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BARLEY *HORDEUM VULGARE* (L) AS A DUAL PURPOSE CROP HAVING GOOD FODDER QUALITY

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SUMMARY

New barley varieties were evaluated for their suitability as a fodder as well as grain crop during **rabi** 2015. Different varieties behave differently for fodder and grain yield and fodder quality. Some varieties are good fodder and grain yielder but have low crude protein (CP) and *in vitro* dry matter digestibility (IVDMD), while others have good fodder quality traits but less yielder. The present data showed that good dual purpose varieties of barley could give 166-185 q/ha green fodder with 61-67 q/ha grain yield. Among the barley varieties evaluated, it was found that two varieties viz., RD 2035 and RD 2552 were very good dual purpose varieties with good fodder quality. Among these two, RD 2035 gave 185.6 q/ha green fodder yield with 21.12 q/ha dry matter yield and 67.18 q/ha grain yield. The fodder of this variety had 12.0 per cent crude protein with 62.4 per cent *in vitro* dry matter digestibility and also had low acid detergent fibre (ADF) and neutral detergent fibre (NDF) values. Significant and positive correlation of green fodder yield was observed with dry matter yield and plant height. Similarly, significant correlation was observed between crude protein and *in vitro* dry matter digestibility, and ADF and NDF. The grain yield was seemed to be positively correlated with 1000- grain weight but negatively associated with green fodder yield (GFY) and dry matter yield (DMY).

Key words : Dual purpose barley, fodder yield and quality, grain yield, correlation studies

Barley is considered as a poor man's crop but it is favoured in India due to its low input requirement and wider adaptability to varying environmental conditions like drought, salinity/alkalinity and marginal land. It is grown in winter season (**rabi**) in the northern plains as well as in northern hills of India on poor to marginal soils. Until 1990's forage barley varieties had rarely been selected for improved forage quality but selection was made only on the basis of yield and other agronomic traits (Surber *et al.*, 2011). Large variability among the barley lines for green fodder yield and grain yield from the regenerated crop has been reported (Srimali, 2008). It is, therefore, very important to screen the gremplasm for identification of lines that gives high green fodder yield, dry matter yield and grain yield with good quality fodder.

The correlation analysis is used widely in many crop species by plant breeders to define the nature of complex interrelationships among yield and its components and to identify the sources of variation in yield. Knowledge derived in this way is used to identify the efficient selection criteria that can be used to improve yield and quality traits. The efficiency of selection will increase if the nature and magnitude of inter-relationships among component characters and grain yield is understood. Correlations provide the estimates of degree of association between characters and determine the components on which the selection can be based for any improvement. The present study was, therefore, undertaken to estimate correlations and path coefficients for important characters in barley.

MATERIALS AND METHODS

The experiment for evaluation of barley varieties to be utilized as dual purpose was carried out during **rabi** 2015 at experimental area of Forage and Millet Section, Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana which is situated 256 m a.s.l. at 30°91' N and 75°85' E in the Punjab state of India. The material consisted of 17 barley varieties which were sown with a plot size of four rows each with a row to row spacing of 25.0 cm and row length of 5.0 m. The varieties were harvested for green fodder yield after 55 days of sowing and for grain yield at physiological maturity. Recommended doses of nitrogen and phosphorus fertilizers were applied @ 60 and 30 kg/ha

(Anonymous, 2016) to raise a good crop. The data were recorded for days to heading, days to maturity, plant height at fodder cutting stage and at maturity on five randomly selected plants, green fodder yield (GFY), dry matter yield (DMY) and grain yield on plot basis, 1000-grain weight (g), crude protein (CP) (%), acid detergent fibre (ADF) (%), neutral detergent fibre (NDF) (%) and *in vitro* dry matter digestibility (IVDMD) (%). Green fodder yield was recorded by cutting the crop after 55 days of sowing. After that, the crop was allowed to grow and grain yield was obtained to identify dual purpose genotypes.

RESULTS AND DISCUSSION

Yield and Yield Component Traits : On the basis of mean performance, variety BH 1008 gained maximum plant height at fodder cutting stage (i. e. 55 days after sowing) with a mean plant height of 25.3 cm and recorded green fodder yield of 179.0 q/ha with dry matter yield of 20.8 q/ha but it recorded less grain yield (48.3 q/ha) though its 1000-grain weight was 36.5 g (Table 1). Maximum green fodder yield of 249.4 q/ha with maximum dry matter yield of 30.6 q/ha was recorded by JB 325 variety which also produced 50.8 q/ha grain yield. JB 325 also attained plant height of 21.1 cm at the stage of fodder cutting. On the other hand, maximum grain yield of 70.8 q/ha was observed in KB 1401 variety which also gave a green fodder yield of 165.8 q/ha with a dry matter yield of 19.1 q/ha. Due to faster growing and more tillering ability, KB 1401 gave good fodder as well as grain yield.

KB 1420 is a two-rowed barley variety which recorded very good grain yield of 65.9 q/ha with a 1000-grain weight of 39.6 g but it was poorest fodder yielder among all the varieties tested, whereas RD 2715 ranked third for green fodder yield (196.1 q/ha) and dry matter yield (21.6 q/ha) but it is the poorest grain yielder (31.7 q/ha) as it has lowest 1000- grain weight of 25.7 g. RD 2928 was also observed to be a very good variety for fodder as it gave second highest green fodder yield (215.9 q/ha) and dry matter yield (24.3 q/ha) but it is poor grain yielder as it gave only 34.2 q/ha grain yield with a grain weight of only 27.0 g. The low grain yield of RD 2928 may be due to the reason that the time gap between date to fodder cutting and date of maturity was very less (29 days) which may result in poor grain filling as observed from very low 1000-grain weight. On the other hand, variety RD 2035 took 38 days to maturity after cutting for fodder which may result in good grain filling and more tillering. RD 2035 also seemed to be good dual purpose variety as it gave 183.6 q/ha green fodder yield, 21.1 q/ha dry matter yield and 67.2 q/ha grain yield. The results revealed that barley varieties could be identified which could be utilized for dual purpose with good green fodder, dry matter and grain yield. The results are in accordance with the findings of Jarial (2015) who identified an improved variety BHS 380 with better fodder, grain and straw yields.

TABLE 1
Performance of Barley varieties for yield, quality and component traits

Varieties	Days to heading (75%)	Days to maturity (75%)	Plant height at fodder cutting stage (cm)	Plant height at maturity	Green fodder yield (cm)	Dry matter yield (q/ha)	1000-grain weight (g) (q/ha)	Grain yield (q/ha)	CP (%)	NDF (%)	ADF (%)	IVDMD (%)
RD2715	124	161	20.9	95.0	196.1	21.6	25.7	31.7	13.8	39.5	26.3	66.0
UPB1054	123	151	14.6	92.3	165.2	20.8	32.2	49.3	14.8	39.3	23.4	69.1
KB1420	124	158	14.8	94.0	95.7	11.9	39.6	65.9	15.0	37.9	22.0	69.8
BH1008	121	154	25.3	89.0	179.0	20.8	36.5	48.3	13.8	40.6	27.0	64.2
RD2927	124	159	18.5	86.8	169.7	19.1	33.5	42.7	14.5	41.5	22.7	66.6
RD2035	118	156	17.9	88.8	183.6	21.1	36.0	67.2	12.0	42.1	27.1	62.4
BH1010	119	152	16.5	83.3	140.4	17.7	35.6	62.4	12.9	41.5	27.1	60.4
JB325	124	157	21.1	78.8	249.4	30.6	32.5	50.8	10.3	43.0	27.9	62.8
RD2925	114	156	23.4	85.8	153.7	17.8	30.0	39.0	13.9	41.8	22.4	67.1
AZAD	119	148	19.2	98.5	147.5	16.6	30.0	48.8	14.3	38.9	24.3	68.3
RD2552	117	155	17.2	81.1	165.8	19.4	34.5	60.9	12.5	42.3	26.3	63.7
KB1401	125	159	19.3	86.0	165.8	19.1	30.0	70.8	10.8	43.6	28.0	62.1
UPB1053	118	148	15.0	82.8	118.4	14.8	34.0	67.4	14.3	39.2	23.1	66.8
JB319	122	151	14.9	94.5	136.2	14.9	38.7	47.0	12.9	42.6	26.8	63.1
RD2928	128	157	21.5	86.5	215.9	24.3	27.0	34.2	14.5	39.8	22.6	66.9
JB322	122	148	15.7	91.1	106.3	13.3	27.5	40.7	12.4	42.0	24.6	61.3
NDB1650	122	156	15.7	84.8	112.3	13.6	29.4	55.8	13.4	42.2	26.4	65.0
C. D. (P=0.05)	5.7	10.4	6.4	8.1	25.3	10.4	5.5	15.3				

Fodder Quality Traits : Based on fodder quality traits, KB 1420 which was a two-rowed barley variety recorded maximum crude protein of 15.0 per cent with highest *in vitro* dry matter digestibility of 69.8 per cent. KB 1420 variety also had lowest values for neutral detergent fibre (NDF) and acid detergent fibre (ADF) which means the fodder of this variety had best nutritive value and digestibility. Variety UPB 1054 had 14.8 per cent crude protein and 69.1 per cent *in vitro* dry matter digestibility and value of acid detergent fibre was also low (23.4%) indicating that the fodder of this variety was also nutritive and had very good digestibility.

Our investigations revealed that good dual purpose varieties of barley could be identified with high fodder as well as grain yield; and better fodder quality having high protein and *in vitro* dry matter digestibility. Among the barley varieties evaluated, it was found that two varieties viz., RD 2035 and RD 2552 were very good dual purpose varieties with good fodder quality. RD 2035 gave 185.6 q/ha green fodder yield with 21.1 q/ha dry matter yield and 67.2 q/ha grain yield. The fodder of this variety had 12.0 per cent crude protein with 62.4 per cent *in vitro* dry matter digestibility and also had low ADF and NDF values. Similarly, RD 2552 recorded good green fodder yield (165.8 q/ha), dry matter yield (19.5 q/ha) and grain yield (60.9 q/ha) with good fodder quality having 12.5 per cent crude protein and 63.7 per cent *in vitro* dry matter digestibility with low NDF and ADF values. For fodder purpose variety JB 325 recorded the highest green fodder yield (249.4 q/ha) and dry matter yield (30.6 q/ha) with 50.8 q/ha of grain yield but quality-wise, it possessed low protein content (10.3%). This shows that different varieties behave differently for fodder and grain yield and fodder quality. Some varieties are good fodder and grain yielder but have low crude protein and *in vitro* dry matter digestibility, while others have good fodder quality traits but less yielder. Similarly, some varieties are good fodder yielder but poor grain yielder and vice versa. According to Giunta *et al*. (2015) understanding phenology is critical for the success of a dual purpose crop as it determines both the duration of grazing and affects the recovery period. Decrease in grain yield after clipping was attributed to a reduced number of spikes/m^2 at harvest in barley. However, increase in grain yield after a cutting or grazing during green stage may be due to decrease of lodging. In our study, variety KB 1420 gave better grain yield with less fodder yield of high protein which was contradicted by the findings of Beji (2016) who observed more fodder yield in dual purpose barley but less grain yield after forage use, but higher plant protein (18.2%) and grain protein in barley. The present data also showed that good dual purpose varieties of barley could give 166-185 q/ha green fodder and 61-67 q/ha grain yield which was in accordance with the findings of Kharub *et al.* (2013) who reported that, on an average, 180-240 q/ha of green fodder and 24-35 q/ha grains could be produced from dual purpose barley. It can be concluded that dual purpose barley varieties can be developed with good fodder and grain yield that can provide better quality of fodder during the lean period in the areas where irrigation facilities are less and other high water requiring fodder crops cannot be grown.

Correlation Studies : The association among morpho-physiological and quality traits is presented in Table 2. The correlation studies showed that dry matter yield was significantly and positively correlated with green fodder yield but negatively correlated with grain yield indicating that with increase in green fodder yield the dry matter also increased but the grain yield would be reduced. Significant and positive correlation between green fodder yield and dry matter yield was also reported by Sukhchain *et al.* (2011) but, on the other hand, Kumar and Shekhawat (2013) observed positive and significant correlation between green fodder yield and grain yield. Green fodder yield was also significantly and positively correlated with plant height at fodder cutting stage i. e. plant height at 55 days of crop stage which was in accordance with the findings of Kumar and Shekhawat (2013) who also reported positive and significant correlation between plant height and green fodder yield. Dry matter yield showed positive and significant correlation with plant height because green fodder yield and dry matter yield were significantly correlated with each other. The results are in accordance with the findings of Bibi *et al.* (2016) and Kumari *et al.* (2016) who also observed significant and positive correlation of plant height with green fodder yield and dry matter yield. The correlation studies showed that the genotypes gaining more plant height will yield better green fodder yield and dry matter yield but it is not clear from the analysis whether these genotypes will also give better grain yield as no correlation was observed between plant height at maturity and grain yield. But significant and positive correlation between plant height and grain yield was reported by Tofiq *et al*. (2015). Grain yield was observed to be significantly and positively correlated with 1000-grain weight which was also confirmed by Tofiq *et al.* (2015).

TABLE 2
Correlation studies among morpho-physiological and quality traits in barley

Traits	GFY (q/ha)	DMY (q/ha)	Grain yield (q/ha)	Plant height at fodder cut (cm)	Plant height at maturity (cm)	1000-grain weight (g)	CP (%)	ADF (%)	NDF (%)	IVDMD (%)
GFY	1	0.8823	-0.3285	0.6391	-0.2922	-0.3124	-0.3556	0.2187	0.3128	-0.1230
DMY		1	-0.2257	0.5029	-0.4654	-0.3520	-0.3988	0.3073	0.3953	-0.1508
Grain yield			1	-0.4408	-0.3071	0.4522	-0.3103	0.1369	0.2870	-0.2186
Plant height at fodder cut				1	-0.1254	-0.2889	-0.1035	0.1058	0.1302	-0.0211
Plant height at maturity					1	-0.0386	0.4628	-0.5196	-0.2368	0.4065
1000-grain weight						1	0.1228	-0.0839	0.0062	0.0390
CP							1	-0.8230	-0.7950	0.8041
ADF								1	0.6503	-0.7875
NDF									1	-0.7829
IVDMD										1

In the present study, green fodder yield and dry matter yield did not show any correlation with any of the fodder quality traits. Significant and positive correlation between green fodder yield and crude protein was also reported by Bibi *et al.* (2016). Crude protein showed significant and positive correlation with *in vitro* dry matter digestibility indicating that selection for one quality trait will be helpful in simultaneous improvement in the other quality trait. The results of Kumari *et al.* (2016) are in accordance with the present investigations who also showed positive and significasnt correlation between crude protein and IVDMD. But crude protein showed significant and negative correlation with acid detergent fibre and neutral detergent fibre. Acid detergent fibre showed significant and positive correlation with neutral detergent fibre but negative correlation with crude protein and *in vitro* dry matter digestibility. Similarly, neutral detergent fibre showed significant and positive correlation with acid detergent fibre but significant and negative correlation with crude protein and *in vitro* dry matter digestibility. This showed that simultaneous improvement for crude protein and *in vitro* dry matter digestibility could be made along with reduction in acid detergent fibre and neutral detergent fibre while selecting genotypes for either of these two quality traits.

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