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Development of a method for careful lifting and cleaning of valerian roots

The state of the art equipment for harvesting valerian roots is not efficient enough. Therefore, the aim of this study is to create a method for careful lifting and successful cleaning of the roots. For that purpose, a new cleaning system "rotation" is developed and compared with two other existing systems in a field trial with regard to the parameters "root mass loss", "ingredients loss" and "cleaning intensity". No differences regarding the ingredients are found, but there are significant differences with respect to the root mass loss and the cleaning efficiency. However, taking all results into consideration, all three systems are suited for agricultural practice.

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Valerian, harvester, root mass loss, ingredients content, cleaning effect

Abstract
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In Germany, the acreage for valerian roots amounts to less than 50 ha [1]. This means that of the total German demand for valerian roots of about 2.000 t per year only 10 % can be covered from domestic production [2]. One reason for this low self-sufficiency is the high labor demand for manual harvesting, since available mechanization systems for valerian root harvest are not efficient enough. Valerian roots may only be placed on the market if they are pure and contain sufficient concentrations of essential oils and valerenic acid as specified in the European Pharmacopoeia [3]. Ingredients for therapeutic use are extracted only from the subterranean parts of the valerian plant. Therefore, these parts should be harvested completely and with minimum soiling. In practice, due to the morphology of the plant together with frequent unfavorable weather conditions at harvest time, automatic harvesting of valerian roots is often very challenging.

Harvesters are designed to lift the valerian roots, clean them and convey them to a transport unit. Sieving webs (**Figure 1**) are used as standard cleaning systems. Sometimes cleaning turbines from sugar beet harvesting are applied, also (**Figure 2**). While sieving webs are typically considered inefficient, cleaning turbines are suspected to damage the roots. To evaluate different systems for the harvesting of valerian

Fig. 1

Sieving web (Photo: G. Neumaier)

Fig. 2

Cleaning turbine (Photo: G. Neumaier)

Fig. 3

Cleaning system „rotation" (Photo: G. Neumaier)

roots, an innovative cleaning technique based on "rotation" was compared to two other existing technologies with regard to the parameters "root mass loss", "ingredients loss" and "cleaning intensity" during a field trial.

Material and methods

For this comparative trial, the two existing cleaning systems were optimized for harvesting valerian roots. The system "rotation" (**Figure 3**) is an innovative technology designed by the authors especially for valerian roots.

This innovative system uses a sieving web which is inclined in such a way that the roots are rotated. Due to the centrifugal forces acting on the thin roots, these are stretched, the rootstock is opened, and the soil trapped between the roots is shaken out.

For the field trial, the three cleaning systems were implemented in a potato harvester in a modular fashion. Via a blade and conveyors the roots were transported to the cleaning system. The loss of root mass caused during the conveying process – termed pre-cleaning loss – is collected manually. Since it is not effective to calculate these from the yield, unavoidable mass losses on the trial plots were recovered using a foil underneath the harvester. To determine the yields from the individual plots, adhesive soil was separated from harvested roots in a drum washer. In addition to adhesive soil, sieved soil was collected separately for each plot. Both adhesive and sieved soil is a measure of cleaning efficiency. For the analysis of important ingredients, the roots were washed and dried at a temperature of 42 degrees centigrade so they could be stored.

Results

Ingredient contents

For all of the four harvest dates in 2011, the contents of the important ingredients valerenic acid and essential oils in the valerian roots were at a similar level regardless of dry or wet soil conditions during harvest (**Table 1**). No significant differences due to the cleaning systems could be found.

Root mass loss

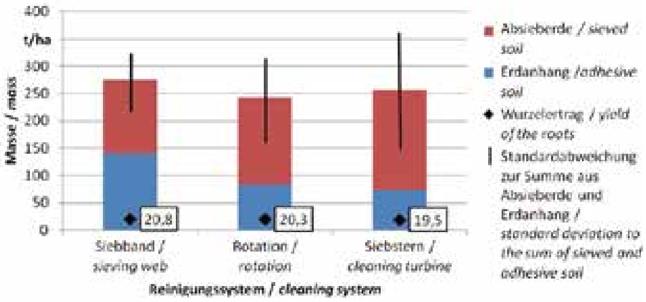
With respect to root mass loss, the cleaning systems showed only slight differences. For the first three harvests which were tested five-fold, the "cleaning turbine" caused significantly higher root mass losses than the "sieving web". On the fourth harvest date, repeat measurements were not possible due to soaked soil conditions. On this date, the "sieving web" caused a root mass loss of 0.16 %, compared to losses of 0.67 % for the "rotation" and 0.81 % for the "cleaning turbine". On the overall

Table 1

Ingredients content of valerian roots depending on cleaning system and harvest time

Erntetermine und Anzahl an Wiederholungen ***Harvest time and number of repetitions***	**Ernte 1** **17. Aug. 2011** **n = 5** ***Harvest 1*** ***17th Aug. 2011*** ***n = 5***	**Ernte 2** **14. Sept. 2011** **n = 5** ***Harvest 2*** ***14th Sep. 2011*** ***n = 5***	**Ernte 3** **5. Okt. 2011** **n = 5** ***Harvest 3*** ***5th Oct. 2011*** ***n = 5***	**Ernte 4** **13. Okt. 2011** **Einzelwert** ***Harvest 4*** ***13th Oct. 2011*** ***single value***
Bodenfeuchte/*Soil moisture*	**trocken/*dry***		**nass/*wet***	
Reinigungssystem/*Cleaning system*	Ätherischer Ölgehalt [ml/100 g TS]/*essential oil content [ml/100 g DM]*			
Siebband/*Sieving web*	0,77 ± 0,07	0,69 ± 0,06	0,67 ± 0,02	0,74
Siebstern/*Cleaning turbine*	0,84 ± 0,06	0,77 ± 0,03	0,74 ± 0,06	0,70
Rotation/*Rotation*	0,78 ± 0,04	0,71 ± 0,07	0,74 ± 0,05	0,65
	Valerensäuregehalt in der TS/*valerenic acid content in dry matter* [%]			
Siebband/*Sieving web*	0,39 ± 0,06	0,35 ± 0,06	0,29 ± 0,05	0,29
Siebstern/*Cleaning turbine*	0,39 ± 0,04	0,39 ± 0,04	0,34 ± 0,06	0,30
Rotation/*Rotation*	0,37 ± 0,02	0,36 ± 0,02	0,31 ± 0,03	0,29

Fig. 4



Mass movement [t/ha] depending on cleaning system

average, the sieving web showed 0.6 % mass loss as opposed to 1.2 % for the rotation and 1.6 % for the cleaning turbine. The pre-cleaning losses during the conveying process amounted to 2.0 % on average. Thus the mean drug recovery for all four harvest trials was 97 % of the maximum possible yield.

Cleaning efficiency

Regarding cleaning efficiency, the sieving web appeared clearly inferior to the other two systems. As an example, **Figure 4** shows the mass movement depending on cleaning system for the third harvest date of 5^{th} October 2011. On the day before harvest, plots had been irrigated with 25 L per m^2.

As can be seen from the sums and standard deviations of sieved and adhesive soil, the field trial was quite homogeneous on the third harvest date. The cleaning systems were fed with almost identical amounts of soil. Also, there were no significant differences in root yields between the plots. The only significant differences were observed for adhesive soil between "sieving web" and "cleaning turbine". On average, adhesive soil was reduced by 66 t per ha with the "turbine system" and 57 t per ha with the "rotation system", compared to the sieving web.

On the average for all four harvest dates, adhesive soil was 39 % lower for the "rotation system" and 55 % lower for the "cleaning turbine", in comparison to the sieving web. However, with regard to the absolute amount of adhesive soil, the influence of the cleaning system was of secondary importance compared to the effect of soil moisture. For example, on the first harvest date with dry soil conditions, 39 t per ha of soiling were recovered from the harvested roots, whereas for almost saturated soil conditions on the fourth harvest date, the amount of soiling increased by a factor of more than 4 to a value of 188 t per ha.

The "cleaning turbine" achieved the highest cleaning efficiency during all harvest dates. Although the differences observed between the "turbine" and "rotation" systems with regard to cleaning efficiency and mass losses were not significant, the "cleaning turbine" appeared to have a better cleaning efficiency, while the "rotation" caused less root loss.

Conclusions

In our field trials, the content of important ingredients of harvested valerian roots was not affected by the three different cleaning systems tested. Differences observed between the systems concerning root mass loss were rather small. Detrimental effects on yield or quality of harvested roots as postulated for the cleaning turbine system could not be proven. Concerning cleaning efficiency, the sieving web is clearly inferior to the other two systems. However, for further development of a system for the careful harvesting of valerian roots, the sieving web is still considered useful as it is more effective for uplifting than a turbine. By installing a mechanism for rotation, the sieving web can be enhanced in such a way that the effective cleaning of roots can be switched on and off as demanded. For deflecting the flow of material into a specific direction, e. g. into a conveyor, the cleaning turbine is superior to the sieving web. Therefore, future work will have to focus on a system that combines the advantages of both systems.

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