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Assessment of the relationship between soil properties, *Striga hermonthica* infestation and the on-farm yields of maize in the dry Savannas of Nigeria

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ABSTRACT

A study was conducted in Kano and Bauchi States in the dry Savanna of northern Nigeria to determine *Striga* incidence and infestation and relate these to soil fertility status and yield of maize. A three-stage sampling technique was used to select communities and fields in targeted Local Government Areas in the two States. The soils in the two States were generally of low fertility, characterized by low levels of total N, organic C, available P and exchangeable bases. In Kano State, *Striga* incidence ranged from 0 to 100%. One hundred percent of the maize fields sampled in Bauchi State had *Striga*. In general, *Striga* population was more than twice higher in Bauchi State [3.1 plants m^{-2}] than in Kano State [1.4 plants m^{-2}]. There were differences in *Striga* population and severity of attacks between the States and between communities within States. In Kano State, the *Striga* population was negatively related to latitude, total N, and exchangeable K and was positively related to sand and silt. In Bauchi State, *Striga* was negatively related to clay, exchangeable K, and Ca, and was positively related to pH and latitude. In both states, the *Striga* population was negatively correlated with maize grain yield. Up to 75% of the variations in maize grain yield in Kano State could be explained by *Striga* population and soil organic C. Management of *Striga* usually requires several measures, however, improving the levels of soil fertility should be the central component of any integrated *Striga* management approach.

1. Introduction

Crop production in sub-Saharan Africa, especially in the semi-arid and sub-humid Savannas, is often limited by biophysical constraints, including poor soil fertility (Giller et al., 2011; Manu et al., 1991); infestation of *Striga* and other parasitic weeds (Rodenburg et al., 2005; van Ast et al., 2005; Weber et al., 1995); and low and erratic rainfall pattern (Affholder et al., 2013; Nnoli et al., 2006). Crop yields are generally very low, determined by the biophysical limitations of the environment. Tittonell and Giller (2013) singled out soil fertility and nutrient availability as the major biophysical limitations to agricultural production in sub-Saharan Africa.

In the Sudan and Northern Guinea Savanna region of Nigeria agricultural production is mainly done under smallholder, resource-constrained, rain-fed farming systems on inherently poor soils. The soils of the region are mostly sandy with very low organic matter, low water holding capacity, low nutrient contents, and are often prone to water and wind erosion (FFD, 2012; Jones and Wild, 1975). The problem of low soil fertility is further aggravated by low annual precipitation, high evapotranspiration and very high inter and intra seasonal rainfall variations (Ati et al., 2002; Nnoli et al., 2006).

Apart from the low yields resulting from the poor soils and the erratic weather, very high yield losses in sorghum, maize and cowpea due to infestation by *Striga* have been reported in the Savannas of Nigeria (Dugje et al., 2006; Lagoke et al., 1991; Showemimo et al., 2002). *Striga* is a parasitic weed affecting up to 50 million hectares of land and adversely impacting nearly 300 million people in sub-saharan Africa (Ejeta, 2007). The extent to which *Striga* reduces the growth of its host is highly variable and depends on factors such as host plant genotype, parasite infestation level, and environment (van Ast et al., 2005). There is direct relationship between the level of *Striga* infestation and the fertility of the soil. Several studies have attributed high incidence of *Striga* to poor soil fertility, intensification of land-use through continuous

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cultivation and an expansion of cereal production (Rodenburg et al., 2005; Weber et al., 1995; van Ast et al., 2005; Vogt et al., 1991). *Striga* infestation has been reported to be more severe in areas with low soil fertility, low rainfall and little or no fertilizer use (Larsson, 2012; Sauerborn et al., 2003). In smallholder farms, crop production practises such as soil fertility management, hand weeding, crop rotation and seed treatment have been used to control *Striga* with limited success (Oswald and Ransom, 2004; Showemimo et al., 2002). In order to develop effective *Striga* management strategies, the relationships between *Striga* levels and other biophysical characteristics of the crop production environment need to be properly understood. This study assessed level and extent of infestation of maize fields by *Striga* in the dry Savannas of Nigeria. It also assessed the relationship between soil properties, *Striga* infestation and the yields of maize.

2. Materials and methods

2.1. Sampling procedure

A field survey was carried out in October 2011 in five selected Local Government Areas (LGAs) each of Kano and Bauchi States in the dry Savannas of Nigeria (Fig. 1). A “three stage sampling” technique was used to select communities and fields for sampling in each LGA. To select communities, grid cells measuring 10 km × 10 km were super-imposed on a base map of the study area, from which five communities were randomly selected in each LGA (Kamara et al., 2014). The geographical coordinates of the selected communities were recorded. Twelve farmer's maize fields were sampled from each community. Starting from the center of each selected community, maize fields were systematically selected from four cardinal points at every 5 km along a transect. The geographical position of fields sampled in each community was recorded with a Global Positioning System [GPS]. A total of sixty fields were sampled from each LGA (Table 1).

Table 1
Survey sites in Kano and Bauchi States.

State/LGA[a]	AEZ[b]	Number of fields sampled	Communities
Kano			
Kiru	SS	60	Lamin Kwai, Kyarana, Kiru, Badafi, Baure
Bebeji	SS	60	Kofa, Danmako, Kuki, Gajale, Bebeji
Tudun Wada	NGS	60	Pata, Baburi, Rufa, Unguwan Galadima, Kanwa, Yaryasa
Doguwa	NGS	60	Marmara, Falgore, Burji, Dariye, Katakau
Rano	SS	60	Saji, Rurum, Kunda, Gazobi Tsoshuwa, Babuha
Bauchi			
Dass	NGS	60	Dot, Gwaltukurwa, Tak Bundila, Dajim, Bundot
Toro	NGS	60	Bababe, Reshi, Unguwar Gulawa, Lame, Rinjim
Ganjuwa	SS	60	Ganjuwa, Gali, Durum, Zandanga, Dasha
Bauchi	NGS	60	Gubi, Bishi, Buzaya, Kutaru, Yamrat
Alkaleri	SS	60	Gar, Gwarum, Tumburu, Bajoja, Alkaleri

[a] LGA: Local Government Area.
[b] AEZ: Agroecological zone (SS: Sudan Savanna, NGS: Northern Guinea Savanna).

In each maize field, five 2 m × 2 m quadrats were pegged out along two intersecting diagonals transects. Three quadrats were pegged out on one diagonal while the remaining two were pegged out on the opposite diagonal. In each quadrat, emerged *Striga* plants were counted. The number of maize plants attacked by *Striga* was enumerated. In each quadrat, severity of *Striga* attack on maize was assessed visually using a rating of 1–9 where 1 = no symptoms, 2–3 = mild firing on 1 or 2 leaves, 4–5 = firing on 3 to 4 leaves, 6–7 = severe firing on 4 to 5 leaves, 8 = severe firing on almost all leaves, stunting, and 9 = complete scorching of all leaves causing premature death of host plant and no ear formation (Kim and Adetimirin, 1997). From each quadrat soil (0–15 cm) was collected from two points using an auger. Soil samples were collected from a total of ten auguring points and bulked together to give a composite sample. All soil samples taken from the field were air-dried and sieved through a 2 mm mesh sieve before storing for analysis. The samples were analyzed for some physical and chemical properties using standard procedure (IITA, 1982): particle size analysis was carried out by the hydrometer method; soil pH in water was determined with a glass electrode pH meter at a soil/solution ratio of 1:1 (weight/volume); organic carbon was determined by the wet oxidation method of Walkley and Black (1934); exchangeable bases were displaced with 1 N NH_4OAC buffered at pH 7.0, K in the extract were determined by flame photometry while Ca and Mg were determined by atomic absorption spectrophotometry; total N was determined by the macro-Kjeldahl

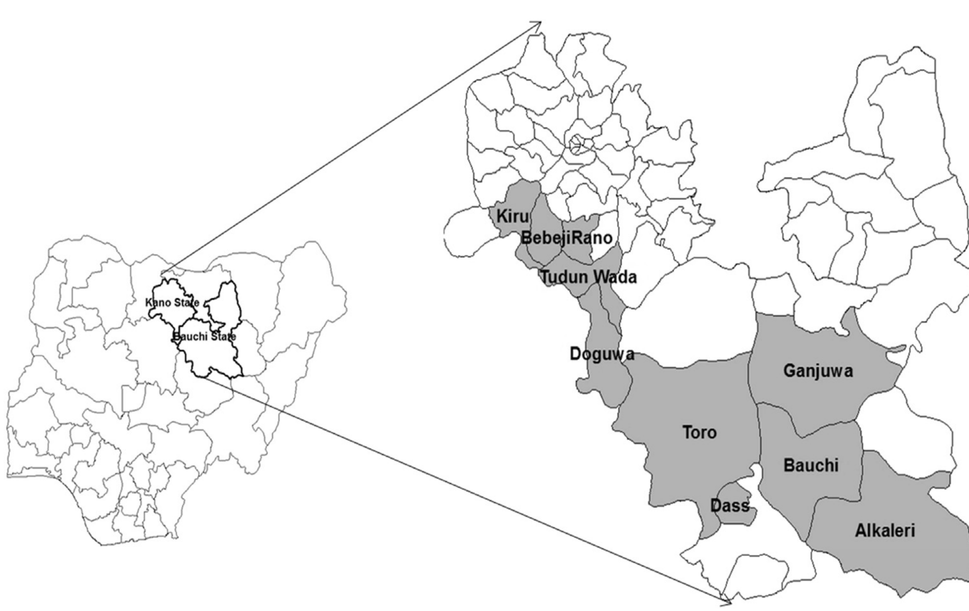

Fig. 1. Map of Nigeria (left) and map of Kano and Bauchi States showing the local governments areas (LGAs) of the Study.