CHICORY ROOT PRODUCTION

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SUMMARY

1. Chicory is a root crop cultivated to produce inulin which is a prebiotic fiber.
2. There are similarities in production practices and equipment for chicory and sugar beet production suggesting commercial production in the Red River Valley (RRV) is viable.
3. Chicory emergence, growth and development, and root yield in an experiment conducted near Prosper, ND in 2018 was similar to production in Nebraska.
4. Inulin content in chicory roots harvested near Prosper, ND was similar to inulin content in roots harvested in Nebraska. Low bitterness also was measured making the RRV a viable location to grow chicory roots for Blue Prairie Brands, Inc. More research is needed to determine inulin functionality and potential end uses.
5. Chicory production is preferred in irrigated fields due to shallow seed placement at seeding.

BACKGROUND

Society is currently subjected to diet-related medical illnesses including obesity, coronary heart disease, and diabetes. There growing prevalence highlights the importance of research to investigate functional foods that may improve health. Chicory is one such food. Chicory is an herbaceous plant, with several cultivated varieties in the United States, 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 consumed in salads.

Industrial chicory root is a subspecies of *Cichorium intybus* known as sativium and is cultivated to produce fructose and the valuable soluble fiber, inulin. Made popular in North America by General Mills' FiberOne products, inulin is a sugar that cannot be digested. Known as a prebiotic, inulin provides energy to the probiotic microbes in our gut which in turn provides health benefits. Currently production is centered in Northern Europe and serves a rapidly growing global market valued over $1.3 billion. With increased demand for this fiber source in the United States, domestic production of inulin for large food companies (e.g. General Mills, Cliff Bar, etc.) needs to be explored further, and integrated into established cropping systems throughout the country. Chicory root production currently is leading this effort.

The production of chicory roots for inulin has become an important segment of the world chicory market. Over 20 years ago, University of Nebraska professor, Dr. Robert Wilson, recognized the potential of chicory root as a rotation crop for sugarbeet growers in the Panhandle "High Plains" region in Nebraska. Chicory root cultivation leverages existing sugarbeet growing practices, infrastructure, machinery, and land to produce a root crop possessing the valuable fiber source, inulin. Growers producing sugarbeet have experiences and machinery to grow root crops similar to chicory. No new equipment is needed, and root chicory is added to a rotation without replacing existing sugarbeet production. A grower could replace a lower margin commodity crop such as corn or dry beans with a high margin root crop. With adequate field management, chicory roots can be readily adopted by sugarbeet growers interested in additional crop markets. Standard crop management practices have been developed for chicory production and should be followed to achieve desirable yields.

Field Selection

Several factors need to be considered before selecting a field for chicory production. The high input system required of chicory should not be put at risk with poor field selection. Fields optimal for chicory production should have well balanced soil fertility that is ideally under pivots (irrigated), well drained, and subject to multiple weed management strategies annually. Chicory can be grown in different soil types, but soil with heavy clay can create problems with irrigation/drainage and at harvest with cleaning roots prior to processing. Previous crop should be a grass including corn or small grains. It is recommended to avoid the use of winter wheat or other spring harvested cereals prior to planting chicory in the same field as it may introduce insect pests such as cutworm during the emergence window for chicory.

Planting and Irrigation

Chicory should be planted as early as possible in the spring in order to extend the growing season and maximize root yields. At time of planting, the soil should be free of compaction layers to a depth of 14 to 18 inches for the taproot to elongate naturally. Moldboard plow and "zone" tillage are the most frequently adopted strategies to prepare a level seed bed to seed chicory seeds. Chicory is planted using standard sugarbeet planting equipment. which typically results in chicory planted in rows spaced either 22 or 30 inches apart. Growing chicory with a narrow row spacing is ideal because it will result in canopy closure in the summer much sooner, helping manage any weed problems until harvest in fall. Chicory seed needs to be planted no more than approximately 0.5 inch deep. Soil surface should be firm, so one can achieve accurate depth control. Plant population between 60,000 to 80,000 plants per acre at harvest is optimum. Therefore, one should seed 100,000 seeds per acre or seed spacing of 2 and 7/8 inches between seeds in rows spaced 22 inches apart. Access to irrigation is critical as soil must be kept moist for at least 7 to 10 days for seeds to germinate and establish structural roots. Irrigation should continue from the spring through fall months as needed. The volume of irrigation water used will rely on several factors including the field soil water holding capacity (texture), and ambient weather conditions.

Emergence and Field Scouting

Chicory will start emerging about 7 to 10 days after planting. There are currently no hybrid varieties of root chicory available to the growers and there are no glyphosate resistant varieties of chicory. Thus, growers need to take a strategic approach to weed management. There are only a few herbicides approved for use since chicory is still considered a "new crop" in the United States. A preplant broadcast application of Treflan (trifluralin) must occur before planting. Irrigation water cannot be used to incorporate Treflan as it is very insoluble in water. This results in the concentration the Treflan right over the chicory seedling which kills or injures the crop. Raptor (imazamox) is approved as a post-emerge herbicide to control for weeds in chicory. Apply Select Max (clethodim) to control grass weeds or volunteer corn if the field previously was planted to corn and volunteer corn is a production challenge. Growers should row-cultivate chicory as needed for weed control and wind erosion protection if adequate weed control is not achieved with herbicide. Hand-weeding may also be needed to remove weed escapes.

Fertility

Root chicory requires nitrogen, phosphorous and potassium as well as magnesium and boron for optimum yield. Soil tests (no more than 3 years old) from the field for both primary and secondary nutrients is important so that accurate fertilizer recommendations can be made. For nitrogen, there needs to be about 100 pounds of available nitrogen in the upper 3 feet of soil. Nutrients can be applied before planting or side dressed after the crop has emerged. Do not place nitrogen in the seed furrow with the planter as it may affect seed germination.

Harvest

Chicory roots are typically harvested in late September to early November in Nebraska. The date of harvest can significantly impact the root weight and inulin content in the roots. Root yields can nearly double from the first of September to mid-November. Chicory roots contain nearly 70% inulin on a dry matter basis, so it is important to consider the inulin composition (chain-length) prior to harvest, as this will impact the end use of the recovered inulin as a functional food ingredient. While there are similarities between chicory and sugarbeet harvest methods (e.g. defoliating, monitoring soil moisture and temperature (pulp) conditions at harvest), there remain important differences that will determine the recovered yield from the field. Chicory is typically much smaller in diameter, with longer taproots compared to sugarbeets making them harder to remove from the soil. While a sugarbeet harvester (often equipped with grab rolls and a squeeze or "scrubber" chain elevator) is recommended to harvest chicory roots, modifications to the implement are necessary to accommodate the different root shape and size. Narrower gaps in scrubber chains, softer grab rolls, and adjustments to the pinch wheels are several of the accommodations that are needed to effectively harvest chicory roots in the fall without significant loss.

Storage
Depending on the intended end-use, chicory roots can be stored using several different methods. Like sugarbeet, chicory roots can be frozen and stored in large ventilated outdoor piles for several months. Other ways to extend the processing window for chicory roots includes storing it indoors under similar conditions utilized for potato storage.

Blue Prairie Brands
Over two decades of dedicated research has resulted in the development of cropping systems that successfully grow chicory roots in Nebraska. Blue Prairie Brands chicory flour is a product developed in Nebraska through years of research and development. Identification of a low bitter chicory variety was performed at the University of Nebraska Panhandle Research & Extension Center. The company developed a proprietary processing method to produce a low bitter chicory flour and continues to explore its applications as a functional food ingredient in multiple end-use scenarios including: extruded rice and corn puffs, cookie doughs, chewy fiber bars, high fiber pasta and other high fiber foods.

With the market demand for inulin increasing annually, Blue Prairie Brands is beginning to explore other areas of the United States in addition to the Panhandle of Nebraska where sugarbeet are grown, including the Red River Valley. With future market demand in mind, an experiment was conducted in the Red River Valley to determine growth and development and yield of a low-bitterness root-chicory variety and determine if root-chicory grown in the Red River Valley maintain product concept levels of inulin (soluble fiber) and low bitterness trait.

MATERIALS AND METHODS

Experiments were seeded near Prosper, ND and Rothsay, MN in 2018. Experimental design was a randomized complete block with three replications. The experiment at Rothsay was terminated in June due to inadequate chicory stands. At Prosper, the experimental area was prepared on May 11, 2018 with a Kongskilde 's-tine' field cultivation equipped with roiling baskets. Soil sampling conducted the previous fall indicated nutrient levels of nitrogen, phosphorus, and potassium at 18 pounds per acre, 44 parts per million (ppm), and 270 ppm, respectively, with an organic matter of 3.9. Treatments were broadcast urea fertilizer (46-0-0) at 0, 60, and 120 lb/acre. Tillage immediately followed broadcast fertilizer application. 'Chrysolite' chicory was seeded 0.25-inch deep in 22-inch rows at 110,000 seeds per acre on May 14, 2018. Individual plots were 6 rows wide by 30 feet long. Experimental area was hand-weeded as needed and Rhizoctonia root and crown rot caused by *Rhizoctonia solani* and Cercospora leaf spot caused by *Cercospora beticola* were controlled with soil and foliar fungicides as needed to reduce overall effects of disease.

Chicory stand density was evaluated June 5, June 15 and June 22 by counting number of chicory plants in 10 feet of row, in the middle two rows (rows 3 and 4) in each 6-row plot. Chicory growth and development was determined by counting leaf numbers of random plants in rows 3 and 4 on July 2, July 12, July 20, July 24 and July 31. Chicory was hand-harvested on September 20, 2018 and October 17, 2018 by taking 5-feet of row from rows 3 or 4 at both front and back of the plot, totaling 10-feet row per plot. Samples were sent to Blue Prairie Brands, Gering, NE for quality analysis.

RESULTS

Chicory stand density was numerically greatest in the untreated check and density was less in plots with fertilizer treatment (Table 1). It is possible chicory germination and emergence was influenced by tillage following fertilizer treatments. Chicory is seeded 0.25-inch-deep and moisture loss from tillage may have reduced germination and emergence. Treatment differences tended to decrease as the number of days after seeding increased. However, chicory germination and emergence is an agronomic challenge due to very shallow seeding rate. The experiment near Rothsay, MN experienced unacceptable stand establishment and was terminated even though the experiment was planted into moisture. Chicory is planted in fields with overhead irrigation in Nebraska and probably should be planned for fields in Minnesota and North Dakota with irrigation to ensure acceptable stand establishment.

Table 1. Chicory stand density per 100 ft row at Prosper, ND in 2018.

	Evaluation date		
Treatment	June 5	June 15	June 22
	-------------------------Number per 100 feet--------------------------		
Untreated Check	73	67	140
Urea, 60 lb/A	38	48	112
Urea, 120 lb/A	48	48	107
LSD 0.05	NS	NS	NS

There were no visual differences in chicory growth and development across fertilizer treatments (Figure 1). Chicory plants were at the 6-leaf stage on July 2 and the 23-leaf stage on July 31. Chicory averaged approximately 4-leaves (2 pairs) per week. Chicory plants covered the row (22-inch spacing) on approximately July 25. No visual differences in susceptibility to springtail, Rhizoctonia root and crown rot, or Cercospora leaf spot were observed in chicory compared to other sugarbeet experiments conducted at Prosper, 2018.

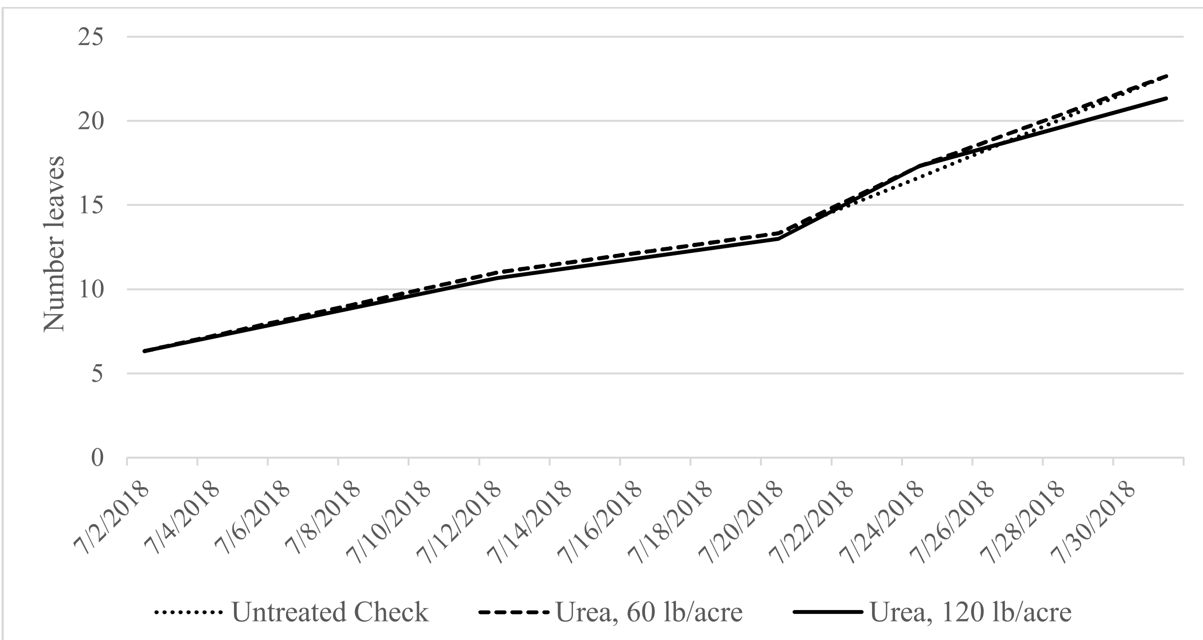

Figure 1. Average number of chicory leaves per plant from July 2 to July 31 when fertilized with urea (46-0-0) at 0, 60, 120 lb/acre, Prosper ND, 2018.

Chicory root and inulin yields in the RRV compared favorably to Nebraska (Figure 2 and Figure 3). Chicory root yield ranged from 17 to 19 ton per acre (ton/A) across treatment at Prosper compared to 14 tons per acre at Nebraska. Inulin yield averages were 4376 pounds per acre (lb/A) to 9076 lb/A in Nebraska and Prosper, respectively. It should be reiterated that yields from the Prosper trial were taken by hand harvesting while yields from Nebraska are from commercial fields using modified sugarbeet lifters where approximately 1 to 3 tons per acre harvest loss occurs due to roots escaping harvest equipment.

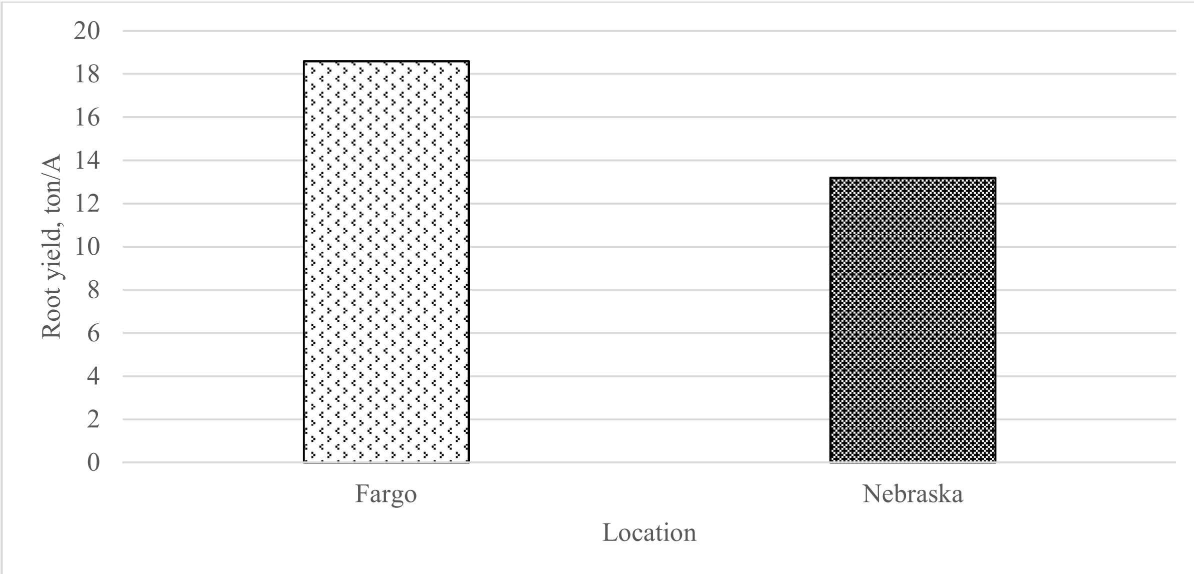

Figure 2. Chicory harvest root yield when fertilized with urea (46-0-0) at 0, 60 and 120 lb/acre, Prosper ND in 2018.

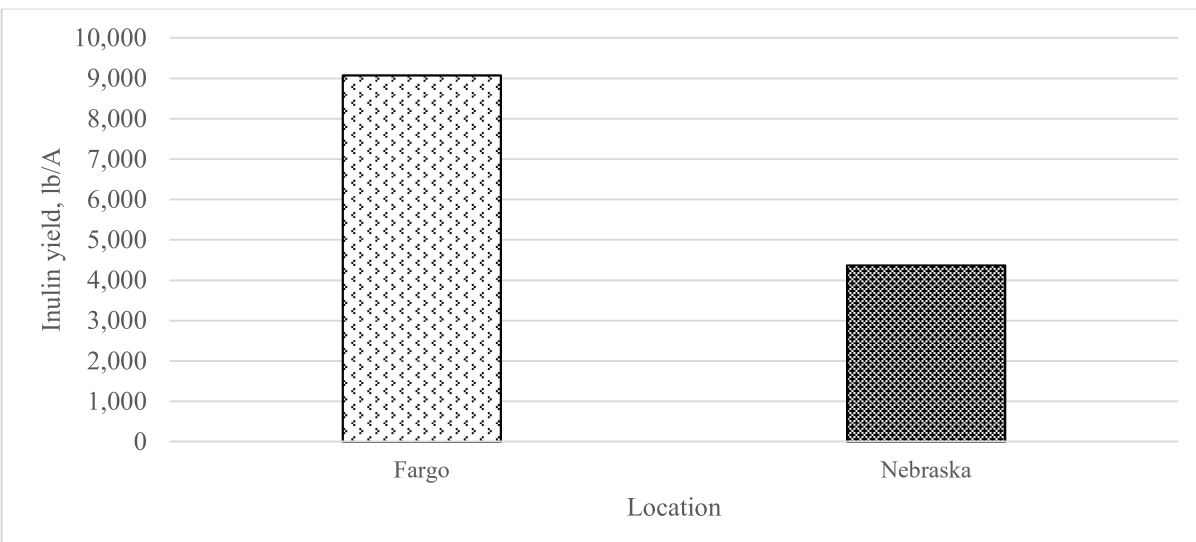

Figure 3. Inulin yield from chicory across urea (46-0-0) fertilizer rate, Prosper ND and compared to Nebraska, 2018.

Inulin soluble dry matter content was measured using a refractometer. Soluble dry matter content ranged from 20 to 25 (no units) depending on urea fertilizer rate and harvest date (Figure 4). Generally less fertilizer gave greater soluble dry matter. Soluble dry mater of 21 to 26 is desired by Blue Prairie Brands for optimum quality. Bitterness was also measured in chicory roots from this trial and was found comparable across treatments to bitterness measured in Nebraska chicory roots (data not shown).

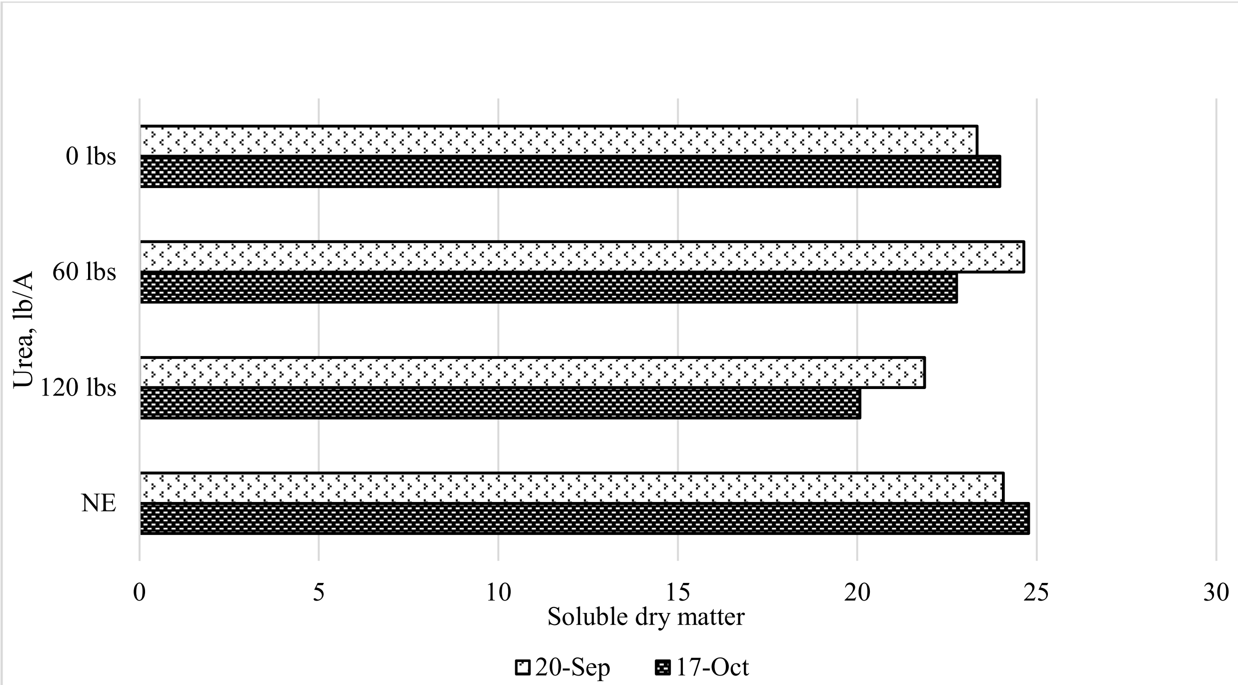

Figure 4. Soluble dry matter as measured by refractometry, Prosper, ND, 2018.

SUMMARY

Many agricultural producers in the Red River Valley (RRV) have experience with and equipment for growing root crops like sugarbeet. These are valuable factors in determining where chicory root production could be viable. Chicory grown under various nitrogen rates in a trial at Prosper, ND in 2018 had root yield, inulin content, and low bitterness metrics similar to chicory grown in Nebraska. Stand establishment was the main challenge in the experiment conducted at Prosper and emphasized the importance of early season moisture required for adequate stand establishment. Chicory production in the RRV may be viable alternative to sugarbeet or other row crops in the future. However, more research evaluating agronomics are needed before chicory can be considered an alternative crop in RRV.