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CHARACTERISATION OF WHEAT (*TRITICUM AESTIVUM L.)* CULTIVARS GROWN IN LESOTHO BY MORPHOLOGICAL MARKERS

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ABSTRACT: *Wheat is one of the major cereal crops grown in Lesotho, ranking third after maize and sorghum. Cultivars of wheat are imported from South Africa without characterization. The study was therefore conducted with the following objectives; (1) to distinguish wheat cultivars grown by farmers, (2) to estimate genetic distance among wheat cultivars and (3) to identify the characters that have high discriminatory power. Complete Randomized Block Design with ten treatments and three replications were applied. Data were collected using Descriptor and analysed using GENSTAT software to perform cluster and principal component analysis. The first three principal components constituted 84.572% of the total variation. First principal component variation accounted for 55.738%, while second principal component contributed 15.737% and third principal component constituted 12.858%. Characters responsible for variation in the first component were spikelets, spike height and tillers. Separation among second component was brought about by plant height, reproductive tillers and seeds per spike. Variation in component three was due to glume hairiness, seed size and plant height. Cluster analysis formed two groups, A and B, and one outlier. Group A comprised of Gariep, Koonap, Elands and Senqu while Group B consisted SST374, SST356, PAN3195, PAN3379 and TugelaDN. Group C was an outlier containing Matlabas. The findings showed that the cultivars were different from each other and as such genetic variation exists that broaden the spectrum of germplasm, from which farmers can make a wider choice.*

KEYWORDS: wheat, morphological characters, cluster analysis, principal component analysis, lesotho

INTRODUCTION

Wheat (*Triticum aestivum L*.) is believed to have originated in south western Asia (Acquah, 2012). Its domestication is thought to have occurred in the fertile crescent of the Middle East (Hirst, 2018). First domestication started with the diploid and tetraploid wheat followed later by hybridization of the hexaploid wheat (Feuillet *et al*. 2007). *Triticum aestivum L*. is a descendent from a cross between spelt and Persian wheat (T. *persicum*) (Acquah, 2012). Wheat belongs to the kingdom "Plantae", division "Magnoliaphyta", order, "Cyperales"; Family: "Poaceae" and Genus: "Triticum" L. Species: "*Triticum aestivum*" L. Of all the known wheat species, only three are of importance in Lesotho, common wheat (*Triticum aestivum L*.), durum (*Triticum durum L.*) and spelt (*Triticum spelta L.*) (Makhale, 2001). Common wheat is the most cultivated type of wheat constituting about 95% produced wheat world-wide (Food and Agriculture Organization, 2019). Wheat is classified based on three primary characteristics; agronomic production needs, kernel colour and endosperm quality (Loomis and Connor, 1992). Based on agronomic needs, wheat can either be spring, winter wheat or facultative. Seed colours for wheat can either be red or white and kernel hardness can be classified into hard or soft wheat (Acquah, 2012).

In Lesotho, common wheat is the third most important cereal as evidenced by production and area under which it is grown (Morojele and Labuschagne, 2010). A large quantity of wheat is grown in the mountain and foothills ecological zones of Lesotho because of environmental conditions that favour growth and development such as low temperature inducing vernalization at tillering (Morojele and Sekoli, 2016). Small pockets of wheat are found in lowlands grown in winter season (Bureau of Statistics, 2015/16). It is grown predominantly under dry land conditions by small scale farmers with low management practice and external production inputs (Makhale, 2001). As a result, productivity and quality are low. Government is making an effort to improve wheat productivity and quality by introducing proper agronomic practices and newly developed cultivars (Morojele and Sekoli, 2016).

Many cultivars of wheat are brought into Lesotho every year by the farmers, seed companies, new and existing projects, non-governmental organizations and, Ministry of Agriculture and Food Security (Morojele and Sekoli, 2016). Most of these cultivars are registered and released in other countries under their laws, after being characterized morphologically and otherwise. Concepts such as distinctness, uniformity and stability are applied (Simmond, 2011). Recently, European countries in particular Britain introduced value for cultivation and use to apply stringent measures to plant breeders releasing new cultivars (Kirby, 2002; Fenwick, 2010). Nonetheless, in Lesotho, wheat cultivars are brought in without being checked for distinctness, fraudulence and duplication. It is a common knowledge that one cultivar may be given many names in different places as if they are different and also new in the seed market. It is therefore of paramount importance to characterize each of these cultivars to determine as to which ones are similar and separate those that are different based on morphology. The study was therefore conducted with the following objectives; (1) to distinguish wheat cultivars grown by farmers in Lesotho, (2) to estimate genetic distance among wheat cultivars and (3) to identify the characters that have high discriminatory power.

MATERIAL AND METHODS

Study area

The study was conducted at National University of Lesotho, Roma campus, in Lesotho. It is situated 34 km South East of Maseru, the capital city of Lesotho. The coordinates are as follows; longitude is 29°26 27°42'27 E., while latitude is 29°11'27'S. The altitude is 1610 m above-sea level. The climate in the area is temperate with high temperature of 35^0 in summer and -5^0 in winter. Snow is experienced in winter. An annual rainfall is 750 mm, most of which is falling from October to February when it reaches the peak. It falls drastically in March and becomes dry in May to August.

Experimental design

Pot experiment was adopted in the greenhouse using Complete Randomized Block Design with 10 treatments (cultivars of wheat) which were Matlaba, Koonap, Elands, Tugela DN, SST 356, PAN 3379, Gariep, SST 374, Senqu and PAN 3195. Each treatment was replicated thrice. Pots of

30 cm diameter used were filled up with soil mixture of vermiculite and sandy loam soil at a ratio of 1:2, respectively. A compound fertilizer of 2:3:2 (22) + Zn was added to each pot. Five seeds of each cultivar were planted in each pot. A total number of 30 pots were planted. Water was applied weekly to provide moisture to the growing plants until they reached late grain-filling stage.

Data collection

Descriptor developed by International Board of Plant Genetic Resource Unit of FAO (1981) was used to collect data. The following parameters were recorded; growth class and seasonality, plant height at maturity measured in cm from ground to the spike top excluding awns, days to flower counted as days from sowing to 50% of plants in flower, spike density, awnedness, glume colour, glume hairiness, number of spikelets per spike, the average number of spikelets per spike, number of seed per spikelet, the average number of seeds from a spikelet, seed colour, seed size and seed vitreousness,

Data analysis

Data generated using the afore-mentioned parameters were subjected to produce cluster and principal component analysis using GENSTAT recovery version 16. Cluster analysis was conducted using square Euclidean distance and complete linkage method. Principal Component Analysis was carried out based on the phenotypic correlation matrix of the adjusted means of the populations for all 14 descriptors.

RESULTS

Cluster analysis

The parameters measured were used to differentiate the cultivars into groups of cultivars that possessed similar characters and separate dissimilar ones. The cultivars were similar to approximately about 88% and different to about 12%.

The dendrogram generated from cluster analysis (Fig.1) revealed two big groups A and B, and an outlier which was C. Group A comprised of Gariep, Koonap, Elands and Senqu while Group B consisted of SST 374, SST 356, PAN 3195, PAN 3379 and Tugela DN. Group C was an outlier containing Matlabas. Group B was further divided into sub-groups i and ii, and iii was an outlier. Subgroup i consisted of two cultivars which were Tugela DN and PAN 3379 while group ii consists of PAN 3195 and SST 356, and SST 374 was an outlier in group iii.

PAN 3195 and 3379 from the same company, Pannar, fell in one group (B). Similarly, SST 374 and SST 356 originated from the same company, Sensako. Gariep, Koonap, Elands and Senqu were also from the same company, Small Grain Institute of Agricultural Research Council (SGI-ARC). Tugela DN and Matlabas were originally from (SGI-ARC) but were not among the groups of their origin. Tugela DN was among the SST and PAN cultivars. Matlabas was an outlier.

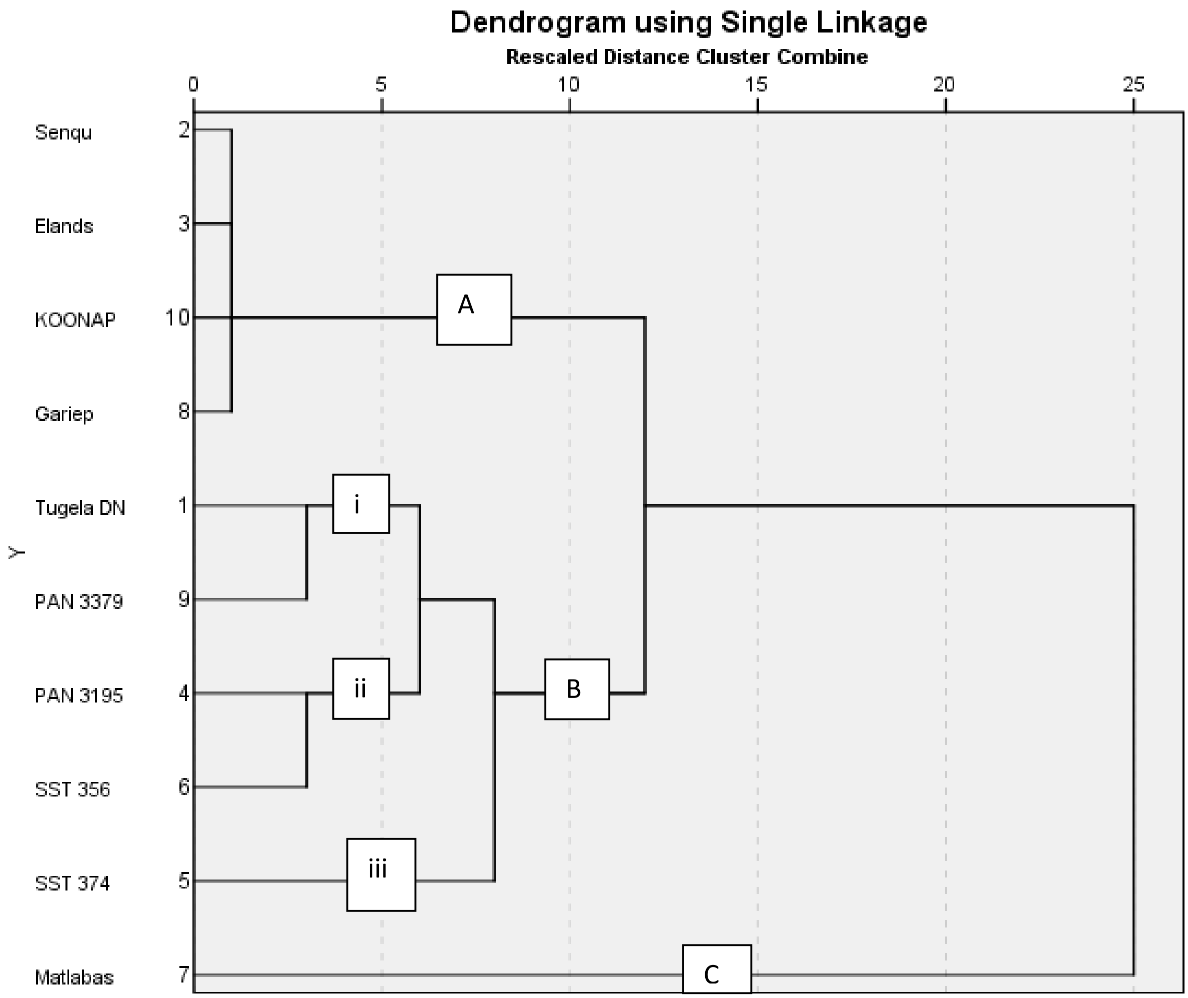

Figure 1. Dendrogram showing wheat cultivars

Principal component analysis

Principal component analysis was used to determine characters with high discriminatory power influencing segregation among wheat cultivars (Table 1). Out of ten principal components, only the first three were considered which constituted 84.572% of the total variation. The first principal component comprised 55.7375%. The second principal component constituted 15.737% and the third one constituted 12.858%. Thirteen characters were used to determine variation among 10 wheat cultivars (Table 2). The most responsible characters for variation in principal component 1 were number of spikelets (0.962), spike height (0.954) and number of tillers (-0.949). Plant height (0.843), reproductive tiller (-0.546) and number of seeds per spike (0.381) were responsible for variation among cultivars in principal component 2. For principal component 3, glume hairiness (0.735), seed size (-0.438) and plant height (-0.408) influenced the variation among the cultivars.

Table 1. Principal component analysis of wheat cultivars

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	5.574	**55.737**	**55.737**
2	1.598	**15.977**	**71.714**
3	1.286	**12.858**	**84.572**
4	0.619	6.187	90.759
5	0.428	4.280	95.039
6	0.240	2.403	97.442
7	0.179	1.789	99.231
8	0.052	0.524	99.755
9	0.024	0.245	100.000
10	1.465E-16	1.465E-15	100.000

Table 2. Principal component matrix

	Component		
	1	2	3
Plant height	0.011	0.843	-0.408
Number of tillers	-0.949	-0.203	0.124
Glume color	0.883	0.335	0.004
Glume hairiness	0.385	0.102	0.735
Number of spikelets	0.962	-0.057	-0.082
Number of seeds per spike	0.634	0.381	0.437
Seed size	0.767	-0.352	-0.438
Spike density	0.722	-0.359	0.334
Reproductive tiller	0.631	-0.546	-0.202
Spike height	0.954	0.156	-0.147

DISCUSSION

Cluster analysis

In the study conducted, the relationships in characters grouped cultivars into two large groups which shared two or more characters. Further sub-division into subgroups showed that there were some cultivars closely related to each other and shared the characters with more distinguishing power. The close relationship could be due to the fact that they share the same progenitors down the inheritance line. One cultivar which had characters mostly different from others formed an outlier group.

Figure 1 consisted of a large group of four cultivars which were evidenced by the low level at the graph to be closely related and share most features. Senqu, Elands, Koonap and Gariep were the cultivars that shared most of the characters with most discriminating power.

Pasandi *et al* (2014) grouped fifty six wheat cultivars into five groups using dendrogram which were said to have the most genetic diversity. Ahmad *et al* (2014) obtained three groups when using cluster analysis to determine relationship among fifteen cultivars. Hailegiorgis *et al* (2011) on the other hand grouped forty-nine wheat cultivars into twelve different sub-groups using cluster analysis. Similarly, Ahmad *et al* (2014) characterised nineteen cultivars into three cluster groups in Pakistan. Ajmal *et al* (2013) and Pasandi *et al* (2014) indicated the importance of using morphological characters in distinguishing wheat cultivars and for germplasm improvement. Furthermore, Morojele and Labuschagne (2010) conducted a genetic diversity study on wheat cultivars and found wheat cultivars forming big groups, which further sub-divided into sub-groups. The sub-groups also divided further into small groups. Outliers were also observed as the groups sub-divided.

Principal Component analysis

The principal component analysis showed that the first three principal components accounted for 84.572% of the total variation. According to the standards, number of principal components considered are those that would constitute 70% of the total variation (Morojele and Labuschagne, 2010), hence three components were used for this study.

Differentiation of wheat cultivars was made possible where two or more characters were used. No one character was found to be solely responsible for distinguishing one cultivar from another. Thirteen morphological wheat characters were used to adequately discriminate ten wheat cultivars. Not less than two characters were responsible for the segregation among cultivars. Findings of this study were consistent with those of Hailegiorgis *et al* (2011) who evidenced that more than one characters were responsible for discriminating forty-nine cultivars he studied. Hailegiorgis *et al* (2011) conducted a similar study with forty-nine wheat cultivars and found morphological markers having a high discriminatory power in distinguishing cultivars. In their research, three and more characters were able to segregate cultivars such that only 8 were appeared the same. International Plant Genetic Board Unit of Food and Agriculture Organization (1981) compiled a descriptor that enables the wheat cultivars to be differentiated easily.

Implications

The study showed that wheat cultivars are different from each other in terms of morphological features. This translates into genetic variation since the features are conferred by the genes. The genetic variation that exists among the cultivars of wheat broadened the spectrum of germ-plasm from which the farmer can make a choice. Farmers can choose the cultivar suitable for a particular locality where it will perform much higher than other localities. The importation of cultivars benefits the farmers and wheat industry at large because of high quality and yield of new cultivars substituting obsolete ones.

CONCLUSION

Number of spikelets, spike height, number of tillers, plant height, reproductive tillers, number of seeds per spike, glume hairiness, seed size and plant height were responsible for the differentiation of wheat cultivars.

Dendrogram initially generated two groups which further sub-divided into sub-groups with varying number of cultivars in each. Outliers were also found as groups were divided and further sub-divided into sub-groups.

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