Experiences in Brazil with no till vegetable system (NTVS) – Brassicas

Introduction

The Brassicaceae (Cruciferae) family is constituted by a vast number of cosmopolitan plants with a relevant socioeconomic importance, being essential to human health and nutrition. In Brazil, amongst the species grown as vegetables, are:

- Cabbage (Brassica oleracea var. capitata);
- Kale/Collards (Brassica oleracea var. acephala);
- Broccoli (Brassica oleracea var. italica);
- Cauliflower (Brassica oleracea var. botrytis).

Other species are also cultivated but with less significance in terms of harvested area and production volume, such as chinese cabbage (Brassica rapa var. pekinensis); arugula or salad rocket (Eruca sativa); radish (Raphanus sativus); watercress (Rorippa nasturtium-aquaticum); leaf mustard (Brassica juncea); turnip (Brassica napus); chingensai or pakchoi (Brassica rapa var. chinensis) a chinese type of cabbage with a different morphology and smaller in size; and Brussel sprouts (Brassica oleracea var. gemifera).

The core acreage of these brassicas is concentrated in mountainous areas with an intensive soil and water use. Erosion is often observed and threatens the entire agricultural sector. It’s also an issue associated with a range of consequences such as nutritional disorders, diseases, pests, that lead to high production costs. In order to mitigate the devastating effects of erosion, no tillage farming
(NTF) appears as a step forward, being a promising alternative to achieve sustainable vegetable growing systems.

It can be defined as a water and soil conservative management system that aims to improve genetic potential of cultivated plants. It comprises an integrated complex process based on three principles: minimum soil disturbance restricted to seeds or transplants in rows or holes; diversification promoted by crop rotation; and the soil surface protection by the adoption of cover crops to produce biomass.

Increase in the adoption of these techniques is observed in all Brazilian states and NTF area is estimated at 31.8 million of hectares (78.57 million acres). Typical to soybean, maize, cotton, beans and sugarcane production, NTF has a growing demand and ongoing experiences focusing crops like tomatoes, onions, pumpkins and leaf vegetables, receiving a different denomination in the vegetables sector- NTVS (No Till Vegetables System).

**No Till Vegetables – Brassicas production**

**General aspects**

Brassicas in NTVS started being evaluated back in 70’s by Dr. Ron Morse, an emeritus Professor of horticulture at Virginia Tech University in the United States. His efforts to solve soil erosion problems resulted in the adoption of several cropping methods by vegetable farmers in a wide area of that country, both conventional as organic. The erosion effects faced by USA farmers are also common to Brazilian growers, especially in slope mountain regions (Figure 1).

In these locations, the land use pressure coupled with the lack of planning production activities contributes to the advance of environmental degradation. To change this scenario, a considerable number of research trials and satellite plots/observation trials involving NTVS were carried on by Embrapa in different conditions, evaluating the performance of brassica species (Figure 2).

When compared to conventional tillage, NTVS has shown significant advantages in economic, social and environmental aspects. As regards the soil quality and health, it has contributed to improving physical, chemical and biological properties. In sum, soil losses in trials conducted at Embrapa Vegetables were reduced 70% compared to conventional tillage, water losses around 90% and soil organic matter increased. Results conducted from plan areas showed that biomass fulfills the function of protecting the soil from erosive impacts of rain. Although reports from scientific journal have shown restricted control of erosion in areas with sloped relief, they have not been considering yet the NTVS and recent trials using maize as a cover crop, proving the efficiency of its biomass to reduce soil losses in these conditions.

![Figure 1. Erosion affected areas where brassicas are commonly grown – Sumidouro (A) and Nova Friburgo (B), Rio de Janeiro State, Brazil.](image)
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In addition, biomass is the primary factor for water saving, as increasing amounts of mulch are directly related to lower losses. Brassicas have a high water use, thus less evapotranspiration and maintenance of soil profile moisture resulted in yields and quality aspects (size and uniformity) of marketable products similar to conventional tillage production.

Despite the recognition of NTVS as a technological breakthrough in sustainable farming, it is important to recognize that many challenges arise from the needs of its adopters. These challenges are mainly related to the system establishment, and require the efforts of different actors in the vegetable sector to achieve a stable situation, resulting in benefits to farmers and society as a whole.

**NTVS establishment**

**Requirements for pre-establishing**

Research conducted over the years shown that the NTVS needs some pre-establishing adjustments related to soil management and fertility status:

- plots should be planned leaving no limitations to planting, growing and harvesting operations;
- soil acidity (pH), toxic elements such as aluminum (Al) and low calcium (Ca) levels should be adjusted;
- nutrients with low mobility on the soil like phosphorus must have their levels raised in advance;

**Figure 2.** Cauliflower grown under maize mulch (A), cabbages (B), broccoli grown under pearl millet (C) and Chinguensai/Pak choi grown on permanent beds covered by oat mulch (D).
• soil compaction, particularly below the topsoil, should be alleviated.
• The selection of appropriate cover crops species for biomass production is mandatory;
• a crop rotation and succession scheme should be considered regarding NTVS maintenance and brassica production.

Climatic conditions
Endemic to temperate climate European countries, brassica crops are sensitive to high temperatures and heavy rainfall that increases the length of leaf wetness time. These conditions are inherent to Brazilian climate and other tropical regions, causing the occurrence of diseases and physiological disorders.

Cauliflower is the B. oleracea botanic variety with a considerable flexibility in terms of planting periods. This adaptive advantage can be attributed to secular migration to India and mid-season and summer hybrids bred to tolerate to higher temperatures. Inverse behavior occurs in cauliflower winter hybrids, which require specific climate conditions for the inflorescence induction, in temperatures between 14 °C and 17 °C (57.2 °F to 62.6 °F). In Brazil, these conditions are found mostly at the Southeast and South regions, with exceptions occurring in altitudes above 800 m or at rainy periods where variations in temperature are lower. Likewise, broccoli has its inflorescence development arrested when average temperatures exceed the limit of 30 °C (86 °F), especially in the early stage of floral buds formation. The sprouting broccoli type tolerates higher temperatures, with variations that go beyond the species range without compromising its quality. This characteristic allows commercial production in rainy regions of lower latitude and hot climate, like in the Amazonas state. For cabbage, when day and night temperatures are uniform, ranging from 15 °C to 20 °C (15 °F to 68 °F), better quality of the heads is attained. Above 25 °C (77 °F), the shape and firmness of heads are harmed. During hot and dry periods, the petioles of the leaves length increase and its characteristic aroma is attenuated.

Traditional brassicas production areas will be significantly impacted by climate change especially by increasing the average temperature. Extreme weather conditions are expected to occur, culminating in intense rainfall within short periods of time and longer droughts. This can lead to reduction in the quality of commercial product and yield losses. In this manner, growing vegetable brassicas will require, above all, heat tolerant cultivars. Cropping systems modifications in order to uphold microclimate conditions and adequate levels of soil moisture and temperatures extremes, like NTVS, will also be crucial.

Crops biomass covering the soil possesses insulating effects that alleviates extremes and provides adequate temperatures near the canopy area, especially at leave expansion and at early inflorescence formation stages (Figure 3).

In South-Central Brazil, especially during rainy season from November to March, plowing and harrowing the soil may cause compaction or may even not be feasible. With the aforementioned climate changes, this situation can become more frequent in the future, leading to soil losses, water runoff and flooding. In compacted soils, puddles are formed at the soil surface for an extended period of time (Figure 4), causing deformities to the root system, an effect of decreasing water infiltration capacity and aeration, increasing sheet erosion and diminishing yields.

Growing cover crops with deep and aggressive root system can alleviate compaction. However, NTVS alone is not able to mitigate the effects of compaction in soils with strong resistance, requiring the integration of other soil conservation and management practices.

Fertilizer and soil amendments management
Brassicas have the ability to extract large amounts of soil nutrients, responding with a high conversion rate within a relatively short time. Small cabbage seeds can turn in 50 t of product or even more in about three and a half months. Thus, to provide these nutrients in adequate and balanced quantities, it is necessary to know the nutritional requirements of each species. R$ 46.9 million (US$ 11,65 million - currency conversion rate of R$ 4.00 to US$ 1.00 dollar) were spent in 2012, ranking broccoli among the ten species of vegetables with higher fertilizers consumption in Brazil.
On the subject of soil correction, the optimum pH for brassicas is between 5.5 and 6.8 for the main botanical varieties like broccoli, cabbage and cauliflower. Lower pH values increase micronutrient deficiencies as molybdenum, resulting in the disorder known as “whiptail”, which shortens the leaf area and cannot be corrected during the development of the plant. For the farmer is only viable to fix and increase the levels for the next crop. Higher values of pH increase boron deficiency, which is related to the appearance of disorder known as “hollow stem”. Both liming as fertilization are critical for systems that seek higher brassica yields in order to maximize the diameter and mass of the curds in broccoli/ cauliflower or cabbage heads. The pH adjustment should be done prior to NTVS establishment, with limestone incorporation closer to the root development zone, until 20 cm or 25 cm soil depth. After this soil test should be done once a year. When the percent base saturation is 10% lower than the recommended, usually around 70% in brassicas, limestone surface application is recommended.

Soil acidification process in NTVS occurs slowly and in a concentrated form, particularly in the 0 cm...
to 5 cm depth (2 inches), due to the mineralization of plant debris on the surface and the use of nitrogen fertilizers. When compared to conventional cropping, limestone reapplication is done more often, but in smaller doses. For fertilization, same recommendations used in conventional systems are adopted, with minor adjustments. In trials carried out at Embrapa Vegetables and satellite plots, it was established that the nitrogen doses can rise 20% to 50% when grasses like pearl millet, maize, oat, rye or wheat are used as cover crops and produce large quantities of biomass.

The anticipation of first nitrogen broadcasting is necessary due to its sequestration by microorganisms to decompose biomass. After few weeks the nutrients will be released back into the soil solution. This fact causes deficiencies in the initial development stages of the brassica plants. When leguminous species or consociated mixes of leguminous are chosen as a cover crop, one must calculate the expected nitrogen contribution, being able to reduce the levels used in topdressing in relation to what is commonly done by 20%.

In Brazilian soils, phosphorus (P) is very low concentrated in soil solution. However, in areas of intensive farming, especially in vegetables, it’s common to see considerable accumulation of this nutrient due to constant fertilization and inadequate management of soil fertility. In NTVS, as mentioned, a previous P correction is needed to its establishment, according to the regional recommendation, aiming to raise or provide adequate levels. Results for $P_2O_5$ dosages that surpass the regional recommendations have been observed in soils with high content of this element, producing crops like broccoli, cauliflower and cabbage. Cauliflower grown under NTVS in Embrapa Vegetables, responded positively to doses ranging from 200 kg ha$^{-1}$ to 500 kg ha$^{-1}$ (440 pounds to 1102 pounds) per hectare. All dosages above 200 kg ha$^{-1}$ ($P_2O_5$) extrapolated the local state recommendation.

However, despite the observation of these results, it should be considered that the botanical varieties of *B. oleracea* have different responses to phosphate. Moreover, with advancing the years of NTVS adoption, reducing phosphorus fertilization around 30% to 50% is possible, maintaining high levels of yield, especially when localized applications are used instead of broadcast done in total area.

There is a pressing need for updating fertilizer recommendations under NTVS adoption. The content of nutrients in soils cultivated for years with vegetables, especially phosphorus, and the adoption of new brassica hybrids, particularly ones with earliest cycles are factors involved in this updating necessity also. Over several years adopting NTVS, when the system is fully established, and phosphorus and organic matter levels are appropriate, as is observed in grain crops, broadcast fertilization can be an option. At this stage, the small channels formed by cover crops roots, which are desiccated or rolled, are in charge of taking nutrients down to the deeper soil layers.

The recommended potash (K) dosages for the conventional system can be maintained in brassicas grown under NTVS. The presence of crop biomass and fertilization with (P) contributes to (K) levels accumulation in the surface layers so as to be absorbed by crops. Fertilizing can be performed in two ways:

a) broadcasting, in total area, prior to permanent beds formation, with partial incorporation of fertilizers by superficial tillage, considering that this practice can reduce the efficiency of phosphate fertilizers;

b) simultaneously with row drilling (planter) using machinery adapted to NTVS.

In small properties of Nova Friburgo county, Rio de Janeiro state, farmers open holes immediately after sowing cover crops as a management practice related to fertilization for broccoli and cauliflower. Cover crops seeds are broadcast and incorporated superficially at the soil, along with opening holes and fertilizer placement. Later, between 45 and 90 days, the cover crops are desiccated or rolled. This conjunct procedure allows the visualization/alignment of planting holes, which later will receive transplants. Therefore, spreading spaces between biomass residues to place the seedlings is not necessary.

Opening large holes or using wide rows is not necessary in NTVS, because seeds, transplants or fertilizers can be limited to where they’re placed. Further, in the case of areas with high levels of phosphorus and other nutrients, a marker tool or a hand transplanter can be used for this purpose.
In areas under NTVS, the continued input of organic matter for fertilization, the use of cover crops, secretions released by roots and renovation of roots and shoots that die naturally or by desiccation, stimulate biological activity in the soil. The final product of this interaction, at different stages of decomposition works as stabilizing agents in the soil aggregates formation. This continuous supply and slower degradation by non-incorporation of crop residues also allows reductions in the demand for fertilizers.

The result of this process in the soil is a greater stability of organic matter, increased biological activity and infiltration capacity, when the surface is covered with biomass. Due to its structure and quality, NTVS soil is close to the stage/quality of natural vegetation areas over the years of adoption. This confirms that it’s not necessary excessive tillage to promote the root system development and fertilizer supply as well as big holes to retain water close to the plants.

Crop rotation and succession

A proper choice for succession and rotation of crops is critical and a set of factors should be well-thought-out to decide which species will be select. Cover crops, sometimes called also green manure, should be vigorous in its growth, with a deep root system that can recycle nutrients in layers unreached by brassicas. Their main aspect is the ability to produce biomass, protecting the soil and releasing nutrients.

In brassicas production, grass species (Poaceae) such as maize, sorghum, pearl millet (Pennisetum glaucum), oats; leguminous species (Fabaceae) like sunn hemp (Crotalaria spp.), black velvet bean (Stylozobium aterrimum), dwarf pigeon pea (Cajanus cajan), hairy vetch (Vicia villosa), among others were evaluated in Brazil. In addition, the consortium of grasses with legumes (eg: maize + black velvet bean; pearl millet + sun hemp; oats + hairy vetch) combining two, three or even a “cocktail” of species is used to attend different purposes (Figure 5).

Figure 5. Cover crops: (A) pearl millet, (B) maize; (C) winter rye and (D) sunn hemp.
The adoption of consociated species of grasses and legumes have, plus the ability to promote higher nitrogen (N) levels, the function of improving soil quality, particularly by raising levels of stable fractions of humic substances, consequently increasing soil organic matter. Among the general benefits of using cover crops are:

- cover crop species with high carbon/nitrogen ratio (C/N) provide slow biomass decomposing, protecting the soil and improving its quality;
- biological nitrogen fixation, with the cultivation of leguminous species for later release to subsequent crops and the possibility of reducing nitrogen fertilizer doses;
- fast nutrient release for subsequent crops, for example through the use of radish and other species with low carbon/nitrogen ratio (C / N) that decompose rapidly;
- diseases suppression by planting grasses, for example growing wheat during winter;
- less inoculum dispersion in areas with occurrence of soil diseases;
- reduction of nematodes population, for example, by using sunn hemp - *Crotalaria spectabilis*;
- soil decompaction promoted by species with an aggressive root system such as pigeon pea, radish, maize, among others.

In addition, grain species of commercial value such as maize, sorghum and wheat, can be used for grain harvest and biomass production to NTVS or used exclusively for the production of biomass, managed in fully vegetative growth, between 45 and 90 days depending on the species and climate conditions. The use of saved seeds, like maize open pollinated varieties for example, can be a lower cost alternative to biomass formation. Sunn hemp and velvet bean, among other leguminous crops, are usually managed in full flowering stage, before the seed maturation stage.

Nevertheless, seed production of these cover crops species is an interesting opportunity, as an economical alternative to specialized farmers, due to the growing demand. In this option, one must be cautious at harvesting, so that seeds do not fall to the soil, competing with subsequent crops.

The management of cover crops can be made by a roller/crimper, stalk chopper, rotate mower or brush cutter in organic farming, whereas in conventional systems is common to associate these mechanical practices with desiccation using herbicides like paraquat and glyphosate.

The belief that NTVS is necessarily tied to the use of herbicides is not true. The same techniques used in conventional systems to control weeds by hoeing/weeding, done manual or mechanically, are also recommended. In some cases, especially with cover crops such as millet and oats, desiccation is done when the plants are still up occurring a natural lodging. This takes about two or three weeks, depending on the species and climatic conditions.

In organic systems, attention must be given to the establishment of cover crops, sowing them in a higher density and handling before the seed maturation stage. Still, it is important that the areas should have a low occurrence of troublesome weeds such as nutsedge (*Cyperus rotundus* L.), bermuda grass (*Cynodon dactylon* L.), wormwood (*Artemisia verlotorum* L.) and tropical spiderwort (*Commelina benghalensis* L.).

Farm machinery attached to tractors (Figure 6) or handled manually, and even the adaptation of logs or other instruments to roll the cover crops are options, according to the farmer investment capability.
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Pest and diseases management

The management of pests and diseases in brassicas under NTVS resembles the conventional farming system. The differential is in prioritizing the system’s health as a whole, emphasizing no tillage, crop rotation and the presence of biomass covering the soil. With that, changes happen in the dynamics of plant health problems, as well as the plant yielding potential. Aphids, whiteflies and caterpillars are the main groups of brassica pests encountered in Brazilian.

Diamondback moth (*Plutella xylostella* L.), is considered the most important pest among them, being responsible for severe damages and losses. Its population density was smaller in NTVS cabbage growing, compared to the conventional system. Changes occur in the entomofauna, attributable to no soil disturbance, with higher diversity of natural enemies in NTVS compared to conventional cultivation.

In NTVS special attention should be given to other pests such as worm-screw, termites and phytophagous beetles, commonly known as white grubs. In highly infested sites, it is clear that the succession of crops provides an enabling environment, with higher quantities of biomass and almost none in certain periods of the year. The white grubs are generally beneficial insects to the soil, by digging galleries that allow water infiltration and root growth, while incorporating straw. But this imbalance throughout the year can raise the population of white grubs, reaching the level of economic damage. Crop rotation with non-preferred species or not host, like sunn hemp species, is in general more efficient than chemical control with insecticides.

For the management of diseases, especially nematodes, there are fewer juveniles and adults in NTVS. Fewer juveniles of *Meloidogyne* 2nd stage were observed in broccoli and fewer juvenile and adults of *Pratylenchus brachyurus* with the use of a maize velvet bean mix. There are reports of trials conducted in the US and Norway that the spread of *Alternaria* and clubroot, caused by *Alternaria brassicicola* (Schwn.) Wilt, *A. brassicae* (Berk.) Sacc. and *Plasmodiophora brassicaceae* (Wor.) is limited in NTVS. Less incidence of leaf spot alternaria were attributed to reduced soil contact of the cabbage leaves from the increased soil coverage. Positive residual effects of NTVS were found to reduce clubroot infection. These results are significant but were obtained in temperate climatic conditions. To date, no trials evaluating fungal diseases in brassicas under NTVS were stablished in Brazil, yet.

As mentioned, NTVS adoption at slope mountain regions results in lower runoff, as sediment transport and the volume of soil splash, with inferior dispersion of spores. It is worth mentioning that in these places dealing with clubroot has been made possible by increasing organic matter content and microbial community diversity, with no soil disturbance, which reduces the spread of the disease.

Yet, only practical observations are registered, needing R&D results and validations, since diseases such as leaf spot alternaria are favored by the presence of crop residues. Therefore, for the management of such diseases, aiming to grown

Figure 6. Cover crops mechanical management: (A) crimper/roller, (B) stalk chopper.
NTVS brassicas, choosing species to succeed the cash crops, for crop rotation and to increase the soil organic matter content are essential.

The farmer, even on a commercial scale with tight planting schedule, should avoid repeating brassicas species in the same area for more than two years in a row, especially when observed the occurrence of these diseases. A crop rotation or succession scheme, in order to maintain NTVS, should preferably follow the sequence “vegetable – cover crop – vegetable – cover crop”.

Other management practices

As for fertilization and disease control in NTVS, other management practices are similar to those used in conventional systems, such as weed control and irrigation. Weed control is favored by the presence of biomass, requiring less hoeing/weeding and lower labor costs for its realization. There are few research results related to weed control in brassicas under NTVS in Brazil. However, an average of 75% weeds reduction in total area was observed. Despite these promising results, more studies are needed in this direction, given the diversity of weeds and their phytosociological interactions. Brassica crop requires specific irrigation management, as a result of lower evaporation in NTVS and reduced water losses. Lower demand for irrigation in NTVS is more significant in the early stages of growth, with savings close to 30% and ranging from 10% to 15% throughout the rest of the cycle.

On the other hand, when irrigation is made improperly, adopting the same frequencies and water amounts recommended for conventional systems, yields may be lower as a result of a higher diseases incidence with reductions in water use efficiency, caused by excesses.

Examples of brassica production under NTVS in Brazil

In sequence, cabbage, cauliflower and broccoli production examples are presented, as these varieties are the most relevant in terms of socioeconomic importance to Brazil. Organic no-till broccoli production, using different cover crops and doses of organic compost were evaluated in 2007. Broccoli yield was significantly affected by cultivar and by the interaction between cultivars and cover crops. For cultivar heading broccoli Green Storm Bonanza, pearl millet used as a cover crops significantly outyielded maize (10.76 t ha\(^{-1}\) and 8.70 t ha\(^{-1}\), respectively), whereas for sprouting broccoli cultivar Ramoso Piracicaba the difference in yield was not significant (7.53 t ha\(^{-1}\) in maize and 6.60 t ha\(^{-1}\) in pearl-millet). When cultivars were compared within the same cover crop strip, differences were significant only when pearl-millet was used 10.76 t ha\(^{-1}\) for cultivar Green Storm Bonanza and 6.60 t ha\(^{-1}\), for cultivar Ramoso Piracicaba. The absence of significant effects of compost doses over yield might be due to the high soil fertility level (Figure 7).

Figure 7. Organic no-till sprouting (A) and heading broccoli (B).
The effect of different levels of phosphate fertilization (200 kg ha\textsuperscript{-1}, 300 kg ha\textsuperscript{-1}, 400 kg ha\textsuperscript{-1} and 500 kg ha\textsuperscript{-1}) in cauliflower production under NTVS was evaluated in 2008. ‘Barcelona’ cultivar was harvested earlier, with average cycle of 87 days, compared with 104 days for ‘Teresópolis Precoce’. There was a linear response to phosphate fertilizer, but point of maximum production wasn’t reached. ‘Barcelona’ was superior in the quality of the curds, with an average weight of 888 g, a 3.39 score in a visual aspect scale of 1 to 5, yielding 25.3 t ha\textsuperscript{-1} (Figure 8).

The effects of NTVS using different rates of maize biomass on cabbage water use efficiency were evaluated in 2010. Four rates of maize biomass (0.0 Mg (Megagram) ha\textsuperscript{-1}, 4.5 Mg ha\textsuperscript{-1}, 9.0 Mg ha\textsuperscript{-1}, 13.5 Mg ha\textsuperscript{-1} of dry matter) were evaluated in a latosol soil, using as control the conventional tillage system. Average head weight reached 2.71 kg (75.2 t ha\textsuperscript{-1}), with a diameter of 22.4 cm (8.8 inches) and only 1% of non-commercial heads, but these variables were not significantly affected by treatments. The total water depth applied along the entire crop cycle in NT treatments was up to 13% smaller than the treatments without biomass. Water savings during the 30 days following transplanting reached 28%. The water productivity index increased linearly with crop residue rates under NTVS conditions, and was up to 21% higher than in the conventional treatment (Figure 9).

Figure 8. No-till cauliflower cultivation in different development stages - leaves expansion (A) and curd formations (B).

Figure 9. No-till cabbage in different development stages - leaves expansion (A) and heads formation (B).
Broccoli production in summer under NTVS was evaluated in 2010. Cover crops were: pearl millet (Pennisetum glaucum), maize (Zea mays), a mix of corn and black velvet-bean (Estilozobium aterrimum), sorghum sudangrass (Sorghum bicolor x S. sudanense), besides conventional tillage (CT) - soil after fallow prepared with plow and disk harrow. The cultivars were: Avenger, Demoledor, Grandisimo, Green Storm Bonanza, Legacy and HECB-01-06 (an experimental hybrid from Embrapa collection germplasm). No differences were found among NTVS and CT concerning broccoli yield. There were significant differences between cultivars for the evaluated variables. Cultivar Avenger presented the highest yield (13.2 t ha\(^{-1}\)), average weight of 458 g (1 pound), diameter of 15.3 cm (6 inches) and quality of the curds (visual aspect index of 4.0 in a 1.0 to 5.0 scale). Therefore, considering the benefits achieved by NTVS, with the maintenance of good productive levels, equivalent at CT, its adoption was recommended (Figure 10).

![Figure 10. Broccoli cultivated under no till system in different development stages - leaves expansion (A) and curd formations (B).](image)

**Final considerations**

The improvement of sustainable vegetable production systems is vital, especially considering agriculture in tropical climates.

No-till vegetable system (NTVS) appears as a promising alternative, as it can be developed in many different environments and realities.

For brassica crops, the advantages presented show that NTVS adoption can benefit production in many aspects.

There is a pressing need for further studies in NTVS brassica crops in order to strengthen the knowledge generated so far and to make information available to farmers and extension/technical assistance professionals.

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Embrapa Hortalícias
Endereço: Rodovia BR-060, trecho Brasília-Anápolis, km 9, Caixa Postal 218, CEP 70275-970, Brasília-DF.
Fone: (61) 3385-9000
Fax: (61) 3556-5744
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www.embrapa.br/hortalicas

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