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THE EFFECTS OF SEEDING PATTERNS, NITROGEN AND PHOSPHORUS FERTILIZATIONS ON PRODUCTION AND BOTANICAL COMPOSITION IN LUCERNE-SMOOTH BROMEGRASS MIXTURES

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Abstract

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Lucerne and smooth bromegrass are commonly cultivated in irrigated and dry lands in intercropping systems in the world. The aim of this study was to determine the effects of seeding patterns (mixed, alternative and cross-seeding patterns), nitrogen (0, 60, and 120 kg N ha^{-1}) and phosphorus fertilizer (0, 40, 80 and 120 kg P_2O_5 ha^{-1}) rates on dry matter yields, botanical composition and crude protein yield of lucerne-smooth bromegrass mixture in an intercropping system. The experiment was established in 2001 and data were collected in dry matter yield and legume ratio for four years (2002-2005) and in crude protein yield for two years (2002-2003).

The results showed that the highest dry matter yield was produced by a alternative seeding pattern. However, the highest legume ratio and crude protein yield was produced by mixtures sown in cross seeding pattern. Nitrogen fertilizer application decreased legume ratio but increased crude protein yield. Phosphorus fertilizer application had no effect on dry matter yield, legume ratio or crude protein yield of the lucerne-smooth bromegrass mixtures.

Introduction

Lucerne (*Medicago sativa* L.) is frequently used in mixtures with perennial grasses to increase forage production, and to reduce incidence of bloat and to balance forage quality and mineral element composition. Because successful forage mixtures are more efficient in utilizing environmental resources, they often give better yield and quality than those of pure stands. However, unsuitable mixtures may not yield more than pure stands of either species. Lucerne and perennial grass grown in combination complete one another above and below ground for use of light, water and nutrients. Some researchers have reported no yield advantage for legume-grass mixtures over legume or grass alone (Coulman, 1987). However, other researchers have found that intercropping generally have more productivity than mono cropping (Altin, 1982a; Serin et al., 1998; Koc et al., 2004; Erkovan et al., 2008). The Lucerne was sowed with smooth bromegrass (*Bromus inermis* Leyss.) both in abundant precipitation or irrigated areas and in dry areas (Acikgoz,

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2001). The lucerne-smooth bromegrass mixtures have been found high yielded (Altin and Gokkus, 1988), persistence and very productive. However smooth bromegrass is a very competitive species with lucerne (Serin et al., 1998). Therefore, manage of lucerne-smooth bromegrass mixtures can be more difficult than pure stands of either lucerne or smooth bromegrass.

Plant distribution is an important factor in competition between species in the root zone and aerial space within a mixture. Determining of correct seeding patterns can help balance rivalry between species in intercropping systems. Generally, species can be seeded as mixed, alternative and cross seeding patterns in mixtures (Acikgoz, 2001). Different seeding patterns affect forage yields (Altin, 1982a; Altin and Gokkus, 1988; Oljaca et al., 2000; Kumar et al., 2003; Chen et al., 2004), crude protein yield, botanical composition (Altin, 1982 a,b), macro (Yolcu and Serin, 2009) and trace mineral content (Yolcu and Turan, 2008) in mixtures.

Applications of fertilizer are also an important factor in competition between species in mixtures. When species having different nourishment requirements are cultivated altogether, applications of fertilizer need to be carefully in mixtures (Serin and Tan, 2001). Different fertilizer applications affect yield, botanical composition (Holt, 1983; Halvarson and Bauer, 1984; Chen et al., 2004; Ghaley et al., 2005) and mineral content (Yolcu and Serin, 2009; Yolcu and Turan, 2008) of mixtures. Nitrogen and phosphorus fertilization have a special importance in the production of mixtures. Because of N biologically fixed by legumes in mixtures (Zemenchik et al., 2001; William et al., 2001), determining amount of supplemental nitrogen fertilizer is very important topic in intercropping systems. Besides, nitrogen fertilizer positively affects to grasses and phosphorus fertilizer also affects to legumes in intercropping systems (Acikgoz, 2001).

Productivity and long-term maintenance of lucerne-smooth bromegrass mixtures depend on the right management of intercropping systems. For this reason, determining ideal seeding patterns, nitrogen and phosphorus fertilizer rates are a very important research topic. Therefore, the purpose of this study was to evaluate the effect of different seeding patterns, nitrogen, phosphor fertilizers on lucerne and smooth bromegrass mixture in an intercropping system.

Materials and Methods

The study was conducted at Agricultural Research Station of Atatürk University in Erzurum (39^o 55’N and 41^o 61’E, elevation 1860 m), Turkey. Binary mixtures of lucerne and smooth bromegrass were sown in the spring of 2001. Dry matter yield and legume ratio data were collected from 2002, 2003, 2004 and 2005, although crude protein data collected from 2002 and 2003.

Plots were 3.0 m long by 1.8 m wide, and row spacing was a 30 cm. Each plot was 1.8 x 3=5.4 m^2 in size. A legume-grass mixture rate of 10 kg ha^{-1} of ‘Bilensoy’ alfalfa (*Medicago sativa* L.), 10 kg ha $^{-1}$ of ‘Tohum Islah’ smooth bromegrass (*Bromus inermis* Leyss.) (Serin and Tan, 2001).

The climatic conditions at the site are characterized by low humidity, short dry summers and long cold, snowy winters. Mean annual temperatures in the region for 2002, 2003, 2004 and 2005 are 4.1, 5.2, 4.4 and 5.1 °C, respectively. Total annual precipitations in the region for the same years are 488.6, 424.3, 440.8 and 479.9 mm, respectively. Mean relative humidity of the same years are 63.2, 61.6, 60.9 and 69.4 %, respectively. The soil of experiment area is a silt loam. The pH of the plot area was 6.9 and P and K levels were 137.4 kg P_2O_5 ha^{-1} and 67.7 kg K_2O ha^{-1}, respectively. Organic matter content was 0.79 %. In calcareous soils in eastern Turkey, lucerne production requires phosphorus addition (100-150 kg P_2O_5/ha) as the soils are naturally P deficient or very high P sorption isotherms (Ozgul et al., 2006, Turan et al., 2008).

Lucerne and smooth bromegrass were seeded in mixed-rows, alternative-rows and cross -rows patterns. Nitrogen was broadcast at 0, 60 and 120 kg N/ha^{-1} rates on the plots each spring as ammonium sulphate $(NH_4)_2SO_4$. Phosphorus was broadcast at 0, 40, 80 and 120 kg P_2O_5/ha^{-1} rates on the plots each autumn in the form of triple super phosphate.

Three nitrogen, four phosphorus rates and three seeding patterns were established in a factorial arrangement of a randomized complete block design in three replications. Dry matter yield was not taken in the seeding year (2001). All plots were harvested at the early flower stage of lucerne (Manga, 1978) by harvesting 1 meter square areas in each plot in all the years (2002, 2003, 2004 and 2005). Species were separated into lucerne and smooth bromegrass. These sub samples were dried 78°C for 24 hours and weighted to determine dry matter yield. Legume ratio was obtained by calculating the percent by weight of the total yield represented by each species. Lucerne and smooth bromegrass crude protein content was determined using the Kjeldahl procedure and then converted to crude protein yield by multiplying crude protein content by dry matter yield.

The statistical procedures of MSTAT-C were used for data analyses to test the effects of seeding patterns, nitrogen, phosphorus fertilization and all interactions. All means were separated using least significant differences ($P<0.05$).

Results and Discussion

Dry matter yields of lucerne and smooth bromegrass mixtures

The seeding patterns significantly affected dry matter yields over the 4-years. The highest dry matter yield was gained from the alternative seeding pattern (10001.0 kg ha^{-1}). This seeding patterns was followed by cross seeding pattern (9772.5 kg ha^{-1}) and mixed seeding pattern (9572.9 kg ha^{-1}), respectively (Table 1). Researchers have previously reported that legume and grass mixtures in the alternative seeding patterns was better than others (Heinrichs, 1971; Altin and

Table 1

The effects of seeding pattern, nitrogen and phosphorus fertilization on dry matter yield of lucerne-smooth bromegrass mixture in intercropping system, kg/ha

Seeding Pattern	Nitrogen	Phosphorus				
		0	40	80	120	Mean
	0	9513.7	9921.0	10527.3	11410.1	10343.0
Mixed	60	9363.4	9203.1	9374.5	8645.1	9146.5
	120	8888.3	8928.2	9191.3	9908.4	9229.1
Mean		**9255.1**	**9350.8**	**9697.7**	**9987.9**	**9572.9 B**
	0	9364.4	10672.3	9373.9	8779.6	9547.6
Alternative	60	8860.7	9434.2	9833.1	9846.1	9493.5
	120	10234.2	11523.4	11443.8	10750.9	10988.1
Mean		**9486.4**	**10543.3**	**10216.9**	**9792.2**	**10001.0 A**
	0	9674.3	9940.6	10330.6	10140.0	10021.4
Cross	60	9748.4	10252.9	9961.6	10371.2	10083.5
	120	8823.1	9253.3	8603.4	10170.2	9212.5
Mean		**9415.3**	**9815.6**	**9631.9**	**10227.1**	**9772.5 AB**
	0	9517.5	10177.9	10077.3	10109.9	9970.7
	60	9324.2	9630.1	9723.1	9620.8	9574.6
	120	9315.2	9901.7	9746.2	10276.5	9809.9
Mean		**9385.6**	**9903.2**	**9848.9**	**10002.4**	**9785.1**
LSD. SP x N: 853.8 SP x N x P: 1021.2						

Probability: 0.01

Gokkus, 1988; Sheaffer and Marten, 1992), on the other hand, Kilcher (1982) found that a cross seeding pattern was better than the others. Kilcher and Heinrichs (1971) stated that productions of cross and alternative seeding patterns were similar. Similarly, in our study, dry matter yields of alternative and cross seeding patterns were also statistically the same group.

Nitrogen and phosphorus fertilizers rates also had no effect on dry matter yields; however the seeding patterns x nitrogen rate interaction did significantly affect dry matter yields. The highest dry matter yields were produced by alternative seeding patterns x 120 kg N ha^{-1} (10988.1 kg ha^{-1}) and mixed seeding patterns x non nitrogen (10343.0 kg ha^{-1}), respectively. Nitrogen fertilization also increased dry matter yields significantly in alternative seeding patterns. However, nitrogen fertilization decreased on dry matter yields in the mixed seeding patterns and in the cross seeding patterns. Dry matter yields in the 0, 60 and 120 kg N ha^{-1} treatments averaged 10343.0, 9146.5 and 9229.1 kg/ha^{-1} in mixed seeding patterns, 9547.6, 9493.5 and 10988.1 kg ha^{-1} in alternative seeding patterns 10021.4, 10083.5 and 9212.5 kg ha^{-1} in cross seeding pattern, respectively. This results show that there was a better response to nitrogen in the alternative seeding pattern than the other patterns.

Seeding patterns x nitrogen x phosphorus fertilizer interactions also significantly affected dry matter yields of intercropping mixture. The highest dry matter yields were produced by the alternative seeding patterns x 120 kg N ha^{-1} x 40, 80 and 120 P_2O_5 ha^{-1} (11523.4, 11443.8 and 10750.9 kg ha^{-1}), alternative seeding pattern x 0 kg N ha^{-1} x 40 kg P_2O_5 ha^{-1} (10672.3 kg/ha^{-1}) and mixed seeding patterns x 0 kg N ha^{-1} x 80 and 120 kg P_2O_5 ha^{-1} (10527.3 and 11410.1 kg ha^{-1}), respectively.

Table 2

The effects of seeding pattern nitrogen and phosphorus fertilization on legume ratio of lucerne-smooth bromegrass mixture in intercropping system, %

Seeding Pattern	Nitrogen	Phosphorus				
		0	40	80	120	Mean
Mixed	0	45.3	38.6	40.2	36.8	40.2
	60	49.7	49.3	51.6	43.5	48.5
	120	24.1	30.4	35.4	39.4	32.3
Mean		**39.7**	**39.4**	**42.4**	**39.9**	**40,3 B**
Alternative	0	44.9	40.5	39.8	42.3	41.9
	60	29.8	32.2	37.1	53.8	38.2
	120	33.1	28.6	28.2	31.9	30.5
Mean		**35.9**	**33.8**	**35**	**42.7**	**36,9 C**
Cross	0	48.9	57.1	60.1	56.5	55.7
	60	43.9	39.7	38.8	28.9	37.8
	120	52.3	53.8	49	44.2	49.8
Mean		**48.4**	**50.2**	**49.3**	**43.2**	**47,8 A**
	0	46.4	45.4	46.7	45.2	45.9 ***A***
	60	41.1	40.4	42.5	42.1	41.5 ***B***
	120	36.5	37.6	37.5	38.5	37.5 ***C***
Mean		**41.3**	**41.1**	**42.2**	**41.9**	**41.6**
LSD. SP x N: 3.9		SP x P: 4.5		SP x N x P: 6.2		

Probability: 0.01

Legume ratio of lucerne and smooth bromegrass mixtures

Different seeding patterns affected the ratio of legume in lucerne and smooth bromegrass mixtures (Table 2). The greatest the ratio of legume was found in cross seeding pattern (47.8%). Legume ratios of mixed and alternative seeding patterns were 40.3 and 36.9 %, respectively. The checkered pattern and saucer-shaped from cross seeding reduces runoff and erosion by water and the squares in the check board pattern ponded water, however slightly (Kilcher, 1982). Therefore, because Lucerne is also given net yield increases to irrigation (Serin and Tan 2001), lucerne ratio may increase in cross seeding patterns. In others studies, botanical composition variation inside different seeding patterns has been reported by Hanna et al. (1977), Altin (1982b) and Chen et al. (2004) in mixture in an intercropping system.

The other factor affecting of legume rate is nitrogen rates. Application of nitrogen decreased the ratio of legume with no nitrogen, 60 and 120 kg N ha^{-1} applications producing 45.9, 41.5 and 37.5% legume, respectively. Because high nitrogen application negatively affects nodulation (Silva et al., 1993) and symbiotic fixation (Fan et al., 2006) in legumes, it encouraged the grass components (Acikgoz, 2001). Therefore, legume rate decreased when mixtures were fertilized with nitrogen. This finding is similar with findings of Holt (1983), Halvorson and Bauer (1984), June and Bratney (1987) and William et al. (2001).

The interaction of seeding pattern and nitrogen fertilization also significantly affected on the legume ratio. Because seeding pattern affects shoots/root ratio, use of water and spread of plant in the soil, absorption of mobile nitrogen in the soil may have changed different seeding patterns. Cross-seeding patterns and no nitrogen plots had the highest legume (55.7%). As a result squares ponded water in cross-seeding patterns (Kilcher 1982); lucerne may show positively response to available water in non nitrogen fertilizer conditions. On the other hand, alternative seeding patterns and 120 kg N ha^{-1} application produced the lowest ratio of legume (30.5%). Grass development was encouraged with high rates of nitrogen and this reduces legume growth.

Applications of phosphor fertilizer had no effect on the ratio of legume; however, seeding pattern x phosphor fertilization interactions did affect legume ratios. The highest legume ratios were found in the cross seeding pattern x 0 (48.4%), 40 (50.2%), 80 (49.3%) kg P_2O_5 ha^{-1} applications. Seeding pattern x nitrogen x phosphorus fertilizer interactions also sig-

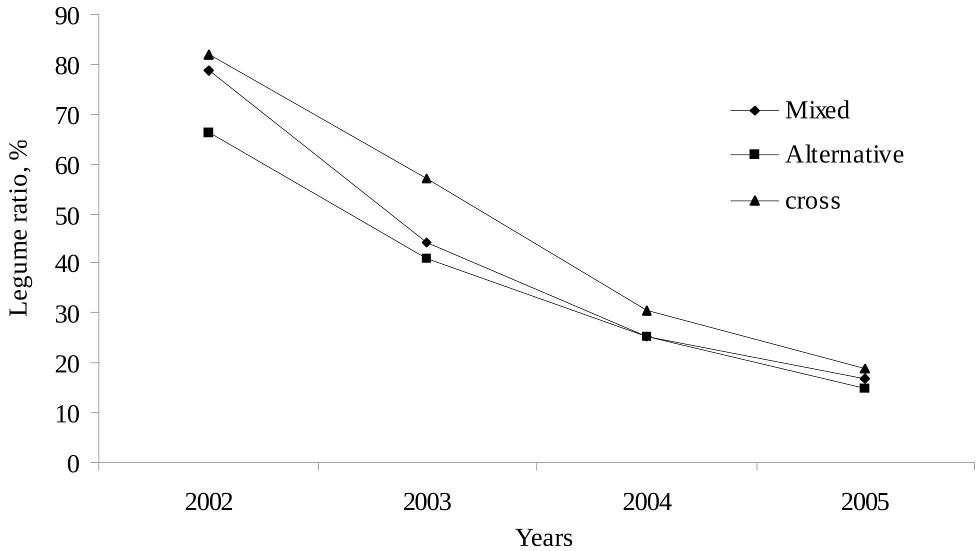

Fig. 1. The effects of seeding patterns on legume ratio of lucerne-smooth bromegrass mixture in intercropping system

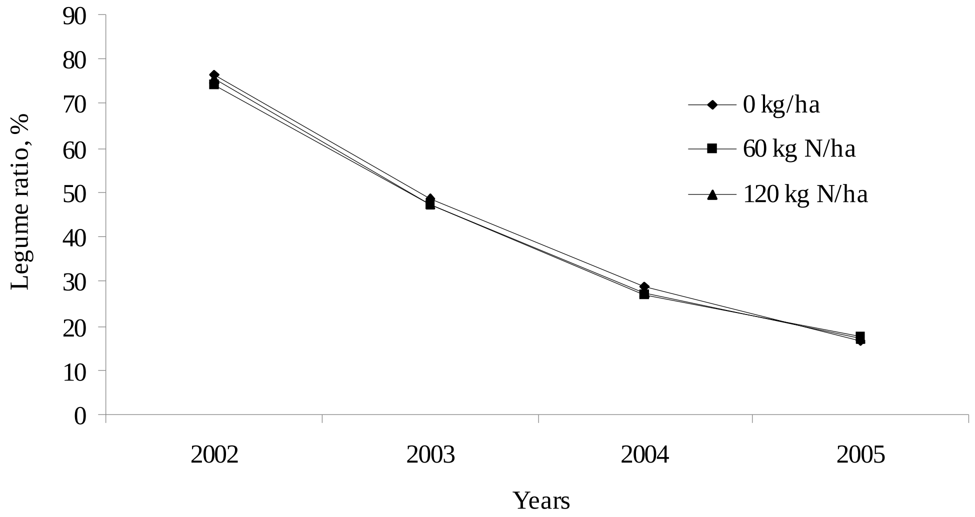

Fig. 2. The effects of nitrogen fertilization on legume ratio of lucerne-smooth bromegrass mixture in intercropping system

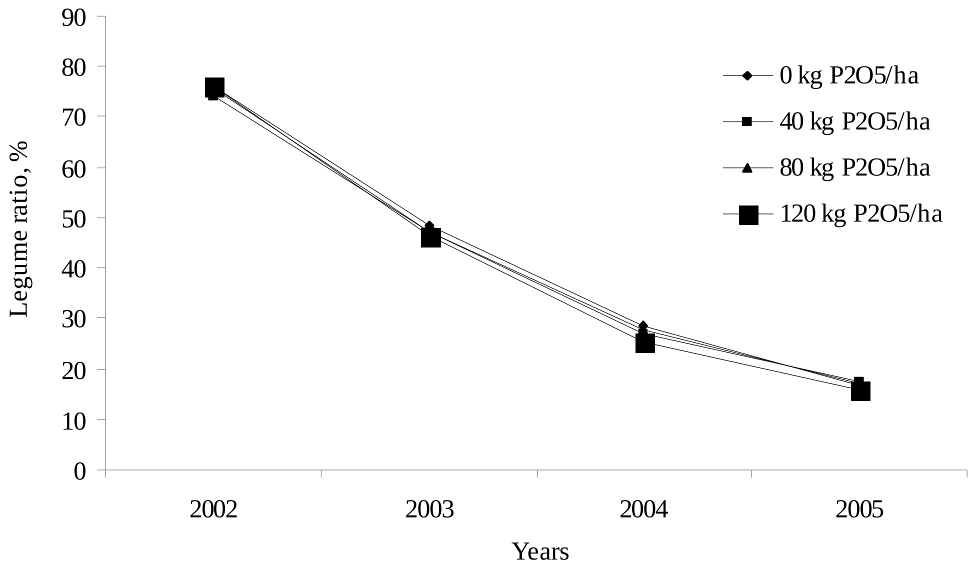

Fig. 3. The effects of phosphorus fertilization on legume ratio of lucerne-smooth bromegrass mixture in intercropping system

nificantly effected on the legume ratio in the mixtures. The highest legume ratios were found in the cross seeding pattern x non nitrogen x 40 (57.1%), 80 (60.1%) and 120 (56.5%) kg P_2O_5 ha^{-1}. The lowest legume ratio was determined in the mixed seeding patterns x 120 kg N ha^{-1} x non phosphorus fertilizer (24.1%).

Because botanical composition in mixtures affect yield and the feed value of the forage, it is very important, therefore, it is desired that species ratios continues into later years of mixtures (Serin et al. 1998). When legume ratio in the mixture was examined according to years (Figures 1, 2 and 3), the legume ratio was high in 2002, but declined in favour of grasses in advanced years. According to the years, the effects of three factors were similar on legume ratios (Figures 1, 2 and 3).

Table 3

The effects of seeding pattern. nitrogen and phosphorus fertilization on crude protein yield of lucerne-smooth bromegrass mixture in intercropping system. kg/ha

Seeding Pattern	Nitrogen	Phosphorus				
		0	40	80	120	Mean
Mixed	0	151	149	167.7	170.8	159.6
	60	195.3	169.3	168.3	188.2	180.3
	120	201.2	211.1	189.7	180.4	195.6
Mean		**182.5**	**176.5**	**175.2**	**179.8**	**178.5b**
Alternative	0	166	169.2	151.8	167.2	163.5
	60	167.7	179.4	181.7	178.8	176.9
	120	172.8	189	191.4	235	197.1
Mean		**168.8**	**179.2**	**175**	**193.6**	**179.2b**
Cross	0	166.5	173.1	169.7	176	171.3
	60	191	190.6	197.1	181	189.9
	120	217.4	197.4	203.9	195.5	203.5
Mean		**191.6**	**187**	**190.2**	**184.2**	**188.3a**
	0	161.1	163.8	163.1	171.3	164.8C
	60	184.7	179.8	182.4	182.6	182.4B
	120	197.1	199.2	195	203.6	198.7A
Mean		**181**	**181**	**180.1**	**185.9**	**182**
SPxNxP(0.05): 29.3						

Capital letter probability: 0.01. Lower case probability: 0.05

Crude protein yield Legume ratio of lucerne and smooth bromegrass mixtures

Different seeding patterns significantly effected ($p<0.05$) the crude protein yields of the mixture (Table 3). The highest crude protein yield was found in the cross seeding patterns with crude protein yields of the mixed, alternative and cross seeding pattern were 178.5, 179.2 and 188.3 kg ha^{-1}, respectively. This may result from the fact that the cross seeding pattern had the high legume ratio and yield. Application of N-fertilizer affected crude protein yield of the mixtures ($p<0.01$). While control parcels have 164.8 kg ha^{-1} nitrogen yield, other parcels (60 and 120 kg ha^{-1} nitrogen applied parcels) produced 182.4 and 198.7 kg N ha^{-1} crude protein yield, respectively. Nitrogen application increased a crude protein yields. In other studies, nitrogen application also increased both crude protein content and yield (Comakli et al., 1998; Karaca and Cimrin, 2002; Chen, 2004), in mixtures therefore, harvested crude protein yield was found greater at N fertilized plots.

Phosphorus application had no effect on the crude protein yields of the mixtures. However, seeding pattern x nitrogen x phosphorus fertilizer interactions have significantly effected on crude protein yield. The highest crude protein yields was found alternative seeding pattern x 120 kg N ha^{-1} x 120 kg P_2O_5 ha^{-1} (235.0 kg/ha^{-1}), cross seeding pattern x 120 kg N ha^{-1} x 0 kg P_2O_5 ha^{-1} (217.4 kg/ha^{-1}) and mixed seeding pattern x 120 kg N ha^{-1} x 40 kg P_2O_5 ha^{-1} (211.1 kg/ha^{-1}), respectively.

Conclusion

Performance of lucerne and smooth brome grass mixtures were affected by different seeding patterns and nitrogen fertilizer rates but not phosphorus fertilizer. Seeding pattern affected dry matter yield, legume ratio and crude protein yield. Nitrogen application decreased legume ratio and increased crude protein yield but had no effected on dry matter yields in mixture. Phosphorus fertilizer rates had no effect on dry matter yields, legume ratio and crude protein yield.

According to these results, If farmers want produce both high dry matter yields and crude protein yield, they should select alternative seeding pattern x 120 kg N ha^{-1} x 120 kg P_2O_5 ha^{-1}. But, these results should be correlated with other studies including different plants and ecological condition.

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