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THERMAL CONTROL OF HAZELNUT SUCKERS

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ABSTRACT The emission of suckers in hazelnut (*Corylus avellana* L.) negatively affects crop management. Several applications are required to eliminate basal shoots every year with associated recurrent costs. Mechanical, thermal or chemical treatments can be used. A thermal control method was recently investigated. Its desuckering effectiveness was evaluated by applying an open flame in a hazelnut orchard. With this technique, a short blast of intense heat is carefully directed at the basal shoots keeping a short distance from the target. Flaming was carried out with two apparatus. The first equipment was a set of two handheld torches and the second was a tractor-operated orchard-vineyard type fitted with a set of 8 burners. The operative parameters for the handheld equipment were: LPG consumption of 1.8 kg/h per torch at a pressure of 0.1 MPa, 60 s or 30 s exposure time per plant. For the tractor mounted apparatus, the parameters were: LPG consumption of 20 kg/h at a working pressure of approximately 1.8 bar (0.18 MPa), treatment time was 10 s per plant. The effectiveness of the treatments was evaluated two weeks after their application. The single torch at 30 s application resulted in high effectiveness. The 60 s application scorched vegetation excessively. The 8 burners 10 s application achieved good but not homogeneous results. Flaming is easy to use, requires low cost equipment and low fuel consumption. The handheld equipment allows the operator to intervene in a precise manner. The tractor mounted machine saves time but the orientation of the burners must be fine-tuned because heat must impact on suckers all over their length.

Keywords: Basal shoots, open flame, LPG, *Corylus avellana* L.

INTRODUCTION In Italy a necessary agronomic practice in the cultivation of hazelnut (*Corylus avellana* L.) is the elimination of basal shoots. Suckering aptitude in hazelnut differs among cultivars, ranking from highly to scarcely suckering. The influence of the

propagation method is strong, plants obtained from rooted suckers produce yearly a significant amount of suckers.

Tree training system has a smaller influence, with no differences between the single trunk vase and the multi-stemmed bush (Radicati et al., 1994). Clonal selection for low suckering tendency has provided improved clones of cultivar "Tonda Gentile Romana", characterized by a limited sucker aptitude (Monastra et al., 1997). During the annual cycle many shoots grow at the base of the trunk and are regarded as a problem both for plant yield and also for crop management. Suckers negatively influence plant physiology, signifying non-fruit bearing vegetative growth. On the other hand selecting some suckers may help replace old branches in the multi-stemmed bush. The crown of suckers that develops around the trunk at the base of the tree interferes with the execution of cultural practices and with the work of the machines. The elimination of suckers that have grown is necessary every year and sometimes the practice is repeated more than once during the growing season. The costs associated with these operations are high especially if all the work is completed using hand tools. With the single-trunk tree shape it is easier to carry out all the mechanical operations for cultivation within the orchard and especially the harvesting of fruits.

Different methods can be used for controlling basal shoots: mechanical, chemical and physical. The different techniques may be applied by hand or mechanically. Removal of suckers by hand, through the use of cutting tools (scissor, hatchet, hoe) requires a lot of working hours and is uncomfortable and tiring for workers. An advantage associated with this method is that the job is completed making only one pass through the field over the year, also at the same time the selection of suckers can be done, for renewing the fruit-bearing branches of multi-stem trees. Hand operation overall has a very negative impact on crop income because associated to a high cost of labour.

The mechanical elimination of suckers is a speedy method and can be repeated during the year whenever it is requested. This method will not allow for the selection of the suckers, cutting away all of them indistinctly, and could cause injury to the trunk with the approaching of cutting heads to the tree so that it must be carefully conducted. Different tools are employed for this operation, ranging from simple handheld powered devices to tractor mounted agricultural machinery. The handheld string trimmer is used adopting a cutting head either with the flexible nylon line or with the disk blade for cutting the basal shoots. Tractor attachments that are employed are the common the flail mower used for cutting the grass and weeds in the orchard to which a side-cutter with rotary disk is assembled with a swing-arm linkage so that it may go around the tree base.

Another application is done with the vineyard desuckering machine, that is provided with a horizontally rotating drum on which special nylon wires are mounted. They rotate from the upper to the lower part, making a desuckering work on the vine stump and a grass cleaning work in the inter-row. (Lisa et al., 1995).

Chemical herbicides, single or multiple applications, are very useful on herbaceous suckers but they are associated with residue problems and a large environmental impact (Dolci et al., 2001). Physical methods principally make use of two thermal control procedures: water steam and open flame (Colorio et al., 2006). A short blast of intense heat is directed on the suckers keeping a short distance from the target. Both treatments

cause tissue scalding and in a few days the treated vegetation will wilt and die (Storeheier, 1994).

Desukering can be carried out in different stages, on herbaceous or lignified stems. If performed early on small suckers there will be a successive regrowth and a second treatment may be required. A late season treatment on lignified suckers with chemical or physical techniques will require the hand removal of the wilted stems (Fig. 1).

Figure 1. Herbaceous suckers (left) wilted stems (right)

The effectiveness of the thermal control techniques was studied through desuckering tests carried out, at the vegetative restarting, in a hazelnut field. The purpose was to establish the technical feasibility for the use of the thermal desuckering techniques, considered very interesting because environmentally-friendly.

MATERIALS AND METHODS Studies were conducted on the hazelnut cultivar "Tonda Gentile Romana", grown in a two hectares orchard at the Field Station of the Fruit Research Institute based in Rome. At the beginning of the trials plants were 15 years old. Other characteristics of the orchard were: single trunk vase tree shape with low inserted branches, 5x5 m tree spacing, orchard irrigation.

The open flame treatment was carried out with flame-weeding machines manufactured in Italy by Officine Mingozzi. In the trials two different thermal weeder models were employed. The common feature of both tractor-mounted machines is the frame, connected to the three point hitch. Both models carry two LPG cylinders for supplying fuel to the burners. These large gas bottles are held in a container that is filled with warm water, in this way the heat required for the phase transition of the fuel from liquid to gas is provided to the LPG cylinders, thus preventing the gas valve from freezing.

The first machinery is a semi-mechanized model, having two handheld torches, each with a 5 m extension tube (Fig. 2). Two operators walking along the row can work simultaneously on two rows. The principal settings for the operative parameters in the field tests were: LPG gas consumption of 1.8 kg h^{-1} for each torch and LPG pressure adjusted at 0.1 MPa.

The second model used in the tests was developed for the orchard and vineyard context and is an automatic apparatus, fully operated by the driver directly from the tractor cabin. This machine has a head provided with eight burners carried underneath a stainless steel cover and arranged side by side into two groups carrying four burners each.

Figure 2. Semi-mechanized model

The groups are assembled on a pantograph-shaped frame provided with hydraulic side shift and hydraulic lift used for controlling the distance from the row and the height above the ground, respectively. For each group the inclination towards the ground of the burner nozzles can be separately adjusted, in a way that the flame produced will envelop the suckers entirely, from the apex to the base. (Fig. 3).

Figure 3. Automatic "Orchard-Vineyard" model

Each assembly of torches is coupled with a flat fan nozzle placed just above the group, providing a powerful laminar air flow generated by a centrifugal fan. The airflow acts as a shield avoiding that the heat moves upwards and protecting the foliage on the plant from the flame. The blower is powered by a hydraulic pump connected to the PTO. An electronic connection box, with a magnetic base, allows operation from the cabin. LPG

working pressure is 1.8 bar and LPG total hourly consumption is approximately 20 kg h-1 (2.5 kg h-1 per torch).

The research was tested for two years. Two treatments were made: plot F1– flame applied with the semi-mechanized model using a hand operated torch (Fig 4); plot F2– flame applied with the automatic apparatus (Fig 5). A randomised complete block design was applied, with three replications and five plants for each plot. Along the rows, two plants were left between plots as border. During the winter, suckers were removed from the plots, so that the treatments were conducted on the new suckers sprouted in spring. The most appropriate state for the flame application was established monitoring the growth of the suckers and intervening when the vegetative development reached a height of 20 cm and suckers were still in the herbaceous state, meaning approximately in the second half of May.

Figure 4. Hand operated single-torch field treatment

Figure 5. Automatic weeder field treatment

For the F1 treatments, two heat exposure times were compared: 30 s and 60 s per plant. For the F2 treatment, exposure time was 6 s per plant. This particular length resulted from the tractor's forward speed of 800 m/h, and considering that the diameter of the crown of suckers around the plant base had an extension of 60 cm. A particular aspect to consider for the F1 and F2 treatments is that the heat intensity, considered as the total energy input

per tree, is comparable: F1 uses about 30 g of LPG in 60 s, F2 uses about 33 g of LPG in 6 s. The effectiveness of the treatments was evaluated at two different moments. After three days a visual assessment was carried out adopting quality classes described as: A – high efficiency; B – medium efficiency and C – low efficiency. After 15 days the efficiency of the treatments was evaluated through the percent ratio between number of wilted suckers an the total number of suckers for each plant. The results were classified using the following categories: good effect with more than 90% of the suckers killed; medium effect with wilting between 70 ÷ 90 %; low effect with less than 70 % wilting.

RESULTS AND DISCUSSION At treatment time a great variability was found between the tested plants, both concerning the number of suckers per plant and the height of the suckers. The first results were obtained through a visual assessment, three days after the treatments (Fig. 6 and Table 1).

Fig. 6. F1 plot 30 s flame treatment, after 3 days

The effects of the treatments, indeed, are already visible after three days, though the real effectiveness is best evaluated after 15 days, when new shoots that eventually develop both from the apex and from the lateral buds are noticeable. The assessments after 15 days, for both test years, confirmed the results of the first control. Results in table 2, for both years, show that the F1 treatment gave a high effectiveness, starting with the 30 seconds application time. While the 60s treatment caused an exaggerated effect on suckers, scorching vegetation excessively, meaning a useless consumption of fuel. The F2, automatic flame application, showed a medium effect, with more than 70% of the suckers wilting. Application time used with the "Orchard-Vineyard" model, is an outcome variable that depends on the forward speed used in the test. The resulting 6 seconds per plant has provided good results, although the effect is not completely homogeneous between the plots (medium to high efficiency). In comparison to the hand operated equipment, with this appliance the control of the flame direction is less efficient, notwithstanding the comparable energy input of both systems. In fact, the setting of the burners is done before starting the test and the flame's direction cannot be changed while working. With the current model only the distance from the ground of the operational head can be adjusted in real time (while working). The accurate application and the precise operation that can be achieved with the hand-drawn implements by the operator are irreproducible with the machine. A particular aspect is that the tractor must advance at the centre of the row, which is quite narrow due to the growing of the branches towards

the middle, so that it may be complicated to draw close enough to the tree bases without risking the impact into the branches. A compact, low to the ground, tractor and a lateral moving linkage arm would be very useful. On the contrary the orchard machine has an hourly productivity way higher and needs a single operator to simultaneously drive the tractor and carry out the treatment.

Table 1. Results of visual assessment 3 days after the treatments

Year	F1		F2
	30 s	60 s	6 s
2007	A	A	B
2008	A	A	B

Legend: A - high efficiency; B - medium efficiency; C - low efficiency

Table 2. Percent of wilted suckers 15 days after the treatments

Year	F1		F2
	30 s	60 s	6 s
2007	95	100	69
2008	90	99	71
Avarage	92.5	99.5	70

CONCLUSIONS The growth stage of suckers is a key factor that heavily affects the treatment effectiveness. The particular growth stage of suckers adopted in the trials was a good compromise between treatment precociousness and the need to delay sucker regrowth. The effectiveness of treatments was in general good with both flaming machines and no damages to plants were observed.

The general evaluation for the flaming treatment is positive. Flaming is an easy to use technique, the purchase cost of equipment is low, and fuel consumption, per year and per hectare, is low. The hand operated equipment could be too slow and too demanding for labor (a tractor operator and two field workers). This could represent an obstacle for making two applications during the annual crop cycle. In order to optimize the treatment carried out with the “orchard-vineyard” model, a careful tuning of the machine is necessary and a correct setting of the operating parameters is required. An big improvement would be the possibility of changing the burners vertical inclination, while the machine is at work., to make sure that flame hits the sucker entirely, from apex to

base. The working speed of the tractor needs to be regulated, slowing down when there are more suckers on the plant, or in alternative increasing the LPG gas pressure and consequently flame intensity. The use of the open flame needs precautions to avoid the fire hazard, such as carrying out the work early in the morning (morning dew) and in the beginning of spring (green field), and also removing dry grass cuttings from the orchard.

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