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Alternate Wetting–Drying Enhances Soil Nitrogen Availability for Rice Crops

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Abstract

Alternate wetting and drying (AWD) irrigation influences soil nutrient cycling and the functioning of soil microorganisms. However, the effects of AWD on organic nitrogen (ON) partitioning in rice-microbe ecosystems and soil microbial communities are poorly understood. A root-box microcosm experiment with two rice varieties two irrigation regimes (conventional flood irrigation (CF); AWD) and three N application levels (zero N, N_0; medium N, N_1; high N, N_2) was performed based on the ^{13}C,^{15}N-labelled glycine and ^{13}C-phospholipid fatty acids (PLFA) techniques. Compared to CF, AWD increased soil dissolved oxygen, microbial growth and the enzymes related to N transformation, thus enhancing rice growth and the N utilization index (NUI). Approximately 4.9–10.3% and 7.7–13.6% of the exogenous glycine was directly utilized by Nip and YD6 seedlings, respectively, and its ratio increased with increasing N levels, whereas 4.4–11.2% and 4.6–10.3% were incorporated into soil microbes. It seems that rice has an appreciable capacity to utilize organic N despite fierce competition with soil microbes. The ^{13}C:^{15}N ratio showed that 12.5–37.5% and 11.0–41.0% of the added glycine was taken up intact by soil microorganisms in the rhizospheres of Nip and YD6. At the N_1 and N_2levels, AWD increased rice ^{15}N-glycine uptake but decreased microbial ^{15}N-glycine uptake. Rice intact glycine uptake and soil inorganic N contents were positively correlated with rice biomass and NUI, indicating that the enhanced inorganic N under AWD is beneficial for soil ON availability and rice growth.

Keywords: Alternate wetting and drying**;** Organic nitrogen**;** Microbial community**;** ^{13}C; ^{15}N-glycine

Introduction

Estimating flood damage is crucial for developing efficient flood risk management strategies. Flood damage functions have been used as a basis for evaluating flood damage in many studies and practical applications. Damage functions are generally classified into an empirical form based on the post-event flood damage data, and a synthetic form that provides hypothetical damage if a specific flood event occurs under certain conditions. The synthetic function is less dependent on datasets, and its transferability is better for different regions or events, although some additional data are required for function calibration and validation [1-2].

The most dominant factor governing flood damage is inundation water depth, being commonly used as a proxy of flood magnitude in hazard analysis; therefore, the invariable functions, which assume that flood damage increases monotonically with inundation water depth, are used in the vast majority of related studies. However, the flood damage variability is not fully explained by this single variable, and estimating flood damage with inundation water depth may become an important source of uncertainty. In fact, in the agricultural sector, flood damage is controlled by inundation depth, other flooding characteristics (e.g., duration, flood timing, flow velocity, water contamination, and sediment load) and the physical characteristics of the rice varieties (growth stage and rice height). For instance, floods, even with medium water depths, would have a catastrophic impact on agriculture after prolonged inundation.

Literature Review

Dominant Factor

In addition, previous studies have shown that assessing flood damaged based on invariable functions may be underestimate the risk of flood disasters, and multivariable function approaches perform better than invariable function methods Numerous researchers recently incorporated more variables into their studies, such as water depth, inundation duration, and flow velocity Furthermore, water contamination, return period, and the time of flooding are also considered as factors that influence the damage in some models [2].

This study presents the first attempt to derive a synthetic multivariable lookup table flood damage function for rice crops in Vietnam by aggregating fragmented information sources of physical and direct damage caused to rice crops by flooding. Specifically, the study identifies valuable information on the causal relationship between dominant flood parameters (inundation duration and inundation level) and rice yields variations considering the rice growth stages scattered in different existing literatures, such as research papers and documents published by related institutions, and then assemble all the information into a lookup table rice damage function for the respective growth stages and different rice varieties. This is aimed at improving damage function applicability by overcoming the limitations of invariable functions and the dependence on event-based and/or site-specific information. The derived function is validated against data collected for four recent floods in the southern rural area of the river basin [3]. Spatio-temporal crop damage estimated by the derived function and the invariable damage functions proposed in past studies are then compared and evaluated. The documents collected

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for developing the damage function cover several varieties of rice, and therefore the function is not intended for a single variety but describes a holistic inundation-damage relationship of rice crops; however, this study is limited to the use of summer-autumn.

For 1, 3, and 5 days of inundation, the following damages are expected: 0–6%, 0–7.6%, and 8.5–11%; among which the lower and upper ends are described, respectively. As for the upper end for 7 days of inundation and the damage ratio for 15 days of inundation, we use 11% because there is no information available and they should be at least equal to 11%.

The damages incurred during 1, 2, and 3 days in the event of 75% flooding were collected as 10% respectively. We determined the lower end for 1, 2, and 3 days of 75% inundation to be 6.5%, which is used as the lower end for 3 days of 100% inundation. A 20% damage ratio for 3 days of inundation proposed was not incorporated because the damage ratio would become high, thereby violating the monotonic increasing property, if it is employed as the upper end. Thus, the damage ratios when subjected to 1, 2, and 3 days of 75% inundation are 6.5–9.2%, 6.5–10%, and 6.5–11%, respectively proposed different damage ranges for 5 days inundation as 8.5–27.5% and 18–40%, respectively, while suggests 14.6–27.5% for 7 days of inundation. Considering all of the information, we determined that the damage range for 5 days of inundation was 8.5–18% in order to increase the lookup table function monotonically. Refs proposed 27.5% and 40% damages for 8 days of inundation. We used these values as the lower and upper bounds, while employing 40% as the maximum damage ratio for 75% inundation [4-6].

Vegetative Growth Stage

In all three growth stages, the rice plants were found to be the most robust in the reproductive stage. When the rice is inundated at approximately a depth of 35 cm at this stage (corresponding to 75% inundation level), the yield hardly decreases even after 7 days of submergence (21% loss). With complete submergence lasting for 7 days, the yield is reduced by almost half. If the tolerance criteria for the rice yield loss is 10%, complete submergence for up to 2 days is accepted at the reproductive stage.

In the vegetative growth stage, the average rice height was only 20 cm. The effects of submergence on rice yield at this early stage are more severe compared with the reproductive stage. A remarkable loss in yield of 50–90% was found when the complete submergence was imposed for 5–7 days, whereas the rice yield loss decreased significantly for the three-quarter submergence. At the vegetative stage, either the three-quarter submergence for 3 days or the complete submergence for 1 day is accepted to maintain a decrease in rice yields within tolerable bounds [7].

At the ripening stage, the rice yield loss caused by complete sinking was found to be most important. The reduction in yield was up to 30–50% once complete sinking was obligatory for less than 2–4 days. Within the case of 5–8 days of sinking, the yield loss was equally damaging to the vegetative stage (approximately 50–90%). The sinking at the ripening and vegetation stages for 4–5 days was equally harmful as that of seven days at the generative stage.

Application and validation of the developed operator

To validate the developed operation table harm operate, we tend to applied it to estimate the rice damage caused by flood events that occurred in rural areas southeast of Nghe province at the geographical area, Vietnam. The study space covers adorned Nan commune, adorned Nguyen (the red polygonal shape within the lower left of, that is found within the Lam geographical area, wherever the dominant support is agriculture with seventy seven of the population active about five hundredth of the study space is employed for rice. the realm is especially flat with a median elevation of two.5 m and extends for less than vi.7 km^2. Ground elevation for the district doesn't exceed 6m and reduces to a pair of. Rice paddies are placed in a {very} very low-lying space, only 1.1 m, with a bit distinction of 1.2 m between paddies. The left dyke of the Lam watercourse is that the northern and western boundary of the study space, that prevents the urban district from being flooded, whereas the Lam watercourse forms the southern and jap boundary; that's, the study space is found outside of the flood protection dyke system. the general tillage within the study space, particularly relating to summer – fall crops, angular distances been stable throughout the study amount (290 angular distance and a hundred forty five ha, severally), within which there's a minor amendment in planting structure of summer – fall rice fields, with V-E Day most decrease in rice space in ten years [8].

The developed operation table operate shows smart performance for the floods in 2010, 2017, and 2018. However, there's a substantial discrepancy between the particular and calculated flood damages in 2011. The 2011 flood was severe and similar in magnitude to the 2010 flood, whereas its actual harm was virtually half that of the 2010 flood. The inundation depth of the 2011 flood was medium, however it occurred within the ripening amount, and its length was terribly long (approximately one month). The operation table operate mirrored these factors and calculated the massive harm amounts. The particular harm in 2011, that was smaller than expected, could be influenced by early harvest home to mitigate flood harm. Online news reported that farmers and native governments learned from past floods experiences to require actions to avoid damages, as well as early harvest home. To boot, once we visited the study space for a field survey, a farmer told North American country that he harvested rice crops sooner than usual in 2011. This means that early harvest home before flooding in 2011 was conducted to a particular extent, however not across the study space, which could have reduced the flood harm.

Discussion

The worst performance is found for the 2011 flood, BIAS is quite 99%. The tiniest BIAS magnitude was obtained for the 2010 flood, 6.0%. This smart performance is perhaps as a result of most of rice crop was broken thanks to the extraordinarily high inundation level within the ripening amount, and so, the harm estimation was comparatively straightforward for this flood case. The variations between the particular and calculable damages for the 2017 and 2018 floods were larger than for 2010 [9]. The floods in 2017 and 2018 were tiny and medium, respectively, and each occurred within the generative growth stage, within which rice crops are comparatively resilient to flooding. Beneath these things, the harm varies greatly with each the inundation level and length. Poor results for the 2017 and 2018 floods indicate that there's potential for additional improvement of the operation table operate to suitably capture the inundation impacts on rice crops. Improper estimation of the inundation level and length may be another excuse for the poor performance of the operate, though the chance isn't terribly high as a result of the study space is low and flat and therefore the inundation level estimation supported ascertained watercourse water levels ought to work well, as is seen in section.

Conclusion

The present study developed a multivariable operation table flood harm operate for a rice crop by aggregating fragmented secondary data sources of physical harm caused to rice crops in Vietnam. Operator was applied to a southern geographical region of adorned Nguyen, geographical area. Its performance was verified and compared with those of the invariable (inundation depth) harm functions projected in a very previous study (exponential, quadratic, and S-shape functions).

The application discovered that the operation table operate provided smart estimations of rice crop harm caused by floods, conjointly outperformed the invariable functions projected within the past study, particularly for tiny and medium floods. The advantage of the developed operation table operate is that it's supported voluminous data on the inundation conditions effects on rice harm and incorporates the inundation length and rice growth stage and inundation depth as instructive variables for crucial the magnitude of the harm. Consequently, it overcomes the limitation of the invariable functions that considerably depend upon the datasets used for calibrating the spontaneous relationship between inundation depth and harm magnitude.

The present study recommended that besides the purposeful forms, associate correct understanding of temporal flooding patterns and therefore the inundation magnitude powerfully impact the reliable estimation. Throughout extreme flooding, within which inundation water levels reach nearly the most important record, it's comparatively straightforward to estimate the injury as a result of the rice may be utterly broken even with a really short period. Estimating rice injuries for tiny to traditional floods entails uncertainty since each inundation depth and period will hold the same degree of management on the damage magnitude for such floods. Precise analysis of inundation conditions is so crucial for providing an honest estimation of rice injury caused by little to traditional floods.

The search table injury perform developed within the gift study will be any improved by addressing the subsequent. First, the search tables will be additional elaborated and extended by appending data relating to relationships between inundation conditions and rice damages, that haven't been incorporated into the present search table perform. For instance, the current study doesn't contemplate the results of sediment and inundation flow rate, and therefore the search table perform will be careful by together with these effects. Second, the relevancy of the developed search table performs to larger abstraction scales ought to be explored to elucidate its shortcomings. Applications to completely different regions in terms of climate and topography would additionally facilitate to envision its validity and enhance its relevancy. It ought to be additionally noted that a search table perform developed for a crop might not be applied for different crops, clearly as a result of crop damages caused by floods square measure extremely smitten by physical options of given crops, furthermore as geographical characteristics of the target. Developing and examination injury functions for several different crops and varieties would facilitate to seek out similarities and variations in their flood injury characteristics.

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