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Evaluation of Growth Performance and Biomass Yield of Oat (*Avena sativa* L.) and Lucerne (*Medicago sativa* L.) in Intercropping

S.D. Ninama[1*], J.C. Shroff [2], S.N. Shah[3] and M.K. Rathwa[1]
[1]Ph.D. Scholar, Department of Agronomy,
Anand Agricultural University, Anand-388110, (Gujarat), India.
[2]Associate Professor, Department of Agronomy,
Anand Agricultural University, Anand-388110, (Gujarat), India.
[3]Associate Director of Research,
Anand Agricultural University, Anand-388110, (Gujarat), India.

(Corresponding author: S.D. Ninama)*
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ABSTRACT: A field experiment was conducted during *rabi* 2018-19 to study the growth and yield performance of Oat and Lucerne intercropping systems at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The study aimed to compare the productivity of Oat + Lucerne intercropping system with sole crops; and also to figure out most economical planting ratio for growing Oat and Lucerne in intercropping system. The experimental soil was loamy sand with good drainage and moisture retention capacity. Altogether, eight treatments comprising combinations of Oat + Lucerne with varied row ratios; along with sole Oat and Lucerne treatments were laid down in randomized block design replicated four times. The results showed that row ratio of 2:1(Oat + Lucerne) was suitable for attaining better plant growth, yield, Oat equivalent yield, land equivalent ratio and BCR. However, sole cropping of Oat and Lucerne was equally effective in producing higher number of tillers and increased yield attributes as compared to 2:1 row ratio (Oat + Lucerne).

Keywords: Intercropping, Land equivalent ratio, Oat equivalent yield and Net returns.

INTRODUCTION

India has largest livestock population of 512.05 million heads, which is about 15 % of the world's livestock population (Iqbal *et al.*, 2018). Livestock rearing plays a vital role in the rural economy of India by supplementing the family income. The productivity and availability of good quality feed and fodder has a prime importance in the development of livestock. The country has about 4.4 % (Maughan *et al.*, 2019) of the cultivated area covered under fodder crops with an annual total forage production of 833 MT (390 MT green fodder production and 443 MT dry fodder production). Whereas, the annual forage requirement is 1594 MT (1025 MT green fodder production and 569 MT dry fodder production) to support the existing livestock population indicate short supply of feed and fodder (Anon., 2009).

Gujarat state has total animal production of 18.44 million and their optimum fodder requirement worked out is 42.2 MT, whereas only 20 MT of fodder is made available in normal year. As a result, livestock suffers continuously with malnutrition for the years round in general, resulting in their production capacity at sub-optimum level. Availability of green forage for animal is the key to success to achieve higher milk production of dairy enterprises and it is difficult to maintain health and production of the livestock without supply of green fodder (Griffiths *et al*., 2003).

Oats and Lucerneare fodder crops with wider adaptability in Indian condition. Oats are consumed as human food and fodder for cattle. The protein quality of Oat is excellent. Approximately Oats are believed to produce high green fodder (50-60 t/ha), dry matter (17-18 t/ha), CP (12%) and IDVMD (66 %).Lucerne is called as King of forage crops being most diverse cross pollinated crop well suited to warm temperature and cool climate conditions.Lucerne is commonly called as "*rijka*" in northern India popular as Green gold of forage crops as it is rich in protein (18-22%), amino acids, fiber (20-30%) and vitamin 'A 'content (Eliza and Mieczyslaw, 2020).

Intercropping of cereal forage with legume enhances the total productivity and improves the quality of forage as well as maintains soil fertility. Oat intercropped with legumes at proper row ratios produced significantly higher green forage, dry matter and crude protein yield also. Lucerne, besides supplying nutritious fodder; increases the yield of cereals by making additional nitrogen available to main crop (Das & Khurana, 1964). Looking to the scenario, an experiment was undertaken

to study growth and yield performance of Oat and Lucerne under intercropping system.

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of the year 2018-19 at Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand to study the growth and yield performance of Oats (*Avena sativa* L.) and Lucerne (*Medicago sativa* L.) in Oat and Lucerne intercropping systems. The experimental soil was loamy sand in texture and alkaline in reaction. The experimental soil was low in organic carbon, medium in available nitrogen, moderate in phosphorus and high in potassium content. The field experiment was laid down in randomized block design replicated four times. In the experimental year, the maximum temperature values ranged between 20.2 to 34.5 ˚C and minimum temperature ranged between 7.1 to 16.1 ˚C during the crop season. The average humidity ranged between 26.4 to 65.9 per cent and total rainfall was 0.0 mm during the crop season.

The experiment was carried out with Oat cv. **Jo 3-91** and **Lucerne cv. Anand 2 (GAUL 1)**. Eight treatments comprising different combinations of Oat and Lucerne varied by row ratio in intercropping system were evaluated. The treatments include T_1: Oat (sole), T_2: Lucerne (sole), T_3: Oat + Lucerne (1:1), T_4: Oat + Lucerne (1:2), T_5:Oat + Lucerne (2:1), T_6:Oat + Lucerne (2:2), T_7:Oat + Lucerne (2:4) and T_8:Oat + Lucerne (4:2).The economics was worked out on current market price basis. The variances of different sources of variation in ANOVA were tested by "F-test" and compared with the value of Table-F at 5% level of significance. The values of S. Em ±, C.D. and C.V.% were also calculated.

Oat equivalent yield

Yield of individual crop was converted into equivalent yield (q ha^{-1}) on the basis of prevailing market price of the crop. (Anjaneyulu *et al*., 1982). It was calculated by the following formula:

$$OEY = \text{Yield of Oat} + \frac{\text{Yield of Lucerne} \times \text{Price of Lucerne}}{\text{Price of Oat}}$$

Land equivalent ratio. It is the relative land area under sole crop that would be required to produce the yield achieved in intercropping. It is usually assumed that level of management must be same for intercropping as for sole cropping. This was calculated as per method given by Willey & Osiru (1972). It was calculated as following:

LER = LER (Oat) + LER (Lucerne)

$$\text{LER (Oat)} = \frac{\text{Yield of Oat under intercropping}}{\text{Yield of Oat under sole cropping}}$$

$$\text{LER (Lucerne)} = \frac{\text{Yield of Lucerne under intercropping}}{\text{Yield of Lucerne under sole cropping}}$$

LER > 1 indicates yield advantage

LER = 1 indicates no gain or no loss

LER < 1 indicates yield loss

Benefit cost ratio

$$\text{BCR} = \frac{\text{Total realization (₹ ha}^{-1})}{\text{Total cost of cultivation (₹ ha}^{-1})}$$

RESULTS AND DISCUSSION

The data and results pertaining to present study are been explained in detail under the following heads:

Growth parameters. The results of the experiment indicated that changes in plant population per meter row length at 20 DAS as well as plant height at each cut did not reach to the level of significance as affected by different row ratios under intercropping system (Table 1).

Among growth parameters, highest number of tillers per meter row length was observed under sole cropping of Oat and Lucerne at each cut as well as in the mean data as shown in Table 1. It was observed that with subsequent cuts, the number of tillers were increased, which could be the result of efficient utilization of natural resources and minimum competition between the plants of different species. Similar trend was observed by Meena *et al.* (2011); Amonge *et al.* (2013); Verma and Jeengar (2015); Bhagat *et al*. (2017); Singh *et al.* (2017); Iqbal *et al*. (2018); Ganvit *et al.* (2018).

Growing sole Oat and/or sole Lucerne was found to be superior and recorded higher leaf: stem ratio as recorded at first, second and third cut as well as in mean data, respectively (Table 1).

Table 1: Effect of different row ratios on growth parameters as influenced under inter cropping system.

Sr. No.	Treatments	Plant population m^{-1} row length		Plant height (cm)		Number of tillers m^{-1} row length		Leaf: stem ratios	
		Oat	Lucerne	Oat	Lucerne	Oat	Lucerne	Oat	Lucerne
T_1	Oat (Sole)	46.40	-	85.56	-	73.92	-	4.66	-
T_2	Lucerne (Sole)	-	42.50	-	67.85	-	55.67	-	1.72
T_3	Oat + Lucerne (1:1)	45.87	42.78	82.21	65.90	68.25	48.75	4.23	1.63
T_4	Oat + Lucerne (1:2)	45.57	42.53	85.74	68.53	68.42	49.83	4.29	1.68
T_5	Oat + Lucerne (2:1)	45.27	41.70	87.52	70.31	72.92	54.25	4.57	1.70
T_6	Oat + Lucerne (2:2)	45.42	42.83	83.04	66.36	66.33	46.75	4.21	1.56
T_7	Oat + Lucerne (2:4)	45.65	41.78	82.77	67.18	66.25	46.00	4.19	1.52
T_8	Oat + Lucerne (4:2)	45.95	42.70	82.53	66.19	65.92	45.50	4.19	1.51
S.Em. ±		1.19	1.11	0.83	1.17	1.03	0.93	0.11	0.02
C.D. at 5 %		NS	NS	NS	NS	3.05	2.75	0.33	0.07
C.V. %		5.24	5.25	2.60	3.47	2.99	3.74	5.05	2.86

The increase in leaf: stem ratio might be due to more supply of nitrogen leading to more protein synthesis which might have triggered increase in the number, size and succulence of leaves. These findings corroborate with the observations of Amonge *et al.* (2013); Bhagat *et al*. (2017); Singh *et al.* (2017); Ganvit *et al.* (2018); Iqbal *et al*. (2018).

Yield attributes and yield

Green Forage Yield. The results revealed that yield attributes and yield was significantly influenced by different row ratios in intercropping system (Table 2). The green forage yield was significantly influenced by different row ratio and recorded significantly higher under treatment T_1 (sole Oat) during first cut only however, it was remained at par with treatment having Oat + Lucerne row ratio of 2:1 (T_5). In second cut treatment T_5 (Oat + Lucerne, 2:1) recorded significantly higher green forage yield of 333.00 q ha^{-1}, although it was failed to prove its significant superiority over treatment T_4 (307.00 q ha^{-1}). During third cut and total yield, treatment T_5 (Oat + Lucerne, 2:1) recorded 225.00 and 785.00 q ha^{-1} of green forage yield, respectively and proved its significant superiority over the rest of the treatments. There was 14.14 per cent higher green forage yield recorded in total yield as compared to sole Oat and 53.00 percent higher than sole Lucerne. The lowest green forage yield was recorded under treatment T_2 (sole Lucerne) during individual cut as well as in total green forage yield. However it was found at par with treatment T_1 (sole Oat) during third cut only.

The higher green forage yield under particular treatments is attributed to better development of various growth parameters of respective crop. Moreover, under cereal legume intercropping system leads to better utilization of the resources that might have increased the yield of both crops. Being legume nature of Lucerne it adds nitrogen into the soil and plant can utilize that nitrogen which increased the protoplasmic constituents and accelerated the process of cell division and elongation which in turn gave luxuriant vegetative growth. Yield advantages under cereal legume intercropping system have also been reported by Surve *et al*. (2011); Meena *et al.* (2011); Deore *et al.* (2013); Amonge *et al.* (2013); Verma and Jeengar (2015); Bhagat *et al*. (2017); Singh *et al.* (2017); Ganvit *et al.* (2018); Iqbal *et al*. (2018).

Dry Fodder Yield. Intercropping Oat and Lucerne recorded significant changes in the dry matter yield as reported in Table 2. Significantly highest dry matter yield was recorded under treatment T_5 (Oat + Lucerne, 2:1) at first, second and third cut as well as in total yield, respectively. The dry matter yield observed in growing Oat + Lucerne (2:1) was higher to tune of 41.85 per cent than total dry matter yield obtained by growing Oat alone; and 44.78 per cent higher than sole Lucerne. During third cut only treatment T_5 failed to exhibit statistical superiority over treatment T_4 and was found at par with treatment T_4 (Oat + Lucerne, 1:2).

The lowest dry matter yield of 20.20 and 20.33 q ha^{-1} was recorded under treatment T_2 (*sole Lucerne*) and T_1 (sole Oat) during first and third cut. Similar trend was observed during second cut and total yield, treatment T_2 and T_1 were found at par in recording the lowest dry matter yield.

This may be due to higher fertility levels and suitable row ratios under intercropping system both crops behave as component crop. Addition of the legume crop in series leads to increase the availability and absorption of nutrients to the plants which resulted into more vegetative growth helps in increase the plant height and tillers on the account of enlargement of cells and enhanced photosynthesis, which resulted in higher dry matter yield. The results are in conformity with the findings of Surve *et al*. (2011); Meena *et al.* (2011); Deore *et al.* (2013); Amonge *et al.* (2013); Verma and Jeengar (2015); Bhagat *et al*. (2017); Singh *et al.* (2017); Ganvit *et al.* (2018); Iqbal *et al.* (2018).

Oat equivalent yield and Land equivalent ratio. Higher land equivalent ratio value of 1.47 indicate supremacy of intercropping over sole cropping as an outcome of cooperation between species and it was observed under T_5 (Oat + Lucerne, 2:1) as shown in Fig. 1. Land equivalent ratio more than 1.0 indicates suitability of practice in quantitative term. The results corroborate those achieved by Surve *et al*. (2011); Singh *et al.* (2017); Iqbal *et al*. (2018); Ganvit *et al.* (2018).

Significantly the highest total Oat equivalent yield (835.13q ha^{-1}) was recorded under treatment T_5 (Oat + Lucerne in 2:1 row ratio) and the lowest total Oat equivalent yield was recorded in T_2 treatment with mean yield 443.00 q ha^{-1}. This is in harmony with the published work of Amonge *et al.* (2013); Singh *et al.* (2017); Iqbal *et al*. (2018) (Table 2).

Economics. The regional adaptability of any agronomic practices in the yield of any crop is completely based on the highest economic return of a treatment. Therefore, it is necessary to work out economics of different treatments for valid comparison of agronomic practices and sound recommendation. On the basis of prevailing market prices of green forage (Oat & Lucerne) and different variable and non-variable inputs, the cost of production, gross realization, net realization along with the BCR were calculated for different treatments graphically illustrated in Fig. 1.

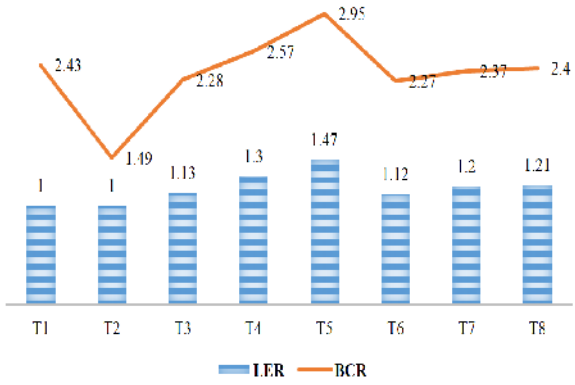

Fig. 1. Land equivalent ratio and Benefit cost ratio as influenced by different row ratios under intercropping system.

Data presented in Table 2 shows that row ratio 2:1 (T_5 Oat + Lucerne) generated maximum gross and net realization of 1,04,391 and 69,067 q ha^{-1}, respectively, while treatment T_2 (sole Lucerne) recorded the minimum gross and net realization of 55,375 and 18,272 q ha^{-1}, respectively. With respect to BCR, treatment T_5 recorded maximum BCR of 2.95, while the lowest of 1.49 was recorded for treatment T_2.

Table 2: Effect of different row ratios on green forage yield, Dry matter yield, Oat equivalent yield, LER and BCR as influenced under inter cropping system.

Sr. No.	Treatments	Green forage yield (q ha^{-1})			Dry matter yield (q ha^{-1})			Oat equivalent yield (q ha^{-1})	LER	BCR
		Oat	Lucerne	Total yield	Oat	Lucerne	Total DMY			
T_1	Oat (Sole)	674	-	674	82.84	-	82.84	674.26	1	2.43
T_2	Lucerne (Sole)	-	369	369	-	78.67	78.67	443.00	1	1.49
T_3	Oat + Lucerne (1:1)	442	176	618	58.59	47.68	106.27	653.54	1.13	2.28
T_4	Oat + Lucerne (1:2)	491	212	703	64.83	60.43	125.26	745.56	1.30	2.57
T_5	Oat + Lucerne (2:1)	532	253	785	71.32	71.14	142.46	835.13	1.47	2.95
T_6	Oat + Lucerne (2:2)	438	177	616	54.35	49.53	103.88	651.01	1.12	2.27
T_7	Oat + Lucerne (2:4)	449	200	649	56.51	54.84	111.34	688.57	1.20	2.37
T_8	Oat + Lucerne (4:2)	462	194	656	56.28	56.03	112.31	695.45	1.21	2.40
S.Em. ±		12.58	7.67	10.92	2.08	2.66	2.97	11.32	-	-
C.D. at 5 %		37.38	22.80	32.10	6.18	7.89	8.73	33.29	-	-
C.V. %		5.05	6.79	3.44	6.54	8.89	5.50	3.36	-	-

CONCLUSION

By looking at the current population of livestock, the forage and fodder availability is likely to be declined somewhat at some extent. The above research on forage intercropping was carried out by looking this scenario to full fill the requirement. The intercropping of oat and Lucerne with 2:1 row ratio found suitable for attaining better plant growth, yield, oat equivalent yield, land equivalent ratio and BCR. However, sole cropping of oat and Lucerne was also found equally effective in all those parameters.

FUTURE SCOPE

(i) The projected livestock population estimation in India are increasing day by day, hence it is important to maintain the sustainability in livestock feed and fodder.
(ii) Fodder and forage crops have several applications and uses and hence they serve as good sources of living fence, improved fallow, improved pastures, mulch, bee forage, fuel wood, timber, fertility enhancement, soil stabilization, oxygen, wildlife habitat, increased self-sufficiency, nutrient cycling and farm diversity.

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Conflict of Interest. None.

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