Analysis of various implementations of hop strings during hop production

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ABSTRACT

Hop purchasers impose still higher requirements on the quality of the final product, which is why hop granules have to be divested of all possible impurities. One of the places that are most at risk from the given point of view is the making of hop strings and the way they are attached to the hop-field supporting structure. Commonly used hop string attachments very often remain on the supporting structure after the harvest, spontaneously loosen in the following years, penetrate into the post-harvest processing stage of the technological procedure and negatively influence the output quality of the hops. The article summarizes the results of field experiments done during the pull-down of hop vines using a common hop string, but with various attachments with the aim of looking for the most suitable treatment which would exclude the risk of impurities penetrating from this stage of the technological procedure into the final product. The measurement carried out shows that so far the most advantageous treatment is hop string with simple attachment formed by twine 12 500. Breakage of hop strings occurred in 93% in twine, while with the rest of the vines only in wire.

Keywords: hop; granule; impurity; growing; processing

For the Saaz aroma variety the majority of hop growers use a guide wire of 1.06 mm in diameter as a hop string. Only for less common hybrid varieties (Sládek, Premiant, Agnus, etc.) a wire of 1.12 mm in diameter is used (Basařová et al. 2010).

The current method of hop string attachments (guide wires) to a supporting structure by means of polypropylene twines of varying strength and different attachments methods (according to the tradition and experience of individual growers) bears the risk of hop product contamination by these attachment residues (Rybáček et al. 1980).

There are a number of requirements for hop strings and their attachments. A hop string must be able to be easily hung on the supporting structure with the use of suitable attachments, its other end stuck in the ground, and allow an easy spiral hop vine distribution. Hop vines must cling to hop strings and during the vegetation period they must not slump. A guide wire must be, from the point of view of strength, proportioned for the gradually increasing weight of growing hop vines, for the risk of weather impact (wind gusts, persistent rains, etc.), and for the corrosive effects resulting from frequent application of agrochemicals (Portner 2007). Both hop strings and attachments must allow the pulling machinery an easy and fluent hop vine pull-down (Rybka et al. 2011). Last but not least, the operation makes heavy demands on both manual and machine work as well as on total financial inputs (Portner 2009, Gobor and Fröhlich 2010).

The present conception, which is used by practically all growers, does not present an ideal strength proportions between hop strings and their attachments. When hop vines are being pulled down (during the harvest), hop strings are mostly broken and the attachments, possibly along with some parts of wires, are left on the hop-field trellis. In the following years, mainly due to the influence of applied chemicals, these attachments spontaneously come loose and are one of the causes for penetration of impurities into another stage of the technological process where they are separated only with difficulty (Matthews 2000).

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Thus with hop growing technology, it would be suitable for mechanized pull-down of harvested hops to pull down the guide wire along with the hop vines and their attachments in such a way that the whole attachment stayed connected to the wire and there would be only attachment residues left on the hop trellis (Srivastava et al. 1993, Ciniburk et al. 2009). Both wine bines and hop strings (ideally including attachments) would be left at the stationary picking machine after the hop cones were picked off. These would then be cut up into little pieces by a cutting machine and taken to be composted, possibly to be ploughed in. Wire and attachment residues would decompose in short a time in the ground (Hůla and Procházková 2008).

On the basis of field measurements of axial force during the pulling of hop vines and hop strings with a variety of attachments, some alternative solutions were analysed with the aim of finding the most favourable treatment which would exclude the risk of impurities penetrating from this part of the technological process into the final product. Subsequent laboratory experiments make the information for the analysis complete, including specification of information about individual parts of the hop-field (Heřmánek et al. 2011).

MATERIAL AND METHODS

The field experiment was based on a hop field belonging to CHMEL-Vent spol. s r.o. with the Saaz aroma variety – clone 72, and the original plan included eight combinations of hop strings (black annealed wire of 1.06 mm in diameter) and different versions of attachments. The material used for attachments was polypropylene twine made by JUTA a.s. of different strength, labelled by the manufacturer as – 10 000, 12 500, 14 000 and 17000 (www.juta.cz). For each twine strength two kinds of attachments were created – simple and double (Figure 1). In the last stage of preparations for launching the experiment, however, a mistake occurred when a treatment of twine labelled as 17 000 with simple attachment was not prepared at the expense of two treatments with double attachment. Each of the combinations was carried out in three rows with approx. 30 hop strings in one row.

Before hanging the hop strings the trellis supporting wire was purged of any attachment residues from previous years. Figure 2 shows a layout of a hop field with an established field experiment.

The object of the experiment was:

(1) To measure the force at breakage of hop-string or its attachment during hop vine pulling.

(2) To discover hop vines fallen down spontaneously during the pulling.

(3) To record the weight of measured hop vines.

(4) To locate the point of breakage during the pulling (wire or twine).

(5) To take samples of wire and attachments for further laboratory measurements.

Description of measurement equipment. The construction of a commonly used puller for hop harvesting did not enable the placement of power sensors directly on the puller. Therefore a special device was created (Figure 3) in which the pulling was carried out under the same conditions as with pullers and it was also possible to measure hop vines one by one in the row. The device was placed on a trailer pulled by a tractor, and the trailer was completed with a frame designed for a swing anchorage of the pull-sensor. The other

Figure 1. Sample of simple and double hop-string attachment

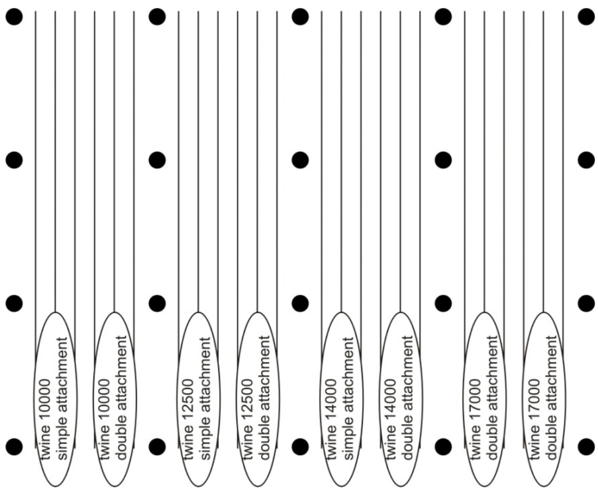

Figure 2. Schematic representation of the layout in the experimental hop-field

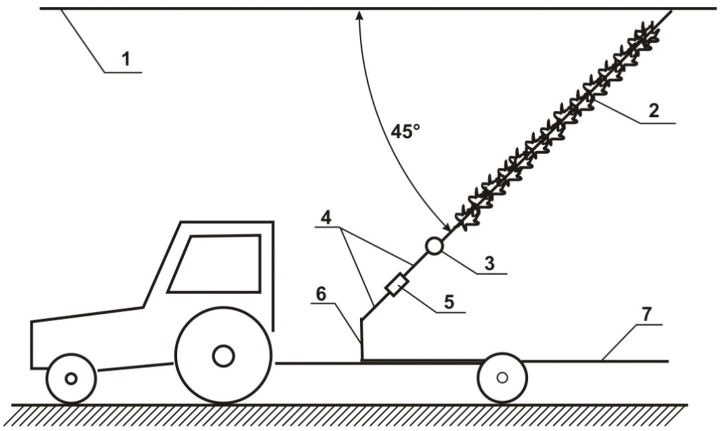

Figure 3. Schematic representation of the device for measurement of tensile force during hop vine pulling. 1 – supporting wire of hop-field trellis; 2 – hop vine on hop string; 3 – loop for attaching hop vine to tensile force sensor; 4 – swing arms of the sensor; 5 – tensile force sensor; 6 – frame for attaching the sensor arm; 7 – trailer

end of the sensor was extended by a hanger for attaching the hop vines while being pulled down. In terms of dimensions this device was designed in such a way that the pulling procedure was done under the same conditions as with pullers during the harvest. That means that both the place of hop vine attachment during pulling and the hop vine deflection during pulling were maintained. Due to the swing placing of both ends of the tensile force sensor it was discovered that only the axial force of the hop string will be measured at the pulling. The sensor used to measure the tensile force was made by HBM Brno (exclusive representation by the Hottinger Baldwin Messtechnik GmbH) with a type designation of U9B and a measuring range of 0–1 kN. The output signal from the sensor was processed by means of MGC Plus mobile central measurement station, also produced by Hottinger Baldwin Messtechnik GmbH (Darmstadt, Germany) (Figure 4), connected to a laptop. The central measurement station, sensor, and storage of measured data were secured by the Catman Easy program, which is supplied to the central measurement station.

Methodology of measurement. After installing the entire measurement device, sensor calibration was carried out by means of a suspension device weighing 30 kg.

Out of every treatment for hanging the hop vines (Figure 2), two rows were reserved to measure the force at pulling and one row for taking samples for subsequent laboratory measurements. Before measurement, the hop vines on the hop strings were labelled with a serial number (max. of 30 hop vines). Measurement was carried out every time during a continual uninterrupted pulling in one row of the experimental hop-field. The hop vines were cut off above the ground at the height of approx. 1.2 m, threaded through the loop on the sensor arm, and stretched at a 45° angle (Figure 3) by a smooth drive of the tractor with a trailer. Due to the smooth pull the hop vines were pulled down and the hop strings or their attachments were broken. After the pull-down the hop vines were put on the trailer. The hop vines which fell down due to the trellis shaking were not included into the measurement. During the pulling the sensor measured a tensile force with a frequency of 50 Hz (Brzkovský 1993).

After the pull-down of every row, the weight of hop vines was assessed and the breakage point (wire or twine) was located. Also the number of hop vines fallen down spontaneously was recorded.

RESULTS

On the basis of the above described methodology, measurements were carried out with seven different combinations of hop string and its attachments. To show the course of the measurement, Figure 5 presents a record of the initial values of tensile force arisen from measurement No. 1.

From the record of initial values of the tensile force and with the help of a database program,

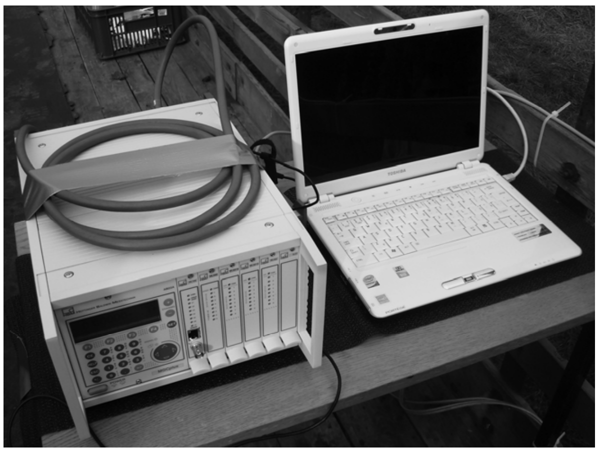

Figure 4. MGC central measurement station connected to a laptop

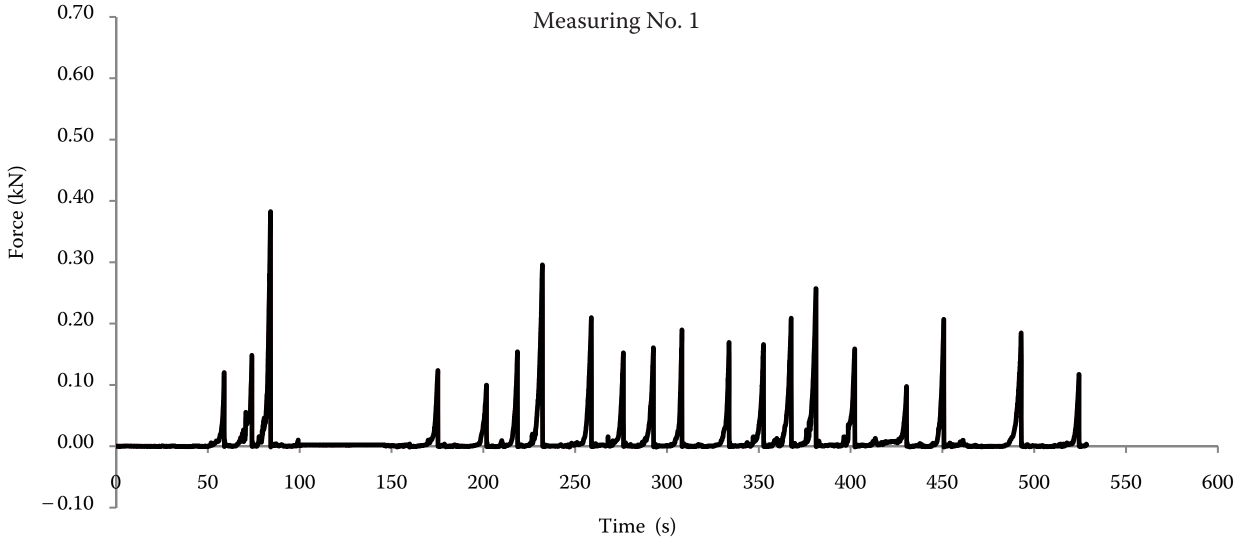

Figure 5. Graph of the course of tensile force measurement during the pulling of hop vines in one row (measurement No. 1: hop string – guide wire of 1.06 mm in diameter and simple attachment made of twine labelled as 10 000)

a selection of forces was made in Excel, and the weight was assigned to every single hop vine. Specific values of measured tensile force, weight, data concerning the breakage points and spontaneously fallen hop vines, are shown in Table 1.

Summarised results of the measurements are shown in Table 2. The table includes the average values of the measured tensile force for a given treatment, statistical assessment of its variability (standard deviation, variation coefficient), vine weight including statistical data, percentage share of breakage point (twine/wire), and percentage of spontaneously fallen hop vines.

Table 2 clearly shows a substantial variability of tensile force which is well-documented by standard deviation and variation coefficient, and which does

Table 1. Hop vine label, tensile force, vine weight, breakage point or spontaneously fallen vine (measurement No. 1: hop string – guide wire of 1.06 mm in diameter and simple attachment made of twine labelled as 10 000)

Vine No.	Force (N)	Weight (kg)	Breakage point M-twine, D-wire	Vine No.	Force (N)	Weight (kg)	Spot of breakage M-twine, D- wire
1	120	1.38	M	16			spontaneously broken
2	148	2.62	M	17	169	2.95	M
3	383	4.06	M	18	166	4.30	M
4			spontaneously broken	19	209	3.55	M
5			spontaneously broken	20	257	3.68	M
6			spontaneously broken	21	159	2.92	M
7	123	2.06	M	22			spontaneously broken
8	100	4.65	M	23	97	3.65	M
9	154	2.68	M	24	207	3.22	M
10	296	3.61	M	25			spontaneously broken
11			spontaneously broken	26			spontaneously broken
12	210	1.91	M	27			spontaneously broken
13	152	1.98	M	28	185	2.76	M
14	160	3.52	M	29	117	0.85	M
15	189	2.64	M				
Average values					180	2.95	

Table 2. Average values gained from individual treatments of field measurements during hop vine pulling

JUTA polypropylene twine label	Attachment version	F	s_F	v_F	m	s_m	v_m	M/D	Share of spontaneously fallen hop vines to total number
		(N)		(%)	(kg)		(%)		
10000	j	180	67.30	37.38	2.95	0.95	32.31	100/0	31.0
	d	346	28.97	8.37	2.50	0.97	38.63	52/48	0
12500	j	314	54.03	17.18	2.67	1.08	40.37	93/7	3.4
	d	404	69.27	17.16	2.86	0.93	32.62	0/100	0
14000	j	341	45.00	13.20	2.09	0.85	40.84	81/19	10.3
	d	390	63.61	16.31	2.23	0.81	36.16	0/100	0
17000	d	412	83.76	20.34	3.39	0.99	29.34	0/100	0

F – force at breakage of the hop string or attachment; s_F – standard deviation of force at breakage; v_F –variation coefficient of force at breakage; m – weight of hop vine on one hop string; s_m – standard deviation of hop vine weight; v_m – variation coefficient of hop vine weight; M/D – share of breakage in twine or wire; j – simple; d – double

not conclusively depend on any input parameters of individual treatments. Nor is the dependency of tensile force on the weight of hop vines obvious, which is in contrast to tensile force relatively balanced in all the measured treatments.

Further, it is possible to assess, on the basis of input parameters and measured tensile force, the share of breakage in twine or wire and the share of spontaneously fallen hop vines.

We can clearly read in Table 2 that the ideal hundred-per-cent breakage occurred only with the simple attachment and twine strength labelled as 10 000. However, the percentage of spontaneously fallen hop vines is very high. The given data represent approx. 129 fallen hop vines of one loaded trailer, which is absolutely unbearable in practice. It should also be noted that on the basis of rough laboratory tests the used twine did not reach the tensile strength which is described by the producer. The number of spontaneously fallen hop vines might possibly be lowered by using Horti Twine, a polypropylene twine (JUTA Inc.), for which the producer guarantees that exposed to ultraviolet radiation the twine strength does not decline under 50% of guaranteed strength over the period of 12 months counted from the date of purchase. This way we might be able to find out the share of pesticide application in the decline of strength.

Better results are seen with the treatment of a simple attachment and twine strength labelled as 12 500. Breakage occurred in 93% in twine, while with the rest of the vines only in wire. There are, however, 3.4% of spontaneously fallen vines, which on the other hand represents only one fallen vine out of given set of measurements, that is 227 vines per ha and approx. 14 vines from one loaded trailer. This fact is already bearable in practice.

As for the treatment of a simple attachment and twine strength labelled as 14 000, the share of breakage in wire and twine partly increased in favour of twine. In this treatment spontaneous fall occurred in the case of three vines which within the measurement represents 10.3%.

One disadvantage to the experiment is that the treatment with twine 17 000 and simple attachment was not tested, as it is expected that it would confirm the gradual increase in breakage in wire at the expense of twine with its higher strength.

As for the double attachments the recorded breakage in twine is approx. 50% at the strength of twine labelled as 10 000, while in the other treatments the breakage in twine is 0% which means that in all cases the breakage in wire occurred.

From the point of view of the requirement of absolute exclusion of impurities from the final hop product, one of a number of technological steps used when hops are harvested from a classic high trellis is a task of handling mechanized pulling in such a way that hop vines would be pulled down together with hop strings and their attachments. The whole attachment should be connected to the hop string, and only a minimum of these attachments should remain on the hop-field trellis. In the event that a hop string (wire) breaks at a different height when being pulled down, a wire of different length, including its attachment, remains on the hop-field trellis and it has to be disposed of at the expense of additional financial costs.

The measurement carried out shows that so far the most advantageous treatment is hop string with simple attachment formed by 12 500 twine. The given conclusion is, however, stated on the basis of mere partial measurement which will have to be necessarily repeated and extended in another season. To get a complete result it will be necessary to observe if the breakage at those hop vines fallen spontaneously occurred in wire or twine. The above-mentioned conclusions need to be related to the current practice when most growers use a twine labelled as 17 000, and 14 000 as a second in line, for the wire of 1.06 mm in diameter. This way the growers make sure that vines with hop strings do not fall down just before the harvest due to either increased weight of growing vines, or due to weather impact and corrosive effects. The growers might not be aware of the fact that this negatively influences the subsequent penetration of impurities into further stages of the technological procedure.

In further growing seasons it will be necessary to extend the number of treatments and repetitions, and also to go back to the treatments used in the past and experiment with them, to use experience from abroad, and implement certain experiential output of the research team which resulted from previous experiments.

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