Research Application Summary

Speargrass as a soil fertility indicator along a deforestation chronosquence

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Abstract

This study estimated the time taken for speargrass (*Imperata cylindrica*) to occur on arable fields along a deforestation chronosquence; established the effect of burning on soil properties and determined the reliability of speargrass as a soil fertility indicator. Results showed that speargrass never grew in the study fields within the first six years of cultivation. During the same period average values for bulk density, total N, K, organic matter and soil pH were within the recommended ranges for optimal crop growth. After six years of cultivation in burnt and un-burnt fields on both Nitisols and Red Latosols, average values of the above parameters decreased below their critical levels and continued to deviate negatively from the critical range by years of cultivation. During the same period, speargrass infestation set-in and shoot count rose with time. Speargrass populations rose faster in fields with lower total N, K and organic matter and higher bulk density. This confirms that speargrass infestation and subsequent invasion is favoured by declining soil fertility thus, indicative of soil degradation.

Key words: burning, *Imperata cylindrica*, deforestation, soil fertility, soil properties

Résumé

Cette étude a estimé le temps pris par le chiendent (*Imperatacylindrica*) pour se produire sur les terres arables le long d'une chrono séquence de déforestation; elle a établi l'effet du brûlis sur les propriétés du sol et a déterminé la fiabilité du chiendent comme un indicateur de fertilité. Les résultats ont montré que le chiendent n'a jamais poussé dans les milieux d'étude dans les six premières années de culture. Au cours de la même période, les valeurs moyennes de la densité apparente, de N total, de K, de la matière organique et du pH du sol étaient dans les limites recommandées pour la croissance optimale des cultures. Après six années de culture dans les champs brûlés et non brûlés tous deux en Nitisols et Latosols Rouges, les valeurs moyennes des paramètres ci-dessus ont diminué en dessous de leurs niveaux critiques et ont continué à s'écarter négativement de la zone critique au cours des années de culture. Durant la même période, l'infestation du chiendent se présenta et le nombre de pousses a augmenté avec le temps. Les populations de chiendent ont augmenté plus rapidement dans des champs à plus faible N total, K et matière organique et à densité apparente plus élevée. Cela confirme que l'infestation du chiendent et l'invasion subséquente sont favorisées par la baisse de la fertilité du sol et donc, indicatrices de la dégradation des sols.

Mots clés: brûlis, *Imperatacylindrica*, déforestation, fertilité des sols, propriétés du sol

Background

In East Africa, speargrass is considered an indicator of declining soil fertility (Mairura *et al*., 2007). Identification of plant species and soil characteristics that demonstrate changes in soil (Masto *et al*., 2007). Farmer perceived indicators of soil fertility have unfortunately not been studied to establish their reliability. These if reliable have potential for use as they are of no cost to farmers. This study was therefore carried out to determine the reliability of speargrass as a soil fertility indicator.

Literature Summary

The impact naturalised non- native plants have on natural and managed ecosystems has drawn interest among land managers because some are indicative of habitat niche characteristics (Johannes and Anton, 2003). These plants have for a long time been used as indicators for habitat quality especially in finding suitable places for housing, agriculture and forestry, for drinking water and other soil resources. The attributes of habitat quality indicated by plant distribution include light and temperature microclimate, soil moisture, pH, fertility, salinity and presence of heavy metals (Johannes and Anton, 2003).

Speargrass (*Imperata cylindrica*) is one of the most dominant, competitive, and difficult weeds to control in the humid and sub-humid tropics of Asia, Sub-Saharan Africa, and Latin America (Garrity *et al*., 1997). In Sub-Saharan Africa, it is a serious weed of intensive agriculture particularly in areas prone to recurrent burning (Chikoye *et al*., 1999). The negative impact of speargrass on agriculture includes severe crop yield losses and high investment in labor for weeding. Crop yield reduction attributable to competition from speargrass has been estimated at 76-80% in cassava, 78% in yam, and 50% in maize (Chikoye *et al*., 2002).

The need to increase food production to meet the demand of the increasing human population in sub-Saharan Africa has, however, forced farmers to reduce the fallow period (<3 years) and to cultivate available land more intensively (Akobundu *et al*., 1999). The reduction in fallow periods is associated with speargrass infestation (Santosa *et al*. 1997), strengthening the hypothesis that speargrass is indicative of exhausted soils.

Study Description

The study was conducted during the second rainy season of 2011 in Wakisi sun-county, Buikwe district within the Lake Victoria Crescent, Uganda. The study site was chosen because it had secondary forests, young and old farmers' fields and speargrass. Thirty two fields were chosen for the determination of speargrass populations. The fields chosen for this study were categorised according to years under cultivation (0.5-2; 3-6; 7-10; 15) and according to the plant residue management regime employed by farmers at land preparation (burning and zero burning). Secondary forests (>10 year fallows) were considered as controls (Chikoye *et al*., 2002). To extensively follow up the effect of burning on speargrass population dynamics, of the eight secondary forests; four were those which had experienced some form of burning. The fields considered for the study were those on which fertilisers had been applied and whose rotation involved maize, cassava, beans and potatoes. They were also divided into nitisols and red latosols).

Each field was considered a replicate. Of the eight fields within each category, four were fields on which farmers burnt plant residues while on the other four fields were never burnt during seed bed preparation.

Soil sampling was carried out on a 25 m grid according to Pariera and Clain (2008). Soil was sampled in a 0-20 cm depth as the bulk of speargrass rhizomes are concentrated in this depth (Chikoye *et al*., 2005) and hand hoeing, the tillage method in the study area rarely exceeds 20 cm (Chivenge, 1990). No heating also occurs below 20 cm (Debano, 2000) . A pre-soil sampling counting of speargrass shoots using a series (three) of 1 m^2 quadrants established at random within the 25 m^2 grid following a procedure described by Lopez (2007).

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Table 1 gives characteristics of soil in the study fields over time (data is only presented for the Nitisols). In the first six years of cultivation on both burnt and un-burnt Nitisols and Red Latosols, no speargrass infestation was observed on arable croplands.

Table 1. Relationship between selected soil properties and speargrass infestation in a burnt and un-burnt nitisol along a deforestation chronosquence in Uganda.

	Total N		OM		K^+		Mg^{2+}		Ca^{2+}		Fe^{2+}		Av.P		BD		Soil pH		Speargrass counts	
	%				cmol(+) kg^{-1}						mg kg^{-1}				g cm^{-3}				Square root	
	B	ZB	B	ZB	B	ZB	B	ZB	B	ZB	B	ZB	B	ZB	B	ZB	B	ZB	B	ZB
Forest soil	0.33		4.7		3.4		6.6		9.8		1.1		1.4		0.93		6.4		0.00	
0.5-2 years	0.25	0.30	4.4	4.3	20.5	6.9	5.3	4.1	25.5	24.7	4.2	0.5	6.3	0.7	0.85	0.92	7.1	6.9	0.00	0.00
3-6 years	0.28	0.21	5.0	4.5	6.5	4.0	7.0	4.8	26.0	8.9	0.1	1.0	6.5	0.9	0.98	0.99	6.4	5.8	0.00	0.00
7-10 years	0.19	0.12	3.8	2.1	2.1	0.8	8.0	6.9	13.4	13.3	1.0	2.6	3.6	2.1	1.16	1.17	5.6	5.4	1.58	6.40
15 years	0.22	0.19	3.3	2.6	1.3	0.8	7.0	9.5	13.4	5.6	1.9	1.1	2.1	1.0	0.95	0.94	5.5	5.7	1.98	4.17
LSD ($p<0.05$)	0.14		0.7		8.3		4.9		9.6		2.4		10.7		0.24		0.6		4.09	

OM = soil organic matter; BD = dry bulk density; Av. P=available phosphorus; B = Burning; ZB = Zero-burning; LSD = Least Significant Difference.

During this period, average levels of soil organic matter, total N and total K were above their critical levels 3%, 0.2% and 1.28 cmolkg^{-1} (Foster, 1981), respectively. Bulk density was also within the desired range (0.8-1.0 g cm^{-3}) (Taylor *et al.*, 1966). Speargrass infestation set-in after 7-10 years after forest clearance. During this period, average levels of organic matter, total N and total K reduced to levels that cannot support optimum crop production. Bulk density also increased to between 1.1 and 1.4 g cm^{-3} implying enhanced runoff rates, and thus greater nutrient depletion rates.

The values of the above parameters continued to deviate negatively from their critical levels with years in cultivation. On the other hand, the population of speargrass increased significantly along the chronosquence. This confirms that speargrass infestation and subsequent invasion is in the direction of declining soil fertility status and thus, indicative of soil quality degradation., It is therefore advisable that that judicial enhancement of soil N, K and organic matter be initiated as soon as farmers indentify speargrass on their fields. In this study, speargrass population was positively associated with exchangeable magnesium suggesting that it is the main soil fertility nutrient influencing its distribution. This could be attributed to the fact that the plant's above ground biomass is only composed of leaves (ano, (MacDonalano, 2004) where magnesium is a major element as it is key in chlorophyll formation and photosynthesis (Mengel and Kirkby, 2001). In general, the survival of the plant depends on the amount of carbohydrates manufactured and stored in its rhizomes (Holm *et al*., 1977). Therefore, reliability of speargrass as a soil fertility indicator can only be conclusive in the context of the existence of exchangeable magnesium.

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