Symposium 16 (S16): Protected Cultivation 2002: In Search of Structures, Systems, and Plant Materials for Sustainable Greenhouse Production

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1100–1140
S16–O–1
GREENHOUSE STRUCTURES AND PLANT GROWTH CONTROL SYSTEMS

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Engineering the design of greenhouses for high solar radiation inputs through the glazings is essential for most crops, especially during the low light winter periods. Structural framing and glazings, however, can also be designed to reduce infiltration and add thermal insulation to the greenhouse. With night curtains, a daytime glazing is maintained and insulation is added when it is most needed at night. A summary of savings expected due to structural choices will be illustrated in comparison to single pane glass. Data on air leakage rates will be presented for both glasshouses and poly covered houses. And, solar techniques such as pumping polystyrene pellets into and out of acrylic and polycarbonate panels will be discussed and illustrated for both night insulation and selective summer shading. New aerodynamic design techniques for naturally ventilated greenhouses will be illustrated. Structural variables such as greenhouse widths, roof and side vent locations, vent opening widths, aerodynamic profiles, internal and external shading systems, and benching for various wind speeds and directions have been studied with fluid dynamic models and tested for verification on commercial structures. Most greenhouses use fossil fuel for heating and pricing structure for fuels such as gas, oil, and coal will be illustrated and compared based on common energy units. Both central boiler systems and unit space heaters will be discussed. The choice of system depends on the type of fuel available, the amount of greenhouse space to be heated, and the level of capital investment. Each heating system should be designed and installed to optimize heat recovery from the burners and deliver the heat directly to the plants at the correct temperature. The process and success of integrating temperature, humidity, Ph, EC, and solar radiation into a unique decision support system for automated plant growth control will be discussed. The interactive model can be found on the Internet at: http://www.oardc.ohio-state.edu/hydroponics/. Probability of success is constantly displayed while the user is adjusting the interactive variables on the single web-page. The model, based on current commercial practices and literature, has five key tests for each of five growth stages and three light levels to achieve high yield, high quality fruit. While users are interacting directly with the model, changes are being recommended for temperature, humidity, and EC are given in order of urgency to achieve high yield and quality. Some of these same management parameters can be used to minimize total greenhouse energy use. For example, decreasing night temperatures alone will reduce annual fuel costs by approximately 6% for each 1 degree °C in temperature reduction. During the day, savings can be achieved by growing plants at the lower but acceptable temperature and radiation ranges. This requires uniform heat distribution over the cropping area and well calibrated temperature sensors that are highly representative of the crop specifications.

1140–1200
S16–O–2
THE SOLAR GREENHOUSE, TECHNOLOGY FOR LOW ENERGY CONSUMPTION

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High energy consumption is still a bottleneck for sustainable greenhouse production. Therefore reduction of absolute energy consumption has high priority. In the Solar Greenhouse project the ultimate goal is to develop a greenhouse system with full sustainable energy supply. The first step in the project is to substantially decrease greenhouse energy demand. Therefore new covering materials have to be developed which provide high insulation with high light transmittance. New flexible or rigid plastic materials with a geometry designed for high light transmittance are promising. Also anti-reflective coating of glass is promising. In addition to improve insulation, the greenhouse itself and its climate conditioning has to be redesigned. Active, energy friendly dehumidification has to be developed. Progress in this field is reported. On a year round basis sustainable solar energy is sufficient to cover the low heat demand of well-insulated greenhouses, even in North Western Europe. Long term energy storage in aquifers can link available surplus of sustainable energy in summer with energy demand in winter. This energy is available at low temperature level, so a heat pump has to be applied. . The potential of a crop to integrate temperature as determined by crop science, may decrease the overall heat demand of a greenhouse. Crop tolerance has to be quantified to exploit it in control strategies. In these strategies costs and benefits can be optimised applying optimal control theory. The implementation of models is essential in greenhouse climate control enabling the prediction of systems behaviour. The accuracy of the models can be improved by updating and tuning them through actual greenhouse climate measurements.

1200–1220
S16–O–3
FACTORS INFLUENCING INVESTMENTS IN ENVIRONMENTAL SOUND AND ENERGY SAVING TECHNOLOGIES BY GLASSHOUSE GROWERS

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Energy is an important production factor in glasshouse horticulture. However in recent years glasshouse growers are faced with increasing energy prices and growing environmental concerns. In 2000 the Flemish government decided to stimulate environmental sound investments by means of investment subsidies. In the current research the factors influencing the adoption of environmental sound and energy saving technologies by glasshouse growers are analysed. Based on the innovation diffusion theory the hypothesis is that external factors, personal characteristics of the firm manager (personal objectives, age, education level, importance attached to subsidies) and firm characteristics (business objectives, business size, modernity) determine investment behaviour. Data for the research are obtained from accounting data and interviews at 58 holdings specialised in vegetable production and 79 holdings specialised in production of ornamental plants belonging to the Farm Accountancy Data Network of the Centre of Agricultural Economics. Discriminant analysis is used to analyse the data. The most important investments are the changeover from fuel oil to natural gas and investments in energy saving screens. An important obstacle determined by this study to the changeover to natural gas is the lack of natural gas pipelines in the surroundings of the glasshouse holding. The holdings which are already using natural gas are mainly large and energy-intensive businesses with a younger manager. Those who are intending to changeover to natural gas attach a great importance to investment subsidies and do have a smaller but growth-oriented business. Investments in energy saving screens are important for producers of energy intensive ornamental plants. In most of the cases these investments consist of replacement of the existing energy saving sceens more efficient ones.

1220–1240
S16–O–4
THE POTENTIAL OF RETRACTABLE ROOF GREENHOUSES TO DOMINATE GREENHOUSE DESIGNS IN THE FUTURE

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Retractable roof greenhouses (RRG) have been commercially available for almost 10 years. Roof designs are becoming standardized, but there is a lack of understanding of the positive impacts of RRG on plant health, plant growth, and the subsequent production costs/savings. While opening up the roof obviously provides better airflow so that summer temperatures in the greenhouse are cooler, users of RRG are experiencing improved environments in many other ways. These may include: up to a 100% increase in solar radiation, cooler and more uniform temperatures throughout the greenhouse; lower daytime

humidity. Plant responses in such environments have included: increased transpiration resulting in a stronger root system, reduced internode lengths, a thicker cuticle which has resulted in reduced disease and insect pressures with subsequent reduction in pest control costs; and plants that are more acclimated to the outside environment, thus resulting in reduced transplant shock. Management has an improved ability to 'time' the crop and to reach the target maturity date, especially during warm weather. Growers of outdoor crops, in particular those growing plants in containers, have found that they have benefited greatly from growing outdoor crops in RRG. Some of the benefits that they have realized include up to 50% reduction in production period, and up to 70% reduction in water usage. RRG have been successfully used in flower and vegetable production, and for producing stock plants for cutting propagation, as well as plug production, growing, and finishing. This presentation will address the impact of RRGs on the plant growing environment, the greenhouse design and layout, as well as the impact on the production practices, and environmental control of a greenhouse having an open roof.

1340–1440

S16–P–5

FLORAL DEVELOPMENT AND FLOWER-STALK ELONGATION OF SPINACH GROWN UNDER VARIOUS LIGHTING CYCLES RANGING FROM 16 TO 40 H

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The photoperiod and the dark period can be independently chosen using artificial light, so that the lighting cycle (photoperiod + dark period) does not have to be 24 h. In the present study, floral development and flower-stalk elongation of *Spinacia oleracea* L. cv. Dimple were determined under lighting cycles of 16–40 h, photoperiods of 8–12 h and dark periods of 4–28 h (16 treatments in total) to construct a new theory of photoperiodism that can predict bolting of spinach under any photo- and dark periods. In addition to those 16 treatments, a continuous lighting treatment was applied. Air temperature, relative humidity and integrated photosynthetic photon flux during a 30-d experiment were 23 ^{0}C, 65% and 207 mol·m^{-2}, respectively in the all treatments. Dark periods shorter than 4 h significantly promoted floral development of spinach and resulted in formation of flower clusters, while only differentiation of flower cluster was observed in the treatments of dark periods longer than 8 h 30 days after sowing (DAS). Flower-stalk lengths under dark periods shorter than 4 h were 101–174 mm, while those in other treatments were 3–26 mm at 30 DAS. A determinative factor for bolting of spinach was not clarified from the present study, since the spinach bolted (i.e., flower structures are formed and flower-stalk length is greater than 1 mm) in the all treatments. However, results indicate that short dark period enhances the floral development and flower-stalk elongation of spinach under a non-24-h lighting cycle (16–40 h) as it does under a 24-h lighting cycle.

1340–1440

S16–P–6

UTILIZATION OF COMPOSTS AND COVER CROPS IN HIGH TUNNEL CROPPING SYSTEMS: OPPORTUNITIES AND CHALLENGES

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High Tunnels are an emerging technology notable for their ability to provide season extension in temperate climatic regions at low construction and maintenance costs. The technology appeals largely to small and mid-size farming operations looking to supply fresh vegetables and small fruit to niche markets such as restaurants, farmers markets, and CSA businesses. Because High Tunnel crops are generally cultivated in-ground, the opportunity exists for utilizing organic amendments such as compost and cover crops to improve soil fertility, structure, and biology. At the Penn State High Tunnel Research and Education Facility, the use of compost in High Tunnels has been an on-going topic of investigation. Since 1999, research has examined the use of locally produced composts in the cultivation of a number of vegetable crops including bell peppers, leafy greens, broccoli and Brussels sprouts, and culinary herbs. These studies have highlighted differences in crop response as influenced by such factors as compost variability, application rates, nutrient turnover and retention, and herbicide persistence in finished compost products. Further research is currently underway to determine optimum application rates when used in combination with cover crops in alternate years. The use of winter cover crops within High Tunnels is of considerable interest to growers trying to maximize season extension. Replicated trials using annual rye and hairy vetch are currently being conducted to determine ideal establishment and incorporation dates while maximizing tunnel availability for cropping. Because all outside precipitation is excluded from High Tunnels by design, moisture delivery systems and frequency of irrigation have been a major focus of this research. Additional topics being investigated include determining the mineralization rates of incorporated residues, establishing seeding rates and recommendations, and developing cover crop management guidelines.

1340–1440

S16–P–7

PRIMARY GAS EXCHANGE AND LEAF PUNGENCY OF LEEKS GROWN IN CLOSED ENVIRONMENT SYSTEMS (CES)

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This research represents the first detailed examination of the growth of leeks (*A. porrum* L., cv. Tadorna) in Closed Environment Systems (CES) and the relationship between leaf gas exchange and tissue pungency. The net carbon exchange rate (NCER) of leek growing at 20 C (15 μmol·m^{-2}·s^{-1}) was in the range of typical C3 plants and was negatively affected by increased temperature. Immature leaves had lower NCER and displayed a significant decline in photosynthesis and transpiration during the photoperiod. A pungency differential was observed in leaf tissue. Levels of flavour precursors, *S*-alk(en)yl-L-cysteine sulfoxides (ACSOs) decreased significantly from leaf tips to mid-leaf and lower leaf regions. This differential was less prominent as plants reached ages greater than 20 weeks. The combined results suggest a link between ACSO production and conditions that promote oxidative stress in photosynthetic tissues. Such a relationship may lead to new cultivation practices, allowing for the control of Allium crop pungency in CES or field conditions. Detailed knowledge of their growth in CES is essential for producing high-flavoured Alliums in current bio-regenerative life support systems designed for long-term manned space missions, such as NASA's CELSS program.

1340–1440

S16–P–8

MODIFICATIONS OF ENVIRONMENT AND PLANT GROWTH WITH RETRACTABLE OR PERMANENT SHADE

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Shade structures with retractable roofs are becoming more common for growing container plants in nurseries in the Southwestern United States. Retractable shade structures take advantage of the outdoor environment when growing conditions are optimal. During unfavorable growing conditions that are characterized in the Southwest by high day temperatures during summer, and low night temperatures during winter. Environmental variables in retractable shade structures, permanent shade structures, plastic-covered hoop houses and outdoors were collected in two commercial nurseries in Arizona in summer and winter with the objective to develop management strategies to optimize the growing environment for nursery stock with retractable roofs. In summer, the retractable shade structure with a roof at 4.9m or the permanent shade structure with 30% green shade cloth reduced photosynthetic active radiation (PAR) by 64 to 70% compared to outdoors. The retractable shade structure with a roof at 2.7m reduced PAR from 43–57% compared to outdoors. Air temperatures at canopy level oscillated between 40.5 °C maximum and 21.1 °C minimum in the different environments, while soil temperatures in containers fluctuated between 33 °C and 21 °C. Water use of high and low water use species differed between environments, species, and time of the day. In winter, temperature at canopy level in the plastic tunnel was generally 16 °C higher on sunny days during the day, and 5 °C warmer at night. The retractable shade structure maintained a warmer canopy environment at night, similar to that of the plastic tunnel, and a canopy temperature of about 5 °C less than the outdoor temperature during the day. Soil temperatures of container plants in the retractable shade structure were generally about 2 °C to 5 °C higher than in

containers growing outdoors. Fluctuations between day/night temperatures and environments were much smaller on overcast days.

1340–1440

S16–P–9

GREENHOUSE ENVIRONMENT AND GROWTH OF GREEN PEPPER (*CAPSICUM ANNUUM* L.) IN GREENHOUSE COVERED WITH ANTI-DROPPING POLYETHYLENE FILM

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Spectroradiometric light transmittance from 300 to 1,100 nm in the greenhouse covered with the anti-dropping film was greater than that in the greenhouse covered with P.E. (polyethylene) film (control). As a whole, solar radiation transmittance into greenhouse was a half level, due to shades by double wall covering, frame and equipment. Net radiation energy emitted throughout surface of the greenhouse covered with anti-dropping P.E. film was 5424.5 $W \cdot m^{-2}$, which was lower by 2.9% than that of the greenhouse covered with P.E. film. Photosynthetically active radiation from 400 to 700 nm of the greenhouse covered with anti-dropping P.E. film was 3861.2 $W \cdot m^{-2}$, which was higher by 3.8% than that of the greenhouse covered with P.E. film. Accumulated minimum air temperature of the greenhouse covered with anti-dropping P.E. film was 100.5 C, which was higher by 2.5 C than that of the greenhouse covered with P.E. film from Oct. 7, 1997 to Oct. 16, 1997 in Suwon, Korea. As results, plant height, stem diameter, leaf count, leaf area, fresh weight and dry weight of green pepper and group production system were enhanced. The green pepper at 30 days after transplanting in greenhouse covered with anti-dropping P.E. film was better than that of the greenhouse covered with P.E. film. Fruit weight in the greenhouse covered with anti-dropping P.E. film was 11.28 g and was 1.25 g per fruit greater than that in the greenhouse covered with P.E. film, because of increased fruit diameter and flesh thickness. Percent marketable fruits produced in the greenhouse covered with anti-dropping P.E. film were 96.1%, and was greater by 2.7% than that of the greenhouse covered with P.E. film, due to decreased infection, sterility, severe curve and twisted fruits.

1340–1440

S16–P–10

EFFECTS OF DIFFERENT TYPES OF GREENHOUSE ON CANOPY, GROWTH AND YIELD OF GREEN PEPPER (*CAPSICUM ANNUUM* L.)

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Light transmittance in glasshouse was the highest by 64.7% among different greenhouse structures. Water droplet formation rate was negatively correlated with light transmittance. Relative humidity was decreased and air temperature was increased as water droplet formation was decreased. Clear differences were observed in leaf areas and plant heights 30 days and 50 days after planting, respectively. The differences were the highest in hydroponic culture in glasshouse, and there was no difference between PC house and PET house. Difference in PE house was the lowest. Optimum LAIs calculated from LAI and CGR were 6.35 in glasshouse, 4.32 in PC house, 3.62 in PET house, 3.57 in PE house. Branch numbers per plant in glass, PC, PET and PE house were 279, 254, 247 and 126, respectively. Light interception rate at the center of canopy at 1 month after planting showed similar tendency to the canopy occupancy rate and the differences among greenhouses were decreased at 2 and 3 months after transplanting. Leaf dry weight was the lowest at 1-2 nodes and was the highest at 8–9 nodes. Stem dry weight was the lowest in main stem and showed normal distribution centered at 6th node. Fruit dry weight distribution was centered at 4–8 nodes except in PE house. Nodes differentiations in green pepper observed at 70 days after transplanting were 12th node in glass and PC, 11th in PET and 10th in PE houses. Leaf numbers showed significant differences among greenhouses with 908 in glass, 634 in PC, 577 in PET and 311 leaves/plant in PE houses. Numbers of fruits/plant were 36, 26, 24 and 14 in glass, PC, PET and PE houses, respectively. The ratio of leaf/stem dry weights was the highest in the PE house with 1.58, and the leaf thickness was also the highest. Days to first flowering was the shortest in glasshouse with 72.7 days. Flower shedding rate was the highest in the PE house with 12.6%. Days to harvesting was the shortest in glasshouse with 14.3 days.

1340–1440

S16–P–11

FRUIT PROTECTED CULTIVATION IN CHINA

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Fruit protected cultivation in China has developed very quickly from early 1990s, and now it has become an important branch in fruit cultivation. Brief introduction, including developing history, areas, outputs, distribution in the whole country, fruit species, and etc, were summarized in this paper. Characteristics of the dominant kinds of greenhouse, enviromental control methods and standards of temperature, humidity, light and carbon dioxide for different fruit species were also introduced. Varieties, growing benefits, special management practices and other aspects of the main fruit species used for protected cultivation, such as strawberry, grape, nectarine, peach, apricot, cherry, and plum, were also concerned in this paper.

1340–1440

S16–P–12

THE DESIGN AND EVALUATION OF A SHADE SCREEN TO OVERCOME WITHIN-ROW VARIABILITY OF TOMATO CROP GROWN IN SMALL EXPERIMENTAL GLASSHOUSE COMPARTMENTS

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Long season tomato plants at the ends of rows intercept more light, particularly the south end of rows that are orientated north-south where they are in direct sunlight for much of the day. The use of extra guard plants to minimise the within row variability is not always practical. Within an experimental facility at HRI tomato crops are grown in double rows which are orientated north-south. A light interception model was developed and used to design a screen and an experiment investigated the effectiveness of the screen in reducing the end of row effects. For the model, the canopy was assumed to be a solid cuboid of horizontally parallel rows of rectangular cross-section of finite length. Shading was provided by a vertical screen at the south wall at the same height as the crop canopy. Numerical integration techniques simulated the distribution of transmission of light on each cuboid face for the months March to August with a range of screen transmissions. The model predicted that a screen would considerably improve the uniformity of light distribution. A '50' shade screen was positioned on the south wall of a compartment and adjusted with the height of the tomato crop. Each double row was split into four sections SW, NW, SE and NE and crop performance compared with compartments without shade. In the unshaded compartments there was considerable within-row variability with significant effects both on the mean fruit size and the proportion of class 1 fruits. The screen had a significant effect on the pattern of yield within the house and created a more uniform distribution in mean fruit size. The screen also reduced the incidence of gold marbling and uneven ripening, and increased the percentage of class 1 fruit from plants that had been on the south ends of the rows.

1340–1440

S16–P–13

TIME DOMAIN REFLECTOMETRY ACCURATELY MONITORS AND CONTROLS IRRIGATION WATER APPLICATIONS IN SOILLESS SUBSTRATES

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Most horticultural soilless substrates have a small range of easily-available water (EAW) for optimum plant growth, and therefore require frequent irrigation. Most soilless substrates generally hold EAW in the range from 0 to –10 KPa matric potential (Ym), with most plant-available water in the range 0 to –5 KPa. Knowledge of volumetric water (Wv) content of the substrate can be used to precisely define irrigation applications, if an accurate method for sensing Wv is available. Until now, no technology has existed to do this in soilless

substrates with any degree of precision. Accurate monitoring and control of irrigation water should retain nutrients in the root zone and maximize plant growth, while minimizing leaching volumes. There are few data to indicate how substrate Wv and plant water use are correlated, or if Wv is correlated to plant water-stress. Six soilless substrates, Pro-Mix 'BX', a commercial pine-bark mix, a commercial hardwood-bark mix, medium-grade perlite, rockwool, and sieved sand were studied in a range of experiments designed to test these assumptions, using various column (container) heights. Mean TDR coefficients of variation ranged from 0.8% to 7.9% over all substrate and column heights, proving that TDR can precisely measure water contents in soilless substrates under most conditions. Water-release and TDR curves for each substrate indicate that Wv is primarily determined by substrate characteristics, but container height also affects Wv, especially near 0 KPa (container capacity). Experiments with azalea in growth chamber and greenhouse experiments showed that a TDR-monitored and controlled irrigation system precisely controlled cyclic irrigation events, with initiation at -10KPa and termination of irrigation at -1KPa. TDR sensors need to be placed vertically in the rootzone, especially with drip emitters. Water and nutrient leaching volumes were significantly reduced compared to an irrigation method based on container weight.

1340–1440

S16–P–14

GROWTH RESPONSE OF LEAF LETTUCE (*LACTUCA SATIVA* L.) IN DIFFERENT PLANT FACTORY SYSTEMS

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This study was conducted to investigate the response of lettuce growth and quality in different plant factory systems. Lettuce seeds 'Danhong' were sown in polyurethane foam cubes. At two weeks after sowing, the seedlings were transferred to experiment systems (NFT). Lettuce was grown in two plant factory systems (closed plant factory with artificial lighting, plant factory with natural and artificial lighting) and glasshouse during 3 weeks. The treatment conditions were 16/8h (day/night), 60–80% (RH) and 1500–2000 $mg \cdot L^{-1}$ (CO_2) in closed plant factory with artificial lighting (metal halide + high pressure sodium lamp), 16/8h (day/night) and 60–80% (RH) in plant factory with natural and artificial lighting (high pressure sodium lamp) and natural lighting in glasshouse. Two plant factory systems provided plants with greater fresh weight, number of leaves, dry weight and leaf area, and without statistically significant differences in two systems. Photosynthetic rate was the higher in plant factory with natural and artificial lighting than in closed plant factory with artificial lighting. Daily light integral (DLI) and water use efficiency (WUE) were the highest in closed plant factory with artificial lighting. Ratio of leaf length to leaf width (LL/LW) was highest in closed plant factory with artificial lighting. Also chlorophyll, flavonoid and anthocyanin contents were highest in the closed plant factory with artificial lighting. Carbohydrate content was not significantly different in the three systems. Generally, among the three different systems, the growth and quality of lettuce were highest in closed plant factory, while there was the lowest growth in the a glasshouse.

1340–1440

S16–P–15

EFFECT OF IRRIGATION CONTROL BY INTEGRATED SOLAR RADIATION ON GROWTH, YIELD AND QUALITY OF LETTUCE IN HYDROPONICS

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This study was conducted to determine the effect of two different irrigation control methods (time clock and integrated solar radiation) on net CO_2 assimilation rate, transpiration rate, growth and yield of lettuce plants (*Lactuca sativa* L. cv. 'Gang San Sarada') in a greenhouse. The frequency of irrigation was controlled by either time clock or integrated solar radiation of 0.21, 0.42, 0.63, 0.84 and 1.26 $MJ \cdot m^{-2}$ in nutrient film technique (NFT) system. Net CO2 assimilation rate was the highest in the integrated solar radiation of 0.21 $MJ \cdot m^{-2}$, and the lowest in the integrated solar radiation of 0.84 and 1.26 $MJ \cdot m^{-2}$. Transpiration rate was not significantly different between the integrated solar radiation of 0.21, 0.42, 0.63, 0.84 $MJ \cdot m^{-2}$ and the time clock, except for the integrated solar radiation of 1.26 $MJ \cdot m^{-2}$, which showed the lowest value. The growth of lettuce at 15 days after treatment was higher in the integrated solar radiation of 0.21-0.63 $MJ \cdot m^{-2}$, and the lowest in the integrated solar radiation of 1.26 $MJ \cdot m^{-2}$. The growth of lettuce at 25 days after treatment was the highest in the integrated solar radiation of 0.21 $MJ \cdot m^{-2}$, but there was no significant difference the integrated solar radiation of 0.42, 0.63, 0.84 $MJ \cdot m^{-2}$. Higher incidence of tipburn was observed in the integrated solar radiation of 1.26 $MJ \cdot m^{-2}$ and the time clock. The irrigation control method using integrated solar radiation of 0.21-0.84 $MJ \cdot m^{-2}$ in a greenhouse showed high growth yield and quality.

1340–1440

S16–P–16

DESIGN AND THE EFFECT OF CHINESE GREENHOUSE WITH UNSYMMETRICAL AND MULTISPAN STRUCTURE

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A Chinese greenhouse with un-symmetrical and multi-span structure (patent No. ZL 00 2 02521.3) is one kind of greenhouse structure designed according to the needs of the inland climate in Northern China. There is a larger transparent roof with the proper angle for light entering. It can ensure light transmission rate theoretically up to 95% in main growing season (with solar day more than 10 hours). The main energy of the greenhouse comes from solar radiation. The big back wall (north wall) can reduce radiative heat from the greenhouse to outside during night in addition to absorb and store heat during the day. Meanwhile, there are facilities for a screen system for keeping heat in the greenhouse, which may reduce heat emission and reduce heating cost. Compared with traditional lean-to Chinese greenhouse, this greenhouse design is 6-10 times larger, and it can save farmland 40%, which is important for modern China with too much population and too fewer farmlands. There are also heating and misting and CO2 supply equipment in the greenhouse. Land use production efficiency increases 3 times, and the yield of tomato per square meter is up to 22.5 kg, and labor production efficiency increases 15 times in the greenhouse. This kind of greenhouse may transfer light and heat resource of Northern China to crop production.

1340–1440

S16–P–17

INTEGRAL APPROACH OF SUSTAINABLE AND COMPETITIVE FARM SYSTEMS IN THE HORTICULTURE

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An important target of the Dutch glasshouse industry in the year 2010 is to comply with the Dutch Integral environmental terms of reference (IMT-2010). This means an enormous effort to reduce the consumption of energy, nutrients and chemical crop protection compounds and other environmental demands from government and society toward 2010. Researchers have found many possible innovations and improvements to be implemented in the glasshouse horticulture. Examples of innovations are new glasshouse constructions and covers, new crop production systems, alternative energy supply systems and new crop protection strategies. Some of these innovations may adverse and other may reinforce each other. For example the effect of an energy screen on energy savings is counteracted by artificial lighting but reinforced by temperature integration. Modern and well-equipped glasshouse firms were used as reference to test and discuss innovative developments. Due to an integral approach of innovations, using simulations and economic and environmental models, we can show for several crops how it is possible to have a sustainable and flourishing glasshouse horticulture in 2010. The results will present the net financial results and the environmental effects (in terms of reductions of consumption levels and according to the life cycle analysis).

1340–1440

S16–P–18

RADIATION TRANSMISSION DIFFERENCES IN EAST–WEST ORIENTED PLASTIC GREENOUSES

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In the Mediterranean coast of Spain there is an increasing trend to improve the technological level of the greenhouse industry, based on low-cost plastic greenhouses of very small roof slopes. In recent years, the growers are begining to build east-west oriented saddle roof plastic greenhouses of higher slopes. This east-west orientation improves the greenhouse transmission in the autumn and winter, as compared whith the north-south orientation, but generates radiation transmission differences between the different zones of the greenhouse. A study about the radiation differences between the various spans of a multispan greenhouse showed relevant differences, with higher transmission in the southern located span around the winter solstice.These results point out that conclusions of radiation studies on single span greenhouses are not suitable for multispans. Complementary information on the spatial distribution of radiation in each of the spans of three different roof slope greenhouses, quantified using five linear solarimeters per span, will be presented.

1340–1440

S16–P–19

GROWTH, YIELD AND DEVELOPMENT OF STRAWBERRY CV. ELSANTA UNDER NOVEL PHOTOSELECTIVE FILM PLASTIC CLAD GREENHOUSES

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Plastic greenhouse covers are typically used to protect horticultural crops from low temperature and high rainfall conditions. However, a range of novel plastic films have been developed, which filter specific wavelengths with the aim of providing the grower with more control of crop growth and development. A replicated experiment was conducted in small experimental greenhouses using 8 different photoselective films, characterised by a range of red/far-red ratios and PAR transmissions on the growth, yield and quality of strawberry cv. Elsanta. Marketable yield per plant was 64% greater under the film with the highest light transmission (control) compared with the lowest transmission film. Similarly, unmarketable fruit number and average unmarketable individual fruit weight per plant was lowest under the film with the highest light transmission and least under the lowest light transmission film. Cropping duration was shorter under films with a low red/far-red ratio and longer under films with high red/far-red ratio. Also, plants under high red/far-red ratio were more compact (due to shorter petiole lengths) compared to plants grown under low red/far-red ratios. There was no significant afffect of the film types on individual marketable fruit weight, total yield per plant or sugar content determined by total soluble solids. These results are discussed in relation to the increased use of photoselective films in protected horticultutre and the increased need for higher qualtiy fruit and vegetables.

1340–1440

S16–P–20

MEASUREMENT OF THE OPTICAL PROPERTIES OF GREENHOUSE CLADDING MATERIALS: HARMONISATION AND STANDARDISATION

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The aim of an European SMT project entitled 'New testing methods for plastic films used as greenhouse covering materials' is the development of testing methods for measuring the ageing and the condensation behaviour of plastic films. For the ageing task the degradation rates of the most important physical, optical and mechanical properties of the film were measured. Amongst others harmonisation had to be achieved on measuring the optical properties of plastic films. Identical samples of four different co-polymer films and also special anti-fog films were measured by the partners. The radiometric properties measured at the participating laboratories were: total direct visible light transmittance; total diffuse visible light transmittance; spectral transmittance—UV (ultra violet), visible light, NIR (near infrared) and IR(infrared); haze (scattered part of the light). Harmonisation has been achieved on the terminology, methods, set-up, repetitions, wavelength bands, etc. The partners for measuring the optical measurements are: the institutes IMAG (Wageningen, The Netherlands), ITG (Hannover, Germany) and Cemagref (Montpellier, France) and the industries CIBA (Bologna, Italy) and Hyplast (Hoogstraten, Belgium). The total direct (visible) light transmittance at wavelength band 400-700 nm is measured following different methods: 1) small samples with a spectrophotometer and 2) large samples with a large integrating sphere (diameter 4 m). For the diffuse (visible) light transmittance the method with the large integrating sphere and a diffuse light source available at IMAG, ITG and Cemagref proved to be the best technique. The transmittance for IR radiation in the wavelength band of 3000–16000 nm (Far Infrared) was measured by ITG, Hyplast and CIBA, presented as a graph and the integral was calculated and suggested as a standard figure.

1340–1440

S16–P–21

CO_2 ENVIRONMENT IN LEAN-TO SOLAR GREENHOUSE AND EFFECTS OF CO_2 ENRICHMENT ON PHOTOSYNTHETIC RATE AND DRY MATTER PRODUCTION IN CUCUMBER

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Lean-to solar greenhouse is one of main forms for protected cultivation in spring and winter in northern China. During conventional winter-spring cultivation of cucumber, the daily maximum concentration of CO_2 in greenhouse decreased gradually, in general, the daily minimum concentration and daytime average concentration dropped at first, then went up. The CO_2 deficient time continued daily with CO_2 deficiency 3 hours after the straw covering was unveiled in the morning in December and only 1hour after that in March. In daytime, both before and after ventilation, solar greenhouse often showed serious CO_2 deficiency that lasted 4–8 hours a day. In the morning, photosynthetic rate of cucumber plants with CO_2 enrichment (780_1215?l L^{-1}) at fruiting stage was 2.10 to 2.75 times that of plants with non-enrichment (280?l L^{-1}); In the afternoon, photosynthetic rate of plants enriched at 500_700?l L^{-1} was about 1.8 times that of plants with non-enrichment(250?l L^{-1}). Experiments at cucumber seedling stage indicated that: in comparison with non-enriched plants, dry matter weight of plants with CO_2 enrichment at 1100 ±100?l L^{-1} for three hours every morning increased by 76.63%–113.85%; however, dry matter weight of plants with CO_2 enrichment for three hours both in the morning and in the afternoon was 53.11%–68.08% more than that only in the morning, which was 2.70–3.59 times that of non-enriched plants. As a result, CO_2 enrichment in afternoon when CO_2 deficiency happened was a positive and effective measure for improvement of photosynthesis and dry matter production in solar greenhouse-grown vegetables.

1340–1440

S16–P–22

THE DEVELOPMENT AND PROSPECT ON PROTECTED CULTIVATION IN MAINLAND CHINA

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China is a very big country in the protected horticulture. Since the 1980s, the cover materials such as plastic film, shade net, pest-protecting and non-woven cloth are more and more used in agriculture in Mainland China. The total area of protected vegetables cultivation in different types of greenhouse was 1,395,510 ha in 2000. The mainly protected horticulture crops are vegetables, melons and watermelons, fruit trees and flowers. Making use of modern scientific technology to develop and extend protected horticulture applied technique is very important for taking precautions against natural calamities, taping the latent power of agriculture, bringing agriculture to sustained high efficiency top quality and high output, and realizing development of the national economy in a sustainable, rapid and healthy manner. In this paper, development, problems and countermeasures of the protected horticulture in Mainland China will be given.

1340–1440

S16–P–23

COMPARISON OF DIFFERENT LIGHT SOURCES AT EQUAL *PPF*

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Supplemental irradiation of ornamental crops aims at the improvement of the plant growth or at the influence on plant morphology. Various experiments on growth and development were completed with different light sources (modified High Pressure Sodium lamps) at equal *PPF*-level. The results show in general, that at equal *PPF* the plant growth (as compared by dry matter) tends to be the same. The light quality on the other hand influences plant height, flower size and time of flowering. Therefore, the proper choice of light quality could help to avoid the use of chemicals for the control of the crop height.

1340–1440
S16–P–24
FORCING CULTURE OF *ZYGOPETALUM* UNDER SPOT COOLING SYSTEM USING SPOT AIR-CONDITIONER

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Zygopetalum orchid plants are getting popular in Japan, in part because of their sweet smell. Time of flowering for the conventional cultivation is usually in December. This study investigates whether a spot cooling system accelerates the time of flowering and improves the quality of the flowers. Two benches were prepared in a greenhouse. One was the experimental bench equipped with an economical spot air-conditioner and cool air was supplied into the tunnel covering the bench. The other was the control bench for conventional cultivation. Orchid plants were placed on the control bench on 22 July and on the experimental bench on four different occasions between 22 July and 5 September. When the length of flower stalks was over 10 cm, the experimental plants were moved to the control bench. Daily mean temperature was kept 4 to 7C lower and the daily fluctuation of relative humidity was smaller at 90% RH on the average under the spot cooling condition than the control condition. Plants grown under the spot cooling condition since 22 July flowered on 3 October, approximately three months earlier than the plants under the control condition. The number of florets and flower size across the different conditions was not different. Plants placed later on the experimental bench flowered later than the ones placed earlier.

1340–1440
S16–P–25
THE PENNSYLVANIA STATE UNIV. HIGH TUNNEL RESEARCH AND EDUCATION FACILITY

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The High Tunnel Research and Education Facility is located at the Horticulture Research Farm, Rock Springs, PA. The facility consists of twenty-four (17 x 36 foot) research size high tunnel units, one (21 x 36 foot) unit, one (30 x 36 foot) unit and three (17 x 96 foot) commercial size high tunnel units. An on-site weather station monitors outside environmental conditions, which are then compared to environmental conditions inside the high tunnels. A (24 x 24 foot) building houses an office for graduate students and support personnel and also storage for equipment and supplies. Three large field plots are maintained adjacent to the high tunnels to allow comparison between field production and production in the high tunnels. Research objectives are focused on measuring environmental conditions, evaluating high tunnel components, horticultural crops and production systems. Different types of plastic coverings, plastic mulches, row covers and low tunnels are being evaluated for their ability to maintain optimum temperatures. The following crops are being evaluated in the high tunnels: vegetables, small fruits, cut flowers and tree fruits.

1340–1440
S16–P–26
PHOTOSYNTHETIC RESPONSE OF VEGETABLE CROPS TO CS LIQUID

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A special kinds of liquid, named as CS liquid that means clear surface, was used to carry out daily photosynthetic change (DPC) of cucumber eggplant cauliflower and tomato by means of a special kind of tiny glasshouse. The daily photosynthetic change of cucumber eggplant cauliflower and tomato under CS liquid is almost as same as that under znatural condition, which also shows double peak trend. But the DPC of cucumber performed a absolutely opposite results.The midnap of photosynthesis still appears, it proves further light is not the main factor to result in the midnap. The change of Stomatic Opening keeps the same trend with photosynthetic rate, it is also related to the midnap. Among four kinds of employed vegetable crops, cauliflower shows clearest double peak curve considered as the best crop to study daily photosynthetic change.

1340–1440
S16–P–27
TO BE ANNOUNCED

1440–1500
S16–O–28
THE EFFECT OF ROOF INCLINATION ON THE CONDENSATION BEHAVIOUR OF PLASTIC FILMS USED AS GREENHOUSE COVERING MATERIALS

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Different antifog greenhouse films were investigated concerning their condensation behaviour at different roof inclinations in comparison to a standard copolymer LDPE film. The disadvantage of plastic films used as greenhouse covering in comparison to glass is their hydrophobic behaviour. Dropwise condensation leads to light reflection and to droplets falling onto the plants. Therefore special additives are integrated into the film in order to change the condensation into a water film condensation. The problem is that no standardized testing method for an objective evaluation of the antifog effect of greenhouse films exists. In this project the plastic films for greenhouse covering were characterised by studying the condensed water pattern formation with an IR-camera and measuring relevant physical properties of the film influenced by the condensation, for example, the light reflectance with a reflectometer. The measurements on the greenhouse films were performed under laboratory conditions with a specially designed contact angle measurement device and an inclinable hot box located in a cold room. It was possible to predict the critical roof inclination of a film concerning the sliding and dripping of droplets with the measurement of single droplets. Also for the antifog-films a certain inclination angle existed, below which the condensate drips onto the plants. This angle is different for each material. The reflectance measurements showed that there was a critical inclination for a non-wettable material like the standard LDPE-film but not for the tested antifog films. The present work is carried out under the "Standard, Measuring and Testing" research programme funded by E.U.: "New testing methods for plastic films used as greenhouse covering materials" . The cooperative project started in January 1998. Participants are the Dept. of Agricultural Engineering of the Agricultural Univ. of Athens (Greece), Cemagref (France), CIBA Specialities (Italy), the Institute of Agricultural and Environmental Engineering IMAG (The Netherlands), HYPLAST NV (Belgium) and the Institute of Horticultural and Agricultural Engineering of the Univ. of Hannover ITG (Germany).

1500–1520
S16–O–29
GREENHOUSE DESIGN FOR THE FUTURE WITH A CLADDING MATERIAL COMBINING HIGH INSULATION CAPACITY WITH HIGH LIGHT TRANSMITTANCE

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Two types of future greenhouses, glass-covered and plastic-covered, have been developed for the world exhibition Floriade to be organised from April until October 2002 in The Netherlands. This paper is focused on the greenhouse design with plastic double-web zigzag-sheets. The greenhouse is developed by IMAG together with the General Electric Plastics company, Bergen op Zoom, The Netherlands. The basic material of the sheets is polycarbonate which has a good impact resistance and self-extinguishing properties in case of fire.

Intensive research was completed to develop the special zigzag shape of the plastic sheet, which results in an enhanced light transmission. The final material is a double-web sheet where the zigzag shape of both the upper and bottom layer are connected by vertical webs made of the same material. The sheets will be provided with special coatings for better light transmittance and condensation behaviour. Calculations and measurements of the strength, the light transmittance and the insulation value were completed. The optimal dimensions for the sheets with respect to light transmission, strength and insulation, is a pattern of 50 mm for the zigzag shape, a thickness of the sheet of 25 mm and the slope of the pattern of 48 degrees. The sheets can be mounted without glazing bars, because of the snap-in connections on the sides of the sheets. With this design the diffuse light transmittance of the entire greenhouse (with a double cladding) is 78.7%, the same as that of a single glass greenhouse. The U-value (insulation value) is calculated to be 3.4 W per m^2 per K, which compared to a single-glass covering gives a yearly energy saving of approximately 20% (including the loss caused by the necessary ventilation). This energy saving can be improved to about 40% using energy friendly dehumidification.

1520–1540
S16–O–30
CONTROL AND OPTIMIZATION OF THE GREENHOUSE ENVIRONMENT USING INFRA-RED SENSORS

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Wide-angle infra-red (IR) sensors are being used to monitor and control plant canopy temperature (CT) in greenhouses in summer in the UK. It is CT rather than air temperature (AT) that determines plant growth and development, and these two temperature measures frequently differ greatly, especially under conditions of high AT and high irradiance. The relationship between CT and AT also differs between species, and under the same high AT and irradiance conditions, the CT of chrysanthemum is generally well below AT whilst the CT of dieffenbachia is generally well above AT. CT is affected by stage of crop development, and the CT of flowering crops can be particularly high and potentially deleterious, since flowers have few or no stomata and their evaporative cooling potential is low. IR monitoring on a commercial begonia nursery has shown that CT at night is generally below AT in summer, and that reducing AT at dawn to give compact plants (DROP) does not always result in comparable reductions in CT. This is because increasing irradiance at the start of day tends to nullify the effect of lowered AT on CT. We believe that environmental optimization, plant quality and energy usage will benefit greatly if greenhouse operation (heating, use of shade screens etc) is based on CT rather than AT (or outside irradiance in the case of shading), and this has become known as 'the speaking plant' approach. The feasibility of this approach has been demonstrated over two seasons by linking IR sensors directly to the environmental control computer in air-conditioned greenhouse compartments.

1540–1600
S16–O–31
HYDRION-LINE: ON-LINE MONITORING AND CONTROL OF CLOSED GREENHOUSE SYSTEMS

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There is increasing pressure to develop closed greenhouse systems that avoid negative effects on the environment. By fully recirculating the nutrient solution, loss of nutrients to the soil and surface water can be avoided. However, current technology does not allow full re-use of recirculated water. A team, consisting of groups of the Wageningen Univ. & Research centre and a number of companies, is developing a closed greenhouse system that technically and economically permits the complete recirculation of process water in greenhouses. In order to add the proper amount of nutrients, the demand of the crop needs to be known at every moment. An important aspect of the project is therefore the development of a system that can measure the status of the crop. In combination with crop growth models, the water and nutrient demand of the crop is predicted. An advanced control system then ensures the optimal water and nutrient supply to the crop. Finally, a water treatment system is being developed that will eliminate unwanted salts from the recirculation water. Controlled nutrient supply will lead to a more efficient use of resources. And by using this completely integrated (with self-learning capacities) system it becomes possible to optimize your growth strategies in order to obtain certain postharvest quality traits. We are thinking of enhancing secondary metabolites associated with human health promotion.

1600–1620
S16–O–32
A STAND-ALONE LIGHT INTEGRAL CONTROLLER

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Control of the daily integral of Photosynthetic Photon Flux Density (*PPFD,* $mol \cdot m^{-2} \cdot day^{-1}$) is necessary for predictable plant growth and meeting specific crop production goals. A stand-alone light controller would greatly help both commercial growers and researchers meet this requirement in a cost-effective manner. Intelligent light control can also save money by making optimum use of off-peak electrical energy for lighting. Researchers are often faced with balancing light conditions between two greenhouses or growth chambers for experimental research. This has proven to be very difficult even with identical equipment. Controlling light to a daily *PPFD* integral offers a mechanism to easily match light conditions in multiple plant growing facilities. Light control is achieved by a series of rules that turn lights on and off and open and close a mechanical shade curtain. Total moles of light (integral), light intensity, and photoperiod are controlled. Mechanical shade in greenhouses is used to limit light and can be used to prevent high temperatures, as well as rain and wind damage in open roof structures. Control of mechanical shade, employed as a thermal curtain, offers additional energy savings by reducing heat lost at night. An off the shelf, single board computer programmable with the high level language C was selected. The controller has a small form factor, ample processing power and memory, a real-time clock, and several analog and digital inputs and outputs. A quantum sensor is used for accurate PAR measurement. Since the light sensor output is in the microampere range, amplification is necessary to provide a signal compatible with the computer input. A vegetable production greenhouse equipped with High Intensity Discharge (HID) lighting and a retractable shade curtain serves as a test bed for the controller. The design of a stand-alone light integral controller is presented with performance data.

1620–1640
S16–O–32–A
TO BE ANNOUNCED

1640–1700
S16–O–32–B
TO BE ANNOUNCED

Tuesday · August 13

1100–1140
S16–O–33
STRATEGIC CROP MANAGEMENT IN MILD WINTER CLIMATE GREENHOUSES

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In the last decades, the increase of protected cultivation in glasshouses has been very scarce as compared with the large spread of low-cost plastic greenhouses around the world. The greenhouse area in northern Europe has been

almost stable, while protected cultivation expanded enormously in the Mediterranean basin, enhanced by the enlarging demand of vegetables for the export and domestic markets, resulting from economic development. In the past, the production strategies in the Mediterranean greenhouse industries have been mainly related with the adaptation of the crops to a suboptimal environment, due to the limited greenhouse climate control. There is now a general trend to better equipped greenhouses with improved climate management, in order to increase product quality. Achieving an economic compromise between the higher costs of improved greenhouses and their increased agronomic production are requiring different solutions, according to the local technical and socio-economic conditions, in order to produce proper quality commodities at competitive levels, relative to the higher performances of the sophisticated glasshouse industry of northern European countries. The distance from the European markets, in export focused production, increases the transportation cost of Mediterranean production, limiting its competitiveness. Diverse studies have been made to improve the greenhouses technological level, including greenhouse design and climate management, crop techniques and practices (cultivars, cycles, plant protection, irrigation, substrates) in the various conditions of the Mediterranean basin. The cultural level of the growers, in the different countries, can be a limiting factor to improving the technological level of the greenhouses and great efforts are been made to transfer the technological knowledge to the growers, providing them with the methodology of optimisation of their production systems.

1140–1200

S16–O–34

THE INFLUENCE OF WIND DIRECTION ON GREENHOUSE VENTILATION

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Wind-driven ventilation of a square 1/3 scale model of a Venlo greenhouse with roof ventilators was studied experimentally in a novel boundary layer wind tunnel. The model comprised five spans with a total of 25 ridge hinged ventilators. The air flow in the wind tunnel was created by 56 propeller fans, the speeds of which were set to create a vertical velocity profile and the speeds fluctuated about their mean values to reproduce wind turbulence. The rates of air exchange were measured using nitrous oxide as a tracer gas. The gas was injected at a constant and measured rate through an array of five perforated pipes. Samples of greenhouse air were taken from five locations and mixed before measurement of the tracer gas concentration. The model could be oriented so the direction of the air flow was either at right angles (transverse flow) or parallel (axial flow) to the gutters. Ventilation measurements with transverse flow were made with leeward ventilators open, windward ventilators open and both leeward and windward ventilators open. Measurements with axial flow were made with the ventilators on one side and both sides of the ridge open. In transverse flow, windward ventilation gave a much higher rate of air exchange than leeward ventilation for the same ventilator opening, and combined leeward and windward ventilation gave a higher air exchange than the sum of the leeward and windward exchange rates. In axial flow, the air exchange rates were higher than those for the corresponding transverse flow case. A simple model was fitted to the experimental data.

1200–1220

S16–O–35

CFD PREDICTION OF THE NATURAL VENTILATION IN A TUNNEL-TYPE GREENHOUSE USING A TRANSPIRATION ACTIVE CROP MODEL

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The computational fluid dynamics (CFD) modelling of airflow patterns in a ventilated greenhouse is an important development tool for the analysis and the prediction of the inner climate of a greenhouse, as a function of environmental and structural parameters. Some authors have performed numerous simulations with different CFD packages in order to determine the influence of the geometry and the location of the ventilators on the airflow in the greenhouse. Nevertheless, almost the whole of these models doesn't take into account the presence of a crop, or they only consider the momentum transfer between the airflow and the crop using a porous media concept. A new model developed with the CFD2000 package is evaluated, which takes into account the crop like an active 3D region : the momentum transfer is considered (porous media) as well as the heat and humidity transfers between the crop and the inside airflow. The model consists in the determination for each node of the crop grid of the energy balance between the transpiration flux and the radiation flux. The heat and humidity transfer coefficients are determined from the leaf laminar boundary layer characteristics which are calculated with the local velocity of air in the crop. The active crop model is applied to a tunnel-type greenhouse with five vents on each side and a five rows mature tomato crop. A side wind perpendicular to the longitudinal axis of the greenhouse is considered and the boundary conditions for the velocity distribution in the vents are determined with a preliminary, purely mechanical, 3D simulation of the greenhouse and its environment. The results show clearly the 3D heterogeneity of the temperature and humidity fields both in the inner airflow and crop and also the influence of the location, in relation to the vents, on the transpiration flux of the crop. The results are in good agreement with experimental results performed in a similar tunnel-type greenhouse.

1220–1240

S16–O–36

EFFECT OF LOW-TEMPERATURE PULSE AT NIGHT ON PHOTOSYNTHESIS AND CARBOHYDRATE PARTITIONING OF GREENHOUSE TOMATO GROWN UNDER SUPPLEMENTAL LIGHTING

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Studies of the activity of sink organs are indispensable in the attempt to improve the harvest index and the marketable yield by the horticultural industry. Our previous studies showed that under extended photoperiod and high p (CO_2), greenhouse tomato plants developed leaf chlorosis, rate of carbon assimilation was reduced and yields were no longer increased. This phenomenon was accompanied by an important increase in soluble sugar and starch accumulation in tomato leaves. However, under extended photoperiod supplied by supplemental lighting and high p (CO_2), the influence of low night temperature on the carbohydrate metabolism of tomato remains to be found. The objective of the present work was to investigate whether low-temperature pulse at night affects the carbohydrate partitioning between fruits and vegetative parts and improves the photosynthesis activity of greenhouse tomato grown under extended photoperiod (18 h, HPS of 100 $\mu mol \cdot m^{-1} \cdot s^{-2}$). Two night temperature treatments were compared (1- 17 C; 2- 13.7 °C) for a similar 24-h average temperature (18.3 °C). In treatment 2, a rapid drop of air temperature has been done at the end of the photoperiod in order to keep a low temperature of 12 °C for 2 h (low-temperature pulse at night). During the six weeks of experimental period, leaf, fruit, root and air temperatures have been monitored. The CO_2 assimilation rate and fluorescence have been measured at 4-h intervals, and 5th, 10th and 15th leaves from the apex collected for carbohydrate analysis. Growth parameters and yield have been weekly measured. For all leaf positions and temperature treatments, the Fv/Fm ratio and CO_2 assimiation rate decreased at midday. The Fv/Fm ratio recovery of the 5th leaf was faster at low night temperature treatment, coinciding with a higher CO_2 assimilation rate. Results will be discussed in terms of source and sink capacity of tomato grown under extended photoperiod and high p (CO_2).

1340–1440

S16–P–37

XYLEM SAP TRANSPORT IN TOMATO PLANTS UNDER VARYING LIGHT LEVELS

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Xylem sap transport (whole-plant transpiration) was measured with a heat-balance sap-flow gauge in tomato plants grown in a growth chamber. Different light levels ranging from 125–500 $\mu mol \cdot m^{-2} \cdot s^{-1}$ were applied to measure the

response of xylem sap transport which was rapidly altered and closely followed by the light level available to the leaves. When the light level of 125 $\mu mol \cdot m^{-2} \cdot s^{-1}$ was given, however, only a small amount of sap was transported, suggesting that at least certain minimum light level is required to conduct sap transport. The importance of light environment for tomato production in the greenhouse during winter is discussed in view of the stomatal conductance, photosynthetic activity and xylem sap transport to the leaves.

1340–1440

S16–P–38

POSSIBILITIES OF GROWING GLASSHOUSE VEGETABLES IN A CLOSED SYSTEM USING COMMON SOIL AS A SUBSTRATE

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As a possibility to avoid the emission of nutrients in cultivation of glasshouse vegetables, the Provincial Research and Advisory Centre of Rumbeke (Flanders–Belgium) developed a closed growing system simply by separating the normal growing layer of the soil from the subsoil by a plastic film. Soil texture was sandy loam; depth of the growing layer was 0.40 m. In contrast to many hydroponic, soilless systems this closed system allows free choice of vegetable growing. The new growing system was tested during four years for growing leafy vegetables as well as fruit vegetables. Each year, head lettuce (*Lactuca sativa* L. var. *capitata*) in winter and cucumber (*Cucumis sativus* L.) in summer were grown in the closed system as well as in the normal growing system. For both crops irrigation seemed to be the most critical factor to obtain normal yield and quality in the closed growing system. Cultivar differences were noticed. For head lettuce optimal irrigation was achieved by the use of a slightly modified Penman–Monteith model. For cucumber sap flow measurement was studied as a base for plant dependent irrigation, but further optimisation of this technique is still needed. After four years of use, no abnormal soil compaction could be detected in the closed system. This explains why a sandy layer (0.10 m) just above the plastic lining could not improve growing results. Continuous measurement of drainage water emerging from the drainage tubes in both normal and closed systems provided evidence that, with the type of soil used, in the normal growing system no emission of fertilisers occurred during periods of cultivation. During periods of leaching however, the fraction of percolation was calculated as 18 % of the leaching water at 140 L/m^2 and 59% at 350 L/m^2. The shallow soil layer in the closed system allowed efficient soil disinfestation with quantities of methylbromide and steam much lower than normal.

1340–1440

S16–P–39

MATHEMATICAL MODELLING OF THE FAST DYNAMIC RESPONSE OF TOMATO LEAVES TO SUDDEN CHANGES IN MICROCLIMATE

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All living plants are influenced by their local microclimate (e.g. light, temperature, etc.) and they react dynamically to environmental changes. When it is the aim to optimise a biological process (photosynthesis, transpiration, etc.), this can be realised by controlling the microenvironment around the organism. Therefore, a compact dynamic model, taking into account the response of the organism as an on-line feedback, is absolutely necessary. The integration of these dynamic data-based modelling techniques with new hardware and sensor techniques should make it possible to come to a more efficient kind of model predictive control and the continuous monitoring of bioprocesses. The objective of this study is to explore a possibility of modelling the fast dynamic response of tomato leaves to sudden step changes in the microclimate, using a dynamic simple transfer function model. Moreover, the model order of the dynamic responses was determined. The models were evaluated using the coefficient of determination (R^2) and the Young's Identification Criterion (YIC). Additionally, the symmetry (or asymmetry) of the response in time to step changes up (e.g., light on) and down (e.g., light off) was investigated. Plant responses to step changes in the microclimate appeared to be modelled accurately.

1340–1440

S16–P–40

A PREDICTIVE MODEL OF TOMATO FRUIT CUTICLE CRACKING

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Previous studies of tomato cuticle cracking have largely focussed on one potential causal factor at a time (e.g., the effect of calcium uptake, the effect of EC, etc.). While this has provided much information, there is still limited ability to provide growers with general recommendations to control cuticle cracking. The major climatic and production factors that contribute to the development of cuticle cracking and the interactions that exist between these factors remains to be found. In our study, climatic, cultural and cuticle cracking data were collected for most of the growing season from commercial tomato greenhouses in Quebec and British Columbia, Canada. The information was averaged weekly, and the relative importance of each factor was assessed using step-wise multiple regression or neural network software. In the Quebec study, there was no relationship between cuticle cracking and solar radiation, day and night RH, greenhouse cover, cultivars, substrate, artificial lighting, and EC. However, day and night temperature, and 24 h average temperature significantly influenced cuticle cracking. In the British Columbia study, low day temperature, low day and high night vapour pressure deficit, high CO_2, high EC, low leaf number, long leaves and high crop yield reduced the incidence of cracking. Neural networks were found to be better than step-wise multiple regressions at predicting cracking from known climatic and cultural conditions.

1340–1440

S16–P–41

QUALITY OF GREENHOUSE CUCUMBER FRUIT GROWN ON PERLITE SUBSTRATE OR NUTRIENT FILM TECHNIQUE

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Cucumber fruit (*Cucumis sativus* L. cv. Trópico F1) grown under perlite or NFT were harvested during two seasons (winter and spring) in order to study the behavior of fruit quality. The best cucumber fruit quality as measured by lightness and Hue angle parameters was achieved during at least 20 or 23 days during the winter or spring seasons, respectively. NFT fruit showed darker and greener skin colour (higher Hue angle and lower lightness) as compared with fruit grown in perlite, irrespective of the season considered. Fruit from NFT harvested during the winter season were heavier, wider and larger and with firmer mesocarp than perlite-grown fruit, but no differences were observed during the spring season. During the spring season, NFT-grown fruit were less acid than perlite-grown fruit. Skin colour parameters offered the best quality indices in cucumber.

1340–1440

S16–P–42

EFFECT OF SUPPLEMENTAL LIGHTING DURING THE PERIOD FROM MIDDLE OF NIGHT TO MORNING ON PHOTOSYNTHESIS AND LEAF THICKNESS OF LETTUCE (*LACTUCA SATIVA* L.) AND TSUKENA (*BRASSICA CAMPESTRIS* L.)

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Supplemental lighting during the period from middle of night to morning promotes growth of some leafy vegetables. In this study, we present effects of light quality and light intensity of supplemental lighting on photosynthetic rate during day time and leaf thickness of lettuce and tsukena. We used metal halide lamp (MH) and high pressure sodium lamp (HPS) for lighting. Supplemental lighting was applied to the plant during the period middle of night 23:00 to 7:00. Three levels of light intensity were set as high [76 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (Photosynthetic photon flux (*PPF)*], low (4.8 $\mu mol \cdot m^{-2} \cdot s^{-1}$) and control (0.0 $\mu mol \cdot m^{-2} \cdot s^{-1}$). Shoot fresh weights of lettuce and tsukena under supplemental lighting with high light intensity were 53% and 37% higher compared with the control. In lettuce and tsukena, increase of shoot fresh weight under supplemental lighting was found to be dependent on the light intensity. However, there was non-significant difference between MH and HPS on shoot fresh weight. Photosynthetic rate during day time of lettuce was not influenced by supplemental lighting. On the other hand, photosynthetic rate of tsukena under supplemental lighting was slightly lower than the control. Chlorophyll content per leaf area was 15% in lettuce and 19% in tsukena higher than the control. Further, the leaf thickness was 265 and 477 μm under supplemental lighting and 225 μm and 372 μm without lighting, in lettuce and tsukena, respectively. A dark green leaf color under supplemental lighting resulted from the increase of leaf thickness. The increase of leaf thickness under supplemental lighting was higher under HPS compared with MH. On the contrary, supplemental lighting using MH increased leaf length and width of these crops more than HPS. We conclude that the supplemental lighting change the leaf area and thickness. Additionally, the effect of supplemental lighting on leaf structure could be altered with the light quality of light source.

1340–1440

S16–P–43

EGGPLANT PRODUCTION IN SOILESS CULTURE UNDER SALINE IRRIGATION PRACTICES AND SOIL CONDITIONER APPLICATION

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This work investigates the eggplant variety (Galine F1) response to saline irrigation practice in soiless culture. Three inert substrates, sand, pozzolana and perlite,were utilized, in the absence and with the presence of soil conditioner "Barbary-Plante G2". Saline water with electrical conductivity of around 6.0 dS/m was used for irrigation. The average water consumption of eggplants was about 2900 m^3/ha. The average yield, gained from five harvests,was about 66,2 t/ha, while the average dry matter production was about 8.45 t/ha. In average, the yield water use efficency was about 23.5 g/L and the biomass water use efficiency was about 3.0 g/L. The results of this work indicated that both sand and perlite are more appropiate than pozzolana for growing the eggplants in soiless conditions under saline irrigation practice. In general, the presence of Barbary-Plante G2 in inert substrates did not result in significant improvement of yield and biomass production. The greater improvement of yield water use efficiency of 28% was observed for pozzolana substrate while the increment for perlite and sand was lower of 14 and 8%, respectively. For all the investigated substrates, under the continuous irrigation with saline water during the cropping period, accumulated salts did not exceed the 4 dS/m, particularly at the critical growth stages: flowering and fruit setting ones. Furthermore, monitoring the salt accumulation in the substrates during the cropping period is crucial and leaching should be efficiently practiced if salts are present at a grade up to the 4 dS/m. The results confirmed that saline irrigation practice could be successfully applied for eggplants in soiless culture.

1340–1440

S16–P–44

DIURNAL CHANGE OF NUTRIENT SOLUTION CONCENTRATION FOR CUCUMBER PLANTS GROWN IN RUN-OFF SYSTEM WITH ORGANIC SUBSTRATE

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Bag cultures with run-off (free drainage) systems require simple facilities and low initial cost. But it may cause an environmental pollution by discarded nutrient. If nutrient solutions were applied only during the daytime, the amount of first drainage solutions in the morning might be lowest. In this experiment, therefore, we applied high concentration of nutrient solution at the first application and low one after the second application to the bag culture system using bark / peat moss substrate. Nutrient solution with 2.4 $dS \cdot m^{-1}$ of electric conductivity (EC) was supplied by dripping tube for 5 to 10 minutes each hour from 8:00 to 18:00 in control. Frequency of irrigation was changed 2 to 8 times according to the plant growth. In treatment plots, solutions with EC 3.0 $dS \cdot m^{-1}$ were supplied at 8:00, and solutions with EC 0.3 (well water), EC 1.2, EC 2.0 $dS \cdot m^{-1}$ were supplied at 9:00 and afterwards. The amount of solutions flowed out from beds after the second irrigations were maintained at about 15 % of the applied solutions. Yield increased with increasing EC of nutrient solution applied after second irrigation, with no difference between control and EC 2.0. However, the yield in EC 0.3 was 80% of control, and % marketable fruits did not differ from control. Fresh weight and number of lateral shoot were the lowest in EC 0.3. Total amount of nutrient applied to plant during this experiment increased with increasing EC of nutrient solution applied, but the amount of nutrient absorbed by plant was almost the same in all treatments but EC 0.3 treatment. Nutrient concentration of drainage solution was lower in EC 0.3 and EC 1.2 than that in EC 2.0, which was the same as the control. From these results, EC 3.0 solution as the first irrigation solution in the morning, and EC 1.2 as the following solutions was recommended to achieve sufficient yield with low nutrients in drainage.

1340–1440

S16–P–45

EFFECT OF DAY AND NIGHT TEMPERATURE ON GROWTH AND FRUIT QUALITY IN MELON

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To find the optimum temperature control regime for protected cultivation, Busan #917 (a muskmelon breeding line; a reticulatus group) and Surowang (a commercial F1 hybrid of oriental melon; a makuwa group) were cultivated at 30, 35 and 40 °C during the daytime, and 11 and 16 °C during the nighttime. Plant growth of both cultivars was better and flowering time was advanced by 3 days when grown at 16 °C than at 11 °C at night. Daytime temperature did not affect on plant growth significantly, but the length of leaf petiole tended to get longer at higher temperature. Fruit size in oriental melon was inversely proportional to the daytime temperature. In muskmelon, the size of fruits grown at 35 °C was the biggest and there was no significant difference in fruit size between 30 and 40 °C. The net formed on the fruit skin was thinner at higher daytime temperature. In addition, fruits was longer, fruit skin color was lighter, and the rate of malformed fruits was higher in oriental melon as the daytime temperature increased.

1340–1440

S16–P–46

AERATION IN DIFFERENT GROWING MEDIA FOR GREENHOUSE TOMATO PRODUCTION

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Replacement of rockwool as a growing medium by more readily renewable materials or by waste product is now a worldwide target. Often, other crop performances have been linked to good aeration properties. The purpose of this 2-year study was to identify suitable waste based growing media for greenhouse tomato and to test how their aeration properties were related to crop yield. The performance of seven substrates made of rockwool, sawdust, wood shaving, composted bark and peat, pure or in mixture, were compared in two successive greenhouse experiments. Peat and bark, pure and in mixtures, gave yields similar to those in rockwool while sawdust and shaving lead to lower yield on the second year of experiment. Yield differences were not related to physical properties including aeration although these characteristics varied greatly between substrates. Additional experiments suggested little effect of aeration on tomato plant growth. The results indicated that peat and bark, pure and in mixtures, might replace rockwool for tomato production in greenhouses.

1340–1440

S16–P–47

EFFECT OF SUPPLEMENTARY LIGHTING OF BLUE-LIGHT DURING THE NIGHT ON ANTHOCYANIN SYNTHESIS AND GROWTH OF RED-LEAF LETTUCE

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Poor coloration due to low anthocyanin content in leaves has often happened in hydroponic red-leaf lettuce. Our previous study suggested that supplementary lighting of blue light improves the coloration by increasing anthocyanin content. In this study, effects of blue light supplementation during the nighttime on the coloration and growth were examined to develop practical methods for improving quality of red-leaf lettuce by hydroponics in a greenhouse. Effect of light intensity on anthocyanin level was examined in red-leaf lettuce. The lettuce was grown under sunlight during the daytime and was exposed to blue light from 18:00 to 6:00 (12 hours) for 7 days. The anthocyanin level increased linearly with 60 $\mu mol \cdot m^{-2} \cdot s^{-1}$ or more and reached a plateau with 160 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The coloration obtained at 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ was comparable to that produced in the field. The growth of lettuce was also enhanced by the increase of light intensity. The dry matter rates and thickness of a leaf were increased with 60 and 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light. Effect of lighting duration on anthocyanin level and growth was examined in the lettuce under 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light. The anthocyanin level increased with 6 hours and the highest value was obtained at 12 hours. Under 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light condition, at least 6 hours continuous irradiation was necessary to improve the coloration. At that time, the longer the lighting duration was extended, the greater the growth of lettuce could be seen such as the dry weight, dry matter rates, and thickness of a leaf. The anthocyanin content and/or the dry weight were not affected by the irradiation pattern, continuous and 30 and 120 minutes intermittent lighting, under the condition of 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light for totally 6 hours. It was concluded that 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of irradiation of blue light for more than 6 hours in nighttime was enough to improve coloration and growth in a greenhouse hydroponic red-leaf lettuce.

1340–1440

S16–P–48

EFFECT OF ENVIRONMENTS OF PLANT FACTORY SYSTEMS ON PRODUCTION AND QUALITY OF PEPPERMINT

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The growth of herbs is influenced directly by environmental factors such as climatic environments and root zone environments. These external factors can be controlled properly in a plant factory. By cultivating in a plant factory, it can be respected that the production of high quality peppermint (*Mentha piperita* L.). This study was conducted to investigate the ability of plant factory to produce high quality peppermint. Peppermint was grown in three different plant growth systems (closed plant factory with artificial lighting, plant factory with natural and artificial lighting and greenhouse) during 3 weeks. The treatment conditions were 16/8h (day/night), 60–80% (RH) and 600–800 $mg \cdot L^{-1}$ (CO_2) in a closed plant factory with artificial lighting, 16/8h (day/night), 50 ~ 80% (RH) and 360–450 $mg \cdot L^{-1}$ (CO_2) in a plant factory with natural and artificial lighting, 40–80% (RH), 360–450 $mg \cdot L^{-1}$ (CO_2) and natural lighting in a greenhouse. Electric conductivity (EC) level of the nutrient solution was adjusted to $1.2 dS \cdot m^{-1}$, with the pH levels of 6.0 ± 0.5. Photosynthetic rate, the content of essential oil, vitamin C, calcium and chlorophyll were higher at closed plant factory than others. Fresh weight and dry weight were also higher at two plant factory systems than greenhouse. Generally, among the three different systems, the growth and quality of peppermint were highest in a closed plant factory, while there was the lowest growth in a greenhouse.

1340–1440

S16–P–49

INFLUENCE OF SILICATE APPLICATION ON THE SUCROSE SYNTHETIC ENZYME ACTIVITY OF TOMATO IN PERLITE CULTURE

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This study was carried out to evaluate the effect of silicate application on the activity of sucrose synthase (SS) and sucrose phosphate synthase (SPS) of tomato fruits grown in perlite media culture. The amounts of applied silicate were 0, 1, 2, and 4 $tons \cdot ha^{-1}$. In the enzyme activity of fruits with different ripening stages, SS and SPS showed rapid increase up to 27 days after fruit setting and showed minimum level at 48 days after fruit setting, which was remarkable in proportion to the amounts of silicate application. With the increase of the soluble silicon content in fruits, SS and SPS activity increased and highly positive correlation were shown among soluble silicon content, SS activity, and SPS activity. Regression equations were significant between sugar content and these enzymes in the fruits with variable ripening stages.

1340–1440

S16–P–50

EFFECTS OF DIURNAL EC VARIATIONS ON FRUIT YIELD AND QUALITY OF GREENHOUSE TOMATOES GROWN IN ROCKWOOL

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Diurnal EC fertigation strategy which provided plants with low EC nutrient solution in the morning & noon and with high EC nutrient solution in the afternoon & night were examined in two experiments: one for spring and one for fall tomato. In the spring experiment, 8 treatments were applied: 3 constant EC treatments (2.5, 3.75 and 5.0 $mS \cdot cm^{-1}$), 3 variable EC treatments (feed EC varied from 1.5 to 8.5 $mS \cdot cm^{-1}$, 24-h mean: 2.5, 3.75 and 5.0 $mS \cdot cm^{-1}$) and 2 variable EC treatments (24-h mean: 3.75 and 5.0 $mS \cdot cm^{-1}$) with reduced rockwool slab size. In the fall experiment, 6 treatments were applied: 2 constant EC treatments (2.5 and 3.5 $mS \cdot cm^{-1}$), 2 variable EC treatments (EC varied from 1.5 to 5 $mS \cdot cm^{-1}$, 24-h mean: 2.5 and 3.5 $mS \cdot cm^{-1}$) with feed EC corresponding to current solar radiation and 2 variable EC treatments (24-h mean: 2.5 and 3.5 $mS \cdot cm^{-1}$) with feed EC variation in anticipation of solar radiation variation. It was found that 1) the variable EC fertigation improved tomato growth, yield and quality, 2) low variable EC with an average 24-h EC of 2.5 $mS \cdot cm^{-1}$ was good for low light conditions while medium to high variable EC with an average 24-h EC of 3.5-3.7 $mS \cdot cm^{-1}$ was good for stronger light conditions and 3) close correspondence of slab EC to solar radiation can improve the response of tomato to variable EC strategy.

1340–1440

S16–P–51

STUDY OF GROWING PATTERN FOR HIGH EFFICIENT UTILIZATION IN A GREENHOUSE

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This paper deals with growing pattern in a greenhouse with the utilization of space for high efficiency. Soilless cultivation patterns with leaf vegetable, fruit vegetable, sprout or/and fungus vegetable, and ornamental plant or flowers was designed. That is, leaf vegetable (about 48% of total area), fruit vegetables (about 30%), ornamental plants (12%) were cultivated on a bench bed while mushroom (40%) or sprout vegetables (45%) were grown under the bench bed. In this way greenhouse space utilization rate was up to 130% with leaf area index 2.3. Fungus cultivation ensured the high concentration of CO2 up to 650—780 ppm useful for vegetable photosynthesis. Plant growth was very fast and yielded up to 60 $kg \cdot m^{-2}$ or 45$/$m^2$. This pattern is suitable for China's situation with more people and less farmland, and cheaper labor. This is also a good way for increasing land and fund production efficiency.

1340–1440

S16–P–52

USING VERMICOMPOST IN GREENHOUSE CONTAINER MEDIA

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Organic wastes from agriculture, municipalities, and the food-processing and paper industries are being produced in quantities that deserve our atten-

tion. One promising method that would transform these wastes into more usable materials in an environmentally and economically friendly manner is vermicomposting. Vermicomposting is the process of stabilizing organic wastes with the digestive tract of certain earthworm species (e.g. Eisenia fetida). The final product of this process is an odorless peat-like substance, which has good structure, moisture-holding capacity, relatively large amounts of available nutrients, and microbial metabolites that may act as plant growth regulators. For all these reasons, vermicompost has the potential to make a valuable contribution to soilless potting media especially with supplies of sphagnum peat moss running low. According to current research, plants grown in media containing vermicompost respond with better germination, enhanced seedling growth, stimulated root growth, and increased yield. However, the exact property of the vermicompost that is causing this growth promotion is unknown. Some hypothesized reasons for these differences are the supposed plant growth regulators, overall increased microbial activity, and enhanced nutrient uptake. Because of high cost and low availability of vermicompost, the greenhouse will be the most likely place for vermicompost to be used in the horticultural industry. The objective of this study was to evaluate the quality of the greenhouse crops grown in vermicompost. Vegetable transplants (tomato, eggplant, and pepper) and potted chrysanthemums were grown in a commercial container mix including 0, 10, or 20% worm-worked cattle manure by volume. Pre-plant growth and yield were measured to assess quality of the transplants while vegetative and flower development was examined in the chrysanthemums. No difference in quality has been observed.

1440–1500

S16–O–53

NITRATE ACCUMULATION IN PROTECTED LETTUCE

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Concerns about high nitrate levels in vegetable crops led to the imposition of EU limits on maximum permissible levels of nitrate in lettuce and spinach in 1997. This raises problems for UK growers because poor light quality in northern Europe can restrict the energy available to assimilate nitrate taken up by glasshouse crops. We are conducting research on crop and fertiliser management to reduce nitrate concentrations in soil-grown protected lettuce. Experiments have been carried out to examine the effects of N fertiliser type, its amount and timing on plant uptake and quality; to determine the importance of cultivar effects on nitrate accumulation during winter and summer production; and to identify the causes of the inherent plant-to-plant variability in nitrate uptake and accumulation in glasshouse lettuce. The results show a find dividing line between providing enough N fertiliser to maintain yields and avoiding nitrate accumulation in leafy tissues. The form in which N is applied (nitrate, ammonium or urea) has little effect but late application of liquid nitrate feeds tends to raise nitrate levels in the crop at harvest. Similar trends were observed for butterhead and novelty types of lettuce, although the latter tends to accumulate more nitrate. A prototype version of a new model-based decision support system (LET_N) has been developed to improve the precision of N recommendations for protected lettuce growers.

1500–1520

S16–O–54

CARBON STATUS OF CO_2-ENRICHED TOMATO PLANTS UNDER COMMERCIAL GREENHOUSE CONDITIONS.

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Enriching greenhouses with supplemental CO_2 has enabled tomato growers in British Columbia to exceed annual fruit yields of 70 $kg \cdot m^{-2}$. CO_2 sensors provide information on greenhouse concentrations, but do not assess CO_2 fixation by the crop or plant carbon status. Our objectives were to explore the dynamics of carbon pools, in particular leaf starch, diurnally and throughout the leaf canopy under commercial growing conditions. Two commercial greenhouses were sampled in the Lower Mainland of British Columbia, Canada, during the 2000 and 2001 growing seasons. Leaf samples were collected and analyzed for carbohydrate content. Starch content varied significantly through the canopy, declining from canopy top to bottom. This response was variable throughout the season, possibly reflective of climate variation and/or fruit load. Lower carbohydrate levels were observed in morning and evening, with higher levels at midday. In some cases, leaves carried over large amounts of carbohydrate overnight, implying that carbon supply exceeded capacity for carbon use. In some leaves, over 30% of the dry weight was starch, and correlations between leaf dry weight and starch were high ($R > 0.80$). Possibly leaf dry weight may be an indicator of the carbohydrate status of the crop. This information would optimize CO_2 application by discontinuing or reducing enrichment when plants have adequate carbohydrate pools already warehoused in leaves.

1520–1540

S16–O–55

IMPROVEMENT OF EGGPLANT PRODUCE THROUGH NIGHT TEMPERATURE CONTROL RELATED WITH SOLAR RADIATION AND ENHANCEMENT OF PLASTIC HOUSE COVERING

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Energy saving is a critical issue in horticultural crop production during winter season. This experiment was conducted to determine the optimal night temperature management for eggplant production in winter season in plastic house. Night temperature was automatically adjusted by the amount of solar radiation input during day. When the solar energy input was high, the duration of night temperature above 18 °C was extended until 23:00 pm to promote the photosynthates translocation. The temperature was remained about 14 °C in the rest of night. In contrast, the duration of night temperature was reduced. The energy cost in this system was decreased about 9% compared to the traditional heating program. Also, marketable yield of eggplants increased 9% in 'Senryo-Nigo' and 19% in 'Tsikuyo', respectively. But no difference was found in 'Shyoyaonaga'. Further energy saving was obtained by the addition of covering materials. The average night temperature of the plastic house was remained at 12.1 °C by double covering with polyethylene films (50 μm) whereas the addition of non-woven fabric further increased 3.8 °C of the house. The general plant growth was also favorable including plant height, and leaf number, length, and width in the house covered by non-woven fabric resulting in the yield increase by 84%. The improvement of night heating program and enhancement of covering will increase the productivity of eggplants by saving energy cost and keeping plant Vigour in winter season.

1540–1600

S16–O–56

DEVELOPMENT OF ECO-ORGANIC TYPE SOILLESS CULTURE IN MAINLAND CHINA

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Soilless culture has developed very rapidly during the last fifteen years in mainland China. The area of soilless culture in China was around 0.1 ha in 1985, by 1995 China had 50 ha of soilless culture area, at present there is about 450 ha of soilless culture, It increased about 8 times as compared with 6 years ago. This is mainly due to the development of eco-organic type soilless culture system. Traditional soilless culture systems using nutrient solution is of characteristics of rather high initial investment, running cost, and very difficult to operate for Chinese growers, which limited the extension of soilless culture technique in China. For solving the problem mentioned above, the eco-organic type soilless culture system was developed. As compared with soilless culture using nutrient solution, eco-organic type soilless culture system decreased initial investment and fertilizer cost up to 60%, improved vegetable quality (due to using large amount of organic fertilizers) and simplified the rules of operation. Eco-organic type soilless culture technique using solid fertilizer (80%–100% organic fertilizers plus 20%–0% inorganic fertilizers) instead of nutrient solution to feed crops was first developed in early 1990s. Since then it has been spreaded very rapidly, and reached over 290 ha at the end of 2001, and accounted for over 60% of total area of soilless culture in China. The system introduced the concept of organic agriculture into soilless culture, and greatly promoted the development of soil-

less culture in China, and was awarded second prize of science and technique progress by Ministry of Agriculture of China in 1996. The report introduced the brief histroy and advantages of eco-organic type soilless culture system, the system structure, main progress in research and extension work, at last discussed the future of soilless culture in China.

1600–1620
S16–O–57
EFFECTS OF DIFFERENT LEACHING FRACTIONS AND SUBSTRATES ON TOMATO GROWING

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In Turkey, protected cultivation has an important place in horticultural activities that are practiced on 44000 ha. Production is realised conventionally in soil, but there is an increasing interest in the use of soilless culture techniques due to several reasons in particular related to soil borne pest and disease problems. Till now soilless cultivation acreage has reached to approximately 40 ha in practice. Among the soilless culture techniques, open substrate culture seems to be more promising due to its high adaptability to the farmers' conditions. This study was conducted during the autumn and spring seasons of 2000-2001 to determine the effects of two leaching fractions and four locally available substrates on yield, fruit quality and water consumption of tomato. Irrigation was realised according to the leaching fractions adjusted as 5–10 % or 15–20 %. The tested substrates were (1) zeolite, (2) zeolite + perlite (3:1, v/v), (3) zeolite + perlite (1:1, v/v) and (4) zeolite + perlite (1:3, v/v). The experimental design was split plots with 3 replicates. Cultivars M-09 F1 and Dino RN F1 were grown in autumn and spring seasons, respectively. Planting dates were August 25, 2000 in autumn and March 15, 2001 in spring. Cumulative yield at two weeks intervals and some quality parameters (average fruit weight, total soluble solids, total dry matter content, pH, EC, vitamin C, titratable acidity) were determined. There were no significant differences between leaching fractions and substrates in respect to total yield in both seasons. However, their individual effects and interactions between leaching fractions and substrates were found to be significant in some two-weekly cumulative yields. Generally, fruit quality properties did not change according to treatments.

1620–1640
S16–O–57–A
TO BE ANNOUNCED

1640–1700
S16–O–57–B
TO BE ANNOUNCED

Thursday · August 15

1100–1140
S16–O–58
CONSEQUENCES OF CLOSED SOILLESS GROWING SYSTEMS FOR THE RECIRCULATING NUTRIENT SOLUTION AND THE PRODUCTION TECHNIQUES

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In 1973 NFT changed from a scientific working instrument into a revolutionary production system. The exponential increase in the large-scale applications of soilless culture found its driving force in the economic advantages of it and more precisely in yield increases of at least 25%. Meanwhile far-reaching solutions were realized within the economic, ecological and ergonomic requirements of modern horticulture. A first major problem concerns the quality of the available water. In northern areas the disadvantages of groundwater (Fe, NaCl, HCO_3) have been sidestepped by means of rainwater basins, whereas in southern areas, which do sometimes have abundant precipitation, these basins have hardly found any application. The closed NFT system may be regarded as the precursor of the good ecological practice that is emphsized so strongly today. However, this technique is being applied only on a limited scale for leaf crops and herbs. Within the substrate culture the recirculation of drainwater changed from a compelling guideline into a generally accepted ecological and economic data. Partly also due to the accumulating disposal heap, caused by the rockwool substrate in the eighties, more and more alternative inert lasting (PUR, Perlite) and organic(wood fibres, coir) substrates were introduced. The characterisation of their physical and chemical properties implemented a far-reaching improvement of the control of the nutrient composition and of the trickling regime. Within the NFT system, mechanization developed strongly since the beginning of the eighties in the form of the "Floating Plant System," the "Mobile Lid System," and the "Mobile Gully System." In this process the transition from a longitudinal to a transversal planting concept initiated accurate adjustments of the nutrient solution (Ca, K, NO_3), and of the artificial lighting gradient to the development of the leafy crop. Coupled to this was also the selling of the plant together with its substrate so that the consumer became psychologically involved with the production process. Within the framework of the integrated ecological production system the physical disinfection techniques close the circle. Meanwhile the possibilities and the limitations of methods such as Slow Sand Filtration, Low Pressure UVc and others are being intensely examined today.

1140–1200
S16–O–59
YIELD OF GREENHOUSE TOMATO IN RESPONSE TO SUPPLEMENTAL NITROGEN AND POTASSIUM

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Tomato plants were grown in rock-wool medium supplied with nutrient solutions that differed in concentrations of nitrogen (N) and potassium (K). Yields were compared for plants grown with sufficient N and K, or with N and/or K supplements that increased the concentrations in nutrient solution by about 30% during fruit production. Twelve cultivars were grown in each year and harvested over a 3-month period. In 1999, supplemental N in the form of NH_4NO_3 decreased yield and fruit size uniformly across all cultivars. In 2000, supplemental N in the form of $Mg(NO_3)_2$ increased yield of some cultivars, but decreased yield of others. This was not necessarily related to changes in fruit size. When NH_4NO_3 and Mg(NO3)2 supplements were compared directly in 2001 without supplemental K, they had no significant effect on yield or fruit size. Analysis over years showed supplemental K alone increased fruit size of some cultivars but decreased that of others, and decreased the fraction of green shoulder of some, but not all, cultivars that lacked the uniform ripening gene. In 1999, K increased fruit size in the absence of supplemental N, but decreased it when combined with NH_4NO_3. In 2000, supplemental K alone increased the fraction of fruit with cracked skin, but in combination with $Mg(NO_3)_2$, it decreased this fraction. Thus, the responses of greenhouse tomato to supplemental N or K depend on the concentrations of other elements in the nutrient solution and differ among cultivars.

1200–1220
S16–O–60
HOW TO REDUCE YIELD FLUCTUATIONS IN SWEET PEPPER

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Flushing, i.e., cyclic fluctuations in fruit yield, is an important problem in greenhouse sweet pepper production. We observed that these fluctuations can be explained by cyclic fluctuations in fruit set. Therefore, the relation between fruit set and plant sink and source strength was investigated in several greenhouse experiments. A decrease in plant source strength by decreasing inter-plant distance, light intensity or leaf removal led to a decrease in fruit set. For example, the average fraction of fruit that set was 32, 20 and 16% at a within-row plant distance of 0.80, 0.40 and 0.27 m, respectively. Plant sink strength was varied by the number and position of competing fruits on the plant. Fruit set decreased with increased plant sink strength, e.g. in plants with 0, 1, 2 or 4 early formed fruits, fruit set of four later formed fruits was 78, 56, 28 and 6%, respectively. Average

rate of fruit set could be reasonably predicted from the plant source and sink strength. An increase in seed number, resulting from higher pollen load on the stigma of flowers, increased the inhibitory effect of a fruit on set and growth of later developing fruits. Variation in fruit set and yield was strongly reduced in plants with parthenocarpic fruit growth, obtained by preventing self-pollination and applying a lanoline-auxin paste on the stigma of all flowers on a plant. Hence, developing seeds in sweet pepper fruits are an important cause of the abortion of new flowers, and irregular fruit set and yield. Removal of some young fruits in periods of abundant fruit set did reduce the cyclic fluctuations in fruit set and yield, but less than expected. When planting in late spring, as opposed to a winter planting, yield fluctuations at farm level could be substantially reduced by adopting two planting dates with four weeks in between. For a winter planting, fluctuations at farm level could be reduced by removal of all flowers on half of the plants during a few weeks in late spring.

1220–1240
S16–0–61
REGULATION OF GROWTH BY PHOSPHORUS AND NITROGEN SUPPLY IN TOMATO PLANTS

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Modern nutrient management in glasshouse cultivation implies no losses of nutrients to the environment, while crop growth and quality is controlled in order to meet market demands. The supply of each nutrient must be in proportion to the demand of the crop. For this, knowledge of the regulation of growth by nutrients is essential. We carried out detailed experiments with varying phosphorus and nitrogen supply rates to unravel the regulation of growth of tomato plants by these nutrients. The shape of the response of growth to P or N limitation was quite different for these two nutrients. At severe P limitation extra P was used for extra growth rather than for increasing plant P concentration. This resulted in a sharp increase in growth with plant P concentration at low plant P concentrations and a levelling off at higher plant P concentrations. This in contrast to the response of growth to N limitation, which was gradual. The effects of P and N limitation can be divided into two parts; mild and severe limitation. Mild P and N limitation mainly affected the morphological component of growth, which is leaf area development. At severe P and N limitation the physiological component of growth, which is photosynthesis and respiration, became the most important factor in determining growth. Dry matter partitioning to the roots was linearly related to plant N concentration in the N experiment as well as the P experiment. Only the plants grown at severe P limitation deviated from this linear relationship. This suggests an important role for plant N concentration in regulating dry matter partitioning, also at mild limiting P supply. CO_2 fixation measurements at 2 and 21% O_2 showed that sink limitation increased with decreasing N supply, but decreased with decreasing P supply. This will be discussed in relation to starch accumulation in the leaves.

1340–1440
S16–P–62
EFFECTS OF ELECTRICAL CONDUCTIVITY AND MINERAL NUTRITION ON FRUIT RADIAL CRACKING, RUSSETING AND FIRMNESS OF GREENHOUSE TOMATOES

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Effects of electrical conductivity and Ca and Mg nutrition on tomato fruit radial cracking, russeting (fine hair-like cuticle cracks) and firmness were investigated in a greenhouse in a summer and a fall tomato experiment. Fruit firmness was evaluated by a constant area compression test on specimens of the pericarp, and by a puncture test. Four EC treatments: constant low (2.54 $mS{\cdot}cm^{-1}$), variable low (1 to 5 $mS{\cdot}cm^{-1}$; 24-h mean: 2.54 $mS{\cdot}cm^{-1}$), constant high (3.82 $mS{\cdot}cm^{-1}$) and variable high (1 to 7 $mS{\cdot}cm^{-1}$; 24-h mean: 3.82 $mS{\cdot}cm^{-1}$) were applied in the summer experiment. For variable EC treatments, the plants were supplied with a low EC solution in the morning & noon and high EC solution in the afternoon & night. In the fall experiment, the plants were fertigated with 8 different nutrient solutions consisting of a factorial combination of 2 levels of calcium (150 and 300 ppm) and 4 levels of magnesium (20, 50, 80, and 110 ppm). High levels of Mg increased fruit firmness and had no effects on radial cracking. Fruit russeting peaked at around 50 ppm of Mg. High EC, whether constant or variable, increased fruit firmness, reduced radial cracking and russeting. Similar to high EC, high Ca reduced radial cracking and russeting; however, it also reduced fruit firmness. Thus, the mechanism for reducing fruit radial cracking and russeting by high EC and Ca might be different. High Ca might increase tissue elasticity while high EC will likely increase tissue compactness by reducing fruit water import.

1340–1440
S16–P–63
DEVELOPING WATER AND NUTRIENT MANAGEMENT PLANS FOR CONTAINER NURSERY AND GREENHOUSE PRODUCTION SYSTEMS

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Nutrient management regulations are a reality, or on the horizon for agricultural operations in the United States and Canada. In 1998, the state of Maryland adopted one of the toughest nutrient management planning laws in the US, requiring that virtually all agricultural operations write and implement nitrogen- (N) and phosphorus- (P) based management plans by December 31, 2002. The federal Environmental Protection Agency (EPA) may soon enforce provisions of the Clean Water Act of 1972, to ensure that states implement section 303(d) regulations and identify non-point (diffuse) sources of nutrient loading to the nations' rivers and streams. Writing water and nutrient management plans for most ornamental nursery and greenhouse operations is a complicated task, since these operations grow a large number of plant species, and utilize a range of fertilization and irrigation strategies. We have developed a planning process that combines water management (i.e., leaching fraction, interception efficiency and potential runoff) data with nutrient management (source and application rate) data, to provide an estimate of total daily maximum loading rates. A risk assessment process of site-specific plant production and management processes identifies those operational factors that contribute most to nutrient leaching and runoff. This risk assessment matrix enables targeted best management practices (BMPs) to be identified for that unique growing operation, to reduce the risk of N and P run-off into local surface and groundwater resources. Knowledge of the efficiency of irrigation water and nutrient practices is important, since it not only allows for a proactive environmental assessment of management practices, but it also can allow for cost savings in water and fertilizer inputs. This information allows the grower to implement BMPs, evaluate changes in production efficiency and reduce nutrient leaching and runoff, without sacrificing plant quality or production time.

1340–1440
S16–P–64
CONTROL OF NUTRIENT MINERALS IN PLANT FACTORY FOR LETTUCE

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To achieve optimum nutrient level in recirculating nutrient solution, the supply of nutrients should be more or less equal to the absorption of nutrients by the plants. This study was conducted to determine nutrient management system for butterhead lettuce 'Omega' and leaf lettuce 'Grand Rapids' in relation to nutrient control methods. Four nutrient control systems were experimented: management by distilled water addition (DW), management by pH and EC measurement (CM), management by nutrient solution analysis (MN), management by nutrient solution and leaf analysis (ML). In MN and ML control, the nutrient solution were analyzed every two days and then were adjusted to the same concentration as the initial nutrient solution. Differences between the calculated and observed EC value in the CM were observed, because of accumulation of organic acids, Na, Cl_2 and SO_4 in nutrient solution. High pH influenced CM nutrient solution, low nitrate concentration was observed. In CM control, NO_3-N and K in nutrient solution were maintained without accumulation, while Ca and Mg were beyond the optimum level. There was no accumulation of cation in MN and ML control. Mineral nutrients of ML control were maintained

at optimum level in the butterhead lettuce. In MN control of 'Omega' and 'Grand Rapids', CO_2 assimilation, transpiration rate, and chlorophyll contents were highest. The highest relative growth rate (RGR) was in MN, ML in the butterhead 'Omega' and was not observed for leaf lettuce 'Grand Rapids'.

1340–1440
S16–P–65
EFFECTS OF ENVIRONMENT FACTORS ON THE GROWTH AND INCIDENCE OF BLOSSOM-END ROT IN SOILLESS SWEET PEPPER

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Blossom-end rot (BER), a physical disorder common in tomato and pepper fruits, is related to poor calcium translocation in the fruits. To investigate the effects of air humidity, slab cooling and slab moisture on the incidence of BER in soilless sweet pepper, a series of experiments have been carried out within three years. The comprehensive treatments included air humidity enrichment to 60%, slab cooling to 17 C or not, slab moisture controlled by timer or set at 50% and 60%, compared with the same slab treatments in a humidity control environment. The results showed that air humidity enrichment buffered the acute change of the air relative humidity and the air temperature in the greenhouse, especially during a hot day. The number of vascular bundles in the fruit parts was significantly increased under the humid conditions, and a much higher increase was found in the distal part of the fruit than that in the basal part, with 14.6% and 11.4% increase related to the control plants respectively. The Ca levels were significantly higher in the fruits developed under the humidity conditions, with 19.9% more in the basal part and 16.6% more in the distal part than that in the control. However, the K content was quite stable both in the fruits and in the leaves. Slab cooling resulted in higher oxygen content in the root environment, which improved root activity and merited element absorption. It was clear that air humidity enrichment, slab cooling as well as slab moisture 50% significantly lowered the incidence of BER. And there was cumulative effect of air humidity enrichment, slab cooling and slab moisture on the occurrence of BER in soilless sweet pepper. But no explicitly significant differences of the harvested fruit number and the yield were observed among the different treatments throughout the growing season.

1340–1440
S16–P–66
USE OF COLOR MULCH FOR VEGETABLE CROP PRODUCTION

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In 1985, M.J. Kasperbauer and P.G. Hunt (USDA-ARS) conducted a tomato production trial with plastic mulch in cooperation with Dennis R. Decoteau from Clemson Univ.. They painted black polyethylene mulch red, yellow, blue, orange and green with latex paint. Tomatoes grown on red mulch produced a 20% increase in number-one fruit compared to black mulch. The change in tomato and vegetable crop yield in response to the different mulch colors is due in part to an increase in soil temperature and the range of reflected wavelengths produced by individual mulch colors. Different colors will absorb and reflect different wavelengths of light and plants are very sensitive to the color of light their leaves intercept from the sun and reflected surfaces. Red and far-red light (between 600 and 800 nanometers) produce the largest growth responses in plants. Light that has a lower far-red to red (FR/R) ratio will cause a plant to develop shorter stems and larger roots. A higher FR/R ratio will cause a plant to direct more new growth into shoots, resulting in a taller plant with more leaves. Different mulch colors reflect different wavelengths and thus different FR/R ratios. There are differences in color retention and film appearence of the different colored plastic mulches currently on the market. This difference in film characteristics can affect plant responses. Over the last 8 years, we have evaluated tomato, pepper, muskmelon, summer squash, eggplant and potato on several different mulch colors including; black (standard), white, clear, blue, red, silver, thermic green and thermic brown. In general, crop response to colored mulch results from changes in soil temperature and reflected light intercepted in the plant canopy.

1340–1440
S16–P–67
RESPONSE OF GREENHOUSE MELON AND TOMATO CROPS TO WASTEWATER FERTIRRIGATION

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The increasingly water demand and the lack of natural resources in arid and semiarid areas justify the present interest in the reuse of wastewater. Since 1995 purified and ozone- treated wastewater from Almeria (Spain) has been used to irrigate greenhouse crops. The higher nutrient content levels of this effluent requires special management strategies. In this paper, the effects of wastewater fertirrigation on the N, P, K content in soil and plants were studied on melon and tomato crops. Melon cv. Galia in a spring cycle (124 days) and tomato cv. Daniela in an autumn-winter cycle (185 days) were grown under greenhouse conditions. The experiment was arranged in a randomized complete-block design with two treatments and four replications. The different treatments were: irrigation with fresh water and with purified wastewater. Purified wastewater was obtained from the Almería Purifying Plant after an ozone tertiary treatment; fresh water was obtained from the underground and desalinized. To prepare the nutrient solution, the chemical composition of each type of water was considered and N and K were added accordingly in order to obtain a similar nutrient solution. Effluents provided significant amounts of N, P and K, this had positive effects on the addition of fertilizer salts since the application of nutrients was reduced. As no significant differences were found among treatments on the tested production parameters in both crops, the nutrient use efficiency was higher in the wastewater treatment. Foliar concentration of N, P and K were similar in both treatments and crops.

1340–1440
S16–P–68
RELATIONSHIP BETWEEN TISSUE NITROGEN AND PHOSPHORUS CONCENTRATIONS OF IMPATIENS AND WESTERN FLOWER THRIPS POPULATION GROWTH AND DAMAGE

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Host plant nutritional status may affect the incidence, development, and severity of western flower thrips [WFT; *Frankliniella occidentalis* (Pergande)] populations. Two greenhouse experiments were conducted to determine the responses of WFT on *Impatiens wallerana* Hook. when fertilized across a commercially-practiced range of N and P concentrations. Impatiens 'Dazzler Violet' were grown for 8 weeks with nutrient treatment combinations of 2 N rates (8 and 20 mM) by 2 P rates (0.32 and 1.28 mM). Each plant was grown in a separate thrips-proof cage and was infested at week 4 with 10 adult female WFT, and plants were destructively sampled weekly during weeks 5 through 8. Plant size and fresh weight were the same across nutrient treatments at each sampling time, but dry weights and N and P tissue contents were different. Applying 1.28 mM P resulted in more flowers (32 vs. 24 flowers/plant) and higher dry weight (4.4 vs. 3.5 g/plant) compared to plants grown with 0.32 mM P at week 8. Interaction between N and P fertilization rates was significant, though N concentration alone did not result in differences in plant growth. N and P tissue concentrations were significantly different across treatments: 8 and 20 mM N resulted in 4.74 and 6.15% N in tissue, respectively; 0.32 and 1.28 mM P resulted in 0.27 and 0.67% P in tissue, respectively. The majority of WFT nymphs, 66.4%, were found feeding inside the nectariferous spur under the flower. As tissue P concentration increased, thrips counts tended to be higher, but differences were not statistically different. N treatments were not correlated with WFT population growth, but plants infested with WFT had significantly lower tissue N than uninfested control plants.

1340–1440
S16–P–69
EFFECTS OF NUTRIENT SOLUTION ON GROWTH AND FRUIT QUALITY OF TOMATOES GROWN IN COIR MEDIUM USING CAPILLARY POTENTIAL AS AN INDICATOR OF MOISTURE LEVEL

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Our earlier experiment showed that tomatoes grown hydroponically in coir (brief discription required for the medium) medium using moisture sensor to control the capillary potential of the medium at the specific level, such as –1.5 kPa and also applying small amount of nutrient solution @ 70 mL/plant each time, seemed to be extremely water-stressed and produced fruits with high soluble solids content, although the yield was lower as reported generally. However, in order to achieve constant production of such fruits, it is necessary to give salinity stress by applying higher concentration of nutrient solution. Therefore, four treatments were consisted of combinations of nutrient solution concentrations (1, 2 and 4 units) and stages at which the nutrient solution was applied (beginning from the 3rd, 4th and 5th flowering stages) to clarify the effects on growth and fruit quality of tomatoes grown in coir medium using capillary potential as an indicator of moisture level. A composition of one unit nutrient solution was that NO_3-N, H_2PO_4-, K^+, Ca^{2+}, Mg^{2+} and NH_4-N^+ were 5.2, 4.0, 3.1, 5.5 and 0.2 mmol·L^{-1}, and EC was 1.1 dS·m^{-1}. Tomato seedlings with 7 to 8 leaves were transplanted in coir fiber medium on April 14, 2000 and the experiment was terminated on July 18. Capillary potential was mostly maintained around –1.0 to –1.5 kPa during the experiment. It was concluded that fruits with higher soluble solids content were able to be produced by a combination of higher unit of nutrient solution and the present growing system. However, because of higher percentage of the incidence of blossom end rotted fruit and reduction of marketable yield, further investigations are needed to clarify relationship between the incidence of fruit and composition of nutrient solution.

1340–1440

S16–P–70

EVALUATION OF THE STICS MODEL FOR PREDICTING YIELD AND WATER BALANCE OF A TOMATO CROP IN TALCA (VIITH REGION OF CHILE)

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STICS (Simulateur mulTIdiscplinaire pour les Cultures Standard) is a generic simulation platform for crops. It is made of modules that describe the development, shoot growth, yield components, root growth and thermal environment of different crop species, and the balances of water and nitrogen in the crop-soil system. Its inputs are climate, soil and cropping system data. The objective of the present research was to evaluate STICS for predicting yield and water balance of a tomato crop in Talca (VIIth Region of Chile). For this purpose, a new component of the model simulating vegetative and reproductive development in indeterminate species was tested. The study was carried out on a tomato crop (*Lycopersicon esculentum* Mill.) produced under greenhouse at the Panguilemo Experimental Station (Talca, VIIth Region of Chile), between September and December 2000. Several irrigation policies led to different levels of water stress. The test of the model focused on the effects of the water stress index on leaf area expansion and fruit setting. The indeterminate development of greenhouse tomato cultivars was properly simulated. A good agreement was found between observed and estimated values of yield and components of the water balance. The estimation of the time course of leaf area index had to be improved by a new parameterization of the effect of water stress

1340–1440

S16–P–71

EFFECTS OF QUANTITATIVE REGULATION OF POTASSIUM CONCENTRATION IN THE MEDIUM SOLUTION OF NFT ON THE FRUIT PRODUCTION OF TOMATO PLANTS

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Potassium is an essential element absorbed excessively by plants grown with a nutrient solution of high concentration of potassium. In the method of regulation by which concentration of potassium ions in nutrient solution are maintained at higher levels, unabsorbed ions are drained into environment, causing water pollution in hydrosphere including both above- and under-ground water. Thus, it becomes of importance to reveal the amount of nutrients required to produce commercially valuable fruits and the best timing of application during fruit production. We studied these subjects in the two-truss culture of tomatoes using the circulating system of nutrient solution of NFT. Potassium absorption, growth of plants and fruits, fruit quality, and content of macro-elements in plant organs were examined in the tomatoes (*Lycopersicon esculentum* cv. Saturn) grown in NFT using nutrient solutions containing different concentrations of potassium during the period of fruit growth. Fruit growth correlated linearly with the fruit potassium content and fruit yield increased with increasing absorption of potassium by the plants up to 2000 mg/plant. In plants which absorbed much more potassium than 2000 mg/plant, however, increase in fruit growth was not observed. The amount of potassium less than the excessive absorption levels can be supplied efficiently during the period of fruit growth. The influence of the amount and frequency of potassium supply during the different period of fruit growth on fruit production were examined in the tomatoes grown using the nutrient solution containing the same total amount of potassium. From the results of the analysis of growth, yield, quality, and mineral content of the plants, it became evident that equal amount of potassium can be supplied during the period of fruit growth and a smaller fluctuation in potassium concentration in the nutrient solution would be required to produce tomato fruits of higher quality.

1340–1440

S16–P–72

TOMATO TRANSPLANTS GROWTH INFLUENCED BY THE TEMPERATURE OF HYDROPONIC NUTRIENT SOLUTION AND INTERNAL CARBOHYDRATE CONTENTS

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To avoid transplanting injury, hydroponic tomato seedlings were grown at different temperatures of the nutrient solution. The seedlings were grown at high (HT, 25–30 °C) and low solution temperature (LT, 10–20 °C) and transplanted in two systems in which nutrient solution temperature was controlled in HT and LT. The seedlings grown in LT before transplanting indicated lower plant growth but higher root activity. Generally when the seedlings were transplanted to HT, root activity decreased rapidly and plant growth was retarded. However, seedlings grown at LT kept higher root activity and growth rate than the ones grown at HT before transplanting. Among the seedlings transplanted into LT, root activity didn't decline in any seedlings and seedlings grown at 25 °C indicated the highest growth after transplanting. Carbohydrate contents in leaves and roots were determined when plants were grown at different solution temperatures. Reducing sugar content was higher at LT and starch content was higher at HT. Starch content declined immediately after transplanting into HT. However, there was less decrease of starch in LT grown seedlings transplanted into HT. When the seedlings were transplanted into LT, starch content after transplanting declined a little in roots and kept constant in leaves. Generally, growth after transplanting decreased when the solution temperature before or after transplanting was higher. Lower solution temperature before and after transplanting reduced transplanting injury and kept vigorous plant growth, which could be explained by higher root activity and suppression of carbohydrate consumption under lower solution temperature.

1340–1440

S16–P–73

EFFECT OF DIFFERENT WATER TREATMENTS ON PHOTOSYNTHESIS CHARACTERISTICS AND LEAVES ULTRASTRUCTURE OF CUCUMBER GROWING IN SOLAR GREENHOUSE

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The photosynthesis rate and stomata resistance of cucumber (*Cucumis sativus* L.)were measured and the ultrastructure of stomata and chloroplasts were observed to study the effects of different soil water moisture on the growth

of cucumber growing in solar greenhouse during different culture seasons .The stomata density and stomata resistance prominently enhanced with the soil moisture decreased, but it was adverse with net photosynthesis rate; The number of chloroplast per cell and number of amyloid per chloroplast were lower when the soil water moisture is lower, at the same time, the grana lamella was thinner and disintegrated, the thylakiod was swollen, and the chloroplast was deformed. Compared with the winter–spring season, those results remained unaltered during the autumn–winter season.

1340–1440

S16–P–74

PREDICTING AND MEASURING TRANSPIRATION BASED ON PHYTOMONITORING OF TOMATO IN GREENHOUSE

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The objective of this study was to develop a model for accurate supply water in greenhouse tomato and to carry out experimental verification. The developed transpiration model is calculated on the basis of greenhouse climate data (solar radiation, air temperature, relative humidity, vapor pressure deficit and phytomonitoring (sap flow, leaf temperature). Stomatal resistance of tomato leaves is significantly correlated to solar radiation. A simple exponential equation could be used to describe the relation between stomatal resistance and solar radiation as followed; $Y = 1039.25 – 4.34X + 0.0058X^2$ (Y: stomatal resistance s/m, X: solar radiation W/m^2). Leaf boundary layer resistance was to assumed as a water temperature of evaporimeter and was parameterized by air temperature as followed; $Y = 8.548 – 1.44X + 0.0557X^2$ (Y: Leaf boundary layer resistance s/m, X: air temperature. The equation for stomatal resistance could explain more than 85% of solar radiation variation and the equation for leaf boundary layer resistance could explain more than 50% of air temperature variation. The calculated transpiration quantity showed good agreements with measured sap flow values in situations independent of which the continuances of the equation were estimated ($R^2 = 0.51^{**}$, $R^2 = 0.79^{**}$, $R^2 = 0.89^{**}$). The present transpiration model was to predict transpiration with considerable accuracy in variable greenhouse climates.

1340–1440

S16–P–75

ACCUMULATION OF PHYTOTOXIC ORGANIC ACIDS IN REUSED NUTRIENT SOLUTION DURING HYDROPONIC CULTURE OF LETTUCE (*LACTUCA SATIVA* L.)

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Lettuce (*Lactuca sativa* L.) was hydroponically grown in nutrient solution. The nutrient solution was reused up to 3 times and designated as 1RNS, 2RNS, and 3RNS, respectively, depending on the reuse times. Organic acids were quantified from the reused nutrient solutions and the root residues by GC/MS following the extraction with diethyl ether. With increasing the reuse time, more organic acids were detected in the nutrient solution and their concentrations were increased. Benzoic, phenylacetic, cinnamic, lauric, phthalic, palmitic, and stearic acids were identified from 3RNS, whereas benzoic, lauric, phthalic, palmitic, and stearic acids were detected from the root residues. To remove the organic acids, activated charcoal (AC) at a concentration of 2.5 g·L^{-1} was added in the 3RNS. In the treated AC in 3RNS following the lettuce growth for 30 days, benzoic, phenylacetic, cinnamic, p-hydroxybenzoic, lauric, phthalic, vanillic, palmitic, and stearic acids were identified, but little or no organic acids were detected in the 3RNS treated with the AC. The organic acids identified from the treated AC in 3RNS were individually added into freshly prepared nutrient solution. The organic acids ranging from 25 to 200 μM inhibited the lettuce growth in a concentration-dependent manner. For preparing the nutrient solution simulating the 3RNS, the individual organic acids each with the same concentrations as in 3RNS were all added into freshly prepared nutrient solution. The lettuce growth was also greatly reduced in the nutrient solution containing the mixture of the organic acids. The growth reduction pattern was similar to that in 3RNS. When AC at a concentration of 2.5 g·L^{-1} was added into the nutrient solution containing the mixture of the organic acids, however, the lettuce growth was not inhibited. Our results demonstrated that organic acids were accumulated in reused nutrient solution and found to be phytotoxic to lettuce growth. However, eliminating the organic acids with AC could reduce the phytotoxic effect.

1340–1440

S16–P–76

RELATIONSHIP BETWEEN CELL SIZE AND SUCROSE ACCUMULATION IN 4-CPA TREATED FRUITS

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Melon fruits (*Cucumis melo* L.) were treated with 4-chloro-phenoxy acetic acid (4-CPA) to verify the relationship between cell size and sucrose accumulation in the fruit. Rectangular parallelepipeds of 7mm removed serially beginning at one side and ending at the opposite side of the maximum transverse diameter from fruits were examined to determine of the number and the size of cells,and the juice was obtained from the each block for measuring sucrose content. Total number of cells larger than 200 micron of the control 40 DAA, 109 increased to 210 55 DAA, whereas the number of CPA fruits was already much more than 160 40 DAA, and it reached about 200 55 DAA. Average number of cells larger than 200 micron in each block of the control 40 DAA, 12 increased to 23 55 DAA. The number of cells in each block of CPA fruits 40 DAA was already around 20 which was almost the same as the number of the control 55 DAA. Sucrose content of 24390 mg·L^{-1} in the control 40 DAA reached 48850 mg·L^{-1} 55 DAA. The content of CPA fruits 40 and 55 DAA was 10000 mg·L^{-1} and 30000 mg·L^{-1}, higher than that of the control, respectively. From these results, it is reasonable to consider that a striking high sucrose content of CPA fruits is provoked by early accumulation of sucrose due to early enlargement of fruit cells caused by 4-CPA.

1340–1440

S16–P–77

EFFECT OF GRANULAR SILICATE APPLICATION ON THE QUALITY AND SHELF LIFE OF TOMATO GROWN BY PERLITE CULTURE

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This research was conducted to evaluate the effects of four different amounts of granular silicate (0, 1, 2, and 4 tons·ha^{-1} of granular silicate) on the quality and shelf life of tomato grown in perlite media, which is the most commonly used for hydroponics of fruit vegetables in Korea. The soluble solid contents of tomato increased with increasing amounts of granular silicate application. However, titratable acidity of the fruits was not affected by the amounts of different granular silicate application. Glucose contents of fruits at 41 days and 48 days after anthesis were relatively higher in 2 and 4 tons·ha^{-1} treatments than in control. Fructose content also showed the same tendency as glucose. The change of fruit color from pink-red to red stage was accelerated 25% more in 2 and 4 tons ha-1 treatments than in control. Lycopene content of fruits was 2.74 times higher in 4 tons·ha^{-1} treatment than in control. The fruits with more soluble silicon had the higher lycopene content. Shelf life of harvested fruits was 4 days in room temperature. Evolved CO_2 was highest in the first day after harvest. C_2H_4 was evolved in two days after harvest. Among granular silicate treatments, the fruits cultivated in 4 tons·ha^{-1} treatment showed the lowest CO_2 evolution and the highest firmness.

1340–1440

S16–P–78

INFLUENCE OF ROOTSTOCK AND SOIL TREATMENT ON THE YIELD AND QUALITY OF GREENHOUSE-GROWN SPANISH CUCUMBERS

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Grafting is one of the most promising techniques used for the substitution of methyl bromide. If it is compared with the others, such as soilless culture, it is an environmentally friendly technique. Even though the grafted plant is at present expensive, the price will likely go down when its use becomes generalised and nurseries produce millions of plants. The most cultivated cv. in the central area of Spain is Serena, which is not resistant to nematodes and

with greater possibilities of having problems in a soil when this crop is grown successively. At present, the growers disinfect soil with methyl bromide, but this causes considerable damages to the environment and it will be forbidden after 2005. For this reason, it is necessary to test other more reliable possibilities. The aim of the study was to evaluate if is possible to use plants grafted on Shintoza (*Cucurbita maxima* x *Cucurbita moschata*), or Camel (*Cucurbita maxima* x *Cucurbita moschata*), rootstocks tolerant to nematodes, or if is necessary to take a complementary desinfection with Fenamifos. The best result was obtained with the combination of both techniques, plants grated on soil treated yielded 85% more than plants non grafted on non treated soils. The use of Fenamifos only, can increase the yield 65%. No differences were found betwen rootstocks, both increased yield near 55% in soil without desinfection and near 10% in soils with desinfection as compared with non-grafted plants in both cases. Differences in the quality parameters were not observed, the use of rootstocks should not create any problems as far as quality is concerned.

1340–1440

S16–P–79

ESTIMATION AND CALCULATION OF THE CONTRIBUTION MARGIN OF GREENHOUSE GROWN CUCUMBERS IN AUSTRIA

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Austrian greenhouse vegetable production is characterized by a high input of energy, high distribution and employment costs and high purchase prices for young plants. In the last few years, the costs of energy units and employment increased, which is shown distinctly in this paper. This increase of costs led to unprofitable production of vegetables in the greenhouse. The deficiency of a conception for the calculation of the contribution margin for cucumber and other vegetables led to perplexity of the decision makers. Another impulse for this work was the changes in the management of horticultural companies. Time management has gained more attention in all levels of horticultural structure and undoubtedly steps to start and accelerate the changes in this area have to be made quickly. To gain clearness about the position, meaning and the increase of the efficiency of horticultural production (especially vegetable production) in the national economy, it is indispensable to collect data about vegetable production in greenhouses in Austria. Ecological beneficial production, efficient use of energy and new technologies (e.g., CO_2-fertilizing) lead to an increase of the costs of vegetable production in the greenhouse (e.g., purchase and preservation costs for the new system). A higher productivity per m^2 should cover for extra financial expenditure. During the last five years an enormous increase of raw material prices and selling-prices has taken place. As the purchasing power of the consumers is limited, the interest in cheaper products of other countries grew. Therefore, it is an important goal for Austrian vegetable producers to decrease production costs to enable them to sell their products at competitive prices.

1340–1440

S16–P–80

EFFECT OF PHOTOSELECTIVE PLASTICS ON THE QUALITY OF LETTUCE

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The aim of the experiments was to assess the effect of far-red filter on the quality of lettuce plants. Half of the experiments with lettuce were carried out in the springtime on the field of my summerhouse near Visusti in 2000 and 2001. Plants were grown on the open land with and without far-red filter. Half of the experiments with lettuce were carried out in the greenhouses of Univ. of Tartu, Institute of Plant Physiology, in 2000 and 2001. The colour of plants grown under far-red filter was beautiful light green compared to plants grown in control, which were yellowish, darker green. Under far-red filter grown plants tasted less bitter compared to plants in control. Scattered radiation penetrated deeper inside of lettuce than direct beam. Therefore spectral filter affected also leaf orientation. Lettuce leaf position became more upright in control plants compared to plants grown under a far-red absorbing film. The incidence of tipburned leaves decreased under far-red filter. The yield was not significantly different. Calcium content was significantly higher under far-red filter. Plants grown under far-red filter contained less dry matter and chlorophyll.

1340–1440

S16–P–81

STUDY OF GROWING PATTERN FOR HIGH EFFICIENT UTILIZATION IN A GREENHOUSE

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This paper deals with growing pattern in a greenhouse with the utilizations for high efficiency. Soiless cultivation patterns with leaf vegetable, fruit vegetable, sprout or/and mushroom, and ornamental plant or flowers was designed. Leaf vegetable was cultivated on a bench bed (about 48% of total area), mushroom (40%) or sprout vegetables (45%) were grown under the bench bed. And one side of the bench bed was fruit vegetables (about 30%) and another side was ornamental plants (12%). In this way greenhouse utilization rate was up to 130% with leaf area index 2.3. Fungus cultivation ensured the high concentration of CO2 up to 650–780 ppm that is useful for vegetable photosynthesis. Plant growing was very fast and it yielded to 60kg/m^2 and 45$/$m^2$. This pattern is suitable for China's situation with more people and less farmland, and cheaper labors. This is also a good way for increasing land and fund production efficiency.

1440–1500

S16–O–82

PRELIMINARY ASSESSMENT OF SWINE WASTE BIOREMEDIATION USING GREENHOUSE TOMATOES

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Lagoon effluent, from a 4000 sow farrow-to-wean facilty with an ambient temperature anaerobic digester (ATAnD) and a traditional anaerobic storage lagoon in series, was used in this experiment. Two seedlings of *Lycopersicon esculentum* Mill. cv.'Trust' were planted in Bato® buckets filled with either 1:1 peat/pine bark or 9:1 pine bark/sand mixtures. Within these substrate treatments, plants were randomly assigned to one of four fertilizer treatments: 1.) modified Steiner Solution (conventional control) 2.) untreated lagoon effluent from the secondary lagoon 3.) lagoon effluent after nitrification (conversion of NH_4 to NO_3) in a trickling biofilter 4.) biofilter-treated effluent with additional $CaNO_3$ and $MgSO_4$ supplements to raise Ca and Mg levels to those in the conventional treatment. For both substrates, electrical conductivity (EC) and pH in the rootzone, measured by the pour-through method, were significantly higher in the lagoon-based treatments (2–4), than the conventional control. Compared to the untreated lagoon effluent (2), biofilter treatments (3,4) had reduced blossom-end rot (BER) incidence and higher average fruit weights and total yields, but total yields and fruit size for the biofilter treatments were lower than in conventionally fertilized plants, and BER incidence was higher. Fruit quality, as measured by Brix reading, was higher (up to Brix of 10) in the effluent treatments (2–4) compared to the conventionally fertilized plants (average Brix of 5). Further research is needed to determine if total yields and fruit weight can be increased and BER decreased in the biofilter treatments by lowering EC and pH and further adjusting the nutrient supply. Research is also needed to determine if the higher fruit quality associated with the effluent treatments can be maintained at the same time that yields and fruit size are increased.

1500–1520

S16–O–83

INTEGRATING CULTURAL MANAGEMENT PRACTICES AND BIOLOGICAL CONTROL TO SUPPRESS INSECT PESTS OF ORNAMENTAL PLANTS

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Studies were conducted to determine the efficacy of *Cryptolaemus montrouzieri*, the mealybug destroyer, in suppressing populations of *Planococcus citri*, the citrus mealybug, on *Heuchera micrantha* 'Palace Purple' growing in protected culture. In addition, the influence of water and nutrient management practices on mealybug populations and the efficacy of *C. montrouzieri* was evaluated. In intensive plant production systems, natural enemies are often absent or not abundant enough to suppress pest populations below damaging levels. When existing natural enemies are scarce, augmentative biological control can be a viable pest management option. It has also been documented that management practices and plant health can influence the performance of herbivores on their host plant, sometimes to the ad-

vantage of the herbivore. For example, hemlock wooly adelgid (*Adelges tsugae*)and elongate hemlock scale (*Fiorinia externa*) develop faster and are more fecund when feeding on hemlocks fertilized with nitrogen than on hemlocks not fertilized. Studies have determined that, in some cases, drought stressed plants are less able to defend themselves from boring insects. In this study, *Heuchera* plants were placed under various management regimes consisting of 6 treatments (2 water treatments: plants that were water stressed and not water stressed, and within each water regime 3 fertilizer treatments: low, moderate, and high levels of nitrogen fertilizer). Citrus mealybug was allowed to naturally infest *Heuchera* plants. Mealybug destroyers were purchased commercially and released (2 releases were made) onto the *Heuchera* plants. Mealybug populations were monitored prior to mealybug destroyer release, and 3 and 5 weeks post predator release on *Heuchera* receiving each of the 6 management treatments. The integration of two management tactics, cultural management practices and biological control, as a means toward more sustainable plant production are discussed.

1520–1540
S16–O–84
TYCLV-CONTROL WITH UV-BLOCKING PLASTIC COVERS IN COMMERCIAL PLASTIC HOUSES OF SOUTHERN SPAIN

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The yellow leaf curl (TYLC) disease of tomato is the main limiting factor for the production of tomato in the south of Spain. The causing agents of this disease are a complex of virus species of the genus *Begomovirus* (family Geminiviridae) that in nature are transmited by the whitefly Bemisia tabaci. Two species have been reported in Spain, Tomato yellow leaf curl virus (TYLCV) and Tomato yellow leaf curl Sardinia virus (TYLCSV). Control of TYLC in protected crops of southern Spain is difficult during the warm season because of the high disease pressure present under the low-technified plastic houses normally used. After more than 50 years of research, only TYLC-tolerant cultivars are commercially available that do not completely satisfy market demands in Spain. In addition, the low effectiveness of the insecticides used to control the insect vector to levels in which TYLC incidence is reduced, makes necessary the search for alternative strategies for the control of this disease. The use of photoselective plastic covers blocking ultraviolet light (UV) has been proposed as a good method for TYLC control owe to interference with *B. tabaci* vision that results in reductions of TYLC incidence superior to 50%. However no data are available about the effectiveness of this control strategy in the low technified plastic houses typical of southern Spain in which large lateral windows are completely opened most of the time. Several field trials were performed during the 1999/2000 and 2001/2002 agricultural seasons in commercial plastic houses of Málaga (southern Spain). In each trial, half of the plastic house was covered with standard UV-transparent film, and the other half with a UV-blocking plastic film developed by Repsol YPF. Our results show a clear reduction of the levels of *B. tabaci* population numbers as well as of the incidence of TYLC under the cover that filters UV light. This resulted in a significant yield increase of tomato crops under that cover.

1540–1600
S16–O–85
SUPPLEMENT OF SOIL MICROORGANISM MITIGATES AUTOTOXICITY OF CUCUMBER CULTURED IN HYDROPONICS

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We reported that the yield of cucumber decreased by the own root exudates accumulated in the nutrient solution during culture. Growth-inhibitors, some phenolic acids, were detected and identified in the exudates. It is known that soil microorganisms decompose phenolic substances. Therefore, it was investigated that the microorganisms reversed autotoxic inhibition and recovered the plant growth. Exp. 1. Supplement of 2,4-dichlorobenzoic acid (DCLBA). Cucumber (*Cucumis sativus* L. var. *Shogoin-aonaga-fushinari*) plants were planted into the plastic container containing 50 liters of nutrient solution with an EC of 2.0 dS/m. The nutrient solutions were prepared by adding DCLBA at concentration of 0, 2 and 10 μmol/liter. Each solution was supplemented with or without a soil microorganism which has been selected on the medium containing this phenolic acid. The nutrient solutions were renewed biweekly. Three plants were planted at each container with three repetitions. The growth and yield of cucumber were decreased by phenolic acid which was added to the nutrient solution. No decrease in fruit yield was observed in this solution supplemented with the microorganisms. Exp. 2. No supplement of DCLBA. During culture, the water level of containers was kept constant by regularly adding tap water. Nutrient concentrations were adjusted as close as possible to the initial concentration at two-week intervals. The soil microorganism was supplemented at the begging of the culture or at the anthesis. No DCLBA was added. The treatment of all renewal of the nutrient solution was set up as a control. The yield of cucumber was decreased by non-renewal of the nutrient solution. When the microorganisms were supplemented in the nutrient solution, the yield of cucumber recovered. It is suggested that microorganisms, if added to the nutrient solution, can catabolize autotoxic substances from cucumber root exudates and resulted in increasing yield.

1600–1620
S16–O–86
A DYNAMIC MODEL TO PREDICT THE GROWTH AND COMPOSITION OF N-STRESSED GREENHOUSE LETTUCE

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Experiments have consistently shown that lettuce plants which are deprived of nitrogen, tend to grow more slowly and that their composition is markedly different from that of normal plants. Under extreme N-stress conditions, nitrate content becomes negligible and reduced nitrogen and water content decrease significantly (dry matter content may increase from the normal 5% to 15% and more). In particular, reduced nitrogen and water tend to be proportional. The results for lettuce are consistent with findings for other young plants, where relative growth rate (RGR) and nitrogen content have been shown to be proportional to the relative addition rate of the limiting nutrient. The 'Nicolet' (nitrate in lettuce) model, designed to predict the growth and composition of lettuce in response to environmental conditions, has now been modified to cover growing conditions where nitrogen availability is severely restricted. The new model is still rather simple. It has three state variables, governed by the carbon balances of three virtual compartments: "structure," "vacuole" and "ecxess-C." N-to-C ratio in the "structure" compartment is fixed, while in the "vacuole" it is governed by the need to maintain turgor. There is no nitrogen in the "excess-C" compartment. Water content is assumed to be proportional to structural carbon. Photosynthesis, uptake of nutrients and respiration are formulated in a standard way and inhibition functions are used to control the essential processes. The predictions of the model for plants exposed to a constant environment, are in agreement with observations: (1) The initially isolated plants grow exponentially and when the canopy closes the RGR declines steadily. (2) The composition of the plants (carbon/nitrate/reduced nitrogen/water) remains constant with time. (3) RGR and N content are proportional to N supply. The model also predicts quite well the variation with time resulting from a sudden N interruption experiment.

1620–1640
S16–O–86–A
TO BE ANNOUNCED

1640–1700
S16–O–86–B
TO BE ANNOUNCED

Friday · August 16

0800–0900
S16–P–87
IRRIGATION ON PLANT DEMAND BY MEANS OF IRRIGATION MODELS, IN A CLOSED SYSTEM FOR *RHODODENDRON SIMSII*

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In order to optimize the irrigation of azalea plants and to minimize the loss of water, plant dependent models for irrigation were tested. Plants were cultivated in plastic pots on closed system with recycling of the drainage water. Estimation of the plant evapotranspiration is done by means of Penman-Monteith concept and derivates. The stomatal resistance and the amount of the transpiring surface needed for these models are estimated by the use of two submodels. Stomatal resistance was calculated by fitting a function of solar radiation intensity, vapour pressure deficit, and air temperature to porometer measurements of stomatal resistance. The submodel for the transpiring surface was based on the Gompetrz equation and used the indoor shortwave radiation as the only input parameter. There was a good allometric relationship between destructive measurements of leafsurface and crownsurface measured by vertical projection. When plants do not cover the groundsurface, evapotranspiration is estimated the best by the Penman-model because the evaporation rate is relatively high.When plants do cover the entire groundsurface, evapotranspiration is estimated very well by the Penman-Montheith model, but the Priestly-Tailor model also fits well. Simplification of the models is also discussed.

0800–0900

S16–P–88

ENERGY SAVING CLIMATE CONTROL REGIME FOR GREENHOUSE CUT CHRYSANTHEMUM

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In cut chrysanthemum, temperature integration control algorithms are difficult to apply without losses in plant quality and harvest scheduling. Furthermore, temperature integration is often undermined by rigid humidity control. Ventilation or heating or both are used to control humidity while temperature control alone would result in closed ventilation without heating. Our aim was to design a climate regime for cut chrysanthemum based on temperature integration supported by a humidity control concept. We aimed for maximum energy saving, and plant quality and yield comparable to a blueprint. We use temperature integration with an interval of up to six days. Past temperature is compensated during subsequent 24-hours with the aid of weather forecast and simulated greenhouse temperature. Maximum and minimum temperature and integration interval are adjusted specific to the crop developmental stage. Temperature boundaries calculated by temperature integration are bases for short-term temperature control (24-hour cycle). If calculated subsequent 24-hour mean temperature is in between maximum and minimum temperature for temperature integration temperature can freely fluctuate. Temperature dose-response functions for extreme high and low temperatures restrict the system. Maximum temperature is further controlled by a function of crop photosynthesis. An advanced process based humidity control regime supports the temperature control. Fungal plant diseases are taken into account by rules. Minimum and maximum transpiration integrals are applied against Ca deficiencies and leaf water-stress. Empirical functions are implemented for keeping quality and development rate. The regime was investigated in two complete cycles of autumn grown cut chrysanthemum. Four temperature integration margins (blueprint ±2, ±4, ±6, ±8 ^{0}C) and a blueprint where compared. High energy saving margins is possible with this regime. No decreases in yield, development or quality could be observed with a margin of up to ±6 ^{0}C allowed difference to the blueprint; ±8 ^{0}C resulted in developmental delay.

0800–0900

S16–P–89

TESTING BLUE HOLLY (*ILEX* x *MESERVEAE*) AS AN ALTERNATIVE CROP FOR PROTECTED CULTIVATION DURING THE SUMMER

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The background for this project is the problem of variation in profitability during the yearly greenhouse production in Sweden. After the season of flowering pot plants, ending in June, the lack of profitable cultures causes a "summer gap" for the growers leading to economic problems, especially for smaller greenhouse nurseries. *Ilex* x*meserveae* 'Blue Princess' (Blue Holly) is being tested as potential new pot plant for the Scandinavian Christmas market. Holly, with dark green shiny leaves and red berries, fits with its appearance the assortment of pot plants for Christmas. The hardiness of the plant makes it possible to grow the plants during summer in the greenhouse, harden them and store them outside until the selling season before Christmas. So far little is known about the influence of light and temperature on growth and development of *Ilex*. Moreover, the mechanisms of flower initiation are not known yet. In the ongoing study the influence of greenhouse climate on both vegetative and reproductive growth is investigated. The aim of the project is to provide a crop blueprint for the production of small pot plants of holly with ripened berries. Collected data will also be used to build a prediction model as a tool for the grower.

0800–0900

S16–P–90

WATER ABSORPTION PROPERTIES IN C-CHANNEL SUB-IRRIGATION SYSTEM BY WATER LEVELS AND WIDTH OF WICKS

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C-channel (Cs) is a kind of sub-irrigation system for pot plant production. It consists of C-like channels; pots with wicks are put in the channels. A small water tank attached near the channels controls water or nutrient solution levels in the channel, and a supplying tank of water or nutrient solutions. Water or nutrient solutions are supplied from their stock tank to channels through small tanks. Also the wick, attached into the bottom of pot and dipped in channel, plays an important role in supplying water and nutrient solutions form C-channel to pot. With this C-channel sub-irrigation system, this study was conducted to verify water absorption properties of media in pot in C-channel system as affected by water levels in channel and width of wicks. Water levels in C-channel varied with 4.3 (full water level, FWL), 3.0 (middle, MWL), 1.5cm (low, LWL) and width of wicks are 2.0, 1.5, 1.0, 0.5 cm each. And water absorption properties (WAP) in C-channel are compared with ebb & flow (EF) and top watering (TW) as well. In case of irrigation systems, Cs showed rapid water absorption in 24 hour from the beginning and parabolic curves in all treatments, but EF and TW with step-by-step curves. Secondly, in WAP with Water levels in Cs and width of wicks, as water levels higher and width wider, Water content in media increased more. With these results, it is respected to control water content of media in pot by water levels in Cs and width of wicks.

0800–0900

S16–P–91

DOLICHOS LABLAB L.: POSSIBILITIES FOR PROTECTED CULTIVATION IN MILD WINTER CLIMATES

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Research was conducted over a three years to study different production cycles, using a local accession of the accession albiflorus D.C. of *Dolichos lablab* L. (Egyptian Bean). In the first experiment (1996/97), cropping was done into pots with peat substrate in a polyethylene greenhouse, the transplanting dates were 17 September (F1), 21 January (F2) and 6 March (F3). In the other experiments cropping was done in a sandy loam soil in glasshouses; in the second experiment (1997–98) the transplanting dates were 20 October (F1) and 2 January (F2), and in the third experiment (1998/1999) the transplanting dates were 17 September (F1) and 11 January (F2). Plants were placed in rows 1 m apart with 0.5 m between them. Plants were staked and tied. The immature pods were harvested once a week. The accession used adapts well to protected cultivation. The green pod yields obtained (95.200 kg/ha) are much higher than that reported for beans under identical growing conditions (28.000 kg/ha). Transplanting in September allows for high-yield, green pod harvesting year-round, including in winter. Continued experiments are necessary to determine the performance of this plant in subsequent years.

0800–0900

S16–P–92

EFFECT OF SUPPLEMENTARY LIGHTING OF BLUE-LIGHT DURING THE NIGHT ON ANTHOCYANIN SYNTHESIS AND GROWTH OF RED-LEAF LETTUCE

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Poor coloration due to low anthocyanin content in leaves is common in hydroponically-grown red-leaf lettuce. Our previous study suggested that supplementary blue light improves the coloration by increasing anthocyanin content. In this study, effects of blue light supplementation during the nighttime on the coloration and growth were examined to develop practical methods for improving quality of hydroponically-grown red-leaf lettuce in a greenhouse. Effect of light intensity on anthocyanin level was examined in red-leaf lettuce. The lettuce was grown under sunlight during the daytime and was exposed to blue light from 18:00 to 6:00 (12 hours) for 7 days. The anthocyanin level increased linearly with 60 $\mu mol \cdot m^{-2} \cdot s^{-1}$ or more and reached a plateau with 160 $\mu mol \cdot m^{-2} \cdot s^{-1}$. The coloration obtained at 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ was comparable to that produced in the field. The growth of lettuce was also enhanced by the increased light intensity. The dry matter content and thickness of a leaf were increased with 60 and 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light. Effect of lighting duration on anthocyanin level and growth was examined in the lettuce under 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light. The anthocyanin level increased with 6 hours and the highest value was obtained at 12 hours. Under 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light condition, at least 6 hours continuous irradiation was necessary to improve the coloration. At that time, the longer the lighting duration was extended, the greater the growth of lettuce could be seen such as the dry weight, dry matter content, and thickness of a leaf. The anthocyanin content and/or the dry weight were not affected by the irradiation pattern, continuous and 30 and 120 minutes intermittent lighting, under the condition of 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of blue light for totally 6 hours. It was concluded that 120 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of irradiation of blue light for more than 6 hours in nighttime was enough to improve coloration and growth in a greenhouse hydroponic red-leaf lettuce.

0800–0900

S16–P–93

CULTIVATION OF CUCURBITS IN THE HIGH ALTITUDE COLD DESERT (LADAKH) OF INDIA

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In the northernmost part of India lies cold deserts spread over 82,665 km sq in Jammu & Kashmir State. This region is popularly known as Ladakh having altitude ranges 2900 to 5900 m. The climate is harsh, dry and dominated by extreme cold. Subzero temperatures prevail during winter and land remains frozen from November to February. The soil is sandy, lacks organic matter and nutrients. Water is scarce. The Field Research Laboratory (FRL), Leh developed techniques for cultivation of cucurbits using solar greenhouses and plastic mulch. During the month of May the seedlings were raised in upright 8–10 cm high, 5 cm diameter polyethylene bags in solar greenhouses. Night temperature did not go below 5 C. This facilitates germination and growth of cucurbit seeds and seedlings, respectively. Seedlings become ready for transplanting by the first half of June when the outside environment becomes more congenial for growth of plants. Healthy seedlings are planted in plastic mulched field. In unmulched fields, growth of most cucurbits remains very slow with very poor or no production. Mulched fields, however, provide suitable environment for growth and production of cucurbits. With this technique longmelon (*Cucumis melo*), watermelon (*Citrullus lanatus*), muskmelon (*Cucumis melo*) var. *utilissimus*, Sarda melon (*Cucumis melo*), bottle gourd (*Lagenaria siceraria*), pumpkin (*Cucurbita moschata*), squash (*Cucurbita pepo*), ridge gourd (*Luffa acutangula*), sponge gourd (*Luffa cylindrica*), cucumber (*Cucumis sativus*) and bitter gourd (*Momordica charantia*) have been successfully raised. This has opened up new area of cucrbit production in high altitude cold desert of India.

0800–0900

S16–P–94

ENVIRONMENTAL CONTROL MODELS FOR A GROWTH STAGE-DEPENDENT PHOTOAUTOTROPHIC POTATO MICROPROPAGATION SYSTEM

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The growth of tissue-cultured plantlets under photoautotrophic conditions were very sensitive to environmental factors such as photosynthetic photon flux (*PPF*) and CO_2 concentration, and therefore adequate environment controls were very important to ensure the growth and quality of the plantlets. In this study, the whole lifecycle of potato (*Solanum tuberosum* L. cv. Dejima) was divided into three stages based on the growth curve, and their environmental requirements were investigated. Single-node cuttings from potato, subcultured photomixotrophically in vitro, were grown in Magenta vessels, in which the number of air exchanges per hour (NAEH) was 6.2 h^{-1}. Polyurethane medium with 70 mL of liquid MS (without sucrose and vitamin) per vessel was used. Dry and fresh weights, shoot length and diameter, and the number of nodes of potato plantlets were analyzed under 400, 700, and 1400 $\mu mol \cdot m^{-2} \cdot s^{-1}$ CO_2 conditions with 80, 160, and 240 $\mu mol \cdot m^{-2} \cdot s^{-1}$ *PPF* levels during the 1st growth stage, and under 700, 1400, and 1800 $\mu mol \cdot mol^{-1}$ CO_2 conditions with 80, 160, 240, and 320 $\mu mol \cdot m^{-2} \cdot s^{-1}$ *PPF* levels during the 2nd–3rd stages. At 1st stage (lag phase), few differencesbetween the various growth factors were observed in the treatments. However, in stages 2 and 3, the influence of environmental factors on shoot length and diameter, fresh and dry weights, and number of nodes was much greater. At the 3rd stage, for instance, fresh and dry weights showed relatively direct linearity with respect to *PPF* (80–320 $\mu mol \cdot m^{-2} \cdot s^{-1}$) at 1400 $\mu mol \cdot mol^{-1}$ CO_2, but were non-linear with a saturation point around 240 $\mu mol \cdot m^{-2} \cdot s^{-1}$ *PPF* at 1800 $\mu mol \cdot mol^{-1}$ CO_2. Using all the relationships among growth and environment factors, several environment control models with growth stage were developed.

0800–0900

S16–P–95

COLD TRAPPING OPERATION OF RETRACTABLE ROOF STRUCTURES REGULATES GROWTH AND DEVELOPMENT OF RHODODENDRONS

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Spring growth and flowering of rhododendrons grown in retractable roof structures operated for cold-trapping was compared to rhododendrons grown in seasonally-covered quonset structures, or compared to rhododendrons grown without cover. Each growing area was replicated three times, and each of three rhododendron cultivars was replicated 30 times within each growing area to create a split-block arrangement in a randomized complete block design. Plants were grown in 2.7-liter containers, and irrigation, fertilization and other crops cultural procedures were similar among all growing areas. Compared to the no cover or the seasonally-covered growing areas, the retractable roof structures provided lower daily maximum temperatures, lower average daily temperatures (ADT), and higher daily minimum temperatures. Flowering of 'Hino-Crimson' and 'Gibraltar' was 35 days later in the retractable roof compared to the seasonally-covered structure, and 12 days later compared to plants grown without cover. Flowering of 'Scintillation' was not influenced by type of growing structure. Initial spring vegetative growth was 42, 35, and 14 days later in the retractable roof structure compared to the seasonally-covered structure, and 21, 7, and 7 days later in the retractable roof structure compared to plants grown without cover, for 'Hino-Crimson,' 'Gibraltar,' and 'Scintillation,' respectively. The lower ADT in the retractable roof structure operated for cold-trapping delayed flower or vegetative budbreak for all three cultivars, allowing the grower to delay development of plants being shipped into markets with colder climates. 'Hino-Crimson' and 'Gibraltar' had larger shoots and more shoot dry weight when grown in the retractable roof compared to the seasonally-covered structure or compared to noncovered plants. Shoot size and shoot dry weight of 'Scintillation' was not influenced by type of growing structure.

0800–0900

S16–P–96

IMPROVING YIELD, QUALITY AND PARTITIONING OF CA TO FRUITS OF PLUM TOMATO BY MANIPULATION OF NUTRIENT SOLUTION TO THE ROOT ZONE

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Plum tomato (*Lycopersicon esclentum* Mill cv. DRK 2001) plants were grown

with split root systems to determine whether marketable yield and quality could be improved. Nutrient solutions with different Electrical Conductivity (EC) values were supplied equally or unequally to either side of root system. Blossom End Rot (BER) increased as EC increased but was reduced by at least 40% in plants that received nutrient solution with unequal EC. Fresh and dry weight of marketable fruit was lower in plants fed equally with solution of either low or high EC than the plants receiving a combination of high and low EC. Fruit size also tended to be bigger when nutrient solutions with unequal EC were used. The reduction in yield in the high EC treatment was a result of both high percentage of fruit with BER and the smaller size of fruits. Fruit acidity and soluble solids in the unequal EC treatments were higher than the low EC treatments but they were lower than the plants grown with equal high EC. In treatments given unequal EC to the split root systems, Ca concentration in the young fruits was significantly higher than those given equal high EC. High EC reduced Ca concentration in the distal tissues of the fruits, however no difference was found between proximal and distal tissue in the fruits from the unequal EC treatments. We concluded that high EC has beneficial effects on both yield and fruit quality provided that one portion of root system is supplied with either solution of low EC or water.

0800–0900

S16–P–97

RESPONSE OF PLUM TOMATO (*LYCOPERSICON ESCLENTUM* MILL) TO INFRARED REFLECTIVE FILTER: YIELD, QUALITY AND NUTRITIONAL ASPECTS

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Two experiments compared the responses of tomatoes (cv. DRK 2003) grown in a compartment with an infra red reflective filter with those in a compartment without a filter (control). In both experiments, the temperature in compartment with the filter was about 2.5 °C lower than that without filter. Fresh and dry weights of fruits were increased from the plants grown in the filter compartment. Two weeks after anthesis, fruits in the control were larger than those in the compartment with filter but Ca concentration was lower. Faster fruit growth caused by the higher temperature in the control compartment reduced Ca concentration of the fruits in early stages of growth and as a result induced the blossom end rot (BER). BER was observed in the control) compartment (26% and 20% in experiment I and P) but not in the compartment with a filter. Potassium concentration of fruits in the control compartment was higher than that in the filtered compartment and increased the acidity of the fruits. High temperature reduced Ca accumulation but increased K concentration of the fruit. The filter significantly reduced BER by regulation of fruit growth rate.

0800–0900

S16–P–98

DEVELOPMENT OF GROWTH AND NUTRIENT UPTAKE MODELS FOR HYDROPONICALLY-GROWN WATER DROPWORT (*OENANTHE STOLONIFERA* DC.) USING DAILY INTEGRATED IRRADIANCE AND AVERAGE TEMPERATURE

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Models were developed for predicting growth and nutrient uptake of water dropwort based on daily integrated photosynthetic photon flux density (*PPFD*) and average daily temperature (ADT). Various growth parameters were examined to correlate with the fresh weight (FW). Dry weight and leaf area index (LAI) up to linear growth phase were highly and allometrically correlated with FW, each with $r^2 > 0.96$. Using the radiation extinction coefficient (K) of 0.29 in the equation of (1-e-K LAI), the maximum radiation use efficiency (maximum RUE, ?max) was found to be 0.0388 kg·mol^{-1} for the FW of water dropwort. Since RUE value was affected by ADT, the function of ?ADT followed beta distribution (?ADT = 0.0422[(39.0 – ADT)/15.0][(ADT – 7.5)/16.5](15.0/16.5)) comprising minimum, optimum, and maximum temperature of 7.5, 24.0, and 39.0 °C, respectively. The FW was well predicted with the function of FW = 0.0388?ADT??(1-e-K LAI) *PPFD* (bias = –0.195 and RMSE = 0.543). However, different nutrient uptake patterns were observed at 3 levels of *PPFD* or at 5 regimes of ADT. The amounts of K^+ and PO_4-P uptake were highly correlated only with the FW ($r^2 > 0.96$). However, the amounts of Ca^{2+} and Mg^{2+} uptake were correlated with *PPFD* as well as FW. Without compensating based on the nutrient uptake model, the nutrients, K^+ and PO_4-P in the nutrient solution were greatly depleted at harvest, but Ca^{2+} and Mg^{2+} accumulated. When the nutrients were compensated based on the nutrient uptake model, however, the FW could be increased at a rate of approximately 6.6%.

0800–0900

S16–P–99

ROCKET (*ERUCA SATIVA* MILL.) AND CORN SALAD (*VALERIANELLA OLITORIA* L.): CONSERVATION OF TWO LEAFY VEGETABLES GROWN IN A SOILLESS CULTURE SYSTEM

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Fresh-cut products are fresh vegetables and fruits, previously washed and cut, packaged and sealed in bags or containers, and commercialized as ready-to-eat or ready-to-cook products. Consequently, the products present a high added value and, therefore, are highly appreciated by the consumers. Recently, Italy is knowing a booming interest in high quality and tasty ready-to-eat vegetables. Therefore, studies on postharvest conservation and quality of typical Italian salads are necessary. Using soilless culture system (SCS) avoids soil parts to reach the leaves, allowing the production of clean material at harvest, and consequently the reduction of many washing treatments. Plants of rocket (*Eruca sativa* Mill.) and corn salad (*Valerianella olitoria* L.) were grown for Leafy Vegetable Production (LVP) in different containerized cell-trays (40 or 160 cells, with 8 and 2 seeds per cell, respectively), using different growing media (100% rockwool or 75% peat and 25% perlite, in volume), and different nitrogen concentrations in the nutrient solution (30–120 mmol·L^{-1} N). At sampling, leaves were cut and weighed, and were attributed a Quality Index (QI: 100%, 75%, 50%, 25% and 0%, according to marketable values), packaged in commercial plastic boxes, and stored in cool chamber at 4 C, for postharvest conservation phase. Evaluation of post-harvest quality was assessed by variations of fresh and dry weight over time (0, 2, 4 and 6 days after storage), and values of QI (at 0, 2, 4 and 6 days of storage). Fresh mass and QI decreased over time for both species, as expected. However, the values decreased less in plants that were grown in 40-cell trays filled with peat and perlite and fertilized with 30 mmol·L^{-1} of N than in plants that were grown in the other experimented conditions. The QI indicated that rocket and corn salad can be grown with the tested SCS system to obtain high quality ready-to-eat salads.

0900–0920

S16–O–100

THE EVALUATION OF FEVERFEW (*TANACETUM PARTHENIUM*) AS A COMMERCIAL GREENHOUSE CROP AND ITS COST OF PRODUCTION

Ken Ng*[1], David Ehret[2], Diane Kermode[3], Linda Fogarty[4]

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In recent years, the greenhouse vegetable industry in North America has experienced double digit growth with tomatoes, sweet peppers and long English cucumbers as the main crops. Large, efficient greenhouses, new growing technologies, higher producing varieties and improved knowledge of plant management have pushed production to new heights. Unfortunately, the rapid growth in greenhouse vegetable acreage and production has resulted in lower produce prices. As a result, growing these crops in small to medium size greenhouses is no longer viable. As the market for alternative medicines continue to grow exponentially, greenhouse production of medicinal plants may prove to be profitable for small to medium size growers. Feverfew (*Tanacetum parthenium*) was identified as the ideal crop for a commercial greenhouse study. This plant was selected based on its germination and growth rates, method of propagation, growth habit, average production, and pest problems. In addition, feverfew, a plant that is used to treat arthritis and migraines, was found to have a higher potency when grown in a greenhouse when compared to field grown feverfew. One of its active ingredients, parthenolide, was two times higher in the summer and up to six times

higher in the winter months when grown in a greenhouse. A two-year trial was conducted to identify and document basic production, climatic and environmental requirements in a commercial greenhouse. This resulted in the development of a blueprint on feverfew production in a NFT system. In addition, a contribution margin study and sensitivity analysis indicated that feverfew production in a greenhouse was financially viable under specific price parameters and plant growth criteria.

0920–0940
S16–O–101
THE EVALUATION OF FEVERFEW (*TANACETUM PARTHENIUM*) AS A COMMERCIAL GREENHOUSE CROP AND ITS COST OF PRODUCTION

Ken Ng*[1], David Ehret[2], Diane Kermode[3], Linda Fogarty[4]

[1]NG Research and Consulting, 5011 Dellawn Drive, Burnaby, BC, V5B 2M1 Canada; [2]Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada, P.O.Box 1000, Agassiz, BC, V0M 1A0 Canada; [3]Agri-Metric Research and Consulting, Box 4001, Yarrow Station Main, Chilliwack, BC, V2R 5H8 Canada; [4]Century Pacific Greenhouses Ltd., 266 Ross Road, RR #1 Abbotsford, BC, V4X 2M5 Canada

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0940–1000
S16–O–102
PRODUCTION OF SPECIALTY CROPS IN GREENHOUSES—WASABI AS A CASE STUDY

David Ehret*[1], Ken Ng[2], Brian Oates[3], Pascal Delaquis[4], Joe Mazza[4]

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Recent interest in specialty crops derives in part from the economic need to diversify within the horticultural sector, but is also driven by increased consumer acceptance of new food and medicinal crops. The opportunities are great, but potential growers must be aware of the challenges as well. Careful market research and consultation with buyers is essential, as is the need for local infrastructure (for example, warehousing and processing facilities). Production factors such as disease and pest control, quality, cost of production, and yield must all be considered. These issues become all the more important in the context of greenhouse-growing, where start-up and maintenance costs can be much higher than in other areas of horticulture. With this in mind, we will present our research and commercial experiences with wasabi (*Wasabia japonica*), a food crop which has gained substantial interest in recent years.

1000–1020
S16–O–103
ONTOGENIC VARIATIONS OF PHENETHYL ISOTHIOCYANATE CONCENTRATIONS IN WATERCRESS (*NASTURTIUM OFFICINALE* R.BR.) LEAVES

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Watercess (*Nasturtium officinale* R.Br.) is the richest source of the glucosinolate nasturtin, which on hydrolysis produces phenethyl isothiocyante (PEITC). Interest in growing watercress as a salad crop has been stimulated since the potential role of PEITC in protection against cancers associated with tobacco specific carcinogens was demonstrated. Twenty-one days old watercress seedlings were transplanted into growth chambers programmed to maintain 16-h days/8-h nights of 25/22 °C. The photosynthetic photon flux (*PPF*) was ~255 micro mols/square m/s. The study was replicated three times. The watercress leaves were analyzed for the phenethyl isothiocyante and ascorbic acid concentrations at 0, 10, 20, 30, 40, 50, and 60 days of transplanting. The ascorbic acid contents of the leaves were also analyzed at each harvest. The PEITC and ascorbic acid concentrations were the highest in the leaves harvested at 40 days and the lowest in the leaves at transplant. The leaves harvested at 40 days produced about 150% higher PEITC concentrations compared to the leaves at transplant. There was no significant increase in the PEITC concentrations in the leaves harvested at 50 and 60 days compared to the leaves harvested at 40 days after planting. Both the PEITC and ascorbic acid concentrations of the watercress leaves increased linearly with age until 40 days after transplant after which there was no significant increase in the production of either PEITC or ascorbic acid. However, the highest dry mass, and leaf area were recorded in plants harvested at 60 days and the lowest dry mass and leaf area were recorded at transplant.

1020–1040
S16–O–103–A
TO BE ANNOUNCED

1400–1420
S16–O–104
ENERGY SAVING AND PEAK SHAVING FOR CROPS WITH LOW ENERGY REQUIREMENT

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The natural gas market in the Netherlands will be liberalised. This means that the growers will not pay a fixed price for the natural gas anymore, but that the price will depend on individual contracts. In practice, the maximum supply capacity (peaks) of natural gas will largely determine the energy costs. Several limited-acreage crops like lettuce, radish, endive, freesia and buttercup do not need high greenhouse temperatures. This leads to a relatively low energy requirement with relatively high peaks in winter, especially on extremely cold days. Because these peaks will become very expensive, some of the limited-acreage crops may not be grown profitably anymore. Temperature integration and thermal screens are means to save energy and to lower the peaks as well. That is why Applied Plant Research tests these means with the limited-acreage crops. In these tests, the quantity and the quality of the crops as well as the energy requirement and the peak of the energy use are monitored. With these data, we can make an economic judgement whether temperature integration and thermal screens can make limited-acreage crops more profitable in a liberalised natural gas market.

1420–1440
S16–O–105
PROMISING HORTICULTURAL CROPS FOR PRODUCTION IN HIGH TUNNELS IN THE MID-ATLANTIC AREA OF THE US

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At The Pennsylvania State Univ. High Tunnel Research and Education Facility located at the Horticulture Research Farm, Rock Springs, PA, there are

twenty-four (17 x 36 foot) research high tunnel units. The Penn State high tunnels were re-designed so that the endwalls can be raised up to facilitate easy access into the tunnel for a small tractor, rototiller and other machinery. Since completion of the 24 research high tunnel units in the Fall of 1999, there have been many horticultural crops grown in the high tunnels including; many vegetables, small fruits, cut flowers, herbs, and tree fruits. Generally there are at least two crops and sometime three crops grown in each high tunnel per year depending on time to maturity ofthe crop and the crops optimum growing temperatures. Of these crops, the most promising in terms of economics were tomato, bell pepper, garlic, sweet Spanish onion, red raspberry and cut flowers. Most insect problems in the high tunnel have been controlled with the release biological organisms. There tend to be very few annual weeds in the tunnels, but it is important to control perennial weeds prior to establish a crop in the high tunnels. The only serious disease problem that has been encountered in high tunnel crop production has been powdery mildew. Use of powdery mildew resistant varieties helps to control this disease in high tunnels.

1440–1500
S16–O–106
'OUT-OF-SEASON' GREENHOUSE PRODUCTION OF STRAWBERRY AND RASPBERRY

Chaim Kempler*

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Strawberries and raspberries are crops that are traditionally produced in the field. Recently, a desire on the part of consumers for year-round fresh berries has stimulated 'out-of-season' production around the world. A brief review will be presented on the developments in 'out-of-season' production of berries in greenhouses and plastic tunnels. Forcing practices, cultural and production systems will be described. Other important aspects of protected cultivation such as dormancy and chilling requirements, forcing floricanes and primocanes of raspberries and the use of bumblebees for pollination will be discussed.

1500–1520
S16–O–107
A SOILLESS CULTURE SYSTEM TO GROW OUT-OF-SEASON ASPARAGUS WITH A HIGH MARKETABLE VALUE

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In recent years, the area of asparagus production in Belgium, France and, to a lesser extent, in Italy, has decreased. Most of the decrease is caused by soilborne diseases and soil exhaustion. However, the demand for both processing and fresh asparagus is increasing in Italy, as evidenced by an increase in imports. Greenhouse soilless culture offers the potential to limit pests, diseases, to optimize, standardize and increase spear production as well as reduce labor costs. Furthermore, earliness and out-of-season production may be achieved in protected cultivation, increasing the market value. Plastic boxes (460 x 265 x 245 mm) were lined with Styrodur™ (isolating sheets), and filled either with local soil or growing media (60% peat and 40% perlite, by volume). Asparagus rhizomes were kept from Feb. to July in a growth chamber at –1C, then from Aug. to Sept. at 0C and finally brought into the greenhouse for forcing. Either two or three rhizomes were placed in each box, either at the beginning of Oct. or at the beginning of Nov. Boxes were placed on a bench in a greenhouse equipped with heating and cooling capacity, according to a RCBD with 4 blocks, and irrigated throughout the experiments according to needs. Fertilization took place either every week or every two weeks, using 1 g/l of Tipo OT™ (Valagro), a commercial solution for hydroponics. Harvesting started on 24 Nov. and ended on 26 Jan. Growth and commercial parameters were evaluated at each harvest. The effects of the different treatments, with the exception of fertilization, were highly significant. Forcing from Oct. doubled total fresh weight (1188 g v/s 590 g) and spear number (147 v/s 69), while with 3 plants per box the results were 1066 g v/s 711 g of fresh production and 131 v/s 85 spears. With the soilless mix, fresh production and number of spears were respectively 1023 g v/s 755 g and 128 v/s 88.

1520–1540
S16–O–108
CONSUMER AND PROFESSIONAL CHEF PERCEPTIONS AND ACCEPTANCE OF EDIBLE FLOWERS

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A series of studies were conducted to investigate perceptions and acceptance of edible flowers, a potential niche greenhouse crop, by two potential customer segments. The two segments were defined as professional chefs and consumers, both important product users. These two segments were included to help researchers make recommendations to small growers concerning which group they could market the product. Studies were designed to determine acceptance of edible flowers, preference for species, colors, and uses, and to test consumer purchases in an operating grocery store. Consumers and professional chefs evaluated attributes of three edible flowers with both groups rating *Viola tricolor* L. 'Helen Mount' and *Tropaeolum majus* L. 'Jewel Mix' similarly. Other consumer participants would prefer to purchase an 8-oz (227-g) container of edible flowers with all three *Viola* x*wittrockiana* Gams. 'Accord Banner Clear Mixture\ colors tested (blue, yellow and orange) priced at $2.99. Additional consumers participated in another study, using the same size container and price, and selected a mixture of all four nasturtium colors offered. This mixture of peach, cream, orange, and crimson nasturtiums was had the highest utility score (0.091) showing it was the favorite. The addition of other species (viola and/or *Borago officinalis* L. [borage]) to the mix further increased containerís value. The fourth study was implemented in three supermarkets in the Metro-Detroit area. Consumers purchased a total of 243 of 360 containers of edible flowers (6 nasturtiums and 14 viola) marketed in 8-oz. containers at three different prices ($3.99, $2.99, and $1.99) over a six-week period. The optimum price point was $2.99. There appears to be a substantial niche market for edible flowers, especially a mixture of flowers in a small container at a moderate price point.

1540–1600
S16–O–109
NEW VEGETABLE CROPS FOR GREENHOUSES IN THE SOUTHEASTERN UNITED STATES

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Traditional greenhouse vegetable crops grown in the U.S. include tomato, pepper, cucumber, lettuce and herbs. The percentage of the market value projection of these crops is in excess of 95%. Our work in a high-root passive ventilated plastic greenhouses in Florida has led to economic production levels for 'Beit Alpha' cucumbers and 'Galia' melons, two crops which originated in Israel. 'Galia' muskmelon is a green fleshed specialty melon with a yellow netted exterior known for its sweet flavor and is highly desirable presently in the European market. We looked at three plantings over two seasons of various cultivars of 'Galia' type melons. Average weight per fruit of superior varieties was in excess of 1 kg while average yields were 5.5 fruits per plant with Brix readings of 11.3 . 'Beit Alpha' cucumbers are commonly grown in the Middle East. They are parthocarpic, and all female and thus do not require pollination. Various 'Beit Alpha' cucumbers and Dutch type cultivars were grown over several production seasons in the greenhouse. 'Beit Alpha' type cucumbers were successfully grown year-round under Florida conditions and offer an exciting new greenhouse crop for producers. Some cultivars produced in excess of 65 fruits over a 6-week harvest period. Several producers have already picked up information from these trials and have successfully marketed 'Beit Alpha' cucumbers through regional retail outlets. Both of these crops have extremely high quality, superior to existing melons and other types of cucumbers on the market including Dutch type cucumbers. Because of the prolific yields, the economics in growing these crops has been shown to be in favor of the producer. It is very important to keep in mind that although cultivar trials or variety trials that are being conducted may be for a single location, that they may in fact report important information that can be utilized by people in distant locations and, in fact, in other countries.