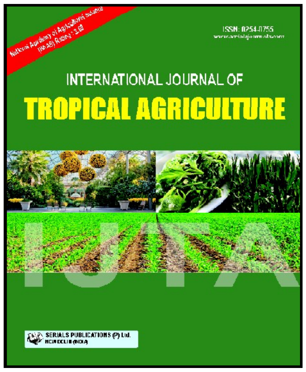

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Developing Dual Purpose Oat Varieties for Food and Fodder Security

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Abstract: Increasing population and decreasing arable lands has forced to search for some viable alternatives which can provide solution for food and fodder. Oats are very important fodder crops and increasingly being used recognized as nutritious breakfast cereal in world. In India most of the varieties released are suitable for fodder production but no variety is available which can be utilized human consumption. To reduce the competition between food, fodder crops dual purpose crops such as oats are very important. Oats provides nutritious fodder which can go for 2-3 cuts in case of sole fodder however in case of dual purpose crops single cut is taken and crop is left for the grain production. In case of fodder attributes high green herbage, high per day productivity, IVDMD, crude protein, leaf: stem ratio and longevity of duration of availability of green herbage most important traits while for grain attributes high grain yield, bold grain size, easy of dehulling, high grain protein per cent, high groat per cent, high grain plumpness, good taste, high grain hardiness and most important is high β glucan content. This paper presents necessity, importance and approaches to be followed for breeding dual purpose oats varieties.

Keywords: *Avena sativa*, fodder quality, dual purpose, β glucan, health benefits.

INTRODUCTION

Cereals are the main source of protein and calories for an estimated two thirds of the world's population. However, protein in cereal grain lacks the balance of essential amino acids required for its complete biological utilization. The genus *Avena* L. belongs to family *Poaceae* is one of the most ancient cereal genera and includes diploid, tetraploid and hexaploid species. Most oat species are wild, and only few - *Avena strigosa* ($2n = 4x = 28$), *A. Abyssinica* Hochst. ($2n = 4x = 28$), *A. sativa* L., and *A. byzantine* C.K. ($2n = 6x =$

42) are cultivated now or were cultivated in the past. Oat is Asiatic origin, Asia Minor is believed to be an origin for oats. Common oats (*Avena sativa*) spread in 80% total oat area. *Avena abyssinica* is Abyssinian oat grown in North Africa. *Avena brevis* is short oat grown in south Europe for green fodder. Oats rank around sixth in the world cereal production following wheat, maize, rice, barley and sorghum. Oat are source excellent green fodder and used for making quality hay and grain has always been an important of livestock feed. Oats are grown as grain as well as for forage and fodder use, straw for bedding, silage and chaff. Livestock grain feed is still the primary use of oat crops, accounting for an average of around 74% of the world's total usage in 1991 to 1992 (Welch, 1995). The total oat cultivation in the country is about 500 000 ha, out of which are under cultivation in Uttar Pradesh is about 34% (Choubey and Roy 2005) followed by Punjab (20%), Bihar (16%), Haryana (9%) and Madhya Pradesh (6%). Having wide adaptability and suitability to different growing conditions, excellent nutritional value for both animal and human consumption, oats provides an opportunity to use as a dual purpose crop. The utilization of available genetic resources and variability for various traits can be utilized to develop dual purpose varieties of oat which can fulfil the requirement of food, feed and fodder.

NUTRITIONAL SIGNIFICANCE

Oat is used as green and hay for fodder and it contain good amount of protein and digestible fibre. Fodder of oat has been rated as one of the best among the cereals. Oat contain 10-12 % crude protein 22-23.5% cellulose (Table 1). Multi-cut varieties oats are important providing green fodder for longer period and whereas single cut varieties more suitable for hay preparation. Nutritionally oats groats (seeds) are far superior to the cereals. They not only possess good amount of protein but essential minerals also in high quantities. The presence of high amount calcium, phosphorous and potassium coupled with good amount of fibre make them extremely desirable from modern nutritional point of view. The grain of oat contain 16.9% protein, 66.3% carbohydrates, 4% soluble fibre (beta-glucan), 10.6% dietary fibre. The oat groat is also rich source different essential amino acids and vitamins (Table 2). Oatmeal is chiefly eaten as porridge, but may also be used in a variety of baked goods, such as oatcakes, oatmeal cookies, and oat bread. Oats are also an ingredient in many cold cereals, in particular muesli and granola. Oats are also occasionally used in several different drinks.

The discovery of their healthy cholesterol-lowering properties has led to wider appreciation of oats as human food. Oat bran *i.e.* outer casing of the oat, consumption is believed to lower LDL cholesterol, and possibly to reduce the risk of heart disease. Oats contain more soluble fibre than any other grain, resulting in slower digestion and an extended sensation of fullness. Soluble fibre, beta-glucan, has been proven to help lower cholesterol. Oats, after maize, have the highest lipid content of any cereal, *e.g.*, greater than 10% for oats and as high as 17% for some maize cultivars compared to about 2-3% for wheat and most other cereals. The polar lipid content of oats (about 8-17% glycolipid and 10-20% phospholipid or a total of about 33%) is greater than that of other cereals, since much of the lipid fraction is contained within the endosperm.

Table 1
Fodder attributes of oats at 50% flowering stage

Crude protein	*Neutral detergent fibre*	*Acid detergent fibre*	*Cellulose*	*Hemicellulose*
10-12%	55-63%	30-32%	22-23.5%	17-20%

Plant Genetic Resources for Oat Improvement

Cultivated oats have wide diversity and all major gene banks of the world have good collection of the germplasm. Oats also provides equal opportunity for the improvement by utilizing genepools. The following strategies can be adopted for the breeding dual purpose varieties.

Table 2
Oats nutritional value per 100 g

S. No.	*Amino acids (g)*		*Vitamins (mg)*	
1.	Tryptophan	0.234	Vitamin C	0
2.	Threonine	0.575	Vitamin (B1)	0.763
3.	Isoleucine	0.694	Vitamin (B1)	0.139
4.	Leucine	1.284	Niacin	0.961
5.	Lysine	0.701	Pantothenic acid	1.349
6.	Methionine	0.312	Vitamin (B 6)	0.119
7.	Cystine	0.408	Total folate	56 mcg
8.	Phenylalanine	0.985	Vitamin-A	0
9.	Tyrosine	0.573	Retinol	0
10.	Valine	0.937	Vitamin (B12)	0
11.	Arginine	1.192		
12.	Histidine	0.405		
13.	Alanine	0.881		
14.	Aspartic acid	1.448		
15.	Glutamic acid	3.712		
16.	Glycine	0.841		
17.	Proline	0.934		
19.	Serine	0.750		

Data source: USDA National Nutrient Database.

Primary gene pool

Incorporating hexaploid species such as *A. sativa* and *A. sterilis*. Hybrids between wild and cultivated taxa can be produced easily. Introgression of desired traits is easy through conventional breeding strategies.

Secondary gene pool

Incorporates tetraploid species such as A. *maroccana, A. murphyi*. Hybridisation is difficult with hexaploids and results in self-sterile F_1 (partial female fertility of F_1 enables use of backcrossing). Reasonable homology of chromosomes and recombination between tetraploids and hexaploids exists.

Tertiary gene pool

Incorporates all diploid and some tetraploid species such as *A. barabata, A. vaviloviana, A. abyssinica, A. agadriana, A. macrostachya*. These species are distantly related and hybridisation between diploid and hexaploid is difficult requiring embryo rescue. F_1 is self-sterile and cannot be backcrossed conventionally. The sterility of hybrids can be overcome by chromosome doubling, which in turn can be further advanced by selfing/ breakdown of polyploidy and/ or back crossing. The highest β-glucan concentrations were found in genotypes of *A. atlantica* (Welch *et. al*., 2000) also comes under tertiary genepool.

Utilization of secondary gene pool

Avena sativa ($2n = 6x = 42$) × *A. maroccana* ($2n = 4x = 28$)
↓
Sterile hybrid ($2n = 5x = 53$)

Colchiploidization ($2n = 10x = 70$) → Selfing

Backcrossing (2-3 cycles) → Stable hexaploids
↓
An array of polyploid lines
$2n = 42, 44, 46, 50, 52, 58, 66, 70$

Use of wild relatives from Primary gene pool

Avena sativa ($2n = 6x = 42$) × *A. sterilis* ($2n = 6x = 42$)
↓
Fertile hybrid ($2n = 6x = 42$)
[Two cycles of backcross for wide adaptability]

Intergeneric/Wide crosses

Incorporates genera related to Avena, *e.g. Arrhenatherum* and *Helichtotrichon*. Crosses with them could provide valuable variation for tolerance to stress conditions and other agronomic traits.

Breeding Varieties for Dual Purpose Use

Some of the desirable traits required for an oat variety to be bred for human consumption and a variety bred for animal consumption are listed in the table 3 below (Gazal *et. al.* 2014). Many of the physical characteristics of milling and feed oats are similar, large differences exist in chemical characteristics. Oats used for human consumption has a breeding target of high β-glucan while as feed oats has a breeding target for lower levels of β-glucan (Winfield *et. al.*, 2007). However variety bred for fodder as well as for grain should have all desired qualities for human consumption coupled with high green fodder, dry matter, high crude protein, high and quick regeneration potential and high digestibility to be used as green fodder or hay.

Table 3
Desired quality traits in oats for human consumption and feed for animals

Trait	*Human consumption*	*Animal feed*
Oil per cent	Low	High
b-glucan	High	Low
Grain protein per cent	High	High
Starch gelatinisation	High	–
Hectolitre weight	High	High
Taste	Not bitter	Not bitter
Groat per cent	High	High
Grain plumpness	High	High
Easy of dehulling	High	High
Hull lignin per cent	–	Low
Grain hardiness	High	–
Grain colour (brightness)	High	High

Improved Oat Varieties

Oat is traditionally being cultivated under low input condition by small and marginal farmers. To boost the production and productivity in oat 29 high yielding varieties have been developed and released for different agro-climatic condition regions of the country by various institute/universities. Varieties Bundel Jai- 822, Bundel Jai- 851, Bundel Jai 992 (JHO 99-2), Bundel Jai 2004 (JHO 2000-4), Bundel Jai 991 (JHO 99-1), Bundel Jai 2001-3 (JHO 2001-3) and JHO 2010-1 were developed by IGFRI, Jhansi. Similarly HJ-8 for dual cut, OS-6, OS -7 both single cut for temperate and sub- tropical region was developed by CCS HAU, Hissar. OL-9 for north, north-west and south hills, OL-125 for north-west and central zone of country, suitable for single/multi cut. Sabzaar (SKO-7) for temperate region of Kashmir and high altitude region of Jammu by SKUA&T, Srinagar. UPO-212 under multi cut system, UPO -94 by GBPUA&T, Pantnagar for north and central India.

Evaluation of Varieties for Extended Green Fodder Production

A field experiment was conducted during winter season (October-April) of the year 2014-15 at the Students Research Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur with objective to select varieties suitable for extended green fodder supply for central Uttar Pradesh conditions. The set of 15 varieties were evaluated under three dates of sowing and results obtained are presented in table 4.

Across all the dates of sowing variety RO 19 produced highest biomass and showed its suitability for all sowing conditions. For early sowing other varieties which showed better performance were OS 7, OS 61 and OL 9. The varieties shown in the October were continuously harvested for 4 times at interval of 45 days till February and provided green fodder from December to February. However for the timely sown conditions RO 19 showed highest GFY and DMY which followed by OS-7 and HJ 8 for GFY and for DMY also RO 19 was best variety followed by OS 7, OL 125 and HJ 8. The green fodder availability from timely sown crop ranged from January last week to March third week. Late sown crop produced harvestable green fodder upto 15 April and the variety OL 9 was last to be harvested, while RO 19 was to produce highest GFY and DMY. Other who performed better under late sown conditions were OS 7 and OL 9 for bot GFY and DMY.

Table 4
Performance of oat varieties under various dates of sowing

		Ist date sowing (October)		IInd date of sowing (November)		IIIrd date of sowing (December)	
S. No.	Variety	GFY (q/ha)	DMY (q/ha)	GFY (q/ha)	DMY (q/ha)	GFY (q/ha)	DMY (q/ha)
1.	Kent	353.0	62.1	388.2	55.7	244.3	38.1
2.	OL 125	364.0	58.2	385.2	64.1	234.5	36.2
3.	OS 7	398.1	58.1	402.1	68.1	288.1	39.3
4.	JO-03-93	350.2	62.3	321.6	51.1	241.2	31.2
5.	RO 19	425.5	88.2	444.1	91.2	335.8	52.1
6.	JO-3-91	252.0	41.1	362.0	52.3	212.3	33.2
7.	OS 6	398.4	62.1	368.4	42.1	263.3	36.5
8.	HFO 114	310.0	45.1	265.0	38.5	220.2	37.3
9.	OS 346	333.1	39.2	363.5	49.3	244.4	35.4
10.	HJ 8	325.0	42.1	333.0	45.1	229.2	38.8
11.	UPO 212	298.5	52.1	258.5	39.3	210.6	32.2
12.	NDO 1	311.0	55.1	341.0	42.5	245.1	35.2
13.	JO 1	298.8	36.2	396.6	64.1	222.5	31.1
14.	NDO 2	355.0	68.2	303.0	37.1	219.4	36.2
15.	OL 9	398.8	88.7	366.5	56.2	266.9	41.2
	Mean	344.8	57.3	353.4	53.1	245.2	36.9
	CD (p = 0.5)	13.33	2.61	11.22	2.30	16.33	3.33

CONCLUSION

Breeding oat varieties for dual purpose is now being focussed in many parts of the world where breeders are interested to develop varieties which can produce green herbage at initial stages and after cutting the crop can produce which should high in quality for human consumption. The hay quality of oats after harvesting of grains should also be ideal to feed the animals. The main health related benefits of oats result from the high viscosity of the soluble β-glucan. The good quantity β glucan accomplishes its nutritional functions by increasing the viscosity of fluids in the gut. Therefore, it has been proposed as a target trait in oat breeding programs so as to double its concentration. Oat β glucan content has been found to be positively correlated with protein content and negatively correlated with oil content. Thus the breeding objectives of the oats needs to be reoriented through the incorporation of traits that are linked with the utilization of crop as fodder and food crop and with emphasis for their simultaneous improvement.

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