Fertigation timing and fertilizer composition affects growth and yield in raspberry long cane and field production

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Fertigation Timing and Fertilizer Composition Affects Growth and Yield in Raspberry Long Cane and Field Production

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Abstract

Successful biennial raspberry production depends on optimal conditions in all developmental phases during the two years. Adequate vegetative growth with many nodes on the primocanes in the first year will provide many flowering sites, and thereafter, favourable conditions for flower initiation and differentiation will optimize yield potential. A high nitrogen status in plants is however, known to increase the risk of winter injury, and this experience has led to a very restrictive fertilizer practice in field production in the Nordic countries with commonly no fertilizer applications after July 1. Since flower initiation and differentiation, beginning in mid to late august in the raspberry cultivar 'Glen Ample' in Norway, also is influenced by plant mineral nutrient status, the present trials were instigated to compare plant and yield responses when fertigation was terminated in July, interrupted in July/August or continuously applied throughout September. The trials were carried out on long canes of the biennial raspberry cultivar 'Glen Ample' in pots, and in a field trial in polytunnels in Southern Norway. The pots were kept in cold storage at -2°C (±1°C) during winter, while the field trial was grown in ambient winter conditions, comprising a minimum temperature of -26°C. The results from the pot trial showed that shoot height, lateral length and yield were influenced by the fertigation strategies. The field trial involved different fertilizer compositions after a pause in fertigation from July 15 to August 15, and indicates that an interrupted and continuous nutrient supply throughout September gave an earlier bud break compared to a restrictive fertilizer strategy. Interrupted fertigation produced the highest total yield in the potted long canes while berry size showed divergent pattern in the two trials. Interrupted fertigation was in general, positive.

INTRODUCTION

Successful biennial raspberry production depends on optimal conditions in all developmental phases during the two years. Adequate vegetative growth with many nodes and long laterals on the primocanes will provide many flowering sites (Sønsteby et al., 2009a), before the decreasing temperature and photoperiod during late summer and autumn, initiate growth cessation and floral primordia (Sønsteby and Heide, 2008), and finally a range of physiological changes that are essential for cane frost hardiness (Palonen, 1999). The period of cane hardening is very important to develop cold hardiness before entering winter, and ample nitrogen application (Nestby and Kongsrud, 1993) and irrigation (Hoppula and Salo, 2006) prior to or during this period is known to increase the risk of winter injury in raspberry. This knowledge has led to a very restrictive fertilizer practice in field production in the Nordic countries, with commonly no fertilizer applications after July 1. Since flower differentiation, which is initiated in mid-August in Southern Norway is very likely to be positively affected by ample access to plant minerals, the present trials were instigated to find how fertilizer rate and composition during the flower differentiation period affected growth, yield and overwintering. Since excessive N application is likely to delay growth cessation, cane hardening and flower differentiation (Sønsteby et al., 2009b), a pause in nutrient application in a period prior to these phenological stages was also included in the trials.

MATERIALS AND METHODS

Long Canes in Pots

Potted 'Glen Ample' floricanes were moved out of the cold store on June 1, transplanted into 7.5 L pots filled with peat and grown in an open polytunnel at Bioforsk (61°N). The plants were fertigated daily with a complete nutrient solution with a combination of two water soluble commercial fertilizers (Yaraliva^{TM} Calcinit and Superba^{TM} Rød 60/40) (Table 1). The electrical conductivity (EC) of the nutrient solution was varied between 1.1 and 1.8 mS cm^{-1}, depending on the weather conditions. The fertilizer composition was constant during the entire trial, also during the harvest period the following season. In each pot, two shoots were allowed to grow into full height, while the other emerging root suckers were removed biweekly. Three treatments, each comprised of nine pots distributed on three blocks with three pots were organized, and from August 1, the different treatments were introduced:

1) Fertigation ended on Aug 1.
2) Fertigation interrupted from Aug 1 to Sept 1. Then fertigation until Oct 1.
3) Continuous fertigation until Oct 1.

Plants that were not fertilized were irrigated with tap water when needed. The floricanes were removed after harvest, and the primocanes were kept outside for hardening until December, when they were moved in to a cold storage and kept at -2°C in the dark during winter. In June they were placed in a polytunnel and grown for fruit production. Total yield and berry size were recorded at harvest, two or three times per week from August 3 to September 25. Number of generative, vegetative and dormant buds were registered on all the shoots, as well as length of the laterals, before the trial was terminated in October.

Soil Grown Plants in Polytunnels at Apelsvoll Research Station

Small plants of 'Glen Ample' were established in polytunnels in 2008. In spring 2009 the shoots were cut to bases, and from mid-June the entire field was fertigated with a nutrient solution of 60% Yaraliva^{TM}Calcinit and 40% Superba^{TM} Rød (Table 1) with an EC of 2.0 mS cm^{-1}. From July 15, five different fertilizer strategies were initiated:

1) Fertigation ended Jul 15.
2) fertigation interrupted from Jul 15 to Aug 15, then fertigation with Calcinit until Oct 1.
3) fertigation interrupted from Jul 15 to Aug 15, then fertigation with Superba until Oct 1.
4) fertigation interrupted from Jul 15 to Aug 15, then fertigation with Calcinit and Superba (60/40) until Oct 1.
5) Continuous fertigation until Oct 1 with Calcinit and Superba (60/40).

EC in all the treatments were constant on 2.0 mS cm^{-1}. Leaf samples were collected in early October and analysed for NPK.

In late February 2010 and early March 2011, three shoots per treatment were sampled in the field, and single node cuttings were forced in a greenhouse at 20°C and artificial light conditions. Date of bud break was recorded on 10 individual buds from the top of the cane.

In spring the first harvest year, the plants were topped at 160 cm, and the shoots were thinned to 10 floricanes m^{-1}. Three replicate plots of 5 meters were harvested three times per week from July 23 to August 30. Berry size and total yield was recorded at each harvest. Temperatures during winter were stable, and comprised a minimum temperature of -26°C, but there were no episodes with mild temperatures followed by frost.

RESULTS AND DISCUSSION

Long Canes in Pots

The early termination of nutrient supply in potted plants resulted in significantly poorer growth, and the primocanes were significantly shorter when fertigation ended or paused on August 1 (Table 2). The number of dormant shoots tended to be higher when fertigation terminated early, but the difference was not statistical significant. The low fertigation rate initiated a significantly lower yield (P=0.020), but also significantly larger berries than when fertigation was reapplied from Sept 1 (P=0.033) (Fig. 1). Nutrient reapplication from September initiated more numerous berries (Table 2).

Soil Grown Plants

A relatively high fertigation rate stimulated an earlier budbreak in spring after forcing at 20°C when compared to the restrictive fertilizer strategy (data not presented). This response was unrelated to fertilizer composition, and was repeated in both years.

Fertigation rate and fertilizer composition affected plant mineral concentration in leaf samples (data not presented). All treatments had low leaf N concentration, but the leaves were sampled very late in the season, and translocation of minerals is likely to have started. Fertigation with Superba after August 15 gave the highest leaf NPK concentration in the present trial. Continuous fertigation may have stimulated more vegetative growth, and diluted leaf mineral concentration. No symptoms of mineral deficiency were visible at any stage during the trial.

The yield responses were significant only for berry size, where the continuous fertigation with a mix of the two fertilizers was superior (P<0.001) (Fig. 2). Total yield tended to be lower when fertigation was terminated in July. There was observed no difference in time to anthesis in the field, but interrupted fertigation tended to accelerate fruit maturation with a few days (Fig. 2).

Temperatures below 15°C induces both growth cessation and floral initiation in 'Glen Ample' raspberry (Sønsteby and Heide, 2008), and is about August 20 in Southern Norway. Fertilizer timing in relation to these key phenological stages is therefore known, but not sufficiently elucidated for precision fertilization in practical raspberry production.

Survival of canes after intermittent periods of warm weather is influenced by numerous endogenous and environmental factors (Palonen and Lindén, 1999), and a high fertigation rate increased the risk of frost damage in the present field trial as a consequence of an earlier bud break in spring, when plants are in the ecodormant stage. Also a delay of flower initiation by excessive fertilization in the vegetative phase may reduce yield potential (Sønsteby et al., 2009b), especially in a Nordic climate where temperature is declining rapidly in the autumn and the period with optimal conditions for flower differentiation is limited. This may have resulted in continuous fertigation in the pot trial producing fewer berries than when fertigation was limited prior to the generative phase (Table 2). In long cane production in pots with controlled overwintering and forcing, there is a potential for a higher yield potential with a relatively high fertigation rate during flower differentiation, but defining how fertilizer timing, rate and termination of fertigation affects berry size is essential. In strawberry, it is known that a high N rate during flower bud differentiation produces more rows of pistils in each flower, and thereby a potential for larger berries (Yoshida et al., 1992). In the present pot trial good nutrient access produced a higher number of berries (Table 2), but decreased berry size (Fig. 1). This might have been caused by an inadequate root volume and capacity to realise the fruit size potential (Fernandez and Pritts, 1993), since in the soil grown raspberries, a continuous fertilizer rate yielded the largest berries. It is not known if differences in berry size were caused by cell number or cell size.

CONCLUSIONS

Reducing fertilizer rates by an interrupted nutrient supply prior to flower differentiation was positive for total yield in long cane production, but may result in a smaller berry size. Fertigation until October decreased the number of days to budbreak and increased the risk of frost damage by forcing the buds to a more frost sensitive stage, but produced the largest berries. The common fertilizer practise with the early termination of fertilization, is limiting yield potential.

ACKNOWLEDGEMENTS

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Tables

Table 1. Mineral composition (%) of the commercial fertilizers used in the trial.

	N	P	K	Ca	Mg	S	B	Fe	Mn	Mo	Zn	Cu
YaraLiva™ Calcinit	15.5			19.0								
Superba™ Rød	8.5	4.9	24.7		4.2	5.7	0.03	0.18	0.07	0.007	0.037	0.01

Table 2. Vegetative and generative responses on different fertilizer strategies in long canes in pots in 2009-2010 (Trial 1). All responses are means per cane.

	Cane height (cm)	Total lateral length (cm)	Total nodes	Buds with flowers	Dormant buds	Number of berries
1. Fertigation ended Aug 1	148 b	457 b	32 a	10 b	22 a	121 b
2. Fertigation interrupted from Aug 1 to Sept 1	153 b	602 ab	31 a	15 a	16 a	169 a
3. Continuous fertigation to October 1	183 a	769 a	35 a	17 a	17 a	130 b
Mean	161	609	33	14	18	140
P-value	0.018	0.009	n.s.	0.002	n.s.	0.002

Figures

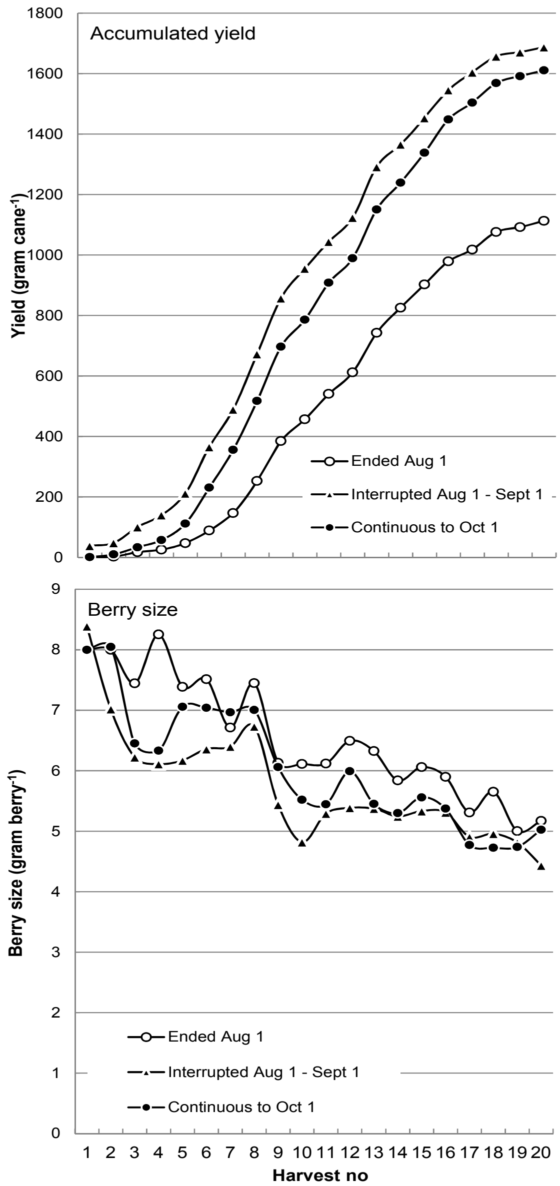

Fig. 1. Yield and berry size in 'Glen Ample' long canes in pots in 2009-2010 after different fertilizer strategies during propagation.

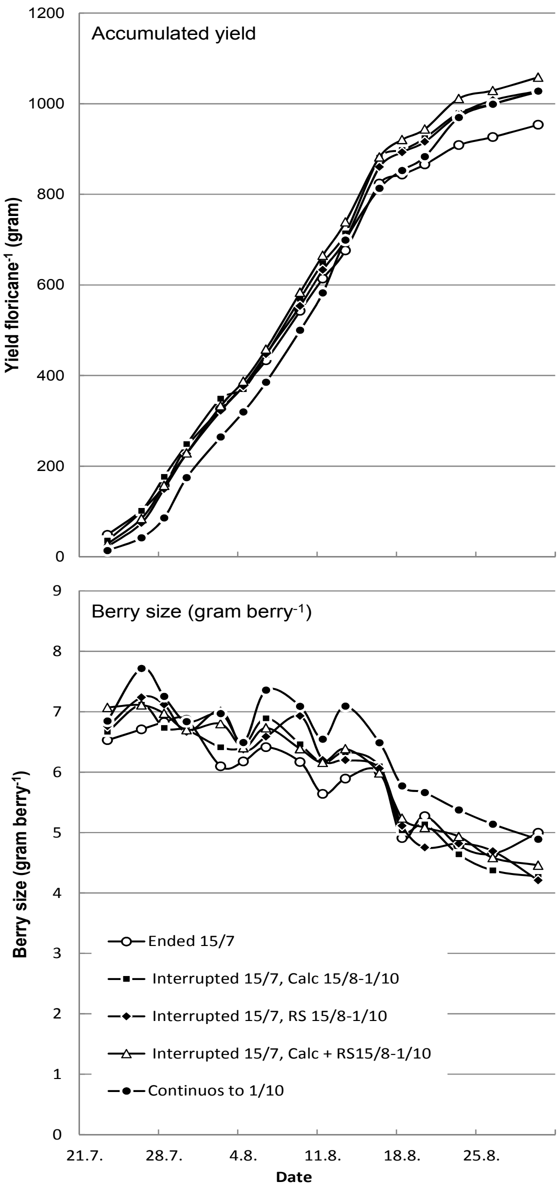

Fig. 2. Yield and berry size in 2009 in soil grown 'Glen Ample' raspberry in polytunnels with five fertigation strategies. Calc; Calcinit (15.5% N), RS; Superba Red (8.5% N).