

Root of the matter

Professor Robert Wilson discusses his fascination with agronomy and details some of the insights yielded by his many years of research into chicory, and his hopes for the future

What led to your interest in agronomy?

I grew up with grandparents who farmed and my father who was a county extension agent, so I have been exposed to agriculture all my life. During my high school years, I worked part-time on a research farm, helping to plant and nurture different crops during the growing season. After, I studied agronomy at the University of Nebraska and during my junior and senior years worked for Monsanto, learning about herbicide testing and development.

I obtained an MSc from the University of Nebraska and a PhD from Washington State University in soil science and agronomy, specialising in agronomy to learn more about selective weed control in cropping systems. I enjoy the research process, from problem identification, through data collection, analysis, result summaries and presentations. There is a sense of satisfaction in completing a project that solves a problem and adds to our knowledge of crop production.

Where did chicory originate and how has its use evolved?

The history of the cultivated chicory plant dates back to ancient Egypt, where it was used for medical purposes and eaten as a vegetable. Today's industrial chicory originated in France around 1805. During the Continental Blockade, Napoleon decided to produce sugar from sugarbeet rather than sugar cane and a coffee beverage from chicory instead of coffee plants. The first industrial production of fructose from chicory roots occurred in 1983 and was soon followed by inulin production by the European companies Orafit, Sensus and Warcoing. In the USA, a small amount of chicory is grown in the south for the beverage market – and in Nebraska dried roots are used for pet food and dried chips roasted for a coffee beverage.

Could you explain some of the insights you have gained from your research into chicory?

In 1994, research was initiated to explore the possibilities of growing chicory in Nebraska. The initial programme was designed to study

European production practices, identify Nebraska research projects, assemble a research team and identify funding sources. Field experiments were conducted to determine the influence of planting and harvesting dates, as well as chicory cultivars, on root yield and carbohydrate composition.

The results indicated that chicory could be successfully grown in Nebraska, with root yields and carbohydrate composition equal to or greater than European trials. Harvesting could be initiated in mid-September and continue through November with root yield increasing 82 per cent from 1 September-15 November. The degree of inulin polymerisation peaks in early October, then decreases following the first frost.

Weed competition early in the growing season limits chicory growth and if not eliminated results in yield loss. A series of experiments identified imazamox as a herbicide which could be applied post-emergence for selective in-crop weed control. Working with the French seed company Florimond Desprez, several chicory breeding lines were evaluated for tolerance to the herbicide combination rimsulfuron plus thifensulfuron. Through further development, plant breeders at Florimond Desprez released a herbicide-tolerant chicory cultivar resistant to rimsulfuron plus thifensulfuron. These developments have provided chicory growers with an effective system for controlling weeds early in the growing season.

Further studies showed that chicory roots harvested in November could be stored for an additional 60 days, providing a processor with a five and a half month processing campaign. More recent studies reveal differences in carbohydrate metabolism among chicory cultivars, with some responding differently to cold than others, suggesting the possibility of developing cultivars with enhanced frost tolerance.

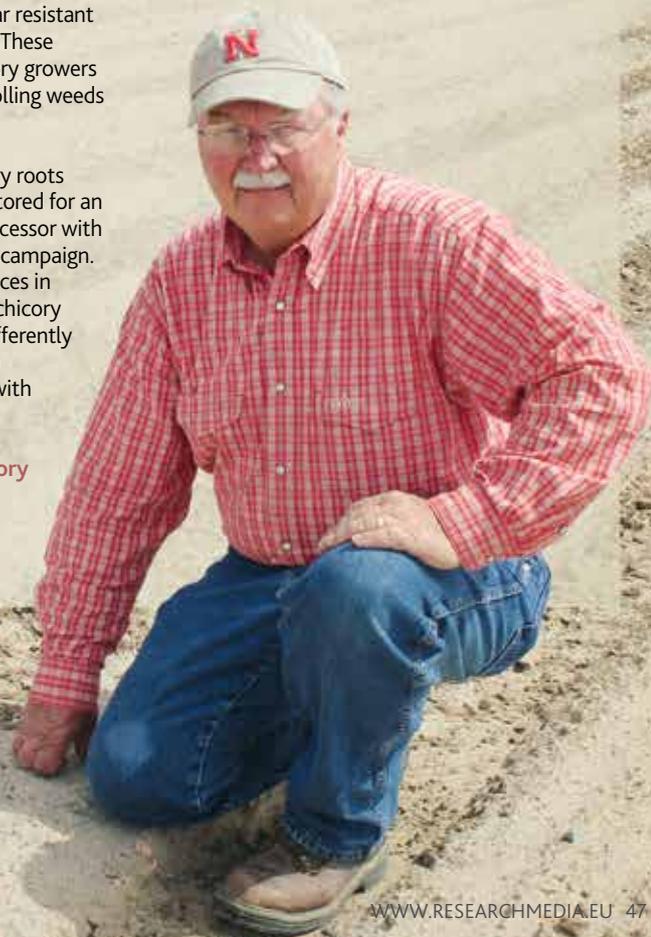
Why is it necessary to store chicory in cold conditions?

In Nebraska and other sugarbeet growing areas in North America,

sugarbeet roots can be harvested from 1 September-1 December, after which low temperatures can cause the soil to freeze, preventing further harvest. Sugarbeet roots can freeze and be stored in large outside piles for several months. Chicory roots differ from sugarbeet roots in that if they are frozen, inulin will break down to form fructose – they can therefore only be stored outside for short periods and need to be processed several days after harvest. One way to extend the processing window for chicory roots is to store them near 4.5 °C in the same environment utilised for potatoes, which reduces the breakdown of inulin. Therefore, chicory roots harvested in November can be stored for several months, increasing the number of days a chicory factory can process roots.

Where do you hope to take this project next?

Chicory research to examine differences among cultivars in their response to frost will continue during the 2013 growing season. Additional experiments to examine organic chicory production will also be initiated this year.



Introducing inulin

Research into chicory at the **University of Nebraska-Lincoln** in the US sheds light on this fascinating, functional food and its promise for Western diets as a specialty crop for the future

AS WESTERN NATIONS grapple with the growing prevalence of diet-related medical conditions such as obesity, coronary heart disease and diabetes, the importance of research into functional foods which can reduce the amount of sugar and fat in our diets will continue to grow. Chicory is one such food – a herbaceous plant, several varieties are cultivated in the USA, including: *Cichorium endivia*, grown for its edible leaves such as escarole and curly endive; *Cichorium intybus*, which has edible leaves and roots; and Witloof or Belgian endive roots, which are harvested and then grown in the dark to produce blanched leaves that are eaten in salads.

Industrial chicory is a subspecies of *Cichorium intybus* known as sativium, cultivated for the production of inulin – a versatile polysaccharide similar to starch. Inulin, which is also known as chicory root extract, is found in many plants and is utilised as an energy reserve – vegetables such as artichokes, asparagus, salsify, leeks, onions, garlic and chicory all contain inulin. It has been harnessed by the food industry as a functional food ingredient serving a multitude of purposes. For example, Inulin is sometimes used as a sweetener in place of sucrose as it has a minimal impact upon blood sugar, making it suitable for diabetics. It also functions as a fat and flour substitute, and can act as soluble fibre.

SUCCESSFUL CULTIVATION

Professor Robert Wilson is an agronomist and extension weed specialist in the Department of Agronomy and Horticulture at the University of Nebraska-Lincoln in the US. His research interests include the development of sustainable weed control systems and the biology of troublesome weeds indigenous to western Nebraska. He has also spent years exploring the root yield and economic potential

of chicory. “Chicory roots can provide large quantities of inulin, a remarkable functional food ingredient,” outlines Wilson. “It is low in calories, can replace sucrose and has a number of health benefits, such as reducing food intake and stimulating beneficial bacteria in the human digestive system.”

Optimising the growth conditions and yield of the plant means selecting a chicory variety that has high root yield potential and is resistant to heat-induced bolting. Ideally, growers should plant approximately 240,000 seeds/ha in late April, keeping the soil surface moist for the first two weeks following planting to ensure an established plant population of some 168,000 plants/ha. Areas lacking in rainfall will also require growers to irrigate their crops throughout the summer. Soil samples should be collected and the soil fertilised to maintain ample levels of nitrogen and phosphorous. The crop also requires a weed-free environment until the chicory leaf canopy covers the soil surface by mid-July and early season insect pests such as cut-worms need to be controlled. Harvesters need to lift as much of the root as possible and take care to prevent small roots from being lost.

FEELING FULLER ON FEWER CALORIES

It has been shown that ingesting moderate amounts of inulin significantly increases levels of beneficial bifidobacteria in the intestinal tract, enhancing the body's absorption of minerals such as calcium and leading to a healthier colon. “Inulin is a mixture of linear chains of fructose units with variable chain lengths or degree of polymerisation,” Wilson explains. “The chemical bonds between these fructose units are not digestible by digestive enzymes in the small intestine, but they are fermented by colonic bacteria.” Inulin has a much lower

caloric content than sucrose and works as a sugar or fat substitute in dairy products, low-fat yogurts, bakery products, cereal bars, fruit juices and processed foods. Foods containing inulin therefore increase the satiating power of foods, so that people feel full while consuming fewer calories.

SELECTIVE BREEDING

Wilson's research has generated several important new discoveries and opportunities, demonstrating that chicory can be stored for several months following harvest by using the same equipment and environmental parameters employed in potato storage, and that industrial chicory cultivars differ in their response to freezing temperatures which occur later in the year. He has revealed that, in some cultivars, the enzyme responsible for inulin degradation (1-FEH) increases following freezing temperatures without a corresponding rise in fructose.

By contrast, other cultivars exhibit an increase in the enzyme responsible for inulin degradation, resulting in a reduction in levels of inulin and a corresponding increase in fructose. These results suggest that there are differences between cultivars in their response to frost – differences which could be exploited in a breeding programme to select cultivars with improved frost tolerance. “Early research also showed that the herbicide imazamox was safe to use on chicory and controlled a wide spectrum of broadleaf weeds,” Wilson reveals. “In a cooperative effort with the Florimond Desprez seed company, a cultivar was developed with enhanced tolerance to the herbicides triflusaluron, rimsulfuron and thifensulfuron. A data package was submitted to US regulatory agencies and a label has been approved for growers to utilise this technology for early season weed control.”





Research conducted in Wilson's lab has also shown that dried chicory roots can be processed into a functional flour; significantly, the processing preserves all the healthy properties of the dehydrated dry root. In 2002, a company called Chicory USA was established at Scottsbluff, Nebraska for receiving and processing chicory roots for pet foods and coffee-like beverages.

INNOVATIVE GROWERS

Pest management is important in all chicory types and some pesticides approved for Belgium endive may not be approved for industrial chicory. Therefore, before a crop can be grown commercially, it is vital that pesticides are evaluated and authorised for use on the crop in question. Seed treatments for control of seedling diseases, insecticides for management of leaf feeding insects and herbicides for weed control all need to be evaluated and approved before crop introduction. This process was initiated in 1995, though it was not until 2013 that all pesticide labels needed for successful crop production received government approval. "Most US growers rely on crop insurance to provide a safety net to cover the expense of crop losses caused by drought, severe storms or frosts and new crops like chicory do not have an established

history; insurers are therefore reluctant to provide growers with crop insurance," Wilson admits. This can be problematic, as, without insurance, bankers are reluctant to lend growers the requisite operating capital. Establishing a successful new crop requires researchers to work closely with the insurance industry to provide them with sufficient crop yield and quality data for a risk assessment to be developed.

New crop introduction also requires innovative growers who are willing to grow different produce. Ideally, there would be a financial incentive as well as an agronomic advantage to replacing an old crop that the grower might have been cultivating for many years. One technique for enhancing the introduction of new crops is to grow them in demonstration plots for several years in different cropping areas, so that growers can gain confidence that it can be successful. The economic return for the variety needs to be competitive, or greater than that for the crop it is replacing. Combining these techniques with Wilson's research into new cultivars will help increase the production of inulin and drive down costs – vital work considering that reducing obesity in humans will be one of the major challenges for society for the next decade and beyond. A cheap and plentiful source of inulin is one tool which will help us meet this challenge.

INTELLIGENCE

CHICORY RESEARCH

OBJECTIVES

- To develop sustainable systems for crop production
- To explore the root yield and economic potential of chicory in western Nebraska
- To work closely with businesses to build a processing industry and establish a new crop for Nebraska growers

KEY COLLABORATORS

Dr Bruno Desprez and Nicolas Henry, Florimond Desprez Seed Company

John Smith, University of Nebraska

FUNDING

Florimond Desprez Seed Company

Western Sugar Cooperative, Sensus

CONTACT

Dr Robert Wilson
Principal Investigator

Department of Agronomy
University of Nebraska-Lincoln
Panhandle Research and Extension Center
Scottsbluff
Nebraska
69361
USA

T +1 308 632 1263
E rwilson1@unl.edu

<http://agronomy.unl.edu/wilson>

ROBERT WILSON began his career at the University of Nebraska after graduating from Washington State University in 1975. He has continued to work for the University for the past 38 years. His research and extension programmes have explored sustainable methods for crop production with emphasis on weed control.

Over the course of his career he has worked with sugarbeet, dry bean, chicory, alfalfa and invasive weed control. He has published the results of his studies in over 130 journal articles.

