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Short Communication

EVALUATION OF OATS (*Avena sativa* L.) GENOTYPES FOR β-GLUCAN, GRAIN YIELD AND PHYSIOLOGICAL TRAITS

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ABSTRACT

The present investigation was undertaken to identify suitable cultivars for commercial grain production for human consumption on the basis of nature of inter-relationship between β-glucan, grain quality and yield. The experimental material comprised of ten oats (*Avena sativa* L.) genotypes which were evaluated under temperate conditions of Kashmir for chlorophyll content, leaf area index, grain protein content, β-glucan content and grain yield. The highest chlorophyll content and leaf area index was recorded in genotype SKO-211 and highest grain protein in genotype SKO-209. The highest β-glucan and grain yield was achieved in genotype SKO-208. Correlation studies on the degree of interrelationship between various parameters revealed that grain yield exhibited a significant positive genotypic correlation with chlorophyll content, leaf area index and β-glucan. From the study it appears oats genotypes *viz.*, SKO-208, SKO-209 and SKO-207 may be suitable for commercial grain production for human consumption on the basis desirable grain quality characteristics and grain yield but these genotypes need further testing under different environments.

Key words: *Avena sativa*, β-glucan, chlorophyll, genotype, oats, protein, yield

INTRODUCTION

Oats (*Avena sativa* L.) crop has lower summer heat requirement and shows greater tolerance to rain than other cereals so is more important in the areas having cool and wet summers. Oats belongs to the family Poaceae and ranks 6th in world cereal production. Oats kernels contain a good amount of β-glucan, a viscous linear polysaccharide made up of (1,3), (1,4)-β-D-glucan units. About 20-30% of the total weight of oat kernels of commonly cultivated varieties consists of hulls. In unprocessed state, the oats kernel contains approximately 85% insoluble dietary fiber, with the exception of naked cultivated varieties, which have a hull content of <5%. Hulls can be further processed to obtain oat hull fiber, which has a dietary fiber content >90%, all of it being insoluble (Cho, 2001). In the remaining edible part, the groat, the total content of dietary fiber is usually 6-9%, about half of which is insoluble fiber, located mainly in the tissues outside the aleurone layer. β-glucan constitutes 1% of wheat grains and 5-11% of barley and oats (Skendi *et al.*, 2003). The principal component of soluble fiber in oats is β-glucan which is located in the endosperm cell wall.

However, the size of endosperm cells, the thickness of cell wall throughout the groat and distribution of β-glucan vary widely among the different cultivated varieties (Fucher and Muller, 1993). *Avena atlantic* and *A. sativa* genotypes have highest β-glucan content (2.2-11.3%) and are useful source for increasing the β-glucan content in cultivated varieties (Welch *et al*., 2000). β-glucan exhibits hypocholesterolemic and anticoagulant properties (Glore *et al*., 1994) and have recently been demonstrated to be anti-cytotoxic, anti-mutagenic and anti-tumorogenic (Chen *et al*., 2011). Further, oats can improve the nutritional value of gluten-free diets without any negative impact on their nutritive values. Therefore, inclusion of oats in gluten-free diets is advantageous as oats are a good source of dietary fiber and minerals (Huttner and Arendt, 2010).

In recent years the amount of oats used for human consumption has increased progressively owing its dietary benefits. In fact, the health benefits of oats rely mainly on the total dietary fibre and β-glucan content (Kerckhoffs *et al*., 2003). Oat protein is nearly equivalent in quality to soya protein, which according to the World Health Organization is equal to meat, milk and egg protein. Oats is the only cereal containing globulin or legume-like protein, avenalin, as the major (80%) storage protein. The globulins are characterized by their solubility in dilute saline. The more typical cereal proteins, such as gluten and zein, are prolamines (prolamins). The minor proteins in oats include prolamine and avenin. The protein content of hull-less oats kernels (groat) ranges from 12-24% which is highest amongst the cereals (Lasztity, 1999).

In India, oats have a wider adaptability, particularly in western and north western regions of the country because of its excellent growing habitats, quick re-growth and better nutritional value. Only a few varieties of oats are available for cultivation and their grain yields under good management conditions vary between 15-25 q ha^{-1}. Development of high yielding varieties of oats, therefore, assumes a greater significance for human consumption. For scientific utilization of elite allelic resources present in the exotic gene pool of oats through hybridization and subsequent selection of recombinants possessing high grain yield potential together with high β-glucan, it is imperative to characterize the genotypes on scientific basis. The climate prevailing in Western Himalayas particularly in Kashmir valley is ideally suitable for oats cultivation. The oats is grown as *rabi* (winter) crop in paddy fields, orchard areas and on Karewa (rain-fed) lands. In view of the facts, the present study was undertaken to identify cultivars for commercial grain production for human consumption on the basis of nature of inter-relationship between β-glucan, grain quality and yield.

MATERIALS AND METHODS

The basic material for the present study consisted of ten genotypes of oats (*Avena sativa* L.) *viz.*, SKO-204, SKO-205, Sabzaar, SKO-207, SKO-208, SKO-209, SKO-210, SKO-211, SKO-212 and SKO-213 which were evaluated for physiological traits, grain yield and quality at SKUAST-Kashmir, Shalimar, Srinagar, J&K (India) during winter (*rabi*) season 2011-2012. The experiment was laid out in a completely randomized block design with three replications. The experimental plot comprized of two rows each of 1 m length. Plant spacing was maintained at 30 cm x 10 cm. The crop was sown in October, 2011. The leaf area index (LAI) of randomly selected leaves from each plot was measured by canopy analyzer (Acuapar LP-80) at the beginning of anthesis. The chlorophyll content was measured in field on fully expanded flag leaves at anthesis with the help of chlorophyll meter (SPAD-502, Konica Minolta Sensing). The average reading was taken and conversion equations used to convert relative SPAD-502 values to leaf chlorophyll concentration (g m^{-2}) [Gandía *et al*., 2007]. At crop the grain quality was determined after the samples were dried and crushed to fine powder. The grain protein content was assayed as per the method of Jackson (1973) and β-glucan content as per Mc-Cleary (2006). The data was subjected to correlation coefficient analysis at genotypic levels according to the method proposed by Al-Jibouri *et al.* (1958) to calculate correlation coefficients between all the possible pairs of characters.

RESULTS AND DISCUSSION

The chlorophyll content in oats genotypes ranged from 0.054 to 0.537 (g m^{-2}) with highest chlorophyll content in genotype SKO-208 (0.537g m^{-2}) followed by SKO-211 (0.536 g·m^{-2}) and SKO-212 (0.536 g m^{-2}) [Table-1]. The leaf area index ranged from 2.93 to 5.90 with highest leaf area index in genotype SKO-211, followed by SKO-208 (5.31) and SKO-205 (5.27). The grain protein content ranged from 8.09 to 10.75% with highest protein in genotype SKO-208 followed by SKO-209 (9.17%) and SKO-207 (8.72%). β-glucan ranged from 3.77 to 8.56% in the genotypes studied with highest value in genotype SKO-208 (8.56%) followed by SKO-209 (8.29%) and SKO-207 (7.23%). Grain yield in oats genotypes ranged from 26.5 to 39.4 q ha^{-1} with highest grain yield in genotype SKO-208 followed by SKO-207 (38.8 q ha^{-1}) and SKO-209 (37.9 q ha^{-1}). Genotypic correlation coefficients serve as a measure of the genetic association among the characters and give idea about the characters which could be useful in the identification of more important ones for a particular selection programme.

Table 1: Quality and physiological parameters studied in oats (*Avena sativa*) elite genotypes

Genotypes	Chlorophyll (g m^{-2})	Leaf area index	Grain protein (%)	β-glucan (%)	Grain yield (q ha^{-1})
SKO-204	0.454	3.18	8.09	4.77	31.6
SKO-205	0.534	5.27	8.37	6.03	32.7
Sabzaar	0.508	2.93	8.23	4.36	26.5
SKO-207	0.526	3.98	8.94	8.29	38.8
SKO-208	0.537	5.31	10.75	8.56	39.4
SKO-209	0.501	3.37	9.17	8.29	37.9
SKO-210	0.508	4.13	8.55	6.34	34.7
SKO-211	0.536	5.90	8.40	6.23	33.9
SKO-212	0.536	4.12	8.29	5.53	31.8
SKO-213	0.505	3.94	8.43	6.25	33.5
Mean	0.515	3.85	8.60	6.30	34.08
SE±	0.007	0.128	0.274	0.439	1.874

The basic requirement of any selection programme is to ascertain the nature and magnitude of interrelationship between yield and its component traits, and also among different traits. It was, therefore, considered imperative to carry out correlation studies for various quantitative traits that contributed to grain yield along with quality. The estimated genotypic correlation coefficients (Table 2) depicted that grain yield had a significant positive correlation with chlorophyll content, leaf area index and β-glucan content so should be given emphasis for future grain yield improvement programs. These results will prove beneficial in devising a selection scheme for the identification of best genotypes possessing higher grain yield and better quality. Based on these results it seems possible that simultaneous selection of these characters for improvement in grain yield in the present set of material would be erective. The results clearly revealed a scope of simultaneous improvement of these traits through selection.

Table 2: Genotypic correlation coefficient between chlorophyll content, leaf area index, grain protein content, β-glucan and grain yield of oats (*Avena sativa* L.) elite genotypes

Characters	Chlorophyll content ($g{\cdot}m^{-2}$)	Leaf area index	Grain protein content (%)	β-glucan content (%)	Grain yield (q ha^{-1})
Chlorophyll content ($g{\cdot}m^{-2}$)	-	0.8213**	0.3412**	0.5478**	0.6341**
Leaf area index	-	-	0.2563**	0.4406**	0.4423**
Grain protein content (%)	-	-	-	0.9421**	0.1341
β-glucan (%)	-	-	-	-	0.8623**
Grain yield (q ha^{-1})	-	-	-	-	-

*, **significant at 5 and 1% level of significance, respectively.

β-glucan yield (the product of grain yield and β-glucan content) was found positively correlated with both grain yield and β-glucan content. β-glucan concentration has been reported to be positively correlated with protein content but negatively correlated with oil content (Cervantes-Martinez *et al*., 2001). Genotypes having high β-glucan content can be used in breeding programmes for increasing the β-glucan content of adapted local germplasm (Welch *et al*., 2000). Reynolds *et al.* (1994) and Zhao *et al*. (2008) observed that chlorophyll content has significant but positive relationship with grain yield. Xie *et al*. (2011) reported that grain yield originated mostly from the photosynthesis and LAI of leaves after heading. Grain yield was significantly and positively correlated with leaf area index and chlorophyll content. These traits were used as selection criteria to improve oat cultivars with higher grain yield.

The present study identifies oats genotypes SKO-208, SKO-209 and SKO-207 suitable for commercial grain production for human consumption on the basis of high grain protein content, β-glucan content and grain yield. However, further evaluation is required across diverse agro-ecological situations to confirm their higher grain yield and nutritional quality potential.

REFERENCES

Al-Jibouri, H.A., Miller, P.A. and Robinson. H.F. 1958. Genotypic and environmental variances and co-variances in an upland cotton cross of inter-specific origin. *Agronomy Journal,* **50**: 633-636.

Cervantes-Martinez, C.T., Frey, K. J., White, P.J., Wesenberg, D.M. and Holland, J.B. 2001. Correlated responses to selection for greater beta-glucan content in two oat populations. *Crop Science,* **42**: 1730-1738.

Chen, S.N., Nan, F.H., Chen, S., Wu, J.F., Lu, C.L. and Soni, M.G. 2011. Safety assessment of mushroom β-glucan: Subchronic toxicity in rodents and mutagenicity studies. *Food and Chemical Toxicology,* **49**: 2890-2898.

Cho, S.S. 2001. *Handbook of Dietary Fiber*. Marcel Dekker Inc., New York, USA.

Fucher, R.G. and Muller, S.S. 1993. Structure of oat bran and distribution of dietary components. pp. 1-24. **In**: *Oat Bran* (ed. P. Wood). American Association of Cereal Chemists, St. Paul, Minnesota, USA.

Gandía, S., Moreno, J., Sagardoy, R., Morales, F. and Verch, G. 2007. Crop photosynthetic pigment composition and calibration of an instrument for indirect chlorophyll content determination. In: *Proceedings of the Final Workshop for AGRISAR and EAGLE Campaigns*, 15–16 Oct., 2007, Noordwijk, Netherlands.

Glore, S.R., Van Treeck, D., Knehans, A.W. and Guild, M. 1994. Soluble fiber and serum lipids: A literature review. *Journal of American Diet Association,* **94**: 425-436.

Huntter, E.K. and Arendt, E.K. 2010. Recent advances in gluten-free baking and the current status of oats. *Trends in Food Science and Technology,* **21**: 303-312.

Jackson, M.L. 1973. *Soil Chemical Analysis.* Prentice Hall, New Delhi, India.

Kerckhoffs, D., Hornstea, G. and Mensink, R. 2003. Cholesterol lowering effect of beta-glucan from oat bran in mildly hypercholesterolemic subjects may decrease when beta-glucan is in corporated into bread and cookies. *American Journal of Clinical Nutrition,* **78**: 221-227.

Lasztity, R. 1999. General characterization of the chemical composition of cereal grains: The structure of the cereal grain. pp. 13-24. **In**: *Cereal Chemistry.* Akademiai Kiado, Budapest, Hungry.

Mc-Cleary. 2006. *Megazyme Mixed Linkage Beta-glucan Assay Procedure.* ICC standard method, Megazyme International Ltd., Wicklow, Ireland.

Reynolds, M. P., Balota, M., Delgado, M.I.B., Amani, I. and Fischer R.A.1994. Physiological and morphological traits associated with spring wheat yield under hot irrigated conditions. *Australian Journal Plant Physiology,* **21**: 717-730.

Skendi, A., Biliaderis, C.G., Lazaridou, A. and Izydorczyk, M.S. 2003. Structure and rheological properties of water soluble beta-glucans from oat cultivars of *Avena sativa* and *Avena bysantina. Journal of Cereal Science,* **38**: 15-31.

Welch, R.W., Brown, J.C.W. and Leggett, J.M. 2000. Inter-specific and intra-specific variation in grain and groat characteristics of wild oat (*Avena*) species: Very high groat (1-3), (1-4)-beta-glucan in an *Avena atlantica* genotype. *Journal of Cereal Science,* **31**: 273-279.

Xie, X.J., Shen, S.H.H, Li, Y.X., Zhao, X.Y., Li, B.B. and Xu, D.F. 2011. Effect of photosynthesis characteristics and dry matter accumulation of rice under high temperature heading stage. *African Journal of Agricultural Research,* **6**: 1931-1940.

Zhao, M., Lafitte, H. R., Sacks, E., Dimayuga, G. and Botwright-Acuna, T.L. 2008. Perennial *O. sativa* × *O. rufipogon* inter-specific hybrids: Photosynthetic characteristics and their inheritance. *Field Crop Research,* **106**: 203-213.