Advances in Crop Science and Technology

ISSN: 2329-8863

Mini Review Open Access

Surface Runoff Phosphorus Losses in Rice-Wheat Crop Systems as Influenced by Rainfall Patterns and Fertiliser Applications

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Abstract

Phosphorus loss from agricultural soils contributes to surface water eutrophication. This field study investigated the effects of precipitation patterns and P application on P loss through surface runoff from rice and wheat growing systems in the Taihu Lake region, China. The study was conducted on two types of rice growing land with different P status, the duration of 3 years in low, high and normal rainfall regimes. Four ratios of inorganic phosphate fertilizers, i.e. P-free, 30 kg P ha–1 for rice and 20 kg P ha–1 for wheat, 75 plus 40 and 150 plus 80 were applied as treatments. Water runoff from individual plots and spill events were recorded and analyzed for total and dissolved reactive P concentrations. Total P and soluble P losses reacted significantly with precipitation depth and P level. Total annual P losses ranged from 0.36–0.92 kg ha–1 in the control group to 1, 13–4.67 kg ha–1 at P150+80 at Anzhen, and accordingly 0.36– 0.48 kg ha–1 to 1.26–1.88 kg ha–1 at Xinzhuang, with 16–49 % of total P as dissolved reactive P. In particular, a large amount of P was lost during heavy rains that occurred immediately after P application in Anzhen. The average of all P treatments, the rice crop accounted for 37–86% of the total annual P loss in Anzhen and 28–44% of that in Xinzhuang. In both crops, P concentrations peaked during the first runoff events and decreased over time. During the rice growing season, the P concentration in the runoff is positively correlated with the P concentration in the field water which is intentionally closed by the construction of a dike around the field. The relatively high P loss during the wheat growing season in Xinzhuang is due to the high P status of the soil. In summary, P should be applied at a rate that balances between crop removal and at a time when heavy rainfall is eliminated. In addition, irrigation and drainage must be managed appropriately to reduce P loss through runoff from the rice-wheat farming system.

Keywords: Agricultural Soils; Wheat; Rice

Introduction

Eutrophication due to the presence of nutrients is a serious problem in many seas around the world. In China, many waters have become severe eutrophication since the 1990s and have not marked improvement in recent years. Phosphorus is often considered a limiting factor for algae bloom in the lake. In China It is estimated that agricultural resources contribute 30-90% P is loaded into many lakes. Therefore, quantification and control of P losses from farmland are of particular importance in reducing eutrophication of lakes. Phosphorus in the soil can be lost to water by two major transport routes, roads in surface runoff or erosioned floor and vertical washout with drainage. Road which governs the total phosphorus loss which usually depends on factors such as weather, topography and soil properties. In most fields, the loss of P is mainly due to surface runoff and erosion [1]. Phosphorus loss due to leaching is usually relatively low due to the high P content Absorbs iron and aluminum oxides in the soil. The risk of loss of P in the surface flow is especially when the terrain is steep and lost Phosphorus binds particles to soil particles that can often be eroded happen. However, substantial sums of money Ground P losses can also occur in flat fields, when the ground is saturated with water and causes additional precipitation flow exceeds saturation. For example, in a study of flat rice fields in Ho Taihu area, found that the annual total P losses due to surface runoff are about 0.9–1.8 kg ha–1 and 3–4 kg ha–1 with a high rate of P application. From the total amount of P lost, P is bound to the particle for 10-80%, showing that erosion even on flat land. In general, phosphorus losses through surface runoff from flat land the landscape increases with the combined effect created by the increase percentage of P added to the soil as mineral or organic fertilizers modified, higher P soil status and increase the depth and intensity of precipitation. Some studies have reported that the time between rain and subsequent runoff event P. Applications play a major role in P loss. That is because new P applied to the soil is immediately available, and a large amount of loss occurs when precipitation directly interacts with this part of the P [2-5]. In addition, the loss of P can be influenced by the vegetation cover on the soil surface, and therefore varies between systems. Most of the reports published in the literature focus on upland farming systems. Previous studies that quantified P losses from flooded rice fields were mostly done a decade ago and these studies often reported that P losses increased with higher P fertilization rates, but the use of P fertilizer use by Chinese farmers has not decreased in the past decade. In addition, none of the above studies analyzed the effect of precipitation on phosphorus loss. The persistent problem of eutrophication in China's lakes in recent years has brought attention back to the management of agricultural phosphorus in rice farming systems. This is mainly because rice is widely grown throughout southern China in regions with extensive water systems [6,7].

Crop systems involving lowland wet season rice and highland winter crops are common in East Asia and South Asia, including many agricultural regions in China. For example, it occupies about 80% of the total arable land of the Thai Ho area. During the rice season, a water depth of 5 to 15 cm, known as a water retaining field, is intentionally surrounded by the construction of a field dyke, and the water is retained to allow part of the plant to grow under water is usually in the early

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Received: 03-Apr-2023, Manuscript No: acst-23-96922, **Editor assigned:** 05-April -2023, PreQC No: acst-23-96922 (PQ), **Reviewed:** 19-Apr-2023, QC No: acst-23-96922, **Revised:** 21-Apr-2023, Manuscript No: acst-23-96922 (R) **Published:** 28-Apr-2023, DOI: 10.4172/2329-8863.1000568

Citation: Dey RK (2023) Surface Runoff Phosphorus Losses in Rice-Wheat Crop Systems as Influenced by Rainfall Patterns and Fertiliser Applications. Adv Crop Sci Tech 11: 568.

stages of growth. In contrast, fields are often drained by open ditches during the winter season. The present study investigated surface runoff-induced P losses from two typical rice soils with 3-year rice and wheat rotation. The objective is to assess the risk of P loss through surface runoff from such a system, to investigate how P loss is affected by precipitation patterns, P utilization rates, and the characteristics of P loss of soil, and thus offer management recommendations to ultimately limit P loss [8].

Phosphorous load by surface runoff

During the 3-year experiment, the Anzhen site lost significantly more P than the Xinzhuang site ($P < 0.0001$). In Anzhen, particularly large losses of total P occurred in the 2001/2002 and 2002/2003 rice crops, when heavy rains occurred immediately after P application. Rice growth accounted for 83-91% of total P annually. In contrast, the wheat growing season, 56–75% of the total annual Plosses, contributed to the relatively larger P losses in Xinzhuang. Regarding the influence of annual rainfall, the total loss of P in the years with high and normal rainfall was significantly higher than in the years with low rainfall ($P<0.0001$) [9,10]. With little added value to crop yield production, over-application of P significantly increased P loss. Over the three years of the trial, the average annual total P loss at both sites was less than 1 kg ha−1 in the control and P30+20 treatments, but significantly increased at the higher P ratio, at 1.08–1.49 kg ha−1 in Tan Trang and 2.07–2.86 kg ha−1 at Anzhen. As with total P samples, the ratio of soluble reactive P to total P also increased with increasing application rate of soluble P. The reactive P was 16–31% of the total P in the control and P30+20 treatments, and 31–49% of the total P in the high P treatments. On the other hand, this indicates that a large proportion (48–84%) of the total P is presented in an irrational form, especially in the zero and low P treatments.

Discussion

Wheat growing season 2000/2001 and all year 2001/2002 in Xinzhuang, where small amounts of runoff or low total P concentrations outcome in low total phosphorus loss. Elsewhere, reports from upland crops have also demonstrated that P losses through surface runoff are influenced by precipitation patterns and subsequent runoff volumes. The timing of rain and the outcomeing runoff seems to play a particularly important role in influencing P loss. In 2001 and 2002, heavy rainfall occurred shortly after P loss. Fertilization of rice caused significantly more P losses in Anzhen than in Xinzhuang with 45-57 days between the first runoff event and P application. The seasonal rainfall was similar and the soil in Anzhen even functioned. Relatively lower amounts of P. Accidental P losses also cause Anzhen to have a significantly larger average annual total P loss than Xinzhuang. In Xinzhuang, the long interval between P application and precipitation may allow adequate interaction of P in field-contained water with plants and soil. During the rice and wheat growing season, the concentrations of total P and soluble P in runoff decreased with time after P application. In the early period after fertilizer application, P was mainly available due to soil and crop limitations Permanent. Over time, P availability decreases as the soil and plant's ability to fix P increases.

Conclusion

Phosphorus losses from rice-wheat farming systems can be influenced by rainfall, P utilization rates and soil P content, as well as field management practices such as embankment construction. and open ditch. In particular, the amount of P loss was large due to heavy rain immediately after P application, and the P loss increased with the increase of P application rate and P content in the soil. Phosphorus concentrations in surface runoff are regulated by phosphorus concentrations in field water during the rice growing season. Phosphorus loss during the winter wheat growing season can be improved by constructing exposed trenches. We therefore propose that the management of rice-wheat cropping systems aim to apply P to avoid heavy rainfall and at a balanced rate of P removal by plants (20–30 kg P ha−1). in this study). In addition, appropriate water management practices should be adopted, including increasing the water holding capacity of the field or using controlled irrigation combined with natural drainage rather than open ditches during the wheat growing season.

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