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Effect of Row Spacing and Seeding Rate on Yield Component and Seed Yield of Alfalfa (*Medicago sativa* L.)

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Abstract

In order to investigation the effect of row spacing and seeding rate on alfalfa (*Medicago sativa* L. cv. 'Mesasirsa') an experiment was carried out at the research farm of Khouzestan Agricultural Research Center from 2000 to 2004. This research was conducted in the form of a split plot design in a randomized complete block, with four replications. Main plot was three row spaces (50, 60 and 70 cm) and sub plots were five seeding rates (5, 10, 15, 20, and 25 kg seed ha^{-1}). Results showed that the highest seed yield obtained in the second year. Seed yield and raceme per m^2 increased with row spacing decreased. Seeding rate did not have any significant effect on pod per raceme, seed per pod and seed weight. The interaction of year and treatments on whole of traits were not significant. It was observed that correlation among seed yield and yield components was positive and significant. It was concluded that with using 15 kg seed ha^{-1} obtained highest seed yield due to increase in raceme per m^2 and seed weight.

Keywords: alfalfa, row spacing, reeding rate, reed yield components, reed yield

Introduction

Alfalfa is a cross infertile from legume grasses. In Iran, planted Alfalfa plot is more than 6.6 thousand header. This plant is cultivated in the most areas of country but North West provinces such as Eastern Azerbaijan and Ardabil allocate 35.7% of this plot (Bolanos-Aguilar *et al.,* 2000; Ministry of Agriculture, 2006). To improve cultivating plant, suitable and enough seed is needed. Most of the areas of country are dry and semiarid; also Alfalfa is one of the main grass plants which is cultivated in dry areas to produce planting seed. Although the condition of this areas provide suitable situation especially in production stage, but Alfalfa seed producing has a little stability and differs from place to place and year to year (Karimi, 1990; Koocheki *et al.,* 1987.) Because seed yield in plot unit is a dependent of seed yield of any plant and plant number in plot unit, so row spacing and seed rate is considered as an important element in seed producing (Koocheki and Marashi, 1989). High bash density is the result of challenge between Alfalfa bashes, which has an undesirable effect on germination and production organs. In the different experiments, low bush density and in creasing the row space is mentioned as an important element in increasing Alfalfa seed production (Koocheki *et al.,* 1987; Kowithayakorn and Hill, 1982; Melthon *et al.,* 1979). Low density of bushes decreases the plant challenge from light, nutrition and water point of view, so strong bushes and more branches are produced, finally they will have more flowered branches (Koocheki and Marashi, 1989). Desirable row spaces depends on different soil elements (tissue, depth, fertility, accessible humidity, soil and water temperature), duration of plant growth season, Alfalfa long life and Alfalfa figures.

Usually because of producing small bushes in shallow and clay soil, row spaces in cultivating Alfalfa seed is considered 40 up to 90 cm (Karimi, 1990). According to the studies of Krayo (1987) on seed yield of Red clover, high seed yield relates to 50 cm row space. Lovato and Mountainair (1987) reported that increasing the row space increased the seed yield and the best yield relates to 50 cm. one of the other elements, which should be considered significant in seed harvesting of Alfalfa, is seed rate, plant space or cultivating rows on the other words. High density of bushes on rows has undesirable effect on production rate. By cultivating low seed rate and thinly scattered bushes, density can be controlled and decreased the bad effect of bush high density. Results of Pedersen and Nye (1962) cleared that increasing seed rate decreased the number of raceme of each bush and seed in raceme.

In another experiment (Since, 1992) resulted that low seed rate causes more seed yield and this case was related

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to increasing stem, raceme number in m^2 also heavier seed weight. In different countries, various even contradictory recommendations have obtained about row space and seed rate (Askarian and Hampton, 1993; Kowithayakorn and Hill, 1982; Lovato and Mountainair, 1987; Pedersen and Nye, 1962). In Newsstand, for example to seed harvesting Alfalfa, row spaces 9-18 cm and seed rate 6-12 kg/hectare by Wynn-Williams and Palmer (1974) and 75 cm and 1 kg/hector by Dunbier (1983) was recommended, although they didn't suggested any special reason to improve it. On the other hand, in United States row space from 60-150 cm and seed rate from 0.5 up to 2 kg/hectare was reported (1969). Seed yield is the result of several parts, which are gained during different growth stages. Seed yield components consist of raceme number per unit, number of pod per raceme, number of seed per pod, and seed weight.

Among the yield components, usually the number of racem per unit and seed weight accepts the highest and lowest effect of environment condition (Askarian *et al.*, 1995; Ozlem and Geren, 2007). According to the research on clover, Abadouz (1999) concluded that the number of festoon per m^2 has the most correlation with seed yield, so that this characteristic was the important part of explanation of seed yield. The aim of this experiment was determine the most suitable space between rows and seed rate until it can produce the most seed yield.

Materials and methods

This experiment carried out for 4 years from 1379, which was the first cultivating year. The place of experiment was Agriculture Research station in the south west of Ahwaz with 31° 20° latitude, 48°, 40° longitude and18 m from sea level. The results of tablet 1 shows that soil condition was mostly suitable based on salinity and acidic level, weak based on azotes and phosphor, average based on potassium and the soil tissue was silt clay Long time average data of mete urology (from 1951 up to 2005) and three year experiments are gathered in Tab. 2. For preparing seedbed, plough, distribution of 300 kg/hectare phosphate Ammonium fertilizer, vertical disk, leveling and creating furrow had been done.

This research was conducted in the form of a split plot design in a randomized complete block with three replication. Treatments including row space at three levels (50, 60, 70 cm) were the main plot and seed rate at five levels (5, 10, 15, 20, 25 kg seed per hectare) was the sub plot. Any sub plot consist of 6 planting row with 10 m long, space between two treatment considered 1 m and between repetitions 2 m. Planted figure was 'Mesasirsa Alfalfa' which cultivated handily in the 2-3 cm depth in 10 the September 1979. The first year considered as a establishment year and taking notes had been done during second up to forth years. Watering farms depends on air condition had been done one time any 9-12 day during cold season and any 5-7 day during warm seasons. During plant, growing time in January mutilating poison was used to fight against snail and hand weeding had been done to repel weed. During each experimental year in the middle of February with the aim of seed harvesting from farm, it did not harvesting to enter growth stage. Therefore, flowering and seed taking time was the first half of April and end June respectively. For measuring the number of raceme in m^2 at the top of flowering time which was the middle of may (average of three times by one weak among them) moderate 0./5 m^2 was used to take note of any sub plot randomly. To measure the number of pod in raceme and seed in pod 50 racemes was choose randomly of any sub plot and after counting the pods of one raceme, they were grinded by hand and the seeds of one pod were calculated. For measuring seed, weight of each treatment 10 number was selected. Balance with 0/001 senility was used. To deter mine the seed yield, the third and forth rows of sub plot by omitting 0.5m of each sod was selected. After taking crops, bushes were dried in natural environment then pods were separated by hard and grinded. After it, the seeds were cleaned and distributed by experimental sieves and Blower. To analyze statistically, MSTATC compound, to compare averages LSD was used. For determine the correlation between adjectives, Pearson method and regression equivalence two by two and step by step by MINITAB was applied.

Results and discussion

Year effect

Results of compound variance analysis tablet showed that the year effect on any traits was meaningful at 1% probability level (Tab. 3).

Results of Tab. 4 showed that at the third year, the number of most measured traits was less rather than second and forth years. Seed yield was significantly more in second experimental year rather than other. At the final three experimental years seed yield was 812.5, 426.6 and 573.7 kg/hectare respectively. The same result obtained for the number of raceme in m^2. The most number of racemes in m^2 during second year was 1174. Long-term aero logy data (average of 55 years) and experimental year was more than 55 years averages in most months. Comparing different months among experimental years showed that April (March-April) which was coincident with beginning

Tab. 1. Soil details of farm before experiment

Soil tissue	Sand %	Silt %	Clay %	Karate	P%	N%	Aced crate	Salinity rate	Sampling depth of soil
	12	42	46	184	4.9	0.67	7.6	3.9	0-30
	10	41	49	171	3.4	0.45	7.9	2.7	30-60

Tab. 2. Average of highest and lowest temperature, raining and sunny hours for 55-year averages and experiment years

	Lowest and highest monthly temperature (centigrade)													
	L	h	L	h	L	h	L	h	L	h	L	h	L	H
55 ear average	18.5	35.9	12.8	26.5	8.5	19.4	7.2	17.5	8.6	20.3	12.3	25.2	17.4	32/1
Second year	2.5	1.2	-.7	0.2	4. 2	1.2	0.7	-0.3	0.7	1.2	1.7	2.2	1.1	-1/7
Third year	2.7	2.2	1.2	0.3	1.7	-0.1	1.6	-1.1	1.9	1.2	0.7	0.5	2.6	1/6
4th year	3.1	1.3	0.4	0.4	2.1	-0.2	3.9	1.6	1.8	1.0	2.6	3.7	0.3	-1/3
	Total raining rate (mm)													
55 ear average	6.6		31.9		48.5		49.8		27.6		28.3		15.3	208
Second year	-2.4		-19.2		83.2		-7.9		-1.6		-14.3		24.7	62.5
Third year	-6.6		-17.4		-13.6		-4.6		-3.2		-4.1		5.3	-44.2
4th year	-6.6		42		-18.3		76.1		-14.4		-15.1		6.7	58.7
	Total sunny hours													
55 ear average	264.1		207.2		173.4		172.8		197.8		210.9		234	1460.2
Second year	10.3		27.4		-11.2		25.8		22.9		40		-42.9	72.3
Third year	10.1		27.6		6.9		27.9		6.3		-17.5		-2.9	58.4
4th year	-0.7		10.7		-13.1		0.3		25.2		46.4		2.8	71.6

of flowering in second and forth experimental years had the less high temperature rather than long-term averages. Raining rate during second and forth years was more than third year and 62.5 and 58.7 mm more than long-term averages respectively. In addition, all of sunny hours from Day to march during second and forth years were more than third year and long-term average (Tab. 2). According to the information, it can be said that cool temperature during flowering time under hot temperature condition of Khuzestan, high raining during growth period and most sunny hours provided suitable condition to pass germination stage and enter reproductive one, high photosynthesize and reproductive limbs production, pollination and better fertilization of flowers condition and sending more materials to reproductive branches. Results of different resources show that because of growing yield components, seed yield takes effect of environment condition very much (Karimi,1990; Askarian *et al.,* 1995, Bolanos-Aguilar *et al.,* 2000).

Number of raceme per m²

Studding the effects of space factor between rows and seed rate on raceme per m² showed that these elements were meaning fully effective on raceme number per m² (Tab. 3). Taylor and Mirabel (1986) reported that raceme number in plant was the main part of Alfalfa seed yield. In addition, Juza (1971) announced that the number of festoon in plant was the most changeable adjective between grains yield component, which depends on plant density. Comparing averages revealed that raceme number per m² decreased when row space increased and the highest raceme number relates to 50 cm space between rows(Tab. 4.) Experiment results in New Zeeland showed that the most Alfalfa raceme number per m² obtained at 60 cm row space (Askarian *et al.,* 1995). Seed rate results showed that by increasing seed rate up to third level (15 kg seed per hectare), raceme number per m² increased and then decreased (Tab. 4).

Askarian *et al.* (1995), Reprove and Zolotarev (1988) showed that by increasing seed rate, festoon number de-

Tab. 3. Summary of compound valance analysis related to yield components per m² and Alfalfa seed yield of 'Mesasirsa' figure during year treatments, row space and seed rate

Change source	Freedom rate	Quadrate average of studied adjectives				
		Raceme number per m²	Pod per raceme	Seed per pod	Seed weight	Seed yield
Year	2	1067206.20**	15.09**	6.00**	0.278**	1706975.70**
Year x repetition	6	24323.82	29.65**	0.217	0.013	1038.80
Row space	2	1404680.60**	1.12	4.157**	0.115**	115940.70**
Row space x year	4	7104.80	0.111	0.255	0.013	10919.90
Error	12	8631.52	2.90	0.575	0.014	4913.80
Seed rate	4	203954.57**	0.098	0.070	0.020	84229.90**
Seed rate x year	8	2470.12	0.007	0.005	0.001	1840.00
Seed rate x row space	8	7040.77	0.030	0.003	0.002	2535.10
Year x seed rate x	16	13496.22	0.004	0.003	0.004	5032.80
Row space error	72	6603.26	0.877	0.272	0.034	5783.10
		8.13	12.74	11.92	6.65	12.59

** Meaningful in 1% probability level.

Tab. 4. Comparing yield component averages and Alfalfa seed yield of 'Mesasirsa' figure during experimental years and row space and seed rate treatments.

Studied adjectives		Raceme per m^2	Pod number per raceme	Seed number per pod	Seed weight	Seed yield (kg/ hectare)
Year	Second year	1174 a	7.9 a	4.8 a	2.88 a	812.5 a
	Third year	879.9 c	6.8 b	4.2 b	2.73 b	426.6 c
	4^{th} year	946.1 b	7.4 a b	4.1 b	2.75 b	573.7 b
	LSD rate	42.7	0.8	0.3	0.1	32.2
Row space (cm)	50	1186.7 a	7.2 a	4.7 a	2.70 b	656.7 a
	60	989.1 b	7.5 a	4.3 a b	2.80 a	600.7 b
	70	828.1 c	7.3 a	4.1 b	2.83 a	555.4 c
	LSD rate	42.7	0.8	0.3	0.1	32.2
Seed rate (kg/ hectare)	5	885.3 c	7.3 a	4.4 a	2.76 a	533.1 c
	10	993.8 b	7.3 a	4.4 a	2.78 a	603.4 b
	15	1126 a	7.4 a	4.4 a	2.82 a	683.1 a
	20	1022 b	7.4 a	4.3 a	2.82 a	624.9 b
	25	972.3 b	7.3 a	4.3 a	2.77 a	567.7 b c
	LSD rate	44.1	0.5	0.3	0.1	41.2

Averages with same letters in each column have meaningful differences in 0/5% probability level.

creased meaningfully. Reprove and Zolotarev (1988) related decreasing seed yield in high density to decreasing pod number per m^2 and seed number per pod.

Pod number per raceme

Second indicator related to seed yield is pod number per raceme. Pod number per plant is a main element in producing seed, because it is effective in seed yield. (Abdoli *et al.,* 2004). Variance Analysis tablet results showed that row space and seed rate has no meaningful effect on this category (Tab. 3). Koocheki and Marashi (1989) concluded that decreasing density caused less plant competition on lights, nutritious and humidity, so plants with more stem and leaf were produced, after it, they themselves produced more flower and pod, but Askarian *et al.* (1995) told that seed rate had not meaningful effect on pod number of raceme. Also, another research by Bilgili *et al.* (2003) on rows space and seed rate treatments on *Brassica rapa*: Showed that pod number in main stem hadn't effected by space between rows, but pod number in plant increased by increasing row space obviously and decreased by increasing seed rate.

Seed number in pod

According to Tab. 3 results: row space treatment only created meaningful effect on seed number in pod and different seed rate levels didn't create meaningful differences on seed number in pod Average result differences showed that the seed number in pod increased meaningful when the row space decrease and this was the same as Abadouz (1999) research. Many factors control the production of seed in pod, and seed number in pod clear the plant sink actually. High number of seeds in pod couses the production and storage of more photosynthesis materials, so the yield increases (Abdoli *et al.,* 2004). Seed number in pod is the stables function in grains, on the other words in as a effect less part of seed yield in plant density treatments (Koocheki and Banayane-Aval, 1994; Askarian and Hampton, 1993; Kowithayakorn and Hill, 1982). Seed number in pod did not affected by used seed rate (Tab. 4). It can be said that the number of seed cells is the same in all ovaries, so seed number in pod and decreasing seed number had not the same effect such as festoon number in plant in yield fluctuations (Koocheki and Banayane-Aval, 1994). According to Bilgili *et al.* (2003); Kowithayakornand Hill (1982) and Askarian *et al.,* (1995) seed, rate treatment had not meaningful effect on seed number in pod in Alfalfa plan. In addition, Scarisbrick *et al.,* (1982) concluded that the reason of being meaningless in seed number in pod in high density of rapeseed plant in compensate effect result was decreasing the pod number in each plant.

Seed weight

Seed weight is a adjective related to figure, but its rate can depend on care condition (Koocheki and Banayane-Aval, 1994). Compound variance analysis tablet results showed that row space treatment has meaningful effect on seed weight but seed rate has not meaningful effect on this (Tab. 3). Some researchers believe that seed weight in legume is a part of adjectives that take little effect of environment (Askarian *et al.,* 1995; Bolanos-Aguilar *et al.,* 2000). Tab. 4 results cleared that increasing row space has meaningful rise in seed weight and the most weight produced in 70 cm row space with 2.83 g. According to results, the interpretation can be as follows: by increasing row space, density and plant competition decreased as a result any pod usage of nutrition increased but because the number of seed per pod hadn't sensible change, so it cleared it's effect by increasing seed weight (Tab. 4). Jefroodi *et al.* (2005) reported such a result for Kidney

Tab. 5. Correlation coefficient between yield and Alfalfa seed yield components of 'Mesasirsa' figure

Studied adjective	Seed yield	Raceme number per m^2	Pod number per raceme	Seed number per pod
Raceme number per m^2	0.73**	$0.04^{n.s}$		
Pod number per raceme	0.29**	0.47**		
Seed number per pod	0.41**	$0.11^{n.s}$	$0.06^{n.s}$	
Seed weight	0.23*		$0.01^{n.s}$	$0.04^{n.s}$

** Meaningful in 1% level, *: meaningful in 5% level, Ns: meaningless

Bean. An experiment on Alfalfa showed that less row space rather than high row space produced small seeds by less seed weight (Askarian *et al.,* 1995). Comparing seed rate treatment overages showed that seed weight had not affected by seed rate treatment Tab. 4). Different research results on legume showed that seed rate treatment had not meaningful effect on seed weight (Zand, 1998; Barry *et al.,* 2003; Shirtliffe and Johnston, 2002).

Seed yield

Seed yield in different levels of row space treatment and seed rate showed meaningful differences in 1% probability level (Tab. 3).

Comparing averages cleared that by decreasing row spaces seed yield increased meaningfully, so highest and lowest seed yield relates to 50 and 70 cm row space with 656.7 and 555.4 kg/hectare rate respectively (Tab. 4).

This was the same as Powelson *et al.* (1999); Krayo (1987); Abu Shakra *et al.* (1969) results. Decreasing seed yield by increasing row space because of decreasing the ing seed rate from five up to 15 kg/hectare, seed yield increased but among 20 up to 25 kg seed rate, meaningful differences had not observed. Totally highest and lowest seed yield earned from 5 and 15 kg/hectare seed rate treatment with 683.1 and 533.1 kg/hectare (Tab. 4).

This shows that seed yield increasing cause to increase raceme per m^2 and seed weight. Probably in this level of density, although there is a little competition between bushes, but the plant has enough time to produce more stem and have more reproductive units following it.

Vuckevic (1996) results also showed that highest Alfalfa seed yield obtained of 15 kg seed rate. Zarifinia (2003) according to a research in SafyAbad of Dezful, obtained the highest seed yield of bersim. Clover from 10 kg/hectare by 10 kg seed rate. Other results have showed that by increasing seed rate on row or density, legume seed yield have increased (Abadouz, 1999; Koocheki *et al.,* 1987, Askarian *et al.,* 1995; Lovato and Mountainair, 1987; Smoke, 1992).

Tab. 6. Regression variance analysis of Alfalfa seed yield of 'Mesasirsa'

Change source	Freedom grade	Raceme number per m^2	Pod number per raceme	Seed number per pod	Seed weight
Regression	1	2508546**	397641**	768430**	247345*
Deviation of Regression	133	16207	32078	29290	33208
Total	134				

* meaningful in 5% probability level; ** meaningful in 1% probability level

raceme number per m^2 and seed number per pod can be interpretable. In addition, it seems that in kozestan province suitable condition for producing reproductive limbs such as enough light during reproductive period in less row space is available, so much seed is provided. Increas-

Tab. 7. Simple regression equivalences of seed yield with Alfalfa seed yield components of Mesasirsa separately and step by step

Method	Regression equivalence	
Simple	$Y=-5.8+0.611^{**}X_1$	$R^2=53.8$
Simple	$Y=-341^{**}+35.8^{**}X_2$	$R^2=8.5$
Simple	$Y=66+123^{**}X_3$	$R^2=16.5$
Simple	$Y=-111+257^{n.s}X_4$	$R^2=5.3$
	$Y=-559.1+0.504^{**}X_1+30.3^{**}X_2+129^{*}X_4$	$R^2=60.58$

Ns: meaning less* meaningful in 5% probability level ** meaningful in 1% probability level; In table: Y seed yield, X_1 raceme number per m^2, X_2 pod number per raceme, X_3 seed number per pod.

Correlation and Regression between adjectives

Tab. 5 results showed that seed yield per hectare has positive and meaningful correlation with seed yield components. Bolanos-Aguilar *et al.* (2000) resulted that seed yield correlation in plant became positive and meaningful with all seed yield components. Other researches showed that seed yield had high correlation with the pod seed number and raceme pod. (Hacquet, 1990; Reprove and Zolotarev, 1988; Rossellini *et al.,* 1990), but Askarian et al. (1995); Kowithayakorn and Hill (1982) reported that correlation between seed yield and seed number per pod did not exist in different management condition. Pod seed number had positive and more meaningful correlation with raceme number per m^2 (Tab. 5). Researchers on grain plants cleared that seed number per pod is one of the elements which have the most and stables correlation with seed yield (Pilbeam, 1991; Singh and Mehndiratta , 1969). It seems that although there is a positive relation between raceme number per m^2 and seed per pod, but increasing

raceme number per pod increased seed yield. Regression variance analysis tablet showed that, regression between adjectives of raceme number per m2 and pod number per raceme and seed number per pod in 1% level and only seed weight in 5% level had meaningful differences with each other (Tab. 6).

Simple regression equivalence results of seed yield with each of seed yield components showed that regression equivalence of seed yield with raceme number per m^2 was meaningful in 1% level and had the biggest confection of determination, accordingly, 53.8% seed yield changes interpreted by raceme number per m^2, but also the smallest confection of determination relates to seed yield regression equivalence which it's seed weight rates was about 5.3% and meaningless (Tab. 7).

Conclusions

According to the results, it can be said that seed yield changes and it's components related to the row space and high seed yield was because of raceme number per m^2 and seed weight and pod number per raceme and seed number per pod accepted no or less effect of experimental treatments. The effect of row space showed that in 50 cm row space, because of suitable plant in unit, suitable settlement condition was provided, so the plant could produce more reroductire parts by using light and environment. In addition, seed rate treatment examination reminds that by using 15 kg seed per hectare, more seed yield, because of raceme number per m^2 and more seed weight, was obtained. By using more than 15 kg/hectare seed, growing rate of germination rather than reproductive was increased, so seed yield decreased.

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