The Effect of Soil Nutrients on the Phytochemical Profile of Nutraceutical Crops

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Definitions and Examples of Functional Foods and Nutraceuticals

Functional foods are defined differently in Canada and the U.S.

Canada: "Foods that are similar in appearance to conventional food and are consumed as part of the usual diet. These foods have demonstrated physiological benefits, and/or reduce the risk of chronic disease beyond basic nutritional functions."

U.S.: "Any food product with added ingredients or fortification to a functional level specifically for health or performance purposes."

Functional food example: Tomatoes rich in lycopene, eggs enriched in omega three fatty acids

The definition of a nutraceutical differs somewhat. A nutraceutical is a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with food. It is demonstrated to have a physiological benefit or provide protection against chronic disease." It is now part of natural health products—medicinal ingredients including herbs, homeopathic preparations, traditional medicines, mineral or a trace element, a vitamin, an amino acid, an essential fatty acid or other botanical, animal, or microorganism derived substance.

Nutraceutical example: capsules containing bioflavonoids or gamma-linoleic acid.

Introduction

- Minor nutraceutical crops
- Deficit of information on optimal production practices that maximize levels of bio actives; many still collected in the wild
- Little consideration given to the impact of mineral nutrition on functionality of the crops
- Great variability between plants; very limited breeding and selection work done
- Processes by which plants synthesize active compounds have not been well elucidated
- Bioactives are secondary metabolites (stress compounds) affected by genetic environmental and plant nutrition factors.

Purple coneflower (*Echinacea* species)

The species is native to North America. It has a long history of medicinal use. Its indications are for prevention and treatment of colds, flu, chronic infections of the upper respiratory tract, and other minority infections. The active compounds are uncertain, likely phenolic compounds (caffeic acid derivatives), alkylamides, and polysaccharides. Immuno stimulatory effect of echinacea has been documented *in vitro,* but clinical evidence from human trials is not conclusive.

Nitrogen (N) and phosphorus (P) appear to have little effect on echinacea yield (**Figure 1**). The effects on phenolic markers were more complex and inconsistent (**Table 1**).

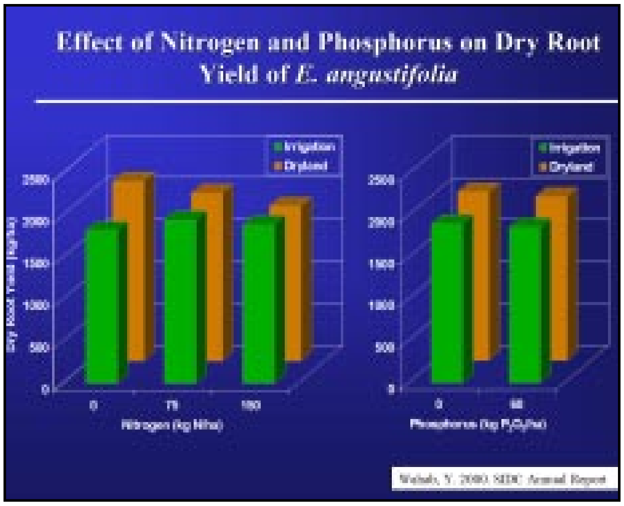

Figure 1. Fertilization with N and P had little effect on echinacea yield.

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Table 1. Combined effect of dryland/irrigation, soil N and P levels, and plant density on phenolic markers of *E. angustifolia* root; 1999 harvest (Outlook, SK).

Trial	Fertility[1]	Echinacoside[2], % Dry	Echinacoside[2], % Irrig	Cynarin[2], % Dry	Cynarin[2], % Irrig	Chlorogenic Acid[2], % Dry	Chlorogenic Acid[2], % Irrig
2-yr E. angustifolia 15 cm in-row sp.	At						
	0N-0P	0.62	0.22	0.14	0.06	0.05	0.03
	0N-60P	0.93	0.25	0.21	0.08	0.06	0.04
	150N-0P	0.71	0.09	0.15	0.03	0.05	0.03
	150N-60P	0.65	0.13	0.15	0.03	0.05	0.03
2-yr E. angustifolia 30 cm in-row sp.							
	0N-0P	1.00	0.18	0.20	0.06	0.06	0.04
	0N-60P	0.84	0.22	0.16	0.08	0.04	0.04
	150N-0P	0.69	0.21	0.14	0.07	0.05	0.05
	150N-60P	0.69	0.15	0.10	0.08	0.03	0.03

[1]Fertilization at 0 to 150 kg N/ha and 0 to 60 kg P_2O_5/ha
[2]All marker compounds are reported on dry weight basis; analyte expressed as a mean (n=2)

St. John's Wort (*Hypericum perforatum*)

The therapeutic indications for the use of St. John's Wort include mild to moderate depression, restlessness, anxiety, and irritability. Biomarkers considered to be related to its efficacy include hypericin, pseudohypericin, and flavonoids (rutin, hyperoside, quercitrin, quercetin).

A study in Outlook, Saskatchewan, found that a fertilizer supplying N and P increased hypericins slightly in St. John's Wort (**Table 2**). The increase appeared to vary among varieties, with 'Antos' showing the greatest response. Flavonoid concentration also tended to be higher with the fertilizer, though not significantly so (**Table 3**).

Table 2. Effect of soil fertility on Hypericins content of 3-year St. John's Wort flowering tops[1]; 2001 harvest (Outlook, SK).

Variety	Fertility[2]	Pseudohypericin, % w/w	Hypericin, % w/w	Total Hypericins[3], % w/w
Anthos	0N-0P	0.07±0.01	0.03±0.00	0.10±0.01
	100N-100P	0.11±0.02	0.04±0.01	0.14±0.03
Elixir	0N-0P	0.08±0.01	0.08±0.00	0.15±0.01
	100N-100P	0.09±0.01	0.08 0.01	0.17±0.02
Standard	0N-0P	0.06±0.01	0.06±0.01	0.11±0.02
	100N-100P	0.07±0.01	0.05±0.01	0.11±0.01
Topas	0N-0P	0.08±0.01	0.08±0.00	0.15±0.01
	100N-100P	0.09±0.02	0.08±0.02	0.17±0.04

[1]Three-year crop grown under irrigation, transplant 23/06/1999, harvest top half aerial parts 31/07/2001
[2]Fertilization at 0-100 kg N/ha and 0-100 kg P_2O_5/ha
[3]Hypericins content reported on "as is" basis; total hypericins refers to the sum of hypericin and pseudohypericin; analyte expressed as a mean±S.D. (n=2)

Table 3. Effect of soil fertility on flavonoid content of 3-year St. John's Wort flowering tops[1]; 2001 harvest (Outlook, SK).

Variety	Fertility[2]	Rutin, %	Hyperoside, %	Quercitrin, %	Quercetin, %	Total Flavonoids[3], %
Anthos	0N-0P	0.51±0.07	0.58±0.06	0.06±0.00	0.01±0.00	1.16±0.13
	100N-100P	0.67±0.16	0.70±0.05	0.08±0.01	0.01±0.00	1.45±0.22
Elixir	0N-0P	0.45±0.01	0.84±0.07	0.08±0.01	0.01±0.00	1.38 ±0.09
	100N-100P	0.47±0.08	0.92±0.14	0.09±0.01	0.01±0.00	1.48±0.22
Standard	0N-0P	0.47±0.10	0.66±0.09	0.16±0.05	0.01±0.00	1.31±0.06
	100N-100P	0.45±0.05	0.66±0.05	0.17±0.06	0.01±0.00	1.29±0.10
Topas	0N-0P	0.42±0.04	0.82±0.03	0.08±0.01	0.01±0.00	1.34±0.07
	100N-100P	0.44±0.05	0.96±0.13	0.08±0.04	0.01±0.00	1.49±0.15

[1]Three-year crop grown under irrigation, transplant 23/06/1999, harvest top half aerial parts 31/07/2001
[2]Fertilization at 0 to 100 kg N/ha and 0 to 100 kg P_2O_5/ha
[3]Flavonoid content reported on "as is" basis; total flavonoids refers to total flavonoids, which were calculated as a sum of rutin, hyperoside; analyte expressed as a mean±S.D. (n=2)

Table 4. Effect of level of fertilizer application on fresh herbage and essential oil yields for three peppermint cultivars over 2 years.

Fertilizer treatment	Herbage Yield, t/ha			Essential Oil Concentration, kg/t			Essential Oil Yield, kg/ha		
kg/ha N-P_2O_5-K_2O	No 1	Tundza	Zephir	No 1	Tundza	Zephir	No 1	Tundza	Zephir
0-0-0	6	9	9	12	9	13	71	82	112
150-0-0	7	11	12	13	10	12	90	107	150
300-0-110	9	14	14	11	10	15	96	136	207
530-180-240	10	15	16	13	12	14	130	179	226

German Chamomile (*Chamomile recutita* L.)

The effect of the growth environment on essential oil production has been contradictory and has not been quantified yet. For example, potassium(K)-rich soil has a positive impact on chamazulene content, but appears to have a negative impact on the essential oil yield.

Demand for N and K is high. It is lower for calcium and magnesium, and lowest for P. A higher rate of K accelerates flowering and increases biomass and production of flowerheads. The most intensive intake of mineral nutrients was recorded during flowering season, when the most increase of dry matter per day occurred.

Peppermint (*Mentha piperita* L.)

Peppermint is one of the most cultivated essential oil crops in the world. The U.S. is the largest world producer, with production mainly in Washington, Oregon, and Indiana.

Its indications are as a spasmolytic and sedative. It increases production of bile due to its essential oils and possibly flavonoids. It is usually fertilized with 140 to 225 kg/ha of N, 110 kg/ha of P_2O_5, and 450 kg/ha of K_2O.

Balanced fertilization of peppermint with N, P, and K increased the yield of herbage and essential oil considerably, with concomitant slight increases in essential oil concentration (**Table 4**).

Summary

Plant production of bioactive compounds is most strongly influenced by genetics and the growing environment. The studies reported above indicate that soil fertility has an important role as well.

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Note: No references provided.