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Ministry of Agriculture

WINTER RYE ´SANGASTE´

Origin of cultivated rye

Winter rye is originated from the southwestern part of Asia, like other common species of cereals (wheat, oats and barley). Archaeological excavations have proofed that rye was grown, or used already on the Neolithic Era. It is speculated that rye was transferred to the north and northwest as a weeds in wheat or barely. However, high vitality and winterhardiness have supported rapid expansion of growth area. Winter rye expanded through Turkey to the Balkans and then further to Europe and over Russia to the west. In the Alpine mountains rye was known the Bronze Age, to the other parts of Europe rye probably expanded in the 1st Millennium BC. In Denmark deposits of rye have been found in Iron Age formations. Rye was widely cultivated in the Roman Empire. To France and England rye cultivation expanded during the reign of Karl the Great. Through Russia rye went round further to Siberia. The North and South America, rye spread with new settlers on 16th and 17th centuries. In southern regions of Finland was rye utilised at the beginning of the 1st Millennium AD. In Estonia cultivation was started 4th-5th Century, in the 11the Century was prevalent the current territory of Estonia.

General description

Rye is relatively undemanding crop, is resistant to the severe winter conditions and grows well even in less fertile soils with high acidity. Therefore, the expenditures for fertilizers and plant protection chemicals on rye cultivation are lower than other on other cereals. Rye plants produce more tillers than spring cereals; its strong root system extends down to 230 centimetres, being able to assimilate nutrients and water from deeper soil layers. Rye is more drought resistant than spring cereals, in drought-prone summers rye outyields spring crops. Rye is resistant plant pathogens and pests, and is good for supressing weeds. Winter rye is a cross-pollinating crop, and therefore in seed production isolation distance requirements have to be fulfilled for purity.

Nutritional value

Consumption of rye and cereal products in sufficient quantities assures a balanced diet. Rye bread incorporates vital macronutrients (carbohydrates, fats, proteins, and water) and micronutrients (minerals, vitamins) to the humans. According to the recommendations, about 50-60% of total caloric intake should come from carbohydrates. Rye starch proportion should be at least 30%. For intake of this amount of energy a person should consume about 100-120 g of bread per day. 100 grams of rye bread contains 6-8 grams of protein. Compared to wheat rye flour has better essential amino acids composition. In comparison to wheat flour general content of rye proteins is more beneficial to the human body; it contains more irreplaceable amino acids like lysine and threonine. Whole grain rye bread contains considerable amounts of vitamins B10, B1, B2, B3 and E. 100 g of rye bread covers at least 10-15% of daily intake of these vitamins. Rye bread is rich of essential mineral like potassium, magnesium, phosphorus, zinc, calcium, iron and selenium. Particularly important are magnesium and potassium, which together with selenium and zinc contribute to protection against cardiovascular disease, benign prostatic hypertrophy, and is a prophylactic against diabetes. Rye has a suppressive effect of the carcinogenesis, as it contains antioxidants (tannins, alküülresortsiin, phytic acid). In the chemical composition of rye grain fibre is important regulating the activities of the human gut and in keeping blood cholesterol levels down.

In accordance with the dietary recommendations, a person should consume 20 to 35 g of dietary fibre per day. 100 grams of dry matter of whole-grain rye bread flour contains about 10 g fibres, of which 2 g is lignin. Dietary fibre helps to control blood glucose and insulin levels, as well to reduce blood cholesterol levels. Consumption of 100-200 grams of rye bread covers daily needs for dietary fibre of human body.

Cultivation

Winter rye is an important cereal crop in many countries. According FAO´s data the growing area of rye in 2010 was 5.3 million hectares and total production volume of rye grain 12.4 million tonnes. About half of the total production is used for the bread making; the rest is used for seed, animal feed and for production of spirits and plastic materials. However rye production is declining on a worldwide basis.

In comparison with the year 2000 rye cultivation in the world has dropped approximately by 4.5 million hectares. According to FAO statistics in 2010 winter rye is most grown in Poland (1.40 million ha), Russia (1.37 million ha), Germany (0.63 million ha), Belarus (0.34 million ha), Ukraine (0.28 million hectares), China (0.18 million ha), and Turkey (0.14 million ha). Rye is an important crop in Denmark, Lithuania, Austria, as well as in Latvia, Finland, Sweden and Estonia. Winter rye was cultivated in the United States on 107 thousand ha and in Canada on 89 thousand ha.

Rye breeding

W. Rimpau started winter rye plant breeding in Schlanstedt (Germany) in 1875, F. Lochow in Petkus (Germany) in 1880 and N. Rudnitsky in Vyatka plant breeding station (Russia) in 1894. Current only variety 'Vyatka' is used to some extent in the agricultural areas of Russia's northwest.

Breeding of rye variety ´Sangaste´

Winter rye breeding in Estonia was the initiated by count Friedrich Georg Magnus von Berg (1845-1938) in Sangaste mansion. The desire count Berg to get purposefully be engaged into plant breeding activities has emerged during his studies and traineeship in England at P. Schireff in 1866-1868. Count Berg started formation of an initial material for plant breeding in 1868. However due to poor winter hardiness of none of foreign varieties obtained from UK, Germany and Finland proved to be suitable. Over 40 crossing combinations between several varieties of rye were made by count Berg. Field test with created lines were conducted over several years. As a result of uncontrolled crosspollination all populations very appeared to be divergent and heterogeneous, count Berg decided to proceed with another, although slower, breeding method, the repeated selection of individual plants. The most suited initial breeding material was obtained from Kuuste manor in Tartu region, which in turn was received for Oisu manor of Viljandi region. Presumably it was Probstei rye as Oisu manor has in early 1850 introduced from Germany Probstei rye seeds. After repeated cultivation of Probstei rye alongside with local rye landraces volunteer crosspollination took place.

In 1875 was developed a local population ´Sangaste´ which was characterised by winter hardiness and large kernels.

Currently winter rye variety 'Sangaste' created by "Count of Rye" Friedrich Georg Magnus von Berg in 1875 is the oldest cultivated rye variety in the world.

At the World Fair held in Paris in 1889 'Sangaste' rye was awarded a large Gold Medal. At the world exhibition in Chicago in 1893 a First Prize was given to the variety 'Sangaste'. Silver medals were awarded to ´Sangaste´ at the All-Russian Exhibitions held in Kharkiv in 1888 and at Tsarksoselskaja Anniversary Exhibition in 1911.
Count Berg immediately started varietal improvement and conservationary breeding of 'Sangaste'. He selected heavier rye spikes, which also assessed larger number of grains and grain weight per spike. Spike length, colour and density were determined in subsequent selection as important traits as well. By the instrumentality of special sowing desk seeds from selected spikes were manually planted on remote fields. Seeds on selected plots were mixed and planted on wide-row plots for multiplication purposes. The yield of multiplication plots was harvested and cleaned with spin-drier and sorting machine designed by Count Berg personally.
Later Count Berg, instead of selection of single spikes introduced a new breeding method, a selection of superior single plants.
Plants characterised by uniformity of plant height, with proper spike shape and density of spikelets were selected on the field. From each plant five long and light-coloured spikes surrounding densely kernels were selected. Kernels were weighed and in further breeding only superior plants characterised by higher grain weight range were used. The progeny of a single plant grain sown in the superior plant nursery was known as „family“. During the growing season observations of families for overwintering, numbers of stems, uniformity in length and head shape were conducted. Families with unsatisfactory winter survival and undesirable phenotype were removed before flowering. Based on selected families a basic seed foundation was created. In 1875-1919 500 superior seed plots were planted annually. However in 1927 eight thousand families were planted already.
Count F. Berg continued versatile development of rye breeding methods. Creation of self-pollinating rye was of particular interest of F. Berg. Breeding nursery established in 1927 counted 3654 self-pollinated lines. Best selected individual plants and most outstanding kernels were exhibited on the 6th seed exhibition. However, despite numerous attempts, isolation selection Count Berg failed to create a self-pollinating rye variety.
The knowledge gained and obtained skills were shared by Count Fr. Berg in newspapers, magazines and books. He actively presented experiments and household to farmers. Count Fr. Berg's lifetime achievement was breeding of winter rye variety 'Sangaste'. Count Berg awards from exhibitions and received official decorations from the government. He was the Honorary Doctorate of the University of Tartu and an honorary member of many societies.

Continuation of Count Berg´s work at Jõgeva

In 1920, the first state research institution the Jõgeva Plant Breeding Station was established. Mihkel Pill, who has served as an assistant to Fr. Berg in breeding, was assigned to work as a director and a breeder of cereal crops.

Winter rye breeding was initiated by M. Pill in 1921. At the beginning he selected superior plants from variety ´Sangaste´, which due to long-term cultivation was well adapted to local

conditions. At the same year he collected more than 30 domestic and foreign samples which were in the autumn. The main goal was to create a new variety similar to 'Sangaste' by winter hardiness, but with shorter stem and better lodging resistance Petkus-type variety.

M. Pill wrote in 1936, "A superior plants were selected from variety 'Petkus' and sample nr.19 (from Viljandi region) in 1921. Single seeds were planted on the same field to be cross-pollinated next spring. This method was believed to increase winter hardiness of Petkus population. Positive impact of cross-pollination was asserted by appearance of spikes of Petkus population similar to the population nr.19. The whole breeding process lasted for 15years. A first winter rye variety of M. Pill was released in 1936 and was named after 'Jõgeva 1'. Compared to 'Sangaste' this variety characterised by short straw, better lodging resistance and 4-5% yielding. However by winterhardiness of ´Jõgeva 1´ was lower than that of ´Sangaste´.

Breeding initiatives of rye variety 'Jõgeva 2' were started in 1921 as well. Sample nr.19 was used as an initial source for selection of superior plants. ´Jõgeva 2´was released in 1937 and compared to ´Sangaste´ had equal winter hardiness, shorter plant height and up to 5% higher grain yielding capacity.

While Count Fr. Berg himself did not arrange comparative tests of 'Sangaste' with other varieties of rye, there are no data about agronomic and economic values of ´Sangaste´ until the end of first decade on 20th Century. Harald von Rathlef conducted field trials of 23 varieties in 1908/1909 and 1913/1914. According to the results 'Sangaste' was not among top varieties by the grain yield.

M. Pill conducted first comparative tests at Jõgeva in the period 1923-1939. The objective was to evaluate existing varieties, to assist farmers in selection of appropriate varieties and find initial varieties for plant breeding. Numbers of tested varieties varied from 4 to12, trials were conducted in four or five replications.
Each cultivar was sown at the same seed rate, for experiments fields with uniform soil characteristics were exploited. Notes on fertilisers and weather conditions were made. During growing season winterhardiness, lodging resistance and disease resistance of varieties was estimated.
Based on the results of the tests it was suggested by M. Pill in 1926 to cultivate more cold tolerant, high-yielding variety 'Sangaste'. Since then a triumph of 'Sangaste' has begun in Estonia.

In 1935 'Sangaste' was occupying nearly half of the rye production area, and it was the most grown winter rye variety into Estonia for decades. M. Pill wrote magazine "Agriculture" in 1935 that variety ´Sangaste' is very well adapted to Estonian conditions and is characterised by good winter and cold resistance, has good lodging resistance, guarantees high yield of grain and straw. ´Sangaste´ has rapidly expanded in Estonia and in these countries which are recognised by high level plant breeding.

At 75th Anniversary of 'Sangaste' rye M. Pill said that 'Sangaste' grain yield potential is around 4000 kg. 1000 kernel weight and hectolitre weight are high, protein content of 11%, it has good baking quality.

Plant breeder H. Tuppits has used cross-pollinated population of varieties 'Sangaste', 'Jõgeva 1' and 'Jõgeva 2' for selection of variety 'Jõgeva 112' in the years 1949-1963. In one year, the population was pollinated by varieties 'Vyatka', 'Petkus' and 'Priekuli'. As a result 'Jõgeva 112' outscored 'Sangaste' by lodging resistance, but winterhardiness was lower.

Since 1939 was selection of 'Sangaste´ conducted in Sangaste Breeding Station under supervision of M. Pill. In 1951-1984 this work was conducted under guidance of Herbert

Tuppits. Currently varietal improvement of ´Sangaste´ is carried on by Lea Rannik and supervised by rye breeder Ilme Tupits from the Jõgeva Plant Breeding Institute.

Cultivation of rye in Estonia

Targeted information activities of rye consumers were initiated Seed Council and the Estonian Variety Improvement Association. First agricultural exhibitions were held in Viljandi (1914), Valga (1915) and Tallinn (1921). Seed main task of exhibitions was to "improve the seed quality, to develop seed production and plant breeding and to promote seed market to consumers through assessment of seed production, variety selection and variety improvement activities."

In 1930-1939 the average grain yield of rye was 1340 kg/ha. National legislation on seed market introduced in 1930 decreased competitiveness of imported cereal crops and foster local farmers' production and marketing activities. Therefore Estonia became fully self-sufficient in production of cereals.

In years 1936-1938 agricultural products amounted to an average of 15.6% of total imports and 50.3% of exports. "Sangaste rye - farmer´s benefit!" In this way, Central Association of Consumers has advertised 'Sangaste' rye. In order to raise the interest of farmers and to facilitate expansion of variety 'Sangaste' rye a 10-30% higher price rate for ´Sangaste´ in comparison to local landraces was fixed.

Traits of rye ´Sangaste´

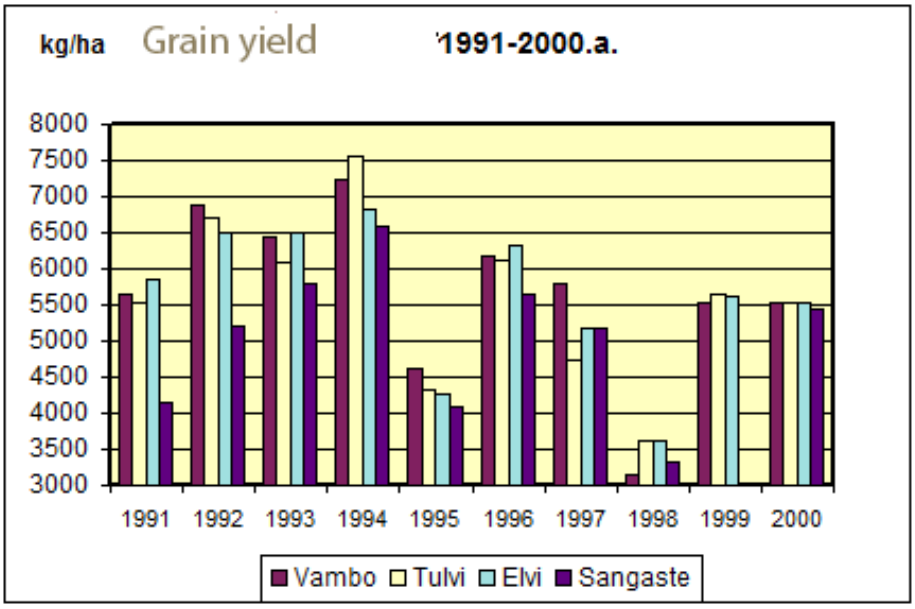
Upon the results of field trials M. Pill compiled following morphological and botanical characterisation of variety ´Sangaste´: "Spikes are prism-shaped, medium to long (11-14 cm), scattered and wide. Awns are spread-oriented, long and strong. Kernels are mostly yellow-green, long, oval, thick and even. Stem tall (170-200 cm), thick, with good resistance to lodging. Medium tillering ability (2-3 tillers). Leaves are strong, broad, often covered with wax. Semi-erect shrub, varies. "

Table. Field test of ‘Sangaste’ at Jõgeva.

Years	Grain yield kg/ha	TKW g	HW g/l	Winter-hardiness	Lodging-resistance	Straw lengths	Spike length cm	No of spiklets	Kernel weight g	Protein %	Falling-number
1926-1939	2349	31,5	726	8,2	7,5	145	-	-	-	10,7	-
1933-1949	2428	30,9	717	-	7,7	144	-	-	-	11,2	-
1968-1973	3460	33,3		8,0	5,8	174	10,4	33	1,7	11,1	-
1994-1998	5730	34,8	625	8,4	5,9	168	11,1	31	2,1	12,5	194
1999-2004	4700	36,2	598	7,3	6,7	174	11,7	34	2,2	11,9	199

The highest grain yield of variety ´Sangaste´ in winter rye trials conducted at the Jõgeva Plant Breeding Institute was obtained in 1994, when the average of trial was 6,580 kg/ha. Lodging resistance was good, 6.6 points. 'Sangaste' has exceeded most varieties by dry matter protein content. Backing quality has been predominantly good.

Table. Grain yield at Jõgeva Plant Breeding Institute.



The average winter hardiness of ´Sangaste´ in 1991-1996 was 8.5 points (Elvi 8.7 points). However weather conditions were mostly favourable and there were no significant differences between the varieties.

Table. Winterhardiness of varieties at Jõgeva PBI (9 – very good).

Variety	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**average**
Vambo	7	8	8,6	8,5	8,6	9	**8,3**
Tulvi	6,2	8	8,2	8,6	8,3	8,8	**8**
Elvi	8,8	8,7	8,6	8,6	8,4	9	**8,7**
Sangaste	7,8	8	9	8,6	8,5	9	**8,5**

In regard to lodging beside traits of varieties have high importance weather conditions during vegetation period and amount of applied nitrogen fertilisers. The results of trials conducted by the Jõgeva Plant Breeding Institute have confirmed that in normal growing conditions and by exploitation of proper cultivation technology lodging of ´Sangaste´ shall not aggravate harvest.

Table. Lodging resistance of varieties at Jõgeva PBI (9 – very good).

Variety	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**average**
Vambo	6,2	9	9	8,2	8	7,5	**8**
Tulvi	5,2	9	9	7,6	8	8,1	**7,8**
Elvi	6,6	9	8,6	8	8	7	**7,9**
Sangaste	3,2	9	7,6	6,6	6	5,4	**6,3**

Kernels of ´Sangaste´ are comparatively large. In some years it has exceeded all other varieties by 4-6 grams.

Table. 1000 kernel weight at Jõgeva PBI (g).

Variety	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**average**
Vambo	33,9	35,4	32,6	37,1	31,4	27	**32,9**
Tulvi	30,4	33,2	33,9	35,5	28,1	27,7	**31,5**
Elvi	31	34,6	32,9	35,2	31,3	27,3	**32,1**
Sangaste	32,2	39,9	40	37,3	32,1	30,9	**35,4**

Development of ´Sangaste´ in Canada

Count Fr. Berg's grandson, Rene Roman Alexander Berg moved from Germany to Canada after World War II. R. Berg worked for a long time at the University of Alberta in Edmonton. In 1951 he obtained some seeds of 'Sangaste' rye for testing and plant breeding purposes. After some years of selection variety 'Sangaste´ was licensed for seed production and marketing in Canada in 1957.

Winter hardiness of 'Sangaste' in Canada was remarkably good. However, in the long-day conditions the lodging resistance was fair. Therefore R. Berg started a breeding project aimed at shortening of straw.

After long-term selection a new variety ´Kodiak´ was register in Canada in 1971. Compared to ´Sangaste´ variety ´Kodiak´ was characterised by 20-25 cm shorter plant height, good winter hardiness and lodging resistance. The kernels were larger than that of other varieties grown in Canada.

In trials conducted in Saskatchewan (Canada) in 1989-1993 the average plant height of ´Kodiak´ was 121 cm. In comparison with other common varieties ('Musketeer', 'Puma') it had equal resistance to snow mold and lodging resistance. The variety 'Kodiak' was widely grown in Canada until the beginning of the 1990ies.

´Kodiak´ has been tested in field trials conducted by the Jõgeva Plant Breeding Institute.

Table. Results of field tests at Jõgeva PBI (the average of 1981-1983).

Variety	Yield kg/ha	HW g/l	TKW g	Winter-hard. p*	Lodg. resist. p*	Straw length cm	Spike length cm	No of kernels	kernel weight g
Sangaste	3600	656	38,2	7,3	3,6	164	10,7	50	1,9
Jõgeva 112	3835	670	34,6	7,8	5,3	160	10,3	58	2,1
Kodiak	3325	682	38,0	7,5	3,8	142	10,5	51	1,7
	*1 – very weak; 9 – very good								

Development of short-strawed lines

One of the main objectives of winter rye breeders is to create varieties characterised by a good or very good lodging resistance. Varieties less prone to lodging do not require application of growth regulators, which enables production cost reduction.

Under unfavourable growing conditions (high relative humidity and temperature) during final stages of ripening varieties with better lodging resistance are more durable to pre-harvest sprouting.

Therefore many plant breeders have been set up a goal to create a rye variety similar to 'Sangaste' on winter hardiness and kernel size, but shorter and with improved lodging resistance. To create short-strawed varieties dwarf lines have been widely used. The straw length of these lines is determined by a dominant gene. However, varieties bred using these dwarf lines are heterogeneous in plant height. Dwarf lines have been exploited in rye breeding at the Plant Breeding Institute since 1975. The first material used was a line EM 1 (Estestvennõi mutant). The author is scientist V. D. Kobõljanski from N. I. Vavilov All-Russian Institute of Plant Cultivation.

Short-strawed mutant DM (author Hugo Remmelg, the Institute of Experimental Biology) and dwarf lines selected from variety ´Sangaste´ have been studied and utilised in the Jõgeva Plant Breeding Institute since 1989. The main goal is to develop a short-strawed lodging resistant variety. Selection of superior plant from Dm populations has been carried on by plant breeder Ilme Tupits since 1997. The average plant height of created lines is 84 cm. However these lines are not homogeneous by plant height – due to genetic divergence about 10-15% plants are considerably taller than the main population.

Table. Characterisation of *Dm* populations at the Jõgeva PBI.

Characteristic	Average	Minimal	Maximal
Plant height cm	84	72	99
Spike length cm	12,0	8,5	14,7
No of spikes per plant	11	6	17
No of kernels per spike	67	50	80
Kernel weight per spike g	2,2	1,6	3,1
No of kernels per plant	697	384	1122
Kernel weight per plant g	22,3	10,7	40,1
TKW g	32,0	23,7	44,4

Table. Agronomic characterisation of breeds and varieties at Jõgeva PBI.

Breed or line	Plant height cm	Spike length cm	No of spikes per plant	TKW g
Dm	117,8	11,5	33,0	44,6
EM 1	131,0	11,0	33,4	39,8
Getera	133,3	10,9	36,9	47,3
Talovskaja 12	129,2	9,8	30,5	41,1
Krona	143,3	11,5	36,6	41,9
Tsulpan	131,3	10,4	34,2	41,1
Vambo	138,8	9,0	33,9	43,8

Recommendations for cultivation of winter rye ´Sangaste´

Selection of site
Rye as winter crop should not be grown in any field, better suite flat, medium-textured fields with the good water drainage capabilities. Waterlogged conditions shall be avoided, because yield and stand in reduced in fields prone to standing water and flooding. Using appropriate agro-techniques can be rye grown on many soil types including light loamy and heavy soils.

Pre-crops
More suitable pre-crops are mixtures of forage grasses and legumes, early and medium ripening spring barley, winter wheat and winter rye. On the fields heavily contaminated by weeds like couch grass, is very reasonable to use fallow land for the purpose of weed control.

Tillage
On conventional tillage system ploughing shall prepare a good seedbed and create favourable conditions for germination and seedling growth. To establish the best conditions for rye a field must after ploughing get compact and firm. On well compacted upper soil layer (4-6 cm) will rye seeds germinate evenly, well-developed root system will be established and optimal number of tillers will be eventually developed.
Properly prepared for sowing the field is one of the most important prerequisite for high yields.

Seed treatment
To evolve resistance to snow mold seed of susceptible varieties shall be fungicide-treated with proper chemicals.

Planting
The recommended planting date is the first decade of September. Depending on the weather conditions good results could be achieved by earlier or later planting date. Planting too early can result in excessive autumn growth and create more winter damage. As a consequence population of weeds will increase. Late-planted rye (after 20 September) misses critical autumn growth period, tillers less and could suffer from winter damage. As a result late-planting has negative effect on grain yield. It is very difficult to make up for late planting by management practices at later growth stages. Rye planted at the optimal period will create extensive root system and promote tillering of plant (optimal is 3-5 tillers per plant). The optimum planting rate is 350-450 kernels per square meter. In case of delayed sowing it is recommended to increase planting rate by 10-20%. However too dense herbage will have fair overwintering, more lodging and greater potential for plant diseases. Optimum seeding depth is 2-3 cm, it is very important to achieve uniform seed depth over a whole field.

Fertiliser management
Fertiliser management program should be based on soil test results. Proper nitrogen rate and timing are important for high tiller numbers and yield. In nitrogen deficiency tillering is poor. Excessive nitrogen can cause lodging, to increase plant disease infection and decrease grain yield. Phosphorus affects positively winter resistance, root development, tillering, timely heading and ripening. Potassium helps to increase resistance to some diseases and reduce lodging.
During an autumn tillage basic fertilisers shall be applied at the following recommended rates: 20 kg N/ha, 100 kg P_2O_5/ha and 100 kg K_2O/ha. It is highly recommended to use organic fertilizer, 60-100 t/ha of manure, for instance. Nitrogen application in spring should be done just before the first joint appears on the main stem and when a rapid growth begins. The rate of N should remain between 60-80 kg N/ha.

The use of growth regulators

When the potential for lodging is high and more than 80 kg N per ha has been applied it is recommended to consider using the plant growth regulator. In general application should be made at stem elongation stage of rye plants. Growth regulators prevent lodging by shortening the plant and strengthening the straw.

Disease management

This is an important component of high-yielding rye production. The most serious diseases affecting rye during the spring and summer growing season are powdery mildew, leaf and stem rust, take-all, eyespot, leaf bloch and ergot. Major rye pests are Swedish fly, hessyan fly, stem sawfly, Rustic Shoulder-knot and cereal leaf beetle. There is a wide variety of fungicides and insecticides to control appearance of diseases and pests.

Harvest

The weather conditions at harvest time have great impact on backing quality. It is important for grain quality that the harvest begins as soon as possible. Relatively high air temperature and humidity at the end of wax-ripening stage or full maturity may determine pre-harvest sprouting of kernels. In most cases, pre-harvest sprouting is not externally visible; however increased activity of alpha-amylase can cause decrease of falling number.

Falling Number

The Falling Number gives an indication of the sprout damage during final stages of ripening of rye and is an indicator of baking quality of rye.

The Falling method is the international standardised and most popular method to determine pre-harvest germination of rye kernels in spikes. The germination causes an accelerated production of the starch degrading enzyme alpha-amylase. To measure activity of alpha-amylase special apparatus is used. The result of test is expressed in seconds. The more sprouted the grain has lower Falling Number. Generally a falling number value of 150 seconds and longer indicates a low enzyme activity and a very good rye quality. Values below 90 seconds characterise rye flour with fair backing quality

Seed production of variety ´Sangaste´

In 2010-2012 the largest seed production area has winter rye variety ´Sangaste´, which was in this period grown in Estonia on 469.7 hectares in total. There were grown varieties of an Estonian origin ´Elvi´ (82.2 ha) and ´Tulvi´ (66.7 ha). Among varieties of foreign origin the largest seed production are was occupied by variety ´Matador´.

Table. Field certification of rye in Estonia (ha).

Variety	2010	2011	2012	Total
Dankowskie Amber			18,5	18,5
Elvi	15,2	18,6	48,4	82,2
Kapitän		22,7		22,7
Matador	16,4	31,3		47,7
Recrut	40	12		52
Reetta			18,2	18,2
Sangaste	**128,8**	**91,4**	**249,5**	**469,7**
Tulvi	29,8	36,9		66,7
Vambo	14,5	4,9	2	21,4
Total	244,7	217,8	336,6	799,1

Seed multiplication and certification of different classes in the years 2010-2012 was as follows: pre-basic 18.5 ha (Sangaste Testing Station), basic 88.6 ha and certified seed 362.6 hectares.

The largest seed production area in Estonia was covered by winter rye ´Sangaste´. In 2010-2012 was in total produced 649 tons of certified seed. The market share of ´Sangaste´ was in 2012 approximately 56% of the total winter rye seed production area.

Table. Seed certification of rye in 2009-2012 (tons).

Variety	2009	2010	2011	2012	Total
Elvi	9000	7650	5000	78330	99980
Kapitän				28000	28000
Matador		30000	22000		52000
Recrut	148000	98000	30000		276000
Sangaste	79300	213400	164770	191800	649270
Tulvi	5950		60000	41000	106950
Vambo	127000	7800	60000	5894	200694
Total	369250	356850	341770	345024	1412894

The highest seed production volumes in 2009-2012 had agricultural enterprises JK Otsa farm (341.8 t), Rannu Seeme OÜ (150.0 t) and Jõgeva Plant Breeding Institute (56.0 t).

Table. Producers of certified seed of rye in Estonia in 2009-2012 (kg).

Producer	**2009**	**2010**	**2011**	**2012**	**Total**
Ants Haasmaa			7800		7800
Esite farm	7000				7000
FIE Janek Sõõrd			1670		1670
JK Otsa farm	55200	204200	66400	16000	341800
Jõgeva SAI	17100	9200	17100	12600	56000
Kesa-Agro OÜ			23200	11200	34400
Laja OÜ			3600		3600
Meelis Ohu				23000	23000
OÜ Kuresoo				24000	24000
Rannu Seeme OÜ			45000	105000	150000
Total	**79300**	**213400**	**164770**	**191800**	**649270**

„Support for cultivation of local plant varieties - measure of the Estonian Rural Development Plan for Action

The goal

The main goal of the project carried on in the frames of the European Union's Common Agricultural Policy to provide support to growers of 'Sangaste' rye and to the preserve genetic resources of an Estonian origin.

Introduction of measure and terms of application

The supportive measure is applied in accordance with the regulation No. 28 of the Minister of Agriculture of the 15th March 2010 "Requirements for support of cultivation of local plant varieties, procedures for application and project management". The organisation responsible for measure management is the Agricultural Registers and Information Board (ARIB). Eligible persons for application for the ´Sangaste´ winter rye cultivation support are self-employed person or a legal person who cultivates the land on a legal basis, is the owner of the land or holds a valid lease agreement. Field for which support is requested must be located in an agricultural area, which is included in the register of agricultural support and fields. All conducted activities must be documented in the field book. At the first submission the applicant commits himself to cultivate winter rye 'Sangaste' for five consecutive years at least on 5 hectares each year. In the support period is applicant obliged to use only certified seed of winter rye 'Sangaste' and to apply seeding rate of 140 kilos per hectare. Planted field must be maintained in each calendar year in proper condition at least until flowering. Seed packaging labels shall be submitted by applicant to the Agricultural Registers and Information Board.

All activities carried on shall be documented in the field book. If the applicant does not comply with this requirement, upon decision of the ARIB reduction of support by 5% is foreseen. In case of repeated violation of rules the reduction of financial support shall be up to 25%. The applicant must comply with all the household's agricultural land and agricultural activities with the decree No. 11 of Agricultural Minister of 17 February 2010 constituted for good agricultural and environmental conditions and requirements. The applicant must comply with all Statutory Management Requirements for Good Agricultural and Environmental Conditions, including the minimised use of fertilizers and plant protection products.
If the applicant violates the requirement to apply seeding rate of at least 140 kg of certified seed per hectare or does not maintain the field of winter rye variety 'Sangaste' until flowering the financial contribution will be reduced up to 40%. In case of repeated violation of terms by the applicant it is foreseen to reduce the contribution up to 60%.

Application of financial support

In 2009-2012 the number of applications for financial aid from the project „Support of cultivation of local plant varieties (rye variety ´Sangaste´)" has been steadily increased.

Following is provided an overview about development of rye variety ´Sangaste´ utilisation assisted by the measure.

Year	No of agricultural entities	Acreage ha	Allocated subsidy EUR
2009	8	308,17	9748,60
2010	20	630,62	20241,00
2011	30	839,30	22785,08

Largest area under the cultivation of ´Sangaste´ rye in 2010-2012 had JK Otsa Farm OÜ (864.88 ha), Otsa Mõis OÜ (309.07 ha), Voore Farm OÜ (149.86 ha) and Kämara Mahe OÜ (129.40 ha). There are applications of 47 agricultural entities in total for 1102.4 hectares accepted in 2012. The largest acreage of rye ´Sangaste´ have agricultural enterprises JK OTSA Farm OÜ (146.6 ha), Voore Farm OÜ (105.5 ha), Kase farm (95.2 ha), P.R. Maaviljeluse OÜ (72.0 ha), Kämara Mahe OÜ (62.1 ha), Otsa Mõis OÜ (62.1 ha) and Kuresoo OÜ (51.7 ha).

Summary

Rye bread has had very significant role in the history and culture of Estonia. There are long traditions, skills and experiences on bread making. Estonian rye bread is a pure natural product. Health benefits of rye bread for the human body have long been acknowledged. World´s latest food and healthy dietary trends have been spread across Estonia. The most valuable features of winter rye variety 'Sangaste' are very good winter hardiness and large kernels. For plant breeding and genetics long spike and strong straw are of interest. Useful features of rye 'Sangaste' are embedded during the long-term natural selection of genotypes and targeted plant breeding activities. Good winter- and disease resistance make it possible to minimize the use of chemicals to control weeds, plant diseases, and create good preconditions for the production of organic rye.

The researchers make attempts to use all the valuable properties of ´Sangaste´ in creation of new varieties, breeding lines or initial material for selection. The variety 'Sangaste' is used in plant breeding as a donor in Russia, Finland, Germany, Canada, Poland and other countries.

Estonia has developed a national strategy for the protection and conservation of biological diversity, which is implemented by the national programme " Collection and preservation of plant genetic resources 2002-2006" and development plan "Collection and preservation of plant genetic resources 2007-2013".

For Estonia's culture, history, science, and agricultural sector it is essential to promote cultivation and to safeguard the valuable population of winter rye variety 'Sangaste'.

This most important task has been completed by application of measure of the Estonian Rural Development Plan for Action „Support of cultivation of local plant varieties" for protection of rye variety ´Sangaste´.

Implementation of this supportive measure of the European Union's Common Agricultural Policy has significantly promoted cultivation of winter rye variety 'Sangaste', and ensured preservation of biodiversity and genetic resources of this outstanding local variety. This country-wide action has assured the fulfilment of international commitments taken by Estonia on preservation of plant genetic resources by ratification of the Convention on Biological Diversity.

Variety 'Sangaste' is currently the world´s oldest registered winter rye variety.

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