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Quality of oats harvested by impact type forage harvester

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■ **ABSTRACT :** A self-propelled flail type flail forage harvester was evaluated for effect on quality of oats fodder at three levels of forward speed of the machine, three levels of flail speed and three levels of rake angle of flail. The minimum loss of moisture (%), maximum crude protein (%) and minimum neutral and acid detergent fibre (%) were obtained with the forward speed of 3.00 km/h, flail speed of 26.86 m/s and flail rake angle of 45°. At this setting corresponding values of loss of moisture (%), crude protein (%) and neutral and acid detergent fibre (%) were 0.57, 8.12, 55.28 and 36.90 per cent, respectively.

■ **KEY WORDS :** Forage harvester, Flail, Fodder quality, Nutrition, Moisture, Crude protein

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Oats is an important *Rabi* forage crop and widely cultivated in monoculture or in mixture with berseem, ryegrass or mustard (Gupta *et al.*, 2004). Intensive forage production system deals with the efficient utilization of limited land resources and other inputs for obtaining maximum harvests of nutrition's herbage per unit area and time. These crops are generally harvested by hand or power operated chaff cutter before feeding it to the animals. The harvesting of forage crop is one of the most important farm operations. The critical period of forage growth, when the nutritive value and dry matter of the fodder maximize, is very limited and any delay in its harvest results in tremendous loss in terms of its feeding value (Chattopadhyay, 1997). Moreover, the genetic potentialities of high yielding animals can only be realized if they are fed with quality fodder. This is particularly true in the case of dairy animals. Hence, to meet the requirements of fast developing dairy industry, fodders of good quality will have to be produced in sufficient quantity to replace the concentrates. Green fodders are 30 per cent cheaper source of total digestible nutrients as compared to concentrates (Saran and Jackson, 1967).

Hence, it is prudent to mechanize the time and labour consuming operation of fodder harvesting not only to overcome labour shortages but also to remove drudgery, hard labour and to enhance labour productivity. The paper deals with the quality of oats fodder harvested by self- propelled flail type forage harvester.

■ METHODOLOGY

A self-propelled forage harvester fabricated in the department of Farm Power and Machinery was used for harvesting of oats fodder. The treatments consisted of three levels of forward speed of the machine (1.5, 2.25 and 3.00 km/h), three levels of flail speed (26.86, 32.51 and 40.26 m/s) and three levels of flail rake angles (25°, 35° and 45°). Oats was sown as per the standard package of practices and was harvested at the optimum stage of harvesting as recommended by Gupta *et al*. (2004). The parameters evaluated for fodder quality were loss of moisture, crude protein, neutral detergent fibre, acid detergent fibre and total ash. The procedure given by Anonymous (1995) and Sastry *et al*. (1999) was used for evaluating the quality of fodder samples. Data collected during experimentation for the evaluation of self propelled forage harvester was statistically analyzed using experiment in randomized block design to see the effect of independent variables on dependent variables. Statistical analysis package named "CPCS 1", developed by Punjab Agricultural University; Ludhiana was used for the data analysis.

■ RESULTS AND DISCUSSION

The effect on the quality of oats fodder as harvested by the machine at various operational and design parameters are given in Table 1 and are discussed as under.

Loss of moisture :

The loss of moisture decreased with increase in forward speed of the machine and flail rake angle, whereas it increased with the increase in the flail speed. The main effects of the forward speed, flail speed and rake angles were statistically significant.

At higher forward speeds, the number of cuts of flails per metre forward travel decreased thereby reducing the loss of moisture. The number of cuts made by the flails per metre forward travel increased with the increase in the flail speed thereby increasing the loss of moisture at higher flail speeds. The increase in the loss of moisture at lower flail rake angles could be attributed to the fact that lower rake angles resulted in large radius of curvature. If the knives have too much curvature, they do not unload the cut material properly resulting in the cut material striking against each other and also remaining in contact with the flail for longer duration of time thereby increasing the loss of moisture.

Crude protein :

The crude protein increased with increase in forward speed of the machine and flail rake angle, whereas it decreased with the increase in the flail speed. The main effects of the forward speed, flail speed and rake angles was statistically significant. The crude protein was higher in all treatments as compared to the crude protein for manual cut fodder sample, which was recorded as 6.99 per cent.

The maximum crude protein in a plant is concentrated in the leaves as compared to the stem portion. The higher forward

Table 1 : Effect of forward speed, rake angle and flail speed on loss of moisture, crude protein, neutral detergent fibre, acid detergent fibre and total ash for oats fodder

Forward speed (km/h)	Flail speed (m/s)	Loss of moisture (%)	Crude protein (%)	Neutral detergent fibre (%)	Acid detergent fibre (%)	Total ash (%)
Rake angle 25 degrees						
1.50	26.86	2.00	7.52	56.62	37.81	8.73
	32.51	2.31	7.32	56.91	37.99	8.81
	40.26	3.57	7.21	57.35	38.13	8.91
2.25	26.86	1.81	7.62	56.21	37.59	8.69
	32.51	2.10	7.44	56.53	37.72	8.78
	40.26	2.65	7.36	57.20	37.94	8.90
3.00	26.86	1.22	7.75	55.92	37.26	8.72
	32.51	1.87	7.66	56.20	37.51	8.80
	40.26	2.46	7.58	57.08	37.75	8.89
Rake angle 35 degrees						
1.50	26.86	1.27	7.64	56.28	37.62	8.74
	32.51	1.96	7.49	56.64	37.82	8.80
	40.26	2.69	7.35	56.93	37.96	8.92
2.25	26.86	1.01	7.68	55.87	37.28	8.73
	32.51	1.66	7.53	56.22	37.54	8.83
	40.26	2.11	7.46	56.55	37.73	8.91
3.00	26.86	0.65	7.98	55.61	37.11	8.70
	32.51	1.07	7.87	55.93	37.33	8.81
	40.26	1.99	7.80	56.28	37.45	8.91
Rake angle 45 degrees						
1.50	26.86	1.02	7.72	55.98	37.39	8.70
	32.51	1.45	7.62	56.23	37.64	8.80
	40.26	2.06	7.44	56.39	37.81	8.93
2.25	26.86	0.90	7.84	55.43	37.09	8.72
	32.51	1.31	7.71	56.11	37.22	8.82
	40.26	1.99	7.56	56.29	37.53	8.90
3.00	26.86	0.57	8.12	55.28	36.90	8.71
	32.51	0.90	8.00	55.54	37.16	8.80
	40.26	1.13	7.90	55.72	37.29	8.90

speeds results in the higher height of cut, which increases the crude protein level at higher forward speed. The higher flail speeds results in the lower height of cut (Khar and Ahuja, 2007) which results in decrease of the crude protein level at higher flail speeds. The higher flail rake angles results in the higher height of cut which results in increase of the crude protein level at higher rake angles. Similar trends have been reported by Downs and Taylor (1989), Khar and Ahuja (2009a) and Khar and Ahuja (2009b).

Neutral detergent fibre :

The neutral detergent fibre decreased with increase in forward speed of the machine and flail rake angle, whereas it increased with the increase in the flail speed. The main effect of the forward speed, flail speed and rake angles was statistically significant. The neutral detergent fibre for the manual cut fodder sample was found to be 58.03 per cent.

The decrease in neutral detergent fibre with the increase in the forward speed was due to the fact that higher forward speeds results in higher height of cut, which indirectly decreases the neutral detergent fibre as the same is concentrated into the stem portion as compared to leaves. The higher flail speeds results in lower height of cut thereby increase in neutral detergent fibre. The height of cut increased with the increase in the flail rake angle of the flails thereby decreasing the neutral detergent fibre.

Acid detergent fibre :

The acid detergent fibre decreased with increase in forward speed of the machine and flail rake angle, whereas it increased with the increase in the flail speed. The reasons for the change in acid detergent fibre are the same as explained in the neutral detergent fibre. The main effect of the forward speed, flail speed and flail rake angles was statistically significant. The ADF for the manual cut fodder sample was found to be 38.53 per cent.

Total ash :

The data indicate that the total ash had no specific trend with increase in the forward speed and flail rake angle. The total ash for manual cut fodder samples was found to be 8.66 per cent. The total ash increased with the increase in flail speed for all the treatments. At a rake angle of 25º, the total ash increased from 8.73to 8.91 per cent, at a rake angle of 35º from 8.74 to 8.92 per cent and at a rake angle of 45º from 8.70 to 8.93 per cent as the flail speed was increased from 26.86 to 40.26 m/s and at a forward speed of 1.5 km/h. Similar trends were observed at forward speed of 2.25 and 3.0 km/h. The main effect of flail speed was statistically significant. The higher flail speeds results in the large turbulence of air within the cutting housing, which results in the soil splashing on the fodder. The splashing of the soil on the fodder increases the total ash.

Conclusion :

The loss of moisture (%), neutral detergent fibre (%) and acid detergent fibre (%) decreased while as crude protein (%) increased with the increase in the forward speed of the machine and rake angle of the flails. The loss of moisture (%), neutral detergent fibre (%) and acid detergent fibre (%) increased while as crude protein (%) decreased with the increase in the flail speed. Based on the laboratory evaluation of the fodder sample, the treatment combination which gave the minimum loss of moisture (0.57%), maximum crude protein (8.12%) and minimum neutal detergent fibre(55.28%) and acid detergent fibre (36.90%) was found to be 3.0 km/h forward speed, 26.86 m/s flail speed and 45º rake angle.

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