Range Mgmt. & Agroforestry 39 (1) : 22-28, 2018
ISSN 0971-2070

Genetic variability, character association and path analysis for forage yield and quality traits of tall fescue germplasm under north western Himalayas

Ankita Sharma*, **V. K. Sood, Jay Prakash and H. K. Chaudhary**
CSK Himachal Pradesh Agricultural University, Palampur-176062, India
*Corresponding author e-mail: sharmaanki444@gmail.com
Received: 12th May, 2017 Accepted: 10th May, 2018

Abstract
Thirty six tall fescue germplasm lines were studied to find out genetic variability and association for green forage yield and its component traits. Analysis of variance revealed significant differences among all the traits studied. The estimates of PCV were higher than corresponding GCV for all the 11 characters studied. High heritability coupled with high to moderate genetic advance was observed for crude protein yield per plant and dry matter yield per plant. Dry matter yield per plant, plant height, tillers per plant, leaf stem ratio, leaves per plant, leaf length and crude protein yield per plant revealed positive and significant correlation with green forage yield per plant. Crude protein yield, leaf length and leaves per plant contributed maximum towards yield indicating that these traits should be given emphasis while selecting high yielding tall fescue cultivar for north western Himalayan regions.

Keywords: Correlation, Genetic Advance, Genetic variability, Heritability, Path analysis, Tall fescue

Introduction
Himalayan region mainly consists of low, medium and high hills but the cultivation of fodder is restricted mainly to the lower hills. Beyond this zone, the cultivation of fodder is not practical because maximum area is under high value cash crops. But due to ever increasing demand of animal products and deterioration of forests, the grazing pressure on these pastures is increasing with constant rate. This has resulted in the deterioration of the grass cover as well as valuable forest species. As a result of this, a significant area of these natural resources has been replaced by noxious plant species (Misri, 1988). All these factors have led to the decrease in carrying capacity of these pastures. The carrying capacity ensures adequate forage for grazing animals and leaves enough residual forage for re growth in the following year. Improving the productivity of a pasture can increase its carrying capacity. The availability of fodder and grasses is dwindling (both in quantity and quality) due to poor management practices and degradation of land. The production of native forage species (tall fescue, ryegrass, alfalfa, orchard grass, timothy, smooth broomgrass etc.) is limited and various corrective measures are required for their improvement, therefore it is necessary to develop high yielding, fast growing, multicut with good regeneration capacity, nutritious and resistant varieties of fodder crops through genetic improvement (Chaudhary *et al.,* 2014).

Among the various grasses evaluated, tall fescue grass (*Festuca arundinacea)* is considered as fodder crop of choice due to its high yield potential (300-500 q of fresh fodder yield/hectare). The tall fescue grass, a native of Europe and North Africa is a deep-rooted, long lived, allohexaploid, cool season, perennial, high yielding and drought tolerant bunchgrass with short rhizomes grown in temperate and sub- temperate regions for pasture, hay and silage (Katoch *et al*., 2013). It is especially well adapted to acidic; wet soils and produces more forage than other cool-season grasses on soils with a pH of less than 5.5. It is best adapted to accumulate growth for use in autumn and winter because it grows at lower temperatures than many grasses, retains its forage quality and can form a dense sod (Lacefield *et al.,* 1993).

Presently, most breeding approaches for tall fescue improvement are in domain of molecular research. Thus in order to isolate improved plant population that can directly be used in molecular breeding for target gene improvement in sustainable way, the knowledge of genetic parameters like genetic variation, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense, genetic advance as per cent of mean, correlation and path analysis among characters is of utmost importance (Dudley and Moll, 1969). Estimates of variance components are used to determine the proportion of phenotypic variance due to genetic effects and the proportion of total genetic variance due to additive genetic effects. This information is useful to estimate heritability and predict genetic gain from selection. In view of this, the present study was undertaken to estimate the magnitude of phenotypic and genotypic variability, heritability, genetic advance, correlation coefficient and path analysis among different quantitative traits in 36 accessions of tall fescue so that this information may be utilized in the development of superior varieties adapted to north western Himalayan regions.

Materials and Methods

Experimental materials: Thirty six tall fescue germplasm lines of diverse origin including four checks *i.e.* Hima-1, Hima-4, Hima-14 and Palam Fescue-1 were used for the present study (Table 1).

Experimental design: The experiment was laid out in a randomized complete block design with plot size of 3.0 × 0.3 m^2 with row to row and plant to plant spacing of 30 cm, respectively with three replications. Each germplasm line was raised in one row of 3 m length and each hill was planted with three root slips of the genotype. Recommended package of practices were followed for raising the crop. Observations were recorded for two cuts during *Rabi* 2014-15 for green forage yield per plant (g), dry matter yield per plant (g), plant height (cm), tillers per plant, leaf stem ratio, leaf length (cm), leaf width (cm), number of leaves per plant, stem thickness (cm), crude protein content (%) and crude protein yield per plant (g). Traits were measured as per standard protocol on five randomly selected plants from each genotype and the mean from each genotype was used for analysis.

Statistical analysis: The data obtained was subjected to standard statistical procedures. Analysis of variance was done using the method of Panse and Sukhatme (1985). Genotypic and phenotypic component of variation, broad sense heritability and genetic advance was computed as per Burton and De Vane (1953). Phenotypic and genotypic correlation coefficients were estimated as suggested by Al-Jibouri *et al.* (1958) and path analysis for estimating direct and indirect effects of traits in green forage yield was performed as per Dewey and Lu (1959). The crude protein content for each entry was calculated by Micro-Kjeldhal Method (AOAC, 1965) and expressed as per cent of protein in plant leaves. The analysis was performed using the software WINDOWSTAT.

Results and Discussion

Genetic variability: Analysis of variance for green forage yield and its components of 36 genotypes of tall fescue revealed that the differences among genotypes were highly significant (P $\leq$ 0.01 or $\leq$ 0.05) for all the characters

Table 1. Details of the plant material used along with source

Source	Genotypes
NBPGR, New Delhi (INDIA)	EC-1942, EC-178188, EC-178185, EC-178184, EC-178181
Selections derived from composite populations of indigenous and exotic collections available at CSKHPKV, Palampur (INDIA)	Sel-6, Sel-8, Sel-11, Sel-47, Sel-48, Sel-49, Sel-50, Sel-61,Sel-63, Sel-66, Sel-67, Sel-68, Sel-69, Sel-70, Sel-71, Sel-84, Sel-85, Sel-86, Sel-87, Sel-88, Sel-89, Sel-90, Sel-91, Sel-92, Sel-93
Hima-1×Hima-4	Hima-15, Hima-3
CSKHPKV Palampur (INDIA)	Hima-1(check), Hima-4(check), Hima-14 (check), EC-178182 (Palam Fescue-1) (check)

Table 2. Estimates of mean squares and variability parameters in combined over the cuts

Characters	Mean squares (genotypes)	PCV (%)	GCV (%)	Heritability h^2bs(%)	genetic advance as % of mean
Green forage yield per plant (g)	291.05**	14.74	10.03	46.40	14.07
Dry matter yield per plant (g)	8.77**	12.49	9.66	59.80	15.39
Plant height (cm)	52.65**	13.36	8.48	40.40	11.10
Tillers per plant	48.28**	13.37	8.47	40.10	11.04
Stem thickness (cm)	0.004**	9.97	7.47	56.10	11.53
Leaves per plant	310.82**	13.98	9.15	42.80	12.33
Leaf stem ratio	0.06**	13.31	9.10	46.80	12.82
Leaf length (cm)	33.84**	13.77	7.41	29.00	8.22
Leaf width (cm)	0.003*	5.05	2.44	23.40	2.43
Crude protein content (%)	2.74**	12.59	8.69	47.70	12.37
Crude protein yield per plant (g)	0.27**	22.91	17.55	58.70	27.69

*(P<0.05); **(P<0.01)

indicating the existence of sufficient variation among the genotypes for green forage yield and component traits studied in the present investigation (Table 2) and therefore, there is a scope for effective selection. These results were similar with other studies, where significant differences for various agromorphological characteristics were observed in tall fescue crop (De Araujo *et al.,* 1983; Afkar *et al*., 2009; Reza *et al*., 2008; Noroozi *et al*., 2013).

The magnitudes of PCV were invariably higher than GCV indicating the influence of environment for quantitative traits which is in consonance with previous reports for *Festuca pratensis* (Kanapeckas *et al*., 2005). A considerable range of variation was observed for all the characters under study. The PCV ranged from 5.05 to 22.91% and GCV from 2.44 to 17.55%. The estimates PCV and GCV were noted relatively high for crude protein yield per plant and green forage yield per plant which were in line with the earlier findings in *Panicum maximum* (Ramakrishnan *et al.,* 2013). Low values of coefficients of variations were observed for all the traits except crude protein yield per plant and green forage yield per plant which could probably be attributed to the presence of both positive and negative alleles leading to low genetic variation.

Heritability and genetic advance: In this study, the high heritability estimates were obtained for dry matter yield per plant, stem thickness and crude protein yield per plant; moderate for green forage yield per plant, plant height, tillers per plant, leaves per plant, leaf stem ratio and crude protein content and low for leaf length and leaf width. The estimate of heritability for dry matter yield is in agreement with those previously reported for *F. arundinacea* (Burton and De Vane, 1953; Majidi *et al*., 2009). Heritability of yield related traits was moderate to high which were in agreement with Ebrahimiyan *et al*. (2013). The traits which exhibited moderate to high heritability revealed lesser influence of the environment and greater role of genetic component of variation. Therefore, selection for these traits on the basis of phenotypic expression would be more effective for indirect improvement of green forage yield. High genetic advance as a per cent of mean was displayed by crude protein yield per plant, moderate for dry matter yield per plant and low for rest of the traits. While in contrast, Bakheit (1986) reported that the genetic advance as a per cent of mean was high for seasonal dry forage yield and seasonal protein yield. The estimates of heritability and genetic advance are two complementary concepts (Hanson, 1963). High heritability with moderate genetic advance as a per cent of mean was observed for dry matter yield per plant, indicating predominance of additive and non-additive gene action in the expression of this trait. Therefore, this character could be improved by careful and restricted selection. Low estimates of heritability and genetic advance as a per cent of mean indicated that inheritance was being influenced by inter-allelic interaction rather than intra-allelic interaction.

Correlation and path coefficient studies: In general, genotypic coefficient of correlation was higher than corresponding phenotypic coefficient of correlation for most of the character pairs (De Araujo *et al*., 1983; John, 2008), and this was in agreement with our own results for all the traits (Table 3). In the present study, most of the characters were statistically significant at both 1% and 5% level with absolute values ranging from 0.1993 to 1.0073. The estimates of both phenotypic and genotypic correlation coefficients revealed that green forage yield per plant found to be significantly and positively correlated with dry matter yield per plant, plant height, tillers per plant, leaves per plant, leaf stem ratio, leaf length, crude protein content and crude protein yield per plant, whereas negative and significant association with stem thickness was observed at genotypic level. This indicated that genotypes having thin stem produced more green forage yield which is desirable. In case of *Panicum maximum* same findings were reported by Ramakrishnan *et al.* (2013) where green fodder yield per plant was significantly positively correlated with tillers per plant, leaves per plant and dry matter content, while positively correlated with leaf stem ratio and crude protein. Niazkhani *et al.* (2014) reported that plant height was positively correlated with wet and dry forage yield. The above results were in line with the present findings. Dry matter yield per plant showed significant and positive correlation with plant height, tillers per plant, leaves per plant, leaf stem ratio, leaf length, crude protein content and crude protein yield per plant at both phenotypic and genotypic levels, while negative and significant correlation with stem thickness was observed at genotypic level. The above findings were in accordance with the findings of De Araujo *et al.* (1983) and Noroozi *et al.* (2013). Khayam-Nekouei *et al.* (2000), Jafari *et al.* (2006) and Majidi *et al.* (2009) in tall fescue and Wilkins (1985) in perennial ryegrass reported significant correlation between dry matter yields with plant height. Aastveit and Aastveit (1989) and Kanapeckas *et al.* (2005) reported that dry matter yield was genetically correlated with quality traits which were in consonance with the present findings. Stem thickness showed significant and

Table 3. Genotypic (G) and phenotypic (P) correlation coefficients of various different traits in tall fescue grass

Traits		Dry matter yield per plant	Plant height	Tillers per plant	Stem thickness	Leaves per plant	Leaf stem ratio	Leaf length	Leaf width	Crude protein content	Crude protein yield per plant
Green forage yield	P	0.8687**	0.5906**	0.4983**	-0.1573	0.4909**	0.1993*	0.6127**	0.0234	0.4079**	0.7254**
per plant	G	0.9944**	0.6219**	0.4658**	-0.2281*	0.4725**	0.7676**	0.6637**	0.1452	0.6379**	0.9830**
Dry matter yield	P		0.5302**	0.4035**	-0.1600	0.4289**	0.2147*	0.5091**	0.0326	0.3718**	0.7972**
per plant	G		0.6241**	0.4784**	-0.2330*	0.5045**	0.6080**	0.6366**	0.1319	0.5162**	0.8985**
Plant height	P			0.0299	-0.2424*	0.0481	0.2065*	0.9037**	-0.0682	0.1384	0.3696**
	G			-0.2248*	-0.3782**	-0.2911**	0.6578**	0.9828**	-0.2432*	0.1659	0.4447**
Tillers per plant	P				-0.2050*	0.8976**	0.0623	0.1011	-0.0137	0.2973**	0.4316**
	G				-0.3815**	0.9999**	0.4311**	-0.2123*	0.2271*	0.2788**	0.4944**
Stem thickness	P					-0.1612	-0.1112	-0.1700	0.3170**	-0.0122	-0.0918
	G					-0.2875**	-0.3455**	-0.2453*	0.7451**	0.0424	-0.1525
Leaves per plant	P						0.0864	0.1073	-0.0220	0.2539**	0.4207**
	G						0.5020**	-0.3479**	0.0976	0.3741**	0.5653**
Leaf stem ratio	P							0.1317	-0.0107	0.2331*	0.2731**
	G							0.6537**	-0.2741**	0.4183**	0.5727**
Leaf length	P								0.0576	0.2179*	0.3927**
	G								-0.0183	0.3994**	0.5856**
Leaf width	P									-0.0289	-0.0276
	G									0.0194	0.0824
Crude protein	P										0.8090**
content	G										0.8365**

*(P<0.05); **(P<0.01)

Table 4. Direct (diagonal) and indirect effects of various metric traits on green forage yield in tall fescue grass

Traits		Dry matter yield per plant	Plant height	Tillers per plant	Stem thickness	Leaves per plant	Leaf stem ratio	Leaf length	Leaf width	Crude protein content (%)	Crude protein yield	Correlation with green forage yield
Dry matter yield	P	**0.7915**	0.0382	0.0958	-0.0081	-0.0075	0.0013	0.0983	-0.0008	0.0813	-0.2213	0.8687**
per plant	G	**-7.3743**	-0.4245	-0.2091	-0.2375	0.4442	0.1392	1.1630	-0.0769	-3.5334	11.1037	0.9944**
Plant height	P	0.4197	**0.0720**	0.0071	-0.0123	-0.0008	0.0012	0.1745	0.0016	0.0303	-0.1026	0.5906**
	G	-4.6023	**-0.6802**	0.0982	-0.3855	-0.2563	0.1506	1.7955	0.1418	-1.1356	5.4956	0.6219**
Tillers per plant	P	0.3194	0.0022	**0.2375**	-0.0104	-0.0157	0.0004	0.0195	0.0003	0.0650	-0.1198	0.4983**
	G	-3.5278	0.1529	**-0.4370**	-0.3889	0.8868	0.0987	-0.3879	-0.1324	-1.9084	6.1098	0.4658**
Stem thickness	P	-0.1267	-0.0175	-0.0487	**0.0507**	0.0028	-0.0007	-0.0328	-0.0073	-0.0027	0.0255	-0.1573
	G	1.7182	0.2573	0.1667	**1.0194**	-0.2531	-0.0791	-0.4482	-0.4345	-0.2902	-1.8846	-0.2281*
Leaves per plant	P	0.3395	0.0035	0.2132	-0.0082	**-0.0175**	0.0005	0.0207	0.0005	0.0555	-0.1168	0.4909**
	G	-3.7203	0.1980	-0.4402	-0.2931	**0.8804**	0.1149	-0.6356	-0.0569	-2.5607	6.9860	0.4725**
Leaf stem ratio	P	0.1699	0.0149	0.0148	-0.0056	-0.0015	**0.0060**	0.0254	0.0002	0.0509	-0.0758	0.1993*
	G	-4.4835	-0.4474	-0.1884	-0.3522	0.4420	**0.2289**	1.1943	0.1598	-2.8633	7.0774	0.7676**
Leaf length	P	0.4030	0.0651	0.0240	-0.0086	-0.0019	0.0008	**0.1930**	-0.0013	0.0476	-0.1090	0.6127**
	G	-4.6945	-0.6685	0.0928	-0.2501	-0.3063	0.1497	**1.8270**	0.0107	-2.7339	7.2368	0.6637**
Leaf width	P	0.0258	-0.0049	-0.0033	0.0161	0.0004	-0.0001	0.0111	**-0.0231**	-0.0063	0.0077	0.0234
	G	-0.9727	0.1654	-0.0992	0.7596	0.0859	-0.0628	-0.0334	**-0.5831**	-0.1328	1.0183	0.1452
Crude protein	P	0.2943	0.0100	0.0706	-0.0006	-0.0044	0.0014	0.0421	0.0007	**0.2186**	-0.2246	0.4079**
content	G	-3.8066	-0.1128	-0.1218	0.0432	0.3294	0.0958	0.7297	-0.0113	**-6.8450**	10.3375	0.6379**
Crude protein	P	0.6310	0.0266	0.1025	-0.0047	-0.0074	0.0016	0.0758	0.0006	0.1768	**-0.2777**	0.7254**
yield per plant	G	-6.6258	-0.3025	-0.2161	-0.1555	0.4977	0.1311	1.0699	-0.0481	-5.7259	**12.3580**	0.9830**

Residual effects (R) = 0.4017

positive correlation with leaf width both at genotypic as well as phenotypic levels. Significant positive correlation was observed for leaves per plant and leaf stem ratio with crude protein content and crude protein yield per plant both at phenotypic and genotypic levels. At genotypic level, leaves per plant showed significant and positive association with leaf stem ratio and significantly negative association with leaf length whereas leaf stem ratio showed significantly positive association with leaf length and significantly negative association with leaf width. Leaf length and crude protein content showed positive and significant correlation with crude protein yield per plant both at genotypic and phenotypic level. Finne *et al.* (2000) in *Trifolium repens* observed that all pair wise correlations between plant height, leaf length, dry matter yield and general performance were positive and significant which were in conformity with the present findings.

The dry matter yield had maximum positive direct effect (0.791) on green forage yield followed by tillers per plant, crude protein content and leaf length at phenotypic level, while at genotypic level crude protein yield per plant (12.3580) followed by leaf length (1.8270), stem thickness (1.0194) and leaves per plant (0.8804) had highest direct effect on green forage yield per plant (Table 4). This indicated that there is always scope for enhancement of green forage yield by selection of these traits. The direct selection for these traits would be effective for crop improvement since most of these traits also showed significant positive correlation coefficients. Similar findings were also observed by Bakheit (1986) and Noroozi *et al.* (2013) which were in conformity with the present study. Suthamathi *et al.* (1998) reported significant and positive direct effect of leaf weight, stem weight, leaf stem ratio and number of tillers per plant on green fodder yield in napier grass (*Pennisetum purpureum*) which was in conformity with the present findings. The characters which recorded direct positive effect on yield had indirect positive effect via other characters. Therefore, they did not affect each other adversely and selection would be beneficial for improving the green forage yield.

Although at genotypic level, dry matter yield per plant had the highest negative direct effect (-0.73743) on green forage yield per plant but its indirect effect via crude protein yield per plant (11.1037), leaf length (1.1630) and leaves per plant (0.4442) was positive which consequently increased the correlation with yield (0.9944).The direct effect of crude protein yield per plant (12.3580) on green forage yield per plant was highest and positive while indirect effects via leaf length (1.0699), leaves per plant (0.4977) and leaf stem ratio (0.1311) were also positive. A residual effect was found to be 0.4017, suggesting that other attributing traits were also important and might play a crucial role in tall fescue improvement.

Conclusion

Dry matter yield per plant, leaves per plant, stem thickness, plant height and crude protein yield per plant had high broad sense heritability, strong genetic association and direct or indirect effect on green forage yield in studied tall fescue germplasm. Thus these plant traits deserve greater attention in further breeding programs for developing high yielding tall fescue genotypes.

References

Aastveit, A. H. and K. Aastveit. 1989. Genetic variations and inheritance of quantitative characters in two populations of meadow fescue (*Festuca pratensis* Huds.) and their hybrid. *Hereditas* 111: 103-114.

Afkar, S., G. Karimzadeh and A. A. Jafari. 2009. A study of morphological variation in some genotypes of *Festuca arundinacea* using multivariate analysis. *Iranian Journal of Field Crop Science* 40: 151-160.

Al-Jibouri, H. A., P. A. Miller and H. P. Robinson. 1958. Genotypic and environment variances and covariances in upland cotton cross of interspecific origin. *Agronomy Journal* 50: 633-636.

AOAC. 1965. *Official Methods of Analysis.* Association of Official Analytical Chemists. Washington DC.

Bakheit, B. R. 1986. Genetic variability, genotypic and phenotypic correlations and path-coefficient analysis in Egyptian clover (*Trifolium alexandrinum* L.). *Journal of Agronomy and Crop Science* 157: 58-66.

Burton, G. and E. H. De Vane. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal* 45: 478-481.

Chaudhary, L., V.K. Sood and W. Hussain. 2014. Genetic analysis for grain and forage yield and its component traits in genus *Avena* under north western Himalyas. *Range Management and Agroforestry* 35: 204-209.

De Araujo, M. R. A., B. E. Coulman., M. A. Faris and C. Wrobel. 1983. Genetic variation and correlation of agronomic traits in tall fescue (*Festuca arundinacea* Schreb.) germplasm. *Canadian Journal* of *Plant Science* 63: 453-460.

Dewey, D. R. and K. H. Lu. 1959. A correlation and path analysis of components of wheat grass seed production. *Agronomy Journal* 51: 515-518.

Dudley, J. W. and R. H. Moll. 1969. Interpretation and use of estimates of heritability and genetic variances in plant breeding. *Crop Science* 9: 257-262.

Ebrahimiyan, M., M. M. Majidi and A. Mirlohi. 2013. Genotypic variation and selection of traits related to forage yield in tall fescue under irrigated and drought stress environments. *Grass and Forage Science* 68: 59-71.

Finne, M. A., O. A. Rognli and I. Schjelderup. 2000. Genetic variation in a Norwegian germplasm collection of white clover (*Trifolium repens* l.). *Euphytica* 112: 57-68.

Graffius, J. E. 1956. Components of yield in oats a genotypic interpretation. *Agronomy Journal* 48: 419-423.

Hanson, W. D. 1963. Heritability. In: W.D. Hanson and H.R. Robinson (eds.). *Statistical Genetics and Plant Breeding*, National Academy of Science, Washington DC. pp. 125-140.

Jafari, A. A., H. Setavarz and M. A. Alizadeh. 2006. Genetic variation for and correlations among seed yield and seed components in tall fescue. *Journal of New Seeds* 8: 47-65.

John K. 2008. Genetic relationship between fodder yield attributes and path coefficient analysis in napier grass (*Pennisetum purpureum K.* Schum.). *Journal of Agriculture Science Digest* 28: 14-17.

Kanapeckas, J., P. Tarakanovas and N. Lemeziene. 2005. Variability, heritability and correlations of genetic resources in meadow fescue. *Biologija* 3: 10-14.

Katoch, R., M. Thakur and N. Kumar. 2013. Effect of morphological stage and clipping intervals on quality and digestibility of tall fescue (*Festuca arundinacea* Schreb.) and Setaria (*Setaria anceps* Stapf.). *Range Management and Agroforestry* 33: 185-192.

Khayam-Nekoueim., A., F. Mirlohi., M. Naderi-Shahab., S. Meon., A. M. Ali and S. Napis. 2000. Genetic diversity of tall fescue in Iran. In: Proc. *4th National Congress on Genetic* (Sept. 26-28, 2000), Malaysia.

Lacefield, G. D., J. C. Henning and T. D. Phillips. 1993. *Tall Fescue*. Cooperative Extension Pub. Co., U.K.

Majidi, M. M., A. Mirlohi and F. Amini. 2009. Genetic variation, heritability and correlations of agro-morphological traits in tall fescue (*Festuca arudinacea* Schreb.). *Euphytica* 16: 323-331.

Majidi, M. M., A. F. Mirlohi and R. Mohammadi. 2009. An assessment of variation, correlation and genetic distance in tall fescue (*Festuca arundinacea* Schreb) accessions. *Iranian Journal of Field Crop Science* 40: 444-450.

Misri, B. 1988. Forage production in alpine and sub-alpine of north west Himalayas. In: Panjab Singh (ed). *Pasture and Forage Crops Research*. IGFRI, Jhansi. pp. 43-55.

Niazkhani, S.M., B. M. Zanjani., M. Zeynali., S. Ahmadour and A. R. Eivazi. 2014. Assessing of morph-physiological traits in tall fescue (*Festuca arundinacea* Schreb.) germplasms. *Basic Research Journal of Agricultural Science and Review* 3: 01-05.

Noroozi, A., M. M. Majidi and M. R. Sabzalian. 2013. Relationship of morphological traits in tall fescue genotypes grown in normal and drought stress conditions. *Iranian Journal of Rangelands and Forests Plant Breeding and Genetic Research* 21: 343-353.

Panse, V. G. and P. V. Sukhatme. 1985. *Statistical Methods for Agricultural Workers*. 4th edn. ICAR Publications, New Delhi.

Ramakrishnan, P., C. Babu and K. Iyanar. 2013. Genetic variability, character association and path analysis studies in guinea grass (*Panicum maximum* Jacq.). *Electronic Journal of Plant Breeding* 4: 1265-1270.

Reza, M., S. M. Khayyam-Nekouei and A. F. Mirlohi. 2008. Genetic variation and heritability of several quantitative traits in selected genotypes of tall fescue. *Iranian Journal of Rangelands and Forests Plant Breeding and Genetics Research* 16: 254-272.

Suthamathi, P., M. J. Dorairaj and A. Amirthadevarathinam. 1998. Character association and component analysis in napier grass. *Madras Agricultural Journal* 85: 113-115.

Wilkins, P. W. 1985. Breeding for dry matter yield in perennial ryegrass by wild hybridization and recurrent selection. In: Proc. 2nd *EUCARPIA Fodder Crop Meeting*, Savalo.