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Interactive comment on "The mutually antagonistic effect of drought and sand burial enables the biocrust moss *Bryum argenteum* Hedw. to survive the two co-occurring stressors in an arid sandy desert" *by* Rongliang Jia et al.

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Referee's comment: This paper presents research on the ability of biocrust mosses - in particular Bryum argenteum - to survive multiple stresses in dryland ecosystems. The concept is good and this research may ultimately support better land management and interventions, enabled by knowing the environmental controls on dryland biota. The novelty of the work is related to the simultaneous assessment of two stressors and their interactions: drought and burial. The experimental work appears to have been planned and carried out carefully with attention to detail, which gives me confidence in

the results. The results are presented in quite a confusing way though, which made it difficult for this reader to draw own interpretation and conclusions. A few details of the method were also not clear enough for me to fully understand the results, for example I was not sure whether the moss is completely buried or whether it sticks through some of the burial treatments, which is very important. A similar problem of detail and clarity affected reading of the discussion but to a lesser extent, and the final parts of the discussion were much clearer. My suggestion for this paper is that the language and content should be revised with the aim of achieving clarity and detail relating to the objectives set out, and this may involve changing the figures too. Focusing discussion more on the fitness and adaptations of the moss is likely to help, and replacing commonly used vague terminology like "positive" and "negative" effects with specific observations or interpretations like "reduced chlorophyll content" or "increased fitness" will help further. I think that the experimental work is well conceived and of good quality, but at present it is hard to be sure whether the conclusions are fully supported by the results. Specific comments below should help the authors see examples in the manuscript relating to the above suggestions:

Authors' response: The language of our manuscript was improved by a European company (International Science Editing Compuscript Ltd.). The expressions were revised point by point according to the reviewer' suggestions to make them be more readable and understandable. In addition, we have carefully proof-read the manuscript to minimize typographical, grammatical, and bibliographical errors. Especially, we have revised the heading of Table 1 and Legends of Figure 2-5 as suggested, and from the data shown in Table 1, one can easily imagine that the mosses within the biocrust were only partially buried by sand when the depth of burial treated was shallow (depth $\leq$2 mm), while, the mosses were completely buried when the burial depth$\geq$ 4mm. We agree that the specific observations or interpretations like "reduced chlorophyll content" or "increased fitness" will help increase the clarity of the results, we used the similar ones although very few. Considering the major objective/focus of this manuscript is to explore the interaction between drought and sand burial on biocrust moss, ie., to make

sure whether their interaction is additive or antagonistic, so the terminology "positive" and "negative" effects were used. While, we have made many modifications in Results to improve its understandability.

Referee's comment: 8 "highest" is suggestive of being superior. Perhaps "latest" would be better? 45 Again use of "highest" does not seem appropriate

Authors' response: Yes, we replaced "highest" with "latest" in L8 and L46.

Referee's comment: 11 surely this is a very large niche, not small as stated

Authors' response: We replaced "small" with "very large" in L11.

Referee's comment: 58 is there a reference to support this?

Authors' response: We have added a reference, "Li et al., 2004", to support this.

Referee's comment: 63 is there a reference to support this (that B. argenteum is usually the pioneer)?

Authors' response: This finding derives from our one recent field investigation conducted throughout China's desert, which will be exhibited in our next paper. As far as I know, there is no published reference in English to support this to date.

Referee's comment: 70 "buried" perhaps a better word than "submerged"

Authors' response: We replaced "submerged" with "buried" in L72.

Referee's comment: 72-76 here setting out the importance of understanding how B. argenteum survives these multiple stressors as a main theme in the work - an interesting objective with practical applications.

Authors' response: I agree, while we are convinced that the original sentences is enough to express the meaning, so we did not add new sentences.

Referee's comment: 85-90 it is stated that drought "protects" (benefit) and burial can "slow water loss" (benefit), so why are these then described as "mutually antagonistic"

on line 87? In this context they are mutually beneficial. I think care is needed here (and earlier e.g. line 33) to note the difference between an apparently harsh environment (for humans) which is actually the niche for which certain biocrust organisms are adapted. Therefore, these harsh conditions are likely a requirement for life of the biocrust organisms being studied. Based on this one may reasonably assume that drought and burial are mutually beneficial for organisms adapted to live in this environment.

Authors' response: Drought and sand burial are two commonly-viewed stressors that severely limit (even damage in most cases by intuition) the growth and distribution of biocrust moss. Here we want to show that they can also induce beneficial effects in some cases, respectively, which would potentially introduce beneficial effects by the combination of some specific level of drought and a certain depth of sand burial.

Referee's comment: 94-99 unnecessary precision of environmental parameters. The time period for which these data relate should be given.

Authors' response: We added "Based on meteorological records from 1956 to 2003" in L98.

Referee's comment: 126 the year should be given (and on line 133) Authors' response: We added "in 2013" in L131.

Referee's comment: 129 "below the ground surface" - where? In situ at the extraction place in the field, or somewhere else?

Authors' response: Yes, we added "and transferred to Water Balance Observation Site (about 1 km away from the sampling place) in Shapotou Desert Research and Experiment Station, Chinese Academy of Sciences." in L128-129.

Referee's comment: 138 please explain the burial a bit more, and refer to this in the introduction and discussion too as appropriate. It is necessary to know whether the burial completely covers the moss, or whether it sticks up through the added sand. This has major implications for the interpretation and understanding of the work.

Authors' response: I think the burial phenomena can be easily and clearly imagined from the data shown in Table 1(similar to Jia et al., Soil Biol. Biochem., 40, 2827-2834, 2008; Martínez, Plant Ecol., 145, 209-219, 1999; Maun, M. A. Can. J. Bot., 7, 713–738, 1998; Maun, M. A. Coastal Dunes: Ecology and Management, Springer, 119–136, 2008.), that the mosses within the biocrust were only partially buried by sand when the depth of burial treated was shallow (depth $\leq$2 mm), while, the mosses were completely buried when the burial depth$\geq$ 4mm. To avoid misunderstanding, we have revised the heading of Table 1 to "Table 1. Changes in the percentage cover of Bryum argenteum Hedw. within a biocrust in response to sand burial depth in spring and autumn.".

Referee's comment: 143 The experiment duration seems rather short but nothing can be done about that now. Perhaps the duration can be explained / justified?

Authors' response: Yes, 72 d is short for each season. We did our best to make it close to real time of each season and to keep them the same in both spring and autumn, but we are convinced that it is enough for this study.

Referee's comment: 147 Would deposited sand be naturally blown off in the field? The answer to this is of interest in relation to how the moss adapts to burial. If the deposit is never blown off then the moss needs to abandon the buried chlorophyll and invest in the tip, however if it might be blown off then it would make sense to retain the buried chlorophyll for a while in-case it will be exposed later.

Authors' response: Yes, the sand deposited above the biocrust moss can be blown off in nature. We had discussed this in L357-358 in Discussion.

Referee's comment: 152 A nice idea to minimise the edge effect. 159 Not clear if "shoot elongation" is the same as "shoot upgrowth" on line 157 – if same then please use same terminology, if different then please explain.

Authors' response: For biocrust moss under sand burial, according to our observation, "shoot elongation" and "shoot upgrowth" have the same meaning.

Referee's comment: 166 Again nice attention to detail in the experimental method here (randomising positions) 185 I think the unit is wrong here Authors' response: We replaced "g" with "rpm" in L187-188.

Referee's comment: 211 and throughout results section: It is not clear what negative and positive effects are. Instead, just state which measurements changed and how they changed (e.g. decrease or increase in chlorphyll content). In general I found the results section quite difficult to follow because of this. Furthermore in some cases the language used unclear phrases (e.g. "decrease in autumn being significantly lower" line 206). There is some interpretation in results which should instead be in discussion.

Authors' response: To improve the understandability, we revised the original sentences to "Drought uniformly imposed negative effects (the slopes of the fitted lines were negative) on the chlorophyll a content (Fig. 2a, b), whereas burial by sand had a dual effect (the slopes of the fitted lines both have positive and negative values) on the chlorophyll a content (Fig. 2c, d)."in L215-217,"Drought consistently exerted negative effects (the slopes of the fitted lines were negative) on the PSII photochemical efficiency (Fig. 3a, b), while burial by sand had a dual effect (the slopes of the fitted lines both exhibited positive and negative values) on the PSII photochemical efficiency (Fig. 3c, d)."in L229-232, "Drought imposed negative effects (the slopes of the fitted lines were negative) on the regeneration potential of detached shoots of B. argenteum (Fig. 4a), while burial by sand had a dual effect (the slopes of the fitted lines both displayed positive and negative values) on the regeneration potential (Fig. 4b)." in L242-244 and "Although B. argenteum shoots were generally less elongated in spring than that under the same treatment in autumn, drought and sand burial, according to the slope values of the corresponding fitted lines, had negative and dual effects on shoot elongation, respectively"in L252-253. In addition, we replaced "decrease" with "amplitude decreased" in L209.

Referee's comment: 284-286 I'm not sure if the effects observed have explained the moss distribution as claimed. Perhaps more explaination of this needed, or remove.

Authors' response: To be more accurate, we replaced "pattern of" with "survival and" in L293.

Referee's comment: 288 The discussion here is interesting, effectively summarising findings for the most part but still a bit confusing in relation to what is a positive or negative, which seems to partly contradict the introductory section e.g. lines 85-90

Authors' response: We think that there is no contradiction and can be explained. The few research cases listed in Introduction showed that drought and sand burial can separately impose only one-way, beneficial effects on biocrust moss besides harmful influences by intuition. While, this study showed that, drought and sand burial singly had more complex, dual effects in most cases, the beneficial and detrimental effects caused by either factor can emerge simultaneously and shift along with the changes in the severity of drought or depth of burial. These indisputably introduced more complicated effects to biocrust moss when then combined. Even though, we are convinced that we have clearly displayed their single or interactive influences on every parameter tested of B. argenteum.

Referee's comment: 370-374 this is a clear and useful outcome of the work. Probably best not to mention the un-published results though.

Authors' response: We deleted the sentence with the un-published results.

Referee's comment: 380 This section also presenting clear and useful findings Table 1. The precision to 3dp seems excessive, making it less clear

Authors' response: We have redrawn Table 1 to make it be clearer.

Referee's comment: Figures 2-5. These are quite complicated and can't be fully understood based on the legend. For instance what is Control, 0.5mm, 1mm etc written at the top? What are the units or scale of drought severity? These details may be elsewhere but it should be possible to interpret the figures alone. I think some work is needed to make these a bit clearer, or if not possible consider using them as supple-

mentary figures and replace with something less detailed which is easier to interpret.

Authors' response: To improve the clarity and understandability, we have revised the legends of Figures 2-5, as shown below:

Figure 2. Changes in the chlorophyll a content of the biocrust moss Bryum argenteum Hedw. following exposure to the combinations of single (receiving natural precipitation amount, control), double (receiving 1/2 of natural precipitation amount) and fourfold (receiving 1/4 of natural precipitation amount) drought and 0 (control), 0.5, 1, 2, 4 and 10 mm depths of sand burial in spring (a, c) and autumn (b, d). Bars represent means ($\pm$ SE). Different letters indicate significant differences between different drought severities and sand burial depth treatments at the $p < 0.05$ level, as determined using a least significant difference (LSD) post-hoc test.

Figure 3. Changes in the PSII photochemical efficiency (Fv/Fm) of the biocrust moss Bryum argenteum Hedw. following exposure to the combinations of single (receiving natural precipitation amount, control), double (receiving 1/2 of natural precipitation amount) and fourfold (receiving 1/4 of natural precipitation amount) drought and 0 (control), 0.5, 1, 2, 4 and 10 mm depths of sand burial in spring (a, c) and autumn (b, d). Bars represent means ($\pm$ SE). Different letters indicate significant differences between different drought severities and sand burial depth treatments at the $p < 0.05$ level as determined using a least significant difference (LSD) post-hoc test in spring and autumn.

Figure 4. Changes in the protonemal area of detached shoots of biocrust moss Bryum argenteum Hedw. following exposure to the combinations of single (receiving natural precipitation amount, control), double (receiving 1/2 of natural precipitation amount) and fourfold (receiving 1/4 of natural precipitation amount) drought and 0 (control), 0.5, 1, 2, 4 and 10 mm depths of sand burial in spring. Bars represent means ($\pm$ SE). Different letters indicate significant differences between different drought severities and sand burial depth treatments at the $p < 0.05$ level as determined using a least significant difference (LSD) post-hoc test.

Figure 5. Changes in the maximal shoot elongation of biocrust moss Bryum argenteum Hedw. following exposure to the combinations of single (receiving natural precipitation amount, control), double (receiving 1/2 of natural precipitation amount) and fourfold (receiving 1/4 of natural precipitation amount) drought and 0 (control), 0.5, 1, 2, 4 and 10 mm depths of sand burial in spring (a, c) and autumn (b, d). Bars represent means (± SE). Different letters indicate significant differences between different drought severities and sand burial depth treatments at the $p < 0.05$ level as determined using a least significant difference (LSD) post-hoc test.

In addition, Figure 4 was replaced with the right one.

All these responses and revised manuscript with the changes marked please see the supplement file.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2017-402/bg-2017-402-AC2-supplement.pdf

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