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Evaluation of oats and barley varieties for fodder yield, quality and nutrient uptake potential under central Gujarat condition

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Abstract
A field experiment was conducted during *Rabi* season of 2012-13 and 2013-14 to study fodder yield, quality and nutrients uptake potential of different varieties of oats and barley. The trial consisted of fourteen treatments having eight notified varieties of oats, three notified varieties of barley and three combinations of mixed crop of oats variety (Kent) with different barley varieties. Single cut was taken when crop was at milking to dough stage for recording data. Overall, oats varieties produced more fodder yield compared to barley and mixed crop treatments. Among oats varieties, the highest mean green fodder yield (26.74 t ha^{-1}) and mean dry matter yield (8.29 t ha^{-1}) was recorded in oats variety JHO 822. Among barley varieties, RD 2715 recorded the highest mean green fodder yield (23.07 t ha^{-1}) and crude protein yield (0.80 t ha^{-1}). But the highest mean dry fodder yield (7.59 t ha^{-1}) was observed in barley variety RD 2035. Among mixed crop treatments, Kent + RD 2552 recorded the highest mean green, dry and crude protein yield of 25.15, 7.54 and 0.73 t ha^{-1}, respectively. Crude protein (10.5 to 10.8 %) and dry matter (31.97 to 35.12 %) contents were higher in barley varieties as compared to oats varieties (8.6 to 9.1 % and 29.18 to 34.72 %).

Keywords: Barley, Forage yield, Nutrients uptake, Oats, Proximate parameters, Varieties,

Introduction

In Gujarat, farmers usually cultivate multi-cut forage crops of lucerne and fodder chicory during *Rabi* season to meet out green fodder requirement of their animals. However, due to increasing risk of Cuscuta (dodder) parasitic weed problem in lucerne and non-availability of any improved/ notified fodder variety of chicory seed; area and productivity of these well adapted forage crops is either stagnant or declining and farmers are looking towards other options like oats (*Avena sativa* L.) and fodder barley (*Hordeum vulgare* L.) which are suitable for green forage feeding as well as ensiling due to rich in carbohydrate (Pachauri *et al.,* 1998). Oats and barley are adapted to different soil types and can perform better on saline-alkaline soils of Gujarat. Due to advantages mentioned above, cultivation of oats and barley crops is becoming popular among farmers. In last several decades, many varieties of oats and barley have been notified for fodder production in north-western parts of country. However, oats- Kent is the most popular variety for fodder cultivation due to its wide adaptability and stability. Sufficient information on other suitable improved varieties of oats and barley for green fodder production, nutritive value and nutrients uptake potential under single cut system is not available for central Gujarat. There is also widespread belief among fodder growers that the yield of mix crop may often be greater than that of either component of the mixture grown alone. It is well recognized that crops does not differ in the amount of nutrients absorbed but nutrient uptake is influenced by a large number of factors including genetics/ varieties. Fodder crops also remove significant quantity of nutrients from soil which need to be replenished by balanced use of organic and inorganic fertilizers. Keeping in view that oats is an important fodder crop and potential of some notified barley varieties for green fodder production and crop-wise varietal nutrients requirement for high and quality biomass production, the present study on fodder yield, nutritive value and nutrients uptake by different varieties of oats, barley and mixed crop was undertaken. The objectives of this study was to evaluate and identify most suitable variety of oats and barley for fodder yield, nutritive value and nutrients uptake potential under central Gujarat condition.

Materials and Methods

***Varieties and experimental details*:** The experiment was laid out in a randomized block design with three replications consisting of fourteen treatments. Treatments consisted of eight oats varieties (T1-Kent, T2-UPO 212, T3-RO 19, T4-JHO 822, T5-JHO 851, T6-JHO 99-1, T7-JHO 99-2, T8-JHO 2004), 3 barley varieties

(T9-RD 2035, T10-RD 2552 and RD 2715) and mix crop of 50 % oats and 50 % barley varieties (T11- Kent +RD 2035, T12-Kent +RD 2552 and T13-Kent +RD 2715). The study was undertaken during two consecutive years 2012-13 and 2013-14 at fodder demonstration unit (FDU) of National Dairy Development Board, Anand (Gujarat) in Randomised Block Design (RBD) with three replications. The soil of the experimental site was loam in texture with EC - 0.30, pH –7.85, total nitrogen-815.95 kg ha $^{-1}$, available P_2O_5 -52.61 kg ha $^{-1}$ and available K_2O-233.23kg ha $^{-1}$. The soil contained DTPA-extractable Fe (15.31 ppm), Mn (20.51 ppm), Zn (2.09 ppm), available S (5.70 ppm) and Cu (2.21 ppm). The crop was sown manually on 30th November during 2012 and 2013. The total plot size was 5 x 4 meter with net plot area of 4.0 x 3.0 meter at harvest. The crop was sown with seed rate of 100 kg ha^{-1} at row spacing of 25 cm. After sowing, the plots were immediately irrigated for proper germination. All the treatments were fertilized with recommended dose of fertilizers (120 kg N: 40 kg P: 40 kg K ha^{-1}). The fertilizers were applied as per treatment with half dose of nitrogen and full dose of phosphorus and potassium in the form of urea, SSP and MOP as basal and the remaining half of nitrogen in form of urea was top dressed at 30 days after sowing. After sowing, pendimethalin herbicide was applied as pre-emergence @ 1.0 litre ha^{-1} to control seasonal weeds. In total 4 irrigations were given during the crop growth period. The crop was harvested at 90 days stage.

Biometrical and qualitative traits: Forage yield, yield attributes and quality components were measured and analyzed at harvest during both the years. After harvest, fresh biomass yield of every treatment was determined and 200 gram chopped fodder samples were dried in ovens separately at 70°C to a constant weight for dry matter content. Plants from each net plot at two randomly selected spots of 1.0 metre row length were harvested and the tillers were counted and recorded as number of tillers per metre row length. Ten randomly selected tillers from 1.0 metre row length were harvested and whole tiller was partitioned of into stem and leaf, sun-dried and finally oven-dried at 70°C to record dry matter accumulation in leaf and stem parts.LSR represents relation between mean dry weight of leaf and dry weight of stem. The leaf to stem ratio (LSR) was worked out by applying the following formula.

$$LSR = \frac{\text{Leaf dry weight (g)}}{\text{Stem dry weight (g)}}$$

Dried samples were grounded (1 mm) for chemical analysis and the amount of N was estimated by using micro-Kjehldal method (Jackson, 1973). Crude protein content was calculated multiplying N amount of each sample by 6.25. Proximate analysis of fodder samples for nutritive value was carried following the standard laboratory procedures recommended by AOAC (2005). Minerals content was determined according to Inductively Coupled Plasma-Optical Emission Spectroscopy, Perkin Elmer, OPTIMA-3300 RL (ICP-OES) test method. Nutrients uptake was calculated based on typical nutrient concentrations and dry matter yield. Total uptake of nutrients was calculated separately by the following formula: Uptake of nutrient (kg ha^{-1}) = (nutrient % × dry matter yield (kg ha^{-1})/100

Statistical analysis: Two years data were pooled and mean values of observations were analysed statistically according to Snedecor and Cochran (1994).

Results and Discussion

Forage yield: Pooled data of two years indicated significant differences between different treatments of pure and mixed crops of oats and barley varieties (Table 1). Among oats crop, treatment T4, recorded significantly higher green fodder yield (26.74 t ha^{-1}) over T6 and was found at par with other oats treatments. But in dry matter yield T4 was found better than many varieties including national check (T1). In oats, significantly higher dry matter yield was recorded in T4 (8.29 t ha^{-1}) over T1, T2, T6 and T8 treatments. Crude protein yield was recorded significantly higher in T7 (0.73 t ha^{-1}) as compared to T1 and T6 treatments in oats. Jehangir *et al*. (2013) reported similar dry matter and crude protein yields in oats. In barley varieties, treatments T9 and T11 were at par amongst themselves but recorded significantly higher green, dry and crude protein yield over treatment T10 (Table 1). Barley treatment T11 recorded the highest green fodder yield (23.07 t ha $^{-1}$) and crude protein yield (0.80 t ha $^{-1}$). Whereas highest dry fodder yield (7.59 t ha $^{-1}$) was found in T9. Sharma (2009) reported that barley variety RD 2715 recorded maximum green fodder yield of 22.92 t ha^{-1}. Higher green fodder yield of treatment T11 might be due to higher number of tillers/metre row length (Table 1). In mix crop of oats + barley, significant differences were observed between treatments T12 and T13 for green and dry fodder yield (Table 1). However, all the treatments were at par in case of crude protein yield in mix crop of oats + barley. Treatment T13 recorded highest mean green, dry and crude protein yield of 25.15, 7.54 and 0.73 t ha $^{-1}$, respectively among mix crop treatments. Overall, oats treatments produced more green and dry matter yield compared to barley and mixed crop treatments. Higher dry matter yield in observed oats treatments might be due to significantly greater dry matter accumulation per tiller in oats treatments (Table 1). Carr *et al*. (1998) also reported similar findings.

Table1. Yield and growth parameters of oats and barley as affected by varieties (pooled)

Treatment (Varieties)	Yield (t ha^{-1})			Growth parameters				
	Green fodder	Dry matter	Crude protein	No. of tillers/ metre row length	Plant height at harvest (cm)	Leaf : Stem ratio (LSR)	Dry matter accumulation per tiller (g)	Dry matter content (%)
Oats								
T1: Kent (NC)	24.39	6.93	0.60	43	117	0.29	4.89	31.08
T2: UPO 212	25.67	7.35	0.67	49	124	0.24	5.16	29.80
T3: RO 19	25.32	7.55	0.68	43	121	0.38	4.42	30.38
T4: JHO 822	26.74	8.29	0.72	45	131	0.23	4.62	32.43
T5: JHO 851	25.39	7.61	0.69	47	124	0.39	3.93	32.48
T6: JHO 99-1	23.98	6.67	0.61	53	122	0.30	4.75	29.18
T7: JHO 99-2	25.25	8.13	0.73	51	121	0.26	4.25	34.72
T8: JHO 2004	25.46	7.44	0.67	47	122	0.31	4.49	30.87
Group mean	**25.28**	**7.50**	**0.67**	**47**	**123**	**0.30**	**4.56**	**31.37**
Barley								
T9: RD 2035	22.60	7.59	0.77	74	105	0.31	2.96	34.43
T10:RD 2552	19.07	5.55	0.61	73	106	0.20	3.73	31.97
T11: RD 2715	23.07	7.52	0.80	80	102	0.24	3.11	35.12
Group mean	**21.58**	**6.89**	**0.73**	**76**	**104**	**0.25**	**3.27**	**33.84**
Oats + Barley								
T12: Kent +RD 2035	22.51	6.24	0.63	66	114	0.32	3.41	28.23
T13: Kent +RD 2552	25.15	7.54	0.73	76	115	0.31	3.43	30.88
T14: Kent +RD 2715	24.21	6.84	0.68	76	115	0.31	3.55	28.28
Group mean	**23.96**	**6.87**	**0.68**	**73**	**115**	**0.31**	**3.46**	**29.13**
S.EM+	0.86	0.29	0.03	5	3	0.04	0.49	1.71
CD at 5 %	2.49	0.84	0.11	14	8	NS	1.00	NS

Growth parameters: Among different growth parameters, number of tillers/metre row length were recorded significantly higher in barley and mixed crop treatment as compared to oats treatments. However, non-significant differences were observed among treatments in oats, barley and mix crop within group (Table 1). Among barley varieties, treatment T11 produced more tillers which might have contributed to more fodder yield. Numbers of tillers per meter^{-2} are directly proportional to fresh fodder yield. Nawaz *et al*. (2004), Yanming *et al*. (2006) and Ahmad *et al.* (2008) also reported tiller number varied among the oats genotypes, which was in agreement with our findings. Kapoor *et al.* (2010) reported that RD-2715 was superior in terms of plant height compare to RD- 2552 and the variety RD-2552 had higher in leaf: stem ratio as compare to variety RD-2O35. Plant height at harvest was observed better in oats treatments compared to barley and mixed crop. Treatment T4 (131.0 cm) at par with T2 and T5 recorded significantly greater plant height at harvest as compared to remaining oats, barley and mixed crop treatments (Table 1). Higher plant height at harvest might have contributed in better green and dry fodder yields in T4 treatment. Dhumale and Mishra (1979) reported that there was a direct correlation of plant height, tillers/plant and yields of forage crops. Non-significant differences were observed for plant height among barley and mix crop treatments amongst themselves. Leaf: stem ratio and dry matter content differences were found non-significant in oats, barley and mix crop treatments (Table 1).

Proximate parameters: All proximate parameters except silica in oats, barley and mix crop treatments differed significantly (Table 2). Barley groups (10.5 to 10.8 %) recorded significantly higher crude protein content as compared to oats (8.6 to 9.1 %). Carr *et al*. (2001) also reported higher crude protein content in barley varieties than oat. Other proximate parameters crude fat, crude fibre and silica were found to be slightly higher in oat treatments as compared to barley and mix crop treatments. Kaur *et al.* (2013) reported higher crude protein (13.3%) and ether extract (2.87 %) contents in barley varieties when green fodder was cut at 45 days after sowing. In oats, T7 at par with T4 and T8 recorded

significantly lower crude fibre content (27.5%) as compared remaining treatments (Table 2). Similar level of crude fibre content (26.5%) was recorded in barley at 60 days stage (Kaur *et al.,* 2013). In barley, significantly lower crude fibre content (26.3%) was observed in T11 in comparison to T10. Although non-significant differences were observed among all treatment for silica but silica percent was found slightly lower in barley and mixed crop treatments as compared to oats.

Nutrients uptake: Significant differences were observed among treatments for primary (N, P_2O_5 and K_2O), secondary (Ca, Mg and S) and micro-nutrient (Zn, Mn, Fe and Cu) uptakes (Table 2). Primary nutrients uptake was found better in barley and mixed crop treatments than oats. While significant differences were observed among treatments for micronutrients uptake in zinc and manganese only.

Nitrogen (N): Among oats varieties, N uptake was found significantly lower in T1 and T6 as compared to T7 treatment. The highest N uptake (115.6 kg ha^{-1}) was recorded in T7 which was at par with T4. In barley, T9 and T11 treatments at par amongst themselves recorded significantly higher N uptake than T10. Amongst all treatments, barley treatment T9 recorded higher N uptake (129.8 kg ha^{-1}) which was significantly higher than many oats (T1, T2, T3, T5, T6 and T8) and mix crop (T12 and T14) treatments. In barley and oats treatment, N uptake ranged 96.7 to 129.8 kg ha^{-1} and 95.1 to 115.6 kg ha^{-1}, respectively. Canadian Fertilizer Institute (2001) reported N uptake of 104.0 to 128.0 kg ha^{-1} in barley and 109.0 to 133.0 kg ha^{-1} in oats. Non-significant differences were observed mix crop treatments for N uptake. Choudhary and Chaplot (2015) recorded N uptake of 60.96 to 78.03 kg ha^{-1} in three dual purpose varieties of barley when crop was harvested for green fodder at 55 days after sowing.

Phosphorus (P_2O_5): Barley treatment T11 at par with T9 recorded significantly higher P_2O_5 uptake (42.8 kg ha^{-1}) among all treatments. Whereas, oats treatment T3, T5 and T7 recorded significantly higher P_2O_5 uptake as compared to T1 and T6 treatments. P_2O_5 uptake ranged between 25.1 to 34.1 kg ha^{-1}, 29.5 to 42.8 kg ha^{-1} and 30.8 to 31.9 kg ha^{-1}, respectively in oats, barley and mix crop treatments. Canadian Fertilizer Institute (2001) reported P_2O_5 uptake between 31.0 to 37.0 kg ha^{-1} for barley crop. Choudhary and Chaplot (2015) recorded P uptake of 22.37 to 28.70 kg ha^{-1} in three dual purpose varieties of barley when crop was harvested for green fodder at 55 days after sowing.

Potash (K_2O): Significant differences were observed between treatments in K_2O uptake. Oats treatment T3, T4 and T7 recorded significantly higher K_2O uptake as compared to T1 and T6 treatments. Highest K_2O uptake (94.5 kg ha^{-1}) was recorded in barley treatment T11. K_2O uptake ranged between 62.8 to 84.4 kg ha^{-1}, 69.0 to 94.5 kg ha^{-1} and 77.1 to 87.0 kg ha^{-1}, respectively in oats, barley and mix crop treatments. Tripathi *et al.* (2003) reported that dry matter yield of 8.0 t ha^{-1} in oats resulted in an uptake of 107.5 kg ha^{-1} of K_2O.

Calcium (Ca): Barley treatment T9 (26.6 kg ha^{-1}) at par with T11 and oats treatment T7 recorded significantly higher Ca uptake as compared to other treatments (Table 2). Among oats treatments, Ca uptake was recorded significantly higher in T7 treatment (25.1 kg ha^{-1}) but it was found at par with T3 and T4 treatments. Mix crop treatments were found at par amongst themselves. Overall Ca uptake was observed higher in barley treatments.

Magnesium (Mg): Oats treatment showed better Mg uptake. In Oats, T7 recorded significantly greater Mg uptake (27.0 kg ha^{-1}) than remaining treatments of oats, barley and mixed crop (Table 2). In barley treatments, significantly lower Mg uptake was recorded in T10 treatment. Whereas, non-significant differences were observed between mixed crop treatments for mean Mg uptake. Overall Mg uptake was observed higher in oats treatments.

Sulphur (S): In oats, T7 at par with T2, T3, T4 and T5 significantly recorded higher uptake than T1, T6 and T8. In barley, significantly lower S uptake was recorded in T10. However, highest S uptake (16.9 kg ha^{-1}) was recorded in barley treatment T9. S uptake varied between 12.6 to 16.0 kg ha^{-1}, 12.1 to 16.9 kg ha^{-1} and 13.0 to 15.4 kg ha^{-1}, respectively in oats, barley and mix crop treatments. Similar observations were reported in Oats (16.0 to 18.0 kg ha^{-1}) and barley (12.0 to 16.0 kg ha^{-1}) by Canadian Fertilizer Institute (2001).

Zinc (Zn): Zn uptake was observed more in barley treatments. Amongst all treatments, T11 at par with T9 significantly recorded higher mean Zn uptake (176.0 g ha^{-1}). Non-significant differences existed between mix crop treatments for Zn uptake. In oats differences were found significant between treatments for Zn uptake and significantly highest Zn uptake was observed in T7 over T1 and and T6 treatments. Zn uptake varied between 120.0 to 141.0 g ha^{-1}, 113.0 to 176.0 g ha^{-1} and 120.0 to 132.0 g ha^{-1}, respectively in oats, barley and mix crop treatments.

Table 2. Proximate parameters and nutrients uptake by oats and barley crop as affected by varieties (pooled)

Treatments (Varieties)	Proximate parameters (%)			Primary nutrients uptake (kg ha^{-1})			
	Crude protein	Crude fat	Crude fibre	Silica	N	P_2O_5	K_2O
Oats							
T1: Kent (NC)	8.6	2.0	30.4	2.5	95.1	25.1	68.0
T2: UPO 212	9.0	2.1	30.3	2.6	106.3	31.7	72.7
T3: RO 19	9.1	2.1	31.5	2.7	109.9	33.6	84.2
T4: JHO 822	8.6	2.0	28.9	3.3	114.7	32.8	83.9
T5: JHO 851	9.1	2.0	31.0	3.2	110.8	33.1	77.7
T6: JHO 99-1	9.1	2.1	30.4	2.4	97.0	26.3	62.8
T7: JHO 99-2	8.9	1.8	27.5	2.2	115.6	34.1	84.4
T8: JHO 2004	9.1	2.2	29.2	3.7	107.8	31.4	70.8
Group mean	**8.9**	**2.0**	**29.9**	**2.8**	**107.2**	**31.0**	**75.6**
Barley							
T9: RD 2035	10.7	1.7	27.3	1.9	129.8	39.9	87.8
T10: RD 2552	10.8	1.3	28.7	2.1	96.7	29.5	69.0
T11: RD 2715	10.5	1.4	26.3	1.9	127.6	42.8	94.5
Group mean	**10.7**	**1.5**	**27.4**	**2.0**	**118.0**	**37.4**	**83.8**
Oats + Barley							
T12: Kent +RD 2035	10.1	1.6	29.6	2.3	100.6	30.8	78.3
T13: Kent +RD 2552	9.8	1.9	29.6	1.9	117.6	31.9	77.1
T14: Kent +RD 2715	9.9	1.9	28.5	2.1	108.8	31.2	87.0
Group mean	**9.9**	**1.8**	**29.2**	**2.1**	**109.0**	**31.3**	**80.8**
S. Em±	0.3	0.2	0.8	0.4	6.3	2.3	4.9
CD at 5 %	1.0	0.5	2.3	1.1	18.3	6.8	14.2

Treatments (Varieties)	Secondary nutrients uptake (kg ha^{-1})			Micro nutrients uptake (g ha^{-1})			
	Ca	Mg	S	Zn	Mn	Fe	Cu
Oats							
T1: Kent (NC)	18.4	19.5	12.6	120	443	2990	39
T2: UPO 212	19.8	20.9	14.6	128	450	3040	43
T3: RO 19	22.0	23.7	15.6	136	479	2960	44
T4: JHO 822	21.4	21.7	15.6	133	599	3383	45
T5: JHO 851	20.2	22.4	14.5	140	502	3670	44
T6: JHO 99-1	16.9	18.6	12.9	118	419	2687	34
T7: JHO 99-2	25.1	27.0	16.0	143	503	2952	44
T8: JHO 2004	20.0	21.1	14.0	132	503	3933	39
Group mean	**20.5**	**21.9**	**14.5**	**131.3**	**487**	**3202**	**42**
Barley							
T9: RD 2035	26.6	20.5	16.9	160	320	3083	48
T10: RD 2552	19.1	15.3	12.1	113	234	2232	39
T11: RD 2715	24.4	19.5	16.2	176	253	2817	49
Group mean	**23.4**	**18.4**	**15.1**	**150**	**269**	**2710**	**45**
Oats + Barley							
T12: Kent +RD 2035	18.8	17.3	13.0	117	329	2269	43
T13: Kent +RD 2552	20.4	19.4	15.4	132	357	2996	41
T14: Kent +RD 2715	21.7	19.0	14.2	120	381	2645	42
Group mean	**20.3**	**19.0**	**14.2**	**123**	**356**	**2637**	**42**
S. Em±	1.4	1.1	0.9	10	34	1150	5
CD at 5 %	4.0	3.3	2.7	21	69	NS	NS

Manganese (Mn): Mn uptake was observed higher in oats treatments as compared to barley and mixed crop treatment (Table 2). Oats treatment T4 recorded significantly highest Mn uptake (599.0 g ha^{-1}) in comparison to rest of the treatments.In barley crop, significantly higher Mn uptake (320.0 g ha^{-1}) was recorded in T9 as compared to other barley treatments. Differences were at par amongst mixed croptreatments.

Iron (Fe): Non-significant differences were recorded for Fe uptake amongst treatments (Table 2). However, Fe uptake varied between 2960.0 to 3933.0 g ha^{-1}, 2232.0 to 3083.0 g ha^{-1} and 2269.0 to 2996.0 g ha^{-1}, respectively in oats, barley and mix crop treatments. Fe uptake was found to be comparatively higher in oats than barley and mix crop treatments.

Copper (Cu): Differences were found to be non-significant for Cu uptake among treatments. However, Cu uptake varied between 34.0 to 45.0 g ha^{-1}, 39.0 to 49.0 g ha^{-1} and 41.0 to 43.0 g ha^{-1}, respectively in oats, barley and mix crop treatments. Roy and Srivastava (1988) reported micro-nutrients uptake in oats fodder /ton of dry matter was 16.5 g, 40.5 g, 31.0 g and 10.0 g in Zn, Cu, Fe and Mn, respectively.

Conclusion

On the basis of two years study, it was concluded that in single cut system oats varieties JHO 822 and JHO 99-2 were better in fodder yield, quality, growth parameters and nutrient uptake as compared to presently popular variety Kent. In barley, RD 2715 and RD 2035 were found to be better than RD 2552 for fodder production. Growing of mixed crop of oats + barley did not give significant yield advantage in comparison to sole crops of oats or barley in fodder production. Quality of barley fodder was found as good as oats. Nutrients uptake potential was higher in barley than oats however; it varied among oats and barley varieties depending upon yield and quality of fodder.

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