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Drip irrigation and fertigation of raspberry

Drypvanding med og uden gødning til hindbær

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Summary

During the years 1986-1989 an experiment with irrigation and fertigation of raspberry was carried out. The period had two dry and two wet years. Irrigation and fertigation tended to increase yield, but the differences were not significant. Fruit size increased significantly in the two dry years, while there were no difference in the wet seasons. The vegetative development of the canes was excessive for both irrigated, fertigated and unirrigated plants. According to leaf analyses all treatments resulted in mineral nutrition within the optimal range for raspberry.

Key words: *Rubus idaeus,* irrigation, fertigation, yield, fruit size.

Resumé

I et vandings- og gødningsforsøg med hindbær i perioden 1986-1989 var der to tørre og to våde år. Der blev vandet ved drypvanding med eller uden gødning i vandet og sammenlignet med uvandet kontrol. Udbyttestigningen ved vanding var i gennemsnit 5 pct. og ved gødningsvanding 12 pct., men forskellene var ikke signifikante. Derimod var der i to af årene signifikant større frugter ved gødningsvanding end uden vanding. Planternes vækst var ved alle behandlinger så kraftig, at udtynding og beskæring var nødvendig. Planternes gødningstilstand var tilfredsstillende for alle behandlinger, idet analyser af bladene afslørede mineralindhold indenfor optimalområdet.

Selv om udbytteresultatet er usikkert, giver den forbedrede frugtstørrelse så store fordele for frugtkvalitet og plukning, at drypvanding med gødning kan anbefales til hindbær.

Nøgleord: Hindbær, drypvanding, udbytte, frugtstørrelse.

Introduction

The vegetative development of raspberry plants influence the yield. Number and size of canes are yield components (5, 11, 15). *MacKerron* (15) demonstrated a positive relationship between cane length and yield and between cane number and yield. However, yield per cane is negatively correlated with the density, so *Terrettaz* and *Carron* (18) demonstrated that increased cane density from 6 to 12 per running meter increased yield by only 30%.

Similarly, too many canes cause a higher yield of smaller berries (5, 18, 19). The relationship between cane height and yield/cane seem to be linear (15, 18).

Irrigation often results in more vigorous cane development (4, 8, 9, 15). However, growers normally thin raspberry canes to between 8 and 12 canes/m row, which influences yield and may modify effects of irrigation. Cane height is often reduced to between 150 and 190 cm with a yield reduction as result. The more vigorous growth caused by irrigation is strongly influenced by cultural practice and the benefit of more vigorous growth may be reduced. For dessert raspberries the fruit size is important, and as irrigation increases fruit size (1, 2, 3, 12, 15) it may be profitable for the berry grower to irrigate.

Fruiting canes may turn yellow at the top and produce too small fruits. In case of N deficiency, this could be affected by N nutrition through fertigation. *Dijkstra* and *van Oosten* (9) mentioned that drip irrigation could cause lower leaf mineral content and yellow apical parts of the canes, which may be caused by leaching of nutrients from the root zone.

One dry year may reduce raspberry yield in at least two years as shown by *Andrews* (1, 2, 3). In the dry season 1976 drip irrigation with 650 mm resulted in up to triple yield and double fruit size. The weak cane development in unirrigated plots in 1976 caused a reduction to half the yield in 1977 although irrigation this year was only 10 mm. In the third year a yield increase still was obvious even irrigation this year was only 12 mm. Also *Crandall* (6) reported reduction in yield fluctuations with irrigation. Several reports support that irrigation increase raspberry yield, but to varying extents (1, 2, 3, 4, 13, 14, 16).

It is still a question, if irrigation or fertigation under soil conditions with sufficient vegetative development and both cane thinning and pruning, can influence yield and fruit size.

Materials and methods

'Meeker' red raspberries were planted in November 1983 and fertigated in 1984 and 1985 before the start of the experiment. Row distance was 3 m and planting distance was 0.6 m. The soil was sandy loam with a clay content of 11-15%. The amount of water given was 3 litres per meter of row per day. Irrigation and fertigation started in the first week of May and stopped around the first of August. Nutrient supply in the fertigation water was: N 102 mg/l, K 69 mg/l, P 30 mg/l and Mg 46 mg/l.

In the years 1986 to 1989 three irrigation treatments were given: 1. No irrigation. 2. Trickle irrigation with tap water. 3. Trickle irrigation with the above mentioned nutrient composition in 1986 and 1987, but in 1988 and 1989 only 102 mg N/l was included in the irrigation

Table 1. Mineral composition of raspberry leaves (% of dry matter) from unirrigated, irrigated and fertigated plants for four years.
Mineralsammensætning af hindbærblade (pct. af tørstof) fra uvandede, vandede og gødningsvandede planter i fire år.

	N	K	Ca	Mg	P
No irrigation *uvandet*	3.36	1.37	1.15	0.32	0.21
Irrigation *vanding*	3.16	1.47	1.09	0.29	0.37
Fertigation *gødningsvandede*	3.19	1.40	1.13	0.32	0.22
LSD	0.09	0.09	NS	0.02	NS
1986	3.47	1.60	1.02	0.32	0.21
1987	3.26	1.43	0.97	0.27	0.23
1988	2.96	1.42	1.07	0.29	0.37
1989	3.43	1.35	1.37	0.36	0.21
LSD	0.12	0.12	0.11	0.02	NS

Table 2. Yield of unirrigated, irrigated and fertigated raspberry 'Meeker', ton/ha.
Udbytte fra uvandede, vandede og gødningsvandede hindbær 'Meeker', ton/ha.

	1986	1987	1988	1989	Mean
No irrigation	6.2	8.2	11.3	10.5	9.0
Irrigation	5.3	10.0	11.9	10.8	9.5
Fertigation	7.3	9.5	12.6	11.3	10.2
LSD	NS	NS	NS	NS	NS

water. Tap water irrigated plots and plots without irrigation were fertilized in spring with 56 kg N, 12 kg P and 68 kg K per ha except in 1989 where only N was given.

The nutrient state of the plants was followed by leaf analysis. Leaves for analysis were sampled from each replicate every year in August.

The experiment was laid out with four replicates and each plot was 8.4 m of which only two m were harvested for yield and fruit size registration.

Fruiting canes and short primocanes were removed after harvest. Late in the winter canes were thinned to 12 canes per m and headed back to 1.80 m.

Precipitation and potential evaporation were monitored. Evaporation was calculated after a modified Penmann method (17). The water balance illustrated in Fig. 1 is calculated as difference between precipitation and evaporation (17) where positive values are rejected and set to zero.

Results

For N the highest leaf content was found in unirrigated plants, while irrigated plants had the highest potassium content, Table 1. Mg leaf content

Table 3. Fruit size from unirrigated, irrigated and fertigated raspberry 'Meeker', g/berry.
Frugtstørrelse fra uvandede, vandede og gødningsvandede hindbær 'Meeker', g/bær.

	1986	1987	1988	1989	Mean
No irrigation	2.93	3.40	3.63	2.68	3.16
Irrigation	3.25	3.68	3.65	3.38	3.49
Fertigation	3.55	3.48	3.63	3.08	3.43
LSD	0,50	NS	NS	0.15	0.15

Table 4. Vegetative development of raspberry plants after first and third year from unirrigated, irrigated and fertigated plots.
Vegetativ udvikling af hindbærplanter efter et og tre år fra uvandede, vandede og gødningsvandede parceller.

	Shoot length cm		Shoot number/m	
	1986	1988	1986	1988
No irrigation	196	291	16	33
Irrigation	218	293	28	36
Fertigation	236	291	25	38
LSD	25	NS	9	NS

tended to be lowest in irrigated plants, and there were no differences in leaf Ca and P content. The leaf mineral content varied considerably between years.

The yield on fertigated plants was 12% higher than on unirrigated plants, Table 2. However, the difference was not significant. Table 2 also shows considerable variation in fruit yield between years.

In two out of the four years, irrigation and fertigation increased fruit size, Table 3. The mean fruit size was about 10% higher with irrigation.

In the dry year 1986 shoot length and number increased with irrigation and fertigation, Table 4. In the wetter season in 1988 no differences in vegetative development were found.

Discussion

According to *Vang-Petersen* (20) optimum mineral content (% of dry matter) of raspberry leaves are: N 2.8-3.0, K 1.2-1.6, Ca 1.0-1.5, Mg 0.2-0.4, and P 0.15-0.25. In this experiment all treatments resulted in K, Ca, Mg and P content within the optimal range, while N content was above for all treatments. The lower N content in irrigated and fertigated plants may be due to a dilution effect caused by the more vigorous growth in these treatment. It can be concluded that the mineral nutrition of the plants was satisfactory.

MacKerron (15) and *Crandall et al.* (7) showed that cane number and cane length are major yield components in raspberry. As the vegetative development in this experiment was excessive for all treatments and a reduction of both

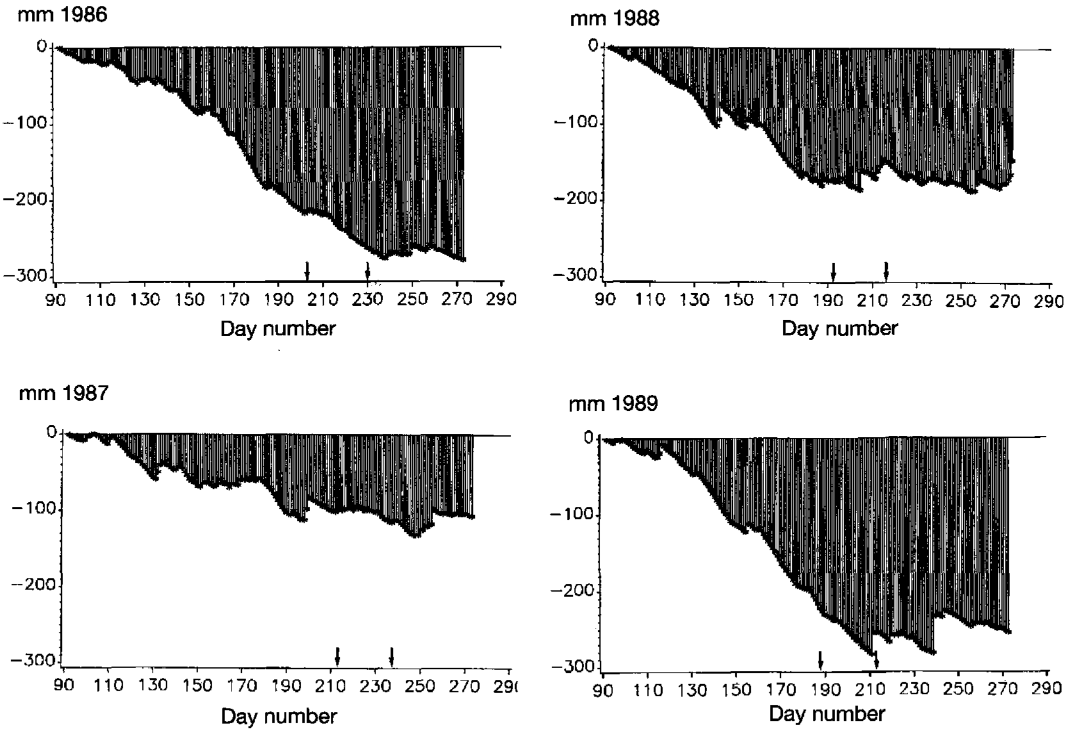

Fig. 1. Potential water balance (mm) in Aarslev for the period of the experiment. Day number for each season is given (90 = April 1). The arrows indicate the harvest period in each year.
Vandbalance (mm) i Årslev gennem de fire forsøgsår. Daglig balance er illustreret (dag 90 = 1. april). Pilene illustrerer høstperioden.

cane length and cane number was carried out resulting in the same cane density for fruit production in both irrigated and unirrigated treatments, one might expect the same yield. According to *Kongsrud* (12) a better lateral development might be expected after irrigation, which should result in a higher yield with the same cane density. In this experiment there was a tendency to increased yield for irrigation and especially fertigation. However, the propability for this result was only 73%.

The better fruit size achieved by irrigation and fertigation caused the tendency to yield differences in this experiment as the fruit number was about the same in all treatments. – Improved fruit size by irrigation is well documented (1, 2, 3, 10, 12, 19).

It may be favorable for the growers to irrigate and especially fertigate due to bigger fruits. The more vigorous growth induced by irrigation may result in thicker canes and as thicker cane give bigger laterals, which produce more fruits (7) one may get a higher yield. When this is not the case, it may be caused by longer internodes, which results in reduced lateral number when heading back is used (7, 15).

The increase in fruit size was different between years and up to 25% in the year with biggest effect. The significant increase in fruit size in 1986 and 1989 may be expected due to a potential water deficit in the harvest period between –220 and –280 mm, while the potential deficit in 1987 was only –100 mm and in 1988 around –170 mm in the harvest period, Fig. 1.

At the experimental site the water holding capacity is about 200 mm down to a depth of 120 cm. As potential evaporation seldom is realized and an upward water movement is taking place there have not been a soil water deficit of the size shown in Fig. 1. Water balance calculated from pan evaporation resulted in 1987 in a positive balance, while of course the Penmann method gave negtive values.

The increase in fruit size may reduce picking costs with about the same percentage as the increase. So even with the same yield irrigation and especially fertigation may be beneficial.

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