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Research Note

Beta-glucan and Grain protein studies of oats (*Avena sativa* L.) under temperate conditions.

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Abstract
The experimental material comprised of ten oats (*Avena sativa* L.) genotypes and their 45 F_1 crosses evaluated for grain protein content, beta glucan % and grain yield (kg ha^{-1}) . The highest grain protein content (10.75%) and beta glucan (8.56 %) were recorded for SKO-208, followed by SKO-209 and SKO-207. The highest grain yield (394 kg/ha) was recorded in SKO-208 followed by SKO-207 and SKO-209. The cross combination SKO-208 x SKO-213 recorded for the highest grain protein content (11.89 %). The cross combination SKO-208 x SKO-209 recorded the highest beta glucan (10.23 %) content while highest grain yield (43.22 kg ha^{-1}) was observed in cross combination SKO-208 x SKO-209. The cross combinations SKO-204 x SKO-208, SKO-205 x SKO-209, SABZAAR x SKO-209, SKO-207 x SKO-208 and SKO-208 x SKO-213were observed desirable with respect to all parameters studied. Beta-glucan content was observed to have significant and positive genotypic correlation with grain protein and grain yield.

Key words:
Avena sativa L., correlation, beta-glucan, protein and grain yield.

Oats (*Avena sativa* L.) are grown in temperate regions. They have a lower summer heat requirement and greater tolerance of rain than other cereals, rich in energy, protein, vitamin, phosphorus, iron and minerals for livestock production. Oats are largely used in cattle breeding and have occurred in human diet for a long time, mainly as oatmeal and rolled oats. But the positive physiological effects of oat products were recognized just rather recently (Drozdowski *et al*., 2010). The amount of oats used for human consumption, though, has increased progressively, owing to its dietary benefits (Regand *et al*., 2011). Oat protein is nearly equivalent in quality to soybean protein, which WHO research has shown is equal to meat, milk, and egg protein. Aside from the higher protein concentration, compared with other cereals oat is also outstanding in terms of the good balance of amino-acids in the caryopsis. The protein content varies from 12 to 24 percent, although changes in these contents hardly influence the proportion of amino-acids (Peterson, 2000). Globulin is the predominant fraction and the lysine concentration is equal to that in rice (3 to 4%) and higher than in other cereals (Peterson, 2000). The protein content of the hull-less oat kernel (groat) ranges from 12-24 per cent, the highest among cereals (Lasztity, 1999). The discovery of their healthy cholesterol-lowering properties has led to wider appreciation of oats as human food. Moreover, β-glucans, which also exhibit an antioxidant capacity, are included in the soluble dietary fibre fractions of oats that participates in the glucoregulation and causes a decrease in serum cholesterol levels in humans (Esposito *et al.*, 2005). Oats are a rich source of soluble fiber, well-balanced proteins, several vitamins and minerals essential for the human health (Esposito *et al.*, 2005).

Keeping the pre-mentioned facts in view, the present investigation was undertaken to identify a cultivar for commercial grain production for human consumption on the basis of grain protein and beta-glucan content and there nature of inter-relationship.

The basic material for the present study consisted of ten diverse genotypes of Oats *viz*., SKO-204, SKO-205, SKO-207, SKO-208, SKO-209, SKO-210, SKO-211, SKO-212, SKO-213, collected from National Bureau of Plant Genetic Resource (NBPGR), New Delhi (Table 1), a released variety, Sabzaar, and 45 F_1 crosses generated by crossing the above lines in diallel mating design (excluding reciprocals) and these were evaluated for quality traits and grain yield. The experiment was laid out in a completely randomized block design with three replications. Each experimental plot comprised three rows each of 4 m length. Recommended agronomic package of practices were followed to raise a healthy crop. The quality parameters *viz*., grain protein content (Jackson, 1973), Beta-glucan percent (Mc-Cleary Methods, 2006) and grain yield kg ha^{-1}, was recorded after weighing the total seeds obtained by threshing 20 tagged plants separately and averaged to a hectare basis. The data were also subjected to correlation coefficient analysis at genotypic levels according to method proposed by Al-Jibouri *et al*., 1958.

The data presented in Table 2 revealed that highest grain protein content (10.75%) of oats among parents was recorded in SKO-208 which was closely followed by SKO-209 (9.17%) and SKO- 207 (8.72%). As regards to beta-glucan%, the highest was observed in SKO-208 (8.56%) followed by SKO-209 (8.29%) and SKO- 207 (7.23%). The highest grain yield q/ha was recorded in SKO-208(39.4) followed by SKO-207(38.8) and SKO-209(37.9). The estimates of seed quality parameters of 45 F_1 hybrids are presented in Table 3. It is evident that the cross combination SKO- 208 X SKO-213 (11.89%), SKO-207 x SKO-208 (11.27%), SKO-205 x SKO-209 (11.24%), SKO- 204 x SKO-208 (11.13%) and SABZAAR x SKO-209 (10.98%) recorded the highest grain protein content, whereas the cross combinations SKO-208 x SKO-209 (10.23%), SKO-207 x SKO-209 (9.81%), SKO-204 x SKO-209 (9.22%), SKO-207 x SKO- 208 (9.21%) and SKO-204 x SKO-208 (9.14%) recorded the highest beta-glucan %. The cross combinations viz., SKO-208 x SKO-209 (4322), SKO- 207 x SKO-209 (4236), SKO- 205 x SKO-208 (4023), SKO-204 x SKO-208 (4022) and SKO-207 x SKO- 208 (4021) recorded the highest grain yield kg ha^{-1}. Cross combinations viz: SKO-204 x SKO-208, SKO-205 x SKO-209, SABZAAR x SKO-209, SKO-207 x SKO-208 and SKO-208 x SKO-213 was observed desirable with respect to all parameters, need critical evaluation during subsequent generation for isolating desirable transgressive segregants.

Development of high yielding varieties of oats assumed greater importance 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 beta-glucan, it is imperative to characterize the genotypes on scientific basis. Use of cultivated oats by food processing industries represents a major market that demands high quality. Oat growers, distributors, millers, and food processors all have unique criteria that determine quality from the perspective of achieving efficiency and profitability at their respective stages of production. Variations in the quantities and properties of the major nutrient components in oats impact oat quality in terms of nutrition and functionality. Beta-glucan is, therefore, an excellent example of how consumer demand for foods with substantiated health benefits has shaped the quality definition and marketability of oats under temperate conditions. Through the combined efforts of each participant in the supply chain, sustainable market opportunities for oats can be expanded to include products offering nutritional benefits and specific end-use attributes that appeal to consumer populations.

Correlation coefficients at genotype level among 3 traits viz. grain protein content, beta-glucan and grain yield are presented in Table 4. Highly significant ($P<0.05$) and positive correlations were found between all the traits. The highest significant correlation coefficient was found between grain protein content and beta glucan (0.6478**) which was followed by beta-glucan % and grain yield q/ha (0.5341**) while the lowest significant correlation coefficient was exhibited by Beta-glucan%, grain yield Kg/ha (0.4423**).

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 the different traits. It was, therefore, considered imperative to carry out correlation studies for various quantitative traits that contributed to grain yield along with quality. These results will be beneficial in devising a selection scheme for identifying best genotypes possessing higher higher beta-glucan and grain protein content.

Genotypic correlation coefficients provide a measure of the genetic association among characters and give an indication of characters that could be useful so as to identify more important ones for a particular selection programme. The results clearly revealed a scope of simultaneous improvement of these traits through selection. Beta-glucan yield (the product of grain yield and Beta-glucan content) is positively correlated with both grain yield and beta-glucan content. Beta-glucan concentration is found to be positively correlated with protein content. These findings were in general agreement with the earlier reports of (Cervantes-Martinz *et al*., 2001; Eshghi and Akhundova, 2010).

Cross combinations viz: SKO-204 x SKO-208, SKO-205 x SKO-209, SABZAAR x SKO-209, SKO-207 x SKO-208 and SKO-208 x SKO-213 was observed desirable with respect to all parameters, need critical evaluation during subsequent generation for isolating desirable transgressive segregants. Grain yield was significantly and positively correlated with beta-glucan and grain protein content. These traits were used as selection criteria to improve oat cultivars.

Genotypes SKO-208 and SKO-209 having high β-glucan content can be used in breeding programmes for increasing the β-glucan content of adapted local germplasm.

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Table 1. Oats genotypes used in the study with their accession number

S. No.	Genotype	EC number/ Place of collection
1.	SKO-204	EC-529089
2.	SKO-205	EC-529090
3.	SKO-207	EC-529092
4.	SKO-208	EC-529093
5.	SKO-209	EC-529094
6.	SKO-210	EC-529095
7.	SKO-211	EC-529096
8.	SKO-212	EC-529097
9.	SKO-213	EC-529098
10.	Sabzaar	Released variety (SKUAST-Kashmir)

Table 2. Grain protein content, beta-glucan and grain yield (kg) ha^{-1} of oats (*Avena sativa* L.) elite genotypes

Parents	Grain protein content (%)	Beta-glucan (%)	Grain yield (kg ha^{-1})
SKO-204	8.09	4.77	3160
SKO-205	8.37	6.03	3270
SABZAR	7.23	3.77	2650
SKO-207	8.72	7.23	3880
SKO-208	10.75	8.56	3940
SKO-209	9.17	8.29	3790
SKO-210	8.55	6.34	3470
SKO-211	8.40	6.23	3390
SKO-212	8.29	5.53	3180
SKO-213	8.43	6.25	3350
Mean	8.6	6.3	3408
SE	± 0.274	± 0.439	± 1.874

Table 4. Genotypic correlation coefficient between Grain protein content %, Beta-glucan% and Grain yield (kg) ha^{-1} + F1,s) generations of oats (*Avena sativa* L.).

S. No	Characters	Grain protein content %	Beta-glucan%	Grain yield (kg ha^{-1})
1	Grain protein content %	-	0.6478**	0.5341**
2	Beta-glucan%	-	-	0.4423**
3	Grain yield (q) ha^{-1}	-	-	-

**significant at 1 % level of significance.

Table 3. Grain protein content, beta-glucan and grain yield (kg) ha^{-1} of 45 crosses in oats

Crosse Combination	Grain protein content (%)	Beta-glucan (%)	Grain yield (kg ha^{-1})
SKO-204 x SKO-205	10.07	5.32	3471
SKO-204 x SABZAAR	9.22	5.12	2952
SKO-204 x SKO-207	9.12	7.34	3957
SKO-204 x SKO-208	11.13	9.14	4022
SKO-204 x SKO-209	10.11	9.22	3441
SKO-204 x SKO-210	8.42	6.21	3672
SKO-204 x SKO-211	9.19	5.24	3421
SKO-204 x SKO-212	10.67	7.29	3334
SKO-204 x SKO-213	9.25	5.89	3224
SKO-205 x SABZAAR	8.92	6.71	2789
SKO-205 x SKO-207	8.56	5.11	3345
SKO-205 x SKO-208	10.16	8.12	4023
SKO-205 x SKO-209	11.24	8.66	3971
SKO-205 x SKO-210	9.64	7.21	3244
SKO-205 x SKO-211	9.34	6.33	3567
SKO-205 x SKO-212	10.26	6.12	3198
SKO-205 x SKO-213	8.97	7.45	3674
SABZAAR x SKO-207	7.56	4.23	2843
SABZAAR x SKO-208	10.21	7.11	3334
SABZAAR x SKO-209	10.98	8.33	3898
SABZAAR x SKO-210	7.76	4.89	3021
SABZAAR x SKO-211	7.79	6.39	2734
SABZAAR x SKO-212	8.44	3.98	2821
SABZAAR x SKO-213	8.48	6.17	3531
SKO-207 x SKO- 208	11.27	9.21	4021
SKO-207 x SKO-209	8.92	9.81	4236
SKO-207 x SKO-210	8.66	5.67	3632
SKO-207 x SKO-211	8.92	8.88	3567
SKO-207 x SKO-212	8.78	6.34	3567
SKO-207 x SKO-213	8.96	6.96	3421
SKO-208 x SKO-209	10.84	10.23	4322
SKO-208 x SKO-210	8.23	7.24	3622
SKO-208 x SKO-211	9.34	8.14	3671
SKO-208 x SKO-212	10.66	6.11	3298
SKO-208 x SKO-213	11.89	8.46	4011
SKO-209 x SKO-210	9.78	7.34	3716
SKO-209 x SKO-211	10.05	8.67	3397
SKO-209 x SKO-212	10.12	6.11	3031
SKO-209 x SKO-213	8.84	7.48	3732
SKO-210 x SKO-211	9.11	6.57	3324
SKO-210 x SKO-212	8.67	5.38	2824
SKO-210 x SKO-213	8.98	7.21	3524
SKO-211 x SKO-212	9.46	5.54	3427
SKO-211 x SKO-213	9.06	7.01	3367
SKO-212 x SKO-213	8.52	5.22	3266
Mean	9.43	6.91	3397
SE	± 0.202	± 0.258	± 0.591