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EVALUATION OF MORPHOLOGICAL AND GENETIC DETERMINANTS OF FODDER YIELD AS A SELECTION CRITERION IN F_2, F_3 AND F_4 GENERATIONS OF OAT (*AVENA SATIVA* L.)

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SUMMARY

A field experiment was conducted as Fodder Section Farm of Department of Crop Improvement, CSK HPKV, Palampur during 2015-27 to estimate the direct and indirect effects of twelve morphophysiological traits towards fresh fodder yield in F_2, F_3 and F_4 generations of oat cross PLP-1 × HJ-8 which revealed that tillers per plant, leaves per plant, dry matter yield per plant and crude protein yield per plant plays chief role as major forage yield component in both early and late generations, therefore selection of these traits would offer the scope for improvement in fresh fodder yield and also the significant correlation between these traits in F_2, F_3, and F_4 generations indicated that these traits are mostly governed by additive gene action and also the suitability of these traits for selection on individual plant basis in the advanced generations of segregating populations which would ultimately help to achieve higher total green fodder yield in oats. In the evaluation of F_2, F_3 and F_4 generations along with parents, about 14.33, 18.44, and 22.89% transgressive segregants, respectively, were obtained for most of the traits which indicated the importance of PLP-1 and HJ-8 as parents in the future breeding programme for improving fodder yield in oats.

Key words : Segregating populations, forage traits, direct and indirect effects, transgressive segregants, selection, fodder yield, oat

Oat (*Avena sativa* L.) belonging to the family Gramineae is a multipurpose cereal crop grown in *rabi* season. It ranks sixth in world cereal production following wheat, maize, rice, barley and sorghum (Kumari *et al.,* 2018). In India, it is used as a grain, green fodder, hay and silage for animals. According to the FAOSTAT database reports, the area sown to oats has fallen sharply over the past century and the entire agricultural scenario in the Himalayan region is typified by conflicts, paradoxes, and inherent natural resource limitations. Land, the basic resource, is the greatest limitation. The situation is worst in the state of Himachal Pradesh, where 40 per cent of farmers own only 0.65 ha or less. At the same time, all small-scale farmers rear animals to complement their earnings but do not have enough land to produce fodder for their sustenance. In the temperate Himalayan regions especially in Himachal Pradesh the area under forage crops has not raised above 1 per cent of cultivated land in the area over the last 30 years because of the severe winters and small land holdings. Therefore, a fodder crop that can provide some output from small land that otherwise would remain fallow in winter is oats because it requires long and cool season for its growth, therefore successfully grown in hilly areas of the country. Oats are also becoming a popular fodder crop in Himachal Pradesh and the Uttaranchal States because of its excellent growth habit, quick recovery after cutting and its good quality herbage. Therefore, there is great need to increase the production of this crop per unit area because of the small land holdings of the farmers for sustainability. Furthermore, the demand of oat for human consumption has increased, particularly because of the beta-glucans, the water-soluble fibers present in oat bran inhibit cholesterol, which helps in preventing heart disease.

The yield of any crop is a complex character, which depends upon many independent contributing characters. Knowledge of the magnitude and type of association between yield and its components themselves greatly help in evaluating the contribution of different components towards yield (Dubey *et al.*, 2015). Yield being a polygenic character is highly influenced by the fluctuations in the environment. Hence, selection of plants based directly on yield would not be very reliable therefore, fodder yield contributing characters (directly or indirectly) needs to be identified which can be used as morphological and genetic determinants of fodder yield for the selection of plants in the segregating and subsequent generations which can help the breeder for the improvement in the fodder yield. The appropriate knowledge of interrelationships between forage yield and its contributing components can significantly improve the efficiency of the breeding programme through the use of appropriate selection indices. The nature of the association between forage yield and its components determine the appropriate traits to be used in indirect selection for improvement in forage yield. The correlation studies simply measure the associations between yield and other traits. When number of characters are included in correlation study the indirect association becomes complex. In such situation, the path coefficient analysis is suggested by Dewey and Lu (1959) which provides a means of untangling the complex correlation into direct and indirect effects of the component characters of yield so as to find out the efficient characters contributing effectively towards the yields. Despite the extensive worldwide use of oat for forage and fodder uses, very little of the world's research plant improvement resources are devoted to the development of the oat crop specifically for fodder uses (Surje *et al.* 2015). Thus, correlation and path coefficient analysis are essential to know the effectiveness of selection for simultaneous improvement in the fodder yield traits. In this scenario, the technique of path analysis has been extensively exploited by many plant breeders to assist in identifying traits that are useful in selection to improve the fodder yield in oat as earlier reported by Bahadur *et al.* (2008) ; Surje and De (2014); Dubey *et al.* (2015) and Jaipal and Shekhawat (2016). McGinnis and Shebeski (1968) have reported the importance of using selection strategies, chiefly for quantitative traits in highly segregating populations. Therefore, the present investigation was undertaken with an objective to determine the morphological and genetic components, directly and indirectly, contributing to the fodder yield which can be used as selection indices in the segregating generations of oat.

MATERIALS AND METHODS

The field experiment was conducted at Fodder Section Farm of the Department of Crop Improvement, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh. The experimental material for present investigation comprised F_2, F_3, and F_4 generations of oat cross PLP-1 × HJ-8 which was raised in an unreplicated trial during 2015-17.

Individual plant selection on the basis of powdery mildew resistance was made in F_2 and selected plants were carried forward to F_3 generation. Similarly, a selection was made in F_3 generations and the selected plants were advanced to F_4. The row to row distance was 25 cm with plant to plant distance of 10 cm apart. Recommended package of practices was followed for raising the crop. Eighty-six plants in F_2, 166 in F_3 and 206 plants in F_4 were selected and data were recorded on individual selected plant with respect to different morphophysiological and forage characters viz., days to 50 per cent flowering, plant height (cm), number of leaves per plant, number of tiller per plant, leaf: stem ratio, leaf area (cm^2), fresh fodder yield per plant (g), dry matter per cent, dry matter yield per plant (g), crude protein content (%), crude protein yield per plant (g) and days to 75 per cent maturity.

The simple correlation coefficient and the path coefficient analysis was carried out to estimate direct and indirect effects of various contributing characters towards fresh fodder yield as described by Karl Pearson and Dewey and Lu (1959) and transgressive segregants for forage and component traits in F_3 and F_4 generations have been identified. Statistical analysis was done using OPSTAT Online Agriculture Data Analysis software.

RESULTS AND DISCUSSION

Results of correlation coefficient (Table 1) revealed that fresh fodder yield per plant exhibited significant positive correlation with tillers per plant, leaves per plant, dry matter yield per plant and crude protein yield per plant in F_2, F_3 and F_4 whereas, leaf area showed positive and significant correlation in F_2 and F_4 and not in F_3. On the other hand, it exhibited significant negative correlation with leaf: stem ratio and dry matter per cent in F_2 and with dry matter per cent in both F_3 and F_4. Bahadur *et al*. (2008), Kapoor *et al*. (2011), Tewari and Pandey (2014) and Dubey *et al*. (2015) also reported a positive correlation of green weight with dry matter yield. Dubey *et al.* (2015) also reported a positive correlation between fresh fodder yield and tillers per plant. Similarly, positive correlation of leaves per plant with fresh fodder yield was reported by Dhumale and Mishra (1979) and Dubey *et al*. (2015). Among other traits days to 50 per cent flowering showed significant positive correlation

TABLE 1

Correlation coefficient among fresh fodder yield and other traits in F2, F3 and F4 generations of oat cross PLP-1 × HJ-8

Characters		Days to 50 per cent flowering	Plant height	Tillers/ plant	Leaves/ plant	Leaf : stem ratio	Leaf area	Dry matter yield/plant plant	Dry matter per cent	Days to 75 per cent maturity	Crude protein content	Crude protein yield/ plant	Fresh fodder yield/ plant
Days to 50 per cent flowering	F_2	1.000	0.043	-0.033	-0.108	-0.217*	-0.141	0.049	0.044	0.741**	-0.050	0.035	-0.039
	F_3	1.000	0.152	-0.001	-0.020	-0.143	-0.123	-0.021	-0.028	0.825**	-0.012	-0.010	0.006
	F_4	1.000	-0.051	0.039	0.064	-0.040	0.021	-0.050	-0.114	0.774**	-0.011	-0.048	0.001
Plant height	F_2		1.000	-0.205	-0.164	0.007	-0.130	0.175	0.402**	-0.091	0.088	0.181	-0.097
	F_3		1.000	-0.014	0.016	-0.244**	-0.057	0.308**	0.286**	0.142	-0.165*	0.298**	0.122
	F_4		1.000	-0.117	-0.091	-0.265**	0.176*	0.315**	0.330**	-0.068	-0.128	0.299**	0.113
Tillers per plant	F_2			1.000	0.814**	-0.160	0.289**	0.529**	-0.145	0.019	0.025	0.512**	0.631**
	F_3			1.000	0.881**	0.026	0.031	0.342**	-0.248**	-0.090	-0.014	0.336**	0.660**
	F_4			1.000	0.892**	0.030	-0.033	0.406**	-0.161*	0.018	0.070	0.411**	0.615**
Leaves per plant	F_2				1.000	0.081	0.255*	0.391**	-0.199	-0.017	-0.034	0.360**	0.510**
	F_3				1.000	0.069	-0.006	0.292**	-0.262**	-0.107	0.018	0.294**	0.620**
	F_4				1.000	0.108	0.024	0.342**	-0.251**	0.033	0.085	0.347**	0.619**
Leaf: stem ratio	F_2					1.000	-0.188	-0.376**	-0.025	-0.060	-0.025	-0.358**	-0.369**
	F_3					1.000	-0.119	-0.267**	-0.129	-0.231**	0.168*	-0.259**	-0.146
	F_4					1.000	-0.068	-0.380**	-0.359**	-0.031	0.119	-0.363**	-0.103
Leaf area	F_2						1.000	0.183	-0.216*	-0.131	-0.071	0.153	0.437**
	F_3						1.000	0.017	0.006	-0.073	-0.044	0.007	0.035
	F_4						1.000	0.337**	-0.191**	0.013	-0.078	0.320**	0.526**
Dry matter yield per plant	F_2							1.000	0.388**	-0.024	0.091	0.986**	0.595**
	F_3							1.000	0.416**	-0.009	0.018	0.992**	0.571**
	F_4							1.000	0.491**	-0.061	-0.044	0.987**	0.663**
Dry matter per cent	F_2								1.000	0.038	0.095	0.398**	-0.392**
	F_3								1.000	0.044	-0.117	0.405**	-0.339**
	F_4								1.000	-0.076	-0.038	0.482**	-0.219**
Days to 75 per cent maturity	F_2									1.000	-0.069	-0.041	-0.118
	F_3									1.000	0.036	0.010	-0.080
	F_4									1.000	0.017	-0.056	-0.025
Crude protein content	F_2										1.000	0.230*	0.050
	F_3										1.000	0.125	0.032
	F_4										1.000	0.096	0.022
Crude protein yield per plant	F_2											1.000	0.574**
	F_3											1.000	0.567**
	F_4											1.000	0.661**
Fresh fodder yield per plant	F_2												1.000
	F_3												1.000
	F_4												1.000

*,** significant at 5% and 1% respectively.

with days to 75 per cent maturity in F_2, F_3 as well as in F_4 whereas it showed a negative correlation with leaf: stem ratio in F_2 only. Plant height exhibited significant positive correlation with dry matter per cent in F_2, with dry matter yield and dry matter per cent in F_3 and with leaf area, dry matter per cent, crude protein yield per plant and dry matter yield per plant in F_4 whereas, it exhibited negative correlation with leaf: stem ratio and crude protein content in F_3 and with leaf: stem ratio in F_4 only. Dubey *et al*. (2015) also reported a significant and positive correlation of dry matter yield with plant height. Leaves per plant were positively correlated with leaf area, dry matter yield and crude protein yield per plant in F_2; with dry matter yield and crude protein yield per plant in F_3 and F_4. It showed a negative correlation with dry matter per cent in F_3 and F_4. Dubey *et al*. (2015) also reported a correlation of leaves per plant with dry matter yield. Leaf: stem ratio exhibited significant positive correlation with crude protein content in F_3 only whereas, it exhibited negative correlation with dry matter yield per plant and crude protein yield per plant in F_2, with dry matter yield and days to 75 per cent maturity and crude protein yield per plant in F_3 and with dry matter yield per plant, dry matter per cent and crude protein yield in F_4. Choubey and Gupta (1986) obtained similar types of results. Leaf area showed a positive correlation with dry matter yield per plant and crude protein yield in F_4 whereas a significant correlation was not observed in F_2 and F_3 and it showed a negative correlation with dry matter per cent in F_2 and F_4. Choubey and Gupta (1986) also reported similar types of results. Dry matter yield per plant showed significant positive correlation with dry matter per cent and crude protein yield per plant in F_2, F_3 and F_4 and dry matter per cent showed significant positive correlation with crude protein yield in F_2, F_3, and F_4. Crude protein content showed a positive association with crude protein yield per plant in F_2 whereas a significant correlation was not observed in F_3 and F_4.

The path coefficient analysis in F_2, F_3, and F_4 (Table 2) revealed that dry matter yield per plant gave the highest positive direct effect towards fresh fodder yield per plant in F_2, F_3 and F_4 followed by tillers per plant, crude protein content and leaf area in F_2; tillers per plant and crude protein yield per plant in F_3 and crude protein yield per plant, leaf area and tillers per plant in F_4. These results are in agreement with those obtained earlier by Kumar and Singh (1997), Sangwan *et al*. (2012) and Jaipal and Shekhawat (2016). Further, tillers per plant were found to contribute fresh fodder yield per plant indirectly through dry matter yield per plant in F_2, F_3 as well as in F_4. The significant positive correlation of fresh fodder yield per plant with leaves per plant was due to the highest indirect effects *via* dry matter yield per plant in F_2 and F_4 followed by tillers per plant and dry matter per cent in F_2; dry matter per cent and tillers per plant in F_4 and in F_3 it was contributed indirectly *via* tillers per plant followed by dry matter yield per plant and dry matter per cent. Leaf area was found to contribute to fresh fodder yield per plant indirectly through dry matter yield per plant followed by dry matter per cent in F_2. In F_4, significant positive correlation with fresh fodder yield per plant was contributed indirectly by dry matter yield per plant whereas, it was not observed in $F_{3.}$ Dry matter yield per plant was found to contribute towards fresh fodder yield per plant due to its own high direct effect in F_2, F_3 as well as in F_4. Crude protein yield per plant showed a positive correlation with fresh fodder yield per plant *via* the high indirect effect of dry matter yield per plant in F_2, F_3 and F_4. These results are in agreement with Dubey *et al*. (2015). Leaf: stem ratio showed significant negative correlation with fresh fodder yield per plant indirectly *via* the negative effect of dry matter yield per plant in F_2 only whereas; it was not observed in F_3 and F_4. Iyanar *et al*. (2010) reported that leaf: stem ratio showed a negative effect on fresh fodder yield in Sorghum. On the other hand, the negative correlation of dry matter per cent with fresh fodder yield was observed due to its own high negative direct effect in F_2, F_3, and F_4.

From correlation and path analysis it can be concluded that tillers per plant, leaves per plant, dry matter yield per plant and crude protein yield per plant plays major role as major forage yield component in both early and late generations, therefore these traits can be used as morphological determinants for the selection and thus, these traits would offer the scope for equal improvement of all these traits which directly or indirectly providing fresh fodder yield. The significant correlation between these traits in F_2, F_3, and F_4 generations indicated that these traits are mostly governed by additive gene action and also the suitability of these traits for selection on individual plant basis in the advanced generations of segregating populations.

Range and mean values for parents and selected progenies in F_2, F_3 and F_4 for various traits are presented in Table 3. The values for days to 50 per cent flowering varied from 116.00-139.00, 115.00-140.00 and 116.00-146.00 with an average value of 126.83, 128.58 and 131.04 days in F_2, F_3 and $F_{4,}$

TABLE 2

Direct and indirect effects of various traits on fresh fodder yield in F2, F3 and F4 generation of oat cross PLP-1 × HJ-8

Characters		Days to 50 per cent flowering	Plant height	Tillers/ plant	Leaves/ plant	Leaf : stem ratio	Leaf area	Dry matter yield/ plant	Dry matter per cent	Days to 75 per cent maturity	Crude protein content	Crude protein yield/ plant	Correlation coefficient (r)
Days to 50 per cent flowering	F_2	-0.001	0.003	-0.006	0.008	0.011	-0.016	0.063	-0.029	-0.047	-0.006	-0.020	-0.039
	F_3	0.076	0.010	0.000	-0.002	0.005	-0.003	-0.011	0.016	-0.084	0.000	-0.002	0.006
	F_4	-0.041	-0.002	0.006	0.006	0.000	0.004	-0.025	0.061	0.006	0.000	-0.012	0.001
Plant height	F_2	0.000	0.072	-0.037	0.012	0.000	-0.015	0.222	-0.267	0.006	0.010	-0.101	-0.097
	F_3	0.012	0.065	-0.003	0.001	0.009	-0.001	0.162	-0.164	-0.014	0.007	0.049	0.122
	F_4	0.002	0.047	-0.017	-0.009	0.000	0.030	0.160	-0.175	-0.001	0.000	0.076	0.113
Tillers per plant	F_2	0.000	-0.015	0.182	-0.062	0.008	0.032	0.672	0.096	-0.001	0.003	-0.285	0.631**
	F_3	0.000	-0.001	0.197	0.076	-0.001	0.001	0.180	0.143	0.009	0.001	0.055	0.660**
	F_4	-0.002	-0.005	0.145	0.087	0.000	-0.006	0.207	0.085	0.000	0.000	0.104	0.615**
Leaves per plant	F_2	0.000	-0.012	0.148	-0.076	-0.004	0.028	0.496	0.133	0.001	-0.004	-0.201	0.510**
	F_3	-0.002	0.001	0.174	0.087	-0.002	0.000	0.154	0.151	0.011	-0.001	0.048	0.620**
	F_4	-0.003	-0.004	0.130	0.097	0.000	0.004	0.174	0.133	0.000	0.000	0.088	0.619**
Leaf: stem ratio	F_2	0.000	0.001	-0.029	-0.006	-0.052	-0.021	-0.478	0.017	0.004	-0.003	0.199	-0.369**
	F_3	-0.011	-0.016	0.005	0.006	-0.035	-0.003	-0.140	0.074	0.023	-0.007	-0.043	-0.146
	F_4	0.002	-0.012	0.004	0.011	-0.001	-0.011	-0.193	0.190	0.000	0.000	-0.092	-0.103
Leaf area	F_2	0.000	-0.009	0.053	-0.019	0.010	0.112	0.233	0.144	0.008	-0.008	-0.085	0.437**
	F_3	-0.009	-0.004	0.006	0.000	0.004	0.022	0.009	-0.004	0.007	0.002	0.001	0.035
	F_4	-0.001	0.008	-0.005	0.002	0.000	0.168	0.171	0.101	0.000	0.000	0.081	0.526**
Dry matter yield per plant	F_2	0.000	0.013	0.096	-0.030	0.020	0.020	1.271	-0.258	0.001	0.010	-0.549	0.595**
	F_3	-0.002	0.020	0.067	0.025	0.009	0.000	0.526	-0.239	0.001	-0.001	0.163	0.571**
	F_4	0.002	0.015	0.059	0.033	0.001	0.057	0.508	-0.260	0.000	0.000	0.249	0.663**
Dry matter per cent	F_2	-0.003	0.029	-0.026	0.015	0.001	-0.024	0.492	-0.666	-0.002	0.011	-0.222	-0.392**
	F_3	-0.002	0.019	-0.049	-0.023	0.005	0.000	0.219	-0.574	-0.005	0.005	0.067	-0.339**
	F_4	0.005	0.015	-0.023	-0.024	0.001	-0.032	0.249	-0.530	-0.001	0.000	0.122	-0.219**
Days to 75 per cent maturity	F_2	-0.001	-0.007	0.003	0.001	0.003	-0.015	-0.030	-0.025	-0.063	-0.008	0.023	-0.118
	F_3	0.063	0.009	-0.018	-0.009	0.008	-0.002	-0.005	-0.025	-0.102	-0.002	0.002	-0.080
	F_4	-0.032	-0.003	0.003	0.003	0.000	0.002	-0.031	0.040	0.007	0.000	-0.014	-0.025
Crude protein content	F_2	0.000	0.006	0.004	0.003	0.001	-0.008	0.115	-0.063	0.004	0.114	-0.128	0.050
	F_3	-0.001	-0.011	-0.003	0.002	-0.006	-0.001	0.009	0.067	-0.004	-0.042	0.021	0.032
	F_4	0.000	-0.006	0.010	0.008	0.000	-0.013	-0.022	0.020	0.000	0.000	0.024	0.022
Crude protein yield per plant	F_2	0.000	0.013	0.093	-0.027	0.019	0.017	1.253	-0.265	0.003	0.026	-0.557	0.574**
	F_3	-0.001	0.019	0.066	0.025	0.009	0.000	0.522	-0.232	-0.001	-0.005	0.165	0.567**
	F_4	0.002	0.014	0.060	0.034	0.001	0.054	0.502	-0.256	0.000	0.000	0.252	0.661**

respectively. The values for plant height ranged from 65.00-156.00 cm in F_2 with a mean of 108.77 cm; 69.00-130.00 cm in F_3 with a mean of 99.05 cm and 61.00-136.00 cm in F_4 with a mean of 100.26 cm. The number of tillers in F_2 varied from 6.00-30.00 tillers per plant with a mean of 12.09 tillers per plant whereas, in F_3 it ranged from 7.00-30.00 with a mean of 15.83 tillers per plant and in F_4 varied from 7.00-30.00 with a mean of 15.04. The number of leaves in F_2, F_3 and F_4 varied from 21.00-100.00 with a mean of 48.63, 25.00-120.00 with a mean of 66.96 and from 25.00-126.00 with a mean of 65.57 leaves per plant, respectively. Fresh fodder yield per plant in F_2 ranged from 32.31-787.65 g with a mean yield of 212.91 g; 33.40-1029.53 g with the mean yield of 224.58 g in F_3 and 70.87-904.66 g with a mean of 226.06 g in F_4. Leaf stem ratio in F_2, F_3 and F_4 ranged from 0.10-0.93 with a mean of 0.54, from 0.14-0.99 with a mean of 0.57 and from 0.15-0.96 with a mean of 0.49, respectively. Leaf area in F_2 ranged from 19.00-53.00 with a mean of 29.83 cm^2; in F_3 ranged from 16.00-54.00 with a mean of 29.97 cm^2 and in F_4 it ranged from 19.00-53.00 with a mean of 30.19 cm^2. Dry matter yield per plant in F_2 ranged from 6.40- 195.57 g with a mean yield of 42.14 g, from 8.40- 153.84 g with a mean yield of 45.02 g in F_3 and in F_4 values ranged from 10.83- 211.57 g with a mean yield of 47.85 g. In F_2 the value for dry matter per cent ranged from 11.20- 26.56 with the mean of 20.40 per cent; from 11.34-28.48 with the mean of 20.90 per cent in F_3 and in F_4 the values for dry matter per cent ranged from 11.30-27.56 with the mean of 21.34 per cent. The values for days to 75 per cent maturity varied from 161.00-183.00 days with an average value of 173.43 days in F_2; 159.00-183.00 days with an average value of 171.43 days in F_3 and 161.00-180.00 days with an average value of 174.61 days in F_4. Crude protein content in F_2, F_2, and F_4 ranged from 7.75-11.69 with a mean of 10.00 per cent, 6.30- 11.20 with a mean of 9.99 per cent and 6.65-11.20 with a mean of 9.68 per cent, respectively. Crude protein yield per plant in F_2 ranged from 0.89-17.69 g with a mean of 4.42 g; 1.04-8.19 g with a mean of 4.52 g in F_3 and from 0.84-14.82 g with a mean of 4.61 g in F_4.

This revealed that there was a significant difference in the parents P_1 and P_2 of oat cross PLP-1 × HJ-8 for most of the traits and transgressive segregation in the progenies have been observed. 14.33, 18.44 and 22.89% transgressive segregants were obtained in F_2, F_3, and F_4 generations, respectively, for forage and component traits. The selected transgressive segregants for most studied traits suggested that the two parents selected for this study had alleles that were associated with high values of these traits. Further studies will be conducted to assure the genetic divergence of the transgressive segregants from their parents on the molecular level. Moreover, these high-yielding segregants selected in this study would be used as a germplasm source for improving oat forage productivity.

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TABLE 3

Range and mean values for parents and selected progenies in F_2, F_3 and F_4 for various traits

Characters	P_1	P_2	F_2 population		F_3 population		F_4 population	
	Mean	Mean	Range	Mean	Range	Mean	Range	Mean
Days to 50 per cent flowering	133.67	128.67	116.00-139.00	126.83	115.00-140.00	128.58	116.00-146.00	131.04
Plant height	103.33	108.33	65.00-156.00	108.77	69.00-130.00	99.05	61.00-136.00	100.26
Tillers per plant	17.66	12.33	6.00-30.00	12.09	7.00-30.00	15.83	7.00-30.00	15.04
Leaves per plant	72.00	47.00	21.00-100.00	48.63	25.00-120.00	66.96	25.00-126.00	65.58
Fresh fodder yield per plant	343.45	255.22	32.31-787.65	212.91	33.40-1029.53	224.58	70.87-904.66	226.06
Leaf: stem ratio	0.55	0.38	0.10-0.93	0.54	0.14-0.99	0.57	0.15-0.96	0.49
Leaf area	33.00	40.00	19.00-53.00	29.83	16.00-54.00	29.97	19.00-53.00	30.19
Dry matter yield per plant	78.07	51.11	6.40-195.57	42.14	8.40-153.84	45.02	10.83-211.57	47.85
Dry matter per cent	21.00	20.28	11.20-26.56	20.40	11.34-28.48	20.90	11.30-27.56	21.34
Days to 75 per cent maturity	182.33	175.66	161.00-183.00	173.43	159.00-183.00	171.43	161.00-180.00	174.61
Crude protein content	10.06	8.58	7.75-11.69	10.00	6.3-11.2	9.99	6.65-11.2	9.68
Crude protein yield per plant	7.92	4.77	0.89-17.69	4.42	1.04-8.19	4.52	0.84-14.82	4.61

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