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Full Length Article

Dry Matter Yield of Oat-Egyptian Clover Mixture under Varying Proportions and Different Growth Stages of Oat

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Abstract

Mixtures of oat (*Avena sativa* L.) with Egyptian clover (*Trifolium alexandrinum* L.) under different seeding rates (100% oat+100%Egyptian clover, 75% oat+100% Egyptian clover, 50% oat+100% Egyptian clover, 25% oat+100% Egyptian clover, 0% oat+1000% Egyptian clover, and 100% oat+0% Egyptian clover) harvested at various growth stages of oat (stem elongation, booting and early heading) were evaluated for dry matter production. Results revealed that dry matter yields increased with delayed cutting from stem elongation to early heading stage. Higher oat proportions in sowing mixture resulted in higher first cut dry matter yields but negatively affected the Egyptian clover first cut and re-growth DM yield. Lower first cut DM yield at lower oat proportions were compensated by vigorous Egyptian clover re-growth. It may be suggested that for obtaining higher DM yield from oat:Egyptian clover mixture under two-cut system best combination of seeding rate and harvesting stage is 25:100% and early heading stage. © 2013 Friends Science Publishers

Keywords: Fodder; Re-growth; Competition; Suppression

Introduction

Mixed cropping is an important element of self-sustaining, low-input agricultural systems (Adesogan *et al*., 2002), while components of a mixture use limiting resources more efficiently than pure stands, thus showing resource complementarily (Atis *et al*., 2012a). For the years cereal-legume mixtures for forages have been advocated for numerous advantages ranging from increased dry matter yield, enhanced forage quality, reduced fertilizer inputs, financial stability to the farmers up to sustainability of the agricultural system (Anil *et al*., 1998; Jabbar *et al.*, 2011). Despite the advantages associated with mixed cropping, their management is rather difficult than sole cropping due to differences in the agronomic practices of the component cops of the mixture. Differences in sowing time, fertilizer and water requirements, growth behavior, phenology and harvesting time of the associated crops poses many problems to the farmers to manage the mixtures. Hence devising the suitable agronomic practices for mixtures under different ecological zones had been the subject of researcher (Carr *et al.*, 1998; Ghanbari-Bonjar and Lee, 2003; Tuna and Orak, 2007; Nadeem *et al*., 2010).

Extent of the competition and facilitation for the resources among the intercrops dictates the potential advantages of the mixtures, which in turn is greatly affected by the relative density of the species in the mixture (Vandermeer, 1990). Over yielding from the mixtures may be obtained if the individuals of the same species compete more to each other than to the individuals of the other species (Caballero *et al*., 1995). However, in forage production system a balanced composition of cereal and legume in final produce is desirable to ensure higher DM yield of improved quality. Relative seed proportion in the mixture is the agronomic practice that will determine the final composition of the produce in a cereal-legume binary mixture. Higher rate of cereal in mixture will increase the total DM of the produce but of low nutritive value while higher rates of the legume in the mixture will serve the purpose of the enhancing the quality but at the expense of DM.

Harvesting time is the most important factor affecting the plant physiology and expression of the yield potential of a crop as the dry matter production and partitioning depends upon the stage of the crop growth at harvesting. This is even more critical for forage production system as the purpose is to find the best time of cutting the mixture to have a desirable combination of biomass yield and quality. Small cereal-clover mixtures have shown the potential in improving the forage productivity in all over the world hence researchers have focused on devising the appropriate agronomic practices to explore the maximum potential of the mixtures. In Pakistan, oat (*Avena sativa* L.) and Egyptian clover (*Trifolium alexandrinum* L.*)* are the main winter cereal and clover forage, respectively. However, the influence of mixture of oat with Egyptian clover in enhancing the animal feed recourses has not yet been studied. Therefore, information lacks on effect of different

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seed ratios of oat on the oat:Egyptian clover mixture and subsequent re-growth of Egyptian clover when first cut is made at various growth stages of oat. So this study was conducted with an objective to assess the dry matter yields of oat:Egyptian clover mixture established with various proportions of oat harvested at different growth stages of oat.

Materials and Methods

Field experiment was carried out at Agronomic Research Farm, University of Agriculture, Faisalabad, Pakistan during the year 2010-2011 and 2011-2012 to determine proper seeding ratios and cutting time of the oat- Egyptian clover mixture for higher forage yield and relative yield advantage. Soil of the site was sandy clay loam and its physiochemical characteristics are represented in Table 1. Mean monthly temperature and precipitation during the experimental period is given in Table 2. Experiment was established on 08th and 12th November during first and second year, respectively. Oat and Egyptian clover sole and in combination at four seeding ratios viz. 100:100 (S_1), 75:100 (S_2), 50:100 (S_3) and 25:100% (S_4) of oat and Egyptian clover, respectively. First cut of the treatments was done at later stem elongation (GS_1), early booting (GS_2) and early heading (GS_3) stage of the oat, respectively and a re-growth cut was taken after 40 days of respective first cut. Seed rates used for oat and Egyptian clover were 75 and 20 kg ha^{-1}. Treatments, each of 3 m × 6 m net plot size, were organized in randomized complete block design (RCBD) with three replications. Oat was sown in 30 cm apart rows by single row hand drill. After the sowing of oat, field was irrigated and Egyptian clover was broadcasted in standing water which is a common practice in the area. Before sowing 60 kg ha^{-1} nitrogen and 80 kg ha^{-1} phosphorus was applied. First irrigation was applied after 40 days of sowing and subsequent irrigation was applied 30 days after first irrigation.

Whole plots were cut and both intercrops were separated and weighed for green forage yield. Dry matter yield was determined by keeping 500 g chopped sample of oat and Egyptian clover separately in an oven at 65°C till constant dry weight was achieved. Dry matter yield of oat and Egyptian clover were separately recorded and then were added to calculate the total dry matter yield (t ha^{-1}). Similar procedure was adopted at re-growth cut. Relative advantage of the mixture over sole cropping was assessed by calculating the land equivalent ratio (LER), which indicates the area under sole crop required to produce the yield equivalent to the yield produced by mixture (Mead and Willey, 1980). LER was calculated by using formula:

$$\mathrm{LER} = \left(\frac{\mathrm{Yab}}{\mathrm{Yaa}}\right) + \left(\frac{\mathrm{Yba}}{\mathrm{Ybb}}\right)$$

Where, Yab and Yba is the yield of intercrop 'a' and 'b' in mixture respectively. While Yaa and Ybb are their sole crop yields. The collected data was analyzed statistically by employing Fisher's analysis of variance technique and treatment means were compared by using least significant difference test at 5% probability level (Steel *et al*., 1997).

Results

Primary Biomass

First cut dry matter yield of oat and Egyptian clover in mixture and sole crop under varying seeding rates and cutting time of mixture are given in table 3. Interaction for oat dry matter yield in the mixture was significant only in first year of experiment. Oat dry matter production was higher in the year 2010 than 2011. Dry matter yield of oat increased as cutting was delayed from stem elongation (GS_1) to heading stage (GS_3). Average dry matter yield of oat under all seeding ratios at GS_1, GS_2 and GS_3 was 3.17, 6.61 and 11.40 t ha^{-1} for first year while during second year values were 2.81, 6.06 and 10.51 t ha^{-1} for second year, respectively. The Dry matter yield of oat in the mixture increased with increasing its proportion from 25% to 100% in mixture. Maximum dry matter yield of oat at each cutting stage was observed from sole oat cropping in both the years. However, overall maximum dry matter yield (13.26 t ha^{-1}) was observed from oat alone when harvested at early heading stage followed by S_1 (12.15 t ha^{-1}) and S_2 (11.90 t ha^{-1}) cut at same growth stage. Even the mixture with 100% oat seed rate could not produce the yield match to sole oat at any cutting time. Average over years and seeding proportions, sole oat produced 1.28, 0.8 and 1.27 t ha^{-1} more dry yield matter than treatment involving 100% oat at GS_1, GS_2 and GS_3, respectively.

Egyptian clover dry matter yield in the mixture was greatly affected by oat seeding ratios and cutting stage (Table 3). At GS_1 suppression of Egyptian clover was less severe as compared to GS_2 and GS_3 and this effect is indicated by the fact that at GS_1 on an average, over years and seeding ratios, Egyptian clover dry matter yield from mixtures was 46.36% of sole Egyptian clover, while at GS_1 and GS_3 the ratio decreased to 28.42 and 29.21%, respectively in 2010, while in 2011 values were 51.9, 32.38 and 24.66%. Increasing the oat proportion in sowing mixture decreased the Egyptian clover proportion in yield. Higher Egyptian clover proportion was observed when oat seed rate was 25% at all cutting stages and least Egyptian clover proportion was noted when full seed rate of oat was used in mixture. Even at 25% oat seed in mixture Egyptian clover % in the mixture was (average of 2 years) 27.37, 16.94 and 13.70% at three cutting time (GS_1, GS_2 and GS_3, respectively). During the first year of experiment, highest Egyptian clover DM as a percentage of sole Egyptian clover was recorded in S_4-GS_1 treatment when it produced 0.79 and 0.65 t ha^{-1} which was 67.5 and 70.65% in first and second year, respectively. However, lowest dry matter yield as percentage of sole crop was recorded to be 0.71 t ha^{-1} and 0.48 t ha^{-1} which was 17.57 % and 12.80% of sole crop in

Table 1: Physiochemical characteristics of soils

Characteristics	Unit	2010-2011	2011-2012
EC	dS m^{-1}	1.53	1.58
pH	-	7.8	8.1
Organic matter	%	0.73	0.77
Nitrogen	%	0.039	0.042
Phosphorus	ppm	6.6	7.2
Potassium	ppm	131	119

Table 2: Average temperature and total rainfall per month during experiment period

Month	Rainfall (mm)		Temperature (°C)	
	2010-2011	2011-2012	2010-2011	2011-2012
October	00.0	00.4	26.3	24.7
November	00.0	00.0	18.8	20.5
December	01.0	00.0	13.3	12.5
January	00.0	3.8	10.1	10.2
February	20.6	08.0	14.4	11.5
March	06.8	1.5	19.6	18.8
April	20.9	10.5	24.8	25.3

Source: Agricultural Meteorology Cell, Department of Crop Physiology, University of Agriculture, Faisalabad

S_1-GS_3 in both years, respectively.

Treatments affected the total dry matter yield at first cut significantly (Table 3). During both years maximum dry matter yield was produced by oat alone when harvested at early heading stage and it was followed by S_2-GS_3 (12.95 t ha^{-1} in first and 11.24t ha^{-1} in second year). Mixtures, at each cutting stage, produced higher DM yield than Egyptian clover alone but lower than oat alone. Dry matter yield of highest total dry matter yield producer mixture (S_2-GS_3) was 97.66 and 92.58% of the oat alone during first and second year, respectively (Table 3). In both years treatment S_4-GS_1 gave the lowest DM yield. Total DM of the mixtures increased with increasing oat proportion in the mixture. Lowest DM yields of the mixtures were recorded at GS_1.

Re-growth Biomass

Oat significantly regrew only when first cut was done at stem elongation stage (Table 4). In mixture oat re-growth DM yield was negatively related with oat seeding proportion in mixture. In both years, however maximum re-growth DM (3.87 and 4.73 t ha^{-1}) was recorded from oat alone at stem elongation stage. Egyptian clover re-growth in the mixture was also negatively related with oat seeding ratio in sowing mixtures. On an average over years and growth stages, DM yields at seeding ratios S_1, S_2, S_3 and S_4 were 10.02, 8.93, 7.25 and 6.08 times of their yield in first cut as compared to 3.42 times in case of sole Egyptian clover. Egyptian clover plants during re-growth did not face any competition for light, space and nutrients from oat at GS_2 and GS_3 because there was no oat re-growth at these stages. Absence of competition in case of Egyptian clover alone resulted in higher first cut and subsequent re-growth yield (Table 4). Egyptian clover re-growth DM yield was higher in sole cropping than Egyptian clover from mixture. On average of all mixtures, Egyptian clover re-growth DM yield was higher at GS_3 (9.48 t ha^{-1}) and GS_2 (8.19 t ha^{-1}) than GS_1 (5.80 t ha^{-1}).

Total Dry Matter Yield

Treatments significantly affected the total dry matter yield of the mixture (Table 4). During 2010 highest total dry matter yield was recorded in S_4-GS_3 which was not statistically different from the mixtures where oat proportion was 75% and 50% at same growth stage (19.28 and 19.19 t ha^{-1}, respectively). During the year 2011 highest TDM yield was 20.04 t ha^{-1} recorded in S_4-GS_3. All the mixtures at each growth stage produced higher total dry matter yield than sole crop of both intercrop under two cut system. Egyptian clover alone under two cut system produced statistically similar yield to oat alone at GS_3 and at GS_1 during both years (Table 4). However, Egyptian clover alone produced higher dry matter yield than oat alone at GS_2 (11.83 vs 7.53 t ha^{-1} in first year and 11.22 vs 7.04 t ha^{-1} in second year) during both years. Highest Egyptian clover alone yield was recorded to be 14.13 and 12.96 t ha^{-1} at GS3 and longer period of growth for first cut and higher re-growth TDM production accounted for this. Egyptian clover re-growth TDM yield from Egyptian clover sole crop increased as first cut was delayed (7.08, 8.97 and 9.65 t ha^{-1} for GS_1, GS_2 and GS_3, respectively) and it may be attributed to increase in plant size with delayed first cut as re-growth potential of a species depends on plant size at first cut (Baron *et al*., 1995).

Land Equivalent Ratio

Relative advantage of mixture over mono-crops is presented in Table 5. Partial LER of oat increased with its higher proportion in sowing mixture. Partial LER of oat was lower at GS_1 than latter growth stages. Partial LER of oat was more than 0.5 in all mixtures at all growth stages (Table 5) showing that there was advantage of sowing it with Egyptian clover at any seeding rate. Partial LER of Egyptian clover increased with decreasing oat proportion however it remained less than 0.5 in all treatments except the treatment when mixtures was cut at 60 DAP using 50 and 25% oat seeding ratio. It implies that sowing of oat with Egyptian clover was disadvantageous for Egyptian clover. Partial LER of Egyptian clover was higher at first cutting time than later cutting time. On average of both years the range of Partial LER of Egyptian clover at first cut was 0.32 to 0.69 as compared to second cut and third cut when oat seed proportion was decreased from 100 to 25%, respectively. Total LER values were significantly greater than unity at all cutting time and over all seeding proportion showing mutual cooperation among intercrops in mixtures. On an average of both years and cutting time total LER values are 1.06, 1.09, 1.14 and 1.15 for oat densities 100, 75, 50 and 25% in the mixture indicating that sole oat (higher DM producer) requires 6, 9, 14 and 15 % more area to produce same yield as by mixtures.

Table 3: Dry matter yield characteristics of oat:Egyptian clover mixtures during primary growth as affected by different oat proportions harvested at various growth stages of oat

Seed proportion (oat:E. clover)	First cut											
	Oat DM				Berseem DM				Total DM			
	GS_1	GS_2	GS_3	Mean	GS_1	GS_2	GS_3	Mean	GS_1	GS_2	GS_3	Mean
						2010-2011						
100:100	3.29 i	6.81 ef	12.15 b	7.42 B	0.35 j	0.63 gh	0.71 gh	0.56 E	3.64 fg	7.44 d	12.86 ab	7.98 B
75:100	3.04 ij	6.65 efg	11.90 bc	7.20 BC	0.44 ij	0.64 gh	1.05 de	0.71 D	3.49 fg	7.29 d	12.95 ab	7.91 B
50:100	2.81 ij	6.44 fg	11.07 c	6.77 C	0.59 hi	0.97 ef	1.20 d	0.92 C	3.39 fg	7.42 d	12.27 b	7.69 B
25:100	2.02 j	5.62 gh	8.63 d	5.42 D	0.79 fg	1.08 de	1.76 c	1.21 B	2.82 g	6.70 d	10.39 c	6.63 C
E. clover alone	-	-	-	-	1.17 d	2.92 b	4.04 a	2.71 A	1.17 h	2.92 g	4.04 ef	2.71 D
Oat alone	4.63 h	7.53 e	13.26 a	8.47 A	-	-	-	-	4.64 e	7.53 d	13.26 a	8.47 A
Means	3.15 C	6.61 B	11.41 A	-	0.67 C	1.25 B	1.75 A	-	3.19 C	6.55 B	10.96 A	
LSD (0.05)	S = 4.881	GS=0.321	S×GS=1.074		S =0.085	GS=0.055	S×GS=0.187		S =0.444	GS=0.255	S×GS=0.959	
						2011-2012						
100:100	2.90	6.16	10.71	6.60 B	0.32 g	0.44 fg	0.48 fg	0.41 D	3.22 ef	6.62 c	11.19 b	7.01 B
75:100	2.74	5.99	10.51	6.42 BC	0.42 fg	0.52 fg	0.72 ef	0.55 D	3.16 ef	6.52 c	11.24 ab	6.97 B
50:100	2.48	5.88	10.12	6.16 C	0.52 fg	0.75 ef	0.97 de	0.75 C	3.01 efg	6.64 c	11.09 b	6.91 BC
25:100	1.80	5.26	9.09	5.39 D	0.65 efg	1.14 d	1.53 c	1.11 B	2.45 fg	6.41 c	10.62 c	6.50 C
E. clover alone	-	-	-	-	0.92 de	2.20 b	3.75 a	2.29 A	0.92 h	2.20 g	3.75 de	2.29 D
Oat alone	4.12	7.04	12.14	7.77 A	-	-	-	-	4.12 d	7.04 c	12.14 a	7.77 A
Means	2.81 C	6.07 B	10.52 A		0.57C	1.01 B	1.49 A		2.81 C	5.90 B	10.01 A	
LSD (0.05)	S =0.408	GS= 0.268	S×GS=NS		S =0.101	GS=0.155	S×GS=0.341		S =0.424	GS=0.244	S×GS=0.916	

Table 4: Re-growth dry matter yield characteristics of oat:Egyptian clover mixtures as affected by different oat proportions harvested at various growth stages of oat

Seed proportion (oat:E. clover)	Re-growth cut								Grand DM (Primary + re-growth)			
	Oat DM				Berseem DM							
	GS_1	GS_2	GS_3	Mean	GS_1	GS_2	GS_3	Mean	GS_1	GS_2	GS_3	Mean
						2010-2011						
100:100	2.12 e	-	-		2.80 j	5.00 fgh	5.23 ef	4.34 E	8.56 i	12.44 de	18.08 b	13.031 C
75:100	2.34 d	-	-		3.86 i	5.14 fg	6.33 d	5.11 D	9.67 h	12.43 de	19.28 a	13.80 B
50:100	3.12 c	-	-		4.46 g	5.72 e	6.91 c	5.70 C	10.98 fg	13.13 d	19.19 a	14.43 A
25:100	3.24 b	-	-		4.66 h	6.29 d	9.01 b	6.65 B	10.71 g	12.99 d	19.40 a	14.37 A
E. clover alone	-	-	-		6.50 cd	8.91 b	10.09 a	8.50 A	7.67 ij	11.83 ef	14.13 c	11.21 D
Oat alone	3.87 a	-	-		-	-	-		8.50 ij	7.53 j	13.26 cd	9.76 E
Means					4.56 C	6.21 B	7.51 A		9.35 C	11.73 B	17.23 A	
LSD (0.05)	S×GS=0.118				S =0.247	GS=0.162	S×GS=0.543		S =0.462	GS=0.265	S×GS=0.997	
						2011-2012						
100:100	2.40 e	-	-		4.09 h	6.01 def	6.33 de	5.48 D	9.78 g	12.62 cde	17.52 b	13.31 C
75:100	3.61 d	-	-		5.15 g	6.87 bc	6.41 bc	6.14 C	11.92 ef	13.38 cd	17.65 b	14.32 B
50:100	4.13 c	-	-		5.29 fg	6.99 bc	9.92 a	6.40 C	12.43 de	13.62 c	18.01 b	14.69 B
25:100	4.51 b	-	-		5.53 efg	7.10 bc	9.75 a	7.46 B	12.49 cde	13.51 cd	20.04 a	15.46 A
E. clover alone	-	-	-		7.66 b	9.02 a	9.21 a	8.63 A	8.58 h	11.22 f	12.96 cde	10.92 D
Oat alone	4.73 a	-	-						8.85 gh	7.04 i	12.15 ef	9.35 E
Means					5.54 C	7.20 B	7.72 A		10.68 C	11.90 B	16.44 A	
LSD (0.05)	S×GS=0.128				S =0.369	GS=0.243	S×GS=0.812		S =0.541	GS=0.311	S×GS=1.169	

Table 5: Partial and total land equivalent ratios (LERs) in oat:Egyptian clover mixtures as affected by different oat proportions harvested at various growth stages of oat

Seed proportion (oat:E. clover)	LER Values								
	Oat partial LER			Berseem partial LER			Total LER		
	GS_1	GS_2	GS_3	GS_1	GS_2	GS_3	GS_1	GS_2	GS_3
					2010-2011				
100:100	0.71 cd	0.91 a	0.92 a	0.30 def	0.21 hi	0.17 i	1.01 b	1.12 ab	1.09 ab
75:100	0.66 d	0.88 ab	0.90 a	0.38 cd	0.22 ghi	0.26 fgh	1.03 ab	1.10 ab	1.16 ab
50:100	0.61 d	0.85 ab	0.83 abc	0.50 b	0.33 def	0.29 efg	1.11 abc	1.18 a	1.13 ab
25:100	0.44 e	0.74 bcd	0.65 d	0.67 a	0.36 cde	0.44 bc	1.11abc	1.12 ab	1.09 ab
LSD (0.05)	S×GS=0.144			S×GS=0.078			S×GS=0.160		
					2011-2012				
100:100	0.71 bcd	0.87 ab	0.88 a	0.35 de	0.21 f	0.18 f	1.06 ab	1.08 ab	1.01 b
75:100	0.66 cd	0.85 ab	0.87 ab	0.46 bcd	0.24 ef	0.19 f	1.12 ab	1.09 ab	1.06 ab
50:100	0.61 d	0.84 ab	0.83 abc	0.57 b	0.35 de	0.26 ef	1.18 ab	1.19 ab	1.09 ab
25:100	0.43 e	0.75 abcd	0.74 abcd	0.71 a	0.53 bc	0.41 cd	1.14 ab	1.28 a	1.16 ab
LSD (0.05)	S×GS=0.168			S×GS=0.137			S×GS=0.239		

GS_1=Growth Stage 1 (stem elongation of oat); GS_2=Growth Stage 2 (booting stage of oat); GS_3=Growth Stage 3 (early heading stage of oat)
NS= Non significant

Discussion

Better nutrient availability due to higher rainfall in the month of February, March and April in 2010 had resulted in higher first cut DM yields during the year 2010 than 2011. Increase in green forage/DM yield with delayed cutting time was obvious and may be attributed to lignifications and increased cell wall contents with advanced maturity (Salawu *et al*., 2001; Alemu *et al*., 2007; Ayub *et al*., 2008; Ammar *et al*., 2010; Atis *et al*., 2012b). According to Edmisten *et al*. (1998) this increase in DM yield with maturity is mainly due to more stem dry matter contents that are mainly associated with plant height. Mixture DM yields during primary growth are comparable to those of Ross *et al*. (2005) who reported DM yields of oat-Egyptian clover mixture at stem elongation, booting and heading stage to be 2.5, 5.1 and 9.0 t ha^{-1}, respectively. During primary growth there was no yield advantage in terms of DM from mixtures and mixture yields were intermediate to sole crops of both intercrops. Similar results from mixtures have previously been documented by Caballero *et al*. (1995), Jensen (1996), Kaiser *et al*. (2007) and Erol *et al*. (2009). Higher DM yield of oat in mixtures proved the oat to be the yield determinant crop because of fast growth, greater vegetative development (Martiniello, 1999) more competitive ability than Egyptian clover (Jacobs and Ward, 2012) and more plant height. More number of plants per unit area with increased oat proportion in mixtures resulted in higher DM production at higher oat ratios. This result confirms the previously work done by Peltonen-Sainio and Järvinen (1994) who reported that increasing seed rate of oat decreased individual plant growth rate however growth rate on area basis increased.

At GS_1 suppression of Egyptian clover by oat was less because oat intercrop did not significantly covered the ground so light and other resources were relatively easily available to the Egyptian clover than later growth stages when oat crop was fully established. Greater suppression of Egyptian clover by oat at GS_2 and GS_3 may be attributed to the taller stature of oat plants clover that altered the penetration of light to Egyptian clover plants that subsequently impaired the photosynthetic efficiency of Egyptian clover. In agreement to this study, Ross *et al*. (2004) reported 47 and 33% decrease in PAR to Egyptian clover in mixture with oat and barley, respectively. Legumes inability of competing with cereals (Jacobs and Ward, 2012) may be the other reason of Egyptian clover suppression in mixtures with oat compared to sole Egyptian clover, resulting in drastic yield reduction of Egyptian clover. These results are in line with Ross *et al*. (2003). They reported that beseem dry matter yield was reduced by 30, 58, 68 and 80% in first cut when sown in mixture with oat at 5, 25, 50 and 100 live seeds m^{-2}. Similarly, Yucel and Avci (2009) reported only 1.8 to 39.9% increase in dry matter share of vetch in mixture with triticale when its seeding proportion was increased from 10 to 90%. Suppression of Egyptian clover even at lower oat density might have been the result of developmental plasticity of oat, as oat plant compensates the lower seeding rates by producing more number of tillers $plant^{-1}$.

Absence of oat re-growth at GS_2 and GS_3 may be referred to the increased shading at the lower parts of the canopy with advanced maturity in oat that greatly reduced the PAR penetration resulting in minimal meristematic activity at the base of canopy that is responsible for re-growth (Baron *et al.,* 1995). However, two-cut oat dry matter yield was less than the single late cut i.e., 90 DAP (Table 4) and this result is supported by (Royo, 1999) who have drawn similar conclusions. At GS_1, lower oat re-growth dry matter yield from mixtures than oat alone may be attributed to the vigorous re-growth of Egyptian clover than oat which suppressed the later. In line with this study, Ross *et al*. (2004) mentioned that during first cut cereal dominated the yield while during second cut Egyptian clover dominated the dry matter production in oat:Egyptian clover mixture. Inverse relationship between higher oat seeding ratios in sowing mixture and Egyptian clover re-growth yield found in this study was quite in line with the findings of Ross *et al*. (2003), Ross *et al*. (2004) and Ross *et al*. (2005). This may be explained by mortality of the Egyptian clover plants under higher level of competition at increased oat seeding ratios that left less residual leaf area of Egyptian clover to support re-growth, as annual clovers mostly depend upon residual leaf area for re-growth, because they do not have stored reserves (Kendall and Stringer, 1985). Egyptian clover alone could not produce DM yield higher or equal to any mixture after two cuts and this was mainly due to the higher first cut DM production by mixture than Egyptian clover alone as a results of oat presence. These results are quite in line with those of Welty *et al*. (1991) who reported 0.5 to 1.0 times higher DM yield of oat-Egyptian clover mixture over Egyptian clover sole under two cut system.

Higher LER values all the treatments indicates supremacy of mixture over sole cropping as an outcome of co-operation between species. Higher partial LER values of oat than berseem refer that being a cereal, oat was the stronger competitor for soil minerals than legumes (Jensen, 1996), and benefitted more from soil mineral resources than its proportionate share in sowing mixture. It also indicates that interspecific competition was less intense than intraspecific competition because intercrops did not compete for same ecological niche (Lithourgidis *et al*., 2011). In general sole crops required 1 to 18% and 1 to 28% more area to produce dry matter similar to mixtures during first and second year respectively. Musa *et al*. (2010), Rahetlah *et al*. (2010) and Atis *et al*. (2012a) recorded higher LER values from barley pea, vetch:wheat and vetch:oat mixture under different seeding proportions, respectively.

Mixtures under all seeding rates were better yielder than sole crop of both intercrop at all growth stages under two-cut system. Results are in line with those of Martiniello

(1999), Ross *et al.* (2003) and El-Kramany *et al.* (2012). Higher DM production from berseem alone than in mixture at each growth stage was due to sufficient Egyptian clover plant size at first cut that ensured more reserves stored in lower part of the plant that helped high re-growth as compared to Egyptian clover in mixtures (Ta *et al*., 1990). Higher DM yield after two cut at GS_3 than at GS_2 and GS_1 may be due to the fact that delayed first cut (from GS_1 to GS_2 and GS_3) subjected the Egyptian clover re-growth to higher temperature as the season progressed (Table 2) which resulted in higher dry matter production. Higher temperatures hasten the maturity (Fales, 1986; Mela, 2003), which may be associated with enhanced activity of lignin synthetic enzymes at higher temperatures (Buxton and Fales, 1994) or with increased partitioning of plant dry matter to more lignified tissues (Cone and Engels, 1990; Da Silva *et al.*, 1987). However, Mela (2003) reasoned that at higher temperatures, rate of respiration exceeds the rate of photosynthesis that promotes lignifications. At higher oat densities, oat and mixture DM yield was higher during first cut which had a negative impact on Egyptian clover DM yield during both primary and re-growth. However, vigorous Egyptian clover re-growth from mixtures with lower oat density compensated the first cut yield differences. Hence, use of higher oat seeding ratios in mixture with Egyptian clover seems to be waste of resources as maximum DM yield after two cuts were recorded from mixtures with 25% oat ratio.

Outcome of this study suggest that mixing Egyptian clover with oat resulted in definite advantage in terms of more DM yield production. Re-growth ability of oat decreased with maturity. While studying the oat-Egyptian clover mixtures, conclusions must not be drawn on the basis of only single cut but re-growth yield should be considered. For oat-Egyptian clover mixture, oat proportion should not exceed 25% of recommended seed rate for higher dry matter yield. Cutting the mixture at early heading stage of oat provided more first cut dry matter yield and vigorous Egyptian clover re-growth which will serve the purpose of providing quality forage over extended period of time.

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