AARHUS UNIVERSITY

Mid-term seminar report

Impact of climate on productivity and quality of raspberry

Tek P. Gotame

Department of Food Science

Supervisors:

Lillie Andersen (AU)

Karen K Petersen (AU)

Julie Graham (JHI)

Carl O Ottosen (AU)

Hanne L Pedersen (AU)

CONTENTS

PhD PROJECT

PhD supervisors

Lillie Andersen – Principle supervisor - AU

Karen K Petersen - Co-supervisor- AU

Julie Graham – Co-supervisor- JHI, Scotland

Carl Otto Ottosen - Co-supervisor- AU

Hanne L Pedersen - Co-supervisor- AU

BACKGROUND

Raspberry *(Rubus idaeus* L.*)* is an important soft fruit crop across cold and temperate regions of the world (Heide *et al.* 2011). Interest in raspberry production in open, high tunnel and greenhouse conditions has been increased (Oliveira *et al.* 2002; Dale *et al.* 2003; Dale *et al.* 2005). However, cultivated raspberry varieties are poorly adapted to warm temperature and high humidity during summer as well as fluctuating temperatures during winter (Ballington *et al.* 2008). Changing climatic conditions are becoming a limiting factor in the sustainable production of berry fruit from existing commercial cultivars in the North Sea Region (NSR). However, the timing and severity of climate stress is unknown. Whilst raspberries are traditionally produced in the field, new protected production systems are now being established so that double cropping systems are possible. These changes in production systems are being introduced given the need to secure productivity during times of changing climate and to increase productivity. These problems need to address to sustain the raspberry industry in future. Within this background, following hypotheses and objectives are formulated.

HYPOTHESES

- Elevated temperature regimes decrease photosynthetic efficiency and change flowering behaviour of annual-fruiting raspberries
- Organic and inorganic management effect on yield and quality of raspberry cultivars
- Elevated temperature regimes regulate heat shock protein and gene expression in annual-fruiting raspberries

- There is functional relationship between raspberry cultivars and climate factors with respect to yield and quality

OBJECTIVES

The overall aim of this project is to evaluate reference selections of raspberries, located at 6 transnational trial sites and to focus on the genotype by environment (G x E) interaction. Plant materials are being evaluated for specific physiological traits representing plant productivity and fruit quality. Climate data are being collected and evaluated across the North Sea Region (NSR) trial sites to identify relationships between climate and raspberry yield and quality. The specific objectives are;

- To find out the effect of elevated temperature regimes on annual-fruiting raspberries cultivars

- To determine the effect of organic and inorganic management on yield and quality of annual and biennial fruiting raspberry cultivars

- To analyse the effect of heat stress on heat shock proteins of annual-fruiting raspberry leaves

- To establish the functional relationship between climate factors and raspberry yield and quality across the North Sea Region (NSR)

Activity 1.

- Evaluation of annual-fruiting raspberry cultivars under elevated temperature regime

Detail in Annex 1.

Activity 2.

- Evaluation of raspberry cultivars under organic and inorganic management system

Materials and methods

The field experiment was established in randomized complete block design with three replications under organic and conventional management system in Department of Food Science, DK-5270, Denmark. Three annual-fruiting cultivars 'Autumn Bliss', 'Autumn Treasure', and 'Fall Gold', and four biennial-fruiting cultivars 'Tulameen', 'Glen Fyn', 'Glen Ample' and 'Octavia' were planted in spring 2010 in a ridge with a crop geometry of 1.7 m x 0.5 m. Mulching was done with Mypex to control weeds and water loss.

Organic management: Organic fertilizer 'Binadan (5% N) was applied at the rate of 15 g N per plant. Plants were drip irrigated with plain water. Pest management was carried out using organic source of pesticides.

Conventional fertilizer: Plant were drip irrigated with fertilizer containing 80:20:120 NPK kg/ha plus 15 kg Mg /ha. Spraying was done in schedule as per requirement.

In the first year (i.e.2010), plants were allowed to grow without pruning and fruits were not harvested for evaluation, however, few plants showed up with fruit in the previous year canes. After the winter was overed in 2nd year (i.e. 2011), they were pruned to ground level. Twenty and twelve plants per m^2 were maintained for annual and biennial cultivars respectively. Harvesting was started from week 26 in biennial cultivars (organic tunnel) which was lasted until week 33 of the year 2011. Evaluation was carried out for the first terminal flowering date, yield per plant and weight of 50 fruits. There were no fruits harvested in inorganic tunnel from biennial cultivars.

Harvesting was started from week 32 and lasted on week 44 in case of annual-fruiting cultivars and evaluation was carried out for yield and postharvest quality.

Evaluation carried out and to be continued…	
First terminal flowering date	TSS (%)
Yield g m^{-2}	Dry matter %
Weight of 50 fruits g	Titratable acidity (TA)
Number of fruits m^{-2}	Colour

Preliminary results- 2011

Table 1. Probability levels of significance for main effects and interactions of organic and inorganic system on yield and quality of three annual-fruiting raspberry cultivars, 2011

Source of variations	df	Yield per m^2	50 fruit weight	No of fruits per m^2	TSS%	TA
Production system (organic vs. inorganic)	1	ns	**	ns	***	ns
Cultivars	2	***	***	***	***	ns
Prod syst. x cultivars	2	ns	ns	ns	***	ns

df; degree of freedom, ns;non significant at P>0.05, **; significant at P<0.001 and ***; significant at P<0.0001

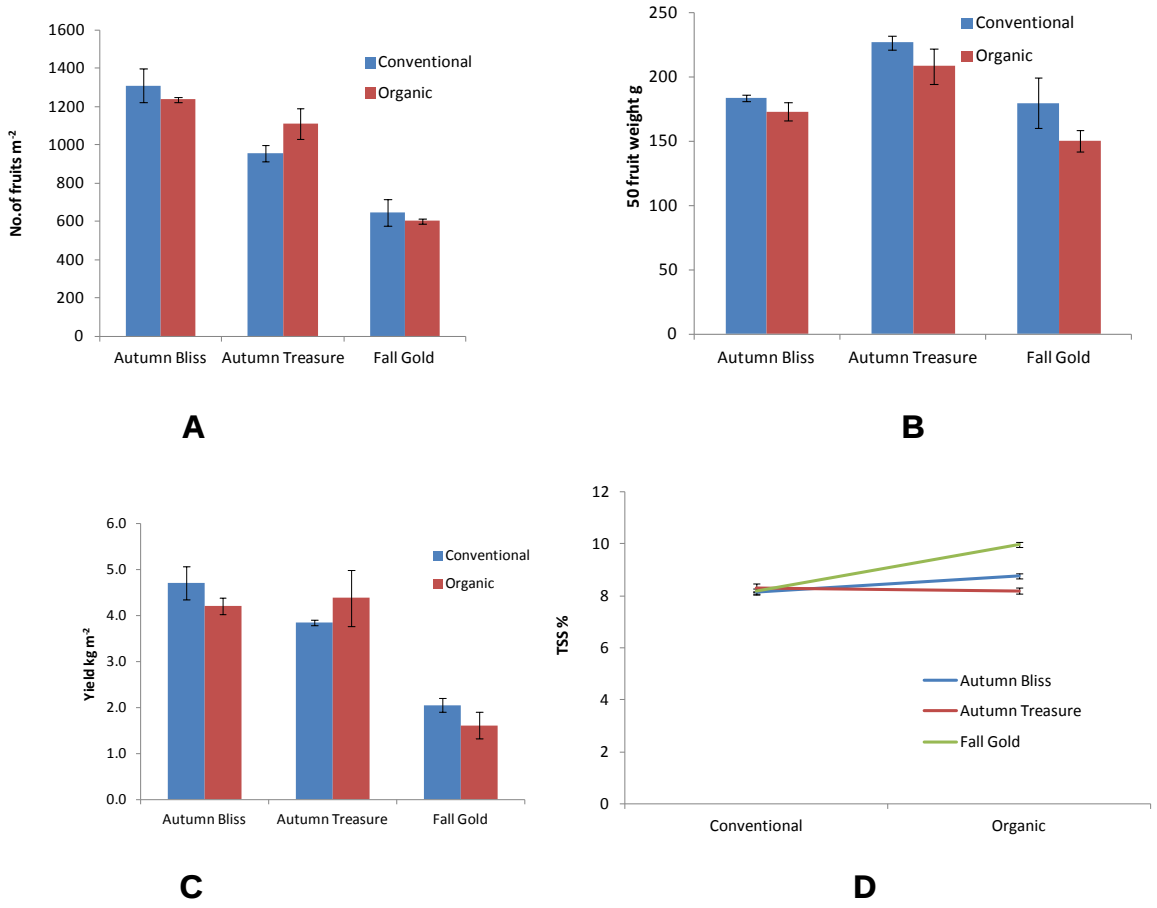

Figure 1. Yield and quality attributes **A)** no of fruits m^{-2}, **B)** 50 fruit weight g, **C)** Yield g m^{-2} and **D)** TSS% of three annual-fruiting raspberry cultivars in high open tunnel conditions in conventional and organic management system. Bars indicate SEM±;n=6 for yield and n=12 for TSS%

Activity 3.

- Study on effect of different period of heat stress on heat shock protein quantification and gene expression analysis

Materials and methods

Treatments	**Early stress**	**Intermediate stress**	**Intermediate stress**	**Late stress**
Temp level	20, 27, 32 and 37 °C			
Stress period	8 hours	24 hours	72 hours	168 hours
Cultivars	Autumn Bliss A. Treasure Erika Fall Gold Polka			
Methods	Proteomic approach- 2-Dimentional gel electrophoresis (Genomic approach –cloned DNA (cDNA) microarray??)			
Target to evaluate	HSPs (60-160 kDa) and small HSP (15-45 kDa)			

The work has planned to carry out in the laboratory of the James Hutton Institute, Scotland from April to June 2012. However, the final schedule and methods to be used will be decided and updated in the PhD plan.

Activity 4.

- Evaluation of raspberry cultivars for yield and quality across the North Sea Region (NSR)
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Background

The productivity and quality of fruit crop depends on its genetic component, the environment and the interaction between genotype & environment (Prive *et al.,* 1994). A range of raspberry cultivars has been developed by the James Hutton Institute, Scotland, UK and distributed to North Sea Region (NSR) for commercial production. Cultivated raspberry varieties are poorly adapted to warm temperature and high humidity during summer as well as fluctuating temperatures during winter (Ballington *et. al.* 2008). Burrow *et. al.,* (2002) reported there were significant genotype or environment and genotype x environment x year effect in quality variables of raspberry in Pacific North West (PNW) region. Prediction of the specific threats to raspberry can only be made when adequately understand the complex interaction between plant and environment factors. This requires experimentation under a range of climatic conditions together with assistance of analytical modeling tools. Therefore, this activity is designed to determine the genotype effect (G), environmental effect (E) and G x E interaction effect on quality and yield of raspberry fruits across NSR.

Climate data are being collected and evaluated across the NRS trial sites to develop predictive tools enabling smart decision making raspberry productivity under conditions of changing climate. Web based predictive modeling tools that allow the NSR raspberry fruit industry to ensure optimal yield and quality with respect to plant material, inputs, and climate events will be developed.

ACTIVITIES SO FAR (Summary)…

Months/ year	What was in PhD plan	What activities accomplished	Output
Aug –Dec 2010	• PhD course -8 ECTS • PhD planning and meeting • Start of 1st year G x E experiments	• Joined PhD courses • PhD Plan submitted • Soil sampling • Weather data collected	• 7-ECTS completed • One meeting in Scotland • Soil analysis done
Jan-July 1011	• PhD course- 16 ECTS • Expt. in greenhouse • Organic and inorganic trial continued • Visit to transnational trial sites	• Pilot trial conducted • 5 annual raspberry cultivars evaluated under 4 temperature levels	• 13 ECTS completed • Chlorophyll fluorescence measured • Flowering behaviour evaluated
July-Dec 2011	• PhD course- 2 ECTS • Organic and inorganic expt. • Submission of first article	• Joined PhD courses • Fruits harvested from organic and inorganic plots • Data analysed, • Introduction, M&M prepared	• 8 ECTS completed • Yield and quality evaluated from organic/conv. • Flowering behaviour evaluated • Back home visited
Jan-July 2012	• Stay at JHI, Scotland (2-3 months) • 2nd year G x E expt. • Expt. on heat stress Submission of 2nd article	• Write up 1st article • Joined PhD courses	• 3 ECTS completed • Mid-term seminar • 1st article is in preparation

PhD-COURSES

Accomplished courses		Month and year	ECTS
1.	Modeling climate effects on cropping system	Oct 2010	5
2.	Nutrient use efficiency	Nov 2010	2
3.	Breeding for adaptation to climate change	Jan 2011	6
4.	Introduction course for new PhD students	Feb 2011	2
5.	Applied methods in crop physiology	April 2011	5
6.	Applied statistics with R	Aug 2011	6
7.	Visual display of quantitative information in plant science	Nov 2011	2
8.	Scientific writing and communication	Feb-Mar 2012	3
Total		**By March 2012**	**31**

MEETING/CONFERENCE/GROUP PRESENTATION

When	Where	Oral/Poster topic
Sept 2010	ClimaFruit 1 year planning and reporting meeting, Scotland	Participation
Jan 2011	PhD course-Breeding for adaptation to climate change, Iceland	'Impact of climate on yield and quality of Raspberry'
May 2011	X-International Ribes and Rubes Symposium, Serbia	'Evaluation of annual-fruiting raspberry cultivars under elevated temperature regimes'
Sept 2011	ClimaFruit 2 year planning and reporting meeting, Norway	'Elevated temperature regimes affects on annual-fruiting raspberry physiology'
Aug 2011	HortTeamExpo-Aarslev	'Impact of climate on yield and quality of Raspberry'

DISSEMINATION ACTIVITIES

When	Where	Presentation
September 2011	Journal Club, Aarslev	**Oral-**'Photochemical efficiency and recovery of PII in grapes after exposure to sudden and gradual heat stress'
January 2011	NOVA PhD course participant -Iceland	**Oral- '**Role of carbohydrate metabolism in the determining winter survival and adaptation of temperate plant species'
September 2011	PhD-Seminar	**Oral-'**Evaluation of annual-fruiting fruiting raspberry cultivars under elevated temperature regimes'
November 2011	Journal Club, Aarslev	**Oral-** 'A protocol to assess heat tolerance in a segregating population of raspberry using chlorophyll fluorescence'

PLAN PUBLICATION LIST

Working titles	Target to submit
1. Chlorophyll fluorescence and flowering behaviour of annual-fruiting raspberry under elevated temperature regimes	Mar 2012
2. Effect of duration of heat stress on heat shock protein in annual-fruiting raspberry leaves	Dec 2012
3. Yield and quality of raspberry cultivars under organic and inorganic management system	June 2013
4. Genotype by environment effect on raspberry fruit yield and quality -co -author	Aug 2013

MILESTONES FOR REMAINING 1½ YEAR PHD PLAN

SN.	Activities	2012										2013							
		Mar	Ap	May	Jun	Jul	Aug	Sep	Oc	Nov	Dec	J	Feb	Mar	Ap	M	Jun	J	A
1	**Subm. of 1st article in Scientia Horticulturae** (IF= 1.04)																		
2	Different period of heat stress and heat shock protein (HSPs)																		
3	Correction and resubm. of 1st article																		
4	Evaluation of 4 biennial and 3 annual cultivars - organic/conv.																		
5	**Write up and subm.of 2nd article -stress & HSPs**																		
6	Back home visit- Nepal																		
7	Data analysis - organic /conv.																		
8	Thesis write up- Introduction																		
9	Thesis write up- M & M																		
10	Correction and resubm. of 2nd article																		

SN.	Activities	2012										2013							
		Mar	Ap	May	Jun	Jul	Aug	Sep	Oc	Nov	Dec	J	Feb	Mar	Ap	M	Jun	J	A
11	Thesis write up-General discussion																		
12	**Subm. of 3rd article-organic/conv.**																		
13	**Thesis-Final version**																		
14	**Thesis submission**																		
15	**Back to Job-Nepal Agri. Research Council (NARC)**																		

THESIS STRUCTURE

The thesis will content at least 3 publications in a peer review Journal, as submitted articles or in manuscript form. There will be a general introduction and a review of existing literature, leading with hypotheses and objectives of the project.

- Introduction
- Hypotheses
- Objectives
- General literature review
    - Raspberry production : past, present and future
    - Effect of climate on
        - Photosynthesis
        - Flowering behavior
        - Heat shock protein and gene expression
        - Yield and postharvest quality
- Materials and methods
- Experiments

Article 1. Chlorophyll fluorescence and flowering behavior of annual-fruiting raspberry under elevated temperature regimes

Article 2. Effect of duration of heat stress on heat shock protein in annual-fruiting raspberry leaves

Article 3. Yield and quality of raspberry cultivars under organic and inorganic management system

Article 4. Genotype by environment effects on raspberry fruit yield and quality -co-author

- General discussion
- Conclusion
- Future perspectives
- References

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Ballington JR, Fernandez GE. 2008. Breeding raspberries adapted to warm humid climate with fluctuating temperature in winter. *Acta Horticulturae* 777. Pp87-90.

Burrows, C, Moore PP. 2002. Genotype x environment effects on raspberry fruit quality. Proceeding of the Eight International *Rubus* and *Ribes* Symposium. Acta Horticulture (ISHS), No 585. Vo 2. Pp.467-469.

Dale A, Pirgozliev S, King EM, Sample A. 2005. Scheduling primocane-fruiting raspberries (Rubus idaeus L.) for year-round production in greenhouses by chilling and Summer-pruning of canes. *Journal of Horticultural Science & Biotechnology* 80.Pp346-350.

Dale A, Sample A, King E. 2003. Breaking dormancy in red raspberries for greenhouse production. *Hortscience* 38. Pp515-519.

Prive, JP, Sullivan, J A, Proctor JTA 1994. Carbon partitioning and translocation in primocane-fruiting red raspberries (*Rubus ideaus L*.). J. Amer. Sci. Hort. Sci. 119 (3). Pp. 604-609.