Indian J. Anim. Nutr. 2022. 39 (4): 426-433
doi: 10.5958/2231-6744.2022.00053.6

Indian Journal of Animal Nutrition

Evaluation of Forage Quality of Oats and Berseem Under Varying Intercropping Row Ratios

Mohamed Arif Khan*, Ravindra Kumar, Arvind Kumar, R. Pourouchottamane, D.L. Gupta and B. Rai
ICAR- Central Institute for Research on Goats, Makhdoom, Mathura, India
*Correspondence: arifkhan.ag782@gmail.com

ABSTRACT

A field experiment was conducted at agriculture farm, ICAR-Central Institute for Research on Goats, Makhdoom, Mathura (Uttar Pradesh) during the *rabi* season of 2020-21 to study the effect of different intercropping combinations on fodder qualities of oats and berseem. The treatments consisted of nine intercropping combinations *viz.* sole oats, sole berseem, oats + berseem (1:1 row ratio), oats + berseem (2:1 row ratio), oats + berseem (1:2 row ratio), oats + berseem (2:2 row ratio), oats + berseem (3:1 row ratio), oats + berseem (1:3 row ratio), oats + berseem (3:3 row ratio). The experiment was laid out in randomize block design with three replications. The result showed that maximum total dry matter yield of intercropping (8.00 t ha^{-1}) was recorded with 2:1 row ratios of Oats + Berseem intercropping combination. Further, in fodder oats, highest value of crude protein (I cut- 12.94%, II cut- 12.17% and III cut- 11.08%), ether extract (I cut- 2.93%, II cut- 2.58% and III cut- 2.05%), TDN content (68.12%), DMI (2.50%), RFV (133.24 %) and NE_l (1.63%) were recorded with Oats + Berseem (1:3) intercropping combination. In fodder berseem, highest value of crude protein (I cut- 19.12%, II cut- 18.22% and III cut- 16.94%), ether extract (I cut- 3.58%, II cut- 3.39% and III cut- 3.08%), TDN content (64.50%), DMI (2.73%), RFV (141.12%) and NE_l (1.55%) were recorded with sole cropping of fodder berseem. However, in berseem 1:3 row ratio of Oats + Berseem intercropping combination recorded at par values of quality parameters with sole berseem treatment. Thus, Oats + Berseem (1:3) intercropping combination is the best combination for fodder quality improvement of cereal component in cereal + legume intercropping.

KEYWORDS: Crude protein, Digestible dry matter, Net energy for lactation (NE_l), Relative feed value, TDN.

Article received: 31 October 2022; Article accepted: 21 December 2022

INTRODUCTION

Oats (*Avena sativa* L.) is considered as the most important winter season forage crop as it is quick growing crop and provides palatable, succulent and nutritious fodder to livestock. It also forms an excellent combination when grown with other winter fodder legumes such as berseem, lucerne *etc.* (Dangi, 2020). Similarly, berseem (*Trifolium alexandrinum* L.) is a prominent leguminous fodder crop of winter season in India as it remains soft and succulent at all stages of growth with better digestibility and palatability (Chaterjee and Das, 1989). In intercropping with reduced seeding rate of cereals, berseem improved the forage quality (Ross et al., 2004). Intercropping of Oats + Berseem increased forage quality and may provide for increased intake and digestibility of forage to support higher livestock productivity (Ross et al., 2005). Intercropping of cereal fodder crops with leguminous fodder crops appears to be a good approach for fodder production, efficient utilization of land resources, fodder quality and for providing stability to the system (Tripathi, 1989). It is also reported that growing of fodder crops in mixture with legumes enhanced fodder palatability as well as digestibility (Ginwal et al., 2019). Cereals and leguminous fodder crops are often intercropped to increase the productivity per unit area and the quality of the mixed forage crops (Ghosh et al., 2009). Therefore, the experiment was formulated to investigate the effect of different

intercropping combinations on dry matter yield and quality of oats and berseem.

MATERIALS AND METHODS

Field experiment was undertaken to study the intercropping of fodder oats and berseem during *rabi* season of 2020-21 at agriculture farm, ICAR-Central Institute for Research on Goats, Makhdoom, Mathura (Uttar Pradesh), India. The soil of the experimental field was nearly neutral in reaction (pH 7.4) with EC of 0.29 dS/m. The soil was low in organic carbon (0.26 %) and available nitrogen (240 kg ha^{-1}); and medium in available phosphorus (39 kg ha^{-1}) and potassium (168 kg ha^{-1}). There were nine treatments *viz.* sole oats, sole berseem, oats + berseem (1:1 row ratio), oats + berseem (2:1 row ratio), oats + berseem (1:2 row ratio), oats + berseem (2:2 row ratio), oats + berseem (3:1 row ratio), oats + berseem (1:3 row ratio), oats + berseem (3:3 row ratio). The experiment was laid out in randomize block design with three replications. The field was allocated into 27 plots and each plot was 6m x 3m in size. Oats variety Kent and berseem variety BB-2 were sown as per the treatments on 7th November, 2020 by using the seed rate of 100 and 25 kg ha^{-1} in sole oats and sole berseem, respectively. Further, the crops were sown with row to row spacing of 25 cm in both sole as well as in intercropping combinations. The crops were harvested in three cuttings; first cutting at 50 days after sowing (DAS) and subsequent ones at an interval of 40 days.

The crude protein was determined by multiplying the N with the factor 6.25, ether extract and ash content were analyzed by AOAC (2005) method. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analyzed as described by Van soest et al. (1991) and AOAC (2005), respectively. Total digestible nutrients (TDN), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and net energy for lactation (NE_l) were estimated according to the following equations adapted from Horrocks and Vallentine (1999) whereas, relative feed quality (RFQ) adapted from Undersander et al. (2010):

$$TDN = \text{“}1.291 \times ADF + 101.35$$

$$DMI = 120/\%NDF \text{ on dry matter basis}$$

$$DMD = 88.9 \text{ “ } (0.779 \times ADF)$$

$$RFV = DMD \times DMI \times 0.775$$

$$RFQ = \frac{(DMI, \% \text{ of BW}) \times (TDN, \% \text{ of DM})}{1.23}$$

$$NE_l \text{ (Mcal/kg)} = [1.044 \text{ “ } (0.0119 \times ADF)] \times 2.205$$

The replicated means were subjected to ANOVA using MS excel (2010). The critical difference (CD) was found by using P=0.05.

RESULTS AND DISCUSSION

Dry matter yield

The dry matter yield of oats and berseem was significantly influenced by different intercropping combinations (Table 1).

Table 1. Effect of sole and intercropping combinations on dry matter yield of oats and berseem

Treatments	Dry matter Yield (t ha^{-1})						
	Oats			Berseem			Total
	I Cut	II Cut	III Cut	I Cut	II Cut	III Cut	
Sole Oat	2.52	2.07	1.87	-	-	-	6.46
Sole Berseem	-	-	-	2.35	2.13	1.63	6.11
Oat + Berseem (1:1)	1.30	1.38	1.13	1.13	1.11	0.82	6.87
Oat + Berseem (2:1)	2.12	2.02	1.65	0.79	0.80	0.62	8.00
Oat + Berseem (1:2)	0.87	1.02	0.77	1.56	1.32	1.00	6.53
Oat + Berseem (2:2)	1.27	1.31	1.09	1.12	1.10	0.76	6.65
Oat + Berseem (3:1)	2.29	1.89	1.71	0.54	0.54	0.40	7.37
Oat + Berseem (1:3)	0.57	0.84	0.57	1.64	1.50	1.03	6.16
Oat + Berseem (3:3)	1.24	1.37	1.03	1.09	1.04	0.73	6.50
SEM±	0.07	0.10	0.11	0.07	0.08	0.07	0.28
CD (P=0.05)	0.21	0.30	0.33	0.21	0.23	0.21	0.84

Significantly highest value of total dry matter yield (Oats + Berseem) was recorded with 2:1 row ratios of Oats + Berseem intercropping (8.00 t ha^{-1}) followed by 3:1 row ratios of Oats + Berseem intercropping (7.37 t ha^{-1}). The increase in total dry matter yield in 2:1 row ratio was 23.8, 30.9, 16.4, 22.5, 20.3, 29.8 and 23.0 % over sole oats, sole berseem, 1:1 row ratio, 1:2 row ratio, 2:2 row ratio, 1:3 row ratio and 3:3 row ratios of intercropping treatments, respectively. The increase in dry matter yield in the intercropping systems might be owing to better utilization of space and light interception, coupled with nutrient contribution of leguminous fodder to cereal. The results are in close agreement with Javanmard et al. (2014) who reported that intercropping of barley with grass pea and vetch produced higher dry matter yield than sole crops. Similar findings were also reported by McGilchrist (1965); and Carry et al. (2004).

Proximate constituents and their yield

Intercropping combinations had significant effect on crude protein, ether extract, ash content Neutral detergent fiber and Acid detergent fiber of fodder Oats (Table 2).

Oats + Berseem (1:3) intercropping combination recorded significantly highest value of crude protein (I cut- 12.94%, II cut- 12.17% and III cut- 11.08%), ether extract (I cut- 2.93%, II cut- 2.58% and III cut- 2.05%) and total ash (I cut- 14.85%, II cut- 14.02% and III cut- 12.18%) content in fodder oats. The increase in crude protein content of fodder oats in 1:3 row ratios was 8.74, 8.76 and 10.69 % over sole oats in I, II and III cuts, respectively. However, intercropping ratios of 1:3, 1:2, 1:1, 2:2 and 3:3 recorded at par values of crude protein, ether extract and total ash content in fodder oats in all the three cuts. The highest values of crude protein, ether extract and ash content of oats in 1:3 row ratio of Oats + Berseem intercropping combination was due to the higher proportion of legume in this combination that might have helped to fix more atmospheric nitrogen as well as increase the availability of many nutrients to the component crops to improve the forage quality. Legumes also help in

Table 2. Effect of sole and intercropping combinations on proximate constitute of fodder oats

Treatments	Crude Protein (%)			Ether Extract (%)			Total Ash (%)			NDF (%)			ADF (%)		
	I Cut	II Cut	III Cut	I Cut	II Cut	III Cut	I Cut	II Cut	III Cut	I Cut	II Cut	III Cut	I Cut	II Cut	III Cut
Sole Oats	11.9	11.1	10.0	2.43	2.12	1.63	13.4	12.5	10.7	50.3	51.5	53.7	27.6	28.6	30.0
Oat + Berseem	12.4	11.6	10.5	2.73	2.39	1.91	14.0	13.2	11.4	48.8	50.0	52.2	26.6	27.4	28.7
Oat + Berseem	12.2	11.4	10.3	2.62	2.23	1.83	13.7	13.0	11.1	49.4	50.7	52.9	27.1	27.8	29.1
Oat + Berseem	12.8	12.0	10.8	2.88	2.52	2.02	14.7	13.8	12.0	47.3	48.4	50.3	25.2	25.9	27.1
Oat + Berseem	12.5	11.7	10.6	2.76	2.43	1.94	14.1	13.4	11.5	48.4	49.5	51.6	26.2	26.9	28.0
Oat + Berseem	12.1	11.3	10.2	2.55	2.17	1.76	13.6	12.9	11.0	49.6	51.0	53.2	27.3	28.1	29.6
Oat + Berseem	12.9	12.1	11.0	2.93	2.58	2.05	14.8	14.0	12.1	46.6	47.8	49.8	24.8	25.6	26.7
Oat + Berseem	12.6	11.8	10.7	2.81	2.47	1.98	14.3	13.6	11.7	47.9	48.8	51.0	25.7	26.5	27.5
SEM±	0.20	0.18	0.17	0.07	0.06	0.05	0.30	0.28	0.26	0.74	0.79	0.84	0.57	0.61	0.66
CD (P=0.05)	0.61	0.55	0.52	0.22	0.19	0.16	0.90	0.85	0.79	2.24	2.39	2.55	1.74	1.86	1.99

NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

mobilization of phosphorus by the acidification of the rhizosphere via root release of organic acids and protons and thus improve P uptake by legume and non legume (Kumar et al., 2014). The results are in close confirmation with Mohsenabadi et al. (2008) who reported that in barley + vetch intercropping, crude protein content of barley increased over sole cropping of barley. Buyukburc and Karadag (2002) observed an increase in crude protein content with increase in legume proportion in cereal + legume intercropping. NDF and ADF contents of fodder oats were also significantly influenced by intercropping combinations. Lowest values of NDF and ADF content were found in 1:3 row ratio of Oats + Berseem intercropping combination, whereas highest value of NDF and ADF were found in sole oats. The lowest value of NDF and ADF in 1:3 row ratios of Oats + Berseem intercropping combination might be attributed due to the fact that higher proportion of leguminous fodder in this treatment provides more nitrogen which ultimately led to higher vegetative growth and reduced fibre fraction. Similarly, Ross et al. (2005) reported that addition of berseem clover to oats in intercrops reduced the neutral-detergent fibre concentration compared with the sole crop of oats.

Similarly, intercropping and sole cropping significantly influenced the proximate constitutes in fodder berseem (Table 3).

The highest value of crude protein (I cut- 19.12%, II cut- 18.22% and III cut- 16.94%), ether extract (I cut- 3.58%, II cut- 3.39% and III cut- 3.08%) and total ash (I cut- 16.33%, II cut- 15.55% and III cut- 13.38%) content was recorded with sole cropping of fodder berseem, whereas the lowest values of these proximate constitutes was recorded with 3:1 row ratios of Oat + Berseem intercropping. However, intercropping row ratios 1:3, 1:2, 1:1, 2:2 and 3:3 recorded at par values of crude protein, ether extract and total ash content with sole berseem. The mean crude protein content of berseem clover in intercrops with oats was less than in berseem clover sole crops, indicating that competition by oats reduced the crude protein content of berseem clover (Ross et al., 2005).

Table 3. Effect of sole and intercropping combinations on proximate constitute of fodder berseem

Treatments	Crude Protein (%)			Ether Extract (%)			Total Ash (%)			NDF (%)			ADF (%)		
	I Cut	II	III Cut	I Cut	II Cut	III Cut	I Cut	II	III Cut	I Cut	II Cut	III Cut	I Cut	II Cut	III Cut
Sole Berseem	19.1	18.2	16.9	3.58	3.39	3.08	16.3	15.5	13.8	42.9	43.6	45.4	26.9	28.4	30.2
Oat + Berseem (1:1)	18.1	17.2	16.0	3.35	3.20	2.89	15.2	14.5	12.9	44.9	45.9	47.3	29.2	29.8	31.5
Oat + Berseem (2:1)	17.5	16.8	15.5	3.25	3.05	2.78	14.7	14.1	12.6	46.1	47.1	48.6	29.6	30.0	32.1
Oat + Berseem (1:2)	18.7	17.8	16.6	3.49	3.31	3.03	15.9	15.1	13.6	44.2	45.0	45.9	27.9	29.0	30.6
Oat + Berseem (2:2)	18.4	17.4	16.0	3.40	3.23	2.93	15.5	14.6	13.2	44.7	45.6	46.9	28.7	29.6	31.2
Oat + Berseem (3:1)	17.3	16.6	15.3	3.10	2.96	2.70	14.6	14.0	12.5	46.5	47.3	48.8	29.8	30.2	32.2
Oat + Berseem (1:3)	19.0	18.1	16.7	3.52	3.36	3.06	16.1	15.3	13.7	44.0	44.8	46.2	27.6	28.7	30.3
Oat + Berseem (3:3)	18.5	17.7	16.1	3.44	3.28	2.98	15.7	14.9	13.4	44.6	45.3	46.6	28.4	29.5	31.0
SEM±	0.36	0.33	0.29	0.08	0.07	0.06	0.36	0.33	0.30	0.66	0.67	0.69	0.45	0.47	0.53
CD (P=0.05)	1.09	1.00	0.87	0.26	0.22	0.18	1.09	0.99	0.92	2.00	2.04	2.11	1.36	1.43	1.61

NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

Legumes contain more crude protein than cereals and when mixed with cereals the crude protein content of mixtures remains lower than legume monoculture (Stout et al., 2001). In berseem, lowest values of NDF and ADF was found with sole crop whereas the values of NDF and ADF improved as the proportion of cereal component increased in intercropping combination and the highest value was found with 3:1 row ratio of Oat + Berseem intercropping. Similarly, Yilmaz et al. (2015) reported that as the proportion of barley increased in the barley and berseem mixture, ADF and NDF values tend to increase.

Further, total yield of proximate chemical constitutes of fodder oats + berseem were also significantly influenced by various intercropping combinations (Table 4).

Table 4. Effect of sole and intercropping combinations on yield of proximate constitute of fodder oats and berseem

Treatments	Crude Protein Yield (kg ha^{-1})			Ether Extract Yield (kg ha^{-1})			Total Ash Yield (kg ha^{-1})		
	Oats	Berseem	Total	Oats	Berseem	Total	Oats	Berseem	Total
Sole Oats	718.8	-	718.8	135.6	-	135.6	797.8	-	797.8
Sole Berseem	-	1114.6	1114.6	-	206.7	206.7	-	942.1	942.1
Oat + Berseem (1:1)	442.6	529.0	971.6	89.9	97.1	187.1	494.5	440.3	934.9
Oat + Berseem (2:1)	661.0	370.6	1031.7	130.8	67.5	198.4	740.6	309.1	1049.8
Oat + Berseem (1:2)	318.1	692.0	1010.2	66.2	128.0	194.2	362.3	584.5	946.8
Oat + Berseem (2:2)	430.1	518.7	948.8	88.3	95.7	184.0	484.2	435.0	919.3
Oat + Berseem (3:1)	669.6	244.5	914.2	129.6	43.4	173.0	745.4	204.1	949.6
Oat + Berseem (1:3)	240.0	757.5	997.5	50.1	139.8	189.9	272.7	634.6	907.3
Oat + Berseem (3:3)	431.2	503.8	935.1	89.5	93.4	182.9	487.5	425.9	913.4
SEM±	24.1	27.8	42.8	5.13	5.80	8.21	27.2	23.6	38.5
CD (P=0.05)	73.2	84.5	128.3	15.5	17.6	24.6	82.5	71.7	115.6

Total crude protein (1114.6 kg ha^{-1}) and ether extract (206.7 kg ha^{-1}) yield were maximum with sole berseem treatment, followed by 2:1 row ratio of Oats + Berseem. However, sole berseem, 2:1, 1:3 and 1:2 row ratios of Oats + Berseem recorded at par values of crude protein and ether extract yield. Maximum total ash yield (1049.85 kg ha^{-1}) was recorded with 2:1 row ratio of Oats + Berseem followed by 3:1 row ratio. These results are similar to Lithourgidis et al. (2006) who reported that crude protein yield was significantly influenced by sole and intercropping of cereal and legumes.

Fodder quality and net energy for lactation

Sole and intercropping combinations had significant effect on fodder quality and net energy for lactation in fodder oats and berseem (Table 5).

Table 5. Effect of sole and intercropping combinations on fodder quality and net energy for lactation in fodder oats and berseem

Treatments	TDN (%)		DMI (%)		DDM (%)		RFV (%)		RFQ (%)		NE_l (Mcal/kg)	
	Oats	Berseem	Oats	Berseem	Oats	Berseem	Oats	Berseem	Oats	Berseem	Oats	Berseem
Sole Oats	64.1	-	2.31	-	66.4	-	119.2	-	120.8	-	1.55	-
Sole Berseem	-	64.5	-	2.73	-	66.66	-	141.1	-	143.2	-	1.55
Oat + Berseem (1:1)	65.7	62.3	2.38	2.61	67.4	65.3	124.6	132.0	127.4	132.1	1.58	1.51
Oat + Berseem (2:1)	65.1	61.8	2.35	2.54	67.0	65.0	122.3	127.9	124.6	127.6	1.57	1.50
Oat + Berseem (1:2)	67.6	63.6	2.47	2.66	68.5	66.1	131.0	136.3	135.7	137.6	1.62	1.54
Oat + Berseem (2:2)	66.3	62.7	2.41	2.62	67.7	65.6	126.6	133.5	130.1	134.0	1.59	1.52
Oat + Berseem (3:1)	64.7	61.6	2.34	2.52	66.7	64.9	121.2	127.0	123.2	126.5	1.56	1.49
Oat + Berseem (1:3)	68.1	64.0	2.50	2.67	68.8	66.3	133.2	137.2	138.3	138.8	1.63	1.54
Oat + Berseem (3:3)	67.0	63.0	2.44	2.64	68.1	65.7	128.9	134.4	132.9	135.2	1.60	1.52
SEM±	0.79	0.62	0.04	0.04	0.48	0.37	2.54	2.01	3.08	2.22	0.02	0.01
CD (P=0.05)	2.40	1.87	0.12	0.12	1.45	1.13	7.70	6.08	9.35	6.72	0.05	0.04

TDN- Total digestible nutrients; DMI- Dry matter intake; DDM- Digestible dry matter; RFV- Relative feed value; RFQ- Relative feed quality; NE_l Net energy for lactation.

Comparative analysis of different sole and intercropping treatments revealed that TDN content in fodder oats (68.1 %) was maximum in 1:3 row ratio of Oats + Berseem, followed by sole berseem (64.5 %). TDN content in forage is inversely related with ADF concentration in feed therefore, as concentration of ADF increases, there is a decline in TDN content which limits an animal's ability to utilize the nutrients that are present in the forage (Carmi et al., 2006). The highest value of dry matter intake (2.50 %) and digestible dry matter (68.8 %) in fodder oats was recorded in 1:3 row ratio of Oats + Berseem intercropping combination followed by 1:2 row ratio, whereas, in fodder berseem highest dry matter intake (2.73 %) and digestible dry matter (66.6%) was observed with sole berseem treatment followed by 1:3 row ratio of Oats + Berseem intercropping combination. NDF and ADF are used to predict the dry matter intake and digestible dry matter, respectively. Dry matter intake is negatively correlated with NDF, whereas digestible dry matter is negatively correlated with ADF. Similarly, Yilmaz et al. (2015) reported that in legume + barley intercropping, dry matter intake increased as with the higher proportion of legume.

Maximum values of relative feed value (133.2 %) and relative feed quality (138.2 %) in oats were recorded in 1:3 row ratio of Oats + Berseem followed by 1:2 row ratio. In berseem, highest values of relative feed value (141.1 %) and relative feed quality (143.26 %) were recorded with sole berseem treatment. Relative feed value (RFV) is an index which is used to predict intake and energy value of forage which is derived from DMD and DMI

(Lithourgidis et al., 2006). Differences in the digestibility of the fiber fraction can result in a difference in animal performance when forages with a similar RFV are fed. Therefore, the relative feed quality (RFQ) index has been developed to overcome this difference. This index takes into consideration the differences in digestibility of the fiber fraction and can be used to more accurately predict animal performance and match animal needs (Jeranyama and Garcia, 2004). Further, higher values of net energy for lactation (NE_l) in fodder oats (1.63 Mcal/kg) was recorded in 1:3 row ratio of Oats + Berseem and sole berseem (1.55 Mcal/kg).

CONCLUSION

Results of the study confirmed that intercropping of fodder oats and berseem significantly influenced the quality of forage crops. The maximum value of crude protein, ether extracts, ash content, TDN, dry matter intake, digestible dry matter, relative feed value and quality, and net energy for lactation in fodder oats were recorded with 1:3 row ratio of Oats + Berseem, whereas in fodder berseem, the maximum values of all these parameters were recorded in sole berseem which was at par with 1:3 row ratio of Oats + Berseem. Thus, the results confirm that as the proportion of legume component increases it increases the forage quality of cereal component in intercropping. Hence, the combination of one row of oats with three rows of berseem is beneficial for obtaining good quality forage.

ACKNOWLEDGMENTS

We acknowledge the support of Director, ICAR-CIRG, Makhdoom for providing necessary facilities for conducting this experiment.

REFERENCES

AOAC. 2005. Official Methods of Analysis.18th Edn. Association of Official Analytical Chemists. Washington, D.C, USA.

Carmi, A., Aharoni, Y., Edelstein, M., Umiel, N., Hagiladi, A., Yosef, E., Nikbachat, M., Zenou, A. and Miron, J. 2006. Effects of irrigation and plant density on yield, composition and in vitro digestibility of a new forage sorghum variety, Tal, at two maturity stages. Animal Feed Science and Technology. 131: 120–132.

Carry, P.M., Horsley, R.D. and Poland, W.W. 2004. Barley, oat, and cereal–pea mixtures as dryland forages in the northern great plains. Agronomy Journal. 96: 677–684.

Chaterjee, B.N. and Das, P.K. 1989. Forage crop production-principles and practices. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Dangi, S. 2020. Oat as green fodder and its intercropping benefits: A review. Agricultural Reviews. 10.18805/ag.R-168.

Ghosh, P.K., Tripathi, A.K., Bandyopadhyay, K.K. and Manna, M.C. 2009. Assessment of nutrient competition and nutrient requirement in soybean/sorghum intercropping system. European Journal of Agronomy. 31: 43-50.

Ginwal, D.S., Kumar, R, Ram, H., Meena, R.K. and Kumar, U. 2019. Quality characteristics and nutrient yields of maize and legume forages under changing intercropping row ratios. Indian Journal of Animal Sciences. 89(3): 281–286.

Horrocks, R. D. and J. F. Vallentine. 1999. Harvested Forages. Academic Press, London, UK.

Javanmard, A., Nasiri, Y. and Shekari, F. 2014. Competition and dry matter yield in intercrops of barley and legume for forage. Albanian Journal of Agricultural Sciences.13 (I): 22-32.

Jeranyama, P. and Garcia, A.D. 2004. Understanding relative feed value (RFV) and relative forage quality (RFQ). Extension Extra, Cooperative Extension Service. SDSU. http://agbiopubs.sdstate.edu/articles/ExEx8149.pdf

Kumar, B., Tiwana, U.S. Ajaib Singh and Hari Ram. 2014. Productivity and quality of intercropped maize (*Zea mays* L.) + cowpea [*Vigna unguiculata* (L.) Walp.] Fodder as influenced by nitrogen and phosphorus levels. Range Management & Agroforestry. 35(2): 263-267.

Lithourgidis, A.S., Vasilakoglou, I.B. Dhima, K.V., Dordas, C.A. and Yiakoulaki, M.D. 2006. Forage yield and quality of common vetch and mixtures with oat and triticale in two seed ratios. Field Crop Research. 99: 106-113.

McGilchrist, C.A. 1965. Analysis of competition experiments. Biometrics. 21: 975–985.

Mohsenabadi, G.R., Jahansooz, M.R., Chaichi, M.R., Mashhadi, H.R., Liaghat, A.M. and Savaghebi, G.R. 2008. Evalaution of barley vetch intercrop at different nitrogen ranges. Journal of Agricultural Science and Technology.10: 23-31.

Ondarza, M.B.D. 2000. Energy. Paradox Nutrition. Nutrition consulting for the dairy industry. http://www.milkproduction.com/Library/Scientific articles/Nutrition /Energy/

Ross, S.M., King, J., O'Donovan, J.T. and Spaner, D. 2004. Forage Potential of Intercropping Berseem Clover with Barley, Oat, or Triticale. Agronomy Journal. 96 (4): 1013-1020.

Ross, S.M., King, J., O'Donovan, J.T. and Spaner, D. 2005. The productivity of oats and berseem clover intercrops. I. Primary growth characteristics and forage quality at four densities of oats. Grass and Forage Science. 60(1):74 – 86.

Sahoo, U.K., Vanlalhriatpuia, K., Singh, S.L., Upadhyaya, K., Lalnilawma and Tawnenga. 2015. Effect of intercropping on forage yield and quality of *Zea mays* L. in Saiha district of Mizoram. Range Management & Agroforestry. 36(2): 183-187.

Stout, W.L. Weaver, S.R. and Elwinger, G.F. 2001. Effects of early season nitrogen on grass-clover swards in the northeastern USA. Agronomy Journal. 93: 1000-1021.

Tamta, A., Kumar, R., Ram, H., Meena, R.K., Meena, V.K., Yadav, M.R. and Subrahmanya, D.J.2019. Productivity and profitability of legume-cereal forages under different planting ratio and nitrogen fertilization. Legume Research. 42(1): 102-107.

Tripathi, S. N. 1989. Mixed cropping of forage species in relation to herbage yield and quality. Indian Journal of Dry land Agricultural Research and Development. 4(2):68-72.

Undersander, D., Moore, J.E. and Schneider, N. 2010. Relative forage quality. Focus on Forage. 12(6): 1-3.

Van Soest, P.J., Robertson, J.B. and Lewis, B.A. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Sciences. 74(10): 3583–3597.

Yilmaz, S., Ozel, A., Atak, M. and Erayman, M. 2015. Effects of seeding rates on competition indices of barley and vetch intercropping system in the Eastern Mediterranean. Turkish Journal of Agriculture and Forestry. 39: 135-143.