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The influence of row spacing on seed yield, yield components and seed quality of alfalfa

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Abstract

In order to determine the influence row spacing has on yield, yield components and the quality of *alfalfa* in agro-ecological conditions of south Serbia, a three year long research has been conducted, testing the *NS Novosadjanka H-11* cultivar of alfalfa. The average seed yield of alfalfa was highest at a row spacing of 40 cm (311.03 kg ha^{-1}), followed by row spacings of 20 cm (286.48 kg ha^{-1}) and 60 cm (264.83 kg ha^{-1}). The highest and lowest number of inflorescences per stem were obtained in rows spaced 60 cm (14.39 inflorescences/stem) and 20 cm apart (9.94 inflorescences/stem), respectively. The widest row spacing of 60 cm (8.14 pods/inflorescence) resulted in the highest number of pods per inflorescence, whereas the lowest number was produced at 20 cm spacing (5.96 pods/inflorescence). Grain number per pod ranged from 3.64 (at 20 cm row spacing) to 4.18 (at 60 cm). The highest quality of alfalfa seed during the three years of research was obtained at the widest row spacing (60 cm). Thousand-seed weight was highest at 60 cm and lowest at 20 cm (2.05 g and 1.99 g, respectively). The highest average values for seed germination rate were reported for 60 cm row spacing (86.92%) and the lowest for 20 cm row spacing (83.83 %).

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Introduction

Alfalfa is a cultivar characterized by high genetic potential for forage yields, which is often negatively correlated to seed yield. It is also characterized by lush vegetative growth, high leaves share in above-ground biomass yield, and thin, delicate and easily weighed down stems.

Due to these characteristics, the alfalfa seed yield is under a great influence of ecological factors and therefore significantly varies depending on the weather conditions during the year, more so than other cultivars. The main characteristic of alfalfa seed production in Serbia is a great variation in seed yields, governed by the weather conditions. This being said, the seed yield can be 10 times lesser in an unfavourable year, than that of a favourable one. For this very reason, Serbia has no specialized seed yielidng planting areas. Instead, seed production takes place on planting areas of combined purpose (production of both forage and seeds). At these planting areas the first and third swath are used for producing forage, wherease seeds are produced in the second swath. In years with greater amounts of rainfall, the producers give up on seed production, and realize harvest solely by producing forage, thus lowering the production risk (Karagić and Katić, 2012).

Beside climatic factors, row spacing also has a significant influence on the amounts of seed yields, in other words, an optimal number of crops per surface unit. Numerous studies have shown that high yields and good quality alfalfa seeds are obtained by seeding alfalfa in wide rows at low seeding rates (Marble, 1970; Erić, 1988; Sowinski *et al.,* 1996; Lukić, 2000; Beković, 2005, Stanisavljević, 2006). However, wide row spacing and low seeding rates do not always ensure high seed yields compared to narrow row spacing of less than 25 cm and high seeding rates used in roughage production (Stjepanović, 1982; Lovato and Montanari, 1991; Vučković, 1994; etc.).

Seed quality of alfalfa is primarily governed by its biology, as well as by other factors, external ones in particular. Appropriate sowing methods and seeding rates contribute to seed quality of alfalfa more than in other crops. There are high variations in seed quality of alfalfa depending on the growth used for seed, sowing method, seeding rate and production year. As a rule, sowing alfalfa at high row spacing leads to better quality seed, with a higher thousand-seed weight and germination rate obtained (Erić,1988; Vučković, 1994). Environmental conditions have a significant effect on alfalfa seed quality; therefore, seed germination rate is considerably lower in years that have higher rainfall amounts than in dry warm sunny years (Vučković, 1994; Karagić 2004).

In various agroecological conditions of Serbia, with good numbers of crops, good care taking and rational usage, the life span of an alfalfa field is three to five years, therefore the establishement of new alfalfa fields is taking place on about 40-50 thousand hectars a year. This means that using 15-20 kg of seed, the yearly needs for seed equal to to 800-1000 t. Out of the entire alfalfa fields land in Serbia, the seed production takes place at 3-10%, with a wide spectar of yields per area unit, ranging from 0, all the way to 1200 kg ha^{-1} (Stanisavljević and Beković, 2012). In order to meet domestic seed needs, alfalfa should be grown on much larger areas, around 20% (Erić, 1988).

The scope of the yield, and therefore the variance in alfalfa seed yields is a very significant problem in Serbia, as well as the world. There are numerous results, including the ways fundamental (genetic research and other), as well as applied research, such as breeding and creating high yield potential cultivars.

However, when breeding alfalfa, the increase in production potential for alfalfa seed yield is quite low Bolanos-Agilar *et al*., 2001). That is the reason why it appears that upgrading agrotechnology has higher contribution to the stability of alfalfa seed yields, as well as its increase. The examination of row spacing influence to alfalfa seed yields has pointed to their direct contribution to the increase of the alfalfa seed yields.

Keeping in mind the fact that increasing the numbers of alfalfa seed yields is of special economic significance, the purpose of this research was to examine the influence ecological conditions and row spacing had on the yield, yield components and the quality of the alfalfa seed. Achieved results would represent a significant scientific and practical contribution to increasing the alfalfa seed production, and therefore the bettering of quality forage production.

Material and methods

To achieve the objective of this study, experimental research was conducted at Ledena Stena, in the Niš suburbs, over a period of three years (2010-2012).

Plant material

Alfalfa cv. *NS Novosađanka H-11* was developed at the Institute of Field and Vegetable Crops, Novi Sad. It was created by individual selection and interspecies hybridization of blue (*Medicago sativa* L.) and yellow lucerne (*Medicago falcata* L.). Botanical affiliation of the cultivar is *Medicago media* Pers. It's characterized by a high resistance to low temperatures, diseases and drought. In different conditions it yields around 70 t ha^{-1} of green forage, while the seed yield goes around 20 t ha^{-1}. The content of crude proteins in dry matter is 19.6 %, and crude cellulose percentage is 23.7. Alfalfa was planted in spring at three row spacings viz. 20 cm, 40 cm and 60 cm using the seeding rate of 15 kg ha^{-1}, 7.5 kg ha^{-1} and 5 kg ha^{-1}, respectively. The soil used in the study was alluvium.

Yield and yield components of alfalfa were evaluated using the first alfalfa growth in the first year (2010), and the second growth in the second (2011) and third years (2012).

Climatic Conditions

In the first year (year of stand establishment-2010), weather conditions were favourable for uniform germination, sprouting and further development of alfalfa crop (tab.1). The second year of study (first year of alfalfa utilisation-2011) was characterised by high amounts of rainfall during the harvest period, which resulted in harvest difficulties and seed yield losses. Alfalfa seed production was most favoured by the third experimental year (second year of alfalfa utilisation-2012), characterised by hot dry summer (tab.1).

Table 1. Mean monthly temperatures (^oC) and total precipitation (mm)- Niš 2010-2012.

Year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII Aver./ Amou-nt
Temperatures (^oC)													
2010	0.8	-1.7	5.1	11.8	16.8	19.0	22.3	20.5	17.9	12.3	5.7	3.5	10.9
2011	-1.5	1.2	6.3	13.3	17.0	20.0	22.9	21.2	18.3	14.0	6.7	2.4	11.8
2012	5.4	6.6	10.0	13.3	18.8	23.6	26.2	24,6	16.1	11.6	4.6	0.8	13.5
Amount of precipitation (mm)													
2010	49.2	60.8	69.5	89.0	103.6	50.8	44.8	85.0	21.1	38.3	42.5	76.4	731
2011	34.0	56.6	85.7	62.6	39.2	67.8	30.9	111.7	15.7	37.2	27.8	51.2	620
2012	29.0	35.9	26.2	16.4	66.5	13.9	7.7	32.2	58.6	131.7	117.3	24.8	550.2

Alfalfa seed yield was determined at a stage when 70-80% of the pods turned brown. The number of inflorescences per stem was identified upon sampling 20 stems per replication, and number of flowers per inflorescence and pods per inflorescence were determined from a sample of 30 well developed inflorescences collected uniformly from the top, middle and bottom portions of the stem in each replication. Seed number per pod was calculated using 30 randomly selected pods in each replication.

Thousand-seed weight (g) was determined by counting out and weighing 4 sets of 100 seeds per treatment. Seed germination rate (%) was assessed under laboratory germination in Petri dishes on filter paper at a temperature of 20°C by counting germinating seeds after 10 days.

Statistical analysis

The results obtained were subjected to an analysis of variance (ANOVA), and the significance of differences between the values was analysed by the LSD test.

Results and discussion

Seed Yield

The three-year data show that the highest seed yield of alfalfa was obtained at a row spacing of 40 cm (311.03 kgha^{-1}), and the lowest at 60 cm (264.83 kgha^{-1}), whereas the 20 cm spacing resulted in 286.48 kg ha^{-1} seeds (tab. 2). When analysed across years, the average yield in the stand establishment year (2010) was found to be satisfactory - 151.19 kgha^{-1}. In the second year (2011), the average yield of 259.0 kgha^{-1} was consistent with the national average, whereas the highest average seed yield (452.15 kgha^{-1}) was produced in the third year (2012). Similar results were reported by Eric (1988) who produced the highest seed yield at 30 cm and 40 cm spacing (251.4 kgha^{-1} and 221.2 kg ha^{-1}, respectively), and decreased seed yields with a further increase in row spacing to 50 cm (194.6 kg ha^{-1}). Askarian *et al.* (1995) showed that the highest seed yield was obtained by sowing the crop at a spacing of 45 cm (177.0 kg ha^{-1}), with seed yield decreasing as the row spacing increased to 60 cm (149.0 kg ha^{-1}) or decreased to 30 cm and 15 cm (166.0 kg ha^{-1} and 136.0 kg ha^{-1}, respectively). Similarly, Stanisavljevic *et al.* (2007) reported that medium plant density (343.6 kg ha^{-1}) gave the highest yields, as opposed to high and low row spacings that induce declining yields.

Number of inflorescences per stem

The number of inflorescences per stem was highest at the widest row spacing (14.39 inflorescences/stem) and lowest at the 20 cm spacing (9.94 inflorescences/stem). In this study, the second year gave the highest number of inflorescences per stem (15.43 inflorescences/stem), as opposed to the crop establishment year (2010) yielding the lowest number (8.93 inflorescences/stem), whereas 13.61 inflorescences per stem were reported for the third year (tab. 2).

Table 2. Seed yield, inflorescences per stem, pods per inflorescence, grains per pod, 1000-seed weight and shooting potential (2010-2013).

Year	Row spacing	Seed yield kgha^{-1}	Yield components			Quality components	
			Inflor. per stem	Pods per inflorescence	Grains per pod	1000-seed yield	Shooting potential
2010	20 cm 40 cm 60 cm	180.35	7.92	4.32	3.05	2.02	89.75
		141.75	8.85	6.25	3.65	2.07	91.50
		131.75	10.01	6.07	3.70	2.08	92.25
average		151.19	8.93	5.55	3.46	2.06	91.17
LSD 0.05		17.78	0.56	0.32	0.19	0.038	1.56
0.01		23.65	0.75	0.42	0.25	0.050	2.07
2011	20 cm 40 cm 60 cm	232.77	11.25	5.95	3.68	2.00	84.25
		288.77	17.08	7.27	3.80	2.03	87.75
		255.46	17.95	8.32	4.10	2.07	89.25
average		259.00	15.43	7.18	3.88	2.03	87.08
LSD 0.05		21.15	1.18	0.34	0.25	0.036	1.44
0.01		28.13	1.57	0.46	0.33	0.048	1.90
2012	20 cm 40 cm 60 cm	446.33	10.65	7.45	4.18	1.99	77.50
		502.57	14.95	10.25	4.45	2.02	78.25
		407.55	15.22	10.05	4.75	2.07	79.25
average		452.15	13.61	9.25	4.46	1.98	78.33
LSD 0.05		26.33	0.94	0.55	0.29	0.030	1.66
0.01		35.02	1.25	0.73	0.38	0.039	2.21
average 2010-2013	20 cm 40 cm 60 cm	286.48	9.84	5.96	3.64	1.99	83.83
		311.03	13.62	7.92	3.96	2.02	85.83
		264.83	14.39	8.14	4.18	2.05	86.92

Number of pod per inflorescence

Pod number per inflorescence ranged from 5.96 (20 cm row spacing) to 8.14 pods per inflorescence (60 cm row spacing). In terms of years, the highest number of pods per inflorescence was observed in the third year (9.25 pods/inflorescence), which was the most favourable year for seed production, and the lowest in the first year (5.55 pods/inflorescence).

Number of grains per pod

The 60 cm and 20 cm row spacings resulted in the highest and lowest number of grains per pod (4.18 and 3.64 grains/pod, respectively). The highest number of grains per pod (4.46 grains/pod) was produced in the third year, and the lowest – in the first year (3.46 grains/pod). Karagic (2004) reported an average of 9.66 inflorescences per stem, 9.03 pods per inflorescence and 5.47 seeds per pod in the second and third years of alfalfa growth. Ilic (2005) obtained 14.0 inflorescences per stem on average in 17 genotypes, whereas Djurovic *et al.* (2007) produced an average of 9.37 inflorescences per stem, 7.31 pods per inflorescence and 5.53 grains per pod in 5 genotypes.

Thousand-seed weight

Thousand-seed weight is an important seed quality component indicating seed size and seed fill. The highest average thousand-seed weight (2.05 g) was obtained at 60 cm, and the lowest (1.99 g) at 20 cm (tab. 2.). Thousand-seed weight was highest in the first year (2.06 g) and lowest in the third year (1.98 g). The finding that wide row spacings increase thousand-seed weight was confirmed by Erić (1988), Lovato and Montanari (1991), Vučković (1994), Askarian *et al.* (1995) etc. In terms of years, thousand-seed weight ranged from 2.02 g (2003) to 2.10 g (2001), suggesting the effect of environmental conditions during seed production.

Conclusion

The three-year results of the present study suggest the following:

Row spacing had an important effect on seed yield, which ranged from 264.83 kgha^{-1} (60 cm row spacing) to 311.03 kgha^{-1} (40cm row spacing). Regarding years, seed yield ranged from 151.19 kgha^{-1} in the crop establishment year to 452.15 kgha^{-1} in the third year. Number of inflorescences per stem was highest at 60 cm (14.39) and lowest (9.94) at 20 cm.

The highest numbers of pods per inflorescence and grains per pod were obtained at 60 cm (8.14 and 4.18, respectively) and the lowest at 20 cm (5.96 and 3.64, respectively).

The average thousand-seed weight was highest at 60 cm (2.05 g), and lowest (1.99 g) at 20 cm. Its values ranged from 1.98 g in the third year to 2.06 g in the stand establishment year, depending on environmental conditions.

The average seed germination rate ranged from 91.17% in the first year to 78.33 % in the third year. At a row spacing of 60 cm, the average value for seed germination rate was 86.92 %, whereas narrow row spacing (20 cm) induced a decline in seed germination rate to 83.83 %. This indicates an important effect of row spacing on seed germination rate.

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