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The effects of forage turnip (*Brassica rapa* L. var. *rapa*) as companion crop on alfalfa yield and quality

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Abstract. The effect of seed rate and harvest stage of forage turnip as companion crop on forage yield and quality of alfalfa stand in the establishment year was studied. Beside to yield, crude protein, ADF, NDF, Ca, Mg, P and K ratios were determined for pure stands and mixtures. Yield values were given as total of season for all plots. The results showed that companion crop, its seed rate and harvest stage showed significant effect ($p< 0.01$) on yield and quality of alfalfa stand in the establishment year. Total yield of mixtures was higher than pure stand alfalfa. In general, forage and protein yield were higher when plots are harvested at the full flowering stage of companion crop. The highest forage (10.91 t ha^{-1}) and protein yield (2.01 t ha^{-1}) were obtained from the alfalfa seeded with 0.6 kg/da companion crop harvested at full flowering stage.

Keywords. Alfalfa – Forage turnip – Companion crop – Forage yield.

Les effets du navet fourrager (*Brassica rapa *L. var.* rapa*) cultivé en association sur la production et la qualité de la luzerne

Résumé. *L'effet de la densité de semis et de la date de récolte du navet fourrager cultivé en association avec la luzerne a été étudié sur la production et la qualité du fourrage. En plus de la production, les teneurs en matières azotées totales, en ADF, NDF, Ca, Mg, P et K ont été déterminées sur les cultures pures et les mélanges. Les valeurs de production sont données pour l'ensemble de la saison. Les résultats montrent que la culture associée, sa densité de semis et son stade de récolte ont un effet significatif ($P<0.01$) sur la production fourragère totale et la qualité de la luzerne. La production des mélanges était supérieure à celle de la luzerne seule. En général, la production de biomasse et de protéines était supérieure lorsque les parcelles ont été récoltées à la pleine floraison de la culture associée. Les productions fourragère (10,91 t ha^{-1}) et de protéines (2,01 t ha^{-1}) maximales ont été obtenues lorsque la luzerne est semée avec 0,6 kg/ha de navet fourrager récolté en pleine floraison.*

Mots-clés. *Luzerne – Navet fourrager – Culture associée – Production fourragère.*

I – Introduction

Alfalfa is a small-seeded, slow-growing perennial legume, making it sensitive to adverse soil and climatic conditions and weed infestation during early growth. So, sowing with companion crop is a common practice for alfalfa. Companion crops also provide additional forage in the seedling year. Using small grains such as wheat, oats and barley to establish alfalfa is a long-standing tradition, however, cereals compete with alfalfa seedlings for light, water and nutrients (Cupina *et al*., 2000). To limit this competition, proper selection of companion crop species and varieties, and timely harvest are critical for long-term highly productive alfalfa stand.

Early maturity is important character to avoid competition and allow more time to grow the alfalfa seedlings. In this respect, brassicas can be good alternative as companion crop. The turnip

(*Brassica rapa* L. var. R*apa)* belongs to the Brassicaceae family, is an important vegetable source and is also used as forage for sheep and cattle. Turnip is deep-rooted cover crop that can reduce surface and subsoil compaction, scavenge N, and suppress weeds (USDA 2013).

In this study, we determined the effect of forage turnip as companion crop on total yield and quality of alfalfa stand in the establishment year.

II – Materials and methods

The effect of the forage turnip (*Brassica rapa* L. var. *rapa*) as a companion crop, its seed rates and harvest stages on alfalfa stand was investigated in seedling year. The experiment was established in Yozgat-Turkey ecological conditions (39°39'00" N / 34°29'37" E) in autumn 2012. The soil at the experimental site taken 30 cm depth is classified as clay-loam with pH:7.34, low organic matter (1.82%), medium P_2O_5 (6.07 kg/da) and high K_2O (201.77 kg/da) content. Annual rainfall, average temperature and moisture are 330 mm and. 11.8 °C and 54.8% respectively in the experimental site.

Bilensoy variety of alfalfa and Lenox variety of turnip were used as plant material. Forage turnip was sown at four seeding rates (0, 0.4, 0.6, 0.8, 1, 1.2 kg/da) with alfalfa (2 kg/da) in the 6 alternative rows (FT:A:FT:A.) with 20 cm distance and 5 m lenght. Alone turnip was sown by 1 kg /da seed rate with 40 cm row distance. The experiment was sown according a split-plot design with three replications on October 16. A dose of 4 kg/da N and 12 kg /da P_2O_5 was applied to plots after sowing. The plots were harvested at two different stages depending on turnip, at 50% flowering and full flowering stages. After companion crop removed in the first cutting, alfalfa was harvested five times when it comes to early flowering stage and, was irrigated after each cutting. To create similar effect as in the mixture, alone alfalfa plots were divided two parts and each part was cut at the same time and same height with companion crop. Total forage yield and mean quality in the treatments were determined as fallows;

$$\text{Quality} = \frac{(Y_{FT}{*}X_{FT}\%)+(Y_{A1}{*}X_{A1}\%+..+Y_{A5}{*}X_{A5}\%)}{Y_{Total}} \quad ; \qquad Yield_{Total} = (Y_{FT}) + Y_{A1} +...+ X_{A5}$$

Qality: CP, AND, NDF and mineral content. Y: yield A: alfalfa. FT: turnip. X; ratio of quality traits in forage.

To determine forage yield, plant samples were dried at 68°C until constant weight. Then samples were ground to pass though 1 mm screen for quality analyses. Crude protein (CP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Ca, P, Mg and P contents were determined by using Near Reflectance Spectroscopy (NIRS, 'Foss XDS') with software package program 'IC-0904FE'. The data were subjected to analysis of variance by means of SPSS V 10.0 (SPSS Inc., 1999). Differences among means were separated by using Duncan Multiple Range Test.

III – Results and discussion

The effect of seed rate and cutting stage of companion crop was significant ($p<0.05$, $p<0.01$) on yield and many of quality traits of alfalfa in the establishment year (Table 1). Compared with sole sowing, forage yield was markedly higher in alfalfa seeded with companion crop. However, majority of this yield was produced by the companion crop at the first cutting. Total forage yield of alfalfa was higher when the companion crop was removed at full flowering stage compared to 50% flowering stage (Table 2), clearly due to the further growth of companion crop. In addition, sole alfalfa produced more yield in the second cutting treatment. Although it is very early for alfal-

fa, to create similar effect, alone alfalfa plots were harvested at the same period as the mixtures. So, this result indicates that alfalfa growth is adversely affected by early harvest.

Considering seed rate of companion crop, the optimum ratio was 0.6 kg/da (Table 2). This mixture produced the highest forage yield at both harvest stages of companion crop. Lower rate of companion crop created low plant density per area, led to formation of robust plant which were more leafy and tall, while higher rates of it led to dense but weak plants. In both cases, the pressure on alfalfa increased, but the yield of companion crop markedly decreased.

Table 1. Analysis of variance for quality and yield traits on cutting stage and seed ratio of companion crop in alfalfa

Traits	HY	CP	CPY	ADF	NDF	Ca	K	P	Mg
Cutting	**	ns	ns	ns	Ns	*	*	ns	ns
Treatments	**	**	**	ns	Ns	*	**	ns	**
Cut. X Treat.	**	*	ns	ns	Ns	*	**	**	ns

* P<0.05, ** P<0.01, *** P<0.001, ns: non significant.

Table 2. Forage yield, crude protein content and yield of alfalfa under different seed ratio and cutting regime of companion crop

Treatments	Hay yield (t ha^{-1})			Crude protein (g kg^{-1})			Crude protein yield (t ha^{-1})		
	Stage 1	Stage 2	Mean	Stage 1	Stage 2	Mean	Stage 1	Stage 2	Mean
Alfalfa (A)	4.73 ef	5.34 de	5.03 d	248.5 a	237.9 abc	243.2 a	1.18	1.27	1.22 b
Turnip (T)	1.66 g	4.69 ef	3.17 e	242.5 ab	149.1 d	195.8 b	0.39	0.70	0.56 c
A + T $_{(0.4\ kg)}$	4.86 ef	8.37 b	6.61 bc	201.7 ad	162.9 d	182.3 b	0.99	1.35	1.16 b
A + T $_{(0.6\ kg)}$	6.41 c	10.91 a	8.66 a	183.1 cd	183.0 cd	183.2 b	1.18	2.01	1.59 a
A + T $_{(0.8\ kg)}$	5.56 cde	8.40 b	6.98 b	179.7 cd	171.2 d	175.3 b	1.00	1.46	1.23 b
A + T $_{(1.0\ kg)}$	6.05 cd	6.07 cd	6.06 c	195.5 ad	192.8 a-d	194.0 b	1.18	1.16	1.17 b
A + T $_{(1.2\ kg)}$	3.98 f	6.56 c	5.27 d	174.8 d	189.9 bcd	182.5 b	0.70	1.25	0.97 b
Mean	4.75 B	7.19 A		203.7	183.8		0.94	1.31	

As excepted, mean crude protein content was the highest in pure alfalfa (Table 2). However, the greatest protein yield was obtained from the treatment of A + T 0.6 kg/da owing to its high yield. The effect of the treatments was not significant on final ADF and NDF content in forage (Table 3). Mineral matter contents showed significant changes depending on cutting stage and treatment. After detailed examination of the data, it can be stated that the change is largely caused by the companion crop. The changes in Ca and K content between cutting stages can be attributed to maturity of forage turnip.

In terms of mineral content, pure stands were advantageous with a slightly higher values compared to mixtures. This deficiency can be compensated with supplementary feeding. So, forage turnip as companion crop can offer great benefits for producing high yielding and quality forage in alfalfa stand in the establishment year. This contrasts with Waddington and Bittman (1984), who stated that rapeseed which is taxonomically in the same family as turnip should not be used as a companion crop for legumes.

Table 3. Quality values of alfalfa under different seed ratio and cutting regime of companion crop

Treatments	ADF (g kg^{-1})			NDF (g kg^{-1})		
	1st Cut.	2st Cut.	Mean	1st Cut.	2st Cut.	Mean
Alfalfa (A)	261.9	282.1	272.0	393.9	415.0	404.5
Turnip (T)	279.5	389.2	334.4	354.5	498.8	426.7
A + T (0.4 kg)	297.8	370.7	334.3	390.7	509.1	449.9
A + T (0.6 kg)	305.8	348.3	327.1	413.0	483.5	448.2
A + T (0.8 kg)	304.2	363.6	333.9	415.1	501.4	458.3
A + T (1.0 kg)	286.6	350.3	318.5	387.2	467.7	427.5
A + T (1.2 kg)	306.5	354.6	330.6	410.5	493.3	451.9
Mean	291.8	351.3		395.0	481.3	
Treatments	**Ca (g kg^{-1})**			**K (g kg^{-1})**		
	Stage 1	**Stage 2**	**Mean**	**Stage 1**	**Stage 2**	**Mean**
Pure Alfalfa	13.80 a	14.53 a	14.17 a	26.87 c	25.93 cd	26.40 c
Pure Turnip	14.13 a	12.20 a	13.17 a	39.73 a	22.50 de	31.12 a
A + T (0.4 kg)	13.50 a	13.80 a	13.65 a	35.47 b	20.77 e	28.12 bc
A + T (0.6 kg)	13.57 a	14.03 a	13.80 a	32.90 b	25.23 cd	29.07 ab
A + T (0.8 kg)	13.00 a	12.87 a	12.93 a	32.17 b	21.23 e	26.70 bc
A + T (1.0 kg)	13.10 a	13.77 a	13.43 a	33.77 b	24.37 cde	29.07 ab
A + T (1.2 kg)	5.83 b	12.83 a	9.33 b	33.20 b	22.80 de	28.00 bc
Mean	12.42 B	13.43 A		33.44 A	23.26 B	
Treatments	**P (g kg^{-1})**			**Mg (g kg^{-1})**		
	Stage 1	**Stage 2**	**Mean**	**Stage 1**	**Stage 2**	**Mean**
Pure Alfalfa	4.03 bc	3.87 bcd	3.95	2.97	2.70	2.83 a
Pure Turnip	4.83 a	3.13 e	3.98	2.47	1.80	2.13 b
A + T (0.4 kg)	4.07 b	3.13 e	3.60	2.17	2.17	2.17 b
A + T (0.6 kg)	3.80 bcd	3.43 cde	3.62	2.17	2.17	2.17 b
A + T (0.8 kg)	3.80 bcd	3.33 de	3.57	1.87	1.93	1.90 b
A + T (1.0 kg)	4.07 b	3.60 b-e	3.83	1.83	2.10	1.97 b
A + T (1.2 kg)	3.73 b-e	3.47 b-e	3.60	2.07	2.07	2.07 b
Mean	4.05	3.42		2.22	2.13	

IV – Conclusions

The present study showed that alfalfa seeded with companion crop produced high forage and protein yield compared to pure stand in the establishment year. However harvest stage and seed rate of companion crop had also significant effects. The seed rate of 0.6 kg/da for the companion crop and removed at full flowering is a best treatment in alfalfa establishment for yield and quality.

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