Scottish Artisan Tea Producers' Network

Tea Growing Feasibility Study

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Study Report undertaken to examine the feasibility

of growing tea commercially in Scotland

Supported by Grant from the Community Food Fund

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The **Scottish Artisan Tea Producers** are a group with the shared aim of growing high value specialty tea in Eastern Scotland. This objective will be expedited by identifying the optimal production conditions for fine locally grown tea, by advancing tea production knowledge, and sharing this among growers. The group will encourage open exchange of tea information by setting up links between Scottish tea gardens and will promote overseas exchanges and visitors to Scotland including from tea research institutions world-wide:
https://www.facebook.com/ScottishArtisanTea/

Teacraft Technical Services is an international tea consultancy company with 36 years' practical experience supporting and advising large and small tea producers in 26 countries around the world:
www.teacraft.com

Cover photograph:

Sowing the seeds of a Scottish tea industry. Some of the 50,000 *Camellia sinensis* seeds being raised under glass by the Scottish Artisan Tea Producers in 2016.

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INTRODUCTION

The purpose of this study is to assess the current interest in growing *Camellia sinensis* tea in Scotland, to consider its commercial feasibility as a business venture, and to develop a detailed set of research objectives meeting the current and future needs of the Scottish tea growing and processing sector with respect to its successful development.

While many of the pioneer planters in traditional tea growing countries hailed from Scotland, tea growing within Scotland is a new idea. There are many facets to growing and producing tea in Scotland, most of which have not been considered previously, and all of which need practical answers, to allow potential growers to assess the risks and benefits of the venture.

Essential questions we need to address in the study are:

Q1. Can tea be grown in Scotland?

Q2. Can tea be grown profitably in Scotland?

Q3. What business approach best balances risk and reward for Scottish tea growing?

This study has answered these questions in practical and business terms drawing on data and examples both from Scotland and from similar tea production operations under fringe conditions; we recognize that many practical details remain to be worked out. The first section of the study looks at the essentials of tea growing, manufacture and marketing that a new Scottish tea grower should appreciate. The second section looks at ways to overcome problems and potential difficulties, and suggests R&D areas that will aid the success of a Scottish tea industry. The third section indicates resources available to assist the new Scottish tea grower.

Who wants to grow tea in Scotland?

The growers and potential growers of the Scottish Artisan Tea Producers' Network organized as a group in 2015. Its formation was spearheaded largely by Susie Walker-Munro who had been learning tea growing for the previous six years, relying mainly on trial and error experimentation. The rationale for forming the network was to bring together a critical mass of growers into a

common interest group, to access professional assistance, and to share ideas and solutions. Susie initially approached the James Hutton Institute for technical assistance for her tea growing but the crop was too esoteric for them to provide practical husbandry advice. Subsequently Teacraft Technical Services has advised her with tea growing and processing guidance.

At the date of reporting there are nine members of the Scottish Artisan Tea Producers' Network, all located in the eastern lowlands (see Appendix 1). Their first meeting was on 10th July 2015; and a Facebook page www.facebook.com/ScottishArtisanTea was set up in the same month. It was clear at the initial meeting that, although unanimously enthusiastic, members were unclear about the requirements for tea growing, or the risks and rewards that should be considered as part of a sound business plan. Consequently, application was made to the Community Food Fund for financial help to establish the feasibility of tea growing in Scotland. A study grant was confirmed in September 2015 and Teacraft Technical Services appointed as consultant to the study.

The Community Food Fund Assessment Panel stipulated that the study project be open to new as well as existing members. Consequently, we have sought information about other Scottish tea growers and invited them to take part. All other tea growers we have identified so far are associated with the Wee Tea Company – see Appendix 2.

Questionnaire results

In December 2015, we circulated a questionnaire (Appendix 3) to the Scottish Artisan Tea Producers common interest group (Appendix 1) plus all other known tea growers and would-be tea growers in Scotland (Appendix 2)[1]. From the results, we collated information on growers' activities and intentions, and listed concerns that they expressed.

We had eleven responders of whom half were planning to grow tea and half were already growing or had seed being propagated for them. Of these, the total number of plants currently envisaged

[1] Wee Tea Plantation, the only other tea growing group identified in Scotland (see Appendix 2) were invited to contribute information to the Feasibility Study via the Grower Questionnaire but declined to take part.

were in the range 100 to 4,000 (100, 500, 1,247, 2,000, 3,000 and 4,000). All growers were considering a final area of from one-half to one acre of tea plants.

Only one grower to date had processed and produced tea that had been sold commercially.

Questionnaire concerns

Responders listed and prioritised the perceived **challenges** that they faced:

First:	**Cold weather/short growing season**	**5 mentions**
Second:	**Lack of sufficient knowledge/skill**	**4**
Joint Third:	**Wind exposure**	**1**
	Winter survival	**1**
	Incorrect soil pH	**1**
	Labour costs	**1**
	Maintaining quality consistency	**1**
	Adverse public perception	**1**

All these issues can be mitigated by the application of skills and expertise derived from a knowledge of international tea growing under marginal conditions, by cross-fertilising techniques from protected agriculture and horticulture, and by the application of standard business skills.

Questionnaire responders were also asked (Question 10) to list all the areas when they felt the **greatest need for future help** to ensure their own success with tea growing.

Here a massive 60% of the 30 replies to this question prioritised access to expert consultancy advice and training – these were split 50% for cultivation consultancy and training, 22% for processing consultancy and training, and 28% for marketing consultancy and training.

Some 27% of the responses prioritised group collaboration and sharing of experience, with 7% calling for help via access to pooled equipment.

Links to other tea groups and access to funding were mentioned by 3% for each of these issues.

Again, this perceived need for help and guidance can be met by judicious input of external consultants in touch with tea expertise around the world and with horticultural expertise in related areas. This need and the strong feeling for sharing and collaboration within the group can best be met by the regular holding of group-funded workshops with an appropriate invited expert.

Figure 1. Responses to Question 10. – Future Needs

Where separate businesses within the group require specific or proprietary guidance and support, the hire of specialist consultants should be undertaken and funded on an individual basis.

Concerns from initial members' meeting

Attendees at the first full meeting of walled tea growers (15th November 2015), when asked for their concerns about growing tea responded with a wide range of questions:

- What is correct planting density?
- What is the best planting direction to maximize interception of sun light?
- How to measure and maintain correct soil and water acidity?
- What are the optimum levels of light and rain for tea?

- Is there a market for expensive tea?
- What ground preparation is needed before planting?
- Should nitrogen-fixing plants be grown before planting?
- What nutrients does tea need and what amounts?
- Is chicken manure good or bad for tea?
- Is wind a problem? Can plants be protected from wind?
- What are the potential pests and fungal diseases of tea?
- Can pesticides be used
- What are the pros and cons of machine harvesting vs manual plucking?
- What small-scale machinery is available?
- How often should we pluck, and how long is the season?
- What is the best size of planting?
- Will other Scottish tea growers share experiences or act cooperatively?

These concerns are much more specific than the questionnaire responses. We have attempted to answer many of these questions and some others within the study.

Findings from visiting each grower in January 2016

As part of the "Scottish Artisan Tea Producers Network: Feasibility Study", Nigel Melican and Beverly Wainwright of Teacraft Technical Services visited ten growers to assess their proposed growing sites for suitability and potential problems – slope, aspect, wind exposure, soil pH, drainage, water availability and herbivorous mammalian pests. These findings are summarised in Appendix 4.

No unforeseen new problems or constraints to tea growing were identified during the visits but it was a valuable experience to make direct comparison of various levels of constraint likely to be experienced while growing tea in Scotland. Not every growing site has all of these constraints, and many of them can be diminished by informed proactive response by individual growers.

We are however very much aware that the growers are tackling a very new crop and with one exception have very little experience of the particular requirements of a perennial crop. Each grower needs to develop a soil preparation plan well before planting to ensure that soil (and water) pH can be brought within the optimal range, a suitable planting density and pattern that will allow the future possibility of mechanical harvesting, and the outline (at least) of a business strategy

We found all group members very willing to discuss their plans and open to collaboration. As the project progresses will be most helpful to group member to continue to share openly their experiences and problems – and, better still, effective solutions.

It should be understood by anyone growing tea anywhere in the world that, unlike an annual crop which gives a fast financial return, tea growing takes time to establish a mature plant thus it is a much longer term investment. In traditional tea countries this period can be from 5 to 7 years; in Scotland it will be longer. Nevertheless, once mature it can be cropped for 50 to 80 years with minimal inputs, so can be highly rewarding. There are not yet available any accurate costs of production for growing tea commercially in Scotland but some estimates have been made in the body of the report. These must be treated with care as provisional estimates highly dependent on local conditions.

PART ONE: What Scottish growers should know about tea

Field production aspects

What conditions does tea require to grow well?

In the traditional tea growing countries, we seek:

- Air temperatures between 20°C and 30°C (tea goes dormant if night temperatures are below 10°C)
- Soil temperature not below 15°C nor greater than 25°C
- Annual rainfall of 1,500 to 3,500 mm well spread through the season
- Soil structure – freely draining but retentive
- Water table – below 2 metres
- Soil pH between 4.5 and 5.5
- Humidity high enough not to limit growth (dormancy onset at saturation deficit below 2.3 kPa)
- Light intensity of at least 700-800 Watts per m2.
  Aspect – generally, in the northern hemisphere, a sloping southerly aspect is preferred to maximise solar flux.

These are the ideal conditions for tea growing but tea thrives in many places under less than optimum conditions. However, as conditions become less ideal productivity reduces – the cropping season becomes shorter (fewer productive months in the year) and the yield becomes less (less weight of leaf in each cropping month). Undoubtedly there are some factors that will kill tea stone dead – waterlogging of soil, or prolonged drought, but other factors affect growth and kill more gradually – for example incorrect pH, over-plucking, and poor nutrition. Our skills as agriculturalists can offset some of these constraints – and frequently we find quality is related inversely to yield – thus tough conditions often give highest prices per kg of tea – though the weight harvested will be less. One thing that is certain about marginal tea growing conditions: yields of the level achieved in

East Africa (5,000 to 8,000 kg of commodity tea per hectare) will never be seen in Scotland. What makes tea growing potentially commercial under the marginal conditions of Scotland is that specialty tea when well grown, well processed and well marketed can achieve prices a hundred times more per kilogram than Kenyan commodity tea ever does.

Can tea be grown in Scotland?

Given knowledge of tea's requirements and the skill to manipulate local conditions tea can in theory be grown anywhere. Since the advent of the specialty tea boom in North America many artisan tea growers have emerged, growing in 17 US states, under a range of challenging conditions.[2] While Scotland is the furthest point from the equator that tea has yet been grown commercially (Forfar is at latitude 57° north), the evidence is in the ground and on retailers' shelves that it can be grown here. The big questions are whether it can be grown here commercially for profit - and if so – how?

Where can we source suitable plant material?

Climatic conditions in Scotland, and indeed anywhere north or south of the Tropics, requires the use of cold tolerant Camellia sinensis var. sinensis – China type or China hybrid varieties. Tea plants have for commercial reasons been introduced into many countries over the years and, while some major tea countries forbid the export of plant material, it is nonetheless quite easily obtained from smaller tea growing countries. Teacraft has obtained seeds from Nepal and the Republic of Georgia for the Scottish Artisan Tea Producers and for other projects plant material (for cuttings) from South Africa, Pakistan, and the USA. All of those countries and many more, have China type plants that would be at home under Scottish conditions. There are import restrictions into many countries

[2] Currently growing in Alabama, California, Florida, Idaho, Kentucky, Georgia, Hawaii, Louisiana, Michigan, Mississippi, New York, North Carolina, Oregon, South Carolina, Texas, Virginia, Washington, and also in British Columbia in Canada.

but tea seed can currently be imported into European Union countries without a phytosanitary certificate.

Seeds or cuttings, or ready to plant saplings?

Seed is the cheapest option and requires the least skill to establish them. Seeds however do not breed true though the resultant plants tend to be tougher and resist field abuse better than their elite clonal cousins. Cuttings allow plant selections to be propagated true to type by VP[3] but getting cuttings to root can be tricky and requires some horticultural skill and a glasshouse. Cuttings material is more expensive to import and is subject to greater restrictions. Planting field ready saplings (either seed or VP derived) is an ideal way to start but is the most expensive as they must be cared for by somebody else in a greenhouse for 12 months. Ideally, the beginner should start with field ready plants, then try growing from seed, and then aspire to propagation from cuttings.

How easy is it to propagate? What are the constraints?

In many countries, tea seed is direct planted into the field. This is not recommended under the severe conditions typical of Scotland. Here the minimum conditions for propagation from seed would be protection under a polytunnel. Seed would be sown into a bed and transplanted into sleeves or pots when germinated. Soil warming is not essential but will give a sturdy plant more quickly. In a basic unheated polytunnel, it will take 12-18 months to produce a viable sapling. The Scottish Artisan Producers are in the main raising their seed in background-heated glasshouses.

[3] VP – vegetative propagation from cuttings

What are the constraints to Scottish grown tea?

Temperature

Looking at the ideal conditions shown above we can see from historical climate records that air temperature will be limiting outside the summer months of June, July and August. Night temperature induced dormancy (nights below 10-11°C) will restrict plant growth for nine months of the year. We can mitigate to some extent this temperature constraint by use of temporary or permanent polytunnels, or by use of horticultural fleece. The local soft fruit industry should give useful guidance. Other constraints to growth are:

Water

Tea needs a minimum of 1,500 mm of rain annually – Dundee receives an average of only 761 mm. In areas where rainfall is unreliable or insufficient, it will be necessary to install irrigation. Given the current level of climate volatility around the world Teacraft advice to all tea growers, irrespective of historical precipitation records, is to install irrigation. Cost can be mitigated by using the system for low labour / high efficiency fertilizer application by fertigation. Drip irrigation is the most effective system in terms of water usage. Tea responds well to drip irrigation.

Soil drainage can be improved by deep cultivation and ditching, though both these need to be adjusted for local conditions of soil depth, stoniness, and slope. On the other hand, soil water retention is enhanced by ridging and mulching and/or planting on the contour; these are useful for alleviating drought conditions.

Soil pH

Tea yield reaches its full potential between pH 4.5 and 5.5 above and below which its performance declines. Tea dies below 3.0 and above 7.0. Thus for a yield of, say, 1,000 kg made tea per hectare at a soil pH of 5.0, the yield from a similar soil at pH of 6.0 would be reduced by 30% to 700 kg MT/ha; similarly with a similar soil at pH 4.0. Input costs, however, would remain the same. The farmer's profit is of course proportional to his tea yield - and directly linked to the correct acidity of his soil.

Soil pH should be frequently monitored; it can be unbalanced by using unsuitable fertilizers, by the rotting of unsuitable mulch, by irrigating with alkaline water, or by run–off from adjacent fields. Soil

pH may be manipulated when necessary: it can be acidified using elemental sulphur, or aluminium sulphate.

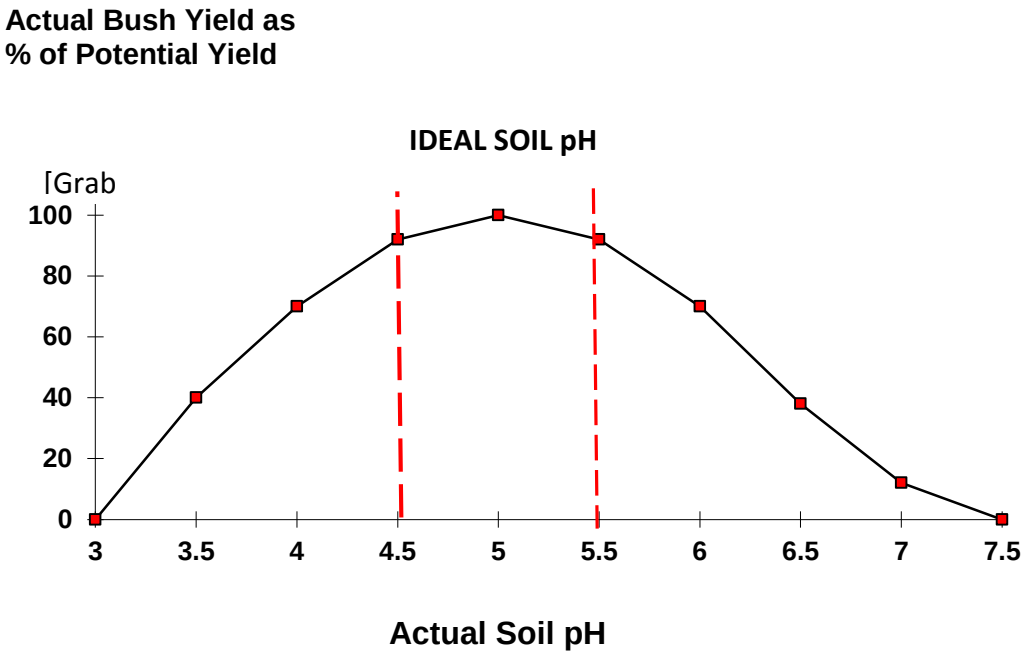

Figure 2. Effect of Soil pH on Actual Tea Yield as Percentage of Potential Yield

It is difficult however to make large reductions in pH using organic inputs, though poultry manure is a possible route. Bracken and/or pine needles will maintain a low pH but are ineffective for rapid reliable acidification. If necessary, a soil can be made less acid by the application of Dolomite (magnesium carbonate). Straight chalk or lime should never be used on tea soils.

Humidity

Tea bushes thrive under humid conditions. Dry air will cause leaf damage – tip burn; this occurs mainly in pot-grown plants and nursery plants. Severely low humidity will actually cause onset of plant dormancy.

Humidity around bushes can be improved by use of shade trees (effective mainly in the tropics as the resultant reduced light restricts growth in temperate areas). Sprinkle irrigation is effective in

the short term but soon evaporates. Thick mulching, though this should not be overdone as many fungal diseases also appreciate a wet environment, can provide longer-term humidification.

Damage and reduced growth because of wind exposure is primarily caused by drying out of the leaves due to excessive evapotranspiration. Growing in walled gardens gives a degree of protection but shelterbelts of trees and windbreaks to the east and west of Scottish plantings may prove necessary to reduce exposure.

Latitude

Yield is maximum at the equator if it is grown at a high enough elevation to maintain its optimum temperature range. Yield falls off as the growing location latitude is increased. Figure shows average annual tea yields from 31 locations spread across latitudes of 0 to 44 degrees north and south. There is a fair spread of yield at any given latitude due to inherent differences in cultivars, bush age, husbandry skill, and the quality and type of tea being grown. However, a linear trend line through the data (shown in solid black) extended to a typical east lowland latitude of 56.5°N (solid

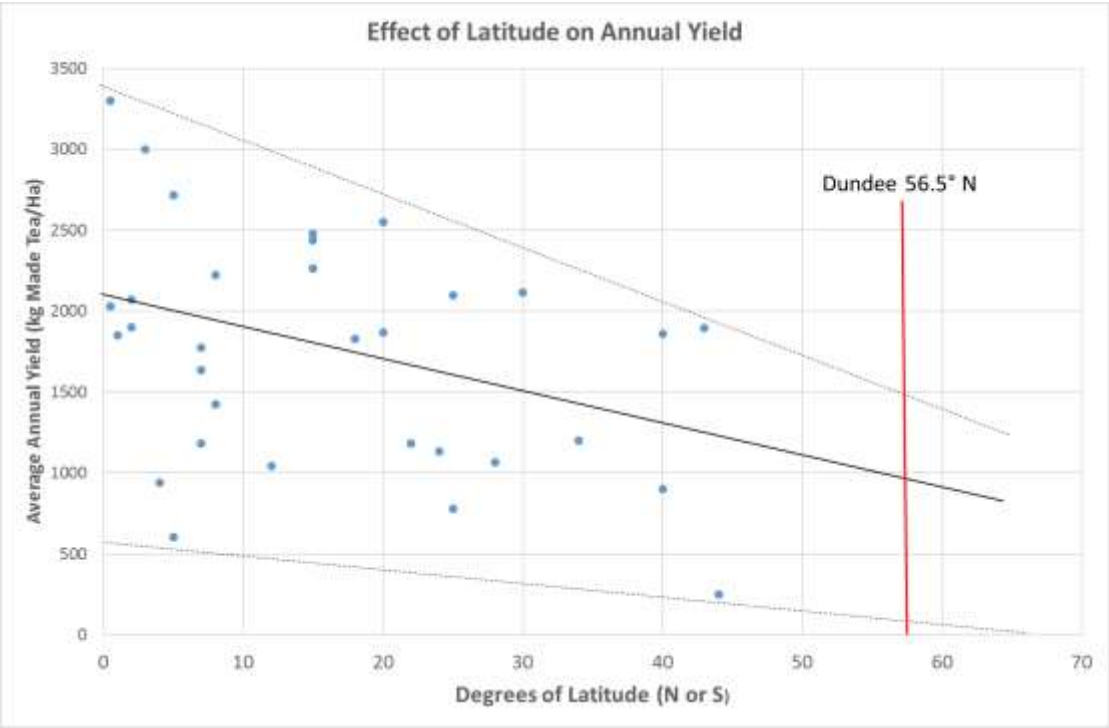

Figure 3. Effect of location latitude on average annual tea yield

red) shows that a yield of 950 kg/ha might be possible. The yield/latitude envelope (enclosed by black dotted lines) indicates a spread from 100 to 1,500 kg/ha. For Scotland we assume a normal season yield of 300 kg/acre plucked at 2L&B standard and 180 kg/acre at 1L&B standard. With full season extension we assume 500 kg/acre if plucked at 2L&B standard and 300 kg/acre at for 1L&B.

Light

Light is the energy source for plant growing. Vigorous growth depends on active photosynthesis that requires adequate light; as light availability decreases so bush growth becomes slower and yield is decreased. The availability of sufficient light is possibly the greatest hurdle to overcome for tea growers outside of the traditional areas within the latitude band of 0-43 degrees. In areas above this the light intensity is progressively lower, short days are greater after the autumn and before the spring equinoxes, and cloudy days are increasingly more common. Figure 4 explains the reduction in light intensity on Forfar (57°N) compared to the Equator (0°) where at midsummer noon a square metre of sunlight falls on a square meter of ground. In Forfar the low angle of the sun at midsummer noon (33°) means that a square metre of sunlight falls across 1.92 m2 of ground – diluting the light to 52% of Equator sunlight.

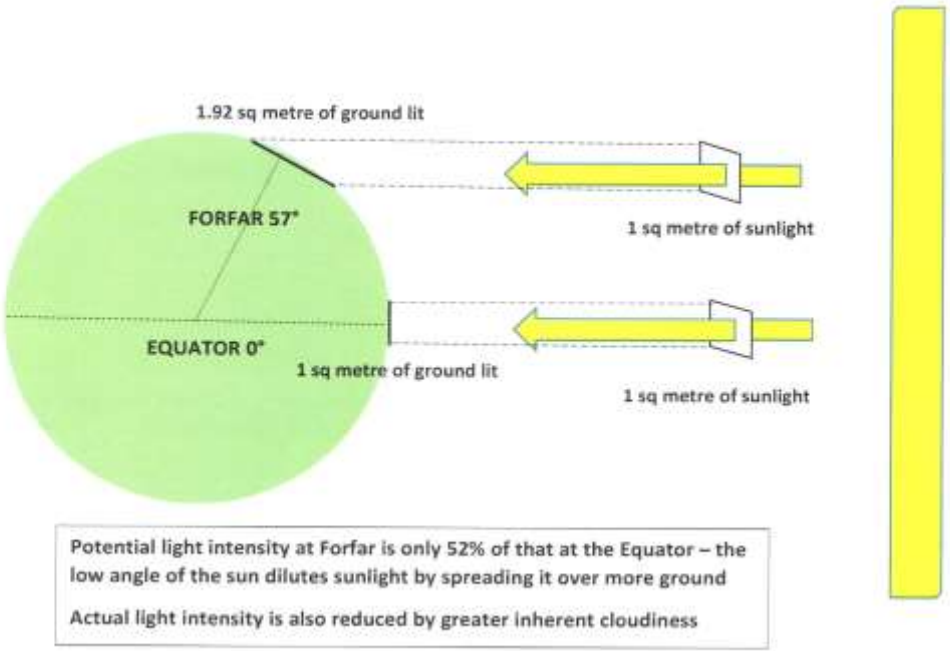

Figure 4. Showing why light intensity reduces away from the equator

Reduction in solar radiation and its soil warming effect slows down growth rate and therefore diminishes commercial yield. Actions on the part of the grower to optimize the availability of light to the plant will pay dividends. See Section "How do we improve our chances of growing tea in Scotland" for some suggestions.

How easy is tea to harvest? What are the constraints?

Tea is traditionally harvested by removing tender new growth by hand using a technique termed "selective hand plucking" where young actively growing shoots or "tips" are removed from the bush. Conventionally for good quality a tip comprising "two leaves and a bud" or 2L&B is chosen. However, when the plucker comes to the bush the tips may be at a continuum of ages from tiny bud initials to three or more leaves and a bud. In selective plucking the older tips (> 3L&B) if any, are plucked and thrown away – called "breaking back". The 2L&B shoots are plucked and collected into the plucker's basket, and the smaller tips and buds are left to grow for the next plucking round. If the round length is chosen wisely then the number of oversized shoots is very small, and the number of 2L&B is maximised – this is the green leaf raw material from which all types of tea are made. Really high value teas are made, when the leaf conditions are right, by selective hand plucking of single leaf shoots with a bud, and even just the plucking the unopened buds without leaves. Constraints to this simple and effective traditional plucking system are:

Skill

It takes a lot of practice and a lot of concentration to maintain precision selective hand plucking for any length of time – nevertheless, skilled pluckers will keep it up for an eight-hour shift and pick around 15 kg of shoots. Any lapse in attention will add coarse leaf to the basket and result in a lower price for the resulting tea.

Yield – the weight of harvested matter

For newcomers, while learning to pluck, it is a very slow job – this increases production costs. When skilled it is still slow procedure, as speeding up invariably reduces green leaf quality – this reduces selling price. Many attempts have been made to introduce mechanization but, while this

improves speed, it has so far only been possible by reducing quality. Speciality teas cannot (yet at least) be made from machine harvested green leaf. However this may change in the future – see Section "Speeding up harvesting" page 48.

What level of yield may be expected?

Yield – the weight of harvested crop per given area [4] – responds to two kinds of influence: i) effects that the grower cannot modify, and ii) effects that can be readily manipulated. Agriculture becomes increasingly effective as we learn to reduce the influence of the former group and maximise the latter.

Tea yields vary considerably around the world - some small organic gardens in Sri Lanka produce only 400 kg MT/ha, China averages 779 kg MT/ha, Sri Lanka average 1,818 kg MT/ha, India 2,128 kg MT/ha, Kenya smallholders 2,028 kg MT/ha, and Kenya estates 3,300 kg MT/ha. The world average is 1,165 kg MT/ha. However good operators will individually achieve much higher than average yields by planting suitable cultivars and following the rules for good growth. In Kenya, Brooke Bond routinely achieve 5,000 kg MT/ha and James Finlay has topped 10,000 kg MT/ha, while Tanganda in Zimbabwe has fields that record 8,000 kg MT/ha.

Factors that often decrease tea yield are:

- Lack of tea growing skills
- Unsuitable soil pH
- Poor soil drainage
- Insufficient precipitation
- Lack of light
- Short growing season
- Poor soil nutrition

[4] In the tea world, this Yield is most commonly expressed as kilograms of made tea (dry finished tea) obtained per hectare of growing land per annum. As a rule of thumb, we get one kg of made tea from five kg of harvested green leaf. A hectare is 2.47 acres.

- Organic growing
- Bad or insufficient pruning
- Unskilled plucking
- Poor plant genetics
- Temperatures too low – or too high
- Humidity too low
- Pests & diseases

Factors that often increase tea yields are:

- Growing in the tropics
- Maintaining the correct soil pH
- Irrigation if rainfall is low or erratic
- Fertilizing to a nutrient budget
- Plant frame training from day 1
- Maintenance pruning suiting local conditions
- Skilfully managed harvest timing
- Plucking coarsely (up to 4L&B)
- The right variety for local conditions
- Constant monitoring of crop growth and correcting observed problems
- Introduction of a degree of protected agriculture

Given the number of influencing factors both positive and negative in effect and our minimal knowledge of tea growing in Scotland, it would be foolhardy to predict a typical yield, nevertheless we need to understand what is possible . Extrapolating from world tea yields across a range of latitudes (see Figure XY) we find 950 kg/ha might be attainable with a yield/latitude envelope ranging from 100 to 1,500 kg/ha. Nevertheless, even given the best husbandry techniques, finely plucked specialty tea would be unlikely to yield more than 1,250 kg MT/ha and would be more likely to achieve 600 to 900 kg MT/ha. This equates to 243 to 364 kg of made tea per acre during

the typical 12 week Scottish tea growing season. Using season extension technology,[5] we may be able to increase yields to 500 kg/acre (see page 32).

We cannot at this stage say what proportion of the crop would be suitable for the very highest tea production – it may be (as in China) that first flush or spring green leaf is harvested by hand for really high end tea with the summer and autumn leaf being harvested by machine for lesser value teas.

What level of quality is possible?

It is easier to predict Scottish tea quality than yield. We know from many instances in the tea world that a degree of plant stress enhances quality while it decreases yield – this is good news for Scottish tea growers. However, the stress must not be too high, and the induced potential quality expected in Scottish grown green leaf must necessarily be maintained by skilful harvesting and sustained right through the manufacturing process.

What resources will I need?

A suitable growing site – deep well drained soil with a gentle slope to aid drainage, a southerly aspect to maximise natural light, and protection from cold, drying winds. Walled gardens are ideal as the Victorian garden planners had similar aims for raising their tender and often exotic plants.

Personal resources required are patience, optimism and resilience.

[5] This may include the use of horticultural fleece, windbreaks, growth sleeves, permanent or temporary polytunnels, soil heating, supplementary lighting, or any other techniques borrowed from current and future commercial horticulture as well as, eventually, improved cultivars less liable to cold induced dormancy.

How much will I need to invest?

Initial financial investment is split across purchase or raising plants and land preparation and planting. Tea is a perennial plant that takes time to come to maturity. Under ideal conditions first plucking may be attempted at three years while full maturity takes five years to achieve, thus there is no income for four years (1 year in nursery and 3 in the field) and six years for full income. Under Scottish conditions, we can expect first plucking at four or five years in the field while full maturity may require seven to eight years. Undoubtedly we shall learn how to accelerate this process but it is a given for tea growing that up-front capital costs and initial delay in income gives tea growing a long time to break-even point. More attractively, tea is a long-lived plant. Some gardens in Darjeeling have large areas of bushes planted in the 1850s that are still being grown commercially. The typical working life for modern tea plants around the world is 50 to 80 years for seedling tea, VP clonal tea[6] was first introduced in the 1960s and while some of this is being replaced by modern higher yielding clones, much of the original material retains its original vigour. Thus, we can defray the start-up costs over a very long asset life.

Actual costs will be addressed in Section "What is the investment cost?" (See page 31). They vary widely depending how much work is outsourced, the scale on which tea is planted, and the degree of mechanization used. A recent artisanal tea propagation and planting operation in the USA costed field establishment at £2.48 per plant or £11,160 per acre.

What labour input is required?

Mechanization is the realm of the large-scale grower. With an acre or less, most tasks will be manual and will require manpower. Phases during bush establishment that are particularly demanding of labour are:

- nursery tube filling, seed planting and transplanting
- marking out for planting

[6] Clonal tea is genetically identical within a clone or cultivar. It is vegetatively propagated (VP) by raising plants from cuttings.

- digging planting holes
- planting
- weeding in the 3 to 5 juvenile bush years
- irrigation if this is not automated

Once bushes are mature, providing that they have been planted at sufficient density their canopies will merge and weeds will be discouraged. Thereafter the principle labour input is plucking (weekly), fertilizing (twice yearly if solid fertilizer is used), skiffing or light pruning (annually), and heavy pruning (five yearly).

How long will it take to maturity?

This depends very much on how swiftly it grows. Under ideal climatic conditions and assuming optimum bush training full maturity takes five years to achieve. Under Scottish conditions, we can expect first plucking at four or five years in the field while full maturity may require seven or eight years. Anticipated yield profiles (as a percentage of the potential mature bush yield) achieved over time under ideal and Scottish conditions are shown in Figure 5.

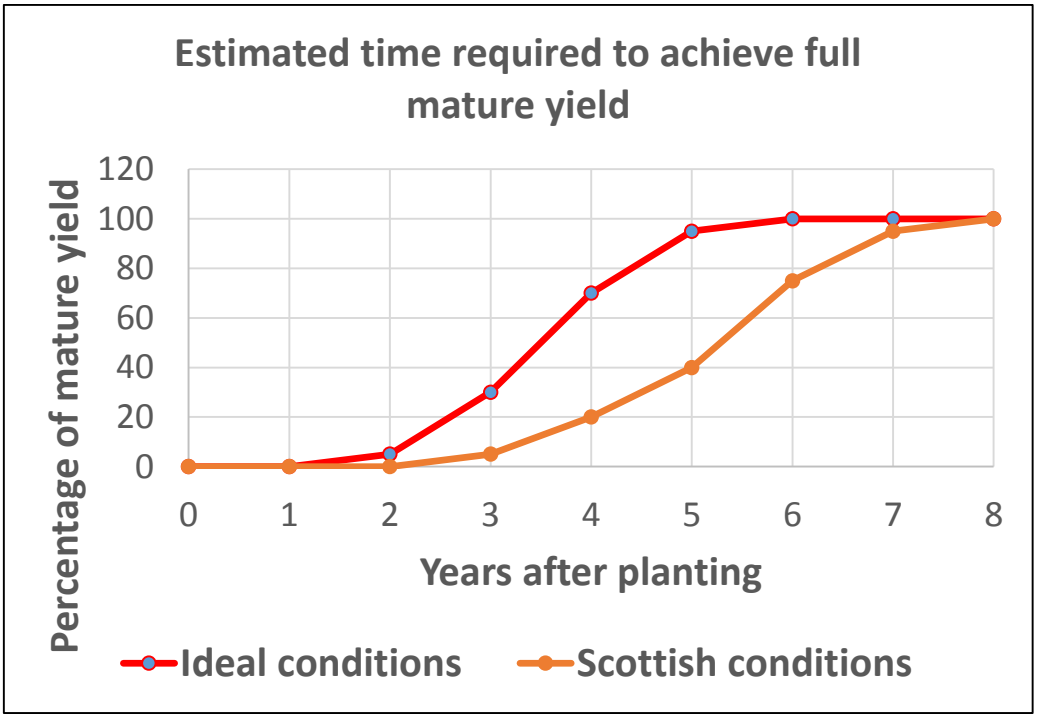

Figure 5. Estimated time to achieve full mature yield under conventional and Scottish conditions

Note that establishing tea under a strictly organic growing regime will delay the time taken to maturity beyond that shown above.

How much tea should I grow?

Choosing the right area of tea to grow is very much like choosing a financial investment that meets one's own risk appetite. On the upside, tea has a high value when well grown and the more one grows relatively speaking the cheaper the cost and thus the higher the reward. On the downside, tea growing has a fair degree of risk of failure and of financial loss and this peril increases by growing it under marginal conditions. To be in the vanguard of a new venture adds the additional danger that the ground rules are not yet established. Plunging into a venture with minimal expertise further compounds the risk. In this scenario about the only immediate action available to mitigate the risk is to choose to grow it on a small scale and build up from there.

Some degree of scale however is necessary – half a dozen pots of tea will not sufficiently develop the grower's skills. Informed judgement would say that under Scottish conditions one quarter to one acre of tea (1,000 to 4,000 plants) reduces the risk for new growers to an acceptable level.

What are the key constraints to production?

Constraints to production and their solutions will be discussed fully in Section 2. In summary they are:

- low levels of natural light
- short cropping season
- plant material not yet selected for local conditions
- lack of appropriate technical expertise
- high labour costs
- grower skills

What are the key drivers to success?

- the emerging high value specialty tea market that allows previously prohibitive labour costs to be used
- perception of health benefits of tea – particularly of some specialty teas
- consumer interest in local food production, and their willingness to support it
- vague consumer distrust of tea growing ethics and practices in traditional tea countries

Processing aspects

Is hand processing viable?

Any successful long-term commercial activity requires that the selling price must exceed the cost of production plus the cost of sale. Hand processing of tea, particularly in a high labour cost economy, is necessarily an expensive undertaking. Many attempts in various countries at making hand created artisanal teas have failed in the past, as there was no ready market for them. What has changed in the past 20 years is the emergence of a specialty tea trend, first in the USA and then in Europe, that recognizes the quality, and is willing to pay the price, for high quality hand made teas. Appendix 7.

Can anyone process tea?

If you are sufficiently skilled and manually dextrous to grow and harvest your own tea you should certainly be able to process your green leaf into made tea. As with cookery, skill comes with practice plus enthusiasm and a willingness to learn. Consistency comes with care and attention to detail.

What sort of tea is best to make?

Experimentation will soon confirm what sort of tea is best made from your tea plants and their interaction with your terroir and processing methods. Strictly speaking, any one of the six tea types can be made from green leaf of any tea bush, but to make an exceptional example of any type requires matching of green leaf quality with appropriate processing conditions. Input from a trained artisanal tea maker put you on the right path and eliminate a good few learning mistakes.

What equipment is needed?

The early tea makers used their hands for rolling and shaping tea and sunlight for drying – nothing else – some artisans in Rep of Georgia and China still create wonderful teas using no more than this. It is still the best way to get to know your own leaf with its advantages and limitations: it is best done at an early stage when it can help define the best investment path for each grower's location to optimize its tea type and quality. Expert assistance at this stage will help eliminate a lot of time and error mistakes. Depending on the amount of tea you want to make, and the type of tea you find is best, some mechanical assistance will be useful. Small scale equipment is available from India and China – see Resources Section.

How much will it cost to process a kilogram of tea? (Cost of Production)

Depending on tea type and the tea maker, it takes around 24 hours to pluck and process a batch of tea. During much of this time it requires no more than an occasional check and adjustment of conditions if necessary. Some tea types – oolong in particular – may require attention during the night. The skilled tea maker when properly organized should be able to produce a kilogram of made tea each day that green leaf is available - but do not expect to reach this level at first. Depending how you cost your time it will be a day's work to make that kilogram. Scaling up production by using appropriate mechanical assistance will give you more weight per day, but your market may value this less than real hand made tea.

For a true calculation of cost of production you must include the labour and agricultural inputs required in the field, the labour cost of harvesting, a share of capital expenditure on equipment, electrical power and process labour, and cost of packaging; also make an allowance for wastage. The labour cost of harvesting green leaf is always the highest element; in large gardens around 50% of the total cost of production.

Should I be a grower, or processor, or both?

Each of these work though splitting roles requires some careful establishment of responsibilities and trust. Provided there is a market established for green leaf the choice of role depends largely

on personal preference. Vertical integration – undertaking both roles gives you total control while choosing just one role allows you to concentrate exclusively on just one job. As a processor, buying in green leaf rather than harvesting it your main contributor to cost of production will be at a price agreed at the beginning of the season. As a grower, you have a steady monthly income rather than waiting until the made tea is marketed.

Commercial aspects

How big should a tea growing business be?

As with planning your tea garden size (page 24), the ideal size for your business depends very much on personal preference, whether you are happiest as a big fish in a small pond, or prefer to be a small fish in a big pond. If you work best on your own a small business is ideal, if you are happiest in a team then a larger business may be best. However, unlike tea planting, business risk relates less to size as to speed. Growing too fast very often increases risk of failure, particularly if you borrow heavily to support its growth.

What is timescale to bush maturity, to break-even, and to end of commercial bush life?

Timescale. In the traditional tea world, the timescale is one year in the nursery, three years to first harvest, five years to bush maturity, and 50 to 80 years of commercial life for bushes.

Under Scottish conditions, we are working somewhat in the dark but our best estimates are:

- time in nursery - 12 to 18 months
- planting to first harvest – 5 years
- time to maturity – 7 to 8 years
- commercial life of bushes – at least 40 years

As a perennial crop, tea takes a fair while to mature but there is a lot of work do during this period. Note that maturity is delayed by poor husbandry in the early years. Just like raising children, the success of mature bushes relies heavily on the right training applied during their formative years.

Bush training comprises:

- curbing excessive growth in nursery to give a 12” stocky plant
- hardening off before planting out
- initial de-centering to 6”when planted to give three shoots
- formative pruning in Field Year 1 to 12” to give nine woody shoots in Year 2

- formative pruning in Field Year 2 to 14” to develop nine woody shoots in Year 3
- formative pruning in Field Year 3 to 16” to give 27 woody shoots in Year 4
- formative pruning in Field Year 4 to 20” to develop 27 woody shoots in Year 5
- table formation in Year 5 allowing a rise to 30” in Year 6
- commence commercial harvesting in Year 7 with table rise (creep) of 2 to 3” per year
- maintenance pruning (reforming the 30” plucking table) is then undertaken on a four year cycle

Test processing and product development can be undertaken in Years 3 to 6 using fresh leaf derived from pruning.

Breakeven point – where total investment is balanced by accumulated income – depends on individual factors that need considering separately in a business. Tea growing typically expects a long period before breakeven due slow maturation of a perennial crop; orchards or woodland have the same problem. Once the crop is established, the input cost element is much reduced and the operating margin after maturity is reached is far better than with annual crops. A typical small tea garden in the temperate tropics will expect to break even in 5 years. In Scotland, this might be closer to 7 to 10 years, depending on the skill of the grower and the level of technology utilised.

Bush life. In the tropics, tea bushes increase their annual yield to a maximum in years 30 to 40 and then begin a decline. Rejuvenation pruning at 40 years can kick start a second youth but 80 years is generally accepted as the limit for commercial purposes, though a high proportion of Darjeeling bushes are 120 years and more. Much tea is replanted before it reaches a terminal decline as plant breeding constantly replaces existing cultivars with higher yielding ones. We have no data to base estimates of the commercial life of tea bushes grown in Scotland; to be on the safe side we might expect 50 years.

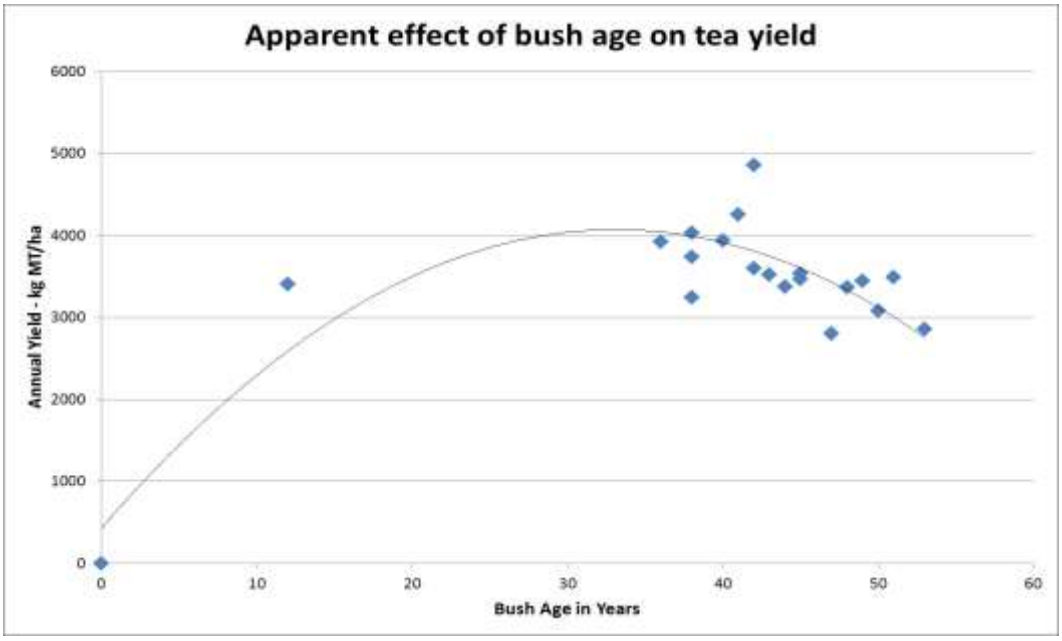

Figure 6. Effect of Bush Age on Yield (data from Colombia)

What is the investment cost and the ROI?

Tea growing, as with any other perennial crop is expensive to establish, slow to mature, but requires minimal input during its long years of commercial harvesting.

Figures from a recently set up artisan tea garden in the USA give an idea of the cost centres and values on a per plant basis:

- Land preparation USD 0.60
- Seed cost 0.12
- Nursery cost 2.01
- Planting labour & inputs 0.47
- Field losses @10% 0.32

Total cost per plant in field USD 3.52 (= £2.48)

We do not yet have equivalent data for Scotland but this will undoubtedly be more expensive for the group as the scale of the Scottish operation is smaller than in the US. For profitability estimation we will use £3.50 per plant in the field[7].

At 4,500 plants per acre,[8] this is an establishment cost of GBP 15,750 per acre by Year 1 (planting year). As experience is gained, future plantings will certainly cost less per plant and the US grower is aiming for a 33% reduction as he gains experience. Land preparation is a big variable depending on previous crop history on the land and any requirement for major drainage or subsoiling, or acidification adds to cost. Note that these estimates do not include the cost of management time or technical consultancy – an activity that reduces wasted time and money but necessitates a significant outlay. Also note that the costs are based on a start-up basis – doing things for a second or third time always reduces cost as expertise is gained. Sharing of experience between growers will inevitably improve success and reduce wastage and loss, leading to significant cost saving.

Costs in the period between planting and first harvest will be low – say, GBP 0.90 per plant - primarily labour for weeding and formative pruning. Weed control labour in particular can be minimized by use of mulching and mowing. Some formative pruning can be mechanized. Cost per acre in Years 1 to 3 will be GBP 4,050. Again, sharing of equipment and expertise within the group can help reduce these costs.

Costs jump in Years 4 and onwards due to the labour demand for plucking and increased fertilizer required to replace nutrients removed in green leaf. Weeding and pruning labour costs will decrease as bushes mature. Annual inputs thereafter, apart from plucking labour, will be around GBP 1,000 per acre. For making the highest quality tea, fine plucking is required. Expect one trained person to harvest half a kilogram of really fine plucked (1L&B) green leaf per hour or 1.5 kg of 2L&B fine standard per hour.

[7] This assumes grower propagation of plants – buying in field ready plants will make establishment considerably more expensive.

[8] Plant density is a variable – if increased to achieve faster ground cover and a shorter time to harvest any increase means higher nursery costs and planting costs. The tea industry norm has increased from 2,150 plants per acre in the 1930s to 4,050 in the 1980s to around 5,000 currently. The optimum figure for Scotland has yet to be identified but we will commence with 4,000 to 4,500 as a target.

Assuming when mature a Scottish tea garden, using season extension technology, may yield up to 500 kg of made tea per annum and that a kilo of made tea requires 5 kg of green leaf then the owner of one acre of bushes will pluck 2,500 kg of green leaf annually. For 2L&B standard this is 1,667 hours of work, which at a pay rate of GBP 8.20 per hour (at current UK Minimum Wage plus £1) the labour cost is £13,669 per acre plus inputs of £1,000 (equivalent to a Green Leaf cost of £5.87/kg). For 1L&B standard, the expected annual yield would fall to around 300 kg/acre. This represents 3,000 hours of plucking labour, which at a pay rate of GBP 10.20 per hour (at current UK Minimum Wage plus £3)[9] the labour cost is £30,600 per acre plus inputs of £1,000 (equivalent to a Green Leaf cost of £21.07 per kg).

Our field costs per acre from establishment to mature tea, being plucked to either a 1L&B or 2L&B standard now look like this assuming tea is grown without added protection i.e. a normal season length:

		Annual costs in £ per acre	
		Plucking 1L&B	**Plucking 2L&B**
Year 0	Costs up to planting	15,750	15,750
Year 1	Prune & weed	4,050	4,050
Year 2	Prune & weed	4,050	4,050
Year 3.	Bushes at 5% of mature yield	5,968	5,460
Year 4.	Bushes at 20% of mature yield	4,672	2,640
Year 5.	Bushes at 40% of mature yield	8,344	4,280
Year 6.	Bushes at 75% of mature yield	14,770	..7,150
Year 7.	Bushes at 95% of mature yield	18,442	..8,790
Year 8.	Mature bushes (100% of yield)	19,360	9,200

[9] Reflecting the extra skill required to pluck green leaf to a truly fine standard.

However, if tea is grown with full protection to give a maximum season extension then our field costs per acre from establishment to mature tea, being plucked to either a 1L&B or 2L&B standard now look like:

		Annual costs in £ per acre	
		Plucking 1L&B	**Plucking 2L&B**
Year 0	Costs up to planting	15,750	15,750
Year 1	Prune & weed	4,050	4,050
Year 2	Prune & weed	4,050	4,050
Year 3.	Bushes at 5% of mature yield	6,580	5,744
Year 4.	Bushes at 20% of mature yield	7.120	3,733
Year 5.	Bushes at 40% of mature yield	13,240	6,467
Year 6.	Bushes at 75% of mature yield	23,950	11,250
Year 7.	Bushes at 95% of mature yield	30,070	13,983
Year 8.	Mature bushes (100% of yield)	31,600	14,667

Plucking costs rise steeply with fineness of pluck (one leaf rather than two) and with season extension (as yield is boosted and more leaf must be harvested).

These costs look like a lot of money being spent. But what can we expect to come in? Providing that the green leaf is correctly processed and the made tea is marketed well a 2L&B Scottish specialty tea should sell at retail on the world market from £50 to £100 per kg, and from £300 to £400 per kg for a 1L&B tea.[10] For the extended season approach gross profit in mature Year 8

[10] Considerably higher retail prices have been achieved in 2015 for Scottish made tea by Wee Tea Company (£2,300 per kg for Dalreoch White Tea) and by Pekoe Tea of Edinburgh (£2,500 per kg for Kinnettles Gold). We consider it unlikely that such high prices are sustainable: £50-100/kg for a 2L&B standard and £300-400/kg for a 1L&B standard match international price realisation.

onwards would thus be around £35,000 per annum per acre for 2L&B tea and £85,000 for 1L&B tea. For normal season growing, gross profit in mature Year 8 onwards would be around £21,000 per annum per acre for 2L&B tea and £53,000 for 1L&B tea.

A simplistic Profit & Loss graph is shown below for extended season grown tea. This needs to be refined for individual businesses.

It indicates a profit situation for 1L&B teas by their fifth year in the field after planting and (because of their lower retail value) in the sixth year for 2L&B harvested teas. Realistically most growers will make some of each type thus an overall 4 year break-even period may be assumed. Note that the yields estimated in this projection do assume that successful season extension measures are in place.

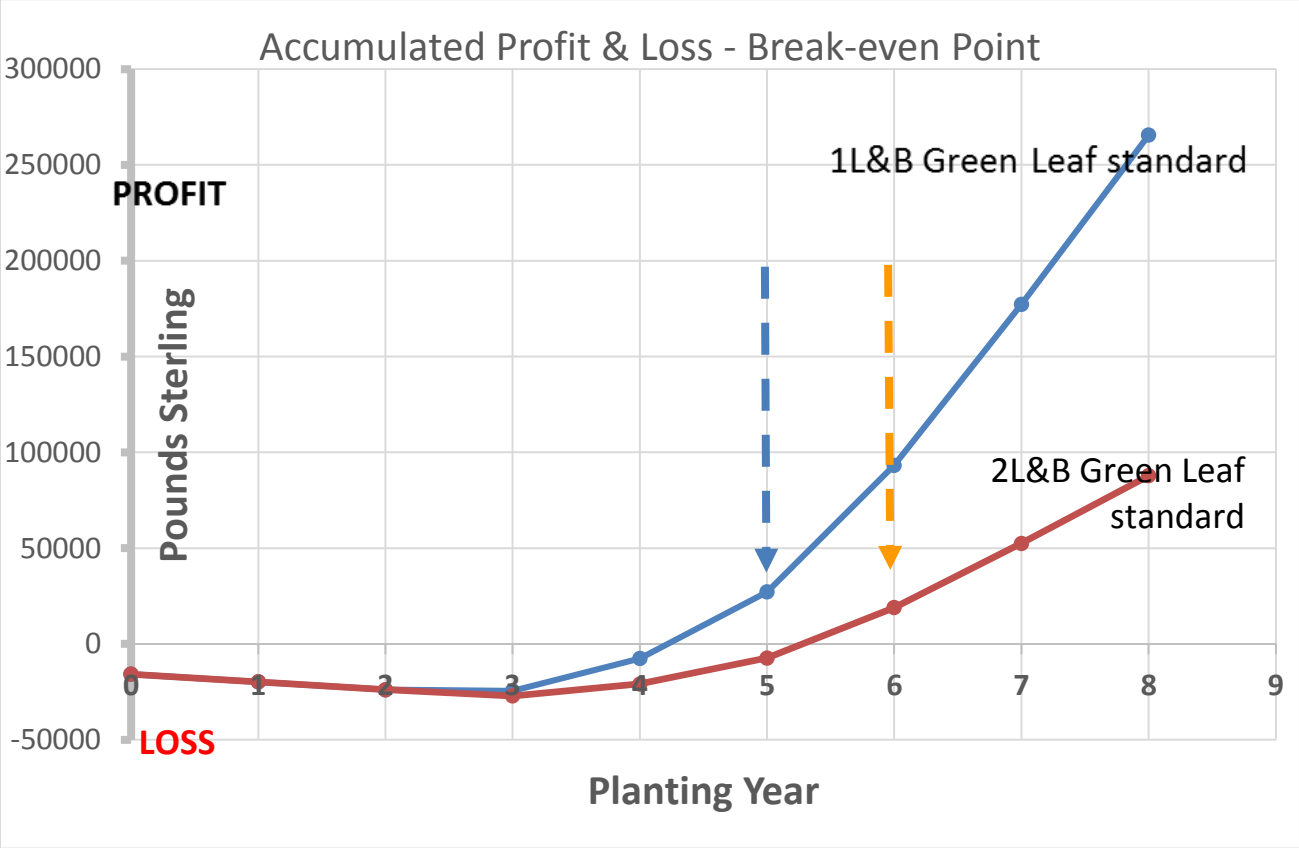

Figure 7. Accumulated profit & loss estimate for two standards of Scottish specialty tea

Without season extension, the breakeven occurs in Field Year 5 (1L&B) and Field Year 7 (2L&B).

Marketing aspects

Who will buy my tea?

Buyers for high class retail outlets such as Fortnum & Mason and Harrods in the UK. High-end hotels in London, Paris, New York, Dubai and Tokyo. Specialist teashops and stores such as Pekoe Tea, Postcard Tea, Canton Tea and Nothing But Tea in the UK, Marriage Freres in France, and Harney & Sons in the USA are keen to spot and feature innovative specialty teas. In the USA specialty tea sales through a myriad of merchants are increasing by 10% year on year and currently stand at $1.9 billion (wholesale value), representing about 17.5% of total US tea sales[11]. Twenty years ago, specialty teas were an unknown segment. In the UK, the total sales value for teas is £0.9 billion with the specialty segment at £100 million. Green tea sales alone in the UK have doubled between years 2009 to 2012 to £30 million[12].

Selling to wholesale distributors is also an option though they do require assurances on volumes. Many tea wholesalers are located in Germany.

A possible alternative outlet for Scottish growers is through direct retailing by e-commerce. While this route is possible for an individual, it represents a large investment of time, money and skill. Serious thought should be given to setting up a direct retailing cooperative of all the growers. This might be in the form of an e-commerce retailing company set up and owned by all the growers to market their teas either under the garden name or blended and branded by the cooperative. The KTDA in Kenya is an example of this type of cooperative organization where individual farmers[13] sell green leaf at an agreed price to KTDA process factories that they hold shares in; this price is paid monthly. The processed tea is marketed by the KTDA and the farmers get a second payment annually depending on the selling price of the factory's tea.

[11] Data from the Tea Association of the USA – though Sage Group International (Ref 11) put the total sales value much higher at $8.2 billion.
[12] Data from Statista
[13] There are more than 500,000 small farmers in the KTDA cooperative.

What are the buyers looking for?

It is important to differentiate high value specialty teas clearly from low value commodity tea. Typically, specialty teas may have one or more of these attributes:

- Rare or limited supply
- Visually different or unusual in style or appearance, colour or taste
- From a named origin, often a named garden or village or individual tea maker
- Crafted by hand or from a small scale operation
- An interesting or intriguing story as background
- Superb quality of their type
- Attractively presented
- Transparently sourced
- Sustainable or GMP credentials

Buyers seek teas of very high quality that show evidence of skilled production and presentation.

The most essential lessons to learn about specialty tea making are how to identify the best tea to make with your green leaf, how to make it, and how to maintain product quality and consistency. It is easy to make the occasional good batch but not so easy to keep doing that consistently due to the large number of variables that have to be juggled in the tea making process every time it is made

How much will they pay?

Very high prices combined with a good story always create headlines [14]and can work as an initial marketing tool but are rarely sustainable in the longer term. Retail prices used on page 34 are in line with current specialty tea trends (see also Appendix 7).

[14] Hawaiian handmade tea sold at Harrods in 2014 for £6,000/kg. Wee Tea is selling Scottish tea at £2,300/kg in 2016.

Retail direct sale versus selling wholesale – which is best?

Producers achieve the best price by selling direct to the end or retail customer. Selling specialty teas to an intermediary wholesaler or distributor will realize only a third to one half of the retail value. However, for a tea grower it is far more complicated, time consuming and expensive to set up as a retailer, whether this is in a "bricks and mortar" shop or a virtual Internet shop. Selling to a middleman is faster and easier, even though the returns are lower. Which route is best depends on individual skills and aspirations, though for many growers selling wholesale initially makes a sensible beginning which allows you to concentrate on tea production, then progressing to retail when time permits.

How should your tea be packaged?

This will depend very much on the type of outlet being sold into and the objectives of the grower. If selling in bulk to an intermediary a simple heat-sealed laminated polyfoil pouch will suffice – this maximizes product protection at minimal cost. The standard selling unit would be one kilogram. Tea should be at or below 5% moisture content when packed.

Growers interested in establishing a brand, or engaging in direct retail sales, should make their packaging support their marketing effort. A strong name, logo, colour scheme, and pack design, plus supporting media materials are an essential part of the specialty tea offer. Unique teas require unique support to justify their high prices.

What is its shelf life – how long will it store?

A well-made and well-packed tea, using suitable packaging materials, can easily have a shelf life of three to four years without loss in quality. European packers usually indicate a two year Best Before Date, this takes into account the often long time delay from garden to packer, and the seasonality of some teas.. Artisan made specialty teas tend to have a faster journey into the

shops[15] and should easily store for three years. However the consumer equates freshness with quality thus except for a few special classes of tea – aged teas and vintage teas - a short declared BBD of 12 months actually enhances the perception of the product.

Generic sale or branded?

Branding adds value to a product. Specialty teas produced under fringe conditions have a high cost of production and producers need to maintain selling margins while remembering that maximising selling price will generally also increase cost of sales. This can be a trick path to tread when computing the advantages of generic wholesale versus branded direct retail sale. Also for consideration comes the cost of packaging, of design, advertising and promotion, and of additional product wastage that retail selling entails.

Paid advertising or free promotion?

Free promotion is rarely free; one generally swaps time for payment. Social media is now a popular and widely used system to engender product awareness but to utilise it effectively requires a consistent message, a light touch, and plenty of time committed to it. Any new business should experiment with the various media available to test which works best with the product and the chosen market.

[15] Mostly they are air freighted

PART TWO: Challenges and Solutions

How do we improve our chances of growing tea in Scotland?

Scottish tea growers need be aware of the excellent market opportunities offered by the burgeoning speciality tea trend, and of the advantages that arise from growing specialty tea in Scotland. There are of course, as with any new venture, some challenges to be faced – and some solutions to be identified. Most if not all these solutions are potentially available to Scottish growers, though each will have a cost implication. For a summary see below:

Opportunities of specialty tea	**Advantages of growing tea in Scotland**
• Exploit a rapidly growing tea trend • Good local and export market prospects • Enter high value agriculture with minimal land • Excellent margins if done correctly • Exclusive niche small business • Recession resistant market	• Pride in local production • Local production minimizes travel miles • More social responsibility in supply chain • Soft fruit season extension expertise • UK production perceived as pesticide transparent • Scotland is recognized internationally as a food and drink origin • Scots were pioneer planters of C19 Colonial tea • Scotland has a plant breeding heritage
Challenges of Scottish tea growing	**Solutions available**
• Short cropping season • Low light intensity • Cold winters • Slow ROI • Obtaining elite plant material • No pool of tea growing expertise • Sourcing the right equipment • Maintaining even process conditions • Scepticism to overcome	• Protected agriculture techniques • Innovative LED light technology • Concentrate on highest possible quality • Select locally adapted seed and cuttings • Access tea knowhow via consultancy • Cooperative self-interest group approach • Develop excellent PR

Maximising productivity

Season extension

The cropping season is the period during summer when sufficient green leaf – the new tips - has grown to make a commercial harvest. The economics of growing tea depend on harvesting green leaf and for this to regrow after each harvest the plant must be actively photosynthesizing. The first leaf collection is normally termed the spring flush and the last collection of the season is the autumn flush. Leaf production continues whenever the plant is not in a dormant state. Dormancy is initiated most commonly by several continuous days of low night temperatures – below 10 to 12°C, depending on tea variety – or by periods of exceptionally low humidity[16]. Dormancy is broken and plants become active again when night temperatures exceed 10 to 12°C for several days. Historical temperature data for Dundee[17] shows the months when the average minimum temperature is below 10°C:

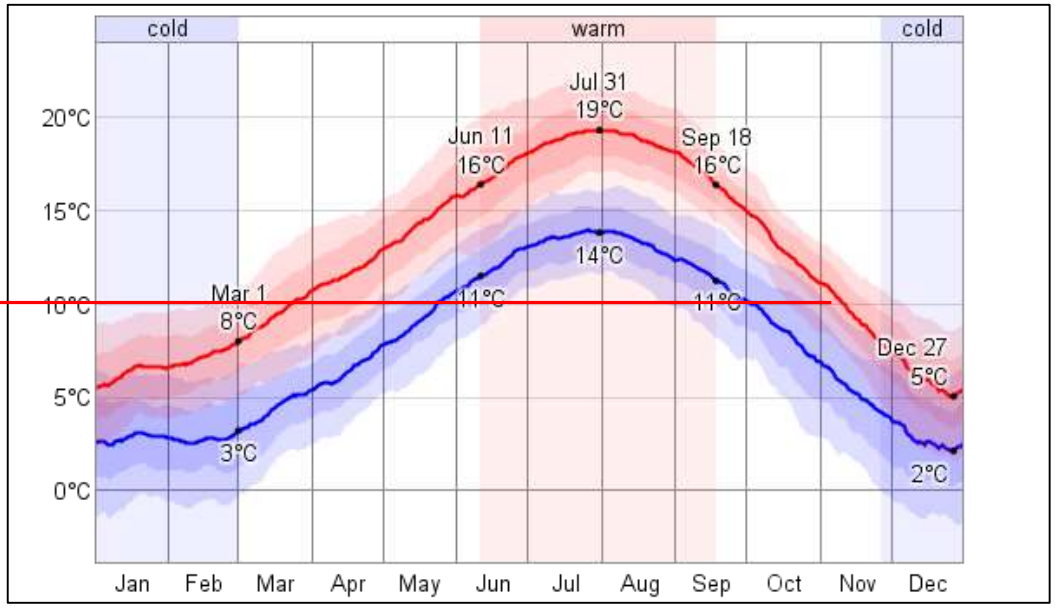

Figure 8. Average air temperatures in Dundee through the year

[16] Unlikely under Scottish conditions.
[17] Dundee Airport from 2000 to 2012 – the closest recording station to Forfar and central to the SATP group locations.

Figure 8 shows that on average the growing season will be 12-13 weeks from mid-June to mid-September. Local variations in temperature will affect this forecast by plus or minus a few days. Assuming (see page 17) an average made tea yield of 300 kg/acre/annum spread though these 12 weeks, we would produce 100 kg per acre per month. Season extension, by just four weeks at either end, will increase annual yield by 67%, to 500 kg/acre.

Season extension can be achieved in the long term by plant breeding for a lower dormancy threshold, or at present by modifying growing temperatures using proven protected agriculture techniques – fleecing, polytunnels, black mulching and geothermal heating. A simple polytunnel alone can offer six weeks extension - see Appendix 5 for more information on Protected Agriculture.

Light

Tea yield correlates with photosynthesis, the more light that is available to the plant the more synthate is produced, and the more green leaf the plant yields. Thus, any photon of light not intercepted by a green leaf is income wasted. Bushes that are too lax and let light through to the ground lose yield for you. Bushes planted too far apart allow light to reach the ground – that's money lost for you. Keeping bushes pruned to form a dense light intercepting layer will maximise yield, as will dense planting with each bush touching its neighbour. In addition, the further benefit is that weed germination and growth will suppressed by the lack of light at ground level.

Adding to natural light

One of the main challenges that Scottish tea growers face is that natural light intensity is low compared to the semi-tropics where tea evolved. Sunlight provides light energy (solar radiation) to power photosynthesis[18] but solar radiation also has other important effects on plant growth

[18] The blue and red light wavelengths in the visible spectrum that are required for photosynthesis are collectively called PAR (Photosynthetically Active Radiation). About 50% of solar radiation is PAR.

(increase in dry matter) and development (morphological change, for example from vegetative to flowering phase). These include:

- Warming of soil. This encourages growth.
- Warming of leaves. This encourages photosynthesis.
- Phototropism. This causes plants to grow towards the direction of the light.
- Photoperiodism. Daylength or the daily duration of light can affect developmental responses like flowering and dormancy.
- Mutagenesis. Some UV in solar radiation can damage cells and cause plant mutations.

In full sun at midday at the equator at the equinox, the radiant energy falling on 1m2 of flat ground is 1,014 Watts – this is called the solar constant. At the same time, at 45°N, because the sun is at a lower angle, the 1m2 is stretched over 1.41 x 1 m and is thus reduced in intensity to 71% of the solar constant. Similarly, at Forfar's latitude of 57°N, the shadows are longer and the 1m2 is stretched to 1.85 x 1m with the solar radiation diluted to 54% of the equatorial sun intensity. The actual values vary with season as the earth tilts on its axis through the year – in winter further reducing the intensity of solar radiation and in summer increasing it. This variation with season is shown below (for 52°N):

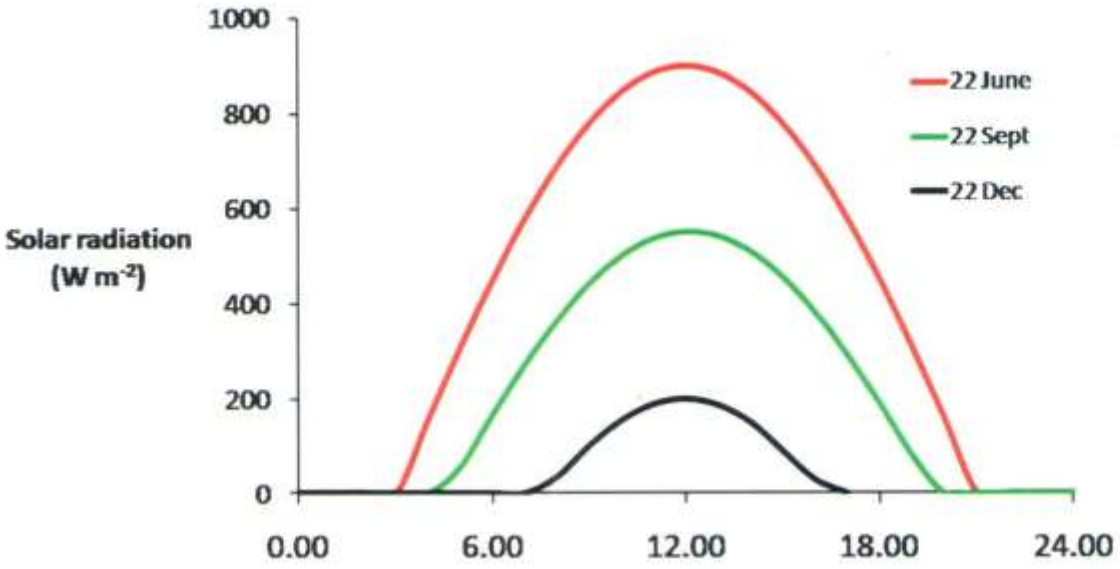

Figure 9. Diurnal variation in solar radiation on 3 days of the year at latitude of 52 deg N

Reflected light

While we can plant bushes at high density to intercept more light we cannot easily achieve ground cover with young tea, so we are wasting light that could have helped to speed up growth and development of the bush. What we can do here is to use reflectors – white or metallic boards erected either side of a row, to bounce light back at the bush, and white mulch on the ground underneath the bushes to reflect wasted light back to the leaves.

Photograph 2. Using light reflective white plastic mulch under young tea plants in Hawaii

Artificial light

Supplementary lighting is commonplace in horticulture to increase the yields of crops (tomatoes, cucumbers, peppers and flowers) out of season. The introduction of high efficiency horticultural LED lighting has slashed the running cost of artificial lighting[19] and promises to revolutionise the

[19] Even more energy efficient are the latest Light Emitting Plasma (LEP) lamps.

scope of protected agriculture. LED horticultural lighting is now being adopted by the European tomato industry and has been pioneered in the USA principally by marijuana growers. There is only one experiment published so far using LED lighting in tea growing (in Japan) and the results are reportedly excellent. See Appendix 6.

Fertilizing optimally

Getting the right fertilizer at the right dose at the right time will help to maximise productivity. Plant nutrition has never been an exact science in tea production. Much yield is wasted by under-fertilizing and much money lost by over-fertilizing. Getting the right ratio of nitrogen to phosphorus and potassium, particularly as the ratio changes during development, is also largely a matter of guesswork. Very few organic tea farms are optimally fertilized resulting in a 30 to 50% reduction in yield when compared to conventional tea gardens – this may be a key business issue for Scottish growers who wish to pursue the organic route; balancing the reduced yield from a typical organic operation with the increased costs of maintaining an organic operation.

Modern horticulture has plant nutrition well understood and tightly controlled, with nutrient application, often by fertigation or by hydroponics, to a planned nutrient budget. The nutrient budget plans the right input of nutrients into the system to balance increasing needs within the system (growth) and losses from the system (cropping). The effectiveness of the budget is tracked by foliar analysis at intervals.

For Scottish tea growers, where conditions are marginal and every gram of dry matter production counts, it is important to get nutrition optimized – that means understanding the plants' requirements and ensuring that you feed them correctly.

Choice of plant material

Scientific plant breeding of tea has been done for nearly a century and for the past 60 years the improved cultivars have been stabilized and propagated vegetatively as clonal teas. So far 500 tea cultivars have been released in the main tea breeding countries. These show much progress in

improved yield, vigour, disease resistance and cup quality, but virtually all this breeding has been centred on semi tropical growing conditions. A 2012 published review of global tea breeding in eleven countries (Ref 10) does not even mention breeding for cold tolerance, low light adaptation, or season extension – all essential attributes for improving tea growing in Scotland.

Until we can interest research establishments in Scotland to work on improving tea plant material and until the length process of perennial plant breeding show results, we have to choose plant material from what is available around the world. So far, Teacraft has imported tea seed unto the UK from Nepal and from ex-Soviet Georgia. Both sources have very cold winters that should ensure their seed and plants will survive Scottish conditions. Teacraft has supplied seed from both sources to the embryonic specialty tea growing industry in the USA where Georgian seed survived winter field conditions down to minus 10°C in 2013 and 2014. The US growers grouped as the US League of Tea Growers has attracted the interest of the Mississippi State University to take on tea breeding of plants to suit local conditions. Initially MSU are building an accession collection of genetic material of *Camellia sinensis* and close relatives.

We have advised using seeds as a starting point for Scottish growers – seeds are tough, easier to establish, and their plants do better under some extreme condition than those derived from cuttings. Unlike VP cuttings seed derived tea plants retain a strong taproot system. As Scottish growers become more proficient and confident there may be some mileage in introducing some elite VP[20] clones as they represent the bulk of tea breeding. Importing live plant material is trickier than dormant seeds but Teacraft has considerable experience with moving VP material around the world.

Synthate partition

In simple terms, this means the division of photosynthesized dry matter (synthate) into saleable material (harvestable leaf) and non-saleable material (the rest of the plant). We could strip the

[20] VP - Vegetatively Propagated using cuttings

leaves from very young plants as the ignorant early British tea growers in Assam did, but this short termism very quickly weakens and kills the bushes.

To create a truly productive bush we must sacrifice early yield to form a strong healthy bush that will be optimally productive in the future. We control synthate partition by pruning. In the first two years, we prune to divert synthate into wood growth of root and stem. When the bush frame is formed, we alter our pruning to encourage synthate into leaf growth to build up a healthy layer of mature leaf (called the maintenance layer) which becomes the powerhouse of photosynthesis. Finally, we prune to divert a proportion of synthate into the harvestable flush layer. To aid optimal synthate partition caused by correct pruning we also adjust nutrition from an initial NPK element balance of 1:1:2 to 1:1:1 and then to 5:1:1.

In the mature tea bush, the ideal total synthate distribution is:

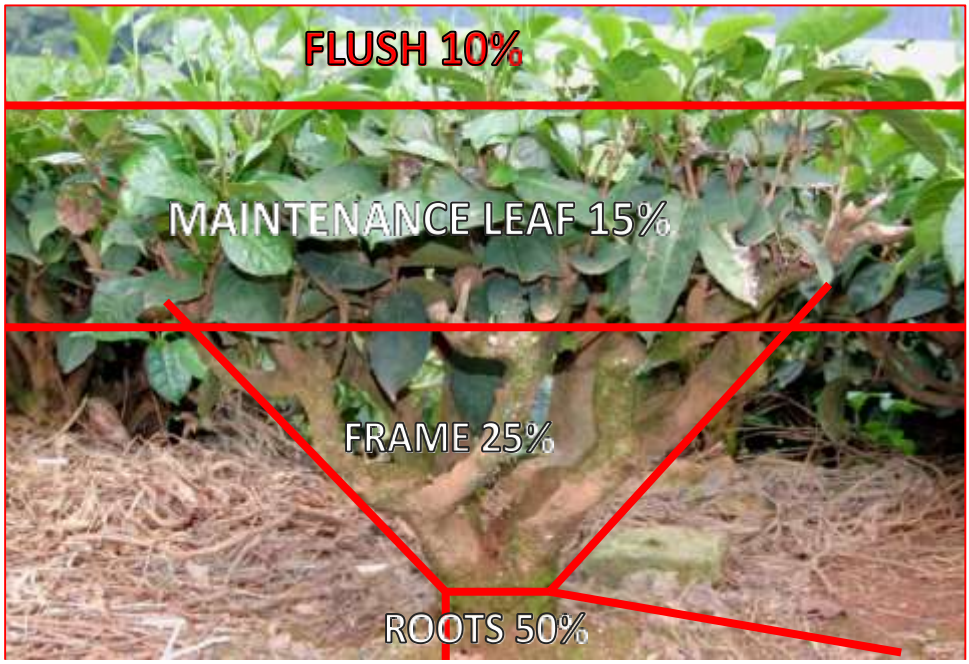

Figure 10. Proportional partition of synthate in the mature tea bush

Deviating from this synthate division due to poor training, or to exploiting synthate for harvested yield in the early stages of development will inevitably lead to weakly plants and low yields in the future.

Physical crop protection

While animals rarely predate mature bushes both rabbits and deer pose a threat for young plants in the east Scottish lowlands – a nocturnal visit could severely reduce the potential productivity of a planting. Growing tea in walled gardens offers some measure of protection if the original gates are in good order. Plantings on open land will need effective fencing – and constant vigilance until plants are mature.

Reducing cost of production

Understanding and monitoring Cost of Production (CoP) is a key to running a profitable business. The principal cost in tea growing is the labour cost of harvesting – some 50% of the total cost of producing made tea. Mechanization in theory can reduce this as it has in other agricultural areas. The limitation to this approach is the effect of mechanization on product quality but, wherever it can be introduced to save labour without loss in quality of either green leaf raw material or final tea product, it should be implemented. Cost of hand digging planting holes can be reduced using a mechanical auger; fertilizer application through irrigation piping (fertigation) which is virtually labour free compared with hand application; labour for hand weeding can be drastically reduced using plastic weed mat.

Speeding up harvesting

With current harvesting machinery, green leaf cannot be harvested of a quality good enough to manufacture specialty tea. In China the high quality first or spring flush is harvested by hand and the later summer and autumn flushes are machine harvested. Typical prices for tea made from machine-harvested leaf are USD 2 to 4 per kg compared to USD 150 to 450 per kg for hand plucked specialty teas. In traditional tea countries, where hand pluckers' daily wage rate is around £1 to £1.50, harvesting costs for machine harvested green leaf are less than half of this. In high labour cost economies the saving would be even higher.

Doubtless, in time, engineering innovation will match or exceed the hand plucked leaf standard. An experimental Australian harvester made by Williames Hi-Tech is claimed to do just this and is now in use by Zeelong, the specialty tea grower in New Zealand, for some of their harvesting.

It is expected that selective hand plucking will be the norm for the Scottish Artisan Tea Producers. Nevertheless, it is highly recommended that all new plantings of tea in Scotland are spaced at planting time to make it possible to change over from hand plucking (of individual bushes) to machine harvesting (of hedges of bushes) should cost effective better harvesting machines become available in the future.

What growers must do before planting tea

Some growers are planting tea to "see how well it grows", however it is firmly recommended that you should assume it will do well and have a business strategy in place before even the first plant goes into the ground. Tea once planted it is in place for 80 years thus any mistake made to begin with will remain a perennial problem. A business strategy will determine how much tea you plant, over what period, what type of tea, at what density, and whether for hand or machine harvesting.

Carefully select your land to give tea plants a chance to thrive; identify mitigating actions where the land is sub-optimal. **Land preparation requires:**

- Soil pH between 4.5 and 5.5 – soil may be acidified using sulphur before planting if higher than pH 5.5 or acidity reduced using dolomite (not lime) if below 4.5.
- A well drained soil with water table below 2 metres – a slope encourages drainage; soil can be mole drained if compacted; cross draining can divert springs if present.
- Soil structure: freely draining but retentive – a sandy loam is ideal but mulching can enhance soil structure.
- Annual rainfall of 1,500 to 3,500 mm well spread through the season – irrigation is virtually a necessity to avoid climate volatility.
- Protection from cold drying winds – trees make good natural windbreaks but may need assistance from artificial windbreaks in their early years. Using polytunnels, at least until

plants attain maturity will be advantageous. Horticultural fleece during winter months may also help. Tree guards will be useful in some exposed sites.

- Avoid known frost pockets to protect plants from frost during spring flush – tea plants are quite hardy when dormant but are susceptible to frost during early season growth. Japanese growers use tall electric fans to stir the air in frost pockets.
- Light intensity of 700-800 Watts per m2 - in the northern hemisphere, a sloping southerly aspect will maximise solar flux but for young bushes some supplementary lighting may be advantageous.
- Absence of leaf or stem eating animals – deer and rabbits must be excluded from young plants – plan fencing if required.

- **Prepare land well in advance of planting time (6-9 months lead time):**
  - Decide on number of plants to be planted out
  - Decide on a plant density and spacing format
  - Mark out the required area
  - Check soil pH and soil CEC
  - Calculate acidification chemical dose if required
  - Deep plough if this is required due to compaction, or has not been done in the past 2-3 years, or as part of acidification treatment
  - Sow a green cover crop if time permits.
  - Plant or erect windbreaks as required
  - Erect deer/rabbit fencing as required

- **Mark out land for planting (3 to 7 days before planting)**
  - Measure and space planting rows
  - Allocate land for paths and tracks (depending on size of planted area)
  - Decide planting method manual or mechanized
  - Mark planting hole positions using stakes or spray paint
  - Procure fertilizer for mixing into planting holes
  - Plan planting logistics – sufficient labour, moving plants to holes, identify place to start, collecting empty pots or waste sleeves, water for watering plants in

Detailed preparation for planting, from developing a business strategy through to making a planting plan are exercises beyond the scope of this feasibility study. They are specific to each individual business and need to be developed with a particular site in mind. However, neglecting to plan properly and in proper detail will surely cause unnecessary expense in putting it right afterwards. Best to do it right first time.

Future R&D needed to ensure success

Many of the major problems that make tea growing in Scotland more of a challenge than it may be in traditional countries have been identified in the preceding text. Some of the conventional issues are relatively unimportant but they become more so as growing conditions become more marginal. Some solutions have been suggested for mitigation but full resolution of these requires some serious research and development.

Topics that would respond well to future R&D work are discussed below. Tea research institutes based on the tropics will not in the normal course of events tackle them. Scottish growers must find their answers locally.

Create an ideal tea variety for Scotland

This would be a tea bush suited to the Scottish environment. It would be:

- cold hardy to withstand extreme winter cold
- have a lower temperature dormancy threshold to give a longer cropping season
- a high photosynthetic efficiency at lower light levels
- fast to commercial maturity
- have an enhance tendency for root storage of synthate

R&D Program. The initial stage of plant breeding would be to collect a wide gene pool of suitable material and to evaluate this under Scottish conditions for a range of attributes. These include: nursery behaviour (ease of propagation, success level, speed of growth); field characteristics (bush shape, bush vigour, leaf angle, leaf size, yield, dormancy temperature threshold, drought tolerance,

pest and disease tolerance); harvestability (shoot density, stem resistance to pluck); biochemical parameters (catechin levels and ratio, net photosynthetic efficiency, caffeine level); and cup quality (suitability for various tea types). Initially all these attributes evaluated for Scottish conditions on a crude scale of: Absent, Trace, Moderate, Acceptable, or Outstanding. Breeding would commence from favourable parent material. Tea breeding is slow work and to make improvements in the near future requires an early start.

Plant exposure - understanding and reduction

Scottish grown tea will feel the effects of wind buffeting, wind desiccation, extreme winter cold and frost during spring flush growth. These adverse influences are not new and many susceptible crops are successfully grown in Scotland – for example berry fruits and broccoli. Moreover, protected agriculture around the world uses various techniques to reduce risk of physical exposure.

R&D Program. Initially desk research to collate what is known:

- investigate what techniques are applied and known to work in other crops
- similarly check current methods employed in tea
- make preliminary recommendations for Scottish tea
- suggest a practical R&D project to evaluate and recommend demonstrable solutions for Scottish tea.

Season extension

The horticulture industry exemplifies the benefits of season extension that can, similarly markedly increase the obtainable commercial yield from tea. Methods to raise and maintain the air temperature above dormancy-inducing levels in tea include polytunnels (though other methods may also be found). Management of a polytunnel requires balancing of some competing demands – while the plastic cover is capable in spring and autumn of raising temperature beneficially it also reduces the already low light levels significantly at those times. Supplementary lighting can increase light levels but the luminaires (lamp housings) shade plants from natural light when supplementary lighting is turned off during the day. Though there are capital and revenue costs involved in supplementing natural light, modern LED systems, as now being used in tomato

growing, run at very low cost and are spectrally controllable. Thus, the balance of the red/blue spectrum is changed during tomato growing to enhance plant development initially and then after flowering to maximise fruit filling, while the green spectrum is diminished overall as it is less effective for photosynthesis. This technology gives maximum response at minimum cost.

R&D Program. To establish:

- Effective management techniques for growing tea under plastic polytunnels in Scottish conditions
- Comparing tunnel growing using plastic throughout the year with plastic removal during the cropping season (not maximise natural light and avoid over temperatures)
- Evaluate what the optimum temperatures are for best yield under Scottish natural available light levels (best balance of respiration and photosynthesis)
- Investigate the cost effectiveness of enhancing natural light by supplementary lighting.
- Investigate and evaluate the optimum spectral distribution of LED light for young plants and mature plants, for leaf flushing and for yield.

Correct pruning for Scotland

We understand the correct pruning techniques to establish a healthy productive mature bush under tropical conditions; these procedures hold up well under temperate conditions.

R&D Program. To establish what if any modifications need to be made to established pruning techniques, under Scottish growing conditions, for formative training of young bushes and for the cyclical maintenance training of mature bushes.

Understanding dormancy

Tea is naturally a perennial evergreen plant of the moist tropics. As such, it grows under conditions that vary very little with season and depends on a natural or inherent cycle of dormancy where growth ceases and actively growing buds cease development. This is termed banjhi and for a given shoot may occur every three months or so. When confronted with less equable conditions the whole plant is triggered into dormancy by cold or by stress. Banjhi dormancy occurring at the

wrong time is commercially disastrous as it lowers leaf quality and reduces yield, sometimes to zero.

Banjhi period may be caused by	natural cycle	
	night cold (several nights below 10-11°C)	
	low humidity (saturated vapour deficit below 2.3 kPa)	
	plant stress	drought stress nutrient stress poor harvest management

R&D Program. To elucidate likely dormancy inducing causes under Scottish marginal conditions, and to identify methods to break dormancy and reduce its adverse commercial effect.

Tea irrigation

Though having a high requirement for water, tea has not traditionally been an irrigated crop as it is normally grown under rain fed conditions that fully meet its needs. Since the 1970s, some overhead sprinkler irrigated tea has been grown in Malawi, Tanzania, Zimbabwe and South Africa primarily to reduce low humidity induced dormancy during their dry season. In the past decade with increasing climate volatility and incidence of drought a move towards irrigation has commenced. Tanzania and India have begun slowly to develop systems using cheaper drip methods.

Precipitation in east Scotland does not meet tea's minimum annual requirement of 1,500 mm. Dundee for example, while having many wet days (165 rainy days annually), these are drizzle more than downpour, and so has a total of only 761 mm annually.

R&D Program. To identify the best method of irrigation – sprinkle versus drip method(s) for tea grown under Scottish conditions for the application of water to supplement natural rainfall and for the application of fertilizer:

- Cost effectiveness for water and for fertilizer
- Ease of operation
- Ease or of installation

- Longevity
- Suitability for tea
- Usage efficiency (litres water used for kg of yield produced)

Caveat

Some R&D work can be done effectively on pot-grown tea that takes two or three years to reach a suitable age for those investigations. However, the majority of tea R&D requires plots of mature plants as research material. Thus, a cohesive R&D program needs long term approach – tea needs to be in the ground long before the experiment is commissioned – this is a major obstacle to tea research in Scotland, or indeed in Europe, where tea plantings are not already in existence. In the USA a wave of small farmer tea growing as a diversification crop in the southern States (Alabama, Florida, Georgia, Louisiana, Mississippi, Texas), has prompted the Mississippi State University to action. MSU is planting out tea bushes this year for research work in the next decade and has (in 2014) funded collection of tea material to form a gene pool for breeding work

How do we ensure we get good prices for our Scottish grown tea?

While marketing hype will sell a tea at high prices for the first time, we have to create a sustainable market for Scottish grown tea. That means embracing quality as our standard - growing for quality, harvesting for quality, processing for quality, and marketing for quality. This concept is not difficult to define, though it is sometimes challenging to maintain. It means understanding each step of production and knowing how adjust conditions to maintain target quality. It requires well-defined quality targets and effective quality control to monitor actual quality levels throughout the production chain. It means understanding and getting to grips with the supply chain, particularly the marketing end. It needs sometimes, the discarding of sub-standard leaf, or rejecting tea when processing went wrong. In addition, deep down it means really understanding what makes specialty tea special to the customer; key to this aspect are:

- Consistency – an “out of stock” notice is better than supplying sub-standard tea

- Integrity – “under-promise and over-deliver” is common business advice but it is far better not to promise what you cannot deliver and to deliver what you have promised. Realistically analysing what you can deliver and actually doing what you say you will and doing it to the best of your ability will establish and enhance your integrity.
- An intriguing story – gain interest and woo the customer; but tell the truth: a “smoke and mirrors“ story is not sustainable.
- Diversity – novelty, specialness and range of choice keeps the customer’s interest – better to have smaller sales of many types than big sales of a single offering.

Conclusions and recommendations:

Tea growing in Scotland is undoubtedly a challenge. Nowhere else in the world is tea grown commercially so far north of the Equator. Nevertheless small-scale experiments have shown that tea will grow under Scottish marginal conditions albeit at high cost and at low yields. Until the recent market development towards high value specialty teas these limitations would normally have killed the project stone dead. However, the ongoing development of a strong specialty tea sector internationally allows small crops of expensively grown tea to be commercially viable.

This study report commenced by asking three questions:

Can tea be grown in Scotland? This study concludes that it certainly can. While conditions are marginal compared to traditional growing areas the knowledge and expertise to improve growing conditions and alleviate shortcomings generally exists. We can modify soil where necessary, supplement rainfall, extend the season, and supplement lighting. We could select more suitable cultivars given time. Many of the tea growing issues and obstacles have been addressed in this report and suggestions made for their alleviation. Content that tea **can** be grown in Scotland we must admit the lack of formalized tea knowledge and practical tea expertise among the novitiate growers. Access to expert consultancy advice and training was top of the list – 60% of the responses - in answer to our questionnaire (see Figure 1). Growers' looming need is for ready access to expert guidance and for a Scottish tea-growing handbook for reference.

Can tea be grown profitably in Scotland? This study takes the view that tea growing and processing can be commercially viable in Scotland. Making some conservative assumptions about potential yield and market prices, and realistic estimates of costs of production, we have shown that specialty tea production can make some impressive income from a tea garden even as small as one acre. Tea plants derived from seed have been recommended for initial planting in Scotland, as they are tougher and more cold hardy than plants raised from cuttings and plant losses are potentially less.

Constraints to Scottish tea growing are:

- low levels of natural light
- short cropping season
- plant material not yet selected for local conditions
- lack of appropriate technical expertise
- high labour costs

Achieving optimum growing conditions by addressing these constraints as outlined in this report will result in optimum yield that, if production cost is minimized, produces the highest profit. In Scotland planting on a southern aspect, maintaining the right soil pH, keeping soil well drained, irrigation when required, correct nutrition, shielding from strong wind, and extending the natural season will help to optimise growth. We conclude however that the factor most likely to challenge profitable tea growing is light intensity. Due to the latitude of East Scotland, the winter and early spring day length is short and light intensity is low. Even at midsummer, the maximum light intensity is lower than places south, and clouded days are higher. It may be that supplementary LED lighting will play a role in intensive tea production, as it does already with tomato, cucumber and capsicum horticulture.

There is a need for guidance and training for Scottish growers to understand cost benefit analysis, and control costs of production while consistently achieving the high quality required by the specialty tea market.

What business approach best balances risk and reward for Scottish tea growing?

Key drivers to the success of a Scottish tea industry all relate to the relatively new changes occurring in the traditional low price commodity tea market:

- the emerging high value specialty tea market that permits previously prohibitive labour costs
- consumer interest in local food production, and willingness to support it
- vague consumer distrust of traditional tea growing country ethics and practices

Large companies like Lipton and Tata Tea have attempted to enter the specialty tea sector but with scant success – specialty tea works best at small scale. A grouping of separate but cooperating artisan producers matches very well the ethos of the specialty tea market. Within this framework,

there is the possibility of individual producers embracing the entire supply chain: grower-processor-packer-retailer, or just one of the links, say an individual grower selling on to a separate processor who sells on to an individual marketer. Certainly the closer the grower is to the retail market the more of the end value they will benefit from – but this benefit comes at a price – it increases risk, financial exposure, dilution of effort, and sheer hard work. Group members have a range of skills and experience of business. They will all benefit from mentoring and access to good quality business building and management advice.

An aspect of Scottish tea production that should be faced up to from the beginning is that the average consumer can, in the hurly burly of marketing, confuse Scottish grown tea with Scottish packed cheap imported tea – sold as Scottish Breakfast and similar names . This confusion, whether it arises by accident or design, can only affect the homegrown tea adversely. Worse still is the temptation to blend a few leaves of Scottish grown tea into a mix of imported tea and pass it off as a local tea. Darjeeling tea has suffered this adulteration for decades but has fought back by gaining Protected Geographical Indication (PGI) see Ref.12. From 2016, Darjeeling Tea has PGI in the EU, in the same way that Champagne and Scotch whisky is protected. Obtaining Protected Geographical Indication and agreeing a quality standard mark for the retail product should be a priority for all Scottish tea growers to protect their pure homegrown product from adulteration and misrepresentation.

PART THREE. Resources available

Books

Most books about tea production are far too general or if detailed are specific to s single country or origin. Tea handbooks are mostly written by experts with experience of only their own country. The problem is that their advice, while it is sound and practical in South India or Sri Lanka, does not necessarily travel well to Scotland. Much experience and a large pinch of salt is necessary before transferring advice from a tea handbook direct to a tea problem in marginal conditions. Mostly even the newest of the handbook type are rather old. Having said that some useful ones are:

Tea Growers Handbook (5th edition). Tea Research Foundation of Kenya. 261 pp. 2002. (Covers nursery and field).

Tea Planters' Handbook. Tea Research Association of India. 138 pp. Undated. (Covers Nursery, field and factory).

Science and Practice in Tea Culture. D.N Barua. Tea Research Association of India. 493 pp. 1989. (In depth coverage of tea plant growth requirements, tea soils, plant improvement, propagation, planting, pruning, plucking, DM partition, shade, nutrition and water management).

Tea Cultivation: Comprehensive Treatise. N Ghosh Hajira. International Book Distributing Company, Lucknow. 518 pp. 2001. (Broad though somewhat superficial coverage of all aspects of tea history, taxonomy and field management including one chapter on organic growing).

Handbook on Tea. Ed. P Sivapalan, S Kulasegaram and A Kathiravetpillai. Tea Research Institute of Sri Lanka. 220 pp. 1986. (Detailed coverage of nursery practices, planting and field husbandry, pests and diseases, tea manufacture and auction marketing).

Tea Manufacture in Ceylon. E.L Keegel. Monographs on Tea Production No.4. Tea Research Institute of Ceylon. 179 pp. Revised edn. 1958. (Comprehensive guide to black tea orthodox manufacture and factory organization).

Tea: Cultivation to Consumption. Ed K.C Willson and M.N Clifford. Chapman & Hall. 769 pp. 1992. (Though expensive, this is undoubtedly the best and most comprehensive treatise on all

technical aspects of tea in the English language. It covers history, botany, physical and nutritional requirements, propagation, field methods, chemistry and biochemistry of non-volatile components and of aroma volatiles, instant tea, specialty teas (the few that were represented in 1992), non-Camellia and herbal teas, world trade, and regulatory standards).

Internet

The Internet is a two edged sword – quick and easy access to endless information, but no way for the inexperienced to assess the veracity of any particular new nugget of gold. Never has the old adage been so appropriate: "if it sounds too good to be true then it probably is". Myths abound and are constantly copied and regurgitated by the ignorant, the naïve and the unscrupulous. Tea is no exception to this.

Nevertheless, not all are bad all of the time. Try:

http://www.tocklai.net/activities/tra-activities/ The website of the Tocklai Tea Research Institute< Assam, North India. Click down the menu for good dependable factual information on Tea Classification, Cultivation, Chemistry, Manufacture, Machinery and Health

http://www.upasitearesearch.org/about-tea-3/ The website of UPASI Tea Research Foundation, Tamil Nadu, South India. . Pages of good reliable technical information about all aspects of tea production.

On social media useful Facebook pages are:

https://www.facebook.com/groups/letsgrowtea/ Discussion group for small tea growers in the USA – includes some ornamental Camellia interest

https://www.facebook.com/TeaAcrossAmerica/ Tea Across America succeeded in getting a living tea plant growing in every one of 50 US states in 2014.

https://www.facebook.com/groups/867508596632619/ Tea STEMS (Science, Technology, Engineering, Medicine & Statistics). Closed group but welcomes the more technically minded

https://www.facebook.com/TheGreatMississippiTeaCompany/ Chronicles one small farmer's venture into specialty tea growing in the US

https://www.facebook.com/usltg/ the page of the US League of Tea Growers cofounded by Teacraft Ltd in 2014 to connect US tea growers, wannabe tea growers, well-wishers, and educators willing to share a vision of Camellia tea being grown and made on North American soil.

The US League of Tea Growers 'website is https://usteagrowers.com/ - It has a wealth of information, blogs and articles relating to small scale marginal condition tea growing.

https://www.facebook.com/ScottishArtisanTea/ and of course the Scottish common interest group's page, now with 673 followers (Likes) spread across 45 countries.

For business plan making the University of Minnesota run a free software service called AgPlan to develop your own farm business plan: https://www.agplan.umn.edu/ There are many other business plan development packages available – some at quite reasonable prices.

Equipment suppliers

Tea processing equipment is generally not available in the UK or mainland Europe; it is mainly available from India and China. Various pieces of machinery can be found on the Internet primarily through Ali Baba and Trade India. Great caution is required if ordering equipment this way that what you are actually ordering is what you think you are ordering. Specifications are hazy at best and sometimes are plain wrong. Remember that you will pay import duty and VAT on top of the apparently low price. Another point to remember is that CE marking will not be included – which means that import into the EU could land you with a hefty fine and confiscation of the import.

Teacraft Ltd has 26 years' experience of importing from India and China and can assist with equipment sourcing on a commission basis.

Plant material supplies

Import of live tea plant material for cuttings and seeds for germination is similarly fraught with pitfalls for the unwary – it is a specialist area. Tea seed loses viability within two months if not kept correctly and much of the seed on offer, even from reputable seed merchants, has a very low viability. Small batches of seeds on offer via the Internet have a very varied germination rate as their age and storage conditions cannot be verified. Teacraft imported for clients in the USA and UK more than a quarter of a million tea fresh seeds in 2015 from the autumn harvest in Nepal and Georgia. We have been handling international shipping of tea whips, rooted tea cuttings and seed from and to South America, North America, UK, Africa and Asia since the 1980s and understand import and export permits and phytosanitary certificates, chilled airfreight and plant security inspection regulations. We welcome enquiries.

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APPENDICES

1. Scottish Artisan Tea Producer Network - members' details
2. Other Scottish tea growers
3. Grower questionnaire
4. Findings from grower visits made in January 2016
5. Protected agriculture
6. Supplementary lighting
7. What are they saying about specialty tea?

APPENDIX 1. Scottish Artisan Tea Producers' Network

Members' details:

Susie Walker Munro (Study Project Manager)
Forfar
Angus

Lisa Dickson
By Crieff
Perthshire

Catherine Drummond-Herdman
Errol
Perthshire

Katie and Robert Elliot
Logie
Fife

Mary Gifford
Kirriemuir
Angus

Monica Griesbaum and Andy Oldroyd
By Auchterarder
Perthshire

Pinky Methven
By Perth
Perthshire

Ronnie Murray-Poore
Crieff
Perthshire

Jane Spencer-Nairn
By Cupar
Fife

APPENDIX 2. Other Scottish tea growers

The James Hutton Institute, Dundee

Scientists there are endeavouring to micro-propagate *Camellia sinensis* using tissue culture techniques. So far, no propagules have been transferred to the field.

Gentech Propagation Ltd, Dundee

Similarly, Gentech (a micropropagation company) has had tea cuttings passed to them but have so far not succeeded in rooting them.

Wee Tea, Amulree, Scotland

All information given here is extracted from publicly available sources including the extensive media coverage of Wee Tea activities.

Wee Tea Company Ltd (WTC). Company registered June 2012 as tea packers and retailers with strong web presence. Directors: Jamie Russell and Derek Walker. Put first Scottish grown tea onto market in 2014

Wee Tea Plantation Ltd (WTP). Dalreoch Farm, Amulree, Perthshire PH8 0BY. Director: Thomas James O'Brien (also known as Tam O'Braan). Company started August 2014, though their tea growing experiments commenced in 2011.

WTC gained a £50,000 development grant from Scottish Edge who report that a programme of high-end tea training is presently underway for the first ever two young British Tea Sommeliers. Both are local young people with appropriately sensitive palates.

Wee Tea Plantation formed a Tea Growers Association with twelve members in mid 2015. The purpose of formation was to pool purchasing power and technical capabilities. The Guardian (July 2015) quotes Tam O'Braan, claiming "Once it hits double figures ,we'll easily get 20 growers on top of that in the next five years". By January 2016, (Financial Times) Tam is predicting "I think there will be 20 to 30 tea gardens in Scotland". Members have the option of selling green leaf to WTP for processing, or to use WTP as a central marketing organization. In Farmers Weekly (August 2015) Tam explained that WTP set up the alliance to pool resources and create a support network that could allow for more than one Scottish tea growing business to exist. "We knew that if we did not share what had been achieved, we'd be limiting the capability that tea offers and did not want to be selfish. It's an industry, not just one farm". Members, it is claimed include growers, herb specialists, market gardeners, royal estates, and highland schools including Lochgilphead Joint campus. Membership of the Association is free.

In April 2014, BBC News reported "2,000 plants in the ground and ready to start using locally grown tea in blends next year". "The garden is 750 metres (2,460 ft.)[21] above sea level". Bruce Richardson after an interview with Tam O'Braan in September 2104 wrote, "Would you be surprised to learn that a Scottish tea garden produced a ton of tea last year?" He had learned from Tam that WTP had yielded 1,100 kg by August 2014 and that 20,000 plants were ready to plant in 2015.

In April 2015, Outlook Magazine reported "14,000 plants growing at 700 ft above sea level." They also quote Tam as saying the first flush at Amulree is in February, as do The Independent, in August 2015.

In January 2016, the Financial Times reports 14,000 plants growing at Amulree.

WTC was selling Dalreoch Scottish grown tea to Fortnum & Mason by April 2015. This is (Daily Mail) "a 100% Scottish tea blend".

WTP claim cutting edge technology used to protect plants and encourage root growth. According to World Tea News WTP, tea plants are "a frost resistant variety developed in Italy. Degradable

[21] Amulree is actually at 286m (939ft) a.m.s.l. Latitude: 56.51215 North, Longitude: 3.79036 West.

polymers placed around the plants prevent moisture loss and reflect sunlight back onto the leaves. It also has the added advantage of deterring insects, negating the need to use pesticides. Once saplings the trees are stripped of their lower leaves and encased in UV reflective tubes that reduce the amount of light reaching the plant. This encourages more rapid growth of the upper leaves during the short growing season". And in Daily Mail (Mail online) "protecting against high winds and frost, development of the plant's root system and maximizing the known seasons of high growth are key to our success . . . (by) using degradable polymers around the plant, we reflect the sun's own goodness upwards, doubling the effect of Scottish sunshine".

WTP polymer technology in action. Photo Wee Tea Plantation

Bruce Richardson (Elmwood Tea, NC) spoke with Tam O'Braan (September 2014) and wrote that "A major part of their innovative growing method for this (Scottish) cold climate involves stripping back 80% of the leaves from their Camellia sinensis plants". Bruce continues, "The slender bushes are then enclosed by a polymer sleeve. Similar to the way sunglasses filter UV rays, these open-ended tree guards hold back 99% of the light spectrum. This retards photosynthesis and forces the bush to reach for the sun as new leaves appear. This also makes a very light leaf with less chlorophyll. The leaf stripping is repeated every six weeks throughout the growing season".

“Plastic tunnels are used to shield the plants from winter rains” according to the Financial Times (January 2016). A tea-processing factory for freshly picked tea leaf is under construction on the Dalreoch farm and will use solar powered electricity.

A new job and programme of high-end tea training not known to exist outside of Asia is presently underway for the two first ever young British Tea Sommelier- both local young people with appropriately sensitive palates.

WTP out-growers

1. Rev. Liz Gibson and Martyn Gibson, Isle of Mull. WTC sell her teas as Scottish Antlers stem tea. She has 100 bushes planted out in 2013
2. Angela Hurrell, Garrocher Market Garden, Newton Stewart, Dumfries & Galloway. WTC supplied plants in August 2014 and commenced plucking and processing in January 2015.

Garrocher Autumn 2014 planting after its first harvest in Spring 2015. Photo Angela Hurrell

3. Other WTP Tea Growers Association members include Chris Henry, Richard Ross (Dalguise Tea - Perth & Kinross), Mike Hyatt (Lismore), Charlies Ball (Dumfries & Galloway), Dan Harrison (Midlothian), and Lynne Collinson (Orkney).

Scottish Tea Growers Association: (Left to Right); Tam O'Braan – Perthshire, Mike Hyatt – Lismore, Charlie Ball – Dumfries & Galloway, Dan Harrison – Midlothian, Lynne Collinson – Orkney, Martyn Gibson – Isle of Mull, Rev. Liz Gibson – Isle of Mull and Richard Ross – Perth & Kinross.

Photo by Angela Hurrell

4. The Dorchester Hotel, London, rooftop garden where WTP has introduced 60 tea plants.
5. Lochgilphead Joint Campus, Loch Fyne, Argyll & Bute, with a tea garden planted in the school's grounds in in August 2015

Samples of Dalreoch, Garrocher and Isle of Mull tea were presented to President Obama June 2015

Tea awards claimed by WTP:

Silver award from the Tea Exchange in London

Gold medal award from the Salon de Thé in Paris in March 2015[22]

Scottish grown tea is on the menu at:

The Balmoral Hotel, Edinburgh

The Dorchester, London

Lowell Hotel, New York

Wee Tea Scottish grown tea has been enjoyed by:

HM Queen Elizabeth II

US President Barrack Obama

First Minister Nicola Sturgeon

And is sold at:

Fortnum & Mason, London

Mariage Frères, Paris

[22] We have been unable to verify the existence of either award.

APPENDIX 3. Grower questionnaire

Feasibility study for tea production in Scotland

Survey Description

This survey has been funded by the Community Food Fund and has been commissioned by Scottish Artisan Tea Producers who are a common interest group. The finished feasibility study will be publicly available and its purpose is to assist anyone either currently producing or interested in producing tea in Scotland. Data collected from this survey will be used only for the purposes of the feasibility study.

1. Do you plan to grow or are you already growing Camellia Sinensis tea in Scotland?

- ○ Yes, I am already growing tea - go to Q5
- ○ Yes, I am planning to grow tea - go to Q2
- ○ No

2. Which year do you plan to start growing tea?

3. How much tea do you plan to grow?

No. of plants?

No. of acres?

4. Where do you plan to plant tea? (Nearest town)

5. In which year did you start to grow tea?

6. How much tea have you planted and/or how many seedlings/cuttings are you currently propagating?

No. of plants?

No. of acres?

No. of seedlings or cuttings?

7. Where have you planted your tea? (Nearest town)

8. Have you processed any green leaf into finished tea?

- Yes, myself.
- Yes, using third party.
- Not yet.

9. What do you consider to be the greatest challenges facing tea growing in Scotland?

1.
2.
3.

10. Please suggest any support measures, assistance or further research that might be useful through the collaborative group?

1.
2.
3.

Done

APPENDIX 4. Grower visits - January 2016

Assessment of Scottish Artisan Tea Growers Signed up for Growing in 2015

Summary of Findings

As part of the Community Food Fund backed "Scottish Artisan Tea Producers Network: Feasibility Study", Nigel Melican and Beverly Wainwright of Teacraft Technical Services visited ten actual and potential tea growers to assess their proposed growing sites for suitability and possible problems – slope, aspect, wind exposure, soil pH, drainage, water availability and herbivorous mammalian pests.

No unforeseen new problems or constraints to tea growing were identified during the visits but it was a valuable experience to make direct comparison of various levels of constraint likely to be experienced while growing tea in Scotland. Not every growing site has all of these constraints, and many of them can be lessened by informed proactive response by individual growers.

We are however very much aware that the growers are tackling a very new crop and with one exception have very little experience of the particular requirements of a perennial crop. Each grower need to develop a soil preparation plan well before planting to ensure that soil (and water) pH can be brought within the optimal range, a suitable planting density and pattern that will allow the future possibility of mechanical harvesting, and the outline (at least) of a business plan.

It will be most helpful to group member to continue to share openly their experiences and problems – and, better still, effective solutions.

Grower 1. Grower was visited during the assessment but subsequently decided not to plant tea due to competing business interests and kindly donated their seed to the group

Grower 2. Fife

Visit date: 23rd February 2016

Initial planting of 2,000 plants to be raised by Susie Walker-Munro in leased glasshouses. Outhouses are available for future processing.

Planting area is a large walled garden much subdivided into formal garden, orchard and kitchen garden. Approximate area available for planting is 0.5 acre in two adjacent patches. Previously

used for market gardening, the area has been fallow for a couple of years, recently glyphosate sprayed and rotorvated. As the planting area is limited, it may require closer spacing than normal.

Not established whether organic or conventional growing is envisaged.

Aspect is 0 to 1 degree slope due south. Elevation 75m.

Exposure. Close to garden wall to east and beech hedge to west – prevailing wind is westerly

Good rich dark soil. Soil pH 5.6 (tested July 2015). Soil pH is 5.5 (top plot) and 5.7 (bottom plot) when tested Feb 2016. This is very close to ideal soil acidity for tea. An acidifying fertilizer regime will be recommended.

Slope is very slight and natural drainage may require some ditching. Area by entrance is low lying and holding water.

Drip irrigation is advised for drought risk mitigation and for fertigation.

Garden has mains water pH is 7.4 (tested Feb 2016).

Employed gardener's name: Brian Grey

Other information. Will benefit from deep ploughing before planting. Needs soil preparation plan, planting plan, and business plan.

Grower 3. Fife

Visit date: 23rd February 2016

Initial planting of 2,000 plants to be raised by grower on site.

Planting area is in a large cereal field currently in stubble. The field was walked and a suitable location identified towards the top end of the east side.

Organic growing is envisaged and the advantages and disadvantages of this route were discussed.

At the preferred location the aspect is a 3-degree slope facing due south.

Exposure. Tree belt protection on field edge to west but open to the east – a tree belt here would be recommended.

Soil pH is 6.6 (tested Feb 2016) and 6.5 (tested Oct 2015). This is well outside the ideal range of 4.5 to 5.5 and requires acidification treatment with elemental sulphur during soil preparation. Depending on sight of a full soil analysis with CEC reading, our provisional recommendation would

be 250 g/m2 of Brimstone 90 split into two applications, half on soil before deep ploughing and second half rotorvated or harrowed in. This treatment should be applied in spring/summer 2016 and a cover crop of clover sown.

An acidifying fertilizer regime will be recommended.

Natural drainage should be adequate; contour bunds will assist water holding..

Drip irrigation is advised for drought risk mitigation and for fertigation.

The local burn runs below the field and may be usable for irrigation – pH 7.2 (tested Feb 2016). Mains water pH is 7.3 (tested Feb 2016)

Likely to have a deer and rabbit problem in early years thus requires fencing.

Other information. Will need deep ploughing before planting. Needs soil preparation plan, planting plan, and business plan.

Grower 4. Angus

Visit date: 24th February 2016

Initial planting of 2,500 plants to be raised by grower on site. These have been sown in root trainers prior to transplanting into deep pots. Very impressive fully automated greenhouse in use. Hard standing available for pots in an old glasshouse which will be renovated for the purpose

Planting area is in an old walled garden laid out in early C18 – NE quadrant. Approximate area 2.0 acres. Garden is under grass and has been fallow for years.

Organic growing is envisaged and the advantages and disadvantages of this route were discussed. Use of polytunnels for season extension would not be entertained, but prepared to use fleece to protect young plants.

Aspect is 1 degree slope due south. Elevation 52m.

Exposure. Little natural protection from east and west – prevailing wind is westerly. A beech hedge has been planted around the proposed tea area. Tree belts outside garden walls are recommended in the long term. There are already some trees on three sides, but Mary feels they are inappropriate for the fourth wall. It would be many years before any trees planted now would be protection for the tea as the garden is so large.

Soil pH is 5.9 (tested Dec 2015). While outside the ideal range of 4.5 to 5.5, this does not justify acidification treatment during soil preparation. An acidifying fertilizer regime will be recommended.

Drip irrigation is advised for drought risk mitigation and for fertigation.

Natural drainage should be adequate.

Garden has mains water (pH is 5.8) tested Feb 2016.

Vigilance will be required to keep the garden safe from rabbits.

Other information. The area is under grass and was ploughed initially but ideally should be ploughed again before planting. Needs soil preparation plan, planting plan, and business plan.

Grower 5. Perthshire

Visit date: 24th February 2016

Initial planting of 4,000 plants to be raised by Susie Walker-Munro in leased glasshouses.

Planting area is in an old walled garden of traditional C19 design – NW quadrant allocated to tea. Approximate garden area 2.0 acres. Garden is has been fallow for years and very weedy. Pigs have been on land since December 2015 to turn up and eat roots but much live weed root remaining.

Organic growing is envisaged and the advantages and disadvantages of this route were discussed.

Aspect is 2-3 degree slope to due south. Elevation approximately 40m.

Exposure. There is some protection to east and west – prevailing wind is westerly from tree belts outside the garden wall.

Soil pH was 6.1 (small enclosure) and 6.6 (large enclosure) when tested in Jun 2015. Soil pH is now 6.8 (tested Feb 2016) doubtless increased by pig activity. All these results are well outside the ideal range of 4.5 to 5.5 and requires acidification treatment with elemental sulphur during soil preparation. Depending on sight of a full soil analysis with CEC, reading our provisional recommendation would be 300 g/m2 of Brimstone 90 split into two applications, half on soil before deep ploughing and second half rotorvated or harrowed in. This treatment should be applied in spring/summer 2016 and a cover crop of clover sown. An acidifying fertilizer regime will be recommended.

Drip irrigation is advised for drought risk mitigation and for fertigation.

Natural drainage should be adequate.

Garden has mains water (sample taken but could not be tested).

The garden is effectively walled and with diligence there should not be a rabbit or deer problem.

Other information. After pigs are removed the planting area will need to be left to grow and then weed killed with glyphosate; deep ploughing will be required before planting and put under a clover or rye/clover mix in 2016. Needs soil preparation plan, planting plan, and business plan.

Grower 6. Perth and Kinross

Visit date: 24th February 2016

Initial planting of 1,000 plants to be raised on site by grower. A walled garden greenhouse will be used for propagation.

The estate has two walled gardens: the smaller one originating from 1575 and a contiguous larger walled garden of traditional C19 design of approximate garden area 2.0 acres. Both gardens are under lawn and the larger garden retains its central path that has newly planted cordon apples in a single row either side of the path. An alternative planting area in the adjacent orchard interplanting tea between new apple trees was discussed but rejected as a plan due i) to poor drainage, and ii) potential shading from apple trees. The C19 garden vista is considered essential to future plans for the house. In view of this constraint, tea could best be incorporated as two parallel hedges either side of the existing path planting of cordon apples.

Organic growing is envisaged and the advantages and disadvantages of this route were discussed.

Garden aspect is less than 1 degree slope due south. Elevation 154m.

Exposure. There is some protection to east and west, and house to north – prevailing wind is westerly.

Soil pH was 6.5 (small walled garden) and 6.3 (large walled garden) when tested in July 2015. Grower will send additional soil sample to Teacraft for testing when the planting site is finalised.

Drip irrigation is advised for drought risk mitigation and for fertigation.

Natural drainage may be problematic depending on the final siting. The C19 garden lawns are mossy, indication low drainage.

The C19 garden has a central manual water pump. Grower will send water sample to Teacraft for testing when the planting site is finalised.

Likely to be a deer and rabbit problem in early years.

Other information. Planted area will need ploughing. Needs soil preparation plan, planting plan, and business plan. The house and gardens are ripe for developing agri-tourism, which venture will be enhanced by having planted tea.

Grower 7. Perth and Kinross

Visit date: 25th February 2016

Initial planting of 3,380 plants to be raised on site by grower. A polytunnel has been set up for propagation.

The farm is on north facing land running down to a small natural lake and brook. It has been fallow for years under rough grass and weeds. The land was walked and various areas discounted based on poor drainage and limited light intensity. The final choice was for an area adjacent to and west of the polytunnel.

Organic growing is strongly envisaged and the advantages and disadvantages of this route were discussed.

Aspect of chosen site is a 2-3 degree slope facing due north. Elevation 106 m.

Exposure. There is little protection on any side – the prevailing wind is westerly along the valley.

Soil pH is 6.1 (tested Feb 2016). This is well outside the ideal range of 4.5 to 5.5 and would benefit from acidification treatment with elemental sulphur during soil preparation. Depending on sight of a full soil analysis with CEC, reading our provisional recommendation would be 150 g/m2 of Brimstone 90 split into two applications, half on soil before deep ploughing and second half rotorvated or harrowed in. This treatment should be applied in spring/summer 2016 and a cover crop of clover sown. An acidifying fertilizer regime will be recommended.

Subsequent Note: As their organic certifying body disallows elemental Sulphur, we have suggested the use of organic poultry manure for soil acidification. This should be pH tested and the correct dose calculated.

Drip irrigation is advised for drought risk mitigation and for fertigation.

Natural drainage should be adequate.

The farm has spring water (reportedly tested at pH 7.7) and it may be possible to utilize the stream below the house.

Likely to be a deer and rabbit problem in early years which will require fencing.

Other information. Monica and Andy are technically minded and solutions driven. They need to make a soil preparation plan, planting plan, and business plan.

Grower 8. Perth and Kinross

Visit date: 25th February 2016

Initial planting of 2,482 plants to be raised by Susie Walker-Munro in leased glasshouses.

There is an old walled garden by the house but the wall has been reduced to 5 ft height, giving no protection, and the land is very flat. An alternative site was sought and found: this comprises a field with hill slope with a 2-5 degree slope about 5 minutes from the house. It is old pasture currently grazed by sheep.

The advantages and disadvantages of organic growing were discussed.

Aspect of chosen site is a 1 degree slope at the top NW corner of the field, facing due south with approximate area of 1.2 acres. Elevation 85m.

Exposure. There is excellent protection due to a tall tree perimeter belt the west and north– the prevailing wind is westerly along the valley. Care must be taken to site the planting at least 20 m from the tree line. There is no protection to the east.

Soil pH is 6.1 (tested Feb 2016). This is well outside the ideal range of 4.5 to 5.5 and would benefit from acidification treatment with elemental sulphur during soil preparation. Depending on sight of a full soil analysis with CEC, reading our provisional recommendation would be 150 g/m2 of Brimstone 90 split into two applications, half on soil before deep ploughing and second half rotorvated or harrowed in. This treatment should be applied in spring/summer 2016 and a cover crop of clover sown. An acidifying fertilizer regime will be recommended.

Drip irrigation is advised for drought risk mitigation and for fertigation.

Natural drainage should be adequate.

The field has mains water supply but it may be possible to utilize the sizable stream below the field.

There will be a deer and rabbit problem in early years that will require fencing.

Other information. Needs to make a soil preparation plan, planting plan, and business plan.

Grower 9. Perth and Kinross

Visit date: 25th February 2016

Initial planting of 2,000 plants to be raised by Susie Walker-Munro in leased glasshouses.

There several small plots around the house. The main area available is about 0.5 acre by the tennis court however the land is very flat. It has been under lawn for about six years. A small additional site is being used as a small football pitch.

The advantages and disadvantages of organic growing were discussed. Ronnie is not keen to use protected agriculture and wants the minimum of disturbance to the land.

Aspect of chosen site is a less than 1 degree south facing slope but with a clear drop of 10 ft on its SE side down to a farm field. Elevation 85m.

Exposure. There is little protection from the prevailing westerly wind though windbreak plastic could be attached to the tennis court fencing to the west. There is some slight protection to the east. Ronnie is not keen to install protection or anything that will spoil the view.

Soil pH is 6.0 (tested Jun 2015) and 6.1 (tested Feb 2016). This is slightly outside the ideal range of 4.5 to 5.5 and would benefit from acidification treatment with elemental sulphur during soil preparation. Depending on sight of a full soil analysis with CEC, reading our provisional recommendation would be 150 g/m2 of Brimstone 90 split into two applications, half on soil before deep ploughing and second half rotorvated or harrowed in. This treatment should be applied in spring/summer 2016 and a cover crop of clover sown. An acidifying fertilizer regime will be recommended.

Drip irrigation is advised for drought risk mitigation and for fertigation.

Natural drainage should be supplemented by ditching between every third hedge of tea, draining to the field below.

The plot has mains water supply adjacent (pH not tested)

There will be a deer and rabbit problem in early years that will require fencing.

Other information. Needs to make a soil preparation plan, planting plan, and business plan.

Grower 10. Angus

Visit date: 24th February 2016

Initial planting of 5,648 plants to be raised by Susie in leased glasshouses.

Site is a Victorian walled garden with a 1-2 degree slope; aspect is due south. Drainage should be no problem though the bottom of the garden is damp due to springs draining down the hill above the garden.

Wind exposure to East and West could be improved by tree planting. Backed to the North by a steep slope with mature trees. Bottom end of the garden tends to be a frost pocket.

Soil pH tested at pH 5.0 (July 2015). Garden has been cropped most recently with red clover (2015)

Drip irrigation advised.

Mains water at pH 5.4 adjacent as well as a spring.

No deer or rabbit problem due to the high walls still intact, though animal proofing of the gate is recommended.

APPENDIX 5. Protected Agriculture

Protected Agriculture (PA) is defined as "modification of the natural environment to achieve optimal growth"[23]. Agriculture, and horticulture in particular, has always sought to accomplish this improvement but modern PA is aimed more at applying technology to address the vagaries of climate volatility (risk reduction) or to challenge conventional climatic limitations to optimal growth (extending agriculture), and for the improving productive use of marginal land (primarily in poverty alleviation).

Glasshouses measuring an acre or even a hectare are commonplace now; Cornerways Nursery in Norfolk has a single glasshouse of 18 hectares housing 250,000 tomato plants that are cropped from February to November. PA glasshouses can include computerised climate control, hot air heating, fan cooling, automatic vent control, automatic shading, CO2 boosting, and lighting by LED; often run at low cost using a biomass powered Combined Heat and Power (CHP) system, plus roof collected rain water recycling through drip irrigation or hydroponics. These are the ultimate examples of PA and allow, for example, around the year tomato, cucumber, pepper and lettuce production in Holland and the UK.

Salad vegetable production by PA without any natural light whatsoever is now being pioneered in Japan – at 10,000 lettuces a day for example (Ref 6).

While a dedicated automated PA glasshouse for tea growing is a practical reality, the investment required may be an initial deterrent until the concept has been better tested on a small scale, so the protected agriculture prospects for tea must rely on less expensive innovations, mainly cross fertilized from other crops.

Horticultural fleece and film – provide warming of soil and air around crops to provide season extension. Spun-bonded polythene fleeces, fine knitted netting and some plastics film mulches can also offer protection against adverse weather including rain, hail and wind, along with eliminating

[23] Jansen and Malter, 1995

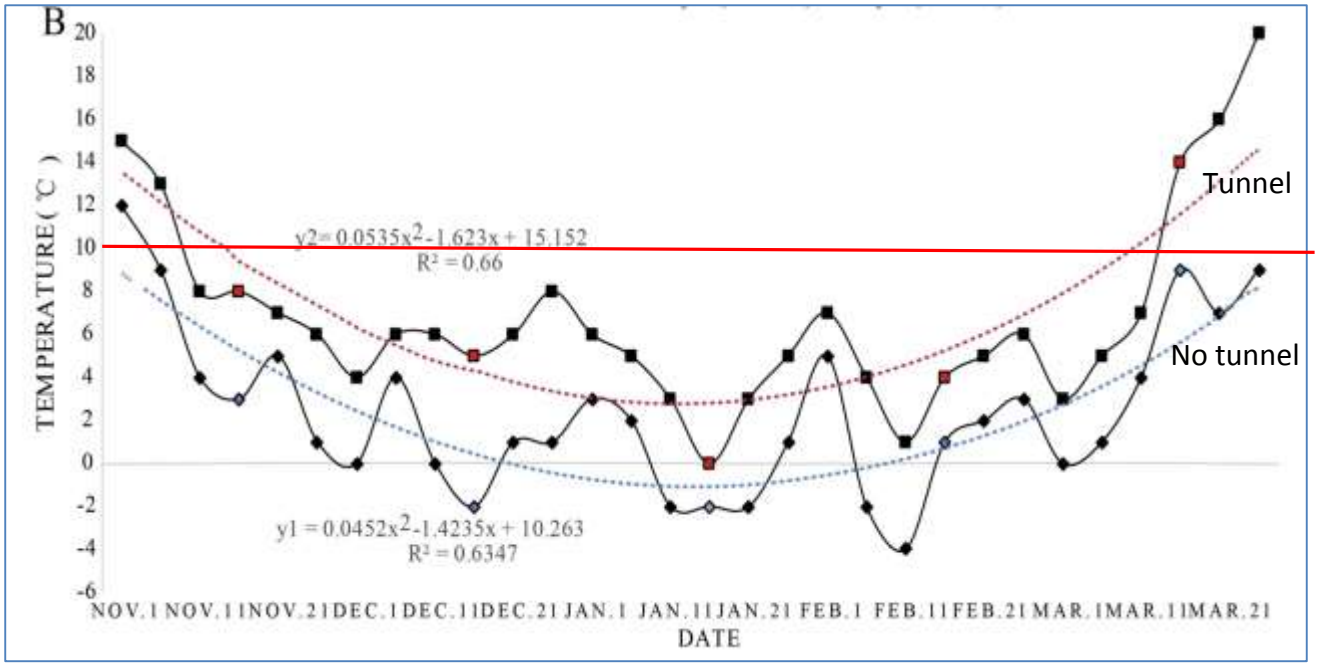
damage from insects, birds and rabbits - helping improve both quality and yield. Used in many overwintered field crops particularly brassicas where the fleece is pegged in place directly over the plants. May give similar protection to newly planted tea saplings. Fleece choice must balance price with degree of protection required and durability. A good review of horticultural fleece options is given in http://www.hortweek.com/horticultural-fabrics/products-kit/article/1362450

Cloches/small tunnels – also known as low tunnels. These are plastic or fleece covered hooped structures that straddle a row, normally intended to protect for a single season. They may be used advantageously for the year after planting tea saplings ex nursery. See Ref.13.

Soil heating. Manure heated hot beds were the secret weapon of the Georgian gardeners and allowed them to produce pineapples and winter cucumbers. Now electricity or geothermal (ground sourced) heating is more appropriate. Tea nurseries certainly can benefit from the technique and it may have application in season extension.

Polytunnels. The classic polytunnel is a simple hooped structure with a single or double skin of clear polyethylene film. There are many sizes and variations, most usefully **D** shaped hoops to improve working height at house edges, and side ventilating using roll up panels.

The effect on growing temperature of a simple polytunnel is demonstrated by Jiazhi Shen et al (Ref 8); see the graph shown below. The bottom trace is open-air minimum temperature during the winter months; the top is minimum air temperature within the plastic polytunnel. Dotted lines are smoothed curves fitting the data points – blue for growing outside and red for growing within the tunnel. The 10°C tea dormancy threshold is shown in red – temperature in the tunnel it remains above above the dormancy threshold temperature longer than outside it. We can calculate from these data that the typical time to reach dormancy break would be 18 days earlier in the tunnel than outside, and that dormancy onset would be delayed by 18 days within the tunnel – a season extension totalling six weeks (41 days).



Good practical advice on the structure and management of suitable greenhouse and polytunnel structures is contained in Ref 13.

Supplemental light – see Appendix 6.

Tree sleeves – conventionally used in mass landscaping of trees along motorways. They vary in opacity from thick plastic that merely protects woody stems from rabbit predation to clear plastic types (illustrated) that allow light to the plant but create a humid microclimate and reduce wind damage. Some types also incorporate a water store to provide drip irrigation during early days after transplanting. Choice of sleeve must take account of the need for annual or twice annual formative pruning.

Mulch is a layer of material on the ground surface. Depending on the mulch chosen, it can reduce weed growth, maintain soil moisture, warm the soil, reduce insect attack, improve soil structure,

provide nutrition, or reflect light back into the canopy. It can be either organic biomass or a man-made plastic. Organic mulch could be grass, bracken, pine needles, or tree bark. Manmade mulch can be granulated car tyres, woven plastic mat or plastic film. Mat is water permeable but film is not. Film can be black, clear or silver. In small plantings of tea, we often plant through plastic weed mat to control weed growth in young tea but build up an organic mulch on top of this.

Shade houses are needed to protect young nursery plants from intense sunlight. They are covered with green or black plastic net with a light transmission degree chosen to match local conditions. Generally unnecessary for seed derived tea but shading is necessary for early growth of tea cuttings even in Scotland.

Windbreaks. It is often necessary to supplement natural tree windbreaks or shelterbelts with temporary artificial windbreaks to lessen wind damage particularly during early growth on new land. As well as reducing physical damage and foliage desiccation they can slow down soil moisture loss, minimise soil erosion, protect from snow, and create a habitat for insects and a wider range of plants (biodiversity). Wind protection should be planted at right angles to the prevailing wind, with actual design depending on the severity of the wind.

A shelterbelt is created from a mix of shrubs and taller trees (over 4.5m/14.5ft) and is usually planted in three or four staggered rows in a triangle pattern.

A windbreak is typically a fence or hedge of a single or double row of tree.

To be effective, windbreaks need to filter 50-60% of wind to reduce its strength. Barriers that are too impervious can cause more damage due to the creation of eddies of wind on either side. Woven hurdles of willow or hazel can be very effective. A windbreak will reduce wind on the leeward side to a distance of 10x its height. Generally, in the UK, prevailing winds are strong and wet from the southwest – these can be at any time of year, or bitter cold north and easterly winds during winter months. Hilly sites may need protection on several sides and wind can be funnelled between lines of trees or buildings, or along valleys.

Artificial windbreaks:

A) Posts under 1.5 m in height need to be at least 9 cm diameter and spaced at two x the height of the screen. Screens over 1.5 m need 15 mm posts spaced at intervals the same height as the screen.
B) Plastic windbreak material needs to be fitted on the windward side and the screen needs to be stretched taut.

Living windbreaks:

Planting for hedges should be close together at spacing 30-90 cm depending on species. Plant deciduous shrubs in the autumn or evergreens in spring. Blackthorn. Berberis, Gorse, Wild Rose, and evergreen shrubs are all suitable.

For shelterbelts, larger trees should be at 2 - 4m spacing with shrubs in between to slow the wind at the base of the belt. Where deep shelter is needed, tall trees can be planted in the centre with bushes front and back. Field Maple, Hazel, Hawthorn, Alder, Mountain Ash, Lilac, Hornbeam, American Lime, White Willow, Lombardy Poplar, Scots Pine, Rocky Mountain Juniper, Norway Spruce, Dwarf Pine, Juniper, and Yew are all suitable. . Evergreens planted too densely they can cause turbulence problems in a shelterbelt so it is best to alternate between evergreens and deciduous trees.

Trees should be guarded from rabbits, well mulched, and watered to establish them. Later on good maintenance pruning will be needed.

In some areas, and particularly where tea is planted without the protection of a walled tea garden, young tea plants may need temporary protection from wind over the winter for their first few years until bushes are mature. This could be using simple fleece tunnels, tall grasses or 1 metre tall mini plastic wind breaks placed along alternate rows at a 45 degree angle to the ground.

APPENDIX 6. Supplementary lighting

This is a very instructive guide to choosing horticultural lamps.

2/19/2016 How To Compare Grow Lights | BML Horticulture

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HOME SCIENCE HOW TO COMPARE GROW LIGHTS

HOW TO COMPARE GROW LIGHTS

Let's face it: comparing various horticulture lighting systems can be a very difficult task. This is especially true due to the amount of exaggerated marketing claims, misleading information and blatantly wrong metrics that are common in the horticulture lighting industry. Hence, we decided to publish a quick guide to help you compare the various lighting solutions on the market. By following these guidelines and asking manufacturers these questions, we believe you be in a much better position to find a horticulture lighting solution that meets your needs.

OK, in order to explain the correct method for evaluating a horticulture lighting system, let's start by highlighting the metrics you should never use when comparing horticulture lighting systems.

DON'T Do The Following:

RULE NUMBER 1
Don't use electrical watts to compare grow lights

RULE NUMBER 2
Don't use Lumens to compare grow lights

RULE NUMBER 3
Don't be fooled by a company that claims to have a magical growth spectrum

RULE NUMBER 4
Don't just look at a single PAR (PPFD) measurement directly under the fixture

RULE NUMBER 5
Don't focus on the wattage of the LED used in the fixture (1W, 3W, 5W, etc.)

In general, if you see a company using any of the above items to promote their horticulture lights, run away and don't look back. Neither of these metrics, nor their derivatives, tell you anything about the performance of a horticulture lighting system.

NOTE:

If you are not familiar with the differences in PAR, PPF and PPFD – please read our article first to get the most out of the rest of the information provided here.

READ ARTICLE ABOUT PAR

As a refresher, PAR (Photosynthetically Active Radiation) simply means the light a fixture emits will promote photosynthesis in a plant. Important - PAR is not a metric, it is simply a type of light. PPF (Photosynthetic Photon Flux) is a critical metric that tells us how much light a fixture emits. It doesn't measure the intensity at any location, but it tells us how many photos are coming out of the light every second. PPFD (Photosynthetic Photon Flux Density) tells us how much light is falling on a very specific location (i.e a specific leaf on your plant) every second. If you have a PAR meter, it is reporting PPFD (umol/m^2/s) measurements. You must understand the differences in these metrics before you can compare various horticulture lighting systems. Many manufacturers realize this can be a confusion topic, so it is very easy for companies to mislead consumers by showing a limited set of metrics. However, once you understand the differences in these metrics, you will be able to cut through all of the 'marketing' and 'hype' and ask manufacturers to provide all of the metrics you need to successfully compare lighting fixtures.

RULE NUMBER 1 Many people use total electrical watts, $/watt or watt/square foot to compare horticulture lighting systems, but these metrics are 100% useless and will most likely lead a consumer to make a poor purchase decision. Why? Simple. Electricity doesn't grow plants. Furthermore, radiometric efficiency (how much light a fixture emits per watt of electricity) can vary by up to 200% amongst the popular LED fixtures on the market today. Hence, since light (not electricity) grows plants, you need to ask how much light a fixture emits. It sounds simple, but 99.9% of horticulture lighting companies do not advertise this metric. Instead, they focus on electrical watts. Why? Because it is very hard to design an efficient lighting system that delivers high light levels (measured in umol/joule), and it is very easy to build an inefficient lighting system that consumes a lot of electricity. High efficiency LEDs, power supplies and optics cost more than less efficient components, and many manufacturers use lower quality components to increase profit margins. To reinforce Rule #1, let's compare two lighting systems using a real-world example.

Let's assume fixture A consumes 333 watts and Fixture B consumes 430 watts. Fixture A costs $1000 and Fixture B costs $1300. By only looking at the electrical watts of each fixture, many consumes would assume Fixture B is a better fixture. After all, the $/Watt is $3 for both fixtures, and many people assume higher wattage lights are better for growing plants. *(See Figure 1)*

However, since Fixture A is 100% more efficient than Fixture B, Fixture A actually delivers 56% more light to the plants, despite costing 23% less than Fixture B. While it may be hard to believe, people who purchase Fixture A actually pay 50% less per unit of photosynthetically active light (PPF) than if they had purchased Fixture B. *(See Figure 2)*

Remember... You are not buying a lighting fixture. You are buying a system that delivers light to grow your plants, so a quantitative measure of light is the only relevant metric you should use to compare horticulture lighting solutions. In this real-world example, Fixture A is our SPYDR 600 GROW-MAX product. Fixture B is an LED fixture made by a competing LED company.

RULE NUMBER 2 is easy to explain. A Lumen is a rating of how bright a light appears to the human eye. However, since human vision is not correlated to photosynthetic grow rates, total lumens is a dead metric. As a rule, if someone is trying to promote lumens for a horticulture lighting system, they should not be selling horticulture lighting systems.

RULE NUMBER 3 Many scientific papers have confirmed that all wavelengths from 400nm to 700nm (the typical PAR range) will grow plants. However, there is a myth that is widely propagated on the Internet that claims plants do not use green light. Many companies promote their magical growth spectrum by publishing the commonly-referenced Chlorophyll A and B absorption spectrum chart. Armed with this chart, they mention that plants are green, so plants reflect green light from the full-spectrum light source. Have you heard this one before? Without going any deeper into this topic, it is important to note that there is no magical spectrum that is going allow a 50W fixture to replace a 1000W fixture because it only uses the "wavelengths that plants need." While plants certainly have multiple pigments and photoreceptors across the PAR range, nothing will trump the need for delivering the required light levels of light to your plants. Spectrum has a very real effect on plant morphology, but be cautious of a company that spends too much time talking

INCORRECT WAY TO COMPARE HORTICULTURE LIGHTS

	FIXTURE A	FIXTURE B	DIFFERENCE
ELECTRICAL WATTS	333	430	29%
FIXTURE PRICE	1000	1302	30%
$/ELECTRICAL WATT	$3.00	$3.02	1%

FIGURE 1

CORRECT WAY TO COMPARE HORTICULTURE LIGHTS

METRIC	FIXTURE A	FIXTURE B	DIFFERENCE

http://www.bmlhorticulture.com/how-to-compare-grow-lights/ 1/3

about their special spectrum (especially if they do not spend equal effort in publishing their delivered PAR measurements.) There is a short list of companies who manufacturer commercial-grade LED fixtures for the professional horticulture industry, and none of them market the number of LED 'bands' in their fixture.

RULE NUMBER 4 Let's take a quick look at Rule 4. Unless you are growing a really small plant directly under your light, a single PPFD measurement doesn't tell you much. By clustering the LEDs closely together and using narrow beam optics, it is very easy for a manufacturer to show an extremely high PAR measurement directly under the fixture. However, unless you are only growing one plant in this exact location, you need to know how much PAR is being distributed across the entire grow area. Since most LED lighting systems centralize the LEDs into a small fixture footprint, these systems naturally produce very high PPFD levels directly under the fixture. However, these light levels will drop significantly as you move the PAR sensor just a small distance from the main fixture housing. Let's take a look at this example. If you are growing over a 4' x 4' area, you need to review the PPFD levels over the expanded footprint to calculate the average light level the lighting system is providing. If you only had the measurement point from Figure 3, you may assume this fixture is extremely powerful. However, you would need multiple measurements across the 4x4 grow area to calculate the average amount of PAR that is provided by the fixture. (See Figure 4) Some companies rely on extremely narrow optics to provide sky-high PPFD numbers, but if your plants are bigger than a few square millimeters (the average sensor size on a PAR meter), then this number does not tell you much about the complete coverage area. Light uniformity across the grow area varies greatly from fixture to fixture, and unfortunately, most manufacturers do not publish complete PAR maps. It is easy to produce high PPFD numbers directly under the fixture, but it takes a very powerful light to deliver high PPFD values to the outer edges of a 4x4 grow area. Compared to fixtures costing less than $2,000, the SPYDR 600 was developed to provide the industry's best uniformity over a 4' x 4' grow area. ***(See Figure 3 and Figure 4)***

This is where a properly calibrated PAR meter is extremely useful. Coupled with a watt meter, these tools are invaluable when comparing the true performance of various lighting systems. If you would average the 400 measurement points in Figure B, you would have the true average light level in your grow area.

As another real-world example, let's study the PAR maps in Fixture 5 and 6. Our SPYDR 600 PAR map is seen in Figure 5, while the PAR map of one of our competitor's fixture is seen in Figure 6. Both fixtures cost approximately $1,000 and they both consume approximately 300 watts. If you only considered the PPFD value directly under the fixture, you would assume the competitive fixture delivers more light than the SPYDR 600. However, since the SPYDR 600 covers a much bigger area, the SPYDR 600 actually delivers 66% more light to the 4x4 grow area.

RULE NUMBER 5 Do you use 1W, 3W, 5W or 10W LEDs? We are asked this question on a frequent basis, but the wattage of the LED does not tell you anything meaningful about the lighting system's performance. Since LED and fixture efficiency varies widely, the wattage of the LED is not a meaningful metric. Remember, the LED wattage is a system Input, and growers care about the system Output. Hence, the LED wattage doesn't tell us anything about the system's ability to deliver light to your plants.

As a simple analogy, the LED inside a lighting system is equivalent to the engine in a car. By itself, the horsepower rating of the engine doesn't tell you how fast the car will go. Pair a high-horsepower engine with a poorly designed transmission, and the car will not go very fast. Hence, as far as the driver is concerned, the relevant metrics for a car are related to the performance the car actually delivers (i.e. 0-60 mph time, top speed, miles per gallon, etc.). Any reference to a component inside the car is irrelevant to the driver. It is the same situation with lighting systems. The amount of light delivered to your grow area, the electrical watt consumption and the light distribution pattern are the important metrics, so ask for more information if a manufacturer wants to focus on the type of LED they use.

Note: *Since LED quality varies by a very wide margin, it is important to know the brand of LEDs used in the lighting system. There are a handful of world-class LED manufacturers, so make sure you find out what type of LEDs are used in the lighting system. Assuming the fixture manufacturer has developed a reliable fixture design, higher quality LEDs should last longer if they are not being over-driven to achieve higher light levels.*

Again, you are buying **light** to grow your plants. In our opinion, you want to buy a lighting system that delivers the required amount of light to your plants for the lowest initial cost while consuming the fewest electrical watts possible. Ask the fixture manufacturer to provide the following pieces on information: PPF, Input watts and PPFD Maps for your intended coverage area. With this information, you can calculate the most important metrics these metrics: PPF/$, µmol/J, light distribution patterns and uniformity levels.

If you have any questions about this process, feel free to email us or call us at 512-524-7640.

Nick Klase
Co-Founder

BML Horticulture

PPF	566	367	54%[1]
µmol/J (electrical efficiency)	1.70	0.85	100%[2]
$/PPF (cost per unit of light)	$1.77	$3.54	101%[3]

Findings:

[1]Fixture A emits 54% more light than Fixture B
[2]Fixture A emits 100% more light per watt than Fixture B
[3]Fixture B costs 101% more per unit of PAR than Fixture A

FIGURE 2

FIGURE 3
1 x 1 grid = 1 measurement point 1000 PPFD only at ONE exact spot as indicated here

The single measurement point only provides the average PPFD (µmol/m2/s) light level over the 1' x 1' grow area.

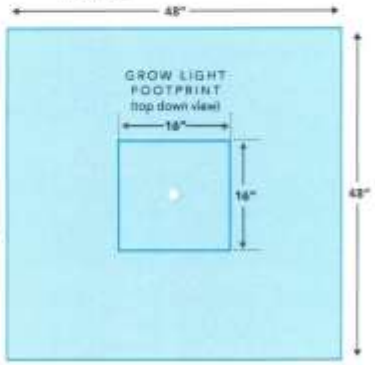
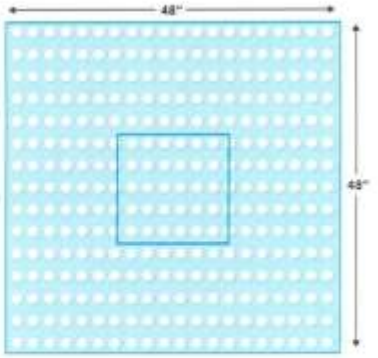


FIGURE 4
20 x 20 grid = 400 measurement points

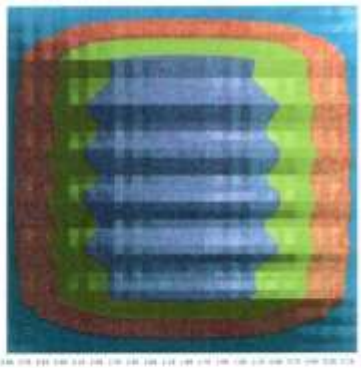
The average of the 400 measurements is the average PPFD (µmol/m2/s) light level over the 4' x 4' grow area



BML **SPYDR 600** PAR MAP
light bars SPREAD
for 4' x 4' coverage

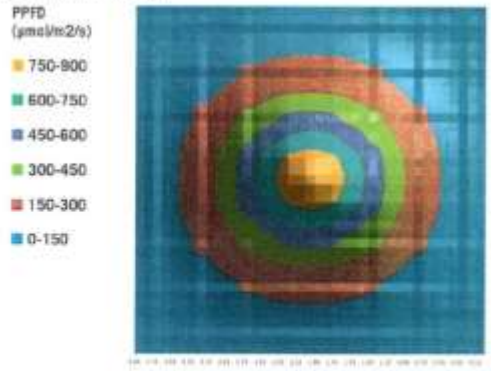
FIGURE 5

PPFD (µmol/m2/s)
- 450-600
- 300-450
- 150-300
- 0-150



Competitor's $1,000 LED Light
PAR MAP

FIGURE 6



RESEARCH & SCIENCE PAGES CATEGORIES NEWSLETTER CONNECT WITH US

APPENDIX 7. What are they saying about specialty tea?

The media have recognised the growth of specialty teas for the last two decades.

Why the US Tea Industry Is Seeing Impressive Growth

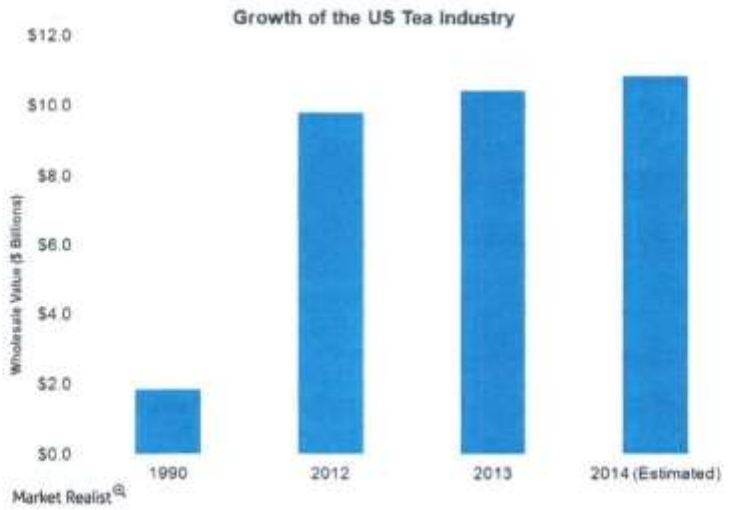
Why the US Tea Industry Is Seeing Impressive Growth (Part 1 of 5)

The Growing Demand for Tea in the US

By Sharon Bailey - Jun 4, 2015 4:08 pm EDT

The World Tea Expo

The World Tea Expo was held from May 6 to May 8 in Long Beach, California. The World Tea Expo is organized by The Beverage Group, an integrated media company that provides business solutions to the global beverage industry. The trade show had participants from over 50 countries.



Growth in tea consumption

Tea is the second most popular beverage in the world, next to water. Though the per capita consumption of tea in the US is quite low compared to countries like the UK and China, the growth in tea consumption in recent years has been impressive. According to the Tea Association of the USA, the total wholesale value of tea sold in the US grew from less than $2 billion in 1990 to over $10 billion in 2014. The preference for healthier beverages is driving consumers away from soda and boosting the demand for tea and other categories like bottled water.

Major players

The major companies in the US tea business include Unilever (UL), R.C. Bigelow, Hain Celestial, and Twinings. Beverage giants like PepsiCo (PEP), Coca-Cola (KO), and Dr Pepper Snapple (DPS) also have some strong tea brands in their respective portfolios. PepsiCo, under its partnership with Unilever, sells ready-to-drink Lipton iced teas. Beverage companies make up ~20% of the portfolio holdings of the Consumer Staples Select Sector SPDR Fund (XLP).

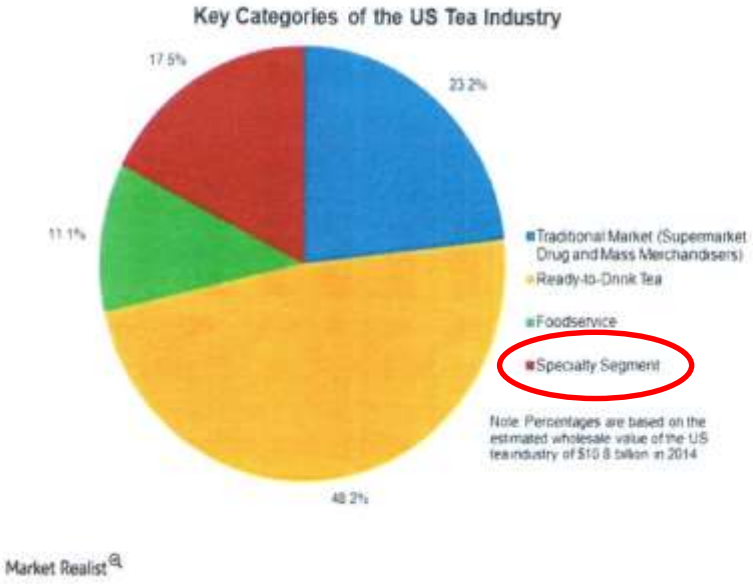
The World Tea Expo discussed several topics, including the general trends and growing demand in the tea industry, direct trade with tea producers, product quality, false marketing and labeling, and commercial production of tea in the US. The expo's primary focus was on specialty and premium teas.

By Sharon Bailey • Jun 4, 2015 4:10 pm EDT

US tea industry

Data from the Tea Association of the USA estimates that the wholesale value of the US tea industry grew by 4.1% to reach $10.8 billion in 2014. The key categories of the US tea segment are:

- ready-to-drink tea
- traditional market, which includes supermarkets, drug stores, and mass merchandisers
- foodservice
- specialty segment



Dominant category: ready-to-drink tea

As indicated in the above chart, based on the data provided by the USTA, the ready-to-drink category is the US tea industry's largest segment accounting for about 48.2%, or $5.2 billion, of the total wholesale value. The traditional segment is the second-largest segment with an estimated value of $2.5 billion in 2014. The specialty tea segment accounted for 17.5%, or $1.9 billion, of the estimated wholesale value, while the foodservice segment accounted for 11.1%, or $1.2 billion, of the estimated wholesale value of the tea industry in 2014.

Popular tea varieties

Americans consumed over 80 billion servings of tea, or more than 3.6 billion gallons in 2014. Iced tea is the preferred choice in the US, and it accounted for ~85% of the tea consumed. In terms of tea varieties, about 84% of the tea consumed in the US was black tea, 15% was green tea, and the remaining portion included oolong, white, and dark tea. Though all these varieties of teas come from the same plant, the difference lies in the degree of processing and the oxidization level.

Some popular tea brands include Starbucks' (SBUX) Teavana brand, Coca-Cola's (KO) Fuze and Gold Peak brands, the Snapple brand portfolio owned by Dr Pepper Snapple (DPS), and PepsiCo (PEP) and Unilever's (UL) Pure Leaf brand.

Unilever makes up ~0.2% of the Vanguard FTSE All-World ex-US ETF (VEU).

What's So Special About Specialty Tea?

By Sharon Bailey | Jun 4, 2015 4:11 pm EDT

Specialty tea

The May 2015 World Tea Expo focused specifically on the specialty or premium tea segment. According to the Specialty Tea Institute, the definition of specialty tea differs across countries. For instance, green tea might be considered a specialty tea in the US, but not in Japan, where green tea accounts for the majority of tea consumption. Generally, specialty or premium tea is used to define tea of high quality. Flavored teas such as Earl Grey, scented teas such as Jasmine, and spiced teas also come under the specialty tea category.

According to the Tea Association of the USA, the specialty tea segment's wholesale value increased to an estimated $1.9 billion in 2014, up 9.8% from 2013.

Stash Tea Company and Teavana are some prominent names in the specialty tea segment. Starbucks (SBUX) acquired Teavana in 2012. Unilever (UL) expanded in the premium tea category through the September 2013 acquisition of T2, a premium Australian tea business.

Coca-Cola's (KO) Honest Tea brand is also a premium brand. In September 2014, Coca-Cola announced that Honest Tea will be available in K-Cup packs for the Keurig hot brewers as part of its deal with Keurig Green Mountain (GMCR). Coca-Cola makes up ~9.0% of the portfolio holdings of the Consumer Staples Select Sector SPDR Fund (XLP).

Premium prices

According to a conference at the World Tea Expo, Growing Tea Commercially in the USA by Nigel Melican, the production of specialty tea costs $10 per pound compared to $0.75 per pound for traditional tea. The quality and production costs involved enable the specialty tea grower to price the product at a minimum of $15 per pound compared to $1.13 per pound for traditional tea. Those manufacturing top grades of specialty tea can look for prices in the range of $59 to $90 per pound.

Favorable factors for specialty tea growth

Specialty tea is attracting affluent, young, educated and health conscious consumers who like to experiment with unique and organic flavors. Also the profitability involved in specialty categories will attract more manufacturers. The number of restaurants serving specialty tea and the number of tea salons have also been increasing over the years.

A current view of the specialty tea sector reprinted from World Tea News, July 2012

Sage Group: Tea Sales are Bigger than you Think

By: **Dan Bolton** | July 12, 2012

WINNIPEG, Manitoba

Every retailer knows tea carries an outstanding markup – it's even more impressive on the grand scale of continents.

In 2011 the United States consumed 116,184,737 kilos (net) of whole leaf and bagged tea, and an estimated 8.6 million kilos (leaf equivalent) of instant tea. Canada imported 19.1 million kilos, re-exported 1.7 million, mainly to the U.S., and drank the remaining 17.5 million kilos accounting for sales of $412 million.

In the U.S. the tea industry's wholesale value exceeds $8.2 billion.

So how much is all that tea worth at retail?

So How Big is the Markup?

Assuming a wholesale cost of goods of $8.2 billion on total sales of $27 billion the gross profit is $18.8 billion and the margin is 70% with a markup of 230%.

RETAIL MARKUP

Selling price: $27 billion
Wholesale cost of goods: $8.2 billion
Gross profit: $18.8 billion
Gross profit margin: 69.63%
Markup: 229%

It is much higher than you think, according to Brian R. Keating, founder of Seattle-based Sage Group Networks.

Market analysts consistently fail to account for several billion in tea sales, according to Keating.

"The total tea market size has been grossly under-reported" and is actually greater than $27 billion, said Keating who last week released Specialty Tea Is "Hot" Report®, the seventh in a series on specialty tea dating to 1993. He and researcher Dan McKeon identified several billion dollars in tea commerce they say is commonly missed by other market researchers.

"Quantification of the tea industry in the United States – all segments, channels and product types – has always been an arduous undertaking with a wide range of estimates as a result," according to the report. "Some sources report ridiculously low totals; others are very high. Few analysts provide details on how they arrive at their conclusions and to be fair, there are many reasons tea market quantifications have historically been disparate and contradictory."

In its *Tea and Ready-to-Drink Tea in the U.S. 2012*, market report, released last October, research publisher Packaged Facts predicted "tea – instant, leaf, liquid concentrate and ready-to-drink – is expected to heat up over the next five years, growing from an estimated $7.4 billion in sales in 2007 to nearly $15 billion in 2012."

Keating said the U.S. blew past those sales total years ago.

Wholesale tea sales totaled $1.84 billion in 1990 and have since grown four-fold, according to the Tea Association of the USA. Tea's retail value has certainly climbed as well, but none beside Sage place the total anywhere near $27 billion.

Packaged Facts and Sage Group agree that tea is "one of the most underdeveloped beverages in the United States. Tea barely compares in size to beverage categories such as carbonated soft drinks, coffee, and water."

"The specialty tea industry is booming across North America. Virtually every distribution channel and product type is experiencing growth and high velocity. Our analysts estimate the U.S. tea industry is substantially larger than anyone has calculated previously," said Keating. "No one has ever taken the effort to drill down into the massive foodservice segment of the tea industry. Yet, industry trade groups estimate more than 75% of all tea consumed in North America is iced or cold. The total tea market size has been grossly underreported."

So just how big is foodservice?

Foodservice sales are huge say experts, but so is the discrepancy in sales estimates.

All agree that black and flavored black iced tea is by far the most popular with restaurant patrons with green the fastest growing segment in hot and cold. The Tea Association reports 85% of the nation's 65 billion annual servings are iced with 65% percent brewed from tea bags.

Keating thinks iced tea sales alone amount to $17 billion based on his calculation that 43% of the dry tea imported into the country winds up as iced tea. The newly developed market quantification model assumes a dry tea retail price (extrapolated all the way down to grams used per serving and subsequent dollars captured) of $350 per kilo.

Servings of iced tea in all restaurants were less than 4 billion annually in 2001 according to market research firm NPD Group which calculated 5.6 billion foodservice servings in 2011, based on its CREST Commercial survey of Servings & Menu Importance of Foods.

Using an industry-standard $2.50 per cup as the average retail price, iced tea would account for $14 billion in sales.

This is $3 billion less than Sage Group's tally.

In its "Coffee and Tea Foodservice Trends in the U.S.," published in March 2012, Packaged Facts estimated coffee and tea beverage sales at $18.7 billion with coffee contributing $10 billion (53.5%) share and tea accounting for $8.7 billion (46.5% share). This forecast did not include foodservice sales at food retailers, convenience stores, non-commercial foodservice, etc.

This calculation is $8.3 billion below the Sage Group estimate.

Package Facts defends its estimates, explaining that non-alcoholic beverages account for 11% share of restaurant and drinking places sales of $496 billion "which aligns fairly well with Census estimates and the market which consists of a higher percentage share at Quick Service Restaurants (QSR) and much lower at full-service restaurants, where alcohol sales come into play."

Data is obtained from the Bureau of Economic Analysis, U.S. Census Bureau, International Trade Centre and U.S.D.A., as well from consumer survey usage tracking analysis and trade interviews.

"At 14%, our market size for tea would be about $11.25 billion," according to Packaged Facts.

"The variance of estimates by virtually every B2B report and source on U.S. total tea sales is massive, with zero chance of alignment occurring anytime soon," said Keating. He recommends analysts examine closely

the relationship between dry tea imports and the most stringent estimates of servings that same tea produces into finished servings.

“Tea industry veterans have reviewed our analytical methodology and consider it entirely plausible,” said Keating.

New methodology

There is general agreement on the amount of tea that arrives in the U.S.
with totals based on Customs declarations of wholesale value and quantities calculated in the GATS (Global Agricultural Trade System) database maintained by the Foreign Agriculture Service.

In 2011 the declared value of all tea (except herbals) was $641,960,000 on imports of 211.5 million kilos. The International Tea Committee (ITC) in London which tracks exports and imports from every producing country reported U.S. tea imports at 127.5 million kilos (excluding powdered/instant tea primarily used to make bottled tea). The U.S. re-exported 11 million of this total.

The Tea Association of the USA estimates the industry’s wholesale value at **$8.2 billion. It is** comprised of the following four segments, derived from several industry sources and a useful benchmark.

Traditional packaged tea sold in supermarkets, drug stores, convenience outlets and mass market accounts for **$2.20 billion** of this total. SymphonyIRI Group, a Chicago-based market research firm, estimates supermarket sales of tea bags at $806.8 million of this total [excluding Wal-Mart] with instant tea accounting for $269.8 million and the remainder sold as loose leaf tea.

Ready-to-drink tea also sold in supermarkets, drug stores, convenience outlets and mass market totals **$3.5 billion**. SymphonyIRI Group estimates the supermarket share [excluding Wal-Mart] of canned and bottled tea at $1.30 billion excluding gasoline/convenience. Sales of refrigerated teas were $442.8 million last year.

Foodservice sales of both hot and cold tea, excluding convenience are estimated at **$1.07 billion** and specialty tea, comprising a broad range of premium loose leaf and packaged tea, excluding RTD, amounts to $1.43 billion of total sales, according to the Tea Association.

Grand total: **$8.2 billion.**

“We’ve undertaken a new effort to produce a revised estimate of the total U.S. tea industry annual sales, using 2011 as the base year,” Keating explains. He also breaks the tea industry down into four segments:

Retail dry tea in tea bags, loose leaf and other non-RTD formats tallied **$4 billion** last year.

Ready-to-drink tea, sold in cans and bottles amounted to **$5 billion** in retail sales.

Foodservice hot tea, served in restaurants of all types including tea rooms amounts to **$1 billion** in sales.

Foodservice iced tea, sold in restaurants of all types, including fast-food and convenience topped **$17 billion** in 2011, according to Keating, making a grand retail sales total of **$27 billion** for the tea industry.

“We started with U.S. tea imports and deducted export to determine the quantity of tea inside U.S. borders in 2011 – a proxy for total 2011 tea consumption,” according to the report. “Though there are many factors that may cause actual tea consumption to vary from this number, it will likely be quite close. We then extrapolated this figure into various distribution channels and product types to generate a clearer picture of the tea industry’s probable values (dollars generated at point of sale).”

The new Sage Group report features extensive coverage of the burgeoning growth of retail tea chains, major investors seeking tea-related deals, and interviews with specialty tea industry masters, pioneers, and experts. Significant coverage of the Canadian specialty tea industry is also part of the new report.

Regardless of the actual retail value, "fresh investment capital will go from a trickle to a stream as cash-heavy investors become more comfortable with the upside potential that specialty tea represents," said Keating. Mergers and acquisitions will pick up speed and retail operations will expand, he predicts.

Very large companies are now diving into diverse tea ventures and "fresh capital sources are lowering their usual minimum investment benchmarks as they discover solid bottom-line profits and untapped growth potential," he said.

To learn more visit www.teareport.com

About Dan Bolton

Dan Bolton edits STiR Tea & Coffee Industry International. He was formerly editor and publisher of World Tea News and former editor and publisher of Tea Magazine and former editor-in-chief of Specialty Coffee Retailer. He is a beverage retail consultant and frequent speaker at industry seminars and conferences. His work has appeared in many beverage publications. He was a newspaper reporter and editor for 20 years prior to his career in magazines. Dan is the founding editor of Natural Food magazine and has led six publishing ventures since 1995. He lives in Winnipeg, Canada.

An article reprinted by permission of the publishers from the Tea &Coffee Trade Journal (April 1) that encapsualutes the industry view of specialty tea 25 years ago.

Defining Specialty Tea

BY RANDY ALTMAN

What is specialty tea in 2001? High-quality tea is now more a factor in retail marketing of specialty product. A few trends in "specialty" do use average- to below-average tea. The good news is that high-quality tea is being cultivated and sold in larger volumes than in previous years, however, the media is largely ignoring this progress.

From a marketing or revenue perspective, at least in the U.S., the definition of "specialty" tea includes whatever is new and profitable. For example, the chai category is still expanding, with the tea quality spanning inferior to excellent. Tea quality in some chai is imperceptible to most U.S. consumers, with heavy ingredients like saturated animal fat, sugar, and strong spices. Tea products that retail-price higher if labeled "specialty" will be marketed as specialty. The latest youth-oriented novelty tea, sometimes called bubble or "boba" tea, can combine, for example, thick chocolatey tapioca, milk, sugar and spice. This really violates no labeling laws if called "specialty" tea. Connoisseurs cringe.

Green tea is a very different category, although its relationship to "specialty" status is also ambiguous. In the U.S., green tea is expanding shelf space in supermarkets. If specialty is defined as "new" or "special," green tea fits that designation in the U.S. Every day, consumers are making their first-time supermarket purchase of green tea, a certainly healthful and probably positive experience. But this favorable consumer choice is usually not within traditional definitions of "specialty" tea.

Yet another new category of specialty tea involves "functional" or nutraceutical tea. This burgeoning category is *not* the same as herbal tea or "tisanes," although the public is easily confused. For example, a pure-tea functional product routinely contains both tea-extract-derived antioxidants and tea. Whatever the taste, vitamin-added or antioxidant-added teas are a growing market niche that is bringing in new consumers.

Celestial Seasonings has a line of "functional" tea that the parent company, Hain Celestial Group, plans as a profit center. These enhanced tea products are probably a profitable long-term category, considering the aging middle-class. One Celestial brand states in bold yellow, "NEW!" and under the "NEW!" proclamation is the phrase, "50% MORE ANTIOXIDANTS than ordinary tea." The ingredient listing is simple, "Tea and tea extract." This is a tea prod-

Premium Teas from India & Beyond

Devan Shah started International Tea Importers/India Tea Importers in 1990. Shah started his career has a sampling boy with a teahouse in Nilgiris, India and has been involved in the industry for 17 years. He started by importing premium teas from India to the U.S. Today, they import teas from around the world and are know as International Tea Importers. Their growth can be attributed to the fact that they distribute as little as 2 lbs. to over 2,000 lbs. to their clients. They carry over 500 premium teas from all over the world with prices as low as US $1.00 a lb. to over US $250.00 a lb.

They also do their own flavoring and all of their flavored teas are done to order in the U.S. They use a variety of base teas from China STD 1265 to a fine Beverly Estate Ceylon OP. However, they do recommend using Nilgiri Teas for flavoring because they are neutral and have a strong cup character. Besides, these teas are high-grown and are of premium quality. Nilgiri Teas tend to have a higher price but many believe you get a better value when Nilgiris are used.

Korakundha/Chamraj Teas

The United Nilgiri Tea Estates Co. Ltd. is also known as the Chamraj Group and are owners of Chamraj, Korakundha, Welbeck and Kotada tea estates in the Nilgiris. These are some of the finest Nilgiri tea estates with some of the highest elevations. Chamraj group teas have been, for a long time, sought after in the European markets and are now available in the U.S. The Chamraj group as been appointed as the sole distributors for the U.S. market and they stock all of them at their facility in Montebello.

Korakundha tea estate is a feather in the cap for the Chamraj Group – Korakundha is the first and the only organic Nilgiri tea estate, which is over 2,500 meters above sea level. It has the highest elevation of any of the Nilgiri tea estates. The flavor of Nilgiri teas is derived from their high elevation and is present throughout the year in varying degrees. Korakhunda estate also has a water process decaf facility on the estate itself and hence is able to produce naturally decaffeinated black and green organic teas of all different grades.

Besides Korakundha, Burnside estate also has the same decaffeination facility and is able to provide decaffeinated black teas at a very competitive price.

The decaffeination facility at the estate makes them a leader in the area of decaffeination. There is no other organic or non-organic estate in the world that can claim to this leadership role in the tea industry.

uct, not an herbal. The side label reads, "Guaranteed to give you 50% more antioxidant power than ordinary tea!" On this same package, the word "power" appears three times, "nurture your good health" twice, "good health" is labeled five times and the organ "heart" gets a total of three mentions.

The Hain Celestial Group is run by Irwin D. Simon, by triune title — chairman, president and chief executive officer. The vice chairman is Mo Siegal, founder of Celestial Seasonings, who returned to active management at Celestial's historical base about 1,500 miles away from Hain headquarters. Last June, Celestial's president and c.e.o resigned, followed two weeks later by five other senior executives.

Celestial retains a valuable brand name, a strongly loyal customer base, and one of the most extensive packaging ranges in the tea trade. Celestial recently streamlined warehousing, inventory and distribution, under orders from Hain, as reported by Prudential Securities analyst John McMillan, who stated for Reuters, "They (Hain) knew they were buying a company that had some excess inventory levels, but no one thought they would be this high."

Stash is another large company with a new line of specialty tea, in an innovative resealable pouch format. The pouch label reads, "Stash Premium loose leaf Tea." Their English Breakfast contains China, India and Ceylon only — an interesting blend. English Breakfast blends also traditionally contain African, but far too often low quality, used as cheap filler or to provide an "exotic" locale on a label. And, for anyone wanting more bergamot, Stash introduces Double Bergamot Earl Grey.

Continuing this "extra-strength" motif is Super Irish Breakfast, described as "the 'espresso' of tea" and as a "robust blend of rich Assams, Ceylons and other premium teas." Stash's descriptions help to educate the public on tea-growing regions. Such regional details on widely-sold tea help promote the specialty market niche, however one defines the niche. Following more traditional specialty styles, Stash's new Full Leaf line has a Darjeeling blend and a single-estate Assam from trademarked Kopili.

Stash sells a separate, older line called Energy Tea, which is serves as a good example of a product that spans traditional tea typology. The label reads, "Energy Tea with Mate and Guarana," and the ingredients listing is informative: "100% Green tea, black tea, ginseng, yerba mate, rooibos and guarana." This superior blend is a tea-and-tisane hybrid, with a high caffeine content. The product is a unique combination of healthful substances (green tea and rooibos) with naturally caffeinated species (guaraña and maté).

Stash, prominently displaying its Oregon, U.S. base, skillfully keeps away from the public eye its lack of autonomy and American control. Stash is a subsidiary of a foreign entity, reportedly wholly owned by one elderly individual in Japan. Celestial Seasonings similarly benefits from perpetuating its image of a free-standing company, prominently mentioning their bucolic Boulder, Colorado, headquarters on their packaging. In fact, the company is now actually run out of Uniondale, New York. Celestial's image as a self-standing enterprise is enshrined

in its street address, Sleepytime Drive, referring to its less-pressured previous days. Boulder is trendy (my daughter lives there), but Sleepytime Drive is awake and anxious over New York cost cutting.

Other roads in the U.S. are named after tea businesses, a little-known fact that is a charming testimonial to the power and positive community-image of the tea business. The Greensboro, North Carolina, division of the British Twining company resides on, yes, Twining Road. Twining is now redesigning both its tins and cardboard boxes, in order to create a more unified, consistent brand image. Lipton, too, will introduce redesigned tea packaging later this year, one of the most significant U.S. brand image renovations this decade.

Specialty tea often connotes a region, such as Darjeeling or Ceylon, or a national heritage, often British. Bad tea can be made anywhere, however exotic or rare the origin. The two worst teas I have ever experienced were premium-priced from Nepal. For marketing purposes, *any* tea can be labeled to consumers as "specialty." One method used to confuse the retail buyer is labeling that accurately states the tea's rarity, even though the tea is truly bad. Rarity is quantifiable, but after five graduate courses in statistics, I still know of no method to quantitatively define "specialty."

More damaging to the market image of "specialty" than bad rare tea is the trend for mediocre tea packaged in nation-of-origin to mimic high-class specialty tea. Often, the packaging is balsa, a porous wood that allows humidity transfer far more easily than hardwood. The packaging paradoxically accelerates the deterioration of the bad tea. Even worse, the internal environment inside the factory where the tea is packaged is generally humid and buggy, with workers not wearing hygienic gloves or facemasks. I have witnessed up-close tuberculosis, a disease common in tea-growing regions, including Multi-Drug-Resistant (MDR) cases actively virulent.

Very high-quality tea can be made in large quantities under modern conditions, proven by Bombay Burmah Trading Corporation, in India, and New Vithanakanda, in Sri Lanka. N.B.H. Pilapitiya owns New Vithanakanda, producing a remarkable 1,152 tons of specialty tea. Pilapitiya combines business leadership in export globalization of high-quality tea with civic leadership as chairman of the Private Tea Factory Owners' Association. Sri Lankan factories are generally the most modern and well-maintained, which can meet German and Swiss expec-

tations, among the most demanding markets. Denzil Soza, chairman and managing director of Needwood Emmag Ltd (NEL), maintains a focus on Europe, where Needwood is a well-known upscale brand name.

In terms of diversity of specialty product from Ceylon, MJF Group always deserves mention, along with the famous family trio of Merrill, Dilhan and Malik Fernando. MJF ranked #1 in bags for export in 2000. Other companies with a good combination of packaging, tea quality and large volume include Mabroc, Standard Trading, Imperial Teas and Tea Tang. The company with probably the most specialty products under one brand name is Mlesna, which states 1,600 tea items. Anselm B. Perera is Chairman and Managing Director of Mlesna. Perera also controls Euro-Scan Exports Ltd, which owns the successful e-mail address: euroscan@slt.lk.

Sri Lanka's famous Kenilworth has a branding advantage because of the Britishness of the name. Kenilworth is also a heavyweight, producing just over 981 tons last year. These amounts in the KT range far outsize the typical estate yield from the world's most prestigious region, Darjeeling. Annualized Ceylon figures are recently verified under the Tea Bureau directorship of A. Hasitha De Alwis, probably the most respected governmental senior tea official in the world. A review of the data shows other weighty Ceylon specialty estates: Courtlodge, 607.2 tons, Pettiagala, 504 tons, Labookella, 602.44 tons, and Tommangong, 471.84 tons. Looking to the future beyond today's statistics, a sign of success in Ceylon's export globalization is the increasing interest from Japanese buyers in Ceylon specialty tea, such as Koslanda organic and St. Clair.

The longest-term perspective on specialty marketing brings news from Bhutan, with reports of a government-sponsored pilot project for fine tea in the Gedu region. Profit for many generations is probably attainable after about five years. Bhutan's infrastructure is nonexistent in most of the nation, but this pioneering project appears supportable. Gedu is situated between the capital, Thimphu, and the nation's primary border city, Phuentsoling. This corridor is the location of the National Highway, providing the required export route to Calcutta, which would re-export the tea. Calcutta has long served as Bhutan's vital hub, even for airmail.

Bhutan's agriculture minister is Lyonpo Kinzang Dorji. Earning hard "foreign" currency is almost certain if they proceed, perhaps with Indian agricultural advisors and military-engineering advisors for road, factory and drainage construction. Reports indicate tea laborers will need training in basic cultivation skills. The more uncertain variables include soil drainage and timing of rain. Reportedly, the project has the backing of elements of the royal family's female side, who hold immense influence because they are related by marriage to the absolute ruler, King Jigme Singye Wangchuck.

Back in the corporate West, authority systems are structured differently, but hierarchy of control is equally real. Celestial answers to Hain, Stash answers to Yamamoto, and Tazo answers to Starbucks. Tazo, winner of well-deserved design awards, appears headed for greater attention and shelf space from Starbucks. Tazo will bring out later this year a precedent-setting Full Leaf Tea Kit with Infuser Canister. The Full Leaf Tea Kit is a genuine breakthrough, allowing a new point-of-consumption method of tea brewing. The Infuser Canister is patented, trademarked and copyrighted.

The Tea Kit is a premium-priced item that provides convenience for the affluent and a novelty-item for the experimentally oriented. Steven Smith, founder of Tazo, retains influ-

ence over the tea world as creative director at Starbucks. Starbucks' senior vice president of New Ventures is Darren Huston, recently appointed to the board of NPower, which itself just announced a Microsoft partnership in its community charities.

The consequence of the past few years of mergers can improve premium tea marketing, because promotion money for specialty tea can come from the larger budgets of the mega-corporations.

The strategic benefit to the specialty trade occurs when big corporations decide their premium tea lines are profit centers and customer-loyalty creators. Tea is gaining greater exposure among the premium-beverage consuming public. The biggest player in the game, Unilever, just shot past 50-billion-dollars annual revenue (now $52 billion). Unilever, while devolving most of its brands, retains Lipton as a "core brand." The public will hear more from upscale Sir Thomas and the less prestigious mass-market Lipton teas, also made under superior quality-control. The big companies know advertising, and Unilever spends far over $100 million a year on tea publicity. The entire Darjeeling region has relatively very little money for consistent promotion.

In some of the world's largest markets, Lipton, is losing market-share, most notably among India's one-billion-plus consumers. Reuters reports at time of this writing that SSKI Securities continues to rank Hindustan Lever Ltd (HLL) as "underperform." Depending on financial criteria for analysis, HLL is India's second or third largest corporation. The point is HLL can afford to, and they plan to, newly promote tea, necessary to keep other beverages from permanently winning stomach-share. Specialty tea's main competitor is not cheaper tea, but non-tea beverage, especially caffeinated, from colas to hot chocolate to coffee.

Tea earns a living for several million humans on planet earth, from Bhutan to Boston, from Bombay to Boulder. Specialty tea is the trade leader in pointing to the future. Value-added product will combine with precisely targeted promotional campaigns to keep tea the choice among the 21st century affluent. Individual specialty estates will become better publicized. This trend of branding more estates by name is visible today, but will proceed at a slow rate, hobbled by the producing regions' major economic problems.

Randy Altman, in addition to being a knowledgeable writer on the subject of tea, has advised the United Nations and other transnational organizations, and has held directorships and officerships at various non-profit corporations. He also holds several adjunct academic appointments.