Production of seeds and seedlings in the no-tillage system of vegetables: a systematic review

Produção de sementes e mudas no sistema de plantio direto de hortaliças: uma revisão sistemática

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RESUMO
Direct Planting is a process of sowing in a non-turbulent soil, in which the seed or seedling is placed in furrows or pits, wide and deep enough to obtain an adequate coverage and a good contact of the seed with the soil. Breaking this dependence, there will be the fixation of the farmer in the field, through the reduction of production costs, improvement of the physical, chemical and biological conditions of the soil, greater sustainability of the system and improvement in the farmer's quality of life. Before implementing this system it is necessary to pay attention to a few details. The production of vegetable seeds is a very specialized activity, usually performed by companies with high technological and infrastructure levels. Its success is directly linked to three important factors: a) availability of cultivars, usually from genetic improvement programs, either public or private; b) specific climatic conditions for each species); and c) production technology. All these factors will influence the achievement of high quality seeds, in genetic, physiological, physical or sanitary aspects.

Palavras-chave: No-tillage; Horticulture; Vegetables;

ABSTRACT
Plantio direto é um processo de semeadura em solo não revolvido, na qual a semente ou a muda é colocada em sulcos ou covas, com largura e profundidade suficiente para se obter uma adequada cobertura e um bom contato da semente com a terra. O Sistema de Plantio Direto de Hortaliças se fundamenta na capacidade de criar uma agricultura onde o agricultor não dependa exclusivamente de insumos externos, pois são estes que, em geral, consomem boa parte do rendimento da produção dos agricultores. Rompendo esta dependência, haverá a fixação do agricultor no campo, através da diminuição dos custos de produção, melhoria das condições físicas, químicas e biológicas do solo, maior sustentabilidade do sistema e melhoria da qualidade de vida do agricultor. Antes de implantar esse sistema é preciso ficar atento a alguns detalhes. A produção de sementes de hortaliças é uma atividade bastante especializada, normalmente realizada por empresas com nível tecnológico e infra-estrutura elevados. Seu sucesso está diretamente vinculado a três importantes fatores: a) disponibilidade de cultivares, geralmente provenientes de programas de melhoramento genético, sejam eles públicos ou privados; b) condições climáticas específicas para cada espécie); e c) tecnologia de produção. Todos estes fatores irão influenciar na obtenção de sementes de alta qualidade, nos aspectos genético, fisiológico, físico ou sanitário.

Keywords: Plantio direto; Horticultura; Hortaliças;

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INTRODUCTION

In a trajectory of more than 25 years of the Direct Planting of Vegetables (SPDH) movement, the challenge is to systematize the knowledge accumulated along this path together with family agriculture and other professionals in the field and their representative institutions (Epagri, 2019).

According to Madeira (2009), the first experiences in Brazil of growing vegetables in no-tillage emerged in Santa Catarina in the 1980s with minimal cultivation of onions. These experiences were motivated by the continuous aggravation of the erosive processes of the soils of that state, which is the largest national onion producer and had half of the cultivated area with the culture in the no-tillage system. However, in the 90s of the last century, the no-tillage area fell and today does not represent 5% of the total.

METHODOLOGY

The methodology of this review was carried out through a bibliometric and systematic review with analysis of articles produced in international databases in the Scopus repository from keywords related to the subject of the study. The search was performed in November 2022.

The terms defined for the search in the database were "no-tillage" AND "vegetables". The search yielded 117 articles, including 113 research articles, 1 book, and 3 book chapters. These articles were chosen to build this literature review based on its main focus: the production of seeds and seedlings in the vegetable no-tillage system. Those that did not present results related to the theme were eliminated. To better understand production in this system, articles were used in addition to this research, creating the context presented during the review.

Using the RStudio software (bibliometrix package), a cloud of words was generated in order to identify groups and relate the keywords that make up this research, as shown in Figure 1. For this purpose, the keywords used in the search were "no-tillage" AND "horticulture", using the Scopus platform, in order to carry out a robust and complete search on the subject. The word cloud provides an analysis of the most common terms and frequent associations or relationships shown in larger words.
NO-TILLAGE SYSTEM GENERAL ASPECTS

The no-tillage is a sowing process in undisturbed soil, in which the seed or seedling is placed in furrows or holes, with sufficient width and depth to obtain adequate coverage and good contact of the seed with the soil (MUZILLI, 1985). The Direct Planting System should not be seen as a ready-made technological package, but as a system that requires respect for its principles and local adaptations.

One of the most important aspects to achieve success in the NTS is the formation of a continuous vegetal layer, living or dead, which is capable of minimizing the erosion process, which leads to a greater retention of water in the soil and which promotes a greater availability of water, nutrients (LOPES et al., 2004).

As a result, it is necessary to comply with certain requirements, such as: tilling the soil restricted to planting rows, diversified land use by rotating commercial crops with cover crops or by integrating crop-livestock, in order to maintain the vegetation cover on the surface, associated with the integrated management of pests, diseases and spontaneous plants (MUZILLI, 2006).

According to Kochhann; Denardin (2000), the no-tillage system is composed of a set of actions, in which the expected result is the sustainability of the agricultural business. However, this system seeks to express the genetic potential of cultures in its fullness, by maximizing the environment factor and the soil factor, reducing the degradation of natural resources.
The SPD recovers the structure and protects the soil against the impact of raindrops, stores water, reduces rainfall erosion, reduces the use of agricultural machinery and implements, reduces labor and production costs. For these reasons, the practice of PD tends to dominate the agricultural scenario in the coming years (GASSEN; GASSEN, 1996).

According to Muzilli (1985), no-tillage is still an evolving system in Brazil and in other countries around the world. To put this system into practice, the producer requires a technical and cultural qualification, as well as his awareness of the real need for its adoption and adequate follow-up of research, technical assistance and exchange of experiences among farmers.

In this way, it is more prudent that at the beginning of the implementation, only a part of the crop is conducted in this system, that is, the adoption must occur gradually so that technicians and farmers become familiar with the requirements and limitations of the system (MUZILLI, 1985).

NO-TILLAGE IN HORTICULTURE

The no-tillage of vegetable system is based on the ability to create an agriculture where the farmer does not depend exclusively on external inputs, as these are what, in general, consume a large part of the farmers' production income. By breaking this dependency, there will be a fixation of the farmer in the field, through the reduction of production costs, improvement of the physical, chemical and biological conditions of the soil, greater sustainability of the system and improvement of the farmer's quality of life (BECKHAUSER, 2008).

Before implementing the SPDH, it is necessary to pay attention to some details. First, it is important to choose an area that receives sun all day and to avoid poorly drained lowlands, compacted soils and high infestation of spontaneous plants (EPAGRI, 2004).

Then, to reduce the farmer's dependence on external inputs, a soil analysis should be carried out, which will help to correct its fertility and acidity, thus avoiding excesses, contributing to the nutritional balance of the soil and reducing production costs (SILVEIRA, 2007). Subsequently, some practices must be adopted to increase fertility and maintain the soil structure, reduce water for irrigation and control pests and diseases, such as: starting the production of straw for the system through summer cover crops and winter and a crop rotation (SILVEIRA, 2007).

PRODUCTIONS OF SEEDS AND SEEDLINGS IN THE NO-TILLAGE SYSTEM

The right of farmers to use their own seeds was ensured by Law No. 10,711, of August 5, 2003. This law, which provides for the National System of Seeds and Seedlings - SNSM), exempts from registration in the National Registry of Seeds and Seedlings – RENASEM, family farmers, agrarian reform settlers and indigenous people who multiply seeds or seedlings for
distribution, exchange or commercialization among themselves, and also organizations representing these actors that multiply seeds or seedlings for distribution to their members.

The production of vegetable seeds is a very specialized activity, usually carried out by companies with a high level of technology and infrastructure. Its success is directly linked to three important factors: a) availability of cultivars, generally from genetic improvement programs, whether public or private; b) specific climatic conditions for each species; and c) production technology. All these factors will influence the obtaining of high quality seeds, in the genetic, physiological, physical or sanitary aspects (EMBRAPA, 2012).

**CLIMATIC ASPECTS OF SEED PRODUCTION**

The production of vegetable seeds must be developed under mild temperature and low relative humidity. These conditions, combined with low precipitation, mainly during seed maturation and harvest, are fundamental for obtaining seeds of high physiological and sanitary quality. The presence of rain and higher temperatures, however, can benefit the cultures in the initial stages, allowing a quick establishment and a vigorous and uniform growth of the plants (NASCIMENTO et al., 1994).

Climatic conditions also influence several other processes. Temperature, for example, influences seed germination and the establishment and development of seedlings in the field. Each species has a minimum, maximum, and optimum temperature for germination. Even within each species, cultivars may show marked differences in terms of germination at different temperatures (NASCIMENTO et al., 1994).

In general, lower temperatures reduce the speed of germination and higher temperatures increase it. The different species of vegetables require specific temperatures to pass from the vegetative phase to the reproductive phase, that is, to flower and produce seeds. For example, brassicas (cabbage, cauliflower, broccoli), onions, carrots, etc. require low temperatures to flower, while lettuce requires high temperatures. Other species such as Solanaceae (eggplant, peppers, tomatoes) and cucurbits (pumpkins, watermelon, melon, cucumber), are not demanding during the flowering phase, but prefer higher temperatures throughout the crop cycle. In general, most vegetables are not dependent on photoperiod (length of daylight) for flowering. However, some carrot and lettuce cultivars, for example, start flowering on long days. Beetroot requires long days and low temperatures to flower (POPINIGIS, 1977).

**SOIL AND FERTILIZATION**

Areas with medium-textured, well-drained, naturally fertile soils should be preferred for seed multiplication. Well-nourished plants have greater production, in addition to better quality
seeds. It is important to remember that plants intended for seed production have a longer cycle, therefore requiring higher doses of fertilization. Fertilization must be calculated depending on the species and soil analysis (EMBRAPA, 2012).

Soil pH correction through liming is extremely important for nutrient availability and, consequently, good plant development. The ideal pH for most vegetable species is 6.0 to 6.5. The addition of organic matter, whether compost or well-cured manure, is recommended for improving the physical and biological conditions of the soil, in addition to providing certain nutrients that are indispensable for the good development of plants and the production of better quality seeds (EMBRAPA, 2012).

SEED ORIGIN AND QUALITY

Low quality seeds tend to originate uneven and problematic fields, with a low technological standard and with low levels of productivity and quality of the intended production. The physiological quality of seeds is determined by germination and vigor, which is the set of characteristics that determine the physiological potential of seeds under different conditions, being related to the speed of germination, emergence in the field, etc. (FILHO et al., 1987).

The physical quality is mainly related to the purity of the seeds; Impure seeds, containing physical contaminants such as pieces of seeds, stones, soil particles, plant remains, etc., should not be used. Biological contaminants are insects and disease-causing organisms (FILHO et al., 1987).

ISOLATION

The isolation of the area consists of separating the seed production fields of the same species or similar species in order to avoid genetic contamination or varietal mixture. For example, seeds of two cultivars of the same species can be produced on the same property, provided that one cultivar is sown two to three months after the other (EMBRAPA, 2012).

In autogamous species (table 1), which are species that produce seeds without the need for crossing different plants, the production of seeds from several cultivars of the same species can be done at the same time, at the ideal time of cultivation, in nearby locations. Care must be taken that the fields are separated by the recommended minimum distance, to prevent the occurrence of mechanical mixing of seeds in the sowing and harvesting operations. In allogamous species (table 1), which are the species where cross-pollination occurs between plants, with the need for pollinating agents, such as insects or wind, care must be observed with the minimum distance between production fields, thus avoiding crossings unwanted by pollinating insects.
Distances between 2,000 and 3,000 meters between production fields of different cultivars are sufficient (PHOELMANM, 1983).

Table 1 - Autogamous and allogamous vegetable species.

<table>
<thead>
<tr>
<th>Autogamous</th>
<th>Allogamous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce</td>
<td>Pumpkins</td>
</tr>
<tr>
<td>Aubergine</td>
<td>Broccoli</td>
</tr>
<tr>
<td>Pea</td>
<td>Onion</td>
</tr>
<tr>
<td>Snap bean</td>
<td>Carrot</td>
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<tr>
<td>Chickpea</td>
<td>Cilantro</td>
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<tr>
<td>Scarlet eggplant</td>
<td>Cauliflower</td>
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<tr>
<td>Lentil</td>
<td>Watermelon</td>
</tr>
<tr>
<td>Pepper*</td>
<td>Melon</td>
</tr>
<tr>
<td>Bell Pepper*</td>
<td>Sweet corn**</td>
</tr>
<tr>
<td>Okra*</td>
<td>Cucumber</td>
</tr>
<tr>
<td>Tomato*</td>
<td>Cabbage</td>
</tr>
</tbody>
</table>

* Autogamous species that may have a cross-pollination rate.
** With the exception of sweet corn, where pollination is by wind, all other species require pollinating insects, such as bees.

Source: Authors.

**CULTIVATION**

Depending on the species, different cultural treatments are necessary. Pruning of the branches, tying up, pruning and staking for the solanaceae, thinning of the plants necessary for carrots and okra, and thinning of the fruits of some cucurbits, hilling, thinning and mulching of the soil, using plastic films or plant material (dry grass, rice straw, etc.). In some cucurbits, it is recommended to perform "combing" of the plants, which is the orientation of the growth of the branches in the same direction, thus facilitating other cultural treatments (EMBRAPA, 2012).

According to Embrapa, some essential cultural treatments for most seed-producing species are described below:

➔ Irrigation: Generally the seed production season coincides with the driest period of the year, thus requiring supplemental irrigation. Light and frequent irrigation should be applied soon after sowing until seedling emergence is complete. The flowering and fruiting stages are the most critical in terms of water deficit, and water cannot be lacking in these two stages. Seepage or drip irrigation should be preferred during flowering and seed maturation periods. Drip irrigation, although more expensive to install, is
recommended for locations with low water availability and/or soils with salinity problems.

➔ Roguing: Field inspections or "roguing", consists in the elimination of sick plants, atypical (outside the cultivar standard) of the same species, as well as of other wild and cultivated species, and should be performed mainly in the pre-flowering, flowering, pre-harvest and harvest seasons. On these occasions it must be observed the architecture of the plant, type of leaves, color of flowers and fruits, flowering time, cycle, among other characteristics. In this sense, the MAPA Ordinance No. 11, from 07/01/1985, establishes the procedures and national standards for the production of vegetable seeds. Size of the areas, number and timing of field inspections, isolation, and other important information are established in this Ordinance.

➔ Weed control: Some weeds produce seed of the same size, weight and shape as vegetable seed and if mixed will cause problems during processing. Weed control can be manual (weeding), animal or mechanical (cultivators), or chemical (herbicides). The weeding also allows the breaking up of the crust in some types of soil, thus contributing to better aeration and water infiltration. There are few herbicides registered for the various vegetables that can be used to control weeds. This practice should receive guidance from a qualified professional.

➔ Control of Pests and Diseases: The control of pests and diseases should be done preferably through the integrated method, seeking all means to keep the insect populations and the inoculum level of fungi, bacteria and viruses below the threshold of economic damage. Important diseases that occur in vegetables can be transmitted by seeds. Insects can cause damage and transmit certain viruses, such as those transmitted by aphids and thrips. Proper cultural practices can help reduce the use of agrochemicals. Dosages and grace periods must be strictly observed.

HARVESTING AND PROCESSING

The harvest should be done as close as possible to the point of physiological maturity, as soon as the degree of seed humidity and local weather conditions allow. The species that present indeterminate growth and/or uneven maturation need to be harvested in portions, removing only the mature fruits (tomato, for example) or umbels (carrot, for example). In the mechanical process, special attention must be paid to the water content of the seeds, as well as to the correct adjustment and perfect cleaning of the machines and equipment to avoid the occurrence of injuries and
mechanical mixtures, respectively. The fruits and/or seeds should be harvested on dry, sunny
days, thus reducing the need for drying (POPINIGIS, 1987).

After harvest and extraction, the seeds present several impurities that need to be removed
for adequate handling and storage. This step is called processing and consists of a set of operations
for seed preparation, which mainly involves pre-cleaning, cleaning, and seed classification. The
separations that are generally made are based on physical differences (size, weight, shape, color)
between the good seed and the impurities that accompany it. This step requires certain equipment
that is available on the market, although most of the time it is not suitable for small quantities of
seeds and/or small seeds, like most vegetables. The main equipment are the pre-cleaning machine,
the air and sieve machine, the gravity (or densimetric) table, the spiral, and the pneumatic blower.
In the absence of this equipment, the seeds can be cleaned manually, with the help of fans (or
wind) and sieves (CARVALHO; NAKAGAWA, 1988).

SEED TREATMENT

The application of chemical or organic products to seeds aims to treat the seeds against
certain pathogens associated with them as well as to protect them during storage or when planting.
There are specific products on the market for this type of treatment. The greatest care must be
taken to ensure that the toxic chemical products do not cause harm to the workers and also to the
seeds, since higher doses than recommended can cause problems. Physical (heat, for example) or
biological treatments can also be used. Seeds of species such as cowpea, pea, or sweet corn can
be treated with insecticides to control woodworm, an insect commonly found during storage.

Currently, different types of seed treatments have been made available for a more
technified agriculture, aiming for a better establishment of seedlings in the field (direct sowing)
or in the greenhouse (transplanting). These treatments allow safer handling of seeds, better control
of microorganisms, faster and greater germination, more uniform emergence, and/or better seed
distribution. Examples of these treatments are filming, scaling, pelleting, and osmotic
conditioning.

SEEDLING PRODUCTION IN NO-TILLAGE SYSTEM

According to the Brazilian Seed and Seedling Trade Association (2013), to ensure
sustainable and efficient vegetable production, the sanitary quality of seedlings is a key factor in
the production process, considering the large number of pests and pathogens that affect crops and
that can easily be spread over long distances through seedlings. The physiological quality of seeds
and proper nutritional management also contribute to the full development of plants after
establishment in production fields.
According to Embrapa (2016), the nursery, to meet the technical needs of vegetable seedling production must conform to current legislation, and have a set of adequate and distinct structures, being:

- **Roads:** It is vitally important that the quality of the roads is guaranteed. Roads with drainage difficulties, in rainy periods, cause puddles that can lead to delays in the delivery of seedlings and the arrival of supplies to the nursery. Access difficulties caused by obstacles along the roads, such as tree branches, narrow or poorly maintained bridges, and marginal erosion, are also points to be considered.

- **Water:** The quality and quantity of water must be adequate enough to supply the site, as well as for possible expansion. The origin of the water can be surface or underground. Preferably, professional nurseries opt for groundwater from artesian or semi-artesian wells, since surface water can be prone to contamination.

- **Windbreaks:** The choice of the type of windbreak will depend on the region, the prevailing climate, the availability of seedlings, the annual cost of maintenance (pruning), cultural aspects, among others. Clonal eucalyptus trees have a rapid and uniform development, benefiting the windbreak function, ensuring uniformity in the application of pesticides, irrigation and fertigation.

- **Greenhouses for seedling production:** can be built in the arched and double-water format. Most greenhouses for vegetable seedling production in Brazil, specifically in the Center-South region, are of the arc type, because it allows a lower investment cost, requires less iron materials and allows coverage with cheaper materials, such as plastic. They also bring as a benefit the factor of having better efficiency in the effect of wind, less impact due to tangential action and not direct.

- **Benches:** Most vegetable seedling production greenhouses in Brazil have benches built in "trellis" systems, with sturdy flat wire, supported on metal, wood or masonry structures, at a height of 30 cm to 50 cm from the ground. The benches must be built in such a way that their resistance allows good tension in the wires that will support the trays, thus avoiding the catenary effect, which will cause accumulation of water, salts and pesticides in the depression regions, causing the formation of algae (slime), phytotoxicity or overdevelopment of the seedlings located in these regions. These factors will result in uneven development of the batch of seedlings along the bench, compromising the final quality.
• Aisles: The internal movement of the trays on the benches is carried out by aisles. These aisles are preferably paved, and can be central or lateral and allow the installation of conveyors or carts for the distribution of seeded trays and the removal of trays for loading onto vehicles. The sanity inspections of the batch, of checking the nutritional state of the seedling and moisture content in the substrate, are made possible by the existence of these corridors.

• Technology: Greenhouses can contain a diverse range of technologies such as: climate control by sensors, movement of screens, roofs and fronts with electronic systems, heating, cooling, mobile benches, in addition to various irrigation systems (bar, microaspiration, foggers, drip tubes or drip stakes), among others.

PLANT ESTABLISHMENT

The fast and uniform establishment of vegetable seedlings in the field is a fundamental prerequisite to achieve an adequate stand, and to guarantee productivity and quality of the harvested product.

In this sense, seedling formation is one of the most important stages in the cultivation of most vegetables, because the final performance of the plants in the field depends on it, both from a nutritional and phytosanitary point of view, as well as the time required for production and, consequently, the number of possible productive cycles per year (VARINA, 1995).

A malformed and weakened seedling compromises the entire future development of the crop, increasing its cycle and, in many cases, causing production losses. In a seedling production system, several aspects such as climatic factors, nutrition, substrates, containers, water quality and irrigation management, cultural treatments, pest and disease control, age for transplanting, among others, should be considered. Seedling quality and factors related to germination and the consequent establishment of plants deserve considerable attention (DUVAL et al., 1999).

Thus, in the production of seedlings in trays, where a seed is placed in each cell, it is necessary that high quality seeds are used to obtain high emergence, high uniformity and plant health, thus maximizing the use of inputs, space, time and income to the producer. Although there are less technified ways of producing vegetable seedlings in our country, such as in field beds (seedbeds), use of bare-root or root ball seedlings, use of other containers (newspaper cups, disposable cups, tubes, etc.) (DUVAL et al., 1999).

CONCLUSIONS
Vegetable seeds from reputable companies usually have high physiological quality and are guaranteed for certain periods after testing. However, most of the time, the seedling producer does not use all the seed, thus needing to store them for a certain period. It is known that seeds tend to lose viability and vigor with the storage period, even under adequate storage conditions. To minimize this problem the seedling producer should take the following care:

(a) determine the need for seeds in advance;

b) acquire seeds in sufficient quantity, thus avoiding surpluses;

c) store the seeds in adequate packages and places;

d) use seeds from packages opened within 6 months, and closed within 12 months; and

e) analyze the stored seeds before use.

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