THE EFFECT OF DRIP IRRIGATION ON THE YIELD AND QUALITY OF APPLES

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Abstract


The paper describes the assessment of the influence of drip irrigation on the quality and yield of apples of the species Golden Delicious/M9 and Gala/M9 in the locality Velké Němčice performed by the Institute of Horticultural Machinery ZF MENDELU in Brno.

The experiment is based in the orchard of the company Sady Velké Němčice, s. r. o. The assessed varieties are Golden Delicious and Gala planted in 2003 with the spacing 3.5 × 1.1 m. The experiment is performed in four rows. In every row four 50 meters long experimental sections are marked. Each section is irrigated in a different way.

The irrigated sections are fitted with driplines (supplied by NETAFIM CZECH, s. r. o.) with different drip-flow rates: 1.6 l/hour (sections labelled “REDUCED”), 2.3 l/hour (“STANDARD”), and 3.5 l/hour (“INCREASED”). Pipes without drippers are installed in the control sections without irrigation (“CONTROL”). The sequence of the sections in the adjacent rows varies to increase the objectivity of the measurement.

During the four-year monitoring a positive influence on the quality and yield of apples has been detected.

apple trees, drip irrigation, yield, dripper

Irrigation plays a very important role in almost every contemporary modern fruit company. It is an important agro-technical element, which distinctly increases the competitiveness and efficiency of production. With irrigation stable and high yields of the highest quality fruit can be achieved (Litschmann, 2004). The use of irrigation systems and their rational control enables producers to meet the demands of their customers (chain stores) for high quality and mutually cost-effective production.

For modern and highly productive plantings of quality species apple trees some additional irrigation is necessary. Their productive potential can only be fully exploited in ideal growing conditions (nutrition, fertilization, irrigation, protection, agrotechnical interventions, etc.). Failure or neglect of any of these conditions results in reduced quality and profitability of the production.

Apple trees belong among crops with high water consumption (about 900 mm for a growing season). Even a temporary lack of water and nutrients in an important growing phase is noticeably reflected on the quality and amount of the production. Therefore irrigation systems are built even in areas where the annual rainfall is above 1000 mm. Here they have a supplementary function of providing immediately acceptable nutrients and water during periods of their insufficiency. Irrigation systems are also built in areas where the annual rainfall is high but uneven throughout the growing season.

The advantages of drip irrigation

Contemporary plantings of apple trees are mostly irrigated by drip irrigation, which belongs to the latest methods of irrigation in orchards. Its most distinct advantage is the application of water straight to the trees. Water is delivered only to those places where it is really required and fully usable for the plants. In comparison with
the sprinkler irrigation, it is possible to achieve significant savings of water – commonly 70–80% (depending on the soil conditions, the type and stage of the growth, quality of the control system, etc.).

A significant advantage of drip irrigation is the possibility to provide fertilizers dissolved in water. The application of fertilizers is again exactly targeted and therefore is also ecological; it achieves an almost immediate effect without a negative impact on the non-target surroundings and environment (Hanisko, 2005).

Another advantage of drip irrigation is the minimal influence on cultivation operations. The dripline suspended on the load-bearing wire of the supporting structure does not obstruct cultivation operations, and is easily controllable and accessible for maintenance. The dripline can work at any time of the day. It can even be used, for example, at the same time as the chemical protection because it does not influence the amount of moisture on the plants and the access of machinery to the orchard. With other types of irrigation this is not usually possible (Litschmann, 2006).

Sprinkler irrigation of new plantings of apple trees is used very seldom, especially because of higher demands on water and energy supplies. If the grower requires the possibility to use irrigation to improve the microclimate or moisten the plants, it is possible to use modern types of micro-sprinkler irrigation or the combination of drip and micro-sprinkler irrigation. Such solutions are very rare due to economic reasons.

MATERIAL AND EXPERIMENTAL METHOD

The experiment is based in the orchard of the company Sady Velké Němčice, s.r.o. The assessed varieties are Golden Delicious/M9 and Gala/M9 planted in 2003 with the spacing 3.5 x 1.1 m. The experiment is performed in four rows. In every row four 50 meters long experimental sections are marked. Each section is irrigated in a different way. To eliminate human influence on the water delivery and the measurement, the different amounts of water supplied are determined by the type of pipeline, or more precisely by the size of the dripper. In each row the irrigation is monitored in three of the sections, with the fourth used as a control section with no irrigation.

The irrigated sections are fitted with driplines (supplied by NETAFIM CZECH, s.r.o.) with different drip-flow rates: 1.6 l/hour (“REDUCED” variant), 2.3 l/hour (“STANDARD”), and 3.5 l/hour (“INCREASED”). In the control sections without irrigation (“CONTROL”) are installed pipes without drippers. The sequence of the sections in the adjacent rows varies to increase the objectivity of measurement.

Besides measuring the atmospheric rainfall by the rain gauge, the quantity of fertilizers supplied to the irrigation water is monitored.

A soil-moisture meter Virrib was installed 0.5 m deep for each monitored variant (i.e., four meters in the whole experimental area). Soil moisture is recorded in one-hour intervals throughout the growing season using the Virriblogger. These values are used to calculate the average daily soil moisture.

The time of irrigation is monitored by the electronic irrigation recorder (dataloger).

Control harvests in the experimental sections are performed before the overall harvest of the fruit to determine the yield and ratio of the quality classes of apples in each particular type of irrigation. For better comparison the values obtained are recalculated for the area of one hectare. The quality is assessed in these categories: Selection, Class I, Class II, and Non-standard (NS).

RESULTS AND DISCUSSION

Water supply (1)

In 2008 the annual rainfall of only 365 mm was recorded, which is absolutely inadequate for apples. During the growing season 960 l of water were supplied per 1 meter of the tree-row. This equals about 260 mm of rainfall. The influence of irrigation was very significant that year.

In 2009 the annual rainfall of 570 mm was recorded. The distribution of rainfall was relatively favourable, except in the dry month of April. During the growing season 440 l of water were supplied per 1 meter of the tree-row. This equals about 120 mm of rainfall. The influence of irrigation was not so significant that year.

In 2010 the annual rainfall of 678 mm was recorded. The distribution of rainfall was favourable. The period from May to the end of August was very rich in rainfall, with the monthly average of more than 100 mm. During the growing season only 1481 l of water were supplied per 1 meter of the tree-row. This equals about 40 mm of rainfall. In that year irrigation was used especially for additional fertilization.

In 2011 the annual rainfall of 408 mm was recorded. The distribution of rainfall was favourable, except in the dry month of April. During the growing season 3171 l of water were supplied per 1 meter of the tree-row. This equals about 87 mm of rainfall. In that year the influence of irrigation was not significant due to positive distribution of rainfall during the growing season and the influence of the previous wet year when the plants were in a very good condition.

Evaluation of yield and quality

2008

The total yield of the Gala variety was 104% higher in the STANDARD variant than in the CONTROL variant without irrigation (I, 2). The ratio of the quality classes Selection and Class I was 63.9% in the...
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The total yield of the Golden Delicious variety was 71.0 % higher in the STANDARD variant than in the CONTROL variant without irrigation (II, 3). The ratio of the quality classes Selection and Class I was 76.4 % in the STANDARD variant and 30.3 % in the CONTROL variant (IV, 5).

In 2009, the total yield of the Gala variety was 40 % higher in the STANDARD variant than in the CONTROL variant without irrigation (I, 2). The ratio of the quality classes Selection and Class I was 67.2 % in the STANDARD variant and 41.9 % in the CONTROL variant (III, 4).

The total yield of the Golden Delicious variety was 33.0 % higher in the STANDARD variant than in the CONTROL variant without irrigation (II, 3). The ratio of the quality classes Selection and Class I was 79.1 % in the STANDARD variant and 47.5 % in the CONTROL variant (IV, 5).

In 2010, the total yield of the Gala variety was 24.0 % higher in the STANDARD variant than in the CONTROL variant without irrigation (I, 2). The ratio of the quality classes Selection and Class I was 71.0 % in the STANDARD variant and 50.8 % in the CONTROL variant (III, 4).

The total yield of the Golden Delicious variety was 29.5 % higher in the STANDARD variant than in the CONTROL variant without irrigation (II, 3). The ratio of the quality classes Selection and Class I was 83.6 % in the STANDARD variant and 52.2 % in the CONTROL variant (IV, 5).

In 2011, the total yield of the Gala variety was 16.5 % higher in the STANDARD variant than in the CONTROL variant without irrigation (I, 2). The ratio of the quality classes Selection and Class I was 79.5 % in the STANDARD variant and 68.8 % in the CONTROL variant (III, 4).

The total yield of the Golden Delicious variety was 17.5 % higher in the STANDARD variant than in the CONTROL variant without irrigation (II, 3). The ratio of the quality classes Selection and Class I was 88.1 % in the STANDARD variant and 55.8 % in the CONTROL variant (IV, 5).

### CONCLUSIONS
Drip irrigation in fruit orchards has a significant role in fruit production regarding yields, quality and economy. This paper describes the assessment of...
2: Apple yields – GALA variety

II: Apple yields – GOLDEN DELICIOUS variety [t.ha\(^{-1}\)]

<table>
<thead>
<tr>
<th>Year / Variant</th>
<th>CONTROL</th>
<th>REDUCED</th>
<th>STANDARD</th>
<th>INCREASED</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>15.5</td>
<td>17.5</td>
<td>26.6</td>
<td>28.2</td>
</tr>
<tr>
<td>2009</td>
<td>18.1</td>
<td>19.8</td>
<td>24.0</td>
<td>24.7</td>
</tr>
<tr>
<td>2010</td>
<td>31.9</td>
<td>36.5</td>
<td>41.3</td>
<td>41.6</td>
</tr>
<tr>
<td>2011</td>
<td>18.9</td>
<td>21.2</td>
<td>22.2</td>
<td>23.5</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>21.1</td>
<td>23.7</td>
<td>28.5</td>
<td>29.5</td>
</tr>
</tbody>
</table>

3: Apple yields – GOLDEN DELICIOUS variety

III: Ratio of quality classes – 4-year average – GALA variety

<table>
<thead>
<tr>
<th>Class / Variant</th>
<th>CONTROL</th>
<th>REDUCED</th>
<th>STANDARD</th>
<th>INCREASED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection [%]</td>
<td>18.3</td>
<td>28.3</td>
<td>31.2</td>
<td>32.5</td>
</tr>
<tr>
<td>Class I [%]</td>
<td>30.1</td>
<td>32.8</td>
<td>39.2</td>
<td>39.7</td>
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<tr>
<td>Class II [%]</td>
<td>33.7</td>
<td>29.9</td>
<td>23.5</td>
<td>22.8</td>
</tr>
<tr>
<td>NS [%]</td>
<td>18.0</td>
<td>9.1</td>
<td>6.1</td>
<td>5.0</td>
</tr>
</tbody>
</table>
drip irrigation on the yield and quality of apples of
the varieties Gala/M9 and Golden Delicious/M9 in
a 4-year period (2008–2011).

The period included two years with low rainfall
(2008 and 2011 – annual rainfall 365/408 mm
respectively), a year with average rainfall (2009
– 570 mm) and a year with high rainfall (2010 –
678 mm).

With the Gala variety an increase in yields was
achieved in the dry year in sections with standard
irrigation (+ 104 %) compared to non-irrigated
control sections. In the following year with average
rainfall the impact of irrigation was not so significant
(+ 40 %). In the next year with high rainfall an
increase in yields was achieved in sections with
standard irrigation (+ 24 %). In the last year of
monitoring the rainfall was below average but its

4: Ratio of quality classes – 4-year average – GALA variety

5: Ratio of quality classes – 4-year average – GOLDEN DELICIOUS variety
distribution during the most important growing phases was very good, and therefore the impact of irrigation on yields was small (+16.5%).

With the Golden Delicious variety increase in yields was achieved in the dry year in sections with standard irrigation (+71%) compared to non-irrigated control sections. In the following year with average rainfall the impact of irrigation was not so significant (+33%). In the next year with high rainfall the increase in yields was achieved in sections with standard irrigation (+29.5%). In the last year of monitoring the rainfall was below average but its distribution during most important growing phases was very good, and therefore the impact of irrigation on yields was small (+17.5%).

In the achieved total yields of apples, especially with the control variant, the influence of the preceding year is evident, with stress and certain yield depression reflected also in the following year. The differences in apple yields in the non-irrigated control variant are not significant in a year with favourable rainfall after a wet year (see 2010 and 2011).

With the Gala variety the quality of fruit from the irrigated sections in the economically most interesting quality classes (selection and class I) reached a four-year average of c. 70% compared to 48% in the non-irrigated control variant.

With the Golden Delicious variety the quality of fruit from the irrigated sections in the economically most interesting quality classes (selection and class I) reached a four-year average of c. 82% compared to 46% in the non-irrigated control variant.

The impact on quality (the ratio of the economically most interesting quality classes) is substantial in both cases and reaches the increase of almost 80% compared to the non-irrigated control.

The monitored varieties showed the best results when the amount of water supplied (by rainfall and irrigation) was 650 mm. The measurements confirm that the effect of drip irrigation is the biggest in years with low rainfall.

**SUMMARY**

It can be concluded that the results of the 4-year monitoring of the influence of drip irrigation on the yield and quality of apples show a very positive influence of irrigation. Its influence on the yield and quality of apples was especially evident in the dry year of 2008. The influence of irrigation on the yield and ratio of the highest quality classes of apples was less evident in 2010 due to abundant rainfall.

**REFERENCES**