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# Fate and transport of urea-N in a rain-fed ridge-furrow crop system with plastic mulch

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ABSTRACT

A better understanding of the fate and transport of fertilizer nitrogen (N) is critical to maximize crop yields and minimize negative environmental impacts. Plastic film mulching is widely used in drylands to increase soil water use efficiency and crop yields, but the effects on fertilizer N use efficiency need to be evaluated. A field experiment with $^{15}$N-urea (260 kg N ha$^{-1}$) was conducted to determine the fate and transport of fertilizer N in a ridge-furrow system with plastic film mulched ridge (Plastic), compared with a flat system without mulching (Open). In the Plastic, the $^{15}$N-urea was applied to the ridge only (Plastic-Ridge), or to the furrow only (Plastic-Furrow). Maize grain yield and net economic benefit for Plastic were significantly higher (by 9.7 and 8.5%, respectively) than those for Open. Total plant $^{15}$N uptake was 72.5% greater in Plastic compared with Open, and $^{15}$N was allocated mostly to the grain. Losses of the applied urea-N were 54.5% lower in Plastic and much more residual $^{15}$N was recovered in 0–120 cm soil compared with Open (42.7 and 26.8% of applied $^{15}$N, respectively). Lateral N movements from furrow to ridge and from ridge to furrow were observed and attributed to lateral movement of soil water due to microtopography of ridges and furrows and uneven soil water and heat conditions under mulching and plant water uptake. The ridges were the main N fertilizer source for plant uptake (96.5 and 3.5% of total N uptake in Plastic from ridge and furrow, respectively) and the furrow was the main source of N losses (78.6 and 21.4% of total N losses in Plastic from furrow and ridge, respectively). Gas emissions, especially ammonia volatilization was probably the main N loss in furrow. Thus, appropriately localized N application – into the ridges, and management strategies should be designed for Plastic to maximize N use efficiency by crops, decrease N gas losses and maintain sustainable agricultural systems in drylands.

## 1. Introduction

To meet the needs of a growing population and ensure food security, large quantities of N are applied to farmland to achieve high yields (Yang et al., 2015; Abbasi et al., 2012). Excessive fertilization, however, results in N losses and environment pollution (Granlund et al., 2008). Maximizing crops yields while minimizing negative environmental impacts is one of the major current challenges in agriculture (Li et al., 2011; Yang et al., 2015).

Plastic film mulching was introduced in China in 1978, originally only for vegetables but now is widely used for maize, wheat, potato and other staple crops (Dong et al., 2009). Plastic film mulching increases crop yield, especially in arid and semi-arid areas, due to higher soil temperature, less water losses and consequently higher soil moisture, and higher nutrient availability (Wang et al., 2004; Bu et al., 2013; Chakraborty et al., 2008; Liu et al., 2015). Plastic film mulching increases soil temperature due to the "greenhouse effect", which plays an important role in the early growth stage of crops (Gan et al., 2013). Soil moisture under mulching is increased by collecting light rain, strongly reducing evaporation, and promoting rainfall infiltration (Wang et al.,

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