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Reply on EC1

Jian-Fang Wang et al.

Author comment on "Investigating the effects of herbaceous root types on the soil detachment process at the species level" by Jian-Fang Wang et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-30-AC9>, 2022

Dear editor

Thank you for inviting us to submit a revised draft of our manuscript entitled "Investigating the effects of herbaceous root types on the soil detachment process at the species level" to *Hydrology and Earth System Sciences*. We really appreciate the time and effort you and each of the reviewers have dedicated to providing insightful feedback on ways to strengthen our paper. We have incorporated changes that reflect the detailed suggestions you have graciously provided. We hope that our edits and the responses we provide below satisfactorily address all the issues and concerns you and the reviewers have noted. The revised part was marked in blue font in the manuscript. The following is a point-by-point response to the questions and comments.

Specific comments:

The Introduction section is quite long and should be shortened.

Response

Done as suggested. After careful consideration, we shortened the introduction and simplified the sentences that were too tedious. The total number of words were decreased from 1,643 to 1,402. This part was revised in the manuscript.

In the Methodology section:

L200: why are you presenting accumulated temperature? (what is its meaning for the herbaceous species?).

Response

The plant growth and development have a lower limit temperature, and it was called the biological starting point temperature. When the temperature is above the lower limit, plants would grow and develop, generally considered to be 10°C. Therefore, cumulative temperature greater than 10°C was used to represent the effect of temperature on vegetation growth and development in the study area, which is more biologically significant than the traditional average temperature.

L204: why the selection of this slope? Is it representative of the Loess Plateau?

Response

Yes, the slope is representative of the Loess Plateau. Two decades years ago, most of the sloping farmland on the Loess Plateau was 15°, which resulted in serious soil erosion. To control soil erosion, the “Grain for Green” project was implemented and vegetation began to succeed naturally. The sloping farmland is converted into grassland, which becomes the dominant ecosystem in this region. Therefore, the slope of 15° was selected in this study.

L205: for how long were the tanks scoured?

Response:

The scouring time for this study was 75 s. Here are some following reasons:

Soil erosion generally including sheet erosion, rill erosion, and gully erosion based on the soil erosion type. For sheet erosion, there is a small amount of erosion and mainly caused by the rainfall. For gully erosion, the amount of erosion is usually large and gravity erosion often occurs, which beyond the traditional erosion process. Among these two erosion types, rill erosion generally is a transitional state in which sheet erosion develops to gully erosion. If corresponding preventive measures are taken at this stage, the type of soil erosion can be prevented from developing to serious gully erosion, so that soil erosion can be effectively controlled.

During the rill erosion process, the soil detachment mainly attributes to the overland flow. For this study, the rill net was well developed and the rill outline was obvious when the tank was scoured for almost 75 s. Meanwhile, the scouring depth was greater than 2 cm after the tank was scoured by overland flow for 75 s, which belongs to rill erosion based on the definition of the rill erosion. Based on the designed flow discharge in this study, long scouring time might result in gully erosion, which complicates the soil erosion process.

Besides, in most of the previous studies, their scouring depth was controlled at 2 cm and the corresponding scouring time was ranged from 3 to 180 s. Considering that the soil detachment rate was calculated based on the scouring time, the varied scouring time may affect the test results. Therefore, the scouring time of 75 s was used for all the soil detachment rate tests.

L239: please, describe the sampling procedure

Response:

Done as suggested. The sampling procedure was revised as following:

“Each tank was left for five days to dry out and it would more suitable for sampling. Then the soil sample were collected in different location of the tank (upper, middle, and lower parts of the slope) to test the soil bulk density, cohesion, aggregation, and soil organic matter content. Specifically, the bulk density was measured using a steel ring 5 cm in height and 5 cm in diameter. Soil cohesion was determined using an Eijkelkamp pocket vane tester (14.10, Eijkelkamp Agrisearch Equipment, Giesbeek). Soil aggregation was measured via a series of sieves with bore diameters of 0.25 mm, 0.5 mm, 1 mm, 2 mm, and 5 mm, and the soil organic matter content was measured using potassium dichromate (Wang et al., 2018a). Except for the soil cohesion was replicated for nine times, all other soil properties were replicated for three times, respectively, and their mean values were represented the soil properties of this slope. The soil erodibility was calculated based on

the soil organic matter content as (Sharpley and Williams., 1990):“(Line 254 to Line 266).

L221: not clear how the soil sampling did not disturb the overland flow and sediment measurements

Response

The sentence “To reduce the potential effects of soil sampling on experimental results, testing was generally stopped at a certain scouring depth of 2 cm” is mixed, we revised this part as following:

“When the rill occurred, rill net was developed, and the rill depth was greater than 2 cm, testing was generally stopped. Considering the scouring time would affect the results of soil detachment calculating, the maximum planting density of 30 plant m⁻² with relatively low erodibility in this study was firstly tested. The scouring time of 75 s was then timed for all scouring tests.”(Line 233 to Line 237)

L223: please, better explain the pretest performed

Response

Considering that the soil detachment rate was calculated based on the scouring time, the varied scouring time may affect the test results. In most of the previous studies, although their scouring depth was controlled at 2 cm, the corresponding scouring time was varied greatly and ranged from 3 to 180 s. In order to eliminate or reduce this effect as much as possible, the maximum planting density of 30 plant m⁻² with relatively low erodibility in this study was firstly tested. When the scouring time was 75s, the rill occurred, rill net was developed, and the rill depth was greater than 2 cm, testing was generally stopped. Then its scouring time of 75 s was then timed for all scouring tests. We also added this information in the paper (Line 233 to 237).

L224: so, only one experiment of 75 s was performed for each tank?

Response

Yes, the test time for all the steel tank was finally set at 75 s.

Based on the designed flow discharge in this study, long scouring time might result in gully erosion, which the gravity erosion might be occurred and thus made the soil erosion process more complicate. During the rill erosion process, the soil detachment mainly attributes to the overland flow.

When the rill occurred, rill net was developed, and the rill depth was greater than 2 cm, testing was generally stopped. Considering that the soil detachment rate was calculated based on the scouring time, the varied scouring time may affect the test results. the maximum planting density of 30 plant m⁻² with relatively low erodibility in this study was firstly tested. When the scouring time was 75 s, the outline of the rill net was obvious. Then the 75 s was applied all scouring tests.

Section 2.3: it is not clear how long the overland flow and sediment measurements took

Response

As mentioned above, based on the rill outline and rill net development, the designed flow discharge, and also the effects of scouring time on soil detachment rate calculation, the

scouring time for all the steel tank was finally set at 75 s.

During the scouring time of 75 s, runoff and sediment samples were collected every 5 s. Meanwhile, the corresponding flow velocity and water temperature were also measured. Totally, 15 group data of runoff, sediment, flow velocity, and water temperature were tested for each steel tank.

Section 2.5: why only analyzing the correlations between all variables? What about differences between experiments with the two plants? What about differences with the different plant densities?

Response

Done as suggested. The differences with the herbaceous plant type and plant densities were analyzed. The following results and discussion section in this paper were also revised. Now this part was revised as following:

"The differences in soil detachment rate, hydraulic parameters, soil properties, and root traits among plant densities and two herbaceous plants were evaluated using the analysis of post hoc multiple comparisons (The Student–Newman–Keuls, significance level = 0.05). Two-way ANOVA was used to analysis the main effects of plant densities and herbaceous plant type, and their interaction effects on soil properties, root traits, hydraulic parameters, and soil detachment rates. Pearson's correlation analyses ($p < 0.05$) were used to analyze relationships among hydraulic parameters, soil properties, root traits, and soil detachment. The qualified relationships between soil detachment rate and hydraulic parameters, soil properties, or root traits were fitted by using nonlinear regression. Stepwise regression was used to estimate soil detachment rate by hydraulic parameters, soil properties, and root traits. The coefficient of determination (R^2) and Nash–Sutcliffe efficiency (NSE) were used to evaluate model performance. All analyses were conducted using SPSS 22.0 and Origin 2018 software."(Line 286 to Line 298)

Section 3: the results of the correlation between variables should be indicated, and not only the level of significance. From the conclusions we can see that the correlations are rather low (mostly < 0.5), although statistically significant. Thus, considering the very limited number of replications the correlations may be questionable.

Response

Done as suggested. Based on the previous data analysis, the method of Two-way ANOVA was used to detect the influence of plant density, herbaceous plant type, and their interaction effects on soil properties, root traits, hydraulic parameters, and soil detachment rate. The corresponding parts of 3.1, 3.2, and 3.3 section were revised and marked.

Also, following the comments of reviewer, the effects of two herbaceous on the soil detachment process are different and worthy to study. We separated fitted these differences that caused by two different herbaceous plants. Besides, each plant density had two repetition tanks, each tank had 15 group data of runoff, sediment, flow velocity, and water temperature. While on the previous analysis, these data were averaged to one value. For this time, the averaged 15 group data were used and the fig.4, fig.5, fig.6, and fig.7 were revised.

In previous studies, their soil sample were collected under nature grassland, and they would give five or six condition of overland flow, for the soil sample was relatively easy to collect. However, the variation of overland flow is ignored when the flow through the

scouring area. This is mainly because the hydraulic parameters cannot be measured, for the sample size is small, especially for short length in previous studies. In fact, the hydraulic parameters in the scouring area are closely related to soil erosion. In this study, the hydraulic parameters were test in the scouring area. Although only one condition of overland flow was given in this study, but there are six plant density and two herbaceous plants, which means twelve conditions of overland flow were used in this study.

In previous studies, they choose more plant species than we do. But some problems they would not be solved very well. For example, in the sampling process, the root would not completely collect due to the limitation of the sample (generally used the rectangular ring with 20 cm in length and 10 cm in width, or circular ring with 10 cm in diameter). The scouring process by overland flow may also affected by the edge wall of the steel ring. The roots of other herbs are also mixed in the sample ring. These factors would all affect the results. It is because of this, we planted the herbs in relative large tank (200 cm in length and 50 cm in width) to avoid these possible impact. With these large soil samples that used in this study, our results would well reflect the effects of herbaceous plant root system on soil detachment, for the root system integrity can be maintained and the initial soil properties of all sites keep consistent, and the influence of edge effect on test results can be ignored. Besides, there are no other herbs root in the sample soil, it is helpful for us to study the effects of herbaceous plants root system on soil detachment at species level. However, the tradeoff for this is that we can't set up too many experimental treatments.

In previous studies, the given overland flow condition is considered as unchanged. The variation of overland flow are ignored when the overland flow through the sample area. This is mainly because the hydraulic parameters cannot be measured, for the sample size is small, especially for short length. In fact, the hydraulic parameters in the sample area are closely related to soil erosion. In this study, the varied hydraulic parameters were test in the sample area, which means that our treatment was added under the six plant density and two herbaceous plants.

Although there is a shortage in treatment, the repetition was added in this study to ensure the data accuracy. For example, two repetitions were designed for each plant density, the measurement of soil properties and vegetation characteristics were tested for six times, For soil detachment rate test, its variation during the scouring process was considered and 15 group data were collected in each soil tank. We will also increase the treatment accounts in future research. For this study, we mainly focused on the effect of herbs on soil detachment at the stable stage of succession this time, for these two herbaceous plants is the main community in study area.

Section 4: the limitations of the study must be clearly indicated and discussed

Response

Done as suggested. Based on data analysis and discussion, the limitation of the study were clearly indicated and discussed in section 4. The corresponding parts of 4.1, 4.2, and 4.3 section were revised and marked.□Line 404 to Line 415, Line 421 to Line 427, Line 455 to Line 459, Line 531 to Line 544□

Section 4.3: it would be interesting to compare your results with results from similar studies with other herbaceous plants

Response

Done as suggested. We compare our results with results from similar studies with other herbaceous plants, and this part was revised as following:

“Previous studies showed that root traits of tree, shrubs, and herb would be used to quantify the effect of plant root system on soil erosion (Parhizkar et al., 2021). The soil detachment rate is insensitive to many of those root traits. When focusing the effects of root system on soil erosion at herbaceous species level, only root length density significantly decreased the soil detachment rate in this study. The quantified relationship between soil detachment rate and root length density were also compared with previous studies (Fig.8). For both planted herbaceous plants all with fibrous root system, BI in this study and ryegrass that reported by Mamo and Bubenzer (2001), the soil detachment rate of BI was almost one magnitude greater than that of ryegrass. The main reason is that the highly planted ryegrass density, which ranged from 4 to 7 plant per cylinders (diameter is 10 cm). Besides, the soil detachment rate was still much higher than that of natural grassland reported by Liu et al. (2019), due to the soil erosion resistance was enhanced by herbaceous plants after thirty-six years of growth. In general, the soil detachment rate of AG in this study was still much high than that of reported by Mamo and Bubenzer (2001) and Liu et al. (2019), showing a low efficiency of herbaceous plant with tap root system in reducing soil detachment. Although only the typical herbaceous plants were selected in this study, some useful results were drawn. Plant root generally scanned using specific software and the root diameter is a mean value for a certain length of root. As a result, the variation in root diameter narrowed. The huge difference in average root diameter among arboreal forest, shrubs, and grassland might cover up this issue. While at herbaceous species level, the difference in average root diameter among herbaceous plants is relatively small, and this problem is highlighted, resulting the effect of root diameter on soil erosion does not seem to be as good as literatures mentioned. Correspondingly, the effects of root surface area density and root volume ratio on soil detachment are also affected, which calculated by root diameter and root length. Determination of root length is not affected by scanning process, and detachment rate decreased with root length density as power functions. So, it may be more effective to study the effect of root diameter differences on soil erosion based on the root order or diameter class, and the root length density would take a priority when detecting the effects of plant root system on soil erosion at herbaceous species level.”(Line 514 to Line 544)

Section 5: the findings are not new. A better link with the two types of plants can be more useful. Please, clearly identify the main findings/novelty of this study and the practical/real implications of this study.

Response

Done as suggested. Our conclusion were rewrote from the perspective of the species level (BI and AG). We also added the main finding AG and the practical/real implications of this study. This part was revised as following:

“The herbaceous plant root system would significantly reduce the soil erosion and its effects also exhibited different behaviors according to herbaceous type. The soil detachment rate significantly decreased with increasing plant density for two herbaceous plants, becoming 85.80% and 81.19% lower than that of the control for the BI and AG grasslands, respectively. BI, which has a fibrous root system, effectively reduced the soil detachment rate, achieving a mean soil detachment rate that was 23.75% less than that of AG, which has a tap root system. The hydraulic characteristics of overland flow, soil properties, and root traits induced by plant density and herbaceous type closely related to the soil detachment, which could be estimated effectively using the overland flow velocity, soil bulk density, and root surface length density. The performance of the model developed in this study was satisfactory. Moreover, the response of soil detachment rate to root diameter does not seem to be as sensitive as mentioned in literatures. Meanwhile, the root order or diameter class was suggested, and the root length density was recommended to detect the effects of plant root system on soil erosion at herbaceous

species level.”(Line 546 to Line 560)

Fig. 1: please, improve the legend to better describe the data shown, including the lines and dots

Response

Done as suggested. The legend was added, and the lines and dots was revised in Fig.1 (Now it is Fig.2).

Fig. 2: please, improve the legend to better describe the meaning of the letters

Response

Done as suggested. The meaning of the letters was presented in notes of Fig. 2 (Now it is Fig.3).

Figs. 3 to 6: it may be interesting to draw different power functions for both plant types

Response

Done as suggested. Different power functions for two plant types were drawn separately in Fig. 3 to Fig. 6 (Now it is Fig 4 to Fig.6).

Table 1 and 3: you may include the results of statistical differences between both plant type experiments in this table

Response

Done as suggested. Differences analysis was added in the Table 1 and Table 3.