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PRODUCTION

Current situation and possibilities of development in the rabbit production sector

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After a decline lasting for several years, the quantity of live rabbits sold (12,761 tons) and the volume of export of slaughtered rabbits (5,615 tons of carcass) increased in 2001. Further changes took place in the production structure. In addition to the approximately 20,000-doe farm owned by two slaughterhouses, the number of farms with more than 200 does increased. The production conditions of these large farms fully conform to the EU requirements. Small farms can become viable if they form integrated production systems. In the year 2001, four rabbit slaughterhouses were in operation, with a rate of utilisation varying between 10 and 96%. Within the exports, the ratio of cut and processed products increased: whole carcasses accounted for 42% while cut products accounted for 58% of the total exports. With regard to the distribution of exports, the Italian share decreased while that of Switzerland increased. Italy continued to have the highest share (46%) of the exports, followed by Switzerland (42%), Germany (8%), Belgium (2%) and Russia (1%). Domestic consumption of rabbit meat continues to be negligible. Although total home-consumption rose, only 1.5% of the processed rabbits were sold on the domestic market.

BIOTECHNOLOGY, GENETICS

Innovative aspects for production, collection and transfer of rabbit embryos

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The availability of follicles suitable for (super) stimulation as well as optimal techniques for embryo recovery and transfer are important in rabbit reproduction. In the future, more attention should be paid to the period from peri-ovulation until pre-implantation which currently poses a bottleneck for rabbit reproduction.

Laparoscopic embryo recovery represents an alternative method to slaughtering or surgical methods for embryo collection. The present studies clearly demonstrate a highly efficient collection rate. The rabbits can be used repeatedly which increases the number of available embryos for further embryo transfers. The repeated collection following mating of animals showed that this minimally invasive technique does not negatively interfere with rabbit fertility. Furthermore, failure of ovulation can be easily detected by endoscopy prior to collection without any further manipulation. These animals can be treated again with hormones resulting in a second chance for embryo collection.

Is there any association between the κ -casein genotype of rabbits and its reproductive performances?

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Rabbit milk protein composition and the encoding genes have been described earlier. The polymorphism of the κ -casein gene was characterised in 1998 and it was shown that the mRNA from both alleles accumulates at similar levels and is translated into identical κ -casein. Those results made it unreasonable to assume that κ -casein polymorphism influences the quality of milk. Nevertheless, in our earlier observation, the frequency of the A allele was found to be higher in two populations of NZW rabbits, which was underlined recently in 12 European rabbit breeds. In one breed, the Chinchilla, the presence of the B allele was not detected, which may suggest that selection at an earlier stage has increased the frequency of the A allele. Based on those data, a preliminary analysis was performed on a limited number of New Zealand White rabbits to determine if the κ -casein genotype correlates with reproductive performance. The aim of this study was to verify and amplify the first results about the principles of the scheme and results obtained in three generations.

HOUSING, WELFARE

Nest building of domestic rabbit (Preliminary results)

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The present study aimed to investigate the impact of nest material and the time of its provisioning on the nest quality and later development of litters. The nest-building behaviour of 67 multiparous Pannon White does was studied in the experiment. A 24 × 55 cm nest box was secluded within an 84 × 55 cm breeding cage. The nest box was empty, and hay was put into the hay-pocket in the cage only. Four experimental groups were formed according to the time when hay was first provided (on day 26, 27, 28 or 29 after insemination, respectively). The entrance to the nest box was also opened on these days. The majority of does (70–84%) started to investigate the hay as soon as it was placed in the hay-pocket, and some of them (13–40%) completed building the nest on the same day (even as early as day 26 of pregnancy). The nest was judged to be good or excellent in 69–82% of the cases. The commonly used nest tray is three times longer than the size of a good nest, making nest formation difficult in some cases. Thirty-four percent of the does partially or completely blocked the entrance to the nest with hay. The timing of nest material provisioning had no effect on the time of kindling, but only late access to the hay (on day 29 of pregnancy), resulted in an incomplete nest. Twenty-eight percent of the nests had to be replaced with wood shavings bedding because of soiling after ten days. There was no significant difference in mortality rate between nests built of hay and the traditional nests made of wood shavings (6.9 and 6.0%, respectively). In nests with soiled bedding material, the mortality rate was slightly elevated

(9.9%). These results indicate that hay could be used as nest material if the nestbox size is reduced.

Free choice of rabbit kits among cages of different size (Preliminary results)

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Eight and 16 rabbit kits, respectively, were reared from 3 to 10 weeks of age (in two repetitions) in two completely identical, 1.5×1 m cage blocks made of wire mesh. The cage block consisted of 4 blocks of different sizes. The smallest (1×) cage had a floor space of 500×300 mm, and included a 10 cm feeder and a nipple. The size of the other cages, the number of drinkers and the length of feeders was twice (2×), three times (3×) and four times (4×) that of the first. The rabbits could move freely among the different cages through swing doors. A 24 hour video recording was made once a week. The number of rabbits staying in the individual cages was recorded every hour and, in repetition 2, the quantity of feed consumed daily was also recorded. Until 5.5 weeks of age the rabbit kits preferred to huddle together in groups. At 3.5 weeks of age they preferred to stay in the larger cage (4×), while at 4.5 weeks of age they stayed in the smaller (1× or 2×) cages (79–93% and 40–54% of the time, respectively). Equalisation of stocking density started from the 6th week, and from 8.5 weeks of age the rabbits equally utilised the available space. The number of rabbits in the cages and the feed consumption were similar, but in cages with more rabbits, the feed consumption was lower than expected, while in those with less rabbits it was higher than expected.

Effect of birth weight, milk supply status and feed quantity on the mortality of suckling and growing rabbits (Preliminary results)

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Newborn rabbits were divided into three groups on the basis of their birth weight (low=35–45 g, medium=53–58 g, high=65–70 g). Eight rabbits were placed in each litter. Half of the litters were reared by one doe and the other half by two does. After weaning at 21 days of age, half of the rabbits received *ad libitum* feeding while the other half were given restricted feeding. Restricted feeding means an access to feed for 10 hours a day from 3 to 6 weeks of age, for 9 hours a day from 6 to 9 weeks of age and for 8 hours a day from 9 to 12 weeks of age, which represented a feed intake corresponding to 85–90% of the *ad libitum* feed consumption.

Of all the factors studied, only the number of does nursing the young exerted a significant effect on mortality between 0 and 3 weeks of age. The mortality of young nursed by one doe was 22.8% while that of young nursed by two does was 9.4%. There were important differences in mortality between rabbits that had been born with a low, medium or high weights (23.1, 17.5 and 11.9%, respectively; $P>0.05$). None of the factors affected the mortality rate significantly after weaning at 21 days of age. The mortality difference between the most disadvantaged group (low birth weight, nursed by one doe, with restricted feeding) and the group being in the most advantageous situation (high birth weight, nursed by two does, with *ad libitum* feeding) at 0–3, 3–6 and 6–12 weeks of age was 21.8, 2.0 and 6.6%, respectively. The mortality of kits of low birth weight can be reduced by litter equalisation and by a better milk supply.

Nursing behaviour in wild and domestic rabbits

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It was demonstrated that approximately 30% of wild and 12% of domestic rabbit does kept in outdoor enclosures nurse their pups more than once a day. It was shown that most of nursing events (84.0 % in wild rabbits and 85.8 % in domestic rabbits) took place in darkness. There was a non-significant tendency that, with increasing size of the housing system (get-away-cages with 1x, 1.5x, 2x and 3x width), the frequency of nursing was decreased. Small rabbit breeds nurse their kits for shorter periods (approximately 192 sec) than larger rabbit does (up to 230 s on average). The mean duration of nursing events was 179 seconds in wild rabbit does. The highest nursing frequency combined with the lowest mean duration of a nursing event took place in the second week after kindling. A circadian rhythm of nursing activity with a peak after midnight (3 to 6 hours after onset of dusk) in wild rabbits and in the first two hours after onset of dusk in domestic rabbits was found. Light-dark change gives a significant cue for nursing behaviour especially for domestic rabbit does. A first analysis of vocalisation in rabbit pups was made. The preliminary results show that during nursing a smacking sound was heard. This indicates real nursing.

REPRODUCTION

Influence of nursing method on the performance of rabbit does

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To study the effect of nursing method on reproductive performance, 232 rabbit does were divided into four experimental groups: FF: free nursing from kindling to weaning at 35 days of age; FC: free nursing from day 0 to 7 and once-a-day nursing from day 8 to 17; CF: once-a-day nursing from day 0 to 7 and free nursing from day 8 to 17; CC: once-a-day nursing from day 0 to 17. From day 17 of lactation to the time of weaning (35 d), free nursing was used in all groups. During controlled nursing the does could visit the nest box between 8 and 9 a.m. every day. Insemination was performed on day 10 *post partum*, within 15 minutes after nursing. The results of three consecutive kindlings were evaluated. The nursing method did not influence sexual receptivity at the time of insemination, but in group CF sexual receptivity was 10% lower (57, 53, 47 and 59% for groups FF, FC, CF and CC, respectively). As compared to FF does, in the other groups both the pregnancy rate (56% vs 69, 62 and 58%, respectively) and the kindling rate (43% vs 58, 49 and 45%, respectively) improved slightly but the increase was not statistically significant. No significant differences were found between the groups in total litter size, live-born litter size and litter size at weaning. The only statistically significant difference was found between Group FF and Group FC in litter size at 21 days of age. Rabbits of Group FC showed the best performance in the

experiment. From the results it can be concluded that change-over from free to once-a-day nursing before insemination can be a successful biostimulation method for improving reproductive performance.

Effects of nutrient supply at fetal, suckling and growing age and of age at first breeding on the performance of does (Preliminary results)

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Newborn rabbits were divided into three groups on the basis of their birth weight (low=35–45 g, medium=53–58 g, high=65–70 g). Eight rabbits were placed in each litter. Half of the litters were reared by one doe and the other half by two does. After weaning at 21 days of age, half of the rabbits received *ad libitum* feeding while the other half were given restricted feeding. Restricted feeding meant access to feed for 10 hours a day from 3 to 6 weeks of age, for 9 hours a day from 6 to 9 weeks of age, for 8 hours a day from 9 to 12 weeks of age, for 7 hours a day from 12 to 15 weeks of age, and for 6 hours a day from 15 weeks of age to the first insemination. This represented a feed intake corresponding to 85–90% of the *ad libitum* feed consumption. In the four days preceding the first insemination, rabbits on restricted feeding received feed *ad libitum* (flushing). All the 12 groups were divided into two halves at random: half of the does were inseminated artificially at 15.5 weeks of age and the other half at 18.5 weeks of age. The results of the first three kindlings were evaluated.

All the factors studied exerted a significant influence on the body weight of does. Does that had been born with a high weight, reared by two does and bred at 15.5 weeks of age were larger. At the first kindling the *ad libitum* fed does were larger, while at

the third kindling those having received restricted feeding weighed more. The number of inseminations necessary for one kindling was significantly lower in the group reared by one doe and fed *ad libitum*. Does that had been born with a body weight of 53–58 g (medium birth weight) had significantly higher total and live-born litter sizes than the does that had been born with a low or high weight. Litter weight at 3 weeks of age was higher in the group of does that had been born with a high weight, reared by two does, received restricted feeding and bred at an older age; however, the differences, though technically important, were not significant.

NUTRITION

Effect of double suckling on some physiological properties of the digestive tract of young rabbits

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The Pannon White rabbits used in these investigations were either reared by a traditional method, i.e. suckled once a day from birth and weaned on day 35 (E35), or suckled twice a day by two mothers from birth until weaning at the age of 21 days (K21) or 35 days (K35).

Rabbits suckled twice (K) had significantly higher growth rate, i.e. body weight and the weight of the GI tract was higher until weaning at the age of 21 days. After that rabbits suckling twice (K35) had significantly higher growth rate than rabbits in the groups K21 and E35. Suckling twice resulted in higher gastric and caecal pH. Changes in lactase, maltase,

sucrase and trehalase activity of the different intestinal parts were influenced age rather than by weaning and suckling. Rabbits suckling twice (K35) had lower maltase and trehalase activity, while lactase activity stayed on a higher level. Maltase activity was significantly higher in early weaned rabbits (K21) than in groups E35 and K35. Sucrase and lactase activity decreased, while maltase and trehalase activity increased with advancing age. By the seventh day, bacteroides were present in large quantities (10^9) in the caecum. There was a temporary increase in the number of coliforms around weaning in K21 rabbits, while in K35 young the number of coliforms remained at a higher level.

Effect of dietary cellulase enzyme supplementation on the performance of early-weaned rabbits

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Sixty NZW rabbits were weaned at 23 days of age and the littermates were divided into two balanced experimental groups based on litter size and individual weight at weaning. Until nine weeks of age a cellulase-hemicellulase enzyme complex supplemented (7040 FPA /100 kg) diet was offered *ad libitum* to the treated group, while a diet with similar composition but without enzyme addition was freely available for the control animals. After nine weeks of age both groups were fed the same untreated control diet. The rabbits were individually housed in wire net cages. The beneficial effect of enzyme addition primarily emerged during the first two weeks after weaning when the five week old treated rabbits reached comparable body

weight (929 vs 947 g) but with a significant 28% lower feed intake (86 vs 118 g) and 24% better feed conversion rate (1.90 vs 2.51) compared to the control. Beyond 9 weeks of age the treated group showed a significant 17% higher daily weight gain (44.1 vs 37.9 g/d) and reached a 3% higher body weight at 11 weeks of age (2778 and 2692 g in the treated and control groups, respectively). There was 21% poorer feed conversion by the treated group between 9 and 11 weeks of age (3.26 vs 2.59 g/g) but their feed intake increased at a higher rate, i. e. by 32% (196 vs 133 g/d in the treated and control animals, respectively).

Amylase supplementation of rabbit diets

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The effects of alpha amylase supplementation on performances in NZW rabbits weaned at 25-d of age were studied over a period of five weeks. BAN 480 L amylase (Novo Nordisk, Denmark) was sprayed on the surface of the diet fed *ad libitum* to the rabbits (n=30). Rabbits in the control group (n=30) were fed untreated diets. There was no difference ($P>0.05$) in body weight gain or feed efficiency between the groups (1676.9±128.3 g, 1.56±0.03 kg/kg vs 1637.8±205.1 g, 1.57±0.04 kg/kg, treated vs control, respectively). But according to the analysis of SD (*F*-test), the amylase supplementation resulted in more consistent performance of rabbits, particularly until 39-d of age ($P<0.001$). Moreover, none of the treated rabbits died of intestinal disorders, while two of the control ones did.

Relationship of genotype, body composition and sexual maturity in females of different rabbit breeds

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A trial using 26 6-week-old female New Zealand White and 22 7-week-old Hungarian Giant rabbits was carried out to establish the total body composition and sexual maturity in relation to feeding intensity. Animals in each breed were divided into two groups: the control ($n_{\text{NZW}}=13$; $n_{\text{HG}}=11$), which were fed *ad libitum* (AL) while their sisters ($n_{\text{NZW}}=13$; $n_{\text{HG}}=11$) were fed 70% of the *ad libitum* intake (RS). The energy concentration of the pelleted feed mixture was 11.5 MJ/kg DE with 15.9% crude protein. The trial lasted from the ages of 6 to 18 weeks for the NZW and 7 to 24 weeks for the HG animals. At the end of the trial the total body composition was measured in all rabbits. In order to follow ovarian and pituitary activity, hCG and GnRH hormonal treatments were given four times to each animal during the trial. At the end of the experiment, the average body weight was significantly lower in the RS groups (NZW: 84.4%; HG: 89.7%) when compared to the AL groups. During the trial the average body weight gains for the AL group were 80.9% in NZW and 87.5% in HG lower than the RS groups. As a result of restricted feeding in both breeds, the ash and protein content expressed as functions of both total body and dry matter were increased, while the fat concentration decreased. Amongst the individuals of both breeds, animals that had the highest body fat content became pregnant the earliest. HCG promoted sexual maturity in both breeds with AL feeding, while with RS no such effect was observed. In the case of GnRH administration, there was no difference between breeds and feeding levels regarding sexual maturity. It was concluded that restriction of feeding intensity of growing breeding rabbits is a delicate procedure

and a 30% decrease exerted unfavourable effects on the body composition, and consequently, slowed down the reproductive maturation of does.

Effect of the genotype (predisposition for fattiness) and feeding (energy intake) on the performance of growing rabbits

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Pannon White rabbits selected for increased (POZ) or reduced (NEG) total body fat content were weaned at four weeks of age and fed three isocaloric diets (12.87, 12.83 and 12.84 MJ/kg DE respectively) having different nutrient density (crude protein: 17.5, 19.8 and 21.9%; crude fibre: 12.9, 13.4 and 14.7%, respectively). Compared to the *ad libitum* fed group (HE), the daily ration was reduced for the treated groups by 10% and 20% (ME and LE, respectively). Thus, the energy intake was reduced while the intake of protein and other ingredients remained similar. Genotype had a significant effect on daily weight gain and feed conversion (36.7 and 37.7 g/day, 3.25 and 3.07 g/g in groups POZ and NEG, respectively). Body weight gain was 41.4, 37.3 and 33.9 g/day, body weight at 12 weeks of age was 2932, 2704 and 2521 g, the feed conversion rate was 3.28, 3.12 and 3.43 g/g and the mortality rate was 29.5, 30.8 and 4.8% in groups HE, ME and LE, respectively. According to these results, the performance of growing rabbits is determined primarily by the energy intake, and it does not depend on the intake of other nutrients. The mortality rate decreased as a result of high dietary fibre content and lower energy intake.

GROWTH AND MEAT

Effects of chronic electrical stimulation on the fatty acid profile of meat type rabbits' *m. longissimus dorsi*

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Two groups of 10 Pannon White male rabbits were treated with transcutaneous electrical nerve stimulation (TENS) for a trial period of 50 days, starting at four weeks of age. The *m. longissimus dorsi* was investigated by means of gas chromatography to follow the changes induced. Rabbits were fed an experimental diet supplemented with 4% sunflower oil. Statistically provable differences exist between the groups C16:0 (palmitic acid), C18:0 (stearic acid), C18:1 n9 (oleic acid), C18:2 n6 (linoleic acid), C20:1 n9 (gondoic acid), C20:5 n3 (eicosapentaenoic acid) and C22:6 n3 (docosahexaenoic acid). The electrical stimulation may similarly affect the muscle fatty acid composition like aerobic physical load, on the basis of the above results. However, authors hypothesize also further microstructural and peroxidative changes in the muscle, which need examinations to complement these, in the field of fatty acid composition.

Effect of age and body weight on some slaughter parameters of growing rabbits

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A total of 238 Pannon White growing rabbits were slaughtered at 10.5, 12 or 13.5 weeks of age, at an

average body weight of 2.53, 2.84 and 3.15 kg, respectively. Within each age groups five body weight categories were formed in such a way that the weight difference between two neighbouring age groups and weight categories was equally 0.3 kg. The design of the experiment permitted the separate examination of the effects exerted by age and body weight on some slaughter traits. Older and heavier rabbits equally had a significantly higher dressing out percentage. The ratio of the fore part significantly decreased with the advancement of age, but it was significantly higher in rabbits of higher body weight. The ratio of the intermediate part was not influenced by age, but it was significantly higher in the heavier rabbits. The ratio of the hind part significantly increased with the advancement of age, but decreased with increasing body weight. The weight of the perirenal fat was lower in the older groups, but it was significantly higher in the heavier rabbits. Thus, it can be concluded that age and body weight sometimes have a synergistic effect while at other times exert an opposite influence on the ratio of the different carcass parts.

Effect of age and body weight on chemical composition of meat

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Pannon White growing rabbits were slaughtered at 10.5, 12 or 13.5 weeks of age, at an average body weight of 2.53, 2.84 and 3.15 kg, respectively. Within each age groups five body weight categories were formed in such a way that the weight difference between two neighbouring age groups and weight categories was equally 0.3 kg. The design of the experiment permitted the separate examination of the effects exerted by age and body weight on chemical composition of meat. Ten hind leg (HL) meat and 10

m. longissimus dorsi (LD) samples were subjected to chemical analysis from each group (from a total of 135 animals). The average moisture, crude protein, crude fat and crude ash content of the two different meat samples was 74.0, 22.2, 3.65 and 1.23%, respectively, in the HL and 74.6, 23.4, 0.80 and 1.31%, respectively, in the LD. Protein and ash content was significantly ($P<0.05$) higher in the LD while fat in the HL. With the advancement of age the water content of the HL increased (73.5→74.4%; $P<0.05$), while that of the LD did not change (74.5→74.7%). With the increase of body weight, water content decreased both in the HL (75.1→72.6%; $P<0.05$) and in the LD (74.8→74.2%; $P<0.05$). Neither the body weight nor the age affected the crude protein content of the meat samples significantly. With the advancement of age the fat content of both the HL (4.60→3.01%; $P<0.05$) and the LD (0.95→0.75%; $P<0.05$) decreased. With the increase of body weight the fat content of both types of meat samples rose substantially (in the HL: 2.30→5.03%; $P<0.05$; in the LD: 0.74→1.21%; $P<0.05$). The crude ash content of the meat samples did not depend on either the age or the body weight.

Carcass traits and meat quality of rabbits reared in cages or pens

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One hundred and twenty NZW rabbits were reared in 40×40 cm cages (3 rabbits/cage, 18 rabbits/m²) and 3 x 3.3 m pens on deep litter (80 rabbits/pen, 8 rabbits/m²). Rabbits in the cage-reared group had higher pre-slaughter body weight (2.44 vs 2.32 kg, $P<0.01$), higher dressing percentage (62.7 vs 61.6%, $P<0.01$), lower ratio of the fore part (31.4 vs 32.3%, $P<0.05$)

and hind part of the carcass (37.9 vs 40.3%, $P<0.001$), and a higher proportion of the intermediate part of the carcass (20.7 vs 37.5%, $P<0.05$). Important differences were found in the quantity of perirenal fat (20.7 vs 10.1 g, $P<0.001$) and in the perirenal fat to body weight ratio (0.83 vs 0.42%, $P<0.001$). The hind leg and *longissimus dorsi* contained less water (73.9 vs 75.0% and 74.0 vs 74.6%, $P<0.001$) but more fat (3.36 vs 2.48%, and 0.90 vs 0.65%, $P=0.023$) and protein (21.5 vs 21.3%, and 23.9 vs 23.6%, $P=0.015$) in rabbits kept in cages compared to those in pens. The method of keeping had no influence on the ash content and pH value of the meat samples.

Selection of Pannon White rabbits based on computerised tomography

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From a population with 40-45 g/day body weight gain, rabbits with higher (i.e. 44-50g/day) values were chosen for CT scanning. Based on the scans taken between the 2nd and 3rd, and the 4th and 5th lumbar vertebrae, the cross sectional area of *m. longissimus dorsi* was measured and the average of the two values was calculated (L value). The linear regression between the L value and body weight was developed, and the rabbits with the most values above the regression line were selected. The L value of the selected animals exceeds the population average by 1.4-1.9 cm². On the basis of our previous studies, nearly 1% higher dressing percentage can be obtained in each following generation.

