DENDROLOGY

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GROWTH AND DEVELOPMENT PECULIARITIES OF *SABAL MINOR* (JACQ.) PERS. IN NIKITA BOTANICAL GARDENS

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Introduction

Palms in landscaping of South Coast of the Crimea (SCC) are rather important for today. These plants are possible to improve ornamentality and aesthetic value of resort landscaping, especially if biological characteristics of a definite cultivar correspond growing conditions, when all growing capacities of any exotic plant can be revealed completely. Trying to find out reasons and factors that favor effective growth and development of *Sabal minor* (Jacq.) Pers. possesses scientific novelty and practical value in terms of the region. This cultivar has got a long 200-years history of introduction testing in Arboretum of Nikita Botanical Gardens (NBG) and now it is considered as quite winter-resistant one. But our inspection of SCC landscaping and 30-years observations of *Sabal minor* experimental plants revealed some specimens died as growing conditions didn`t respond to their biological requirements. Based on analysis of all environmental factors which anyhow impact on plants, we developed agrotechnical recommendations of *Sabal minor* successful cultivation on SCC. The second urgent task was to investigate biology and reproductive capacity of this cultivar being introduced. Study of blossoming process, flower pollination, fruiting, seed quality and their growing biological characteristics will make it possible to obtain seeds and cultivate plants out of local reproduction seeds. Wider introduction of *Sabal minor* on SCC allowing for its biological requirements and growing conditions will enhance its ornamental properties. New approaches in landscape architecture aimed at use of *Sabal minor* in arrangement of green spaces will strengthen ornamental value and aesthetic view of landscaping.

Objects and methods of the research

Objects of our investigations were collection plants of *Sabal minor* in Primorsky park of NBG Arboretum (clump 148 and 154), introduction of 1913 and 1914, and in the Lower park (clump 107), introduction of 1984. Besides all revealed plants of this cultivar either on SCC or within Sevastopol were observed.

The purpose of this work is 1) to reveal reasons why some plants of *Sabal minor* die on SCC applying comparative analysis of climatic data of habitat and area of introduction and to develop recommendations aimed at its successful cultivation; 2) to research peculiarities of *Sabal minor* growth and development on SCC and find out factors that have negative effect on plant vegetative and generative spheres; 3) to study seed efficiency of plants, determine quality, quantity and size of obtained seeds, their real and potential capacity.

The principal task was to study biology of seed germination and develop recommendations for *Sabal minor* seed propagation with further adoption at landscaping of SCC and Sevastopol.

Methods of the research: comparative and analytical methods applying climadiagrams by way of Walter and Leith; visual phenological observations using common methods; observation method of damages caused by frosts during severe winters applying our own working - 6-point scale of palm frosting-up, where 0 – no damages; 1 – tops of leaf segments are damaged; 2 – a half of leaf plate is damaged; 3 – leaf plate is damaged till the point of segment crossing (rachis); 4 – the whole leaf plate and a part of footstalk are damaged; 5 – all crown leaves are damaged, but roots and formative tissue of perennating and dormant buds are kept viable and a plant is capable to recover; 6 – all vital organs are damaged and a plant dies [1, 2].

Climate of *Sabal minor* native habit, the USA northern border, and introduction regions on the Black Sea Coast of Russia is illustrated by climadiagrams, made by method of Walter and Leith, with applications (fig.1). They present a fundamental difference of climate types, what allows to develop agrotechnology of *Sabal minor* cultivation in any introduction regions [3, 9].

Symbols that explain climadiagrams: **a** – a settlement, altitude of observations above the sea level (in brackets), in the second line it`s an index of meteorological point and its coordinates; **b** – average annual temperature (°C) and an average amount of precipitations (mm); **c** – period of observations (in square brackets), years; **d** – a curve of an average monthly amount of precipitation (thick line); **e** – a curve of an average monthly temperature (thin line); **f** – a curve of an average temperature minimum (dashed line); **g** – a curve of the absolute temperature minimum (dotted line); **h** – an absolute minimum since the beginning of the XX century, °C.

Curves of temperature and precipitations parameters are correlated, that is 10°C corresponds 20 mm of precipitations. If a precipitation curve is below the curve of an average monthly temperature, space between these lines is dotted (dry season). If the precipitation curve is above, space is dashed (humid season). Precipitations of 100 mm has a ratio of 1:10 and are blackened. Unfavorable cold periods are pointed on abscissa with different spaces for each month: colored – average monthly minimum is below 0°C; dashed – absolute minimum is below 0°C.

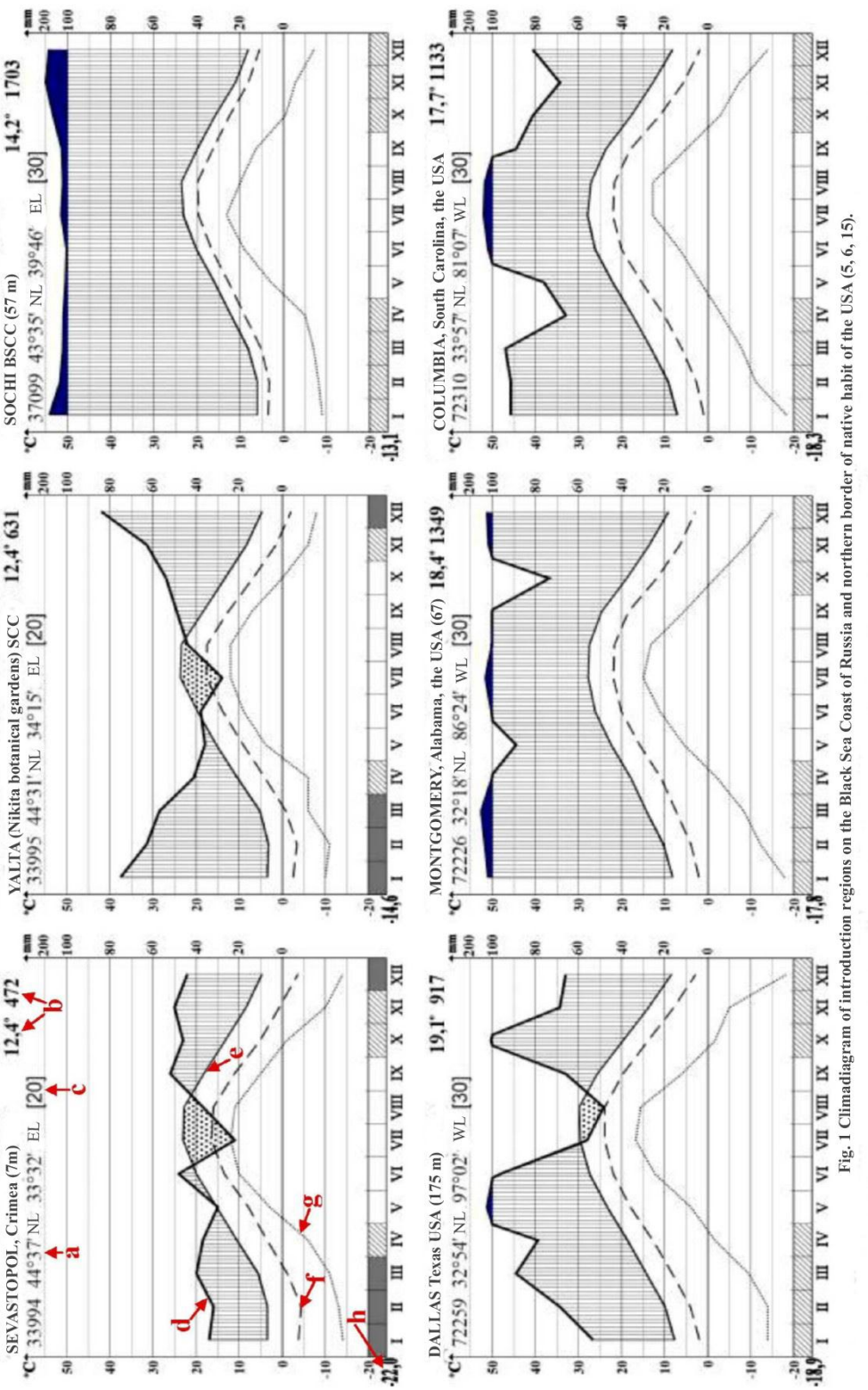


Fig. 1 Climadiagram of introduction regions on the Black Sea Coast of Russia and northern border of native habit of the USA (5, 6, 15).

During dry vegetative period we observed drought damages according to plant growth and crown state. Biometrical investigations included balance of new and died crown leaves, quantity and length of developed flower stacks, quantity and quality of obtained seeds, real product (percentage from potential crop capacity of inflorescences, that is from the total amount of set ovules in the inflorescence). All measurements were carried out using the caliper, linear scale and tape measure. Study results of seed quality, plumpness of endosperm, embryo and external covers gain special scientific value. Longitudinal sections and seed preparation aimed at embryo isolation to fix it, were conducted using scalpel. Seed germination of *Sabal minor* was researched in laboratory on moistened filter paper using Petri dish.

Results and discussion

Sabal minor is a shrubby palm with underground stem, sometimes with overground stem, but not large. Root leaves are fan-shaped, hard, glaucous and green, depending upon conditions they are capable to reach 30 sm - 1,5-2m. Footstalk is equal to leaf plate length or longer a bit. Footstalk edges are bare, sharp, scion on the end of footstalk situated before leaf plate ranges from 2-3 till 4-7 sm, with turned up edge. Leaf plates of 70-100 sm are sectioned radially into folded linear segments, about 40 units. The segments are shortly sectioned and pointed to the end, but not sharp, width ranges from 3 till 6 sm; section of the middle segments is longer than section of the edge ones. A number of inflorescences on one palm varies from 1 till 3, they have complicated and paniculate structure, they are upright, branchy at the top, length gets 2-2,5 sm, width – 2-3 sm at the foot. Flowers are actinomorphous 3,5-5,2 sm across diameter. A fruit is a global drupe with thin seed vessel, 7-10 mm across diameter, brown and black or rather black, glossy. Seeds are rounded 5-7 mm across diameter, brown, flattened a bit (fig.2).

Natural areal of *Sabal minor* is in the USA from the central Florida up to the eastern part of Northern Caroline, in west from Oklahoma till the central Texas (fig.3). At the same time unrelated areas were found out in the Eastern Sierra Madre, Nuevo Leon, Mexico. This cultivar of *Sabal* is the most spread in the USA than others. It prefers marsh and damp soil, along river and reservoir banks, sometimes it forms dense growth; it can be found in drier areas as well, for instance on the slopes of dry hills in Texas. *Sabal minor* plants that grow in Louisiana *(Sabal minor* (Jacq.) Pers.*)'louisiana'*, have got rather big and developed stems, it was considered as a separated cultivar. According to current classification it is one of *Sabal minor* forms [4,7,8]. In countries with subtropical climate it is cultivated as an ornamental plant [10, 11, 12].

Sabal minor is believed as one of the most frost-resistant palms in the world [9, 13]. Having compared climadiagrams (see fig.1, fig.3) of points, situated on the northern border of *Sabal minor* growing area in the USA, it`s possible to conclude that temperature regime is almost the same: absolute minimum since the beginning of XX century ranges from (-18,9)°C in Dallas till (-17,8)°C in Montgomery; average minimum of the coldest month (January) isn`t below 0°C with parameters from 0,9°C in Columbia till 2,1°C in Montgomery. Higher temperature in Montgomery is caused by more southern position than other points according to growth area.

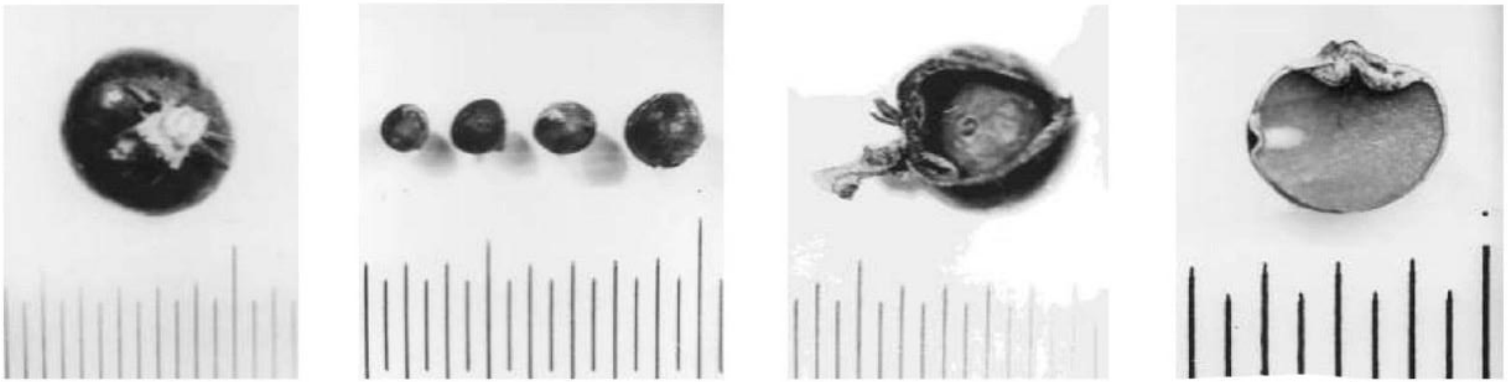


Fig. 2 Sabal minor fruits: a) general view; b) size variations; c) pericarp and seed; d) seed longitudinal section

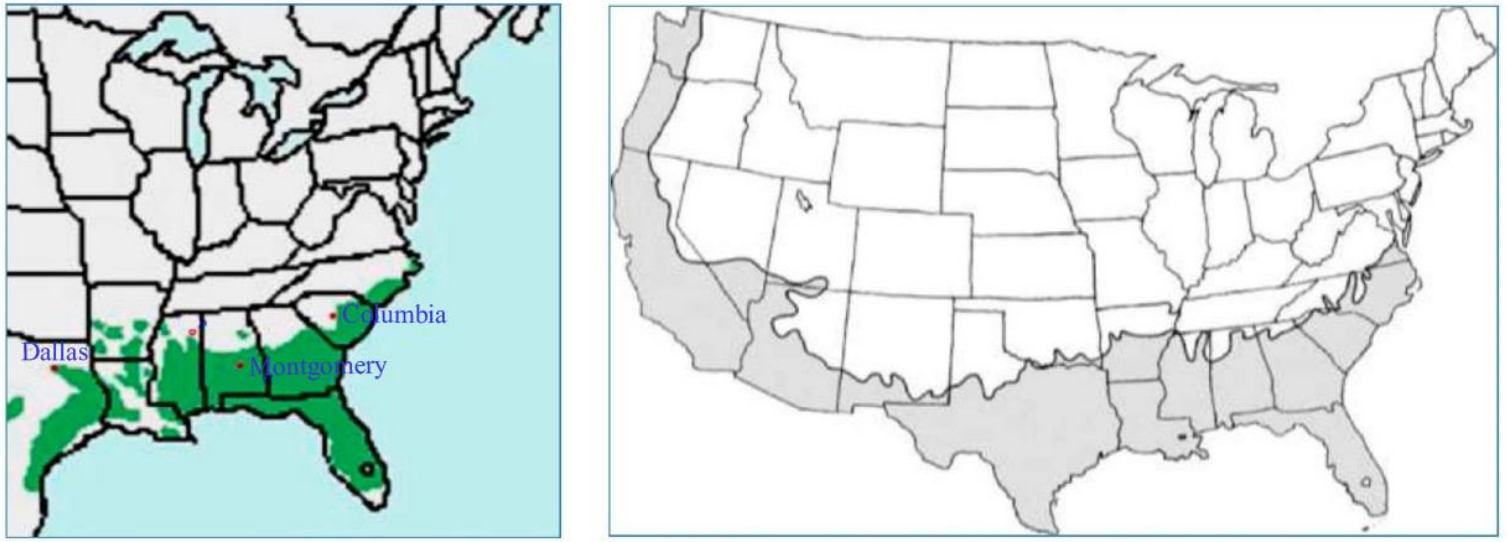


Fig.3 Natural habit in the USA [14] and potential range of plantations [11].

Comparing temperature parameters in the Crimea, Yalta (Nikita Botanical Gardens) and Sevastopol, it`s clear that average annual temperature is the same: 12,4°C, though difference is noticeable at average minimum temperature of the coldest month (February): (-4,4)°C in Sevastopol and (-3,4)°C in Yalta, especially it concerns absolute minimum parameters since the beginning of XX century: (-22,0) °C for Sevastopol and (-14,6) °C for Yalta (Nikita Botanical Gardens.

Such difference at absolute minimum is caused by geographical position of Sevastopol that is absence of barrier that could protect it from cold fronts, in comparison with SCC; this factor gains a great importance for species composition of vegetation. The following should be noted that difference of altitude above the sea level 200 m) reduced considerably the gap between temperature parameters of both points of observation.

Climate of Sochi is milder and more humid 1,5-1,9 times in comparison with the USA points. Average minimum of February makes 3,3°C allowing for absolute minimum of 13,1°C below zero.

Amount of precipitation in study points of the Crimea is much less (1,5-2,9 times) than on the border of *Sabal minor* areal in the USA. Absolute minimum of temperature in Yalta (Nikita Botanical Gardens) are considerably smoothed, but parameters of Sevastopol exceeded parameters of the USA. Only in the city of Okolona, Mississippi what is situated to north, in the region of growth areal border, absolute minimum was fixed – (-21,1) °C, that is possible to compare with Sevastopol - (-22) °C having average minimum of January of 0,3°C. Average minimum of the coldest month in comparison with Columbia for Nikita Botanical Gardens is 4,3°C lower and 5,3°C lower for Sevastopol. Therefore on Sevastopol coast minimum winter temperature is lower, but possible to compare with northern border of the USA areal.

Northern border of growth areal in the USA is situated in the zone of frost-resistance USDA 8a, what corresponds to the range of average annual minimum temperatures (-9,4) - (-12,2) °C. Reference [11] notes that potential range of plantation is from 7b till 11 of frost-resistance zone USDA (see fig.3), that is before the average annual minimum temperature (-15) °C. According to climadiagram of Sevastopol (see fig.1) absolute minimum for 20 years of observation was no less than (-14) °C. It should be noticed that it concerns coastal region of Sevastopol only.

For the first time *Sabal minor* was introduced in NBG by Ch.Ch. Steven in 1814, taken from greenhouse of dukes Razumovskys` botanical garden in Gorenki. S.G. Saakov [7, 8, 9] notes that specimen died and the reasons being unknown. He didn`t point the year of death and the plant age. 100 years later *Sabal minor* was introduced in Nikita Botanical Gardens repeatedly, in 1913 from botanical garden of Sukhumi and in 1914 from St.-Petersburg botanical garden. Majority of plants were planted in Primorsky park of NBG Arboretum on clumps 148 and 154, and some of them were left in NBG greenhouse №2 to have an opportunity to preserve cultivar as it is, if specimens planted into open ground died. Setting palm garden in the lower park of NBG Arboretum (clump 107) in 1984, 5-years seedlings of *Sabal minor* were planted; they were introduced from Sochi. Having inspection of SCC parks in 1985, single specimen of *Sabal minor* was found in Simeiz only. By the beginning of 2000s in landscaping of private areas on either SCC or in Sevastopol they started to plant not only usual fruit-bearing and exotic trees, but palms as well. In 2003 repeated inspection of SCC and Sevastopol parks was carried out; considerable amount of *Sabal minor* was found. Since 1990 the single specimen growing in Simeiz, mentioned above, was also under observation. Since 2003 specimens, planted in Sevastopol were regularly observed, and especially thoroughly during sever winter of 2005/2006 and 2014/2015.

In Primorsky park, Simeiz, there are plants with typical form, grey and green leaves, while Lower Park, Sevastopol, presents *Sabal minor* f. Louisiana with blue leaves.

Primorsky park of NBG has got three fruit-bearing *Sabal minor* plants of more than 100 years old , which don`t reach (crown leaves) even 1,5 m high. A number of crown leaves ranges from 5 to 7 on average. Annually 1-3 new leaves appear and the same number of leaves dies; in this way habit characteristics of the same specimen in 1984 tended to keep unchangeable in comparison with 2014. It`s possible to explain by rubble soil of clumps, that block development of the underground stem and insufficient irrigation reduces growth of vegetative and reproductive plant organs, what sometimes causes chlorosis. Besides outside pneumatophore of the end of U-shaped stem transforms into dry bunch of mass what resembles dried bottom of leave stalks. Practically plant reduces organ that supplies with air like unnecessary one, if it doesn`t grow within marshes. And *Sabal minor* is a helophyte, which should be planted only on projected horizontal areas with sufficient moistening or even if to irrigate enough during vegetative period.

Before planting, soil of projected area is to be prepared properly, at the same time it should be loose without rubble fractions, better loamy. On SCC the best ratio of soil ingredients for *Sabal minor* is the following: 4 parts of chernozem soil, 2 parts of bank sand, 1 part of peat and 1 part of rotted dung. Following these scheme will make it possible to develop full-grown large underground stem with cone-shaped outside pneumatophore, vigorous leaf crown, sufficient number of full-grown reproductive organs and produce germinated seeds, enough for mass cultivation in nurseries with the purpose of wide *Sabal minor* introduction in landscaping on SCC.

Data of long-term phenological observations shows that beginning of growing process after forced dormant season in winter occurs on April the 12-16th and lasts till November the 27th – December the 16th. True dormancy isn`t common for this cultivar. Vegetation period of *Sabal minor* is limited by negative temperature either during autumn-winter or early-spring period and makes 229-233 days on average. Formation of a flower-bearing stem out of the central bunch of leaves starts with growing of the main inflorescence arrow from May the 18th and lasts till June the 11th. As a rule, 5-7 days later arrows of elemental inflorescences differentiate out of the main inflorescence arrow and in 1-3 days flowers appear. High blossoming occurs from June the 10th till 30th and lasts up to June the 21 – July the 8th. Common blossoming period of *Sabal minor* makes about 2 weeks, but sometimes it is 4-7 days more or less. Though according to long-term data blossoming terms are considerably increased and range since May the 24th till June the 26th, what is more than a month flowering period (fig.4). Seed setting during blossoming happens during 1-3 days after flower formation. Order of flower pollination by insects depends upon their formation term and happens 1-3 days later since it is available for pollination. Pollinated or non-pollinated flowers of the main and elemental inflorescences fall out in 2-4 days after formation.

Fig. 4 *Sabal minor* in blossom and its flowers. Primorsky park, NBG

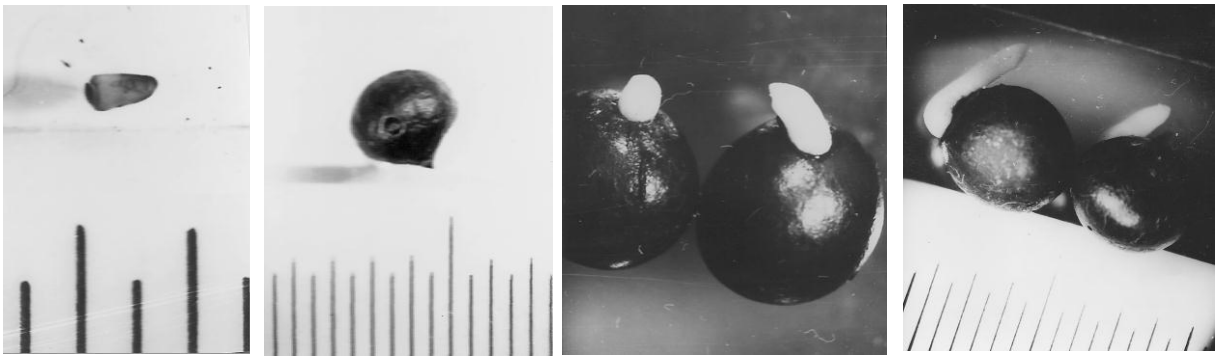
Fig. 5 Fruictiferous *Sabal minor* and its fruit-bearing shoot. Primorsky park, NBG.

The fall makes 27-36% of the total amount of the generated ovules in the inflorescence.

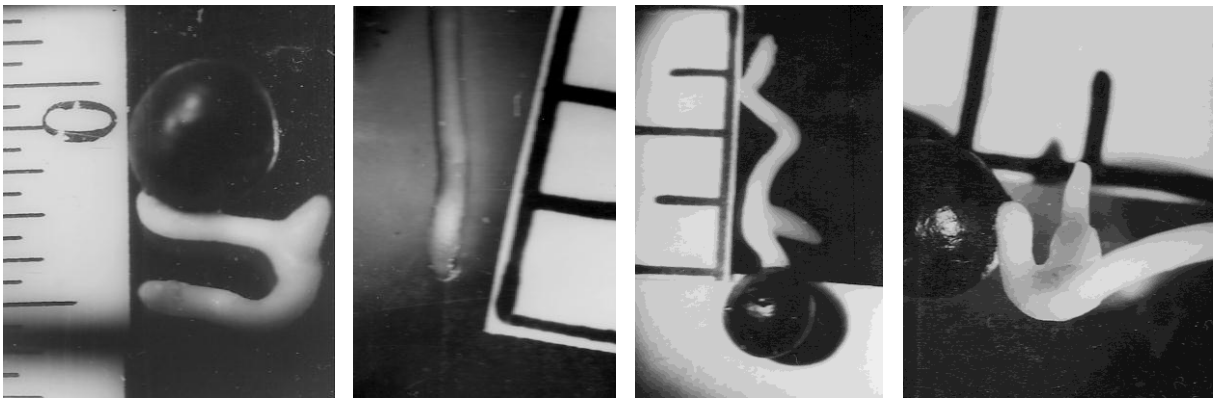
Falling of set seeds happens on their setting and lasts for a week and makes 14-23%. Sum of dead flowers and rejection of some fruits makes 41-59%. Total amount of ovules per one inflorescence has been registered for some years and ranges from 1897 till 2785. In conclusion there are from 1000 till 2000 seeds per one main and 7-11 elemental inflorescences. Actual crop capacity of one inflorescence makes 986-2005 fruits. That is further fruit falling caused by different factors in terms of their ripening ranges from 11 till 13%. Ripening of left set seeds on the main and elemental inflorescences occurs as a rule till the end of *Sabal minor* vegetative period. Coefficient of crop capacity, ratio of real seed productivity and potential one, makes 52-72%. By the end of period seeds ripen completely under conditions of SCC (see fig.2, fig.5).

Quality of seeds, annually yielded in Primorsky park of NBG Arboretum was determined by method of flotation; in this way viable seeds makes more than 90% while unvital – less than 10% of the total amount. Size of *Sabal minor* fruits and seeds harvested from the experimental plants of NBG are 1/3 less in comparison with plants that grow in natural areal and have got the following parameters: fruit diameter with pericarp is x=7,29 mm; Sx=0,10 mm; V=13,25%, without pericarp x=4,08 mm; Sx=0,03 mm; V=7,59%. Probably it is caused by individual inherited peculiarities or unfavorable soil and climatic factors in the introduction region (stoniness and insufficient soil moistening). Such an ecological heterogeneity of seeds often reveals in case of introduction, that is changing cultivation conditions [3]. Further introduction of *Sabal minor* into landscaping on SCC, having conformity of growing conditions to biological requirements of cultivar, will favor investigation of these problems.

Sprouting of *Sabal minor* seeds without pericarp in Petri dishes on moistened filtered paper, was carried out on windowsill having complete solar illumination and indoor temperature (+16, 19°). On the third day some seeds has got germ of future root (according to classification by I.G. Serebryakov [4] this is a shoot of the first order). Process of shoot lengthening of the first order lasts for 6-11 days within all group of seeds (100 units). Some seeds aren`t capable to germinate (3-4%) in spite of that further preparation determined high quality of all structures. In 1-2 days pileorhiza appears on the germ, what protects growth of apical meristems from new underground conditions, supposed by genetics. Having reached 1-2 sm long, germ forms “heel” what develops future stem (second-order shoot), later it transforms into perennial bud with formation of leaf crown and terminal inflorescences, and first-order shoot forms all structures of the underground part of plant. In this way growth velocity of apical meristems with negative geotropism is twice more than those with positive direction. Later it provides development of underground U-shaped stem (fig.7) with further full-grown powerful cone-shaped overground pneumatophore.



a **b** **c** **d**



e **f** **g** **h**

Fig. 6 Peculiarities of *Sabal minor* germination: a) seed embryo; b) location of embryo; c) sprouted seeds; d) root germ; e) phase of germ development; f) root and pileorhiza; g) "heel" formation – future stem; h) stem move out of "heel".

Fig. 7 underground part of a young plant

Fig 8. *Sabal minor* in Arboretum of Sochi

Figure 8 presents plantations of *Sabal minor* in Sochi, where climatic conditions suggest sufficient moistening and not so severe frost periods.

Conclusions

Sabal minor is a quite perspective cultivar for SCC, but slowly-growing one. The principal advantage of these plants is a high winter-resistance. This parameter is the most important limiting factor, that restricts capacity of many palms cultivation on South Coast of the Crimea. Proper soil and high level of agrotechnology are possible to make *Sabal minor* cultivation even in subarid introduction conditions of SCC and ChPK on the same level as within natural areal. Planting pits for seedlings of *Sabal minor* has got the following size: 2 x 2 x 2 m; ground is totally substituted into more favourable mixture (4 parts of chernozem, 2 parts of bank sand, 1 part of turf and 1 part of rot manure). Only flatted area are used for

plantations, because in this way systems of surface and root irrigation are possible to apply. Mulching of circles next to the stem with sawdust (leaf-bearing and defoliation breeds of trees 15-20 sm thick) reduces or even removes any signs of chlorosis. High level of agrotechnology is to supply valuable development of the underground stem, causes increasing of number and size of leaves, inflorescences, flowers and seeds. Vegetative period of subarid regions on SCC and BSCC is rather enough for full-growth and plant development, according to data of phenological investigations. A number of seeds in NBG is rather high and makes 91-96% of the total amount of seeds, marked out by floatation method. Though self-sawing of *Sabal minor* in study regions wasn`t fixed. Cultivation of *Sabal minor* without cover during period of extreme negative temperature on SCC is possible from Laspi on south-west till Sudak on north-east, while on the BSCC from Adler on south-east to Gelendzhyk on north-west. In more severe climatic conditions in the Crimea (Sevastopol, Feodosiya) and on the Black Sea of Krasnodar krai (Novorossiysk, Anapa) *Sabal minor* could be used in landscaping, but limited number of plants, in warmer and more protected from cold winds areas with short-term cover for period of extreme negative temperature.

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The article presents history of *Sabal minor* (Jacq.) Pers. introduction in Nikita Botanical Gardens and distribution of this cultivar along South Coast of the Crimea. It contains data of phenological observations and average quantitative biometric parameters of leaf growth and dying out during vegetative period. Reasons and factors causing irregular blooming and fruiting were determined in terms of the research that is poor rubbly soils and insufficient irrigation. Ornamentality of *Sabal minor* blooming and fruiting is also illustrated here. The article includes data of morphology and anatomy of seeds, embryo and endosperm. Process of seed germination and germ differentiation on root and stem part were traced back as well. At the same time the article contains recommendations in agrotechnology of *Sabal minor* cultivation under conditions of South coast of the Crimea.

Key words: *Sabal minor (Jacq.) Pers., description, distribution, phenology, blooming, fruiting, morphology, anatomy, seed germination, cultivation, South coast of the Crimea*

OIL-BEARING AND MEDICINE PLANTS

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VARIABILITY AND INHERITANCE OF ESSENTIAL OIL CONTENT WITHIN ALLOTRIPLOID LAVANDULA HYBRIDS

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Introduction

Selection of lavandin, perspective for manufacture as oil-bearing crop, is associated with breeding of interspecific hybrids F_1 on diploid level, crossing result of *Lavandula angustifolia* and *L. latifolia.* These hybrids are of great interest as they are characterized by heterosis [1, 7-10]. Lack of theoretical basis at matching of breeding pairs makes difficult directed selection and synthesis of hybrids with set properties. We consider, formation of hybrid genotype applying interspecific hybridization with induced polyploidic forms [3-5] is a quite perspective direction. Previously we need to know regularities of inheritance in such crossing combinations. Decision of this problem involved induction of amphidiploidic forms and directed crossings with detailed analysis of obtained generation to develop theoretical approaches aimed at matching of breeding pairs for crossing and prognostication of its results.

Objects and methods of the research

Initial breeding pairs were introduced by the following chemotypes: *Lavandula officinalis* sort Record with mass fraction of essential oil 2,1% per green weight or 5,8% per absolute dry product, sort Prima with mass fraction of essential oil 1,8% and 5,2% per dry product, Belyanka was chosen as a specimen with mass fraction of essential oil 1,6 per green weight and 4,65% per dry weight. Amphidiploid № 48 was used as a parent form with mass fraction of essential oil 2,5% per green weight or 6,7% per absolute dry weight. Interspecific crossing were carried out between amphidiploids and three sorts of *Lavandula officinalis,* hybrids, as a study results, were investigated to find out essential oil content.

Artificial hybridization was applied to get allotriploidic hybrid F_1 of lavender. Morning is the most convenient time for this method. Technique of interspecific crossings involves: castration before flower opening (phase “pupa”), corolla and its stamens were