
Symposium 2 (S02): Toward Ecologically Sound Fertilization Strategies for Field Vegetable Production

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Location: Metro Toronto Convention Centre, Room 103B

1100–1140

S02–0–1

NUTRIENT BALANCES IN VEGETABLE PRODUCTION SYSTEMS

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Society wants agricultural production to be clean and safe. In the production of field vegetables reducing emissions of nutrients is a major theme in the development of socially acceptable production systems. In 2000 the project "Farming with a future" started in the Netherlands to develop and test sustainable farming systems, including vegetable production systems. The project is being implemented on core farms (experimental farms) and on advanced commercial farms. On the core farms, production systems are being developed that satisfy the most stringent environmental norms. The advanced commercial farms test in practice the measures and systems designed on the core farms. In the paper the first results obtained on the core farm for field vegetable growing will be presented in terms of nutrient balances and promising measures to reduce nutrient emissions.

1140–1200

S02–0–2

YIELD AND QUALITY OF LEAFY VEGETABLES WITH ORGANIC FERTILIZATIONS

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Vegetable production with organic farming has been practiced by many farmers in Japan. However, one of the problems is the lower yield than under chemical production. In this study, several leafy vegetables were grown to see what accounts for the yield limitation and how different in quality are the leafy vegetables under organic or chemical fertilizations. Four fertilizations were made as 1) Chemical, 2) Half chemical and half organic fertilizers, 3) Organic fertilizer-1 and 4) Organic fertilizer-2. Nitrogen amount in chemical fertilization treatment was adjusted equivalent to 70% of the total nitrogen in organic fertilization treatments. Leaf-picking harvest, rather than the usual one time harvest, was adopted to extend the growth and harvest time. Leaf concentrations of sugars and vitamin C as well as nitrate were measured using LPLC. Photosynthesis was measured using LI-6400. Growth at the early stage was lower in organic than in chemical fertilization treatments, which was attributed to the lower availability of nutrients in organic fertilizers. However, at the later stages all vegetables in organic treatments grew better and resulted in a final higher total yield than those with chemical fertilization, which was attributed to the high nutrient sustainability of organic fertilizers. Leaf concentrations of sugars (sucrose, glucose and fructose) and vitamin C were significantly higher but nitrate concentration was lower in organic-fertilized than chemical-fertilized vegetables. The leaf-picking harvest methods showed a potential to obtain more leafy vegetables with higher a quality than one-time harvest. In conclusion, it is possible to produce vegetables with a higher quality and a yield higher than or similar to that of chemical farming if the nutrient supply is sufficient. The yield of leafy vegetables would be much higher than that of chemical farming if the leaf-picking harvest is adopted to extend the growth and harvest time.

1200–1220

S02–0–3

EFFECTS OF NITROGEN ADDITION AND PLASTIC MULCH ON SWEET CORN YIELDS AND POTENTIAL ENVIRONMENTAL IMPACTS OF SOIL NITROGEN

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Excessive nitrogen (N) fertilization can cause environmental damage, while N deficiency decreases crop yield and reduces farmers' profits. Plastic mulch (PM) which increases soil temperature and modifies soil moisture may alter transformation pathways of soil N, and thus the optimum fertilizer N rate for sweet corn. An experiment was carried out to evaluate effects of fertilizer N and PM on sweet corn yields and soil residual mineral N on a Granby sandy loam soil from 1999 to 2000. Two sweet corn varieties were included, Speedy Sweet (SS) and Jester II (JE). In the bare soil, added N did not affect marketable yield (MY) in 1999, but increased MY by up to 9.4% for SS and 7.6% for JE in 2000. In the soil covered with PM, added N increased MY by 32% in 1999 across both varieties and by 96% for SS and 43% for JE in 2000. With PM, the highest MY was obtained at the N rate of 138 kg ha⁻¹ N for both varieties in 1999 and at 175 kg ha⁻¹ N for JE and 134 kg ha⁻¹ N for SS in 2000. Compared with bare soil, PM plus fertilizer N at the maximum yield rate increased MY by 77% across two varieties in 1999, and by 69% for JE and 127% for SS in 2000. Soil mineral N after harvest increased with increases in added N. Compared with bare soil, PM reduced accumulation of residual fertilizer N by 19% and retarded downward movement in soil profile (0–100cm). Plastic mulch increased sweet corn yields and the fertilizer N requirement, and reduced the pollution potential on the environment (water and air).

1220–1240

S02–0–4

ENVIRONMENTAL ASPECTS AND PLANT COMPATIBILITY OF AMMONIUM CONTAINING FERTILIZERS WITH THE NEW NITRIFICATION INHIBITOR DMPP (ENTEC)

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Nitrification inhibitors like DMPP (3,4-dimethylpyrazole phosphate) inhibit the oxidation of ammonium to nitrate via nitrite. For DMPP, the inhibitor of ENTEC fertilizers, it could be shown, that only the first step of nitrification–nitritation–but not the nitration is inhibited. DMPP is highly specific in inhibiting the nitrification with only 0.8% (w/w) needed to inhibit ammonium–nitrogen oxidation of fertilizer granules for several weeks. In incubation experiments with different soils it could be shown that the prolonged ammonium recovery from ASN (ammonium sulfate nitrate) containing DMPP was linearly related to thermal time. The effectiveness of DMPP in inhibiting nitrification was soil dependent. Over all DMPP was more effective in lighter soils than in heavier soils. Hence leaching of nitrate-N from lighter soils was reduced particularly effective using DMPP containing ammonium-based fertilizers. In leaching studies it could be shown that even after heavy rainfall DMPP remains effective in the upper soil layer. This was not the case when e.g. the older nitrification inhibitor DCD was used. Gaseous N₂O emissions were also reduced by DMPP containing fertilizers compared to controls. Plant compatibility of DMPP is particularly high as compared with other nitrification inhibitors. This could be demonstrated among others in lettuce, radish, hop and tobacco.

1340–1440

S02–P–5

COMPOST CAN SUPPLY NITROGEN REQUIREMENTS FOR PEPPERS GROWN IN A PLASTICULTURE SYSTEM

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Field experiments were conducted in 2000 and 2001 in Freeville, NY, to evaluate a manure-based (MC) and a plant-based (PC) compost for their ability to supply the nitrogen requirements of a bell pepper crop (*Capsicum annuum* L.). Compost was tested alone and in combination with mineral fertilizer in a plastic mulch system with drip irrigation/fertigation. Previous research has found improved plant N uptake and yields when compost is combined with low mineral fertilizer rates. Both seasons included treatments of compost at a high 35 t/ac. (79.4 mg/ha) and a low 17.5 t/ac. (39.7 mg/ha) dry matter rate to deliver all or half, respectively, of the nitrogen requirement of the crop. In 2000, high and low compost amended plots were fertigated at a high (85 lbs./ac or 96.6 kg/ha) or low (40 lbs./ac or 45.5 kg/ha) level. Control treatments received no compost but were fertilized at the same rates. In 2001, compost treatments (same as 2000) received either 0 or 60 lbs./ac. (68.2 kg/ha) fertilizer N. Control treatments received only N fertilizer at 0, 60, 120 and 180 lbs./ac. (68.2, 136.4, 204.5 kg/ha, respectively).

Soil samples were taken both seasons at 4 times: transplanting, flower set, fruit bulking and end of season. Soils nitrate and ammonium were extracted with 2 M KCl and N mineralization estimated using an anaerobic 7-day incubation followed by KCl extraction of ammonium. Leaf samples were taken at flower set, fruit bulking, and at end of season for tissue nitrate determination. Plants were harvested 7 times in both years. At the end of the season a subsample of five whole plants were cut at the soil line and fresh and dry weights were recorded. No differences were detected among treatments for yield in either year. Plots amended with 35 t/ac compost had elevated levels of soil nitrate and N mineralization potential, in comparison with non-amended plots, suggesting excess N prone to leaching. Complete results of 2000 and 2001 season will be presented.

1340-1440

S02-P-6

INFLUENCE OF MULCHING FILMS AND TOPDRESSING ON THE GROWTH AND YIELD OF BELL PEPPER AT KARST FIELD

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Application of mulching films and fertirrigation constitutes a significant advancement in the field pepper production. Influence of mulching films (black, white, brown and silver PE-films, control-without mulching) and application of three topdressing rates of liquid N-P205-K20 (7, 5, 9%, respectively) fertilizer in the growing season of bell pepper (cv. Bianca F1) was investigated in the Vrana field in Croatia. The two-year trial was set up according to the split-plot method with three replications. Depending on the mulch type and trial year, the mean decade soil temperatures in May and June, at a depth of 5 cm, were by 1.0–3.7 °C higher under mulch than soil temperatures of unmulched soil. In both trial years, application of black film resulted in the highest plants: 21% and 26% higher four weeks after planting, 15% and 91% higher after seven weeks after planting, and 12% and 9% higher in the autumn than plants grown without mulching. In comparison with the soil that was not mulched and depending on the trial year, 70% and 139%, respectively, more set fruits were recorded on black film, 81% and 109% more on brown film, 16% and 79% more on silver film, but 5% less in one year and 53% more fruits in the other year on white film. Compared to pepper growing without mulching, application of all types of films resulted in yields of marketable fruits that were by 7% to 24% higher in 1997, and 22% to 34% higher in 1998. In comparison with topdressing with 140 kg·ha⁻¹ N, a 7% to 20% lower yield (in both years, respectively) was recorded for topdressing with a 50% lower fertilizer rate, and 4% lower and 14% higher yield (in both years, respectively) for topdressing with a 50% higher fertilizer rate.

1340-1440

S02-P-7

YIELD AND QUALITY OF FERTIGATED GARLIC AS AFFECTED BY SEED SIZE AND PLANT DENSITY

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Given that seed normally represent as much as 50% of the production costs in garlic cultivation, depending on the size of the clove and on plant density, the objective of this study was to analyze the influence of seed size and planting density on yields, bulb size and the profitability of garlic planted under conditions of fertigation. Four experiments were established in order to evaluate: planting densities at the levels of 300,000 to 500,000 plants/ha in the 1998-99 season and 300,000 to 600,000 plants/ha for the 1999-2000 season. Two additional experiments were established in order to evaluate seed size, in the range of 1.9 to 10 grams per clod in 1998-99 and 1.9 to 17 g per clod in 1999-2000. Fertilization was applied at a rate of 400-70-200 (N-P205-K20) and sufficient water was applied under drip irrigation to avoid soil water tensions above 20 kPa during the entire season. Seed of Taiwan type garlic, Tacátzcuaro cv. was used. The experimental design was in randomized block with four replicates. Yields varied from 24 to 30 tons/ha and from 32 to 40 tons/ha for the first and second years, respectively, and yields were directly related to planting density as it was the leaf area indexes (LAI) in both seasons, and highest yields were attained with 500,000 plants/ha and 600,000 plants/ha for first and second year respectively. However, highest profitability was attained with a planting density of 300,000 to 380,000 plants/ha. In the other hand, regarding seed size, the highest yields were attained with the largest-sized cloves, which resulted in higher bulb diameters or com-

mercial classes, although highest profits were obtained with clove sizes of 3.5 g/ clove when the yields were around 24 tons/ha and 7g/clove for yields of around 30 tons/ha. Larger-sized seeds produced lower profits for the producer, even though yields were significantly higher.

1340-1440

S02-P-8

EFFECTS OF N FERTILIZATION ON YIELD, QUALITY AND STORABILITY OF ONIONS (*ALLIUM CEPA* L.)

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The experiments have been carried out in 2000 and 2001 at Lithuanian Institute of Horticulture and in 2001 also at Danish Institute of Agricultural Science. The objective was to estimate how nitrogen affects growth, chemical composition, quality, marketable yield and storability of onions. Different nitrogen rates from 0 to 180 kg·ha⁻¹ N have been investigated. The rates of 120, 150 and 180 kg·ha⁻¹ N were repeated in split applications. The highest amount of N in the soil layer of 0-60 cm. after harvesting was estimated in the treatment with 180 kg·ha⁻¹ N. The splitting of N application did not have a positive effect on yield and storability. Moreover, the high nitrogen rates decreased onion storability. The different amounts of nitrogen did not have a big effect on the chemical composition of onion bulbs, except nitrate content. The yield was lower when onions were grown with the lowest and the highest rates of nitrogen. The onion scale quality, soil mineral nitrogen before sowing, and the optimum amount of nitrogen fertilizers will be discussed in this paper as well.

1340-1440

S02-P-9

AMMONIUM NITRATE CONCENTRATION TRANSFORMS FLAVOR PRECURSOR COMPOSITION IN HYDROPONICALLY GROWN 'GRANEX 33' ONION

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High nitrogen (N) levels used in the hydroponic culture of onion have been shown to change the composition of onion flavor precursors when compared to onions grown in the field. To determine the effects that growing onions hydroponically at lower N concentrations would have on the flavor precursor profile, plants were subjected to 11 different concentrations of ammonium nitrate ranging from 20 mg·L⁻¹ N to 140 mg·L⁻¹ total N. Mature onions were harvested and evaluated for growth characteristics. Bulbs were then cured and analyzed for flavor and sulfur accumulation patterns. Plant bulb, root and shoot mass followed a quadratic response with increasing N concentration. Plant mass decreased at the highest N levels suggesting ammonium toxicity. Both soluble solids and bulb total sulfur showed similar quadratic responses. Pyruvic acid content, an indicator of gross onion flavor, and total s-alk(en)yl cysteine sulfoxide (ACSO) content demonstrated a linear response to N level. Individual flavor precursors showed differing degrees of linear response to increasing N level. Methyl cysteine sulfoxide (MCSO) had a greater slope than both 1-propenyl cysteine sulfoxide (1-PRENCISO) and propyl cysteine sulfoxide (PCSO), suggesting that increasing N nutrition has a greater effect on MCSO than the other flavor precursors. At N levels above 80 mg·L⁻¹ MCSO was the dominant precursor, while at N levels lower than this, 1-PRENCISO became dominant. This indicates that the amount of available N can influence not only gross levels of flavor precursors, but also the relative composition of precursors in an onion bulb. A flavor profile similar to that of a field grown onion can be achieved hydroponically by using lower levels of nitrogen than are found in Hoagland type solutions. Further studies will be done to determine how influential the form of available nitrogen is in determining the flavor precursor profile in onion.

1340-1440

S02-P-10

PLANT POPULATION AND NITROGEN FERTILIZATION FOR SUBSURFACE DRIP-IRRIGATED ONION

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The use of subsurface drip irrigation (SDI) is expanding for onion production. Crop management practices may need to be modified with the conversion from sprinkler or furrow irrigation to SDI. Long day onion (*Allium cepa* L. 'Vision') was subjected to a combination of seven nitrogen fertilizer rates (0 to 336 kg/ha in 56 kg increments) and four plant populations (185,000, 250,000, 300,000, and 370,000 plants per hectare) using subsurface drip irrigation in 1999, 2000, and 2001. Onions were grown on 1.1 m beds with two double rows spaced 0.56 m apart and a drip tape buried 13 cm deep in the bed center. Soil water potential was maintained nearly constant at -20 kPa by automated, high frequency irrigations based on soil water potential measurements at 0.2 m depth. Onions were evaluated for yield and grade after 70 days of storage. Onion yield and grade were not very responsive to the N fertilizer in spite of low soil N test results. Pre-plant soil available N, N mineralization, and N in irrigation water all contributed to provide N to the crop. Onion yield and grade were highly responsive to plant population. Onion marketable yield increased with increasing plant population. Onion bulb diameter decreased with increasing plant population.

1340-1440

S02-P-11

EVALUATION OF NON-CONVENTIONAL ADDITIVES FOR ONION PRODUCTION

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A non-conventional additive can be defined as any non-fertilizer material applied to soil or plants to improve crop production or a standard fertilizer material which is used in an unconventional manner such as very small amounts. Many non-conventional additives are sold for commercial crop production enhancement. The objective of this study was to test the most commonly marketed non-conventional additives for onion production in the Treasure Valley of eastern Oregon and south western Idaho at commercially recommended application rates and methods. Treatments containing single or combinations of commercial non-conventional additives were compared with an untreated check for their effect on long day onion yield and quality, and for their economic efficiency in 1999 and 2000. The treatments were incorporated into standard cultural practices for onions. In both years none of the products tested significantly increased onion yield or quality compared to the untreated check. With minor exceptions, at the application rates used in this study, none of the products supplied sufficient amounts of plant nutrients or humic acid for an improvement in crop production to be expected.

1340-1440

S02-P-12

A MODEL OF QUALITY AND YIELD OF SPINACH AS AFFECTED BY NITROGEN SUPPLY AND HARVEST PROCEDURE

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Growers of spinach (*Spinacia oleracea* L.) for the processing industry are paid according to both quantity and quality of the produce. Therefore they need to optimise cropping measures, because some measures affect yield and quality contrarily. For instance nitrogen (N) fertilisation significantly increases yield but might also decrease quality due to excessive nitrate content. Another important quality parameter of the harvested produce is the leaf stem ratio (LSR), which should be as low as possible. A low LSR can be achieved by an early harvest date and/or by cutting only the upper layer of the plant canopy, thereby, however, taking yield reduction into the bargain. A two years field experiment was carried out with a range of N fertilisation rates (0, 60, 120, 180 kg·ha⁻¹ N). Yield, LSR and nitrate content were measured on different harvest dates, separately for 5 cm thick canopy layers. The treatments significantly affected both yield and quality parameters and significant interactions were found, for instance between N fertilisation and nitrate distribution within the canopy. The paper presents a model that can be used to optimise growers' decisions on N fertilisation and harvest procedures with respect to both quantity and quality of spinach yield.

1340-1440

S02-P-13

LETTUCE GROWTH AND PHOSPHORUS LEACHING IN MEDIA AMENDED WITH PHOSPHORUS-TREATED MAGNETITE

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Magnetite was examined for use as a substrate on which to bind phosphorus (P) for the purpose of reducing P leachate. Magnetite was acid washed, pH adjusted to 5.0, and then shaken in a 10,000 ppm P solution. The P-magnetite was physically characterized to determine the P content (176 mg P/kg magnetite) and surface area. A greenhouse experiment was performed to determine the accessibility of the P from the P-magnetite to the plant and the amount of P leachate. Valmaine Romaine lettuce was sown into Sunshine media SB500 in 5.5 inch standard containers and treated with the following: 250 g P-magnetite (44 mg P), 150 g P-magnetite (26 mg P), 50 g P-magnetite (8.8 mg P), 150 g untreated magnetite, 3 g 15-9-12 Osmocote (119 mg P), 21-5-20 constant liquid feed (5.25 mg P/day), 21-5-20 constant liquid feed with 150 g untreated magnetite (5.25 mg P/day), and no treatment. For four weeks, weekly leachate samples were taken and analyzed for P content. At the completion of four weeks, the roots and shoots were dried and weighed, and foliar P analyses were performed. The constant liquid feed treatments had the highest P leachate, foliar P, and dry weights. Osmocote, 250 g and 150 g P-magnetite had similar P leachate, foliar P, and dry weights. This study demonstrates that P from amended magnetite is accessible for uptake by plants, and leachate was reduced using P-magnetite compared to a constant liquid feed.

1340-1440

S02-P-14

THE INFLUENCE OF GREEN MANURE AND STRAW ON THE LEVEL AND QUALITY OF PLANT YIELD IN VEGETABLE ROTATION

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The effect of catch crops such as green manure (phacelia, rye, winter vetch and faba bean) and straw fertilization with dose of 4 t/ha and 6 t/ha on the yields of vegetables in comparison with the cultivation without manuring and farmyard manure rate 60 t/ha were investigated. The influence of biomass of green manure consisting of the whole plants and plant residue which was ploughed-down, on vegetable yields was also estimated. The catch crops on green manure were sown in the second 10 days of July and ploughed-down in the third 10 days of October. In the first year after organic fertilization cabbage, in the second onion and, in the third year red beet were cultivated. The content of dry matter, reduced and total saccharides and vitamin C was determined in the vegetables. The experiments were carried out in the middle-east part of Poland on brown soil. The green manure applied increased the yields of vegetables in comparison to the control with no manure and farmyard manure. In the first year of cultivation the best yield effects were observed after ploughing-down of winter vetch, while in the second and third year—after faba bean. The cultivation after phacelia being ploughed-down, resulted in the highest content of dry matter in cabbage and of vitamin C and reduced saccharides in onion and red beet. The case of cultivation after ploughing-down of rye increased saccharides content in cabbage and onion, while after vetch the highest increase of vitamin C in cabbage and of dry matter and total saccharides in red beet were observed. The vegetables yields obtained after ploughed-down whole plant biomass were higher than those after ploughed-down plant residues alone. The straw dose of 4 t/ha had a better effect on vegetable yields than that of 6 t/ha. The application of the first straw dose together with green manure, especially, with phacelia or faba bean, increased in the yields of vegetables in comparison with ploughing-down of the green manure alone.

1340-1440

S02-P-15

PRODUCTIVE EFFECT OF GREEN MANURE IN PRO-ECOLOGICAL VEGETABLE CULTIVATION

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The productive effect of green manures (oat, field pea, vetch, and mixtures of oat + field pea; oat + vetch; field pea + vetch; and, oat + field pea + vetch) was investigated in vegetable cultivation. The experiments were carried out in the middle-east part of Poland on brown soil. The catch crops on green manure were sown at the turn of March and April and ploughed-down during the 3rd ten days of May. Two forms of catch crops, used as green manure—whole plant biomass and after-harvest residue, were applied. In the first year after ploughed-down green manure, a variety of headed white cabbage and in the second the variety of an onion were cultivated. Productive effect of green manure was compared to farmyard manure at the rate of 25 t/ha. Results indicate that the catch crops of field pea and mixtures field pea + vetch and oat + field pea + vetch, in the first year after ploughed-down, were more efficient green manure than oat, vetch and mixtures oat + field pea and oat + vetch. Most productive manure was a mixture of oat + field pea + vetch. The productive effect of it was on average 2-times lower than that of farmyard manure. High productivity of green manure from field pea and mixture of field pea + vetch were also found in the second year after ploughed-down in the onion cultivation. The post-effect of mixture of oat + field pea was high also. The productive effect of green manure from field pea and mixtures of field pea + vetch and oat + field pea, in onion cultivation, were similar to that of farmyard manure, whereas, the productive effect of oat, vetch and mixture of oat + vetch were on average 2-times lower and mixture oat + vetch 3-times lower than that of farmyard manure. The form of catch crops use on green manure did not have any effect on the yields of cabbage, however, the onion yields obtained after ploughed-down whole plant biomass were higher than those after ploughed-down after-harvest residue alone.

1340-1440

S02-P-16

NITRATE EXPLOITATION BY VEGETABLES DOWN TO 2.5 M SOIL DEPTH

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Nitrogen budgets are normally constructed on basis of changes in nitrate pools in the top 1 m or less of the soil. This practice is due to crops having the main part of their root system in this soil layer, and the difficulties of doing measurements at larger depths. Nitrate below 1 m depth is generally anticipated to be out of reach for the crops, and nitrate leaching to below 1 m depth is commonly used as a measure of nitrate loss from the system. It is, however, also known that several crops may extend a smaller part of their root system to larger depths, and investigations have shown root growth and N uptake from at least 2 m depth by agricultural crops. To investigate the importance of deep root growth for nitrate uptake in vegetables we studied white cabbage, carrots, and sweet corn under organic farming practice in Denmark. Roots were studied by use of minirhizotrons, and nitrate uptake by deep point injection of $\text{Na}_{15}\text{NO}_3$ followed by harvest of above-ground biomass after 6 days. In the beginning of October, white cabbage was found to have a root depth of at least 2.4 m, carrots of 1.4 m and sweet corn of 0.6 m. The shallow root depth of sweet corn was probably due to an unusually cold summer season. There was a good correlation between root distribution and ^{15}N uptake down the soil profile for each species. Carrots and especially white cabbage showed relatively high rates of ^{15}N uptake below 1 m depth, and both species had low but significant ^{15}N uptake from their root depths of 1.4 and 2.5 m, respectively. The results show that deep soil N can be a potentially important source of N for deep-rooted vegetables. Such vegetables may decrease N leaching from soil layers below 1 m depth. As a result N measurements restricted to upper soil layers may be inadequate for construction of N budgets. This could have important consequences for fertilisation practices, crop rotation planning and evaluation of environmental effects of growing vegetables.

1340-1440

S02-P-17

THE P FERTILIZATION OF POTATO: ENVIRONMENTAL RISK AND AGRONOMIC EFFICIENCY

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The potato is a high-P demanding crop due to high P fixation capacity in acid soils and low P-use efficiency. The P accumulates in soils and becomes gradu-

ally at risk for eutrophication of surface waters. New P fertilization concepts must consider the degree of soil P saturation and higher efficiency of P fertilizers. A soil test saturation indicator was obtained using the Mehlich-III (M-III) routine method. We obtained a highly significant relationship between soil P saturation as expressed by the (P/Al)M-III ratio, and water soluble P as Sissingh P (PW). The critical value of 9.7 mg PW L⁻¹ was selected as environmental limit. The corresponding (P/Al)M-III ratio was 15%. The yield-soil test relationship across 78 trials was improved using the (P/Al)M-III ratio compared to PM-III alone. The critical agronomic value was 8% as (P/Al)M-III. Using a power test, no response to P fertilizers was obtained above 35%. As a result, there was six fertility classes: 0-2 % (extremely low fertility, extremely low environmental risk), 2-4% (very low fertility, very low environmental risk), 4-8 % (low fertility, low environmental risk), 8-15% (medium fertility, medium environmental risk), 15-35 % (high fertility, high environmental risk), and >35% (very high fertility, very high environmental risk). A non linear recommendation model was proposed for the extremely low to medium classes. In the high fertility class, added P must equal crop P removal for a tuber yield of 40 Mg-ha⁻¹. In the very high fertility class, no P fertilizer is recommended. In order to reduce the rate of P accumulation in soils, we examined the partial replacement of inorganic P fertilizers by bio-treated hog manure. Organic ligands compete inorganic P on sorption sites. The organic P source was found superior to mineral P at high yield level in low-fertility soils. Hence, the (P/Al)M-III saturation index and bio-treated hog manure are good P management practices for the potato in acid soils.

1340-1440

S02-P-18

RUNOFF WATER QUALITY IN CALIFORNIA—LAWS, REGULATIONS, AND THEIR IMPLEMENTATION

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Regulations regarding quality of water discharged to land surfaces or water bodies have been in place in California since 1970, when the state enacted the Porter-Cologne Act. It was not until 1972 that the federally regulated Clean Water Act (CWA) was issued. Even though these state and federal programs were initiated almost 30 years ago, strict enforcement has only taken place in the past few years. For the state of California, implementation of waste water regulations is under the control of the Regional Water Quality Control Boards (RWQCBs), of which there are nine for the state. Each region is able to develop and execute its own wastewater quality regulations. Under the Porter-Cologne Act, the RWQCB may issue Waste Discharge Requirement (WDR) permits to those releasing wastewater into state waters, regardless of whether they are point or non-point source polluters. The water quality regulations stemming from the Porter-Cologne Act often meet or exceed the standards set by the federally developed CWA. The CWA contains two programs that will impact the nurseries, the Total Maximum Daily Loads (TMDL) Program and the National Pollutant Discharge Elimination System (NPDES) Program. The policies in the TMDL and NPDES programs regulate waste water discharge from point and non-point sources of pollution, respectively. We will explain the state and federal water quality control programs and how California is implementing these policies. We will also describe the how these programs have negatively and positively impacted the ornamental and floriculture industries of California, discussing the temporal, geographical and political aspects of water quality regulations.

1340-1440

S02-P-19

PREVIOUS CROP MANAGEMENT EFFECTS ON GREEN BEAN YIELD IN A MEDITERRANEAN CLIMATE

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In sustainable agriculture the yielding of agroecosystems must reach a good quantitative and qualitative level through agronomic techniques that reduce the N fertilization. In Southern Italy, characterized by Mediterranean climate, the cropping systems are based on durum wheat crop. In these environments, interesting results have been obtained intercropping a self reseeding annual legume (*Trifolium subterraneum* L.) with durum wheat and reducing the N level fertilization. In the areas where the summer irrigation is possible the cropping systems include a vegetable catch crop, i.e., pepper, eggplant, green bean, squash, etc., that nor-

mally is fertilized with high N levels.

The objective of this study was to evaluate the yielding ability of green bean crop in the utilization of residual fertility of previous crop system. A split-plot design experiment was carried out at Policoro, Southern Italy, in 1998, on a sub-alkaline, clay-silt alluvial soil. The previous crop systems were: i) durum wheat, ii) durum wheat intercropped with subterranean clover. The N levels were 45, 90 and 120 Kg-ha⁻¹ for durum wheat, and 0, 45 and 90 kg-ha⁻¹ for durum wheat+subterranean clover intercrop system. The NO level in the intercrop was introduced to evaluate the residual effect of subterranean clover ploughed in before green bean seeding; the N120 level in wheat crop system was compared with other managements that included lower N fertilization levels. The green bean cultivation, without any fertilization, was carried out from August 11 to October 27; three irrigations of 350 m³-ha⁻¹ each were made. The results showed a significant influence of previous crop and its management on yield and qualitative parameters of production. The lowest yields were obtained after wheat+subterranean clover without N fertilization, the highest one after wheat+subterranean clover and 90 kg-ha⁻¹ of N.y

1340-1440

S02-P-20

THE EFFECTS OF NUTRITION OF ASPARAGUS (*ASPARAGUS OFFICINALIS* L.) ON THE YIELD AND ENVIRONMENT

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Asparagus is the largest vegetable crop by area in Germany. About 15,200 ha were grown in 2001. Therefore, information is needed about the nutrient status of the soil, nutrient need of the asparagus plants, and how to reduce the environmental pollution of the groundwater by nutrients. A field trial was carried out to determine the nitrogen requirement of asparagus by testing four different NMIN target values as criteria for determining how much fertilizer to apply. The trial crop was not irrigated. The yield and quality of spears was determined daily during the harvest period in each of eight years. Total yield and number of spears showed no significant differences among the target values. However, the cumulative yield of grade I spears was 10% higher with the 90 kg N/ha NMIN target value compared with the 30 kg N/ha value. When annual NMIN residues were analysed the influence of weather conditions was greater than the influence of different fertilizer amounts. In all the years, a tendency toward increasing NMIN residues was observed only at the highest N-target value. Fertilizer application based on soil analysis can lead to reduce nitrate leaching in autumn. Additionally the sowing of oil radish between the asparagus ridges is a useful technique to reduce nitrogen content in the soil in autumn, after the growing season of Asparagus.

1340-1440

S02-P-21

MANAGEMENT STRATEGIES FOR CAPTURING THE BENEFITS OF MYCORRHIZAS IN THE PRODUCTION OF FIELD-GROWN VEGETABLES

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The mycorrhizal symbiosis between plants and fungi is a natural biological resource, which enhances the uptake of several plant nutrients. An improved use of this biological resource may increase the sustainability in plant production. Two approaches were investigated: 1) The use of previous mycorrhizal main crops or pre-established mycorrhizal cover crops, which enhance the rate of mycorrhiza formation in young seedlings and 2) the use of transplants, which were pre-colonized by mycorrhizal fungi selected for high nutrient uptake efficiency. Results from field experiments showed that colonization, P uptake and growth of leeks increased if the previous crop was leek or onion compared to cabbage. A cover crop of black medick, established the previous autumn, increased the colonization of leek roots and also increased the plant P concentration and growth. These measurements were, however, not significantly influenced by the date of incorporation or the tillage depth. Results showed that a well-prepared soil bed at sowing or planting is of crucial importance for plant growth. Differences in colonization, P uptake and plant growth diminished during the growing period and nearly disappeared at the final harvest date of the leeks. Leek transplants inocu-

lated with *Glomus intraradices*, *G. fistulosum*, *G. mosseae* or a field population of mycorrhiza increased the colonization, P uptake and growth of field-grown leeks, compared to non-inoculated transplants. Regarding the concentration of P, Zn and Cu, especially the leek roots were influenced by inoculation, compared to the leaves. As for the experiments on previous crops and cover crops, differences between treatments nearly disappeared at the final harvest date. Although, plants were grown in soil low in P, an explanation for this lack of response could be due to a sufficient supply of soil P or other nutrients low in mobility.

1340-1440

S02-P-22

SOURCES AND RATES OF POTASSIUM (K) FERTILIZER EFFECT ON SHALLOT PRODUCTION

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Effects of different sources of K fertilizer (muriate of potash (KCl); wood ash; poultry manure) and K rates (60 or 180 kg K ha⁻¹ for KCl; 74 or 134 kg K ha⁻¹ for wood ash; only basal application of 3t poultry manure ha⁻¹) on growth and bulb yield of shallot (*Allium cepa* var. *ascalonicum*) grown on loamy sand (Gleyic Arenosol) were investigated. Application of wood ash at K rate of 74 kg-ha⁻¹ significantly ($P < 0.05$) reduced net assimilation rate by 44%, 42% and 29% compared with shallots supplied with 60 or 180 kg K ha⁻¹ from KCl, 134 kg K ha⁻¹ from wood ash and those that received only basal fertilizer of 3t poultry manure, respectively. Total plant fresh weight of shallots was not significantly ($P > 0.05$) affected by different sources and rates of K fertilizer. Harvest index was slightly reduced when K fertilizer was supplied in the form of wood ash (0.7) compared with KCl (0.8). Total bulb yield of shallots supplied with KCl or only poultry manure was 8% higher than those supplied with wood ash, but was not significant ($P > 0.05$). Overall, percentage marketable shallot bulb yield increased with application of KCl or only poultry manure to plants during growth. An increase in rate of KCl fertilizer from 60 to 180 kg K ha⁻¹ increased percentage marketable bulb yield from 63 to 75% while an increase in application of wood ash from 74 to 134 kg K ha⁻¹ reduced percentage bulb yield from 61 to 53%. Marketable bulb yield was 71% for shallots that were supplied with only poultry manure. Thus, the proportion of K contained in 3t poultry manure is sufficient for shallot production despite the reduction in net assimilation rate compared with KCl and wood ash.

1340-1440

S02-P-23

YIELD AND QUALITY OF HORTICULTURAL CROPS FERTILIZED WITH AMMONIUM BASED FERTILIZERS CONTAINING THE NEW NITRIFICATION INHIBITOR DMPP (ENTEC)

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Up to date a total of 75 field trials with vegetables in central Europe were conducted and harvested in 1999, 2000 and 2001 where ammonium sulfate nitrate (ASN) with and without the nitrification inhibitor DMPP were compared. In most of these trials comparisons were made both at an optimal and a suboptimal level of N fertilization. Mean crop yields were increased by ASN + DMPP containing fertilizers compared to controls without DMPP for carrots, lambs lettuce, onions, radish, lettuce, Chinese cabbage, cauliflower, leek, and celery. Only in spinach with a very short culture period no yield increase due to DMPP was obtained. The field trials were differentiated in terms of the length of cultivation period among crops, soil texture and precipitation level. Data analysis showed that increased yields due DMPP application were especially high in situations where the likelihood of N losses due to leaching was high. On average the nitrate content of the marketable products was decreased in DMPP fertilized crops. The visual aspect in many trials was improved in DMPP fertilized field plots compared to controls at the same N level. This was due to a more uniform appearance of a population, e.g. less variation in size and weight of lettuce heads. Another factor of outer quality was a darker green color of leaves after DMPP fertilization in many cases. This visible aspect in color could also be proved by chlorophyll measurements. Explanations of positive yield and quality effects of DMPP fertilized vegetables are discussed in terms of an increased efficiency of fertilizer nitrogen and physiological aspects of a mixed ammonium and nitrate nutrition of crops due to the ammonium stabilizing effect of DMPP.

1340-1440

S02-P-24

SULFUR, ITS SOME COMPOUNDS AND NITROGEN IN PLANT AS INFLUENCED BY DIFFERENT S SOURCESE. Szwonek*¹, K. Klamkowski¹, B. Badek¹, A. Sirko², K.A. B_aszczyk²¹Research Institute of Pomology and Floriculture Pomologiczna 18 Str. 96 100 Skierniewice Poland; ²Polish Academy of Sciences Institute of Biochemistry and Biophysics Pawińskiego 5A Str. 02 106 Warszawa Poland

The aim of this initial study was to examine the influence of sulfur-containing carriers on uptake of this element and biomass production. Garden cress (*Lepidium sativum* L.) was grown in this trial. The plants were grown in semi-hydroponical culture under growth chamber conditions. Sulfur (40 mg/L) in the following carriers and fertilizers was added into the nutrient solution: (i) Patentkali (potassium sulfate with magnesium sulphate), (ii) Wigor (elemental sulfur and bentonite), (iii) potassium sulfate, (iv) calcium sulfate, (v) magnesium sulfate, (vi) ammonium sulfate, (vii) potassium hyposulfite and (viii) amorphous S. The nutrient solution without the sulfur addition served as a control. Results showed different response of plants to studied S carriers. Ammonium sulfate and potassium hyposulfite decreased biomass production, while applications of calcium sulfate, magnesium sulfate, Wigor and Patentkali stimulated plant growth. Sulfur uptake rate depended on the carrier. In case of ammonium sulfate and potassium hyposulfite plants absorbed the least amounts of sulfur, while those receiving calcium sulfate or Patentkali took up more sulfur than the control ones. A strong correlation was noticed between uptake rates of sulfur and nitrogen absorption, and biomass production (correlation coefficient was 0.96, 0.84, respectively). Some of the carriers did not affect the uptake rate of sulfur, and even decreased plant biomass production. This could be caused by specific proprieties of these carriers disturbing plant metabolically process or excess S concentrations. Regarding the biomass and thiols concentration in the garden cress, MgSO₄ seems to be a profitable source of sulfur. It appeared as well that uptake of sulfur was distinctly changed by (NH₄)₂SO₄. At the same time an increase of thiols in plants was observed. It may be suspected that this phenomenon was involved by glutathione accumulation in plants.

1340-1440

S02-P-25

A DEHYDRATED ORGANIC FERTILIZER AS A NITROGEN SOURCE FOR BROCCOLICarl Bélec*¹, Jean Coulombe², Louise Dextraze¹, Nicolas Tremblay¹, Rock Chabot³¹Horticultural R&D Center, Agriculture and Agri-Food Canada, 430 Gouin Blvd, St-Jean-sur-Richelieu, Quebec, Canada, J3B 3E6; ²1551 Chemin Royal St-Laurent, QC, CANADA, G0A 3Z0; ³ENVIROGAIN Inc., 1112 Boul. de la Rive-Sud, Bureau 210, St-Romuald, QC G6W 5M6

Areas with intensive animal production can now take advantage of industrial process that can treat the raw manure and turn it into dried granular fertilizer material suitable for transportation over long distances. The objective of this study was to evaluate the agronomic potential as a nitrogen source for broccoli of a granulated organic fertilizer produced by Agrior Inc. The experiment was conducted at two different sites in Quebec. Supplemental nitrogen requirements at 5 wk after planting were assessed with the help of a diagnostic test measuring nitrate in petiole extracts. In 2000, two levels of the organic fertilizer were tested (1 and 2 t/ha banded) in a complete randomized block design with a total of 16 and 12 treatments at Orleans Island and L'Acadie respectively. Arcadia was the cultivar chosen. The same experiment was conducted in 2001 with 13 treatments at both site. The organic fertilizer at the 1 t/ha rate brought in 40 kg/ha of P₂O₅ and K₂O which amount was removed from the base dressing fertilizer recommendation of other treatments. The parameters evaluated included marketable yield, hollow stem incidence, petiole nitrate concentration, soil inorganic N pre-plant and after broccoli harvest, biological activity in soil and total mineral uptake at harvest. The Agrior product in combination with inorganic fertilizer gave as good yields as those obtained with conventional inorganic fertilizer N management. Yields obtained with either 1 or 2 t/ha of organic fertilizer were not different. The amount of N to apply at sidedress was correctly calculated using the analysis of nitrate in petiole extracts. Biological activity in the soil tended to increase with the organic fertilizer rate. Evaluation of the overwinter effect of the organic fertilizer has been done with the establishment in 2001 of a wheat crop on top of the former broccoli set-up. Wheat yields showed a significant long-term effect of the organic material.

1340-1440

S02-P-26

WINTER COVER VERSUS SYNTHETIC N EFFECT ON YIELD, PLANT DRY MATTER AND PHOTOSYNTHESIS OF BELL PEPPER

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The goal of this 2001 study was to determine if winter cover crops could support bell pepper yield, vegetative dry matter and net photosynthesis (Pn) comparable to recommended synthetic N rates. The following winter-spring fertility treatments were applied using randomized complete block design with four replications: 1) 0 N winter-0 N spring, 2) 0 N winter-70 kg N/ha spring, 3) 0 N winter-140 kg N/ha spring, 4) 0 N winter+abruzi rye-0 N spring, 5) 0 N winter+hairy vetch-0 N spring, and 6) 0 N winter+crimson clover-0 N spring. In Spring, 'Wizard 338G' bell pepper were transplanted in all plots. Total yield was compiled over eight weeks and plant dry matter collected at final harvest, while net photosynthesis was measured at different fruiting stages. Highest vegetative dry matter (79.8 g/plant) and total yield (34.2 Mg/ha) was produced by hairy vetch and lowest (22.8 g/plant and 6.3 Mg/ha, respectively) by abruzi rye. Maximum Pn (15.2 μmol CO₂·m⁻²·s⁻¹) occurred at final fruiting. Hairy vetch increased Pn the most, while minimum influence came from the abruzi rye and 0 N treatments. Organic N from hairy vetch and crimson clover produced plant dry matter and yield comparable to those receiving synthetic N. Results indicate that hairy vetch and crimson clover are an effective N source in supporting plant dry matter, total yield and net photosynthesis of bell pepper.

1340-1440

S02-P-27

AVAILABILITY OF SELENIUM IN SOILS AND ITS UPTAKE BY VEGETABLE PLANTS

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In pot experiments with two different soils adjusted to a pH level of either 5 or 7 which were partly amended with metallurgical slag Selenium content as well as the fractions extractable with 1 M ammonium nitrate or 0.01 M calcium chloride + 0.002 M DTPA or 1 M ammonium acetate were determined. Also, the uptake of Selenium by Chinese cabbage and kohlrabi was measured. Selenium determination was carried out by combined Selenium hydride formation and Graphite Tube Atomic Absorption Spectrometry. Total and salt extractable Selenium as well as the uptake by the vegetable species increased with increasing slag amendment. Total Selenium in soils without slag was about 150 μg/kg while it amounted to about 400 μg/kg at 10% slag. The Selenium content of the edible plant parts increased from about 10–20 μg/kg DW to about 100 μg due to the slag amendment. Selenium extractability with the salt solutions mentioned and its uptake was much more pronounced at pH 7 than at pH 5. Correlation between extractable Selenium and its uptake by plants was high (r = 0.95) for all three extractants at pH 7, however, at pH 5 correlation was best with ammonium nitrate (r = 0.79–0.81).

1440-1500

S02-O-28

HIGH IRRIGATION FREQUENCY: THE EFFECT ON PLANT GROWTH AND ON UPTAKE OF WATER AND NUTRITIONAL ELEMENTS

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Reducing the risk of pollution of soil and water resources resulting from intensive fertilization of plants has become one of the most important objectives of the modern agriculture. Adsorption by the solid surface and precipitation of insoluble compounds decrease the concentration of nutrients in the rhizosphere in comparison to that of the irrigation water. These processes are time dependent and therefore, reducing the interval between two successive irrigations may reduce the time-variations of nutrient concentration in the liquid phase. Furthermore, the effect of irrigation frequency and discharge rate on the soil-wetting zone regulates nutrient transport to the root surface, which might influence the acquisition of nutrients by plant roots. Transpiration dur-

ing the day may cause huge differences of water content in the rhizosphere and in the bulk soil. Differences of few percentages in water content of porous media such as sandy soils or artificial substrates can affect their hydraulic conductivity by four or five order of magnitude. Thus, reduction of water content in media may reduce the transport rate of ions to root and limit nutrient acquisition by the plant. Hence, supplying water and nutrients at a rate as close as to that of plant uptake may facilitate the reduction of fertilizer quantities needed to achieve optimum production. In a series of experiment it was found that reducing the NPK level (50–70% from normal) to lettuce or sweet pepper plants exposed to normal frequency of irrigation (1–3 per day) significantly reduced plant production. On the other hand, fertilization levels did not affected the yield of plants exposed to high irrigation frequency. Uptake of P and K was significantly stimulated due to increasing irrigation frequency. These results indicate that it is possible to improve the availability of nutrients to the plants and to reduce of fertilizer levels by increasing irrigation frequency.

1500–1520

S02–0–29

LONG TERM EFFECT OF FERTILIZATION AND IRRIGATION RECOMMENDATIONS ON SOIL-WATER NITRATE LEVELS IN SANDY SOILS

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The Surface Water Improvement Management (SWIM) Act of 1987 declared that several water bodies in Florida were at risk of becoming degraded from point and non-point sources of pollution (including agriculture). The value of the vegetable industry in Florida is estimated to be \$1.2 billion. Approximately 142,000 ha are planted in intensively managed vegetable crops. Consequently state agencies, water management districts, and the Univ. of Florida have tested Best Management Practices (BMPs) aimed at reducing non-point source pollution from agriculture. The philosophy of BMPs is to maintain ground water nitrate nitrogen ($\text{NO}_3\text{-N}$) level at or below the EPA drinking water standard of 10 mg/L $\text{NO}_3\text{-N}$ while producing economical yields of vegetables. Spring and fall vegetables were grown following current recommendations on a 1.6 ha field between 1998 and 2001. Nitrate levels in the soil water at the 1.6 m depth were monitored monthly with suction cup lysimeters while ground water nitrate levels were monitored with deep wells. Nitrate-N in the lysimeters ranged from 20 to 150 mg/L $\text{NO}_3\text{-N}$ except when cover crops were grown between vegetable crops. Under cover crops, the lysimeters ranged between 5 and 20 mg/L $\text{NO}_3\text{-N}$. The ground water monitoring wells were always below 20 mg/L $\text{NO}_3\text{-N}$. Based on these observations it was concluded that it is not possible to maintain nitrate nitrogen levels in the soil water or the shallow groundwater below the EPA drinking water standard, when current recommendations are followed. Reducing fertilizer rates to reduce nitrate levels to or below 10 mg/L $\text{NO}_3\text{-N}$ will result in reduced yield.

1520–1540

S02–0–30

SIX YEARS RESULTS FROM AN ORGANIC VEGETABLE CROP ROTATION AIMED AT SELF-SUFFICIENCY IN NITROGEN

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One of the main constraints of organic vegetable production is lack of available N, which causes reduced yields and quality of the to the crops. Therefore, we started an organic vegetable crop rotation in 1996 where we could study the possibilities for improved N utilisation. The N supply to the crops is based on the effects of nitrogen catch crops, green manure crops and crop sequences aimed at a high utilisation of precrop effects, whereas no input of any manures are made. Measurements and experiments have been made within the crop rotation to test the effectiveness of the N strategies used. The results show that it have been possible to maintain good yields of the crops in the rotation. Yields of leek and carrot have been as high as in conventional cropping. Yields of onion, cabbage, green peas, and the two spring barley crops included in the crop rotation have been lower, but still good by organic standards. The measurements of N dynamics show that autumn soil cover is an important part of

the N strategies. Whether the autumn soil cover is a green manure, a catch crop, or crop residues left growing after harvest, it makes N available in the spring rather than in the autumn, and the available N is found closer to the soil surface. The results also show, that when it is not possible to establish an autumn soil cover, it is important to grow deep rooted crops in the next year, to recover some of the N leached to greater soil depths. Finally, undersowing of legumes in spring cereals have been found to be an attractive method, allowing both a grain cash crop and an effective green manure to be grown within the same year.

1540–1600

S02–0–31

NOVEL TECHNIQUES TO REDUCE NITRATE POLLUTION OF GROUNDWATER FROM HIGH N CONTAINING CROP RESIDUES

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Return of high-N content crop residues to soil, particularly in autumn, can result in considerable environmental pollution, arising both from NO_3^- leaching to water courses, and the generation of nitrous oxides implicated in the greenhouse effect. Considerable amounts of such high-N crop residues are produced in the UK every year, including 4 million tonnes (M t) of sugar beet surface residues, and 1 Mt each of potato and vegetable brassica residues. Under normal conditions these will return between 100 and 200 kg/ha N to the soil, but in high yielding situations this can increase to 300 kg/ha N. There is a need to improve management of such residues in order to reduce losses following harvest and increase cycling of N between crops, particularly in nitrate sensitive areas. This project was designed to examine the potential of using a selection of waste materials and other chemical amendments to manipulate the release of mineral from crop residues in the soil. One approach was to examine the effects of co-incorporating materials with high C:N ratios such as paper waste with the leafy residues to immobilise any organic N mineralised as they decay. Initially the effects of 6 different chemical amendments with widely different C:N ratio on N mineralisation was investigated in laboratory incubation experiments to identify the most promising materials. Of the treatments tested the incorporation of compactor paper waste with a C:N ratio of 513 was the most effective at reducing net mineralisation. Co-incorporating similar material into field soil at a rate equivalent to 3.75 t/ha of carbon together with sugar beet residues had a significant effect in reducing both autumn mineral N levels and subsequent N losses by leaching and denitrification. However the grain yield of a following spring barley crop was reduced compared to a control with just sugar beet residues. Further work is necessary to investigate the longer term effects of this immobilised nitrogen in case it is remineralised in the following autumn.

1600–1620

S02–0–32

USE OF SUCTION CUP LYSIMETERS IN FIELD EXPERIMENTS WITH ORGANIC FERTILIZERS

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It is very important to be able to follow the soil content of plant available nutrients during field experiments with vegetables. Usually soil samples are used, and different extraction methods, for different compounds and varying plant accessibility, have been developed. The Spurway-Lawton method is most frequently used to extract the easiest accessible nutrient fraction. This method is not adapted to the micronutrients. When using organic fertilizers you also have to deal with the risk to get fertilizers into the soil samples. A new approach is to collect the soil water instead of taking soil samples. In experiments with organic production of onions with different fertilizers, suction cup lysimeters were used in 2000 and 2001. The lysimeters were made of Teflon and quarts with the diameter 21 mm and the length 95 mm. The pore size were 2 microns and the porous area were 33 cm². The lysimeters did not retain phosphorus or other chemical compounds which might interfere with the collected samples. The lysimeters were installed 15–25 cm below surface. On the sampling times the field was irrigated the first day and the following day the lysimeters were put under low pressure and the soil water were collected in bottles above ground. Our results show that the increased contents of mineralised nitrogen after dif-

ferent fertilizer application were indicated at the same time with soil samples as with soil water samples. However, the differences were more pronounced with soil water analyses. The method was well adopted for studies of a large number of macro and micro nutrients. Moreover, it was easy to use in comparisons of different treatments at the same time. If the soil water content was the same at all collection times even comparisons between different times were possible to conduct.

1620-1640
S02-O-32-A
TO BE ANNOUNCED

1640-1700
S02-O-32-B
TO BE ANNOUNCED

Friday August 16

0800-0900
S02-P-33

INFLUENCE OF ORGANIC AND COMPLEX MINERAL FERTILIZERS ON THE YIELD OF HEAD CHICORY (*CICHORIUM INTYBUS* VAR. *FOLIOSUM* L.), AND NITROGEN, PHOSPHORUS AND POTASSIUM ACCUMULATION IN PLANTS

Mirjana Eustiaè*, Milan Poljak, Nina Toth, Lepomir èoga, Marija Pecina Univ. of Zagreb, Faculty of Agriculture, Dept. of Plant Nutrition, Zagreb, Croatia

The influence of different fertilizer forms and rates on the yield and nitrogen, phosphorus and potassium accumulation was investigated in red head chicory (*Cichorium intybus* var. *foliosum* L.). For this purpose, field fertilization trials were set up at two locations in northwest Croatia in 1999 and 2000. Trials were laid out according to the Latin square scheme in 5 fertilizing variants with 5 replications. The trial involved: stable manure (5 kg/m²), three complex mineral fertilizer rates NPK-5:20:30 (50, 100 and 150 g/m²), and an unfertilized check. Investigation results indicate that there were no significant differences, between locations and trial years, in the plant nitrogen and phosphorus contents (depending on the fertilization). Significant fluctuation of the chicory potassium content, depending on the fertilization, (3.96–5.75%) was recorded only in 1999, while significantly lower potassium values were obtained in the unfertilized check and the stable manure. All the values were uniform in 2000, ranging from 5.0 to 6.2%. In general, the highest yield was achieved by the application of 150 g of mineral fertilizer in Lika (4.95 kg/m²) in 1999, though there were no statistically significant differences in yields between variants fertilized with 100 and 150 kg/m² of mineral fertilizer on both locations and in both years. Comparing the trial years, yields were generally higher in 1999 (1.58–4.95 kg/m²) than in 2000 (0.4–2.7 kg/m²). This might have been a consequence of adverse weather conditions in 2000—high temperatures with little precipitation. It is interesting to mention for these investigations that there were no significant differences in yield in the application of stable manure and the lowest mineral fertilizer rate.

0800-0900
S02-P-34

MANAGING NUTRITION OF UNITED STATES GOLF ASSOCIATED (USGA) CONSTRUCTED GOLF GREENS UNDER IRISH CONDITIONS

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A United States Golf Association (USGA) specification green was constructed at Teagasc Horticultural Research Station at Kinsealy, Dublin 17. The green was sown with *Agrostis stolonifera* var. *Penncross*. After satisfactory establishment of the turfgrass, the green was divided into 15 plots, each measuring 3.5 x 3.5 m and randomly assigned treatments. Six of these plots contained lysimeters.

An experiment to compare two nutritional programmes under Irish conditions was set up. Programme 1 consisted of alternating weekly applications of ammonium sulphate (21% N) and potassium nitrate (13% N, 38% K). Programme 2 consisted of six weekly applications of Methylene urea (40% N) together with two weekly applications of potassium sulphate (42% K). Phosphorus was applied over six applications to both programmes. The total quantity of fertilizer applied to both treatments was similar: 29.0 gm-m⁻² Nitrogen; 40.15 gm-m⁻² Potassium and 2.7 gm-m⁻² Phosphorus. Tissue and rootzone analysis were carried out as was a grass colour assessment. It was found that water-soluble fertilizers were more efficient producers of a quality sward than slow release types such as Methylene Urea. That slow release fertilizers are susceptible to leaching immediately following a major precipitation event and that such leaching breached European Union limits on several occasions throughout the growing season irrespective of when such fertilizers were applied to the turf. Tissue analysis from both programmes showed potassium and phosphorus levels to be within their sufficiency range, while analysis of rootzone samples suggested a deficiency of both elements. Thus, rootzone analysis as a method for determining nutrient application rates for both elements is moot and furthermore that fertilizer application based on such assessment are very susceptible to leaching. Programme 1 plots achieved significantly higher colour ratings throughout the duration of the trial.

0800-0900
S02-P-35

DEVELOPMENT OF A NITROGEN MANAGEMENT TOOL FOR BROCCOLI

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To manage the large spatial and temporal variability in N requires a combination of both predictive and intervening management strategies to achieve the best congruence between crop N demand and soil supply at all growth stages. The soil mineral N, tissue NO₃-N and foliar nutrition concentrations testing were evaluated as a nitrogen management tool for broccoli production. Broccoli cultivar Fiesta was grown the varying nitrogen supply (62, 122, 182, 242, 304 kg N ha⁻¹). Investigation showed that according to high yield data the optimal N supply at planting of 240 kg-ha⁻¹. It was established that, in broccoli leaves the content of total N is 26-31 g·kg⁻¹ dry wt, P-3-5 g·kg⁻¹, K-24-31 g·kg⁻¹, Ca-35-56 g·kg⁻¹, Mg-5-8 g·kg⁻¹ the production of head is over 10 t·ha⁻¹. High yield crops were optimally supplied with nitrogen when NO₃-N in leaves on the 27th day after transplanting (DAT) was higher than 3500 mg·kg⁻¹, 46th DAT—higher than 3000 mg·kg⁻¹, 59th DAT—higher more 2000 mg·kg⁻¹. Petiole NO₃-N can fluctuate rapidly depending not only on soil NO₃-N supply, but also on moisture regime and environmental conditions. Therefore the NO₃-N concentration in broccoli petioles collected on the 27th DAT poorly correlated with NO₃-N in soil samples. On the 46th DAT NO₃-N concentrations in broccoli petioles correlated (r = 0.59, r = 0.53) with NO₃-N in soil samples from 0–20 cm and 0–60 cm depth respectively. Good correlations were established on the: 27th DAT between the N in leaves and NO₃-N in soil (0–20 cm, 0–60 cm depth) r = 0.74-0.76, 46th DAT—between the NO₃-N in leaves and NO₃-N in soil (0–20 cm depth) r = 0.59 and N in leaves and NO₃-N in soil (0–20 cm, 0–60 cm depth) r = 0.68, r = 0.6.

0800-0900
S02-P-36

USE OF AMINO ACID NITROGEN FOR GROWTH BY PAK-CHOI UNDER STERILE CULTURE

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Effects of 5 concentrations of amino acid and 5 kinds of amino acids on pak-choi [*Brassica campestris* ssp. *chinensis* (L.) Makino] growth were studied under sterile medium culture. Effects of organic nitrogen, inorganic nitrogen and the mixture of them on pak-choi growth were also studied by supply pak-choi with 2 mmol glycine-N, 2 mmol nitrate-N and 1 mmol glycine-N + 1 mmol nitrate-N, respectively. 15N-labelled nitrate was used in the latter. The results showed that pak-choi took up intact amino acid under sterile culture. Concentrations of glycine lower than 2 mmol gave pak-choi normal growth

after 55 days culture, and higher than that gave pak-choi negative effects, i.e., induced brown spots on the stems and inhibited the uptake of water. After 60 days of culture, the fresh weight, dry weight and N accumulation of pak-choi supplied with different amino acids were significantly different. The descending sequence was glycine>glutamic acid>lysine>leucine>alanine. Pak-choi supplied with nitrate-N as sole nitrogen source had the highest fresh weight after 45 days sterile culture. The fresh weight of pak-choi fed on amino acid-N and on the mixture were 53.72% and 76.79% of that of nitrate-N supplied. Pak-choi accumulated more nitrogen when supplied with the mixture than when grown on nitrate-N or amino acid-N. There is no significant difference of dry weight among the treatments. When the pak-choi supplied with 1 mmol nitrate-N + 1 mmol glycine-N, the percentages of N in the plant derived from nitrate-N, glycine-N and the seed were 40.76%, 44.18% and 15.06%, respectively. Pak-choi absorbs amino acid directly no matter there exists inorganic nitrogen or not.

0800-0900

S02-P-37

EFFECTS OF ORGANIC NUTRIENT SOLUTION ON GROWTH AND QUALITY OF HYDROPONIC PAK-CHOI

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Pak-choi [*Brassica campestris* L. ssp. *chinensis* (L.) Mak] is the most popular leafy vegetable in south China. Finding new culture methods to improve the growth and quality of pak-choi was the aim of the paper. Soybean cake was chosen as the source of organic nutrient solution for its high nitrogen content (24.19%) and proper ratio between nitrogen, phosphorus and potassium for vegetable growth. Effects of organic nutrient solution on pak-choi growth and quality were studied by supply pak-choi with organic and inorganic nutrient solution respectively under substrate culture. The concentration of each element in inorganic solution was kept on the same level as those in organic solution. The results showed that the biomass of pak-choi supplied with organic nutrient solution was 25.52% higher than that supplied with inorganic solution. The contents of soluble carbohydrate, soluble protein, α -carotene and diet fiber of pak-choi fed on organic nutrient solution were higher than that fed on inorganic solution by 51.00%, 23.51%, 18.47% and 16.79%, respectively. The differences of chlorophyll, vitamin C, nitrate, nitrite and mineral elements content between the treatments were not significant. Organic nutrient solution made from soybean cake improves pak-choi growth and quality.

0800-0900

S02-P-38

INFLUENCE OF FERTILIZATION ON EARLY SAVOY CABBAGE YIELD

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Six field experiments were carried out during three years (1999–2001) at two locations (Osijek and D. Miholjac) to determine the fertilization influence on yield of early Savoy cabbage (*Brassica oleracea* L. var. *sabauda*). The experiments were conducted in 1999 and 2001 with five N-fertilization levels (without fertilizer, 50, 100, 200 and 300 kg N/ha + 100 kg P₂O₅/ha and 300 kg K₂O/ha) and in 2000 and 2001 with five fertilizer levels (without fertilizer, N₁, N₂, N₂P₁K₁ and N₂P₂K₂). Yields were measured for each of 4 replicates. Yields of Savoy cabbage heads (fresh matter) were 25.4 (without fertilizer)–66.2 t/ha (highest fertilization) in D. Miholjac and 24.3–59.2 t/ha in Osijek. The average weights of Savoy cabbage heads were 406–1059 and 389–947 g, respectively. The fertilization increase resulted with yield increasing on both localities, but year did not affect yield. Experiments with five N levels produced yield increasing up to highest N-level (300 kg/ha), but each linear increment of N-fertilization resulted with a lower yield increase than the previous one. With the two levels of N, P and K there was also an increase of yield up to the N₂P₂K₂ fertilization level, but the influence of fertilization was significantly lower in Osijek. In conclusion, yields of the early Savoy cabbage hybrid increase due to higher fertilization, and the increase is higher on the soils with lower available nutrients level.

0800-0900

S02-P-39

CALCULATOR FOR THE BRASSICAS FERTILIZATION RECOMMENDATION

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The calculator for the calculation of fertilizer doses required for the *Brassicaceae* crops is based on the results of the soil analyses data and nutrients removal by yield of cabbage, Savoy cabbage and cauliflower. The formulas included in the fertilization calculation in this calculator are simplified for the "on line" usage on the Internet and programs are written in JavaScript so that they can be copied and used "off line." Calculator includes introductory part with instruction and part for choice of *Brassicaceae* vegetable species. For the estimation of the fertilizer recommendation it is necessary to select the crop and to enter the target yield. Furthermore, the results of soil analyses should be entered (pH, humus content, mg AL-P₂O₅ and K₂O, N min), then the soil texture (light, medium, heavy) should be selected and the amount and year of the manure application should be entered. Also, the vegetable species depended data are plant density, number of plowed top dressings, what influences on fertilizer requirement and time of application. Data used in formulas are results of four-years field experiments since 1998 and are related to soil and fertilization influence on yield, nutrient concentration and nutrient removal of cabbage, Savoy cabbage and cauliflower plants. The result of the calculation is the recommendation of N, P₂O₅ and K₂O doses for the fertilization of selected vegetable crop. The calculator estimate the amount of certain mineral fertilizers at the same time. The calculated NPK fertilizers amount is the compromise between the requirements of phosphorus and potassium, while the nitrogen fertilization and its distribution are recommended according to crop requirements, soil texture and estimated mineralisation dynamics. The described calculator can be found and used on the Internet at the following addresses: <http://jagor.srce.hr/~zloncar>, <http://jagor.srce.hr/fvukadin> and <http://suncokret.pfos.hr/fvvladimir>.

0800-0900

S02-P-40

INFLUENCE OF NITROGEN AND IRRIGATION MANAGEMENT ON THE ASPARAGUS PRODUCTIVITY UNDER DESERTIC CONDITIONS

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Green asparagus production is an important exporting crop at the Caborca region, covering over 6000 ha. Irrigation and fertilization, especially nitrogen, are two key components of the asparagus production system under these arid conditions; usually, these two components are used in excess with potential consequences on the environment, pest problems and profitability. Therefore, the aim of this study was to determine the best irrigation and nitrogen conditions to get good yield and spear quality. The study was carried out in a commercial 'UC-157' asparagus plantation, three years old, and furrow irrigated. The irrigation (soil moisture levels) and nitrogen rates treatments were applied after harvest (late-March to mid-October); during harvest, irrigation was applied uniformly to all treatments, and no nitrogen was applied. The 35%–35% soil moisture level resulted with 331.6 boxes/ha (30 lb/box) while the control plot yielded 270.6 boxes/ha; regarding to nitrogen rates the best results were obtained with 200 kg·ha⁻¹, while the lower yield resulted with the 600 kg N·ha⁻¹ treatment. The amount of green spears harvested at each cutting date was more determined by the climatic conditions (temperature) and less by the nitrogen and irrigation treatments previously applied. Over 60% of the total harvested spears were obtained during the last three weeks of a total of eight. There is a trend to get a higher percentage of jumbo and lower percentage of small size spears harvested with the higher nitrogen rate.

0800-0900

S02-P-41

EXTENSION OF PRACTICAL SOLUTIONS FOR EFFICIENT NITROGEN MANAGEMENT OF VEGETABLE CROPS: A COMPREHENSIVE GUIDE DEVELOPED USING A UNIQUE APPROACH

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Nitrogen (N) application often exceeds crop needs, particularly in vegetable production, in which the cost of lost yield far outweighs the cost of additional N fertilisation. Yet excessive N use may lead to negative health and environmental effects. While researchers and agronomists agree that many standard methods of making N recommendations do not adequately integrate the N-influencing characteristics of a given field, a comprehensive guide to sustainable nitrogen management in vegetable crops has been lacking. The need for such a guide was the impetus for this work, a collaboration between researchers in Québec and Germany. The guide demonstrates the use of the N balance approach in tailoring recommendations to crop needs. In so doing, it discusses the behaviour of N in the soil-plant-air system, methods for estimating and measuring the various N inputs and outputs, and the practical use of these in making efficient N recommendations on a per field basis. Also discussed are the environmental and health effects of excessive N fertilisation, and how these effects may be mitigated practically. A unique approach to the development of the guide involved its review by agronomists and researchers across the world to guarantee completeness. Its release as an electronic publication facilitates distribution and navigation within the text, and permits frequent updates that will ensure its continued relevance.

0800-0900

S02-P-42

EFFECTS OF COMPOST AND MYCORRHIZAS ON THE PRODUCTION AND CONTENTS OF PHOSPHORUS AND NITRATES IN LETTUCE

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Lettuce (*Lactuca sativa*) cultivar Gallega was field grown, during autumn winter. To improve yield and quality, two fertilization treatments were applied: 1) vermicompost; 2) biostabilised compost and compared with a control without fertilization. Each fertilization treatment was divided in two equal numbers of plants: one part of the plants was inoculated with mycorrhizas and the other part of the plants without inoculation. The plants were harvested at commercial size and fresh weight, nitrates (Cataldo) and Phosphorus (colorimetric) were determined. The results were subjected to ANOVA and post hoc LSD. Biostabilized compost inoculated with mycorrhizas and vermicompost with and without inoculation presented the largest fresh weight per plant, presenting no significant differences between them but with a significant larger weight than the control treatments with and without mycorrhizas and the biostabilised treatment without inoculation. Biostabilized treatment without inoculation showed the highest level of nitrate. The concentrations of Phosphorus were significantly larger with biostabilised treatment with inoculation, regarding to biostabilised without inoculation and of both of them regarding to vermicompost and control treatments with and without mycorrhizas. The cultivation with compost and the inoculation with mycorrhizas showed an important incidence on fresh weight and on phosphorus content regarding to control treatments. The content of nitrate, for none of the treatments exceeded the limits of permission for winter lettuce (*Gazzetta ufficiale* CE, 1992). Concerning the applied treatments: biostabilized compost inoculated with mycorrhizas presented the best result, a good yield, lower nitrates and higher phosphorus contents, therefore this treatment could be a considered as a positive option for a field production with a minimal environmental impact.

0800-0900

S02-P-43

BROCCOLI AND CAULIFLOWER RESPONSE TO SUPPLEMENTAL SOIL SULPHUR

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Fertilization practices for cole crops have evolved from grower experience and local research results. In Eastern Canada, both gypsum and limestones have been used to increase the yield and quality of certain cole crops such as Brussels sprouts and cabbage. Previous published research indicated that gypsum tended to increase marketable yields of Brussels sprouts but calcite and elemental sulphur had little effect on yield. Latter published research stated that additions of supplemental sulphur as potassium sulphate or as gypsum are important in the production of locally grown cabbage. This study was conducted to determine the effects of sulphur and calcium on the yield of two additional locally grown cole crops. Broccoli (cv. Premium Crop) and cauliflower (cv. Andes) were grown at several sites over several consecutive years. Treatments consisted of a control, calcitic limestone (approx. 100% Ca carbonate) at 2088 kg·ha⁻¹, potassium sulfate at 265 kg·ha⁻¹, and gypsum (CaSO₄·2H₂O) at 4000 kg·ha⁻¹. For broccoli, treatments containing S increased yield 2 to 18%, however, yield response in cauliflower was quite variable on sandy loam to loamy sand soils in Prince Edward Island. Calcitic limestone and gypsum tended to increase tissue Ca while gypsum and potassium sulphate increased tissue S. Gypsum decreased while calcite increased soil pH.

0800-0900

S02-P-44

EFFECTS OF A SINGLE ADDITION OF COMPOST ON POTATO YIELDS WHEN NITROGEN AND PLANT AVAILABLE WATER ARE NOT LIMITING

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In 2001, nine field plots at the Univ. Horticulture Research Center in South Burlington, VT were amended with compost at a rate of 0 kg/ha, 7,344 kg/ha, or 14,688 kg/ha. A split-plot design was used and replicated three times at the site. Compost rates were the main plot treatments. Each main plot was comprised of a 24 m double row planting. Plantings of potato (*Solanum tuberosum* L.) cultivars 'Russet Burbank' and 'Butte Russet' were replicated twice in each plot. Subplots consisted of four 4.8 m replications bordered on either end by a 0.6 m section of guard plants. Nitrogen levels were adjusted via fertigation to bring all treatments to similar levels of potential available N. All treatments received the same amount of water during nutrient application. Irrigation based on 65% PAW for all treatments began on August 2 and continued through the month of August. Soil moisture readings were taken daily, summed for each treatment, and irrigation was made based on a 65% PAW threshold for each individual compost treatment. All potatoes were individually graded based on USDA standards. The amount of irrigation water required to maintain 65% PAW was 23.0% less in the 14,688 kg/ha compost treatment than in the zero kg/ha treatment. The addition of compost had no significant effect on total yield of potatoes, but compost effects on tuber number ($P = 0.0023$), number of culls ($P = 0.0001$), and total weight of culls ($P = 0.0025$) were significant. The addition of compost significantly increased tuber number (DMRT, $n = 12$), the number of culls (DMRT, $n = 12$), and the total weight of culls (DMRT, $n = 12$). 'Butte Russet' yielded approximately 22.7% significantly more saleable tubers by weight than 'Russet Burbank' (DMRT, $n = 18$). Interaction effects were not significant.

0800-0900

S02-P-45

FOLIAR FERTILIZATION OF TOMATOES (*LYCOPERSICON ESCULENTUM* MILL.) WITH SULFUR

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Tomatoes are discussed as anti-cancerogeneous vegetables because of their lycopin content. Although sulfur is not an element of the chemical composition of lycopin the biosynthesis of this molecule is connected to a sulfur containing enzyme namely acetyl-CoA. Therefore it seems reasonable to fertilize tomatoes with sulfur containing fertilizers to improve the content of lycopin within the tomatoe fruits. Pot experiments have been done during two years to prove the above mentioned hypothesis. Tomatoe plants have been grown in sulfur free culture medium and have been fertilized with either sulfur free fertilizer or with fertilizer containing 5 mg sulfur or with 25 mg sulfur. The fertilizer has been given on top of the culture medium or has been sprayed on the leaves of the plants. The yield of the fruits and the sulfur content within the fruits have been

improved due to the fertilization. Foliar supply has been superior to culture medium supply.

0800-0900

S02-P-46

INTEGRATED WATER AND NUTRIENT MANAGEMENT FOR BELL PEPPER GROWN WITH PLASTICULTURE

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Producing economical yields of vegetables while conserving water and fertilizer requires an integrated approach to fertilization and irrigation management for vegetable crop production. This approach is central to the development of Best Management Practices (BMPs). Currently, specific fertility recommendations are available, but limited information exists on the interaction between fertilization and irrigation practices. Also, irrigation recommendations for real-time management are currently not available for most drip-irrigated vegetables in Florida. As part of BMP development, bell pepper was grown with plasticulture with factorial combinations of three N regimes (75%, 100% and 125% of the recommended 224 kg N/ha rate) and four irrigation regimes (33%, 66%, 100%, and 133% of a reference rate; I3). Different numbers of drip tapes, two sub-main lines, and three fertilizer injectors were used to create the factorial combinations of N and irrigation rates. For I3, daily drip irrigation was based on class A pan evaporation (Ep) and a crop factor ranging between 0.20 and 1.00 depending on crop age. Seasonal irrigation was 77 m³ per 100m of bed length for I3. Soil water tension tended to decrease with increasing water amounts and remained under 20 kPa with 66% I3 in the top 30-cm soil zone. Bell pepper yields were significantly affected by N and irrigation rates (all $P < 0.01$). Interactions N rate x irrigation rate were not significant for Fancy and marketable yield components. Fancy yield was significantly higher with 125% than with 100% N rate. Fancy and marketable yields responses to water rates were both quadratic ($P < 0.01$) and maxima occurred at 97% and 94% of I3, respectively. Therefore, a combination of 280 kg N/ha and 90% I3 irrigation regime should be used together for highest bell pepper yields grown with plasticulture.

0800-0900

S02-P-47

DETERMINATION OF A CRITICAL NITROGEN DILUTION CURVE FOR LETTUCE

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Field trials were carried out in 1996, 1997 and 1999 in Central Italy (Tevere Valley, 43 N, 165 m a.s.l.) in lettuce [*Lactuca sativa* L. var. *capitata* (L.) Janchen, cv. Audran] to (i) determine the critical % N dilution curve for lettuce and (ii) analyse the effect of N availability on light interception and radiation use efficiency. Lettuce was transplanted in late spring at a density of 10 plants/m², with rows 0.30 m apart. Increasing N fertilizer levels (0, 50, 100, 200 kg ha⁻¹ in 1996-97 and 0, 50, 100, 150, 200, 250 kg ha⁻¹ in 1999) were applied as ammonium nitrate at transplanting. Plants were sampled at weekly intervals until the final harvest to determine dry weights (DW) of stems and leaves, LAI, reduced-N and nitrate-N concentrations. Critical N concentration was determined as proposed by Justes et al. (Annals of Botany 74: 397-407, 1994). Canopy light interception was determined as a function of the crop ground cover. The radiation use efficiency (RUE) was determined as the slope of the linear regression of dry weight on cumulative intercepted light. The critical dilution curve for total-N was % total-N_{cr} = 4.56 DW⁻¹(-0.357) and for reduced-N concentration was % reduced-N_{cr} = 3.79 DW⁻¹(-0.290). The critical dilution curves were applied when above-ground dry weight ranged between 0.9 and 3.4 t ha⁻¹ (from about 25 DAT to final harvest). The two curves differed because lettuce accumulated large amount of nitrates (from 13% to 9% of the total-N uptake) although nitrate concentration was always lower than 2500 mg NO₃ kg⁻¹ fresh weight (i.e. EU limit). In all years, the critical "uptake" curve was very close to the uptake curves obtained with the fertilizer-N rate of 100 kg ha⁻¹ but the highest marketable yields were obtained with 100 kg N ha⁻¹ in 1996, 200 in 1997 and 150 in 1999 due to increase of water content related to osmotic effect of nitrates. Increasing N supply increased LAI, intercepted light throughout the growth cycle but slightly affected RUE.

0800-0900

S02-P-48

NITROGEN UPTAKE IN A BROCCOLI CROP

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An experiment with 3 levels of N (0, 120 and 240 kg ha⁻¹ N) and 2 varieties of broccoli (Milady F1 and Marathon F1) was carried out in the south of Norway to determine the uptake pattern for nitrogen in broccoli. N uptake was measured from transplanting to harvest, at two-week intervals. Samples for total N in plants and Nmin in soil were taken simultaneously. The amount of fertilizer-N was split in four equal parts, applied at planting, and successively 2, 4 and 6 w. after planting. At ample N-supply (240 kg ha⁻¹ N), the early cv. Milady seemed to accumulate N at a very high rate between 5 and 7 w. from planting. In the later maturing cv. Marathon, the N uptake was more evenly distributed between 3 and 9 w. from planting. Total N uptake from planting to harvest was almost equal in the two different cultivars. Between 3 and 5 w. from planting, the difference in N content between N-levels became evident. Plants which received 240 kg. fertilizer N ha⁻¹ maintained a high level, about 5% N in the dry matter from planting to harvest. With 120 kg ha⁻¹ N, the level dropped from 5 to 3.7 % N. In plants which received no fertilizer N, N content decreased 2-3% during the growing period. At harvest time, these plants contained 2.8% N. The lowest N content, 1.9 %, was found in Marathon 2 w. before harvest. At 0 or 120 kg ha⁻¹ N, the soil level of mineral N was low at harvest, about 10 kg ha⁻¹ N. At 240 kg ha⁻¹ N, however, Nmin was never below 50 kg ha⁻¹ N. Total amounts of N absorbed by the crop ranged from 99 to 304 kg N ha⁻¹, and the difference between fertilizer N levels was highly significant. At the intermediate N level (120 kg N ha⁻¹), Milady had a higher amount of N in the crop than Marathon, suggesting a better N efficiency at that soil N level. The % N recovery was higher in Milady than Marathon. This also applied when considering the plant and soil system together. Still, total yield of broccoli heads was the same in the two cultivars at 120 kg ha⁻¹ N.

0800-0900

S02-P-49

THE EFFECT OF NITROGEN ON YIELD AND THRIPS DAMAGE OF SUMMER CABBAGE IN ONTARIO AND EVALUATION OF N DIAGNOSTIC TOOLS

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The recent introduction of nutrient management legislation in Ontario may force vegetable growers to reduce nitrogen (N) application. Experiments were conducted on mineral soil in Simcoe, Ontario in 2000 and 2001 to re-evaluate the N needs of cabbage. N application rates of 0, 50, 100, 150, 200% of the current OMAFRA (Ontario Ministry of Agriculture, Food, and Rural Affairs) recommended rate (128 kg preplant, 35 kg sidedress) were applied to Atlantis, a mid-season cultivar. At 3 times during the growing season, a chlorophyll (Minolta SPAD-502) and nitrate (Horiba 'Cardy' Model C-141) meter were used to determine the N status of the plants. Tissue and soil samples were also sent to a reputable lab for nutrient analysis. To identify the impact of N management changes on pest pressures, the damage caused by onion thrips (*Thrips tabaci* L.) was assessed. Marketable yield was assessed at harvest. Quadratic regression analysis in 2000 ($R^2 = 0.66$; $P < 0.0001$) showed peak yield at 165% of the recommended rate. In 2001, maximum yields were obtained at 150% of the recommended N rate but regression and ANOVA analyses of rate effects were not significant. Low N treatments delayed maturity by 2 to 4 weeks compared with the high N treatments in both years. Over the 2 seasons both the chlorophyll and nitrate meter readings were significantly correlated with yield and lab tissue N results at certain growth stages. Both meters show some promise as N diagnostic tools. Thrips damage was increased in the low N treatments due to the delayed maturity of the cabbage. Decreasing N application in cabbage would result in significant yield reductions, but increased use of N diagnostic tools could allow for reduced environmental impact of excessive N, even at higher application rates.

0800-0900

S02-P-50

PRE-SIDEDRESS SOIL NITROGEN TEST (PSNT) FOR FRESH MARKET SWEET CORN TO IMPROVE EARLINESS AND ECONOMIC YIELDS AND TO MINIMIZE ENVIRONMENTAL DAMAGE

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Excessive nitrogen (N) fertilization may reduce crop marketable yield, delay maturity, and pose potential damages on air and water resources. A soil test tool has to be developed for crops to predict soil N availability, so that fertilizer rates adjusted accordingly. The objectives of the study were to determine the sampling time and depth for pre-side dress soil N test (PSNT) for fresh market sweet corn and to establish the threshold values of PSNT in Ontario. Experiment were conducted at three sites including Harrow, Simcoe and Ottawa, to cover a range of climatic conditions across the province. At each site, N fertilizer at five rates ranging from 0 to 200 kg/ha were applied to create a range of initial soil available N levels. Two cultivars with Speedy Sweet (Temptation in Ottawa) and Jester II were included to test the potential variation of threshold values of PSNT with sweet corn variety. Soil samples were taken at depth of 0-30 cm at V4, V5, V6, and V7 stages, with additional soil samples taken at V6 stage to 60 cm depth. Soil mineral N was analysed using both fresh and air-dried soil samples. Plant tissue samples were taken at stages of V6 and harvest and analyzed for total N content. Data will be analysed to determine the applicability of PSNT. Threshold values will be determined using the Cate-Nelson approach.

0800-0900

S02-P-51

DETERMINATION OF NITROGEN REQUIREMENTS OF A BROCCOLI CROP AT TOPDRESSING WITH SAP TESTS AND SATURATED REFERENCE PLOTS

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The diagnosis of crop nitrogen deficiencies has often been impaired by the lack of proper standards for comparison. Foliar analysis, sap extracts, chlorophyll-meter readings have all been shown able, in well controlled situations, to provide valuable information on the nitrogen status of a variety of crops. However, when such tools are being applied in commercial situations, outside the experimental set-up within which their use has been developed, the influence of several factors (cultivar, soil type, season, sowing date, water balance, plant density, etc) can interfere with the relationship initially developed and make it unusable in practice. The development of calibration covering most of the combination of situations that can be encountered, although theoretically possible, is often an unreasonable task. One promising approach to circumvent this limitation is the establishment of a reference plot, saturated with nitrogen, serving as a benchmark against which the status of the rest of the field can be compared. In so doing, the interacting effects of the above-mentioned variables can be withdrawn from the interpretation process. The fertilizer requirements can be derived from a sufficiency index indicating by which percentage the nitrogen status of the field compares with the one of the reference plot. Development and validation of the reference plot and sufficiency index concept for the sap nitrate content monitoring of nitrogen application of a broccoli crop at 5 wk after planting has been achieved and will be described. The example show robustness against cultivar, site and year effects. Further development of this concept would require research on the best number, size and location of these reference plots, their appropriate nitrogen dosage, and the sources of fertilizers that would be ideal to maintain optimal and steady nitrogen supply under most circumstances.

0800-0900

S02-P-52

HEAVY METALS PLANT NUTRIENTS IN TOMATOES PLANTS CULTIVATED WITH COMPOSTING MADE WITH BIOSOLID AND

SUGAR-CANE BAGASSE

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The use of biosolid in horticulture could contribute to recycle residues produced by men. This work studied the heavy metals plant nutrients concentration (Cu, Mn and Zn) in composting process and when applied this composts in the Red-yellow Latosol, as well as the concentration and uptake by tomato plant. For this, was created composts using sugar-cane bagasse, biosolid and cattle manure in these proportions: 75-0-25; 75-12,5-12,5; 75-25-0; 50-50-0 and 0-100-0 (composts with 0; 12,5; 25; 50 and 100% of biosolid). These composts were applied in the soil, creating 6 treatments: treatments with compost and control (just inorganic fertilization). The control and 0% of biosolid treatment received inorganic nitrogen, what for all treatments had the same amount of N, P and K. After this, two tomato plants were cultivated in each 24 L pot, in acclimatized greenhouse belong Biogeochemistry Laboratory of Technology Dept. in the Faculdade de Ciências Agrárias e Veterinárias of Jaboticabal/UNESP. The experiment had a subdivided parcels scheme, in randomized blocks. It was analyzed Cu, Mn and Zn concentration during the composting process (7, 27, 57, 97 and 127 days after compost mounting), this metals concentration in the soil (0 and 164 days after pots fulfill), the concentration and uptake in the plant. The materials were submitted to digestion with HNO₃, H₂O₂ and HCl and the metals were determined by AAS. There were positive and significant correlation, between Mn in the compost and Mn in the plant uptake (0.46 *P* > 0.05), and between Zn in the compost and Zn in the plant concentration (0.78 *P* > 0.05). There were increase in the Cu, Mn and Zn concentration during the composting process. The biosolid in the compost supplied Cu and Zn to tomato plant, and the cattle manure supplied Mn to tomato plant.

0800-0900

S02-P-53

HOW WELL DO CRITICAL NITROGEN CONCENTRATIONS WORK FOR SELECTED VEGETABLES IN SOUTHERN ONTARIO?

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With the introduction of nutrient management legislation in Ontario, there is a need to improve the efficacy of nitrogen (N) utilisation. One new method is using critical nutrient concentrations. Plant tissue analysis was used to determine the total N and nitrate-N (NO₃-N) concentrations of cabbage (*Brassica oleracea* var. *capitata* L.), carrots (*Daucus carota* L.), and onions (*Allium cepa* L.) in Ontario. Tissue samples were collected from plants as part of N studies in 1999 to 2001 on organic soil in the Holland/Bradford Marsh area and mineral soil near Simcoe, Ontario. Yield was assessed at harvest as an indicator of N sufficiency. Testing the usefulness of critical NO₃-N concentrations was problematic because there were few published references available, tissue NO₃-N concentrations were highly variable, and the field data rarely matched the published references. Total N concentrations from the trials corresponded to published critical N concentrations in some cases. In many instances, the use of published critical N concentrations would have resulted in either over or under-application of fertilizer to the crops. Cultivar, soil type, and climate were shown to affect tissue N concentrations. Local research and field verification is required before tissue N critical nutrient concentrations will be useful for cabbage, carrots, and onions in Ontario.

0800-0900

S02-P-54

THE USE OF SPAD-502 CHLOROPHYLL METER FOR DYNAMICALLY OPTIMISING THE NITROGEN SUPPLY IN POTATO CROP: A METHODOLOGICAL APPROACH

Giorgio Gianquinto*, Paolo Sambo*, Stefano Bona*

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An experiment was carried out in 2000 on potato cv. Primura to test the usefulness of SPAD threshold values in decision making for supplemental nitrogen supply. A non-fertilized control was compared with nine fertilized treatments receiving 30 kg·ha⁻¹ of N (urea 46% N) at crop emergence plus supplementary nitrogen which was applied as follows: i) five treatments provided in-

creasing rates of N (30, 90, 150, 210 or 270 kg N ha⁻¹, urea 46% N) distributed 18 days after emergence, (conventional fertilization, CF); ii) four treatments provided supplemental nitrogen application (urea, 46% N) whenever the SPAD values fell below the critical value of 39 SPAD (dynamic fertilization, DF). This critical level corresponds to 10% deviation from threshold value of 45-45 SPAD calculated in a previous work. Each time, increasing rates of N were distributed to the soil (30, 60 or 90 kg N ha⁻¹—30 DF, 60 DF and 90 DF), or 9.2 kg N ha⁻¹ was applied via foliar spray (foliar DF). In these treatments the number of N applications, and the total amount of N distributed to the crop were 4, 3, 3 and 5, and 120, 150, 210 and 76 kg N ha⁻¹, respectively. Yield response to CF treatments showed best result with 180 kg N ha⁻¹ (180 CF = 30+150 kg N ha⁻¹). Yield of DF treatments did not differ from 180 CF. These results are quite interesting, mainly for 30 DF and foliar DF treatments in which the amount of N distributed was reduced of 30% and 60% as compared to 180 CF.

0800-0900**S02-P-55****THE USE OF SPAD-502 CHLOROPHYLL METER FOR DYNAMICALLY OPTIMISING THE NITROGEN SUPPLY IN POTATO CROP: FIRST RESULTS**

Giorgio Gianquinto*, Paolo Sambo, Ferdinando Pimpini

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0900-0940**S02-O-56****THE ASSESSMENT AND USE OF SOIL AND CROP NUTRIENT STATUS IN THE DEVELOPMENT OF EFFICIENT FERTILIZER RECOMMENDATIONS**

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Groundwater contamination with nitrate-nitrogen from fertilizer is a concern in many vegetable production areas of the United States. Unlike some European countries that are imposing regulation of N fertilizer use based on crop N budget analysis, U.S. growers are being asked to adopt best management practices (BMP) to minimize unnecessary N fertilizer application. Among the most widely utilized BMP is monitoring of soil and crop status to adjust fertilization based on field-specific conditions. Pre-sidedress soil nitrate testing (PSNT), a technique first applied to predict sidedress N requirement for corn, has now been successfully adapted for a range of warm- and cool-season vegetables. Proposed action thresholds of 15–25 mg·kg⁻¹ NO₃-N have been proposed for lettuce, cabbage, celery, and processing tomatoes. Adoption of PSNT could reduce sidedress N application by 30% or more below current industry norms for some crops in some regions. Plant tissue testing has been a widespread practice for years, yet recent research suggests that tissue testing may be of limited value in identifying fields in which N fertilization can be reduced below a grower's standard practice. Work in California showed that

petiole NO₃-N was only weakly correlated with current soil NO₃-N concentration, while research in Arizona found that pre-sidedress soil NO₃-N testing was superior to petiole NO₃-N analysis in predicting crop response to sidedressed N. A variety of on-farm 'quick test' techniques for soil and tissue testing have been developed that offer rapid, semi-quantitative estimates of N status. The advantages and limitations of these techniques will be discussed.

0940-1000**S02-O-57****CRITICAL N-CONCENTRATION IN BROCCOLI**

Ingunn M. Vågen*, Hugh Riley

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Critical %N in *Brassica* crops is an important parameter for modelling their fertilizer requirement. In a simulation model, Greenwood and Draycott (1989) presented an equation to calculate critical %N in arable crops, based on the dry mass of the crop. A later version (Greenwood et al. 1996) introduced an alternative equation for brassicae. Based on data from several experiments in the south of Norway from 1998 to 2001, critical %N and the validity of the above mentioned equations for broccoli is discussed. The nitrogen levels in the experiments ranged from 0 to 300 kg N ha⁻¹ plus soil mineral N. Total above-ground dry matter, crop N-concentration and the amount of soil mineral N was measured at regular intervals during the growing period.

1000-1020**S02-O-58****COMPOSITIONAL NUTRIENT DIAGNOSIS OF HORTICULTURAL CROPS**

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Mineral analysis of plant tissue is the basic numerical information for making a nutrient diagnosis. It could assist in adjusting the fertilization to specific soil-plant systems in order to maintain equilibrium between nutrients and achieve high-yield conditions. The compositional nutrient diagnosis (CND) provides a multi-ratio, nutrient balance, approach that generates linear variables adapted to any linear model and easy to diagnose from generic statistical distribution patterns. Our objective was to develop a method to derive CND norms from survey databases, and validate them with fertilizer trials. A nutrient imbalance index computed as the sum of squared values of CND nutrient indexes (IN, IP, IK, ICa, IMg, and the index for filling value between 100 % and the sum of the 5 nutrients) was distributed like a chi-square value. Using that generic model as a support, CND norms could be elaborated from a small crop database. The CND nutrient indexes ranges computed from a survey database were validated using independent fertilizer trials. The ranges were found to be symmetrical about norms. The method was tested for sweet corn and potato crops. The CND nutrient imbalance index was associated with a chi-square value (CND *r*²) of 3.9 for sweet corn and 4.2 for potato, and was confirmed using a validation sub-population. Critical CND nutrient indexes were found to be symmetrical about zero as follows for sweet corn: -0.70 < IN < 0.70; -0.45 < IP < 0.45; -1.14 < IK < 1.14; -0.63 < ICa and IMg < 0.63; and -1.05 < < 1.05; and for potato: -0.82 < IN < 0.82; -0.80 < IP < 0.80; -0.67 < IK < 0.67; -0.92 < ICa < 0.92; -0.91 < IMg < 0.91; and -0.87 < < 0.87. Summing up squared critical nutrient indexes also gave a CND *r*² of 3.9 for sweet corn and 4.2 for potato. This CND system could be easily updated using small databases for improving fertilizer management in specific agroecosystems.

1020-1040**S02-O-58-A****TO BE ANNOUNCED****1400-1420****S02-O-59****CHLOROPHYLL AND NITRATE METERS AS NITROGEN MANAGEMENT TOOLS FOR SELECTED VEGETABLES IN SOUTHERN ONTARIO**

Sean Westerveld*, Mary Ruth McDonald, Cynthia Scott-Dupree, Alan McKeown

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With the introduction of nutrient management legislation in Ontario there is a need to evaluate methods to improve the nitrogen (N) use efficiency of vegetable production. An Horiba 'Cardy' Model C-141 nitrate (NO_3^-) meter and a Minolta SPAD-502 chlorophyll meter were evaluated and compared to traditional laboratory N analysis in onions, carrots, and cabbage grown on both organic soil in the Holland/Bradford Marsh, Ontario and mineral soil near Simcoe, Ontario in 2000 and 2001. Nitrogen was applied at 0, 50, 100, 150, and 200% (cabbage and carrots) and 0, 100, and 200% (onions) of the of the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) recommended N application rates for each crop and soil type. In an additional treatment for each plot, nitrogen was applied at 50% of the OMAFRA recommendation and sidedress N applications were applied when SPAD chlorophyll readings fell below 95% (2000) and 97% (2001) of the highest applied N rate. At three times during the growing season Cardy NO_3^- meter readings were taken from both plant sap and soil, chlorophyll readings were taken from mature leaves, and soil and tissue samples were collected and submitted for laboratory N analysis. The Cardy NO_3^- meter when used for soil NO_3^- -N analysis was highly correlated with laboratory soil NO_3^- -N results for all mineral soil plots in both years and on organic soil when proper procedures were developed in 2001. Cardy sap NO_3^- -N readings were correlated with laboratory NO_3^- -N results in the majority of sampling dates for the three crops. SPAD chlorophyll meter readings were less correlated with laboratory results, but provided a good indication of total yields when significant yield differences were detected. Evaluation of the SPAD meter for sidedress determination was unsuccessful due to a lack of yield differences. Both meters have potential for improved N management of onions, carrots, and cabbage in Ontario.

1420-1440

S02-O-60

MAPPING WITHIN-FIELD VARIATION IN POTATO NITROGEN STATUS USING THE N SENSOR

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Variable fertilizer N application may result in improved crop performance and a reduced risk of nitrate leaching. This study evaluated the use of the N Sensor to map within-field variation in potato N status as one approach to variable within-field fertilizer N management. In Experiment 1, four N fertility treatment strips (0–150 kg N/ha) were established in a 2 ha field. Crop N status was measured by the N Sensor, petiole nitrate concentration, and leaf chlorophyll index as measured with a SPAD-502 meter. Tuber yield, size distribution, and specific gravity were measured from 56 locations in the field. In Experiment 2, N Sensor readings were taken from a potato field of similar size, but with uniform (150 kg N/ha) N fertilizer management. The N Sensor was effective in mapping crop N status in Experiment 1, where crop N status was manipulated by varying fertilizer N management. N Sensor readings taken early in the growing season in the unfertilized treatment strip were well correlated with relative tuber yield. N Sensor readings taken later in the growing season were well correlated with tuber yield and size distribution. The N Sensor was gener-

ally comparable to, or superior to, other measures of crop N status except for tuber specific gravity for which petiole nitrate concentration was superior to the N Sensor. In Experiment 2, significant variation in N Sensor readings were obtained, however, neither N Sensor readings or petiole nitrate concentrations were well correlated with tuber yield, size distribution, or specific gravity. This suggests that variation in tuber yield, size distribution, and specific gravity were controlled primarily by factors other than crop N supply, for example soil moisture content. This suggests that the N Sensor could be useful as a basis for performing variable rate fertilizer N management in potato fields, however, some caution is required in the interpretation of N sensor results.

1440-1500

S02-O-61

NUTRIENT MANAGEMENT ON VEGETABLE FARMS; WHAT WILL BE THE FUTURE?

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Production of field vegetables is known for its high nitrogen input and consequently high nitrogen losses toward the environment. All over the world research tries to find opportunities to reduce these losses. In the year 2000 the Dutch government initiated and funded a research project to explore the possibilities to reduce the negative effects of nitrogen and phosphate inputs on the quality of soil and surface water by farm management. Additionally, it is explored how field vegetable farms can meet future legislation on nitrogen and phosphate input. The approach chosen was participatory research, so the farmer, the consultant and scientist work closely together in making yearly plans regarding fertilization to reach a number of set goals on the farm level. By registration of all the activities on the farm, the nitrogen input and output could be monitored and additionally residual mineral soil nitrogen was measured on each field at the end of the season. After completion of each season the outcome is compared with the plans and the set environmentally related goals. This results in a new plan for the next season, with a clear intention to approach the ultimately set environmental goals. In this presentation not only the first results will be given, but also the pros and cons of the approach will be discussed.

1500-1520

S02-O-61-A

TO BE ANNOUNCED

1520-1540

S02-O-61-B

TO BE ANNOUNCED

1540-1600

S02-O-61-C

TO BE ANNOUNCED