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Review article

THE EFFECT OF VEGETATION AREA SIZE ON GRASS SEED YIELD

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Abstract: This paper surveys sowing norms (row spacing and seed rate) in both our country and the world, as well as the optimal seed rates in grass seed production. It gives a short overview of row spacings and seed rates applied in our and some other countries. Earlier, grass cultivated for the purpose of seed production was grown on small vegetation area. According to some researches, high seed yields can be achieved by cultivating grass on large vegetation area.

Based on the results obtained, it can be concluded that the highest cocksfoot, timothy, meadow fescue, tall fescue seed yield was achieved with plants grown in 50 cm spaced rows employing lower seed rates (8 and 4 kg/ha of seeds). The highest Italian ryegrass and perennial ryegrass seed yield was achieved with plants grown in 20 cm spaced rows employing 20 kg/ha of seeds.

Key words: grass, seed yield, vegetation area.

I n t r o d u c t i o n

The major factors of the slow spreading of grass seed production in our country are low and unstable yields due to an inadequate cultivation technology. Row spacing and sowing rates are known to be the major factors affecting grass seed yield. Row spacing, i.e. an optimal number of plants per unit area is of major importance in both seed and forage production. The number of plants per unit area can be affected by row spacing and seed rate. A smaller number of plants per unit area is obtained in wide spaced rows using smaller seed rates. A greater number of plants per unit area is obtained in narrow spaced rows using higher seed rates.

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According to numerous investigators in Yugoslavia and abroad, highest grass seed yields were achieved with wide spaced rows using smaller seed rates (Kellner et al., 1979; Nordestgaard, 1979; Zhyamaitis and Malinauskas, 1985; Kellner, 1975; Hanyuev and Behbudov, 1974; Schoberlein, 1980; Fišakov, 1984; Orsi and Talamucci, 1975; Popov and Tomov, 1974; Ivany, 1984; Kopriva, 1980; Polovoi, 1975; Ramoševac and Sarić, 1987; Evseev, 1975;Zhurablev, 1975; Hayes, 1976; Mikhailichenko and Svetlichnyi, 1985; Craiu and Baleanu, 1979; Kostov and Diokov, 1976; Vučković et al., 1999; Vučković et al., 1999; Vučković et al., 2002; Vučković et al., 1998).

However, according to numerous research, high seed yields may also be achieved by cultivating grass on smaller vegetation area (Jarvi, 1982; Nordestgaard, 1975; Popovici et al., 1980; Janovszky, 1983; Yang et al., 1985; Timirgaziu, 1975; Timirgaziu and Mazareanu, 1976; Pritsch and Rosell, 1982; Hryncewicz et al., 1983; Kval-Engstad and Wolner, 1986; Nordestgaard, 1986; Nordestgaard, 1988; Balan et al. 1979; Popov, 1977; Fišakov, 1984; Vučković et al., 1998; Vučković et al., 1998).

The main purpose of this project would be to find the optimum number of plants per unit area for the succesful production of grass seeds. In this paper it is especially wanted to emphasize differences in size of vegetation space for grass crop growing, under various agroecological conditions of some world production regions. It is also wanted to emphasize the results of contemporary research in the world and in our country.

Results and Discussion

Influence of row spacing and sowing rate on cocksfoot *(Dactylis glomerata* L.*)* seed yield

According to numerous investigators in Yugoslavia and abroad, the highest cocksfoot seed yields were achieved with wide spaced rows using smaller seed rates (Kellner et al., 1979; Nordestgaard, 1979; Kellner, 1975; Hanyuev and Behbudov, 1974; Popov and Tomov, 1974; Kopriva, 1980). Based on the results by Zhyamaitis and Malinauskas (1985), the highest cocksfoot seed yields were achieved in 45 cm spaced rows using 6-7 kg of seeds per ha. According to Fišakov (1984), 50 cm spaced rows produces highest seed yields. Based on the results obtained by Schoberlein (1980), the highest cocksfoot seed yields were achieved in 25-33 cm spaced rows using 5-6 kg of seeds per ha. According to Orsi and Talamucci (1975), 5 kg of seeds per ha in 40 cm spaced rows produces highest cocksfoot seed yields. According to Ivany (1984), 40-60 cm spaced rows produces the highest seed yields.

Vučković et al., 1999, studied the effect of row spacing on cocksfoot seed yield under the agroecological conditions of Srem.

T a b. 1. - Influence of row spacing and sowing rate on cocksfoot seed yield kg/ha (Vučković et al., 1999)

Row spacing	1997.			1998.		
	Sowing rate per row					
	1.4 g/row	0.7 g/row	Average	1.4 g/row	0.7 g/row	Average
20 cm (A1)	454.6	529.3	492.0	510.1	589.3	549.7
50 cm (A2)	**713.2**	626.4	**669.8**	**822.1**	625.3	**723.7**
Average	583.9	577.9	(580.9)	666.1	607.3	(636.7)

The highest cocksfoot seed yield was achieved with plants grown in 50 cm spaced rows employing 8 kg/ha of seeds (713.2 and 822.1 kg/ha in 1997 and 1998 respectively). Substantially lower yields were achieved with plants sown in narrow spaced rows employing larger sowing rates. In 1997 and 1998 plants sown in 50 cm spaced rows yielded 669.8 and 723.7 kg/ha of seeds, respectively. In 20 cm spaced rows plants yielded 492.0 and 549.7 kg/ha of seeds, respectively.

Influence of row spacing and sowing rate on timothy *(Phleum pratense* L.*)* seed yield

According to numerous investigators in Yugoslavia and abroad, the highest timothy seed yields were achieved with wide spaced rows using smaller seed rates (Polovoi, 1975; Kopriva, 1980). Based on the results obtained by Ramoševac and Sarić (1987), the highest timothy seed yields were achieved in wide spaced rows using 5 kg of seeds per ha. However, according to numerous researches, high seed yields can also be achieved by cultivating grass on smaller vegetation area (Nordestgaard, 1975). According to Jarvi, (1982) timothy seed yield was significantly higher with 12,5 cm then with 37.5 cm spaced rows. Based on the results reported by Popovic i et al. (1980), the highest timothy seed yields were achieved in 25 cm spaced rows using 4-6 kg of seeds per ha.

Vučković et al., 1999, studied the effect of row spacing on timothy seed yield under the agroecological conditions of Srem.

T a b. 2. - Influence of row spacing and sowing rate on timothy seed yield kg/ha (Vučković et al., 1999)

Row spacing	1997.			1998.		
	Sowing rate per row					
	1,4 g/row	0,7 g/row	Average	1,4 g/row	0,7 g/row	Average
20 cm	350.7	397.6	374.2	523.7	576.8	550.3
50 cm	453.2	443.2	448.2	684.1	709.4	**696.8**
Average	402.0	420.4	(411.2)	603.9	643.1	(623.5)

The highest timothy seed yield was achieved with plants grown in 50 cm spaced rows employing 8 kg/ha of seeds (453.2 kg/ha) in 1997 and employing 4 kg/ha of seeds (709.4 kg/ha) in 1998, respectively. Substantially lower yields were achieved with plants sown in narrow spaced rows (20 cm) employing larger sowing rates (10 and 20 kg/ha). In 1997 and 1998 plants sown in 20 cm spaced rows yielded 374.2 and 550.3 kg/ha of seeds, respectively. In 50 cm spaced rows plants yielded 448.2 and 696.8 kg/ha of seeds, respectively.

Influence of row spacing and sowing rate on meadow fescue *(Festuca pratensis* Huds.*)* seed yield

According to numerous investigators, the highest meadow fescue seed yields were achieved with wide spaced rows (40-60 cm) and lower seed rates (Evseev, 1975; Zhurablev, 1975). However, high seed yields may also be achieved by cultivating meadow fescue on smaller vegetation area (Janovszky, 1983).

Vučković et al., 2002, studied the effect of row spacing on meadow fescue seed yield under the agroecological conditions of Srem.

T a b. 3. - Influence of row spacing and sowing rate on meadow fescue seed yield kg/ha (Vučković et al., 2002)

Row spacing	1997			1998		
	Sowing rate per row					
	1.4 g/row	0.7 g/row	Average	1.4 g/row	0.7 g/row	Average
20 cm	489.4	566.7	528.1	663.1	742.5	702.9
50 cm	724.3	647.7	686.0	897.4	710.6	804.0
Average	606.9	607.2	(607.1)	780.4	726.6	(753.5)

The highest meadow fescue seed yield (724.3 and 897.4 kg ha^{-1} in 1997 and 1998, respectively) was achieved with plants grown in 50 cm spaced rows employing 8 kg ha^{-1} of seeds. Substantially lower yields were achieved with plants sown in narrow spaced rows employing larger sowing rates. In 1997 and 1998 plants sown in 20 cm spaced rows yielded 528.1 and 702.9 kg ha^{-1} of seeds, respectively. In 50 cm spaced rows plants yielded 686.0 and 804.0 kg ha^{-1} of seeds, respectively.

Influence of row spacing and sowing rate on tall fescue *(Festuca arundinaceae Schreb)* seed yield

Under the agroecological conditions of Romania tall fescue has been grown in rows 60-120 cm apart at sowing rates providing plant densities of 80-120 plants/m^2 (Kellner, 1975). Higher seed yields were reported in 18 cm spaced rows (742 kg/ ha of seeds) then with 24 and 12 cm (610 and 700 kg/ ha of seeds).

Optimal seed yields (830 kg/ha) were recorded in 18 cm spaced rows using 25 kg/ha of seed. Less favourable yields were achieved at the rate of 10, 15 and 20 kg/ha of seeds (Yang et al., 1985). According to numerous investigators, the highest tall fescue seed yields were achieved with wide spaced rows and lower seed rates (Hayes, 1976; Mikhailichenko and Svetlichnyi, 1985). According to Orsi and Talamucci (1975), the highest seed yields were achieved with 60 cm spaced rows (860 kg/ha of seeds). Lower yields were achieved with 20 and 40 spaced rows (690 and 750 kg/ha of seeds). Fodder yields decreased with increasing distance between rows. Tall fescue average seed yields were 1240 kg/ha seed with 12.5 cm spaced rows and 900 kg/ha seed with 70 cm spaced rows (Timirgaziu, 1975).

Vučković et al., 1998, studied the effect of row spacing on tall fescue seed yield under the agroecological conditions of Srem.

T a b. 4. - Influence of row spacing and sowing rate on tall fescue seed yield kg/ha (Vučković et al., 1998)

Row spacing	1995			1996		
	Sowing rate per row					
	1.4g/row	0.7g/row	Aver.	1.4g/row	0.7g/row	Aver.
20 cm	441.4	499.8	470.6	550.0	620.2	585.1
50 cm	485.4	570.8	528.1	660.5	700.7	680.6
Aver.	463.4	535.3	499.3	605.3	660.4	632.8

Based on the obtained data, it can be concluded that the highest tall fescue seed yields were achieved on a larger vegetation area considering both trial years. In 1995 and 1996 yield amounted to 470.6 and 585.1 kg ha^{-1} in 20 cm spaced rows, respectively. On the other hand, in 50 cm spaced rows seed yield amounted to 528.1 and 680.6 kg ha^{-1} in 1995 and 1996, respectively. Based on the results obtained, it can be concluded that the highest tall fescue seed yields were achieved in 50 cm spaced rows by employing 4 kg of seeds ha^{-1}. In 1995 and 1996 yield amounted to 570.8 and 700.7 kg ha^{-1} in 50 cm spaced rows by employing 4 kg of seeds ha^{-1}.

Influence of row spacing and sowing rate on Italian ryegrass *(Lolium italicum A. Br.)* seed yield

Under the agroecological conditions of Italy, Italian ryegrass average seed production was 1.03 and 0.89 t/ha with 5 and 10 kg/ha seed, respectively, and it was 1.06, 1.02 and 0.81 t/ha with rows 20, 40 and 60 cm apart (Orsi and Talamucci, 1975). According to Craiu and Baleanu (1979) with sowing rate increasing, seed yields ranged from 1.71 to 1.91 t/ha in rows 12.5 cm apart and from 1.86 to 2.06 t/ha in rows 42 cm apart at the 1st cut and from 396 to

329 kg/ha in rows 12.5 cm apart and from 527 to 438 kg/ha in rows 42 cm apart at the 2nd cut. Germination and germination speed were greater in seeds from plants grown in rows 42 cm apart than in seeds from plants grown in rows 12.5 cm apart. In trials during 3 years, *L. italicum* grown in rows 10, 30 or 50 cm apart and used for seed production in the 1st or 2nd cut gave the highest average seed yields when grown in rows 30 cm apart, 1.64 t/ha in the 1 st cut and 1.38 t/ha in the 2nd cut (Kostov and Diokov, 1976). According to numerous investigators, the highest Italian ryegrass seed yield were achieved with narrow spaced rows and with larger sowing rates (Timirgaziu and Mazareanu, 1976; Pritsch and Rosell, 1982; Hryncewicz et al., 1983; Kval-Engstad and Wolner, 1986; Nordestgaard, 1986; Nordestgaard, 1988).

Vučković et al., 1998, studied the effect of row spacing on Italian ryegrass seed yield under the agroecological conditions of Srem.

T a b. 5. - Influence of row spacing and sowing rate on Italian ryegrass seed yield kg/ha (Vučković et al., 1998)

Row spacing	1995			1996		
	Sowing rate per row					
	1.4g/row	0.7g/row	Aver.	1.4g/row	0.7g/row	Aver.
20 cm	285.7	242.8	264.2	260.1	280.2	270.1
50 cm	185.7	157.1	171.4	180.4	180.6	180.5
Aver.	235.7	199.9	217.8	220.2	230.4	225.3

Based on the obtained data, it can be concluded that the highest Italian ryegrass seed yields were achieved on smaller vegetation area considering both trial years. In the first and the second year the rows 20 cm apart averaged significantly higher seed yield than rows 50 cm apart. In 1995 and 1996 yield amounted to 264.2 and 270.1 kg/ha in 20 cm spaced rows, respectively. On the other hand, in 50 cm spaced rows seed yield amounted to 171.4 and 180.5 kg/ha in 1995 and 1996, respectively. Based on the results obtained, it can be concluded that the highest Italian ryegrass seed yields were achieved in 20 cm spaced rows. In 1995 and 1996 yield amounted to 285.7 and 280.2 kg/ha in 20 cm spaced rows by employing 20 and 10 kg/ha of seeds.

Influence of row spacing and sowing rate on perennial ryegrass *(Lolium perenne L.)* seed yield

Row spacing and sowing rate are known to be the major factors affecting perennial ryegrass seed yield. According to Popov (1977), perennial ryegrass seed yield was significantly higher with 11 cm (1690 kg/ha) compared with 50 cm spaced rows (1320 kg/ha). Kellner (1975) concluded that the most favourable yields were achieved with optimal population density of 120-160 plants per m^2

and with 20-60 cm spaced rows. According to Schoberlein (1980), the most favourable results in the production of perennial ryegrass seeds were obtained by sowing in wide spaced rows (20 cm) using 6-11 kg of seeds per ha. According to Fišakov (1984), the most favourable results in perennial ryegrass seed production were obtained by sowing in wide spaced rows (25 cm) using 20 kg of seeds per ha.

Vučković et al., 1998, studied the effect of row spacing on perennial ryegrass seed yield under the agroecological conditions of Srem.

Tab. 6. - Influence of row spacing and sowing rate on perennial ryegrass seed yield kg/ha (Vučković et al., 1998)

Row spacing	1995			1996		
	Sowing rate per row					
	1.4g/row	0.7g/row	Aver.	1.4g/row	0.7g/row	Aver.
20 cm	750.6	638.4	694.5	560.3	511.2	535.7
50 cm	346.7	320.2	333.5	464.1	468.7	466.8
Aver.	548.6	479.3	(513.9)	512.2	489.9	(501.1)

The highest perennial ryegrass seed yield was achieved with plants grown in 20 cm spaced rows employing 20 kg/ha of seeds (750.6 and 560.3 kg/ha in 1995 and 1996 respectively). Substantially lower yields were achieved with plants sown in wider spaced rows employing lower sowing rates. In 1995 and 1996 plants sown in 20 cm spaced rows yielded 694.5 and 537.7 kg/ha of seeds, respectively. In 50 cm spaced rows plants yielded 333.5 and 466.4 kg/ha of seeds, respectively.

Conclusion

Based on the results obtained, it can be concluded that highest cocksfoot, timothy, meadow fescue, tall fescue seed yield was achieved with plants grown in 50 cm spaced rows employing lower seed rates (8 and 4 kg/ha of seeds).

The highest Italian ryegrass and perennial ryegrass seed yield was achieved with plants grown in 20 cm spaced rows employing 20 kg/ha of seeds.

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UTICAJ VELIČINE VEGETACIONOG PROSTORA NA PRINOS SEMENA TRAVA

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R e z i m e

U radu je dat pregled setvenih normativa, načina setve i količine semena, u našoj zemlji i u svetu, najoptimalnije količine semena pri setvi u proizvodnji semena trava. Takođe je dat kratak osvrt na način i gustinu setve koji se primenjuje u našoj zemlji i nekim zemljama sveta. U ranijem periodu su se biljke za proizvodnju semena gajile na manjem vegetacionom prostoru. Međutim, istraživanja ukazuju da se visoki prinosi semena trava mogu postići pri gajenju biljaka na većem vegetacionom prostoru.

Na osnovu provedenih istraživanja o uticaju načina i gustine setve na prinos semena trava moguće je zaključiti da se visok prinos semena ježevice, mačijeg repa, livadskog vijuka, visokog vijuka postiže setvom semenskog useva na 50 cm i primenom nižih doza semena (od 8 do 4 kg/ha). Visok prinos semena italijanskog i engleskog ljulja se postiže setvom na međuredno rastojanje od 20 cm između redova i primenom 20 kg/ha semena.

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