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UNIVERSITETET FOR MILJØ- OG BIOVITENSKAP MDCCCLIX

The James Hutton Institute

Bioforsk

Effects of environment in the post flowering period on yield, berry quality, and chemical composition of red raspberry cv "Glen Ample".

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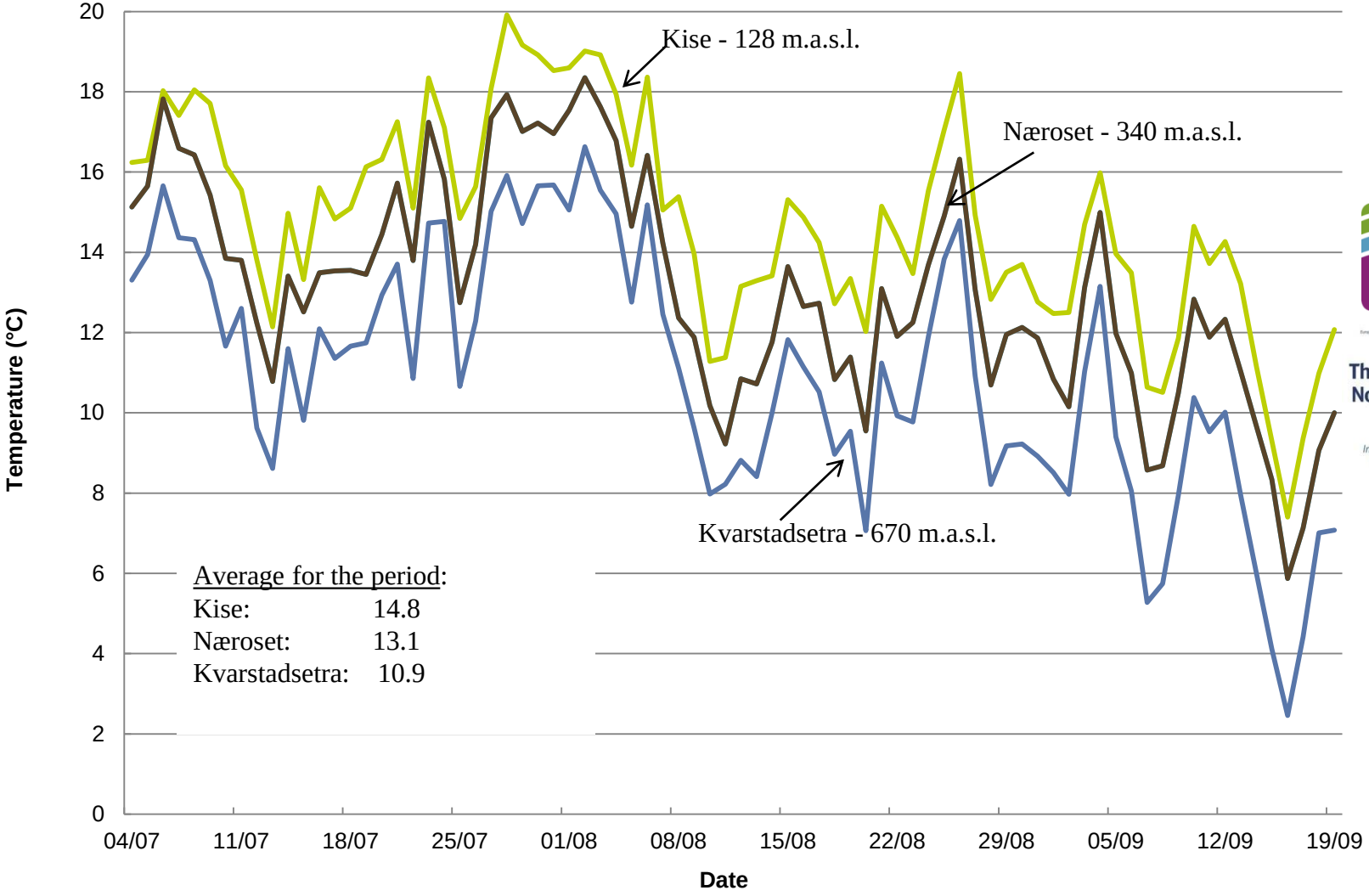
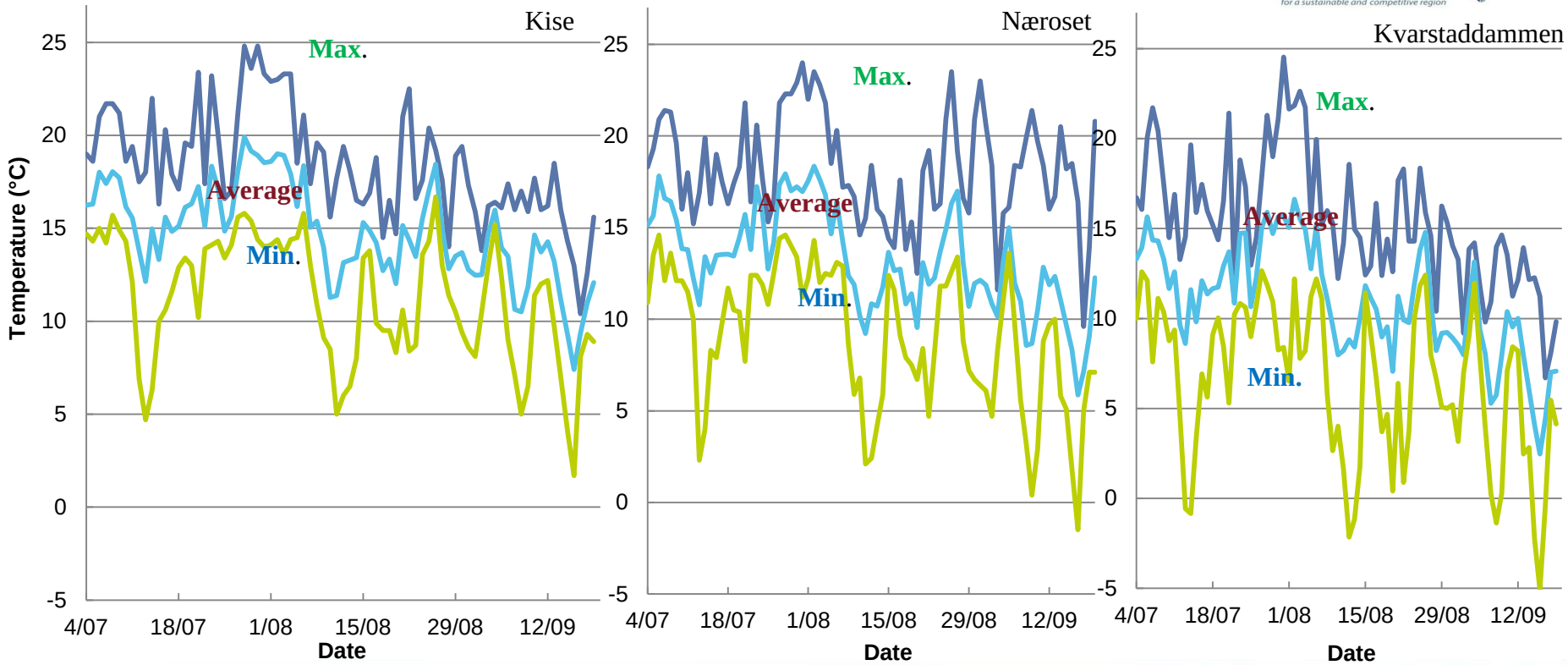
Material and methods

1. Long cane plants of ’Glen Ample’ were produced in pots in 2011
2. The plants were stored at -1° C during the winter and moved to a plastic house in early May 2012
3. The plants were moved to three locations in the middle of the flowering period (July 4), irrigated and fertilized and from then influenced by different environment becauce of different altitude
4. Groups of three plants were placed randomly in three replicates at each location (9 plants per location)
5. Data of temperature and precipetation were collected from local meteorological stations at location 1 and 3 and logged at location 2
6. Fruits were picked three times a week in the main harvesting season
7. Yield, number and weight of all fruits were recorded per cane
8. All fruits were labelled and frosen at – 20° C
9. Fruits collected the first week were recorded, but not used in biochemical analysis
10. To reduce number of samples, fruits picked each week were mixed
11. Analysis were performed at UMB and The James Hutton Institute

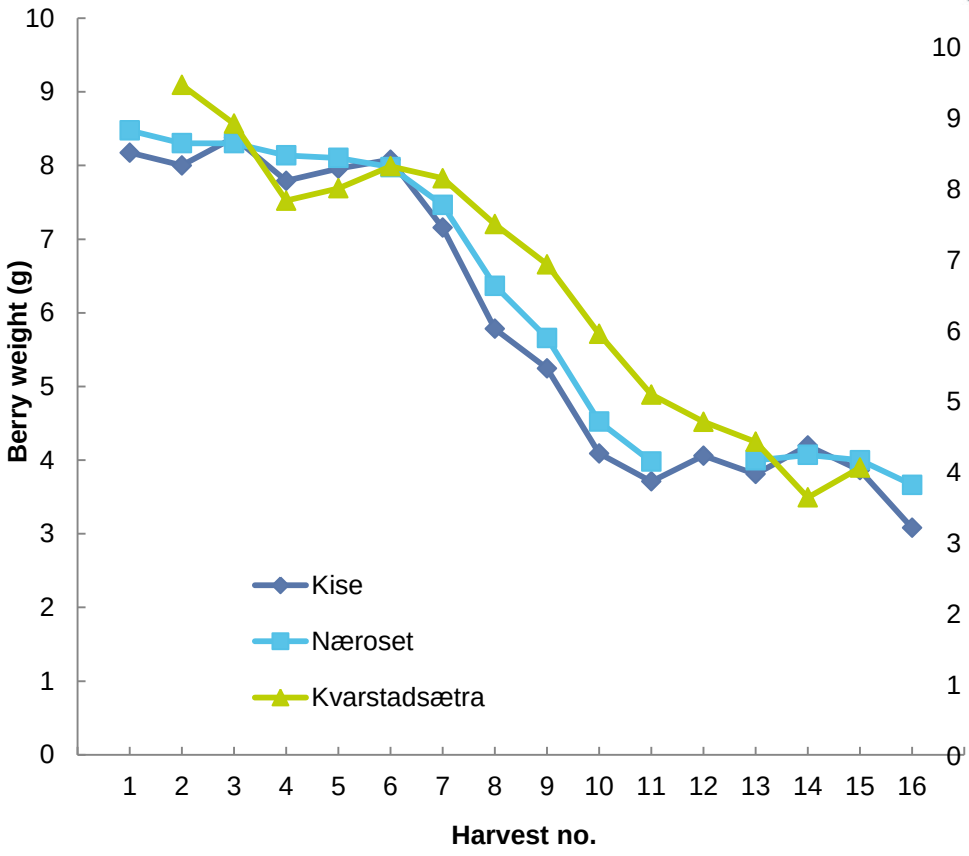
Average temperature during the ripening season at the three locations

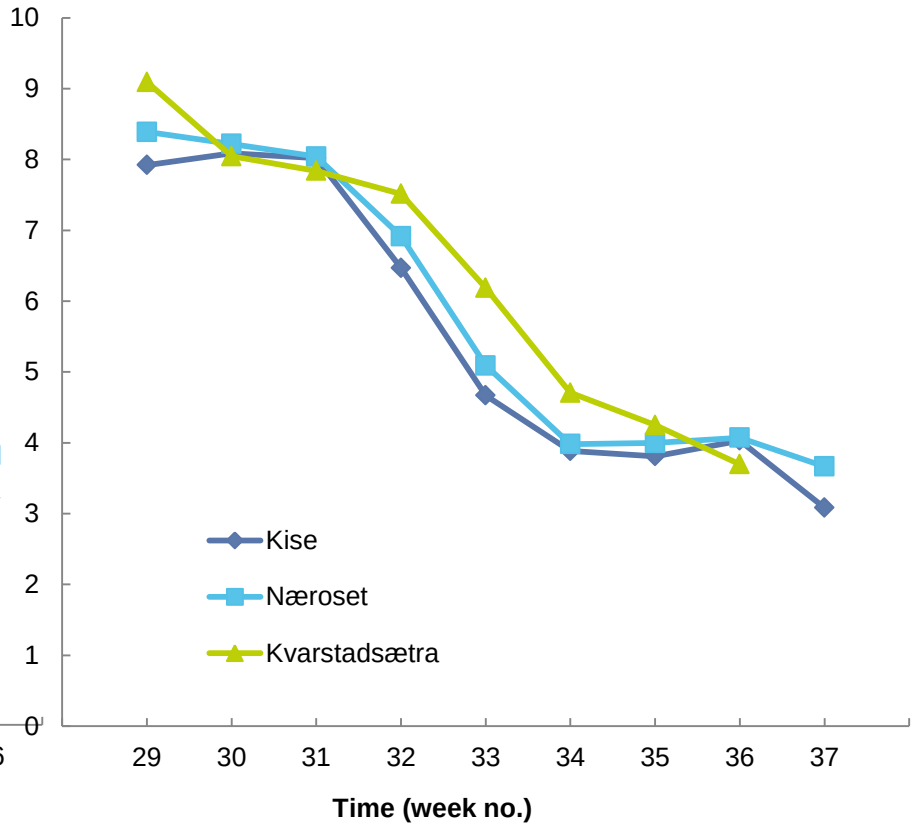


Max., Mean and Min. temperatures at the three locations

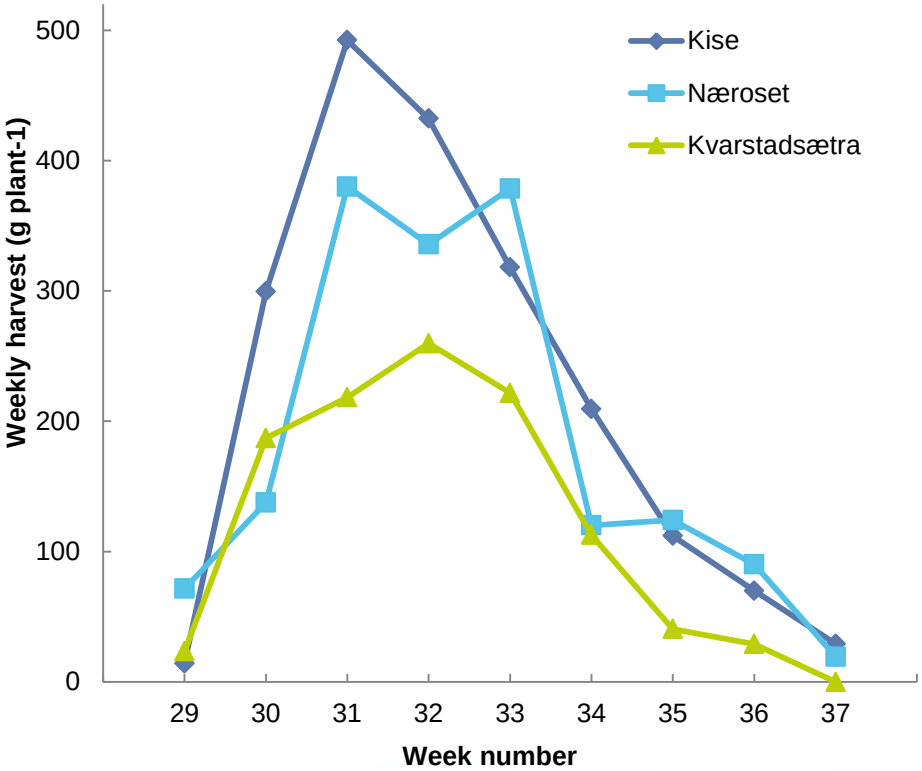


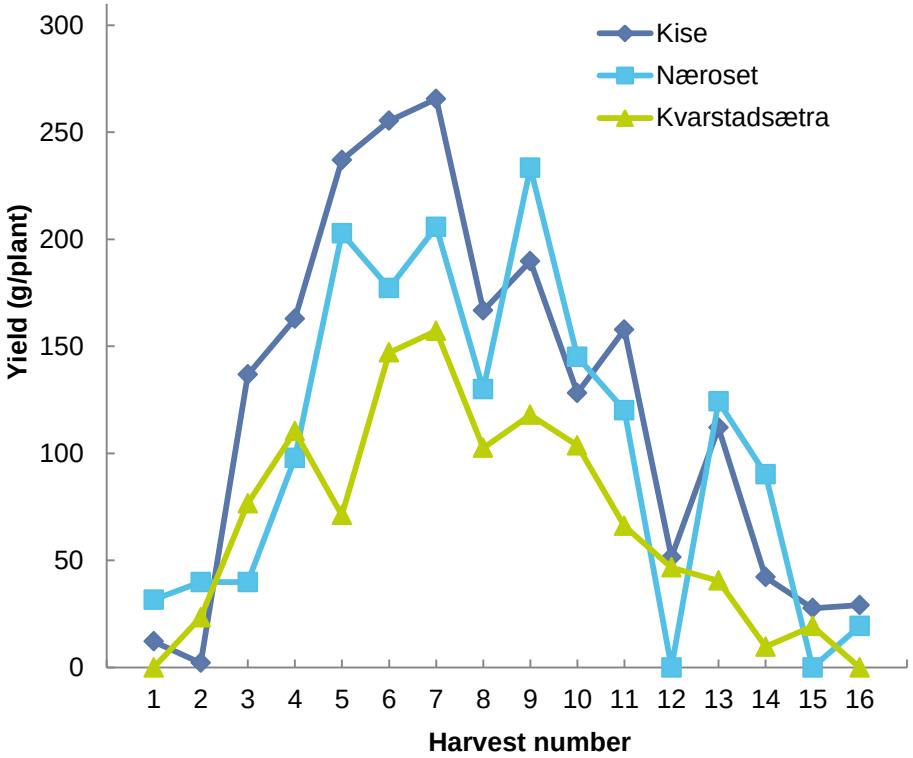
Berry size during the harvesting season at the three locations



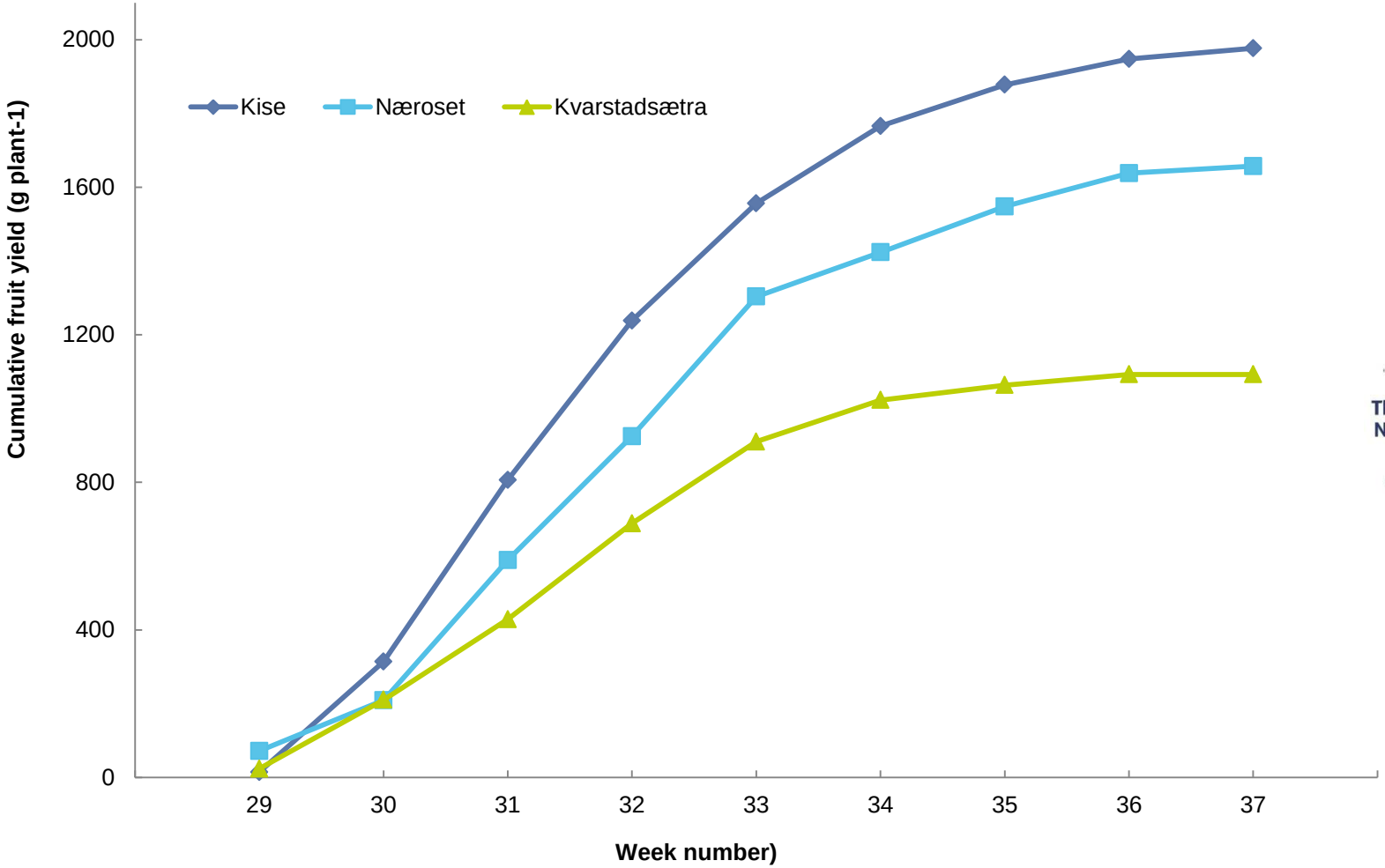


Fruit yield per week and harvest at the three locations





Cumulative fruit yield for the three locations



Ripening, berry size and fruit yield from the three locations

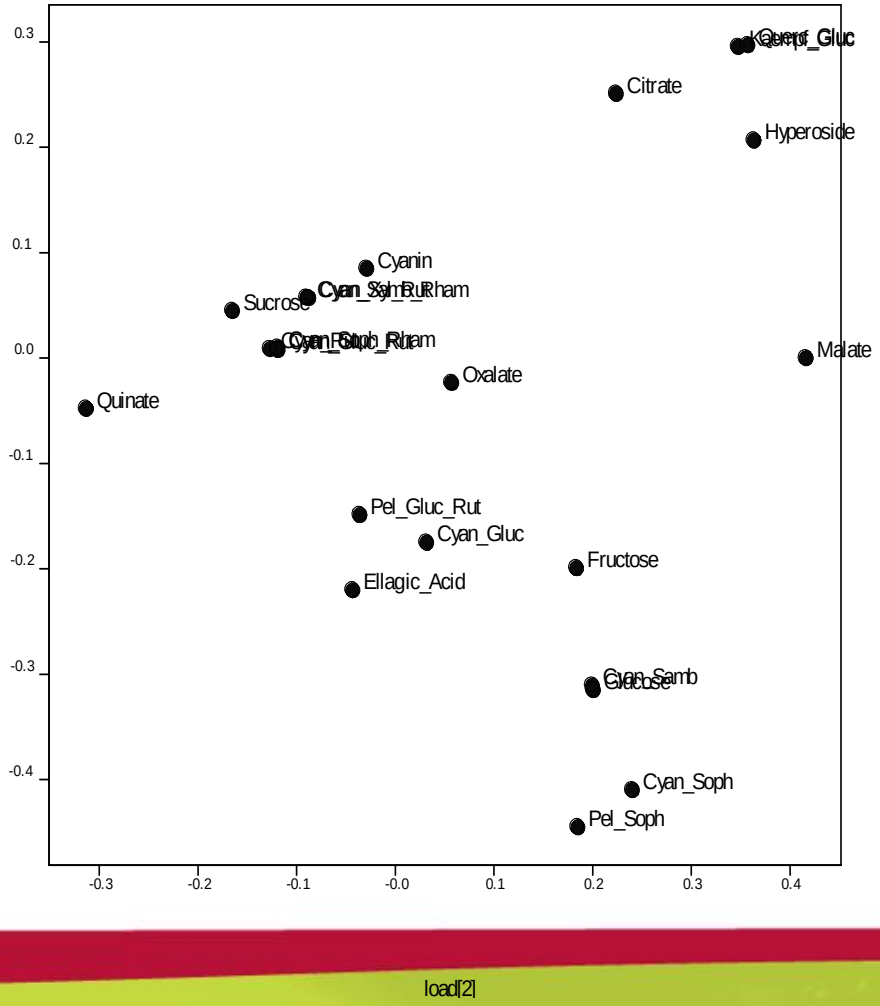
Location (m.o.h.)	Days to 50% harvest*[y]	Fruit yield (g/plant)	No.of harvested fruits	Fruit weigth (g)	Total number of fruits and flowers
Kise(128)	33.3a	1977.1a	345.7a	5.7b	383.3a
Næroset(340)	36.0ab	1657.3b	282.7b	5.9b	312.0a
Kvarstad(670)	38.7b	1092.6c	165.4c	6.6a	325.0a
Mean	*36.0*	*1575.7*	*264.6*	*6.1*	*340.1*
P-value	*0.01*	*<0.001*	*<0.001*	*0.003*	*n.s.*

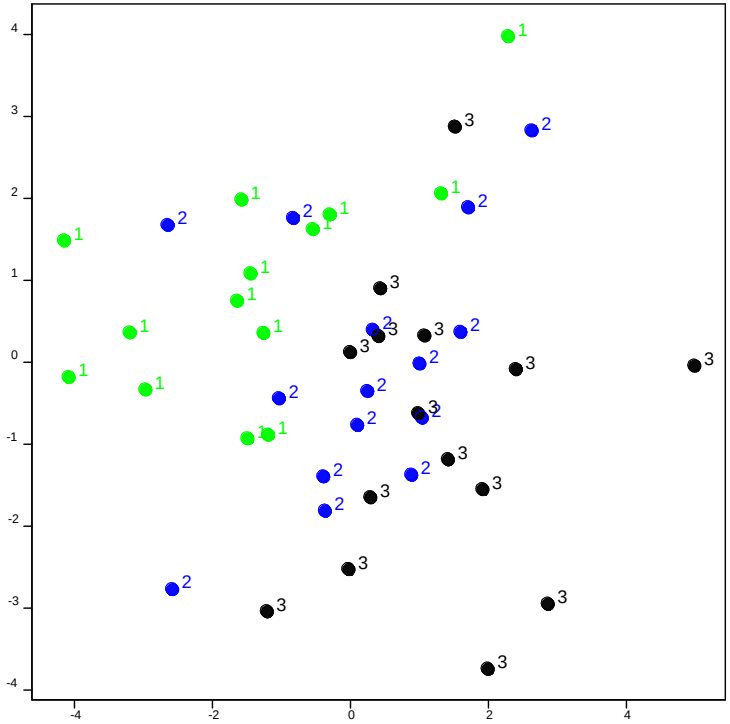
* Counted from the date of estblishing the plants at the three locations (July 4)
[Y] Separation done by Tukeys test

Biochemical analysis

- **LC-MS**
  - **Anthocyanins**
    - Cyanidin-3-O-Sophoroside
    - Cyanidin-3-O Rutinoside
    - Cyanidin-3-O-Glucoside
    - Cyanidin-3-O-Sambubioside
    - Cyanidin-3-Glucosyl-2-Rutinoside
    - Cyanidin-Sambubioside-Rhamnoside
    - Pelargonidin-3-Glucosyl-Rutinoside
    - Pelargonidin-3-Sophoroside
  - **Flavonols**
    - Quercetin-3-O-Glucuronide
    - Hyperoside
- **HPLC PAD (pulse amperometry)**
  - **Glucose, Sucrose and Fructose**
- **HPLC conductivity**
  - **Citrate**
  - **Malate**

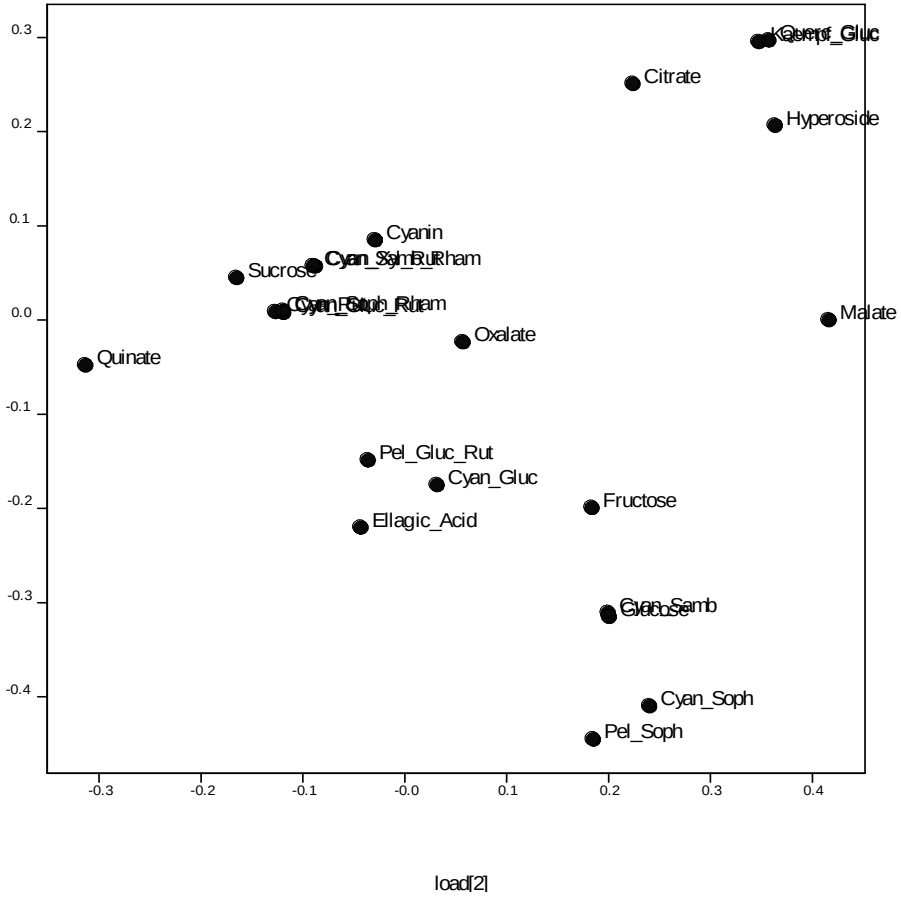
Principal Component Analysis (PCA)

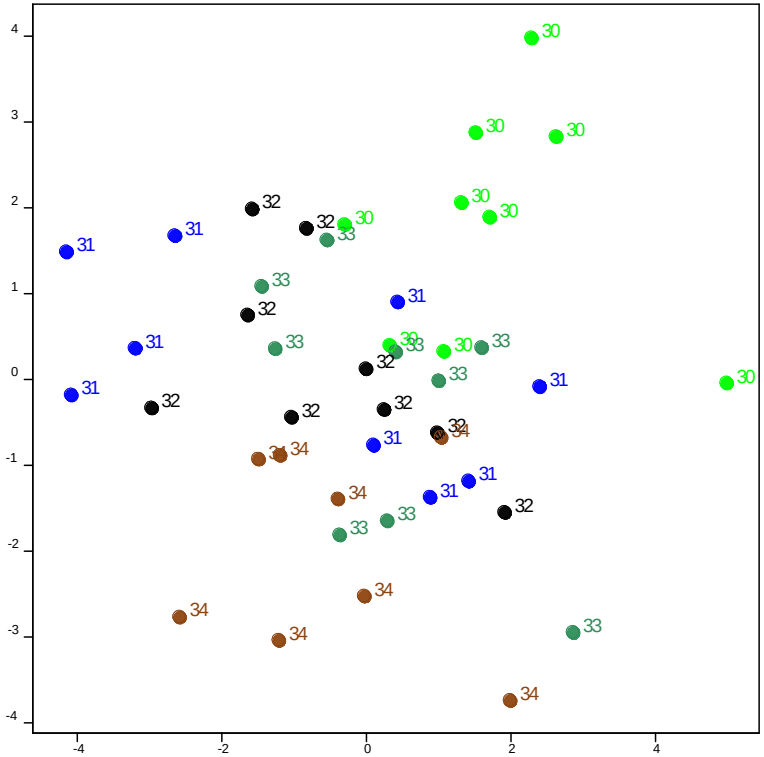




1- Kise
2- Næroset
3- Kvarstaddammen

Principal Component Analysis (PCA)



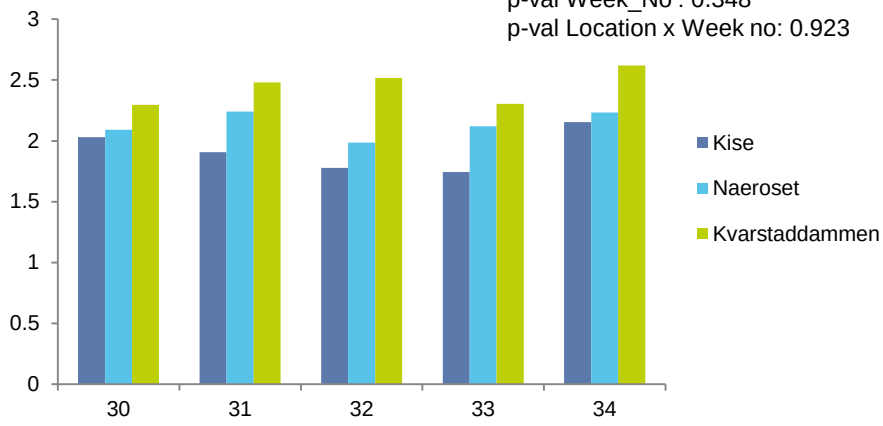


1- Kise
2- Næroset
3- Kvarstaddammen

Analysis of Variance (ANOVA)

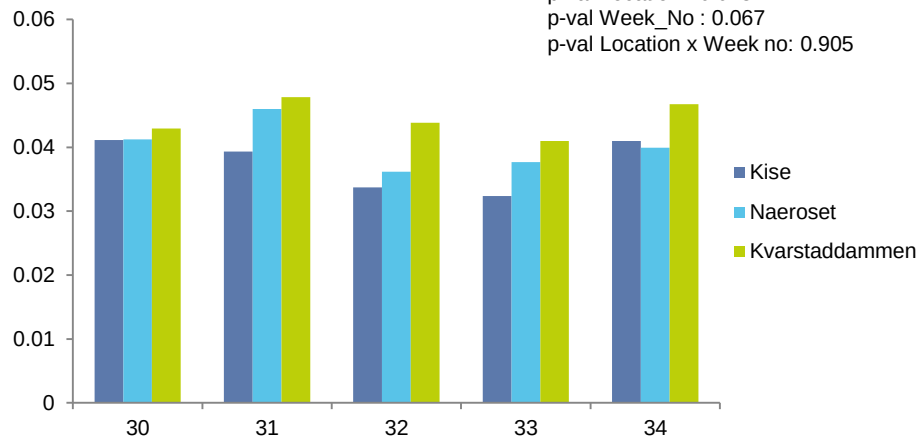
Cyanidin-Sophoroside µg/mg DW

p-val Location <0.001
p-val Week_No : 0.348
p-val Location x Week no: 0.923



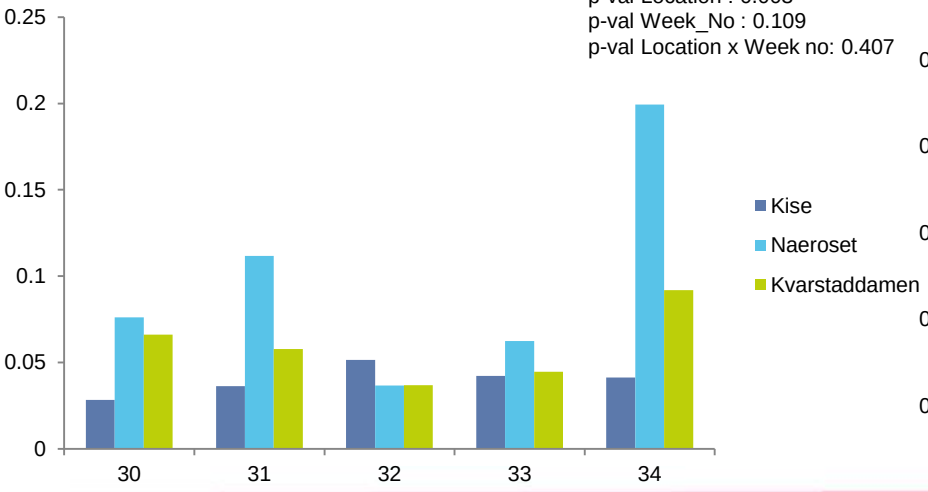
Cyanidin-Sambubioside µg/mg DW

p-val Location : 0.013
p-val Week_No : 0.067
p-val Location x Week no: 0.905



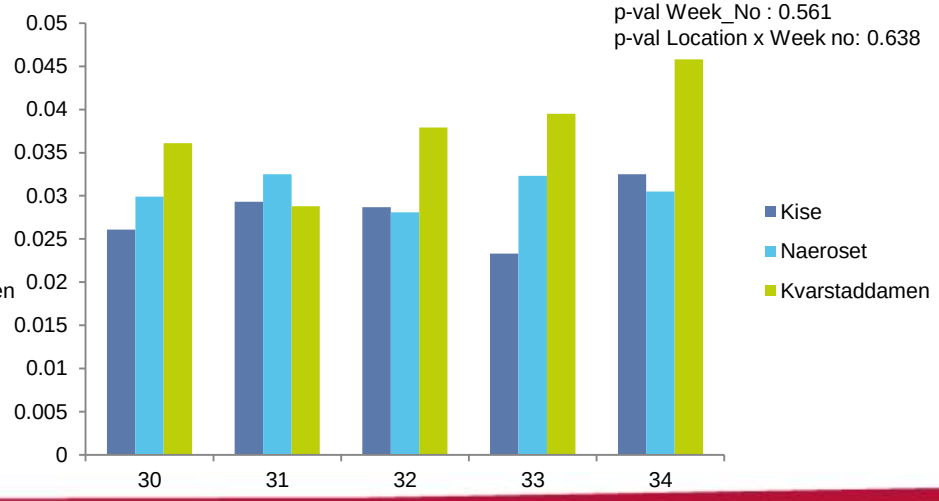
Ellagic acid µg/mg DW

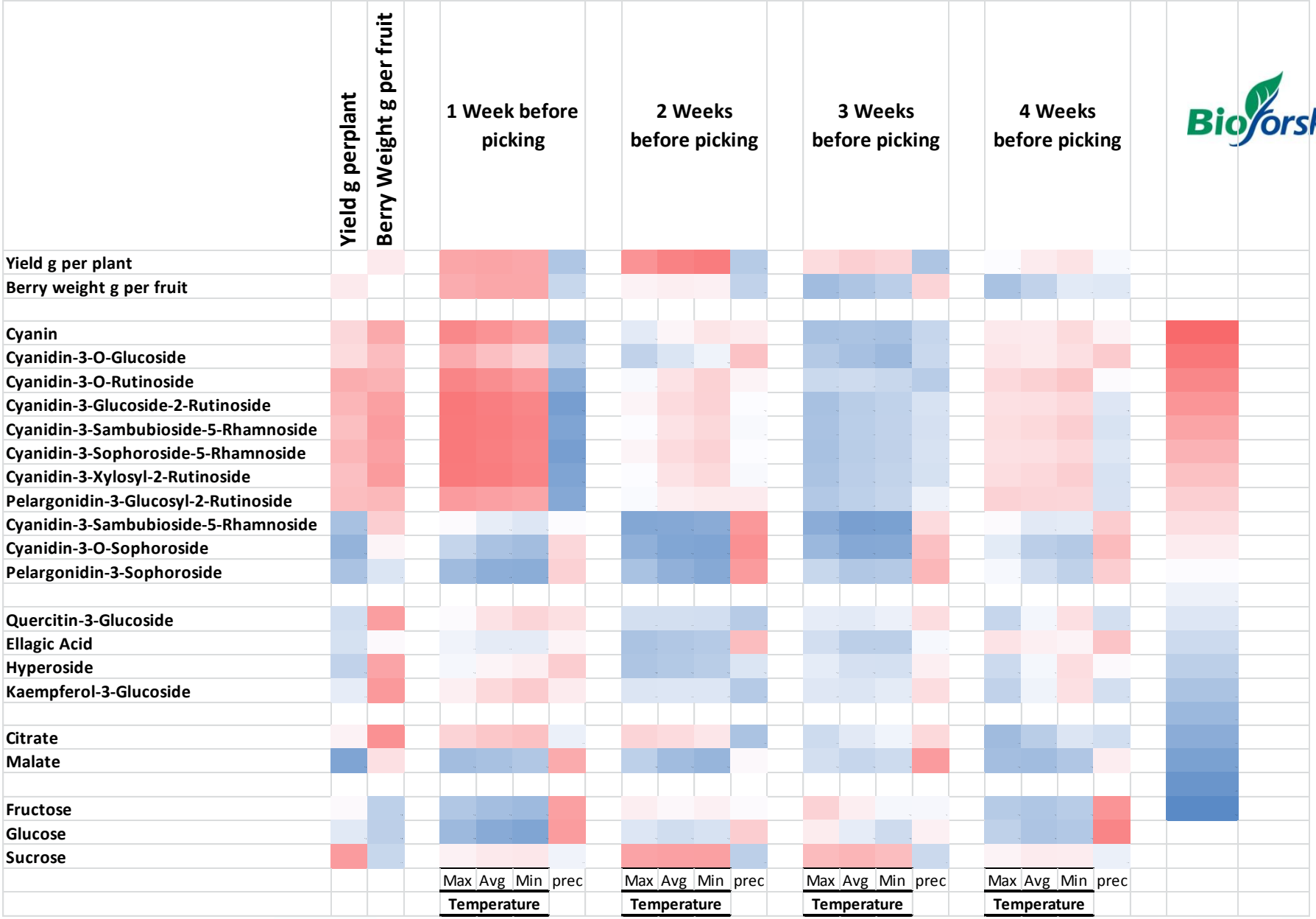
p-val Location : 0.003
p-val Week_No : 0.109
p-val Location x Week no: 0.407



Pelargonidin-Sophoroside µg/mg DW

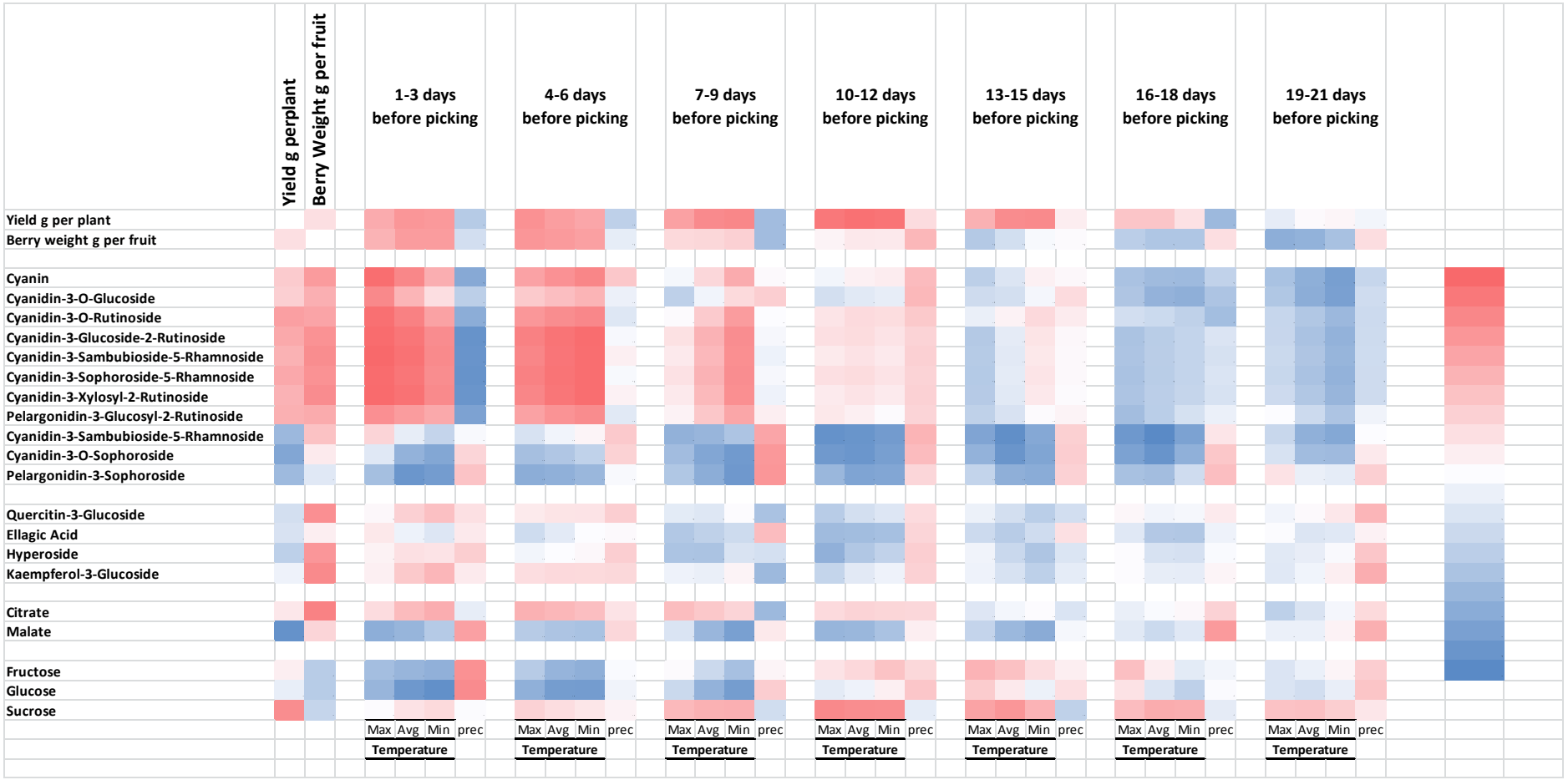
p-val Location : 0.011
p-val Week_No : 0.561
p-val Location x Week no: 0.638



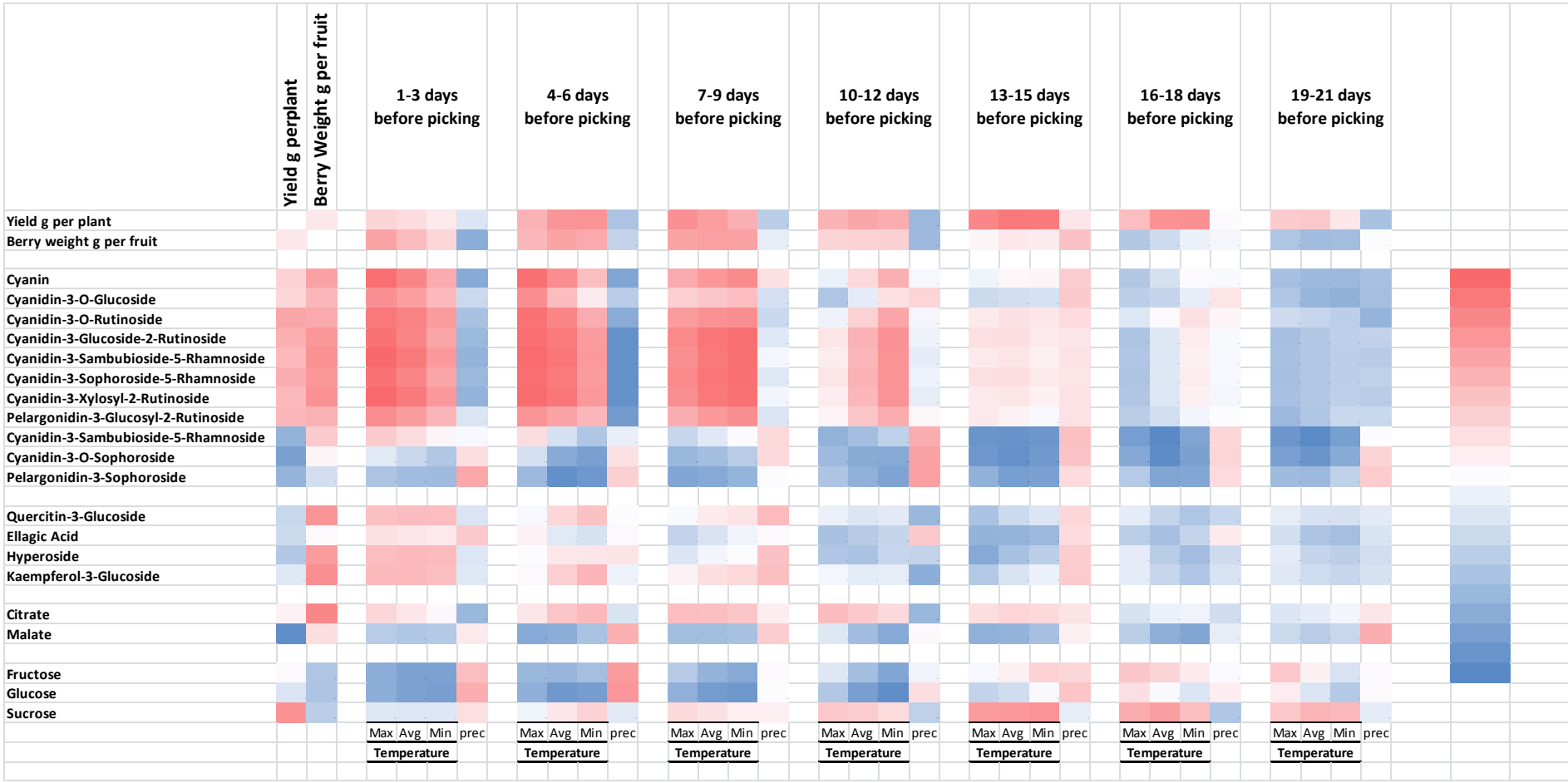

Yield g perplant
Berry Weight g per fruit
1 Week before picking
2 Weeks before picking
3 Weeks before picking
4 Weeks before picking
Yield g per plant
Berry weight g per fruit
Cyanin
Cyanidin-3-O-Glucoside
Cyanidin-3-O-Rutinoside
Cyanidin-3-Glucoside-2-Rutinoside
Cyanidin-3-Sambubioside-5-Rhamnoside
Cyanidin-3-Sophoroside-5-Rhamnoside
Cyanidin-3-Xylosyl-2-Rutinoside
Pelargonidin-3-Glucosyl-2-Rutinoside
Cyanidin-3-Sambubioside-5-Rhamnoside
Cyanidin-3-O-Sophoroside
Pelargonidin-3-Sophoroside
Quercitin-3-Glucoside
Ellagic Acid
Hyperoside
Kaempferol-3-Glucoside
Citrate
Malate
Fructose
Glucose
Sucrose
Max Avg Min prec
Temperature
Max Avg Min prec
Temperature
Max Avg Min prec
Temperature
Max Avg Min prec
Temperature


Yield g perplant
Berry Weight g per fruit
1 Week before picking
2 Weeks before picking
3 Weeks before picking
4 Weeks before picking
Yield g per plant
Berry weight g per fruit
Cyanin
Cyanidin-3-O-Glucoside
Cyanidin-3-O-Rutinoside
Cyanidin-3-Glucoside-2-Rutinoside
Cyanidin-3-Sambubioside-5-Rhamnoside
Cyanidin-3-Sophoroside-5-Rhamnoside
Cyanidin-3-Xylosyl-2-Rutinoside
Pelargonidin-3-Glucosyl-2-Rutinoside
Cyanidin-3-Sambubioside-5-Rhamnoside
Cyanidin-3-O-Sophoroside
Pelargonidin-3-Sophoroside
Quercitin-3-Glucoside
Ellagic Acid
Hyperoside
Kaempferol-3-Glucoside
Citrate
Malate
Fructose
Glucose
Sucrose
Max Avg Min prec
Temperature
Max Avg Min prec
Temperature
Max Avg Min prec
Temperature
Max Avg Min prec
Temperature

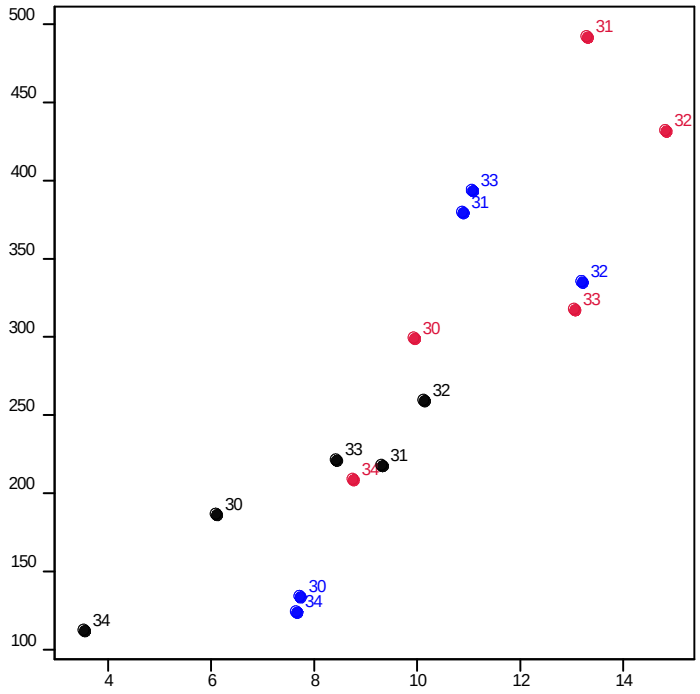
Correlation Analysis



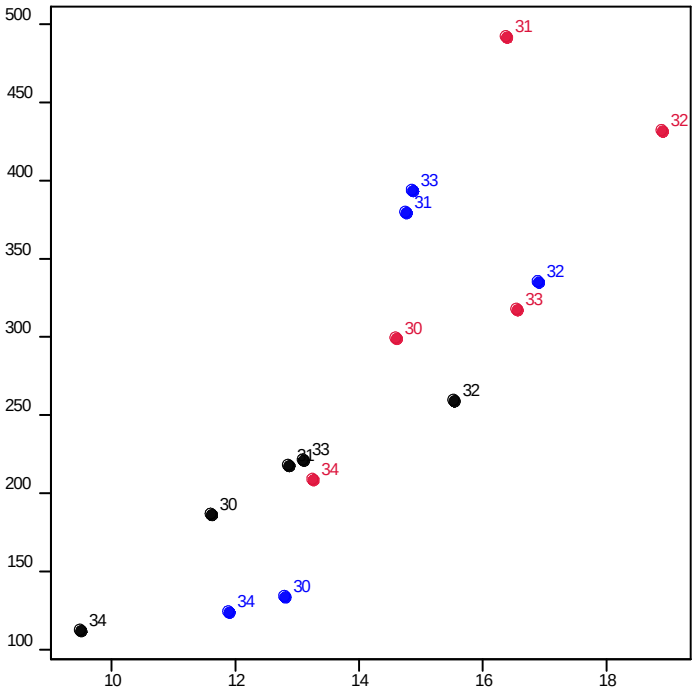
Correlation Analysis



Effect of temperature on yield

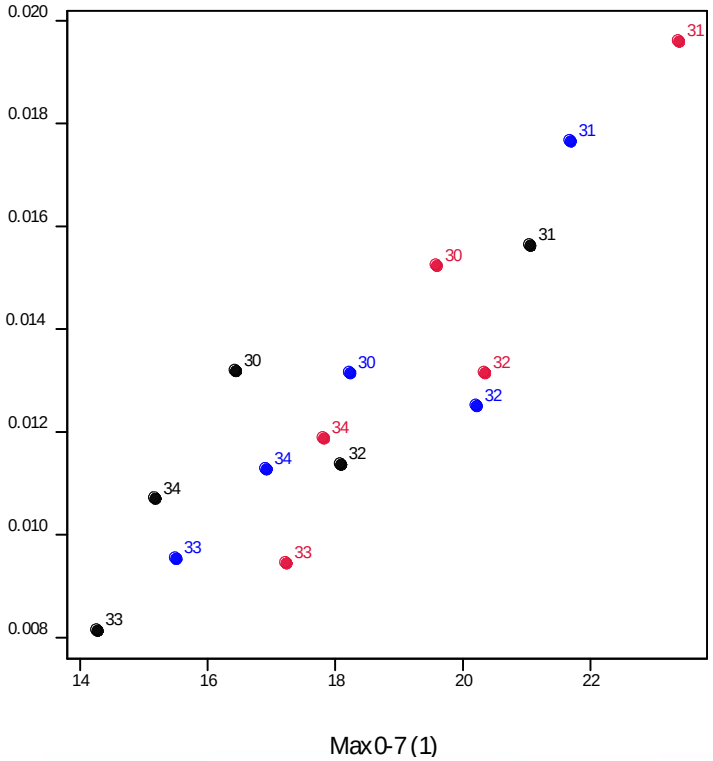


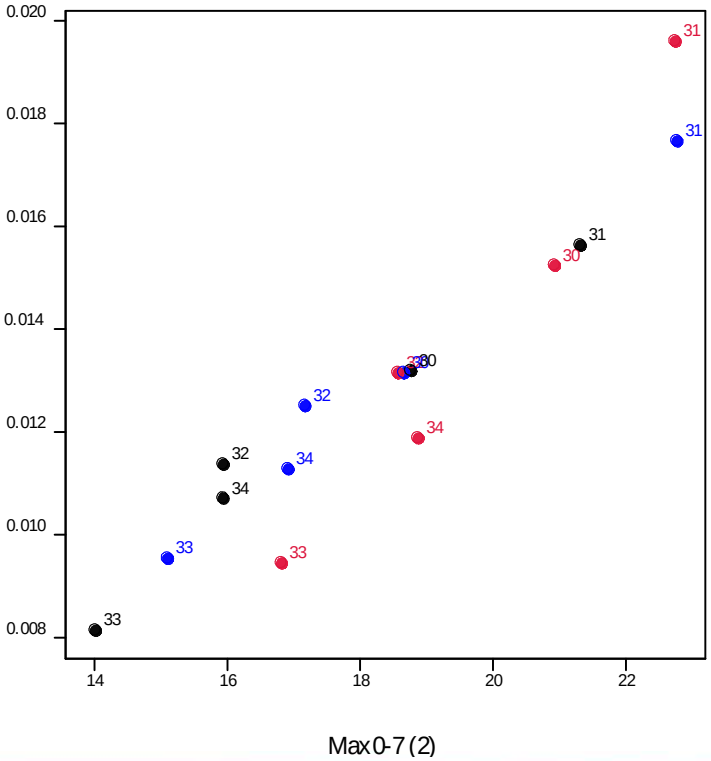
Min 7-14 (1)



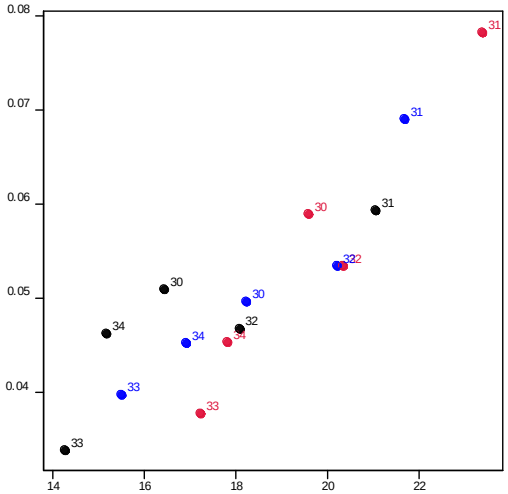
Mean 7-14 (1)

Effect of maximum temperature on Cyanidin-Sambubioside-Rhamnoside

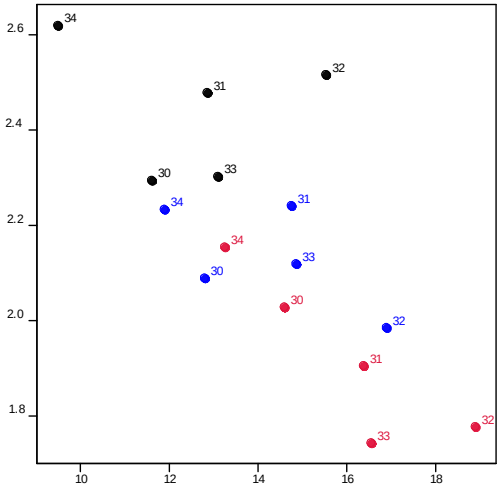




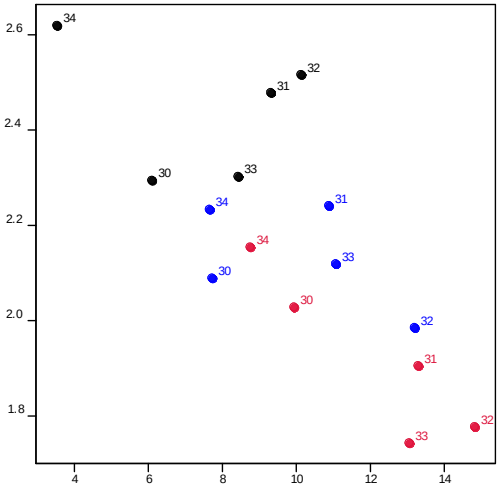
Effect of temperatue on anthocyanin levels



Max 0-7 (1)

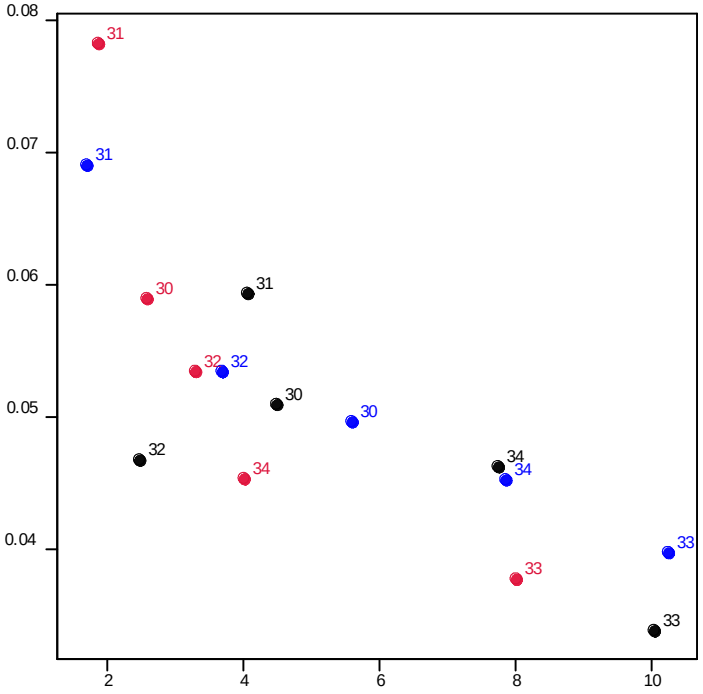


Mean 7-14 (1)

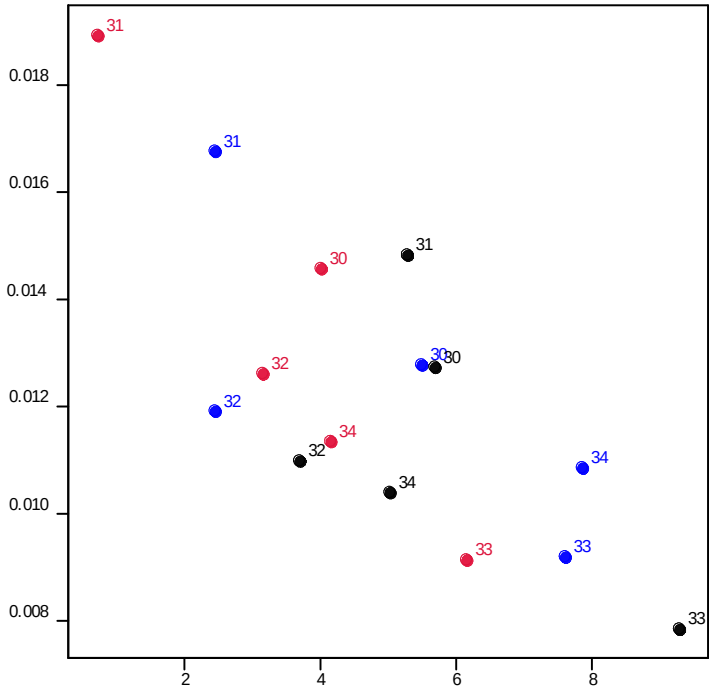


Min 7-14 (1)

Effect of precipitation on Anthocyanin levels

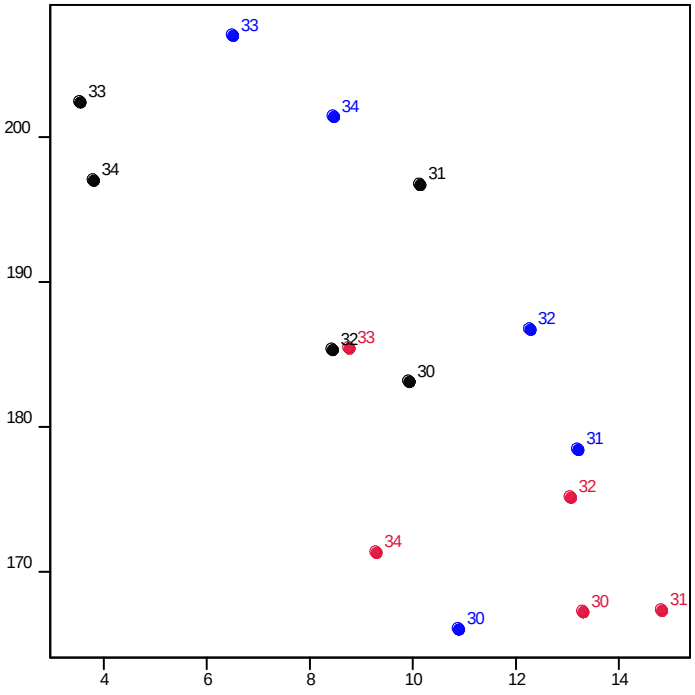


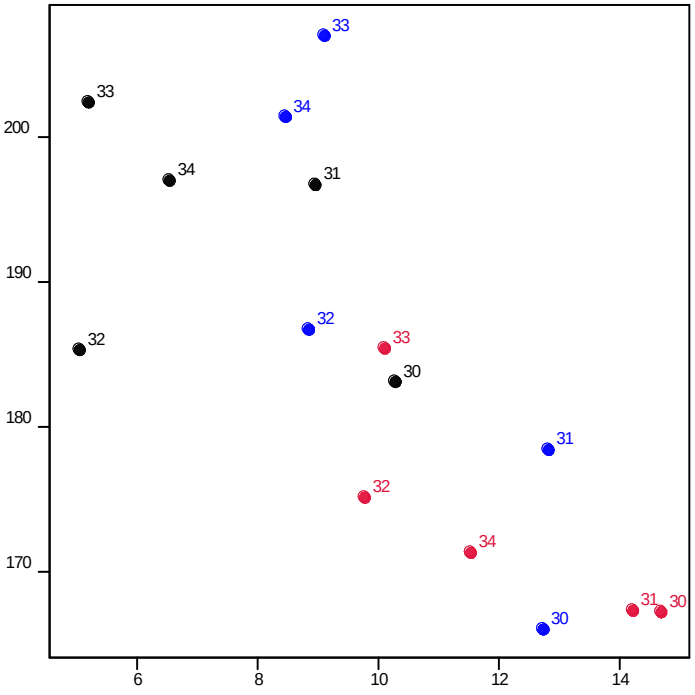
precipitation 0-7 (2)



precipitation 0-7 (1)

Effect of minimum temperature of Glucose levels





Concluding remarks

- Altitude has an effect on the biochemical composition of Raspberries cv Glen Ample, mainly in the levels of some anthocyanins

- Temperature parameters in the week before picking correlate positively with the levels of some anthocyanins

- Minimum temperature before harvest correlates negatively with the levels of Glucose

- Precipitation correlates negatively with the levels of some anthocyanins

- Yield correlates positively with the temperature parameters 2 weeks before picking