



## Studies on seed and forage yield in 10 populations of sainfoin (*Onobrychis sativa*) grown as spaced plants and swards

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Received 10 October 2010, accepted 3 January 2011.

### Abstract

In order to study seed and dry matter (DM) yield and relationships between yield and morphological traits, 10 populations of sainfoin (*Onobrychis sativa*), were assessed in two separate experiments under sward and spaced plant conditions using complete block design with two replications, in Karaj, Iran, during 2004-2007. The data were collected for seed yield, DM yield, plant height, stem number per m<sup>2</sup>, flowering date, inflorescences length and 1000-grain weight. The data were analyzed for individual experiment and combined over two experiments. Results showed significant differences among populations for all of traits except 1000-grain weight in sward and DM yield and stem number in spaced plants. Results of combined analysis showed no significant differences among 2 conditions for both seed and DM yield. However, the average values of 7.3 and 6.2 ton ha<sup>-1</sup> DM yield and 337 and 375 kg ha<sup>-1</sup> seed yield were obtained for sward and spaced plants, respectively. Results showed that, populations of Shahrkord and Kashan with average values of 8.08 and 8.06 ton ha<sup>-1</sup> DM yield and Shahrkord with average values 551 kg ha<sup>-1</sup> seed yield had higher production under sward conditions. For spaced plants, Orumieh and Bijar with average values of 7.98 and 7.67 ton ha<sup>-1</sup> DM yield and Bijar and Esfahan with average values of 510 kg ha<sup>-1</sup> seed yield had higher production. Therefore, the populations of Shahrkord and Bijar were introduced as the best ones for both DM and seed production under swards and spaced plants, respectively. DM yield was positively correlated with seed yield, plant height, stem number and inflorescences length, while seed yield had positive and significant relationships with 1000-grain weight, plant height, stem number and inflorescences length. The relationship between spaced plants and swards as measured by phenotypic correlation was poor for all traits except 1000-grain weight. This suggests that response to selection based on spaced plant data would not be reflected in swards, so, for all characters selection should be based on sward yield.

**Key words:** Sainfoin, *Onobrychis sativa*, forage yield, seed yield, morphological traits, correlation.

### Introduction

Forage legumes constitute herbal vegetation of pasturelands of the country, playing a vital and constructive role in preventing outbreak of destructive floods and also soil erosion. Legumes, with nitrogen stabilization power at root and their fair strength and resistance to conditional tensions, have known as beneficial and fruitful population within the framework of breeding of pasturelands.

According to Flora Iranica, sainfoin in Iran has dispersed from north, northwest, west, central part, northeast and south. Sainfoin grows at almost pasturelands, with over 300 mm rainfall, and enjoys vast adaptation to various climatic conditions <sup>24</sup>.

Since sainfoin enjoys high percentage of contracted tannins, it is the sole herb of Leguminosae population that does not cause flatulence at stomach of animal. Hence, this plant can always be grazed by herds of cattle as livestock feed <sup>11</sup>.

With its contracted tannins, this herb species will cause viscosity of protein molecules at rumen (paunch) of livestock and will free them at small intestine, aimed at being absorbed in the body. For this reason, output of using protein in sainfoin is more than in alfalfa <sup>5</sup>.

Since direct grazing with this species of herb does not cause flatulence, it can be cultivated as pure on dry farming lands and obtained forage can be used at pasture. Attack of pests to *Onobrychis sativa* is less than other forage crops which is regarded as salient specification of the herb. This plant, at the regions where alfalfa weevil (*Hypera postica*) causes remarkable reduction of alfalfa product, is not affected by the pest directly.

Sainfoin can be cultivated on the land areas which are not able to grow alfalfa and clover. Consequently, satisfactory product will be earned as a result of cultivation of *Onobrychis sativa*<sup>16</sup>. With its nitrogen stabilization power in root, this plant does not need consuming nitrogen fertilizer <sup>17</sup>.

Benefiting from genetics and plant breeding science is considered as one of the economical exploitation methods from ranges, pasturelands and farmlands of the country. In the same direction, producing and introducing high-yielding and compatible varieties will cause increase of livestock by-products coupled with development of sustainable agriculture.

Today, increasing of dry matter (DM) yield and producing seed of forage crops has paramount importance and is taken into consideration as one of the most significant objectives in

introducing new variety of sainfoin. For this, introduced forage items should enjoy pleasant and satisfactory seed-yielding potential, aimed at availing to enough seed for development of cultivation of sainfoin.

In some aboriginal and native ecotypes, due to incongruity of appearance of seed sheathes and their drying and falling, yield of sainfoin seed is meager to some extent and is not economical for producer. For this reason, to distinguish high-yield products, it is necessary that the characteristics, which have significant relation with seed yield, should be known, aimed at accumulation of appropriate genes in bred crops with their selection.

On the other hand, in breeding forage crops, evaluation of characteristics is made at spaced plants condition and on mono-plant at the first stage. In the coming generations, evaluation is made at sward condition. Hence, the question "Does selection characteristics on mono-plant at spaced plants condition have similar features to sward condition?" has always been posed.

Jafary<sup>12</sup> reported a meager or partial correlative coefficient between two conditions (spaced plants and sward) for forage yield of ryegrass (*Lolium perenne* L.). He concluded that selection for increase of forage yield at spaced plants condition method does not have any impact on increase of yield at the sward condition. However, Lazenby and Roger<sup>18</sup> on selection of mono-plant with distance of 23 and 70 cm at large, concluded that the less the distance of mono-plant, the more success will be gained in selection for sward condition. In a study on cultivation methods of annual alfalfas, it is stated that cultivation method with "Faro" has supremacy to the manual spraying and superficial cultivation<sup>10</sup>.

In a research on impact of cultivation methods of six varieties of annual alfalfas in two forms of seed spraying manually and planting seed in depth at climatic condition of Khorramabad, scientists reported significant differences between the two said cultivation methods at biological yield and seed yield. They concluded that planting method of seed with pressing work in depth (dry farming) has supremacy to spraying seed manually in terms of acceleration of greening and sprouting seed, fair deployment of plantlet and also establishing herbal congestion<sup>4</sup>.

Another research by Mohammadi *et al.*<sup>21</sup> on 15 populations of landrace (*Onobrychis sativa*) at three various density of bush (200, 400 and 600 bush per each square metre) showed that OSCU population enjoyed the highest amount of (DM) yield with 1962 kg ha<sup>-1</sup> for a period of three years. Tosun<sup>26</sup> compared 36 landrace (*Onobrychis sativa*) populations in irrigation form and observed that three varieties of Khoyvar 2, Khosroshahr and Gavani produced the highest (DM) yield as much as 3.96, 3.83 and 3.81 ton ha<sup>-1</sup>, respectively, in sum of two harvests.

In evaluation of sainfoin varieties, five cultivars of *Onobrychis Sativa* (Tabriz, ShahrKord, Sabzevar, Khoy and Seyah Cheshmeh) were studied at dry farming land of Orumieh as congested form within three years. The results showed that ShahrKord cultivar with average of 2136 kg ha<sup>-1</sup> produced the highest rate of dry matter (DM) yield<sup>1</sup>.

In evaluation of various varieties of sainfoin in different dry farming conditions made at Absard Hamand Pasture Research Center, varieties of *Onobrychis sativa* of Tabriz, Sabzevar, ShahrKord, Nour, Khorramabad and Hamedan were tested in a way that population of Shahrkord with yield of 807 kg ha<sup>-1</sup> DM yield was comparable<sup>19</sup>.

Another study in Kordestan Province reported that amount of 40 kg ha<sup>-1</sup> seed without phosphate fertilizer produced the highest DM yield rate with 1480 kg ha<sup>-1</sup><sup>8</sup>.

Similarly, Ansari and Zohdi<sup>3</sup> studied effects of fertilizer and seed on *Onobrychis sativa* at dry farming land with 30, 40 and 50 kg ha<sup>-1</sup> seed and 30, 40, 50 and 60 kg ha<sup>-1</sup> phosphate fertilizer at climatic conditions of Doroud. They concluded that amount of 40 kg ha<sup>-1</sup> seed and 50 kg ha<sup>-1</sup> phosphate fertilizer with average production of 1433 kg ha<sup>-1</sup> produced the highest rate of DM yield.

Another research examined various levels of fertilizer and seed in *Onobrychis sativa* plant and in dry farming condition of Damavand concluded that consuming 75 kg ha<sup>-1</sup> fertilizer and 45 kg ha<sup>-1</sup> seed will result in producing the highest amount of DM yield as much as 1143 kg ha<sup>-1</sup><sup>20</sup>.

Comparing yield of various populations of *Onobrychis sativa* in other countries and in evaluation of seed and forage yield, Richard<sup>23</sup> reported four varieties of *Onobrychis sativa* (including Eski, Melrose, Remont and Renumex) in U.S. having DM yield of 2000 to 2300 kg ha<sup>-1</sup> and 300 to 450 kg ha<sup>-1</sup> seed under irrigation condition.

Comparing four varieties of *Onobrychis sativa* (including Emyr, Common Costwold, Sombourne and Nova) in China, Anon<sup>2</sup> reported 9, 9.2, 8.3 and 7.2 ton ha<sup>-1</sup>, respectively, DM yield with regard to irrigation cultivation. In another study, a number of 13 varieties of *Onobrychis sativa* in four various irrigation levels were investigated. The results showed that varieties of Pola, Sparta and Remont<sup>22</sup> had the highest amount of fresh yield with the average of 13.4, 12.5 and 12.2 ton ha<sup>-1</sup>, respectively. In another study by Tosun *et al.*<sup>26</sup> the maximum seed yields obtained in Turkey were 472 and 211 kg ha<sup>-1</sup> at 1<sup>st</sup> and 2<sup>nd</sup> harvest, respectively, and seed yield increased upon increasing distance of row up to 52 cm.

In breeding and introducing of new varieties of *Onobrychis sativa*, studying correlation between yield forage and other morphological traits is required, aimed at boosting fruitful genes and plant yield. Unfortunately, less and meager studies have been made in the country in terms of correlation between traits related to the yield of *Onobrychis sativa* and more references and resources in this field is related to other countries. In other words, more research has been done in this field in other countries as well.

Previous work shows that seed yield has positive and significant correlation with traits such as number of inflorescence per plant, the number of seed per inflorescence, seed weight per plant, seed number per inflorescence and 1000-grain weight<sup>27, 29, 30</sup>. In the same direction, seed yield and number of stem per m<sup>2</sup> has negative and significant correlation<sup>26, 30</sup>. It should be noted that correlation between 1000-grain weight and stem number per m<sup>2</sup> was significant and positive but between 1000-grain weight and both plant height and seed number per inflorescence negative and significant<sup>30</sup>. In continuation of the same research made by Turk and Celik<sup>31</sup> on *Onobrychis sativa*, they observed a positive and significant correlation between DM yield and stem number and plant height. Also, there was a positive and significant relation between these two traits.

Despite key and important role of *Onobrychis sativa* in producing forage and also growth of livestock, the number of reports regarding seed production and yield of this plant at two

spaced plants and sward conditions are limited. Moreover, recognition of relation between two cultivation methods is of paramount importance in terms of saving time, manpower, ground and output of selection. For forage crops, getting success in selection of mono-plant strictly depends on their appearance in sward condition. Therefore, objectives of the present research were to 1) obtain high-yield populations of *Onobrychis sativa* in terms of forage and seed production at two conditions of sward and spaced plants; 2) study the relationship between two cultivation conditions (sward and spaced plants) through correlation analysis and 3) determine correlation between seed and forage yield with each of their components at two sward and spaced plants conditions.

### Materials and Methods

The present work was carried out at Alborz Research Center, based in Karaj, Iran. Ten populations of *Onobrychis sativa* germplasms existing at gene bank of natural resources were selected. The research plan was made in 2004 in two condition forms of "spaced plants" and "sward" within the framework of block design with two replications. Spaced plants condition method was made during the first year while sward cultivation was made after three years of evaluation. In spaced plants, each of population was cultivated with 20 seeds and in 20 pots of 1litre. When sprouts were grown appropriately in greenhouse, sampled plants were transferred to the main farmland after six weeks in early springtime. A number of 10 plants with 50 cm distance in one row and 50 cm distance of rows were cultivated at each plot of field. For omitting marginal effects, normal varieties were harvested in between blocks. In sward condition, each plot was cultivated as long as 2 m of seed linearly. The distance between lines of plots was 50 cm. Irrigation was first made at two experiments after cultivation while next irrigation was made according to the requirement of the plants.

In the long run of experiment, agricultural cares including weed control and fertilizing schedule were made based on scientific advices and recommendations. The following traits were measured at two sward and spaced plants conditions:

**Flowering inception date:** Based on number of days as of first day of spring up by the time when 50 percent of plants produced flowers.

**Plant height:** Five plants of each plot were selected and their heights were measured in cm and then their average was taken.

**Plant stem:** The average stem number at 0.5 m<sup>2</sup> from each plot was noted down based on counting.

**Dry matter (DM) yield:** The forage of the two experiments were cut at the first and third harvests at 50% of flowering. They were dried in the open-air area. One sample of which was oven dried at the temperature of 100°C after weighing and dry matter (DM) yield was calculated based on tonha<sup>-1</sup>.

**Inflorescence length:** From among stems of each plant, five flowered stems were taken randomly and inflorescence length was measured with ruler in cm.

**Seed yield:** The second harvest of each of experiments was allocated to the production of seeds. Plants were cut after seeding.

After drying, pounding and sifting operation, the average seed yield was calculated on each plot based on kg ha<sup>-1</sup>.

**1000-grain weight:** 1000 seeds were sorted and separated from seed mass per each plot by seed counting device, details of which were weighed in g.

**Statistical methods:** After harvesting, data of each experiment was subjected to analysis of variance (ANOVA) separately. A total of three harvest biomass was used for analysis of variance of DM yield. Similarly, data of two culture conditions were put under combined analysis. For determination of superior populations, mean comparison for each seven traits was made in DMRT Duncan test.

Correlation coefficient estimation was made between two culture conditions for grasping out the relationship between the two culture conditions. Also, correlation coefficient of phenotype was calculated between traits for data of two culture conditions. In addition, advanced SAS software system was used for analyzing data.

### Results and Discussion

The results of analysis of variance (ANOVA) in two cultivation methods of spaced plants and sward are shown in Tables 1 and 2. In spaced plants condition, effect of population for traits of DM yield, flowering date and seed yield at probability level of 5% and in traits of plant height and inflorescence length at 1% level showed significant difference (Table 1).

In sward condition, effect of population for traits of plant height and seed yield at 5% level and in traits of flowering date, inflorescence length and 1000-grain weight at 1% level showed significant difference (Table 2).

Results of combined analysis of two culture conditions showed that effect of culture condition for traits of plant height, stem number, inflorescence length and 1000-grain weight at probability level of 5% and in trait of flowering date at 1% level were significantly different (Table 3).

In sward condition, effect of population for plant height at probability level of 5% was significantly different and populations of Shahrkord and Golpayegan were tall with 74.2 and 69.2 cm while populations of Karaj and Gorgan-1601 were short with 61.3 and 60.3 cm, respectively.

In comparison with the average 10 populations in spaced plants condition, it became clear that populations of Orumieh are tall with 62.9 cm and two populations of Shahrkord and Karaj were short in height with 45.3 and 38.3 cm, respectively (Table 4).

Effect of culture condition for plant height at probability level of 5% was significantly different. In comparison of averages between two culture conditions, plant height in sward condition with 64.3 cm was more than spaced plants condition with 57.2 cm. More competition of plants for absorbing more sunlight in sward condition could be the main reason (Table 4).

In terms of flowering date, population of Kashan with 50.4 days up to appearance of 50% of flowering was known as the most premature population and not significantly different as compared with other populations. In spaced plants condition, two populations of Shahrkord and Gorgan-1601 were known as late population while two populations of Bijar and Orumieh were premature (Table 4).

**Table 1.** ANOVA of traits at spaced plants condition.

S.O.V	df	DM	SY	IL	SN/m <sup>2</sup>	FD	PH	1000 GW
Population	9	3.31*	28500*	3.92**	29.32	23.51*	143.4**	5.04
Block	1	0.02	2866	0.16	1.36	4.39	52.91	0.31
Error	9	0.96	6891	0.37	12.09	7.59	13.07	1.81
%CV		16	22	7	16	7	6	6

DM = dry matter yield, SY = seed yield, PH = plant height, SN/m<sup>2</sup> = stem number per m<sup>2</sup>, IL = inflorescences length, 1000 GW = 1000-grain weight, FD = flowering inception date. \*significant at the 0.05 probability level, \*\* significant at the 0.01 probability level.

**Table 2.** ANOVA of traits at sward condition.

S.O.V	df	DM	SY	IL	SN/m <sup>2</sup>	DAY	PH	1000 GW
Population	9	6.7	34.4*	1.14**	5.9	2.83**	104.6*	2.68**
Block	1	187.3**	0.22	0.07	280.2**	2.6*	37.9	0.009
Error	9	6.34	9.35	0.18	9.2	0.41	347	0.24
%CV		24	31	5	9	2	10	2

\*significant at the 0.05 probability level, \*\* significant at the 0.01 probability level.

**Table 3.** Summary of combined analysis and the level of significant mean squares for 10 populations of *Onobrychis sativa* under spaced plants and sward condition.

S.O.V	df	DM	SY	IL	SN/m <sup>2</sup>	DAY	PH	1000 GW
Culture (a)	1	16.22	14568	8.49*	1755*	2752**	497.45*	5.98*
Error 1	2	19.39	5354	0.19	64.84	2.59	34.65	0.17
Genotype (b)	9	1.68	17350	2.13**	27.84*	10.29*	71.38**	6.64**
a*b	9	2.38	29627**	3.16**	13.02	13.74**	108.10**	1.39
Error 2	18	1.11	8720	0.29	11.97	4.25	12.26	1.04
%CV		15	26	6	12	4	5	4

\*significant at the 0.05 probability level, \*\* significant at the 0.01 probability level.

**Table 4.** Means comparison of traits in 10 populations of *Onobrychis sativa* under spaced plants and sward condition.

Source	PH		IL		SN/m <sup>2</sup>		DAY	
	spaced	sward	spaced	sward	spaced	sward	spaced	sward
Shahrkord-18	45.3b	74.2a	5.48e	11.13a	16.1bc	35.4ab	38.0ab	51.3a
Golpayegan-181	59.6a	69.2ab	6.09de	8.94b	23.6ab	34.6ab	31.9bcd	51.5a
Esfahan-182	60.8a	62.1cd	7.43cd	8.85b	20.0abc	37.3a	35.1a-d	51.0a
Hamedan-281	61.2a	64.2bcd	7.56c	8.54b	23.1abc	32.6ab	36.2abc	51.0a
Bijar-624	62.9a	64.5bcd	8.00bc	8.03b	26.5a	36.1a	28.7d	51.7a
Kashan-962	62.0a	62.2cd	8.28bc	8.53b	19.1abc	34.7ab	35.8abc	50.4a
Gorgan-1586	62.0a	62.9bcd	8.76abc	8.71b	20.6abc	31.9ab	34.0a-d	51.3a
Gorgan-1601	57.1a	60.3d	9.14ab	9.00b	23.9ab	33.1ab	39.0a	51.3a
Urumieh-1763	62.9a	62.3cd	9.38ab	8.63b	17.2bc	32.7ab	30.9cd	52.4a
Karaj-3001	38.3b	61.3d	9.80a	8.75b	14.5c	28.9b	37.3abc	51.5a
Mean	57.2B	64.3A	7.98B	8.91A	20.5B	33.7A	34.6B	51.3A
Correlation sward and spaced	-0.26 <sup>ns</sup>		-0.59*		0.49 <sup>ns</sup>		-0.45 <sup>ns</sup>	

The means of the populations with same small letters were not significantly different as per Duncan's multi-range test at P<0.05.

The total means of the populations under spaced plants and sward condition with same capital letters were not significantly different.

\*\*, \* , ns : correlation coefficients between conditions were significant at 1% and 5% probability level, and non-significant, respectively.

These traits were used for determination of premature and identification of new populations affluently. It should be noted that in pastureland and forage plants breeding, producing premature populations for early spring grazing and late population for summer grazing delayed in summertime at cold regions is of paramount significance<sup>13</sup>.

In comparing the average DM yield of 10 populations of *Onobrychis sativa* in sward condition, two populations of Shahrkord and Kashan with the average yield of 8.08 and 8.06 ton ha<sup>-1</sup> at each three years had more forage yield (Table 5).

In the same direction, the total average DM yield of populations in 1, 2 and 3 years showed 6.7, 10.3 and 4.6 ton ha<sup>-1</sup>, respectively (the separate data for each year not shown).

Similar research was made by Akbarzadeh and Salari in 1995 with regards to the evaluation of populations of *Onobrychis sativa* and reported that the highest forage yield was produced for a

period of three years at the second year. Of total production of forage yield in three years, average 22%, 34% and 44% was produced at the first, second and third year, respectively<sup>1</sup>.

This trend is common in perennial forage crops, as deployment of plant is made at the first year and its growth is less to some extent, the highest yield is related to the second year<sup>14</sup>.

In comparing the average DM yield of 10 populations of case study in spaced plants condition, two populations of Orumieh and Bijar gave the highest forage yield as much as 7.98 and 7.67 ton ha<sup>-1</sup>, respectively (Table 5).

In comparing two different conditions, the average of two conditions for DM yield was not significantly different. However, the average DM yield in sward condition with 7.3 tons ha<sup>-1</sup> was more than that of spaced plants condition with 6.02 ton ha<sup>-1</sup>. Taking advantage of more space and growth facilities such as light, soil and nourishment was the main reason behind the highest yield at

**Table 5.** Means comparison of traits in 10 populations of *Onobrychis sativa* under spaced plants and sward condition.

Source	1000 GW		DM		SY	
	spaced	sward	spaced	sward	spaced	sward
Shahrkord-18	23.57 a	23.38 a	3.47 c	8.08a	185 b	551 a
Golpayegan-181	20.78 ab	21.81 bc	5.49 bc	7.77a	411 a	360 b
Esfahan-182	24.06 a	22.05 b	5.91 ab	7.48a	510 a	396 bc
Hamedan-281	22.21 ab	21.67 bc	5.24 bc	6.88a	412 a	207 bc
Bijar-624	19.82 b	20.69 c-f	7.67 ab	7.55a	510 a	341 bc
Kashan-962	22.34 ab	20.13 ef	6.14 ab	8.06a	496 a	354 bc
Gorgan-1586	23.46 a	21.25 be	5.65abc	6.62a	389 ab	299 bc
Gorgan-1601	22.13 ab	20.75 c-f	6.89 ab	6.37a	312 ab	223 bc
Urumieh-1763	19.42 b	18.92 g	7.98 a	7.47a	331 ab	295 bc
Karaj-3001	21.03 ab	20.42def	5.86abc	6.74a	195 b	349 bc
Mean	21.90 A	21.10 B	6.02 B	7.3 A	375 A	337 A
Correlation sward and spaced	0.68**		-0.22 <sup>ns</sup>		-0.26 <sup>ns</sup>	

The means of the populations with same small letters were not significantly different as per Duncan's multi-range test at P<0.05.

The total means of the populations under spaced plants and sward condition with same capital letters were not significantly different.

\*\* , ns: correlation coefficients between conditions were significant at the 1% and 5% probability level, and non-significant, respectively.

sward cultivation (Table 4). The results gained from this research activity showed that forage yield was higher as compared with that reported by Tourchi *et al.*<sup>28</sup> with a range between 3.81 to 3.96.

Yield of three harvests was one of the main reasons behind high forage yield in the present work, while total annual yield was related to two harvests at the research activity made by Tourchi *et al.*<sup>28</sup>. It should be noted that results of the present report were in accordance with a report<sup>2</sup> indicating yield of four varieties of *Onobrychis sativa* in China in irrigation culture between 7.2 to 9.2 ton ha<sup>-1</sup>.

In terms of producing seed in sward condition, population of Shahrkord with yield of 551 kg ha<sup>-1</sup> showed the highest seed yield. In spaced plants condition, populations of Esfahan and Bijar exhibited the highest seed yield, each with 510 kg ha<sup>-1</sup>.

In comparison of average between two culture conditions, no significant difference was observed in seed yield. However, average of seed yield in spaced plants condition 375 kg ha<sup>-1</sup> was more than in sward condition with 337 kg ha<sup>-1</sup> (Table 5).

It should be noted that the average seed yield in all populations was accorded with the reports published by Tosun *et al.*<sup>25</sup> from Turkey as much as 472 kg to 211 kg ha<sup>-1</sup> at two consecutive harvests and also with the report by Richard<sup>23</sup> in U.S. with yield of 300-450 kg ha<sup>-1</sup>.

The analysis results of dual correlation of traits are shown in Table 6. In the same direction, correlation coefficient between DM yield with seed yield and stem number exhibited positive and significant difference at two culture conditions. Relationship between DM yield with inflorescence length and plant height was positive at both sward and spaced plants condition, respectively and also showed significant difference at 1% level (Table 6).

Similar to these results made by Turk and Celik<sup>31</sup> in *Onobrychis sativa*, Jafari and Goudarzi<sup>15</sup> on *Medicago sativa*

and Cakmakci *et al.*<sup>6</sup> on vetch, all of them reported positive and significant difference correlation between DM yield with plant height, stem number and seed yield. Seed yield with inflorescence length at two culture conditions and with the stem number and plant height in spaced plants condition and with 1000-grain weight in sward condition showed positive and significant correlation at 1% level (Table 6).

Similar to these results, Tosun<sup>26</sup> and Turk and Celik<sup>30</sup> reported positive and significant relation between seed yield with traits of inflorescence length, plant height

and 1000 grain weight. The relation between seed yield with the stem number at the sward condition was instable and weak. However, Tosun<sup>26</sup> and Turk and Celik<sup>30</sup> reported negative correlation between seed yield and stem number at sward condition.

Recognition of relation between two culture conditions is of paramount importance in terms of saving time and cost in selection and breeding of sainfoin. For this, in forage crops breeding, evaluation of initial offspring is made in the form of mono-plant spaced plants condition but the introduced population should appear in sward form. In the present research, populations were evaluated and assessed at two culture conditions of "spaced plants" and "sward". Therefore, to find out the relation of the two culture conditions, estimation of correlation coefficient method was used between two culture conditions.

The obtained results showed that correlation between two culture conditions, except 1000-grain weight, was positive and significantly different at 1% level. The results were less and instable for other traits (Tables 4 and 5), which indicates lack of existence of strong relation between two culture conditions of spaced plants and sward.

Most of research activities published in line with studying relation of two culture conditions for yield of forage crops were similar to the present findings<sup>7,9,12</sup>.

Generally, it should be stated that despite high precision made in mono-plant form, the gained results cannot be generalized to

**Table 6.** Correlation analysis between seed yield and yield components in 10 populations of *Onobrychis sativa* under spaced plants and sward condition.

Traits	Condition	DM	SY	IL	SN/m <sup>2</sup>	DAY	PH
SY	Spaced	0.42*					
	Sward	0.50**					
IL	Spaced	0.24	0.52**				
	Sward	0.39*	0.75**				
SN/m <sup>2</sup>	Spaced	0.42*	0.52**	0.13			
	Sward	0.54**	0.28	0.18			
DAY	Spaced	-0.34	-0.32	-0.56**	-0.15		
	Sward	0.43*	0.27	0.16	0.46**		
PH	Spaced	0.49**	0.71**	0.67**	0.61**	-0.37	
	Sward	0.21	-0.05	-0.10	0.36*	-0.10	
1000 GW	Spaced	-0.42*	0.08	-0.13	-0.19	0.33	-0.10
	Sward	0.41*	0.76**	0.68**	0.28	0.19	-0.03

\*significant at the 0.05 probability level, \*\* significant at the 0.01 probability level.

sward condition (farmland condition) due to lack of existence of strong relation between two culture conditions of “spaced plants” and “sward”. In other words, it is necessary that the evaluation of traits and breeding of *Onobrychis sativa* at sward condition is made, which is similar to the farmers condition.

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