CULTIVATION TECHNOLOGY OF CLARY SAGE IN THE SOUTH OF UKRAINE: A REVIEW OF CURRENT SCIENTIFIC STUDIES

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Summary. The paper presents the results of a review devoted to the main peculiarities of clary sage cultivation technology in the south of Ukraine. The article focuses on such parameters as terms and methods of sowing, soil tillage, plant care, varietal composition of the medicinal crop. General recommendations on crop cultivation are proposed based on the results of the literature review, as well as weak points in current plant agrotechnology are pointed out.

Keywords: cultivation technology, Salvia sclarea, soil tillage, sowing, varietal composition.

Introduction. Medicinal plant cultivation is a prospective branch of current crop production in Ukraine. Owing to favourable soil and climatic conditions of the country, it is possible to cultivate almost all species of medicinal plants, which are demanded on modern global market of pharmaceutical raw materials. Therefore, the cultivation of medicinal plants deserves the special attention of Ukrainian domestic scientists to support the development of the sector and provide farmers with scientifically sound recommendations on the cultivation technologies of medicinal plants.

Clary sage (Salvia sclarea L.) is among the most prospective medicinal plants for Ukraine. Its raw materials are highly demanded both in pharmaceutical and perfumery industries. The crop is not widely cultivated in Ukraine, mainly because of the lack of scientifically substantiated and generalised recommendations on its
agrotechnology. However, in recent decades, there has been a growing number of scientific research devoted to clary sage cultivation in different agro-industrial zones of Ukraine, appearing in the scientific literature. Therefore, the main goal of current paper is to accumulate and generalize the latest scientific evidence for rational cultivation technology of clary sage in the South of Ukraine, as southern lands of the country are one of the most favourable for the crop cultivation [1].

**Materials and methods.** The basis of the review contained the latest sources from the scientific literature, which describe the results of field trials on the clary sage cultivation technology and the reaction of the crop to different agrotechnological options. The information, reported in scientific sources, was accumulated, generalised and classified by elements of cultivation technology, namely, soil tillage, fertilisation, varietal composition, sowing, plant care, etc.

**Results and Discussion.** Clary sage requires special layer tillage on the fields, which are polluted by perennial weeds. It is better to conduct multiple plough-less and plough loosening at different depth. To destroy perennial root weeds (couch grass, Johnson grass) it is necessary to disc the field in two directions to the depth 10-12 cm to cut the roots into pieces. After the disc loosens, the field should be plucked to a depth of up to 30 cm. The pre-sowing soil tillage is conducted using cultivator with harrows to the depth of 5-6 cm [2].

The best time to plant sage is before winter, when the soil temperature drops to +10...12°C, which usually happens in the late October to early November. In these conditions, the seeds do not germinate in the fall but become slimy, swelling, and will sprout in the optimal spring term.

In Ukraine, there are several zoned varieties of clary sage, namely: Voznesenska 24, Odnorichna, C-785, C-1112, Krymska Piznia. In the southern regions, nitrogen (N\(^{60-90}\)) and phosphorus (P\(^{60-90}\)) fertilisers must be applied to clary sage.

The sowing rate of clary sage is 8-12 kg/ha of conditioned seeds. The plant density in the first year should be 300-400 thousand plants per 1 ha; in the second year it should drop to 150-200 thousand plants per 1 ha. Sowing should be performed to the depth 3-4 cm, with the row spacing 70 cm.

Plant care for clary sage crops starts with preemergence harrowing with light harrows (8-10 days before sprouts appear above the surface). In the phase of 1-2 pairs of leaves, the first interrow loosening is carried out to the depth of 6-8 cm. Subsequent interrow cultivations are carried out if necessary, and they are topped after closing the rows. The plant density should be 25-28 plants per 1 m\(^2\), and 15-20 plants in poor, low-humus soils. The plant density has a significant effect on the development of the clary sage inflorescence. In dense crops (40 pcs./m\(^2\) and more), simple head-shaped inflorescences are formed in the upper part of the stem. They are characterised by small branches, so they quickly fade and lose their essential oils. In the case of sparse standing (7-8 plants per 1 m\(^2\)), the sage is heavily bushed, the side shoots are logging. If there are no critical sub-zero temperatures in winter, two-year forms do not die, and bear fruit in the third and even fourth years of life [3].

Intensive growth of biomass and reproductive bodies is better at average daily temperatures within the range +19...21°C, while oils are better accumulated in warmer conditions [4].
High soil moisture is necessary for good seed germination. The fruit shell absorbs water 42.5 times more than its own weight. The water is held tightly by the mucous membrane, which ensures seed germination. In the event of a decrease in soil moisture during this period, the mucus of the fruit membrane dries quickly, turns into a waterproof film, and prevents the seed from absorbing moisture. This is frequently observed under spring sowing when the moisture supply of the upper soil layer is unstable. That is why at spring sowing clary sage seedlings appear unevenly and are very thin or do not appear at all. Therefore, the main task in the southern region of Ukraine is the preservation of moisture in the upper layer of the soil.

The peculiarities of the climate of the southern steppe zone of Ukraine (short spring period, rapid increase in air and soil temperatures) require spring work to be carried out in short terms, because under such conditions, up to 3...4 mm of moisture is lost from the soil surface per day. Due to harrowing, a loose layer is formed on the surface of the field, which prevents capillary inflow of moisture from the lower layers of the soil [5].

In the conditions of non irrigated agriculture, all agrotechnical measures should be directed towards the maximum conservation of available moisture reserves. Early spring harrowing should be started from the moment of physical maturity of the soil. The best tools to close moisture against the background of basic ploughing-less tillage are needle harrows, disc harrows with flat discs, and against the background of ploughing, common BZSS-1.0 tooth harrows.

On the fallow fields, moisture is closed with toothed harrows. Sometimes, additional soil levelling is necessary, which could be conducted using special levelling machines or common tooth harrows. On the grids that have not been cultivated since the fall, moisture is covered with stubble with rotary tools, and in their absence with disc reapers with an angle of attack of 15 ° to the shallow depth (3-4 cm) to preserve the stubble on the surface of the field, which will create additional mulch and prevent moisture evaporation.

To prevent drying out of the loosened top layer, it is necessary to carry out rolling with ring rollers, especially on the stubble background. This method ensures levelling of the field surface and reduces moisture evaporation. The drier the soil surface, and the higher its graininess, the greater the need for its rolling.

During spring cultivation of fields, it is necessary to achieve maximum levelling of the soil surface and the creation of a fine-grained surface layer. These measures will make it possible to preserve more moisture in the soil, obtain strong seedlings on time, and use the moisture of spring and summer precipitation more effectively [6].

Application and concentration of mineral fertilizers in the upper (up to 10 cm) layer of the soil, especially physiologically acidic forms, leads to its acidification. At the same time, during tillage, the number of microbiota destroying cellulose increases in its upper layer, which increases the decomposition of fibre, together with mineral fertilisers, the process of mineralisation increases, and the ability of soils to ammonify and nitrify increases. These processes do not contribute to the accumulation of humus; its increment is possible only under aerobic conditions and soil moisture, which is higher than the moisture of capillary destruction (wilting point).
Minimizing tillage mostly results in the same yields as with conventional tillage, but a number of important tasks are solved, namely:

- saving manpower, equipment, and fuels;
- high efficiency of field work is ensured, especially in the conditions of limited time and short deadlines;
- improving soil conditions and reducing the risk of water and wind erosion.

To successfully apply the minimization of tillage, to determine its agrotechnological limits, in-depth knowledge of the conditions under which such tillage is possible is necessary. The minimisation of tillage is caused by both permanent factors and temporary reasons. The first group includes factors that affect the structure of the soil, namely: particle size composition, structure, composition of absorbent bases, humus content, etc. Temporary reasons include the availability of appropriate machines and tools, the quality of prior soil tillage, its contamination with latent weeds, diseases and insects, the availability of means for combating them, etc.

So, first, minimum tillage should be applied on black soil, chestnut and other types of well-cultivated soils with favourable agrophysical properties for clary sage plants, as well as on fields free from weeds, or with the systematic use of herbicides.

The most important and general conditions for effective use of minimum tillage for all zones are a high level of agricultural technology, a clear technological discipline in the fields, and the performance of mechanised work in optimal terms with high quality [7].

It should be noted that the limit of rational minimisation of tillage of certain soils is not constant but changes with the rapids of many circumstances. Thus, the suitability of soils to minimize their tillage can be improved by draining, loosening, plastering, and liming, increasing the humus content, and improving the structure. The possibility of minimizing soil cultivation increases significantly with the growth of agricultural practice culture. In recent decades, the following main directions of minimisation of soil tillage have emerged in the southern region:

- Reduce the number of deep tillage in crop rotation and introduce surface and shallow tillage instead of ploughing, especially when preparing fields for winter crops;
- reduction of the number and depth of tillage before sowing and during plant care;
- use of wide-grip flat cutters, heavy disc harrows, peelers, cutters and other tools that ensure high-quality processing in one pass of the unit and reduce the number of passes of tillage equipment on the field;
- combination of several technological operations and measures in one work process using combined tillage and seeding units – complete refusal of mechanical tillage (direct seeding) – no-till technology.

For high-quality pre-sowing soil tillage in one pass, combined units such as AKP-2.5, AKP-5, RVK-3.6, RVK-5.4, AKR-3.6, KFG-3.6, VIP-5.6 are used. The ploughs are equipped with PVR-2.3, PVR-3.5 devices for better soil crumbling and levelling of the arable surface.

To combine pre-sowing soil tillage, fertilisers application, sowing and soil rolling, combined tillage units like KA-3.6, KFS-3.6, as well as stubble planters SZS-2DM, SZS-2DLA are used. Therefore, it is necessary to create conditions for the
preservation of soil moisture and the effective free absorption of precipitation by the soil, and to improve the air regime of the soil, it is necessary to wrap the post-harvest residues in the soil and create conditions for the decomposition of organic matter and its transformation into forms available to plants, to destroy weeds, which vegetate to prevent them from seeding, to interrupt the accumulation of reserve nutrients by perennial weeds and to deplete those that have accumulated [8].

The use of mineral fertilisers, the use of irrigation water leads to an improvement of the water-air regime and an increase in the yield of medicinal crops in general and clary sage in particular.

According to the authors, long-term irrigation determines the effect on the physical properties of the soil: the density of the arable layer increases, the overall porosity decreases, air exchange deteriorates due to soil compaction and the formation of a crust on its surface.

In the case of an increase in the bulk density, the water uptake from the soil by clary sage plants decreases. According to the scientist [9], when the bulk density of chernozem (black soils) increases from 1.1 to 1.6 g/cm$^3$, the dead moisture supply increases from 11 to 19% of the mass of completely dry soil, and when the density increases to 2.0 g/cm$^3$, all moisture becomes unavailable to plants.

As a result of a large amount of precipitation, soil compaction increases due to an increase in its mass or flooding. Irrigation of compacted soils is ineffective, as it often leads to cementation of the surface. After drying, huge cracks usually appear [10].

Therefore, it is necessary to consider all the characteristics and peculiarities mentioned above of the effects of cultivation practices on clary sage plants to develop scientifically sound and reasonable guidelines for crop cultivation, taking into account not only plant biology, but soil and weather conditions of the cultivation zone.

Further scientific research will be done to ensure scientific rationale for the clary sage cultivation technology in the South of Ukraine both in the irrigated and non-irrigated conditions within the framework of climate-smart agriculture [11].

Conclusions. To ensure the best productivity and profitability of clary sage cultivation, it is necessary that crop producers observe the stipulated guidelines and try not to break the general agrotechnological recommendations described in this document. Generally, clary sage cultivation technology is well developed, but on the other hand, it is obvious that there is a great space for further scientific research and improvement of agrotechnology. The value of most scientific studies on clary sage agrotechnology is diminished because of lack of statistical analysis, thus, making it impossible to conduct comprehensive meta-analysis for each cultivation technology element.

References:


