Substrates as an alternative to MeBr for strawberry fruit production in northern Europe

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Strawberry production in EU *

- Total surface : around 47.000 ha
- Protected culture : around 9.000 ha= 20 %
- Soilless culture : around 1270 ha = 2.7 %

(*including Switzerland but excluding 10 new EU-members)

Strawberries in Europe 2004

Country	Total surface in ha	Protected cropping in ha *	Substrate culture in ha **	Tendency substrate culture in the near future
Belgium	2250	470	330	Stable
The Netherlands	2200	170	200	Small increase
United Kingdom	3200	1000	155	Stable
Ireland	200	66	35	Stable/small increase
Germany	11.000	80	20	Small increase
Switzerland	410	50	15	Small increase
France	4500	1930	265	Strong increase
Italy	3900	3025	150	Small increase
Spain	7000	3000	61	Strong increase
Portugal	600	300	45	Increase
Greece	365	320	1	Stable
Austria	1200	10	2	Stable
Norway	1790	10	0.5	Stable
Sweden	1900	15	3	Stable
Denmark	1060	5	1	Stable
Finland	4500	8	4	Stable/small increase

*greenhouses and large tunnels ** exluding Frag. vesca and including outdoor soilless productionsystems

Germany and Scandinavia:

- **Limited interest**
- **Soil disinfection is not allowed or not necessary :enough land available for crop rotation**
- **Short fruiting season due to cold climate and higher risk for frost**
- **Production in tunnels and greenhouses only for small niche markets**

Belgium and The Netherlands, Switzerland

- **Important production technique with a historical development as in vegetables and ornamental plants**
- **Soil disinfection is restricted or not allowed**
- **High cost price of MeBr**
- **Limited land available for crop rotation;root diseases, soil born insects**
- **Longer fruiting season and possibilities for 3 crops per year in greenhouses and 2 crops per year in tunnels which makes the system economically interesting**
- **Production in tunnels and greenhouses is a standard growing method**

UK, Ireland, N-Italy, N-France

- **Soil disinfection is restricted or not allowed**
- **High cost price of MeBr**
- **Limited land available for crop rotation in mountain areas ; root diseases, soil born insects**
- **Longer fruiting season 2 crops per year in tunnels**
- **Heavy soils not adapted to summer production of cold stored strawberries standard variety Elsanta**

Substrate culture-advantages

- **Alternative for contaminated soil with nematodes and fungi and non arable soil**
- **Reduction of herbicides, pesticides and chemical disinfection and possibilities to use biological control**
- **Better fruit quality**
- **Limited surface of growers implicates intensive systems with higher density and increased productivity and profitability**

Productivity and costs of culture of cv. Elsanta in Belgium&Netherlands

	Tunnel production *		Summer production **	
	Soil	Soilless	Soil	Soilless
Yield (kg/m²)	4.7	9.5	2.2	4.2
Costs (Euro/m²)	9.5	14	4	7.6
Total income (Euro/m²)	13	29	6	11.7
Profit (Euro/m²)	3.6	15	2	4.1

* spring and autumn ** 60 day plants

Substrate culture-advantages

- **Better work conditions during harvest and faster picking**
- **In combination with greenhouses/tunnels and cold storage plants avoiding short peak production period with relative low prices**
- **Continuity of supply to the market with fresh strawberries during 8 to 11 months**
- **Spreading labour requirement of growers**

Substrate culture-disadvantages

- **High investments and annual costs**
- **Labourintensive yeararound culture More skills and technical knowledge required**
- **More sensitive to temperature, nutrition and irrigation technique related to problems such as fruit set, colour, splitting of fruits, tip burn, deficiency-toxicity symptoms ..**
- **Waste materials of plastic, substrate...**
- **Regulations for recirculation of drainage water**
- **Expensive disinfectionsystems for the drainage water**

Substrate culture-short history

- **First period of development in 1985 Holland and Belgium because of competition with Spain and France <mainly NFT and bucketculture**
- **Second period of development 1990 in Holland and Belgium with introduction of peatbags**
- **Third period : spreading of substrate systems in UK, Italy, Switzerland, Ireland, France 1996-1998 Development of alternative substrates and systems**
- **Fourth period of development : 2001-2002 in south of France and Spain because of ban of methylbromide in near future (2005)**

Hydroponic culture since 1970 in England,Belgium, Holland

- **Development of bucket systems in Belgium-Holland 1980**

- **Small pot systems (3-4 liter) for early cropping in tunnels in France since 1997**

- **Fragaria Vesca in Belgium (5-6 liter pot)**

- **Fragaria Vesca in Italy (3-4 liter pot)**

Small pot systems (2 liter) in tubes of 15 cm diameter in Holland, Belgium, France since 1997 more popular

First experiments with peat bags around 1975 but breakthrough around 1990 in Holland and Belgium volumes from 8-18 liter

Experiences with rockwool since 1980 in several countries

- Difficult rooting
- High water content
- Less vegetative growth
- Expensive
- Plastic waste and not biodegradable substrate
- Environmental laws

Experiments with stepsystems and A-frames

- **Development of vertical pot systems in Italy late 1970**
- **Double layer system in south France 2002**

Several types of containers (length 40-100 cm) since 1980 but gained new interest since 1997 because of environmental laws

Automatization of filling containers and moving crops out of tunnels and greenhouses, composing substrate

Tendency to open gutter systems without containers for outdoor summer production

SUBSTRATES : developments

- **Environmental restrictions on substrates :**
  ***rockwool and polystyrene forbiden to plough into soil**
  ***tendency towards sustainable substrates organic or locally produced**
  ***alternatively re-use of substrates for strawberries but yield reduction due to :**
  -physical properties (compacting) <defrosting substrates
  -salinity <leaching
  ***plastic waste and costprice of recycling**
  <decline bags and conversion towards containers and pots :
  -60 % containers (10-12 l volume)
  -15 % buckets (5-6 l volume) and 10 % pots (2 l volume)
  -15 % peat bags (8-18 l volume)

Coir and coirfibres

- **High air capacity**
- **Retains less water**
- **Stable composition suitable for re-use**

- **Can be compressed and rehydratated**
- **N-retention 2-4 weeks**
- **High K, Na and Cl**
- **Fixates Ca, Mg, Fe**
- **Tip burn, fruit quality Fe-deficiency**
- **Has to be washed prior to use**

Rice husk

- **Low water holding capacity**
- **High Si and K content**
- **Affects fruit quality**

Argile

- **Low air capacity**
- **Fixation of Fe and Mn**
- **High pH**
- **Compactation**
- **Weight**

Wood fibres, composted pine bark, cork, vine shoots

- **Initially high air porosity**
- **Fast volume reduction**
- **Low water holding capacity <<adapted irrigation**
- **N-retention due to microbial activity**
- **High cationic exchange capacity of some substrates such as composted vine shoots and garden waste**

GLASSHOUSE PRODUCTION

- **Soilless culture in greenhouses : 430 ha in EU**
  << less than 1 % of total surface strawberries in EU
- **Soilless culture : almost 100 % of the area under glass**
- **Systems : substrate (peat,perlite, coir, pinebark) in bags, containers, buckets, pots in tube and hydroponics**
- **High technology: computerized fertilisation and climate control, CO2, artificial lighting, heating, nutrient recycling etc..**

GLASSHOUSE PRODUCTION

- **3 crops per annum in Holland and Belgium : Darselect/Lambada-Elsanta-Elsanta**
  <<harvest period 20 February-15 January
- **2 crops in UK, Switzerland, Germany, Ireland : Elsanta-Elsanta**
  << harvest period April-December
- **1-2 crops in France : Gariguette in spring - summer production with everbearer Cirafine and Mara de Bois, Seascape**
  <<harvest period 15 February-November

GLASSHOUSE PRODUCTION

- **In UK, Ireland, Switzerland, Germany 3.5 m high, 6.4 m wide support structures of metal, glass width of 80 cm**
- In **Holland and Belgium 5 m high and 8 m wide support structures, glass width of 110-120 cm**
- **white coated structures <earlier and later production**

GLASSHOUSE PRODUCTION

- **C02 systems, heat recuperation, heating on gas and gasoil**
- **Range of simple dosage systems, semi-automatic and automatic fertilizer units, mixing and injection units**

TUNNEL PRODUCTION

- **Almost 20 % of the european fields are protected and tendency is positive :**
  -75 % in Italy
  - 50 % in France
  -50 % in Spain
- **Soilless culture in tunnels : 940 ha in EU**
- **2 crops per annum in central Europe : Holland, Belgium, UK, Switzerland, Germany, north France and Italy**
- **1 springcrop per annum in Spain, France, south Italy**
- **1 summercrop in Ireland and Schotland and Ireland**

TUNNEL PRODUCTION

In Belgium, Holland, UK, Ireland, Switzerland two crops per year (May-June and September-October) with variety Elsanta

TUNNEL PRODUCTION

- **In France early production (March-May) of variety Gariguette followed by summer production of everbearing varieties Mara-de Bois and Seascape**

TUNNEL PRODUCTION

- **Late June-July production on high altitude (600-1200 m) in mountain areas in north Italy, Switzerland, Schotland of varieties Elsanta and Darselect**

TUNNEL PRODUCTION

- **Sometimes double large tunnel are used (north Italy) or on the support structures small tunnels (south of France)**

TUNNEL PRODUCTION

- **To improve earliness in not heated tunnels sometimes bags are put on the soil and covered with small tunnels (south of France)**

OUTDOOR SUMMER PRODUCTION

- **Expansion of summer production mainly in Holland, Belgium, UK**
- **Production period of July-August is becoming more popular because of high prices**
- **More herbicides are restricted for traditional soil culture so substrate culture is an alternative**
- **Markets are demanding continuous supply of spring ‘substrate culture strawberries” and do not like swith to soil grown strawberries in summer-more easy to get pickers**

OUTDOOR SUMMER PRODUCTION

- **A minority of growers in Belgium and Holland are using table top system covered with small tunnel**
- **Everbearer Everest (1 plant per 5 liter pot)**

OUTDOOR SUMMER PRODUCTION

- **Most growers in central Europe are growing on containers one or two crops of cold stored Elsanta**
- **Alternatively plants are grown in gutters filled with peat or coir and in hydroponic systems**

OUTDOOR SUMMER PRODUCTION

- **In Ireland and UK the support structures are covered with tunnels for protection against wind, rain and hail**
- **Varieties :**
  <Elsanta (junebearer)
  <Everest (everbearer)

EVOLUTION TOWARDS SUBSTRATE NURSERY

- **Trayplants on substrate since the mid 90's**
- **Plants raised from mother plants grown on substrate**
- **Runner tips taken from mid to end of July**
- **Grown in peat-filled multi-cell trays**
- **Very good adapted to long term cold storage**
- **Well suited for fall and winter production in tunnels and greenhouses, mainly for substrate culture**
- **Larger fruit than waiting bed plants**
- **Higher yield than A+ runner plants**

TRAYPLANTS

EVOLUTION TO RECYCLING

- **Environmental laws on waste water quality :**
  *Evolution towards closed systems
  *Disinfection of the percolate
  *Filtration of all water before discharging to environment
  $NO3 + NO2 < 10$ mg/l
  $P < 1$ mg/l
- **Drainage percentage** :
  more Na, Cl, SO4, Mn leached
  Preplant fertilizers : more leaching of SO4 and K
  Substrates :
  coir< low Ca but high K, Na and Cl
  rockwool<high Ca, Mn and B
  organic substrates < low N
  argile < less Fe and Mn

Leaching of percolate

2 cropping cycles/year		3 cropping cycles/year	
Supply per ha	**Percolate per ha**	**Supply per ha**	**Percolate per ha**
5000 m³ **800 kg N** **180 kg P** **1000 kg K** **150 kg Mg** **700 kg Ca**	**1000 m³** **210 kg N** **40 kg P** **140 kg K** **90 kg Mg** **200 kg Ca**	**8000 m³** **1150 kg N** **290 kg P** **1450 kg K** **225 kg Mg** **1050 kg Ca**	**1600 m³** **320 kg N** **65 kg P** **200 kg K** **135 kg Mg** **280 kg Ca**

Based on greenhouse production Elsanta

Recirculation of percolate

- Conductivity between 1.5 and 2.5 mS/cm <diluting and re-use around 20 %
- pH 1-1.5 units above substrate<acidifying with HNO3, NH4
- Sufficient Ca, Mg, excessive contents of Na, SO4, Cl, B restrict the possibility of re-use
- K, P, NO3 have to be added to new solution
- Risks of transmission of fungi (*Phytophthora, Verticillium, Fusarium*) nematodes, bacteria (*Xanthomonas*)
- Fungicides not registered for irrigation application and soilless culture
- Combination of slow sand filtration, UV-C radiation of percolate and water source
- Reed beds to filter excess water prior to waste

Ultraviolet radiation

- **UV-C treatment mercury vapour lamps mainly 254 nm**
- **100 mJ/cm² effective against Phytophthora, Xantomonas, Fusarium, Phytium**
- **>600 mJ/cm² Verticillium**
- **Inactivates Fe-chelats**
- **Precipitation of Fe and Ca on lamps <automatic cleaning**
- **Prefiltering to achieve good transmission**
- **Adapt nutrition : Fe, Mn**

Slow sand filtration system

- **Different layers of sand and small stones**
- **Minimum temperature for activity is 15°C**
- **Slow water filtration rate 100 liter/m²/hour**
- **Aerobe and anaerobe bacteria activity kills off Phytophtora and Phytium**
- **Verticillium slower water flow needed**

Lava filtration systems

- **Different layers of small lavagranulats (alternatively rockwool)**
- **Rate 250-300 l/m²/hrs**
- **Biological percolation filters with anaerobe bacterial activity**
- **Removes Phytophthora and Phytium**
- **Less successful against Verticillium**

Biofiltration reed systems

- **Treatment of waste water prior do discharge into the environment**
- **Vertical flow reed beds and surface flow systems**
- **Use of different plants mainly reed *Pragmites australis, Typha sp. , Iris pseudacorus etc*.**
- **Biological percolation filters with anaerobe bacterial activity**
- **Reducing nutrients :**
  -P with 70 %
  -N with 60 %
- **Limited effect on Phytophthora**

RECYCLING SYSTEM