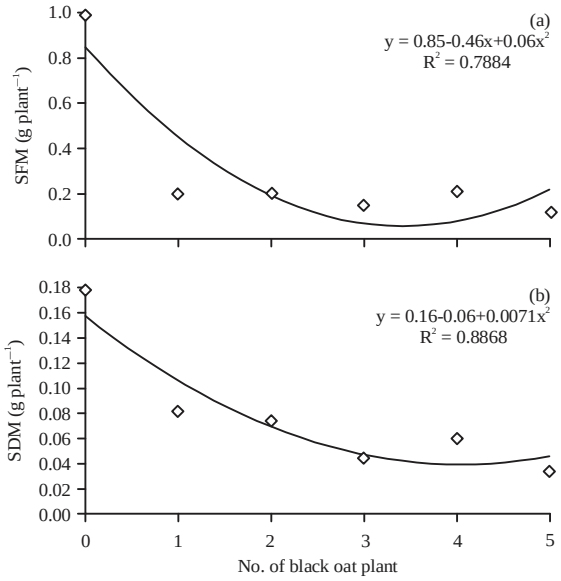

Fig. 3(a-b): Production of (a) Stem's fresh mass and (b) Stem's dry mass per common vetch plant under different black oat densities, UTFPR-Dois Vizinhos, 2015

proportions between the black oat and common vetch plants, Da Silva *et al.*[3] noted that the finest proportion in the consortium is that both correspond to 50% of participation with a balance in the yield of dry mass of both species.

When vetch grows in the presence of oats, the studied variables showed a decreasing behavior with little variation between oat densities.

Land efficient use rate (LER): The LER values showed growth as an augmentation occurred in the consortium density (Table 1, 2). Despite the larger canopying jeopardizing in an individual fashion the black oat plant in consortium with common vetch plants or the common vetch plant in consortium with black oat plants in both cases the broader densities benefitted the consortium because of the increment in biomass produced by the two species and these results are the expression and outcome of more efficient land use.

It can be observed that among all the situations evaluated, the consortia with larger amounts of the vetch plants were the ones that showed greater LER values (Table 1).

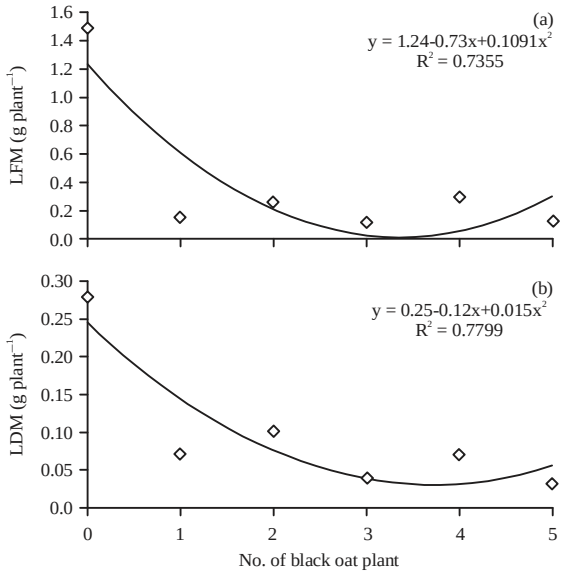

Fig. 4(a-b): (a) Leaves fresh mass production and (b) Leaves dry mass per common vetch plants under different densities of black oat, UTFPR-Dois Vizinhos, 2015

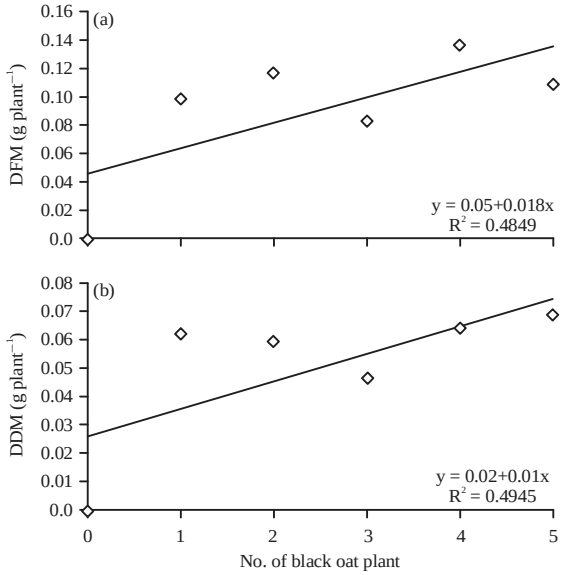

Fig. 5(a-b): (a) Production of decomposed matter fresh mass and (b) Decomposed matter dry mass per common vetch plant under different black oat densities, UTFPR-Dois Vizinhos, 2015

Table 1: Black oat biomass production and common vetch biomass production in isolated and consortium cultivars and the values for the efficient land use rate for black oat (LER_{oat}), for common vetch (LER_{vetch}) and total (LER), UTFPR-Dois Vizinhos, 2015

Consortium	Black oat production	Common vetch production	LER_{oat}	LER_{vetch}	LER
1 oat:0 vetch	2.196	-	-	-	-
1 oat:1 vetch	1.246	0.280	0.567	0.616	1.183
1 oat:2 vetch	1.271	0.401	0.578	0.883	1.461
1 oat:3 vetch	0.890	0.773	0.405	1.702	2.107
1 oat:4 vetch	1.267	0.668	0.577	1.470	2.047
1 oat:5 vetch	0.744	0.914	0.339	2.011	2.350

Table 2: Black oat and common vetch biomass production in isolation and consortium cultivars and values of the effective land use rate for black oat (LER_{oat}), common vetch (LER_{vetch}) and total (LER), UTFPR-Dois Vizinhos, 2015

Consortium	Black oat production	Common vetch production	LER_{oat}	LER_{vetch}	UET
1 vetch:0 oat	-	0.454	-	-	-
1 vetch:1 oat	1.076	0.215	0.490	0.473	0.963
1 vetch:2 oat	1.483	0.234	0.675	0.516	1.191
1 vetch:3 oat	1.923	0.129	0.875	0.284	1.159
1 vetch:4 oat	1.985	0.194	0.904	0.427	1.331
1 vetch:5 oat	2.442	0.133	1.112	0.293	1.405

Differently, if one observes the consortia in which there is a greater participation of black oat plants (Table 2). It is possible to note lower LER values in relation to those with a greater participation of common vetch plants (Table 1).

The black oat, because it is a grassy plant that has a feature of excellent capability for adoptability[1], as in high densities in the consortium, raises the intra and inter-specific competition, resulting in lower biomass values which outright affect the LER value. In contrast, the vetch is a leguminous type, as in consortium with this grassy plant tends to be less competitive[5,13], therefore, when there are common vetch plants in larger densities, the intra and inter-specific competition are not so acute as in situations with larger amounts of black oat.

Nevertheless, although the consortiums present higher LER levels in field conditions they would not be advisable with high proportions of common vetch plants, be it for canopying the soil or for pastures. In treating the common vetch as soil canopy, the common vetch presents a feature of faster decomposition, if compared to black oats[14] and so, its mineralization of residues would take place more quickly and thus reducing the possibility of best usage of succession cultivars made available. In the same way, with respect to the consortium usage for pastures, the largest proportions of common vetch could cause negative outcomes, since this leguminous plant has a lower resilience to stomping and pasturing, if compared to the grassy type. Besides the fact that they are less efficient in growth factors such as water, light and temperature which hinders its re-sprouting and therefore leads to a decline in its participation in the plants selective stand and decreasing production through time[8].

In assessing the land efficient use in the vetch consortium with some cereals, Dhima *et al.*[15] noted that the partial LER value of cereals was always lower than 0.5 demonstrating and edge by the common vetch in relation to other cereals. Nonetheless, in this same study Dhima *et al.*[15] observed that the LER values of the different consortia were always higher than 1.0 which indicates that the consortium favors growth and production of simultaneous cultivars.

Knowledge of the competitive process between plants and the ability of individual plants becomes full relevance for pastures systems.

CONCLUSION

Reductions in variables analyzed in oats, the presence of vetch plants occurs in proportion to the increase in plant densities.

The same occurs when vetch plant is oats in different densities in which case tend reductions occur in the ratio 1:1 (oat:vetch). However, in both situations, the augmentation in density resulted in larger LER values.

The use of the consortium between the two species should be cautious relations of densities, ideally 50% of each species.

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