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Effect of different row ratios on yield and quality of oat (*Avena sativa* L.) and Lucerne (*Medicago sativa* L.) intercropping

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Abstract

The objective of this research is to find out suitable row ratio of oat and lucerne under intercropping system with respect to quality and yield. A field experiment was conducted during *rabi* 2018-19 at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The soil of experimental site was loamy sand in texture having good drainage and moisture retention capacity. Six different combinations of row ratio along with sole cropping of oat and lucerne were tested to fulfill the objective of this study. The treatments were allotted in randomized block design with four replications. All the yield (GFY, DMY, CPY) and quality (Crude protein, ADF, NDF, CF) parameters were recorded significantly superior under the planting ratio 2:1 (oat + lucerne) in intercropping. However in case of yield attributes, sole cropping of oat and lucerne were found comparative to row ratio 2:1 (oat + lucerne).

Keywords: Acid detergent fibre, neutral detergent fibre, crude fibre, crude protein yield

Introduction

Livestock rearing plays a vital role in the rural economy of India by supplementing the family income. It provides employment and contributes 25% to the total agricultural income. India has the largest livestock population of 512.05 million heads, which is about 15% of the world's livestock population. In Indian agriculture, animal husbandry is closely linked with crop production program as a complementary enterprise. Livestock population of India according to 19th livestock census conducted in 2012, is around 512.05 million of livestock, which includes 37.28% cattle, 21.23% buffaloes, 12.71% sheep and 26.40% goats (Anon., 2012) [2]. The productivity and availability of good quality feed and fodder has a prime importance for the development of livestock. However, the present feed and fodder resources of the country are only able to meet 46.6% of the requirement. The country has only 4.4% 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. At present, there is short supply of feed and fodder during summer season, which can meet only 48% of the requirement, with a vast deficit of 61.1% and 21.9% of green and dry fodder, respectively (Anon., 2009) [2].

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. It is therefore, very essential to maximize quality forage production per unit area and time. Fodder and crop residues of cereals are major source of forage but the nutritive value of these fodders is not adequate to achieve higher milk production. Availability of green forage yield of the animal is the key to success of dairy enterprises as it is difficult to maintain health and production of the livestock without supply of green fodder (Griffiths *et al.*, 2003) [7].

The oat plant (*Avena sativa* L.) is an annual grass grown primarily for its grain, which is one of the major cereal grains worldwide. The oat plant grows to a height of 1.2 m. It has a fibrous root system. Its culms are erect, smooth, and hollow.

In India, oat is cultivated on an area of about 2 lakh hectares. In states like Maharashtra and Gujarat oat is being cultivated as quality forage. Oat ranks sixth in world cereal production following wheat, maize, rice, barley and sorghum. The total area covered under oat cultivation in the country is about 5,00,000 ha. The crop occupies maximum area in Uttar Pradesh (34%), followed by Punjab (20%), Bihar (16%), Haryana (9%) and Madhya Pradesh (6%). When oat forage is intended for hay, the level of N fertilizer should not be too high as excess N increases stem fibre levels (ADF and NDF) and decreases water soluble carbohydrates. Cutting at the milky dough stage is the best compromise between high yield and high quality (IGFRI, Jhansi).

Lucerne or alfalfa (*Medicago sativa*) is a deep-rooted, temperate, perennial pasture legume for dairy industry in India. It is the most versatile and cross-pollinated crop known for shy seed production. Lucerne is well adapted to warm temperature and cool climate conditions. It is also called as "Green gold of forage crops" as it is rich in protein (18-22%), amino acids, fiber (20-30%) and vitamin 'A' content. Lucerne is commonly called as "rijka" in northern India. Lucerne is considered as "Queen of Forage crop". It was introduced from Mediterranean region. It is highly palatable, nutritious, rich in protein and mineral constituents, excellent growth habit and quick regrowth after cutting. Lucerne fixes between 10 and 20kg/ha of nitrogen for every tonne of dry matter produced, increasing soil nitrogen levels for subsequent crops. It is grown as a farm crop in Punjab (13,554 acres), western districts of UP, Maharashtra (18400 acres), Gujarat (19,900 acres), Tamil Nadu and WB (Das & Khurana, 1964) [4].

Cereal-Legume based intercropping forages have the potential to supply large amount of energy for animals. Since adequate animal nutrition is essential for high rates of gain ample milk production, efficient reproduction and adequate profits, it is necessary to provide livestock with protein supplements when forage quality is low. Since feed accounts for approximately one-half of the total cost of providing milk, and high quality forage optimizes the productivity of the animals, increasing the quality of forage available is one of the best methods of improving overall feeding efficiency. Incorporation of legumes in cereal silage increases protein concentration and therefore the nutritional quality of silage (Gebrehiwot *et al.*, 1996) [6].

With this background a field trial was undertaken to study the "Evaluation of biomass yield and growth performance of oat (*Avena sativa* L.) and lucerne (*Medicago sativa* L.) intercropping" at Agronomy Farm, Anand Agricultural University, Anand during *rabi* season of the year 2018-19.

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 "Evaluation of biomass yield and growth performance of oat (*Avena sativa* L.) and lucerne (*Medicago sativa* L.) intercropping". The soil of experimental site was loamy sand in texture (locally called as "Goradu" soil) having good drainage and moisture retention capacity. The maximum temperature 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 range was between 26.4 to 65.9% during the crop season. The experiment site was low in organic carbon, medium in available nitrogen and high in potassium. The field experiment was laid out in a randomized block design. Six combinations of oat + lucerne row ratios

along with sole oat and lucerne with four replications. They are T₁ oat (sole), T₂ lucerne (sole), T₃ oat + lucerne (1:1), T₄ oat + lucerne (1:2), T₅ oat + lucerne (2:1), T₆ oat + lucerne (2:2), T₇ oat + lucerne (2:4) and T₈ 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.

Dry matter yield (q ha⁻¹)

$$\text{DMY (q ha}^{-1}\text{)} = \frac{\text{Green forage yield (q ha}^{-1}\text{)} \times \text{Dry matter content (\%)}}{100}$$

Crude protein content (%)

Crude protein content was estimated from the powder of representative oven dried samples (grinded in Willy mixed with 60 mesh sieves) using the NIR Feed and Forage Analyzer developed by FOSS NIR system.

Crude fibre content (%)

Crude fibre content was estimated by boiling the powdered seed samples (grinded in Willy mixed with 60 mesh sieves) with a dilute acid and dilute alkali. The undissolved residues including cellulose, hemicelluloses and lignin obtained during the process represents the crude fibre content (Modified methods described by Motiramani & Wankhede, 1970) [9].

Acid detergent fibre (%)

Thoroughly grind and mixed dry samples of each treatment were taken for estimation of acid detergent fibre (ADF) content (%) by laboratory method.

Neutral detergent fibre (%)

Thoroughly grind and mix dry samples of each treatment were taken for estimation of neutral detergent fibre (NDF) content (%) by using method developed by Van Soest and Wine (1967) [12].

Crude protein yield (q ha⁻¹)

$$\text{Crude protein yield (q ha}^{-1}\text{)} = \frac{\text{Dry matter yield (q ha}^{-1}\text{)} \times \text{Crude protein content (\%)}}{100}$$

Results and Discussion

Quality Parameters

The analysis of variance revealed significantly difference for all the quality characters studied (Table 1). This variance difference was found due to the effect of different row ratios of oat and lucerne under intercropping system as graphically illustrated in Fig. 1 & 2.

Crude protein content (%)

The production of crude protein was also affected significantly by different row ratios in both the crops. However, there was a slight decline in protein content as the crop grew older. Significantly the highest crude protein content was achieved with oat + lucerne, 2:1 row ratio in the mean of all cuts with the values of 12.41 and 24.47% for oat and lucerne, respectively. Increase in crude protein in oat might be due to crop benefited with applied recommended dose of nitrogenous fertilizer as well as the nitrogen added by the lucerne crop, which leads to increase in absorption of nitrogen. This is in harmony with the published work of

Meena *et al.* (2011)^[8], Amonge *et al.* (2013)^[11], Deore *et al.* (2013), Verma *et al.* (2015)^[13] and Ganvit *et al.* (2017)^[5].

Crude fibre content (%)

The crude fibre content was significantly affected by different row ratio in both the crops. Oat + lucerne with 2:1 row ratio (T₅) examined lower values of 20.03, 20.08, 20.26 and 20.12% during first, second and third cut as well as in mean analysis in oat crop, respectively. Similarly lower values of 20.25, 20.40, 20.45 and 20.37% was generated under treatment T₅ in lucerne crop at respective analysis. Lower value of crude fibre recorded under oat + lucerne with 2:1 row ratio might be due to dense and leafy stand with tender stem in oat during early stage. Increasing trend in crude fibre in oat also may be due to maturity of crop at subsequent cut. Lower crude fibre will be more palatable and digestible to the livestock. Increase in crude fibre content in the lucerne crop might be due to advancement in regrowth, which gives less tender stem and ultimately crude fibre increases. Meena *et al.* (2011)^[8] and Verma *et al.* (2015)^[13] found similar result.

Acid detergent fibre (%)

There was an increase in acid detergent fibre with advancement of growth stage. In mean data, the highest acid detergent fibre was recorded for T₈ (Oat + lucerne with 4:2

row ratio) as 59.58%, while significantly the lowest acid detergent fibre content was recorded for T₅ (Oat + lucerne with 2:1 row ratio) as 54.17% in oat crop. Similar trend was observed for lucerne crop, too. The increase in ADF with the advancement in plant age and at subsequent cut was due to more synthesis of structural carbohydrates, cellulose and deposition of fibrous material. Less will be the fibre content easy digestibility of the fodder, hence lower value of ADF will considerable to be safe and it was found in T₅. Meena *et al.* (2011)^[8] and Verma *et al.* (2015)^[13] reported similar findings.

Neutral detergent fibre (%)

Treatment T₅ (Oat + lucerne with 2:1 row ratio) recorded the lowest neutral detergent fibre content in all cuts as well as the mean for both crops. The lowest mean neutral detergent fibre content of 54.58 and 35.25% was recorded for oat and lucerne, respectively. The reduction in neutral detergent fibre content observed in oat might be due to succulence vegetative growth and slender stem. Increasing trend in NDF content at subsequent cut might be due to more synthesis of cellulose and lignin in lucerne crop during later growth stage. Lower value of NDF content at first cut due to early growing stage of crop. The results corroborate those achieved by Amonge *et al.* (2013)^[11] and Verma *et al.* (2015)^[13].

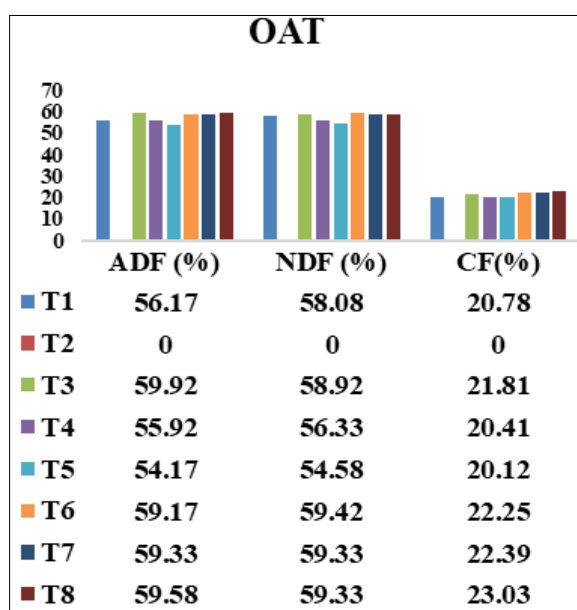


Fig 1: ADF, NDF and CF content of oat crop

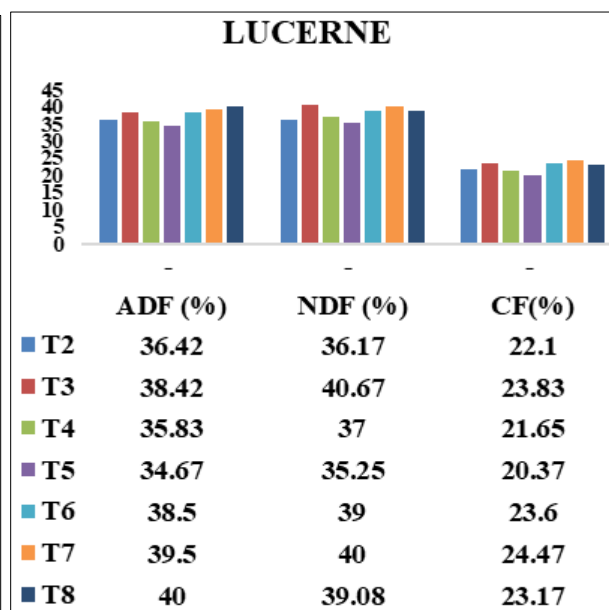


Fig 2: ADF, NDF and CF content of lucerne crop

Table 1: Crude Protein (CP), Crude Fibre Content (CFC), Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) of oat and lucerne crop as influenced by different row ratios under intercropping system intercropping system

Sr. No.	Treatments	Crude protein (%)		Crude fibre content (%)		ADF (%)		NDF (%)	
		Mean		Mean		Mean		Mean	
		Oat	Lucerne	Oat	Lucerne	Oat	Lucerne	Oat	Lucerne
T ₁	Oat (Sole)	11.70	-	20.78	-	56.17	-	58.08	-
T ₂	Lucerne (Sole)	-	23.10	-	22.10	-	36.42	-	36.17
T ₃	Oat + Lucerne (1:1)	10.20	22.58	21.81	23.83	59.92	38.42	58.92	40.67
T ₄	Oat + Lucerne (1:2)	11.18	23.78	20.41	21.65	55.92	35.83	56.33	37.00
T ₅	Oat + Lucerne (2:1)	12.41	24.47	20.12	20.37	54.17	34.67	54.58	35.25
T ₆	Oat + Lucerne (2:2)	10.58	20.72	22.25	23.60	59.17	38.50	59.42	39.00
T ₇	Oat + Lucerne (2:4)	10.05	21.79	22.39	24.47	59.33	39.50	59.33	40.00
T ₈	Oat + Lucerne (4:2)	10.29	20.80	23.03	23.17	59.58	40.00	59.33	39.08
	S.Em. ±	0.38	0.85	0.58	0.82	0.87	0.93	0.97	1.08
	C.D. at 5%	1.13	2.52	1.73	2.44	2.59	2.75	2.87	3.20
	C.V.%	6.96	7.56	5.40	7.22	3.02	4.92	3.34	5.64

Yield Attributes

Data with respect to green forage yield as influenced by different row ratios under intercropping system at individual cut and total of all cuts are summarized in Table 2.

Green Forage Yield (q ha⁻¹)

Significantly the highest green forage yield of 785 q ha⁻¹ was obtained with T₅ (oat + lucerne, 2:1), while, the lowest green forage yield (369 q ha⁻¹) was recorded for treatment T₂ (sole lucerne) in total of all cuts. 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) [11], Meena *et al.* (2011) [8], Amonge *et al.* (2013) [1], Deore *et al.* (2013), Verma *et al.* (2015) [13], Bhagat *et al.* (2017) [3], Ganvit *et al.* (2017) [5] and Singh *et al.* (2017).

Dry Matter Yield (q ha⁻¹)

Dry matter yield observed similar trends as that observed in green forage yield. Treatment T₅ (oat + lucerne, 2:1) was found significantly superior and recorded significantly higher

yield of 142.46 q ha⁻¹ over rest of the row ratio in total dry matter production. 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) [11], Meena *et al.* (2011) [8], Deore *et al.* (2013), Amonge *et al.* (2013) [1], Verma *et al.* (2015) [13], Bhagat *et al.* (2017) [3], Ganvit *et al.* (2017) [5] and Singh *et al.* (2017) [10].

Crude Protein Yield (q ha⁻¹)

Similar trend was observed in crude protein yield as that observed in green forage and dry matter yield. T₅ (oat + lucerne, 2:1) was found significantly superior (26.21 q ha⁻¹) over the rest of the row ratio for total crude protein yield. Protein is considered to be an important constituent in forage crops as it is essential for maintenance and production of new tissues. Hence due to cereal- legume combination with appropriate row ratio more protein content and dry matter yield was obtained under T₅ (oat + lucerne, 2:1). Crude protein yield was computed from crude protein percentage and dry matter production. This is in harmony with the published work of Deore *et al.* (2013), Verma *et al.* (2015) [13] and Ganvit *et al.* (2017) [5].

Table 2: Effect of different row ratios on green forage yield, dry matter yield and crude protein yield under intercropping system

Sr. No.	Treatments	Green forage yield (q ha ⁻¹)			Dry matter yield (q ha ⁻¹)			Crude Protein Yield (q ha ⁻¹)		
		Oat	Lucerne	Total yield	Oat	Lucerne	Total DMY	Oat	Lucerne	Total CPY
T ₁	Oat (Sole)	674	-	674	82.84	-	82.84	9.70	-	9.70
T ₂	Lucerne (Sole)	-	369	369	-	78.67	78.67	-	18.17	18.17
T ₃	Oat + Lucerne (1:1)	442	176	618	58.59	47.68	106.27	5.98	10.75	16.72
T ₄	Oat + Lucerne (1:2)	491	212	703	64.83	60.43	125.26	7.29	14.36	21.64
T ₅	Oat + Lucerne (2:1)	532	253	785	71.32	71.14	142.46	8.84	17.37	26.21
T ₆	Oat + Lucerne (2:2)	438	177	616	54.35	49.53	103.88	5.77	10.24	16.01
T ₇	Oat + Lucerne (2:4)	449	200	649	56.51	54.84	111.34	5.69	12.00	17.69
T ₈	Oat + Lucerne (4:2)	462	194	656	56.28	56.03	112.31	5.73	11.66	17.38
	S.Em. ±	12.58	7.67	10.92	2.08	2.66	2.97	0.29	0.70	0.73
	C.D. at 5%	37.38	22.80	32.10	6.18	7.89	8.73	0.87	2.08	2.15
	C.V. %	5.05	6.79	3.44	6.54	8.89	5.50	8.39	10.36	8.15

Conclusion

Significant results were observed in quality and yield parameters by adopting planting ratio of oat and lucerne under intercropping system. Quality (Crude protein, Acid detergent fibre, Neutral detergent fibre and Crude fibre) and yield (Green forage yield, Dry matter yield and Crude protein yield) parameters were found more effective under 2:1 row ratio of oat and lucerne as compared to other row ratio and sole crops.

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