SURVEY AND MAPPING OF SPEARGRASS (*Imperata cylindrica* (L.) REAUSCHEL) INVASIVENESS USING GIS TECHNIQUES IN TWO AGRO-ECOLOGIES OF NIGERIA.

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ABSTRACT: *Speargrass invasiveness in Derived Savanna (DS) and southern Guinea Savanna – northern fringe (SGS) is influenced by the rainfall amount and cultural practices (weed management methods, tillage method and plant spacing). Studies were conducted between 2015 and 2016 in Eruwa (DS) and Kishi (SGS), to investigate the problem of weed incidence in farmers' fields and the influence of weed control methods adopted on invasiveness with structured questionnaire; the invasiveness of predominant weed [speargrass - Imperata cylindrica (L.) Reauschel]. The geographical analysis were carried out in an ArcGIS environment. Results showed that speargrass was the predominant weed identified by 100% and 90% of farmers in DS and SGS respectively. Other weeds identified were broadleaf (54%), grass (38%) and sedge (8%) in both locations. Manual weeding (slashing and hoe-weeding) was the most common weed control method used among respondent farmers in the two agro-ecologies. 60% and 50% of the farmers adopted manual weeding in DS and SGS respectively. This was followed by chemical weed control (DS 30% and SGS 40%) and manual + chemical was practiced by 10% each of farmers in both agro-ecologies. Frequently used weed control methods followed the order of Manual weeding (MW) > Chemical weeding (CW) > Manual + chemical weeding (MW + CW). Average speargrass density in DS was 140 stands/sq.m (0 - 288 stands/sq.m), while the mean was 39 stands/sq.m (0 - 160 stands/sq.m) in SGS. Speargrass covered 288.07 sq.km (79.80% of surveyed area) with <50 stands/m^2 in SGS, while 231.74 sq.km (57.60% of surveyed area) with density of 150 stands/sq.m in DS. Weed management methods and locations might have influenced speargrass invasiveness.*

KEYWORDS: Speargrass Density, Invasiveness, Manual Weeding, Chemical Weeding, Gis, Derived Savanna, Southern Guinea Savanna

INTRODUCTION

Weeds remain subtle yield 'eaters' in crop production and significant yield reduction has been recorded. Generally, weeds are menace to crop production. Some weeds are of more importance in crop fields as evident in their economic damage inflicted on crop and cost management. Speargrass (*Imperata cylindrica* (L.) Reauschel) is a rhizomatous perennial plant ranked seventh among the world's worst weeds (Holm *et al*. 1977). It has become a major problem in tropical and sub-tropical regions of Africa. It covers 9 – 97% of farmers' field in West Africa and recurs as a major pest in cultivated areas of the upland and moist savanna and humid rain-forest agro-ecozones in Nigeria (Smith, 1992; Smith, 1997; Chikoye *et al*. 1999). It affects 73 countries and has been a major inhibitory force in the cultivation of 35 annual and perennial crops (Brook, 1989; Chikoye *et al.* 2001). This accounts for between 62 and 90% yield reduction in maize, and 28.5% and 52.6% yield reduction in soybean in the middle Belt of Nigeria (Koch *et al*. 1990; Udensi, 1999; Avav, 2000). Generally, speargrass management usually increases the cost of crop production and reduces the revenue generated from harvested produce crop. This cost will increase or decrease as weed species distribution changes in response to future changes in the climate (Hilbert *et al*, 2007). This in turn has adverse effect on the cropping activities of the subsequent years as farmlands are abandoned in speargrass-endemic locations.

The management of speargrass has been a challenging practice among farmers and other land users. Weed control methods applied for speargrass suppression has one or more shortcomings (Udensi *et al*. 1999). Planting of Velvetbean (*Mucuna cochinchinensis*) has cover-crop for speargrass suppression has adoption problem as financial returns is not feasible.

Weed infestation has been a limiting factor in crop production, especially where croplands are infested by noxious weeds. In the face of high land scarcity, coupled with speargrass infestation, farmers may be out of cropping activities and the yields critically reduced. The variation of weed types and level of damage done to crops informed a survey of the farmers' fields to identify the most critical weed problem experienced on the field. Miller and Stafford (1991) proposed a map-based approach in which weed populations located on a map can be converted to a treatment or application map and used to control the sprayer. Since the last two decades, computer technology has been broadly utilized to design application systems for weed management. Researchers can get benefit from the use of Geographic Information Systems (GIS) to fully investigate data and develop spatially accurate graphical data displays (Main *et al.*, 2004; Ahmad *et al.*, 2010). Therefore, the need to map out speargrass incidence and develop distribution maps in the agro-ecologies is essential to generate further information and facilitate the formulation of effective control measures.

MATERIALS AND METHODS

A survey was conducted in two agro-ecologies in Southwest Nigeria namely Ibarapa North-East and Irepo Local Government Areas (LGAs) of Nigeria, where crop production is the major occupation in the communities. Ibarapa North-East Local Government Area (LGA) is in the Derived Savanna (DS), while Irepo LGA is located in the Southern Guinea Savanna-Northern fringe (SGS) of Oyo State, Nigeria. Structured questionnaires were administered to twenty (20) farmers per location to ascertain weed infestation challenge and weed control methods adopted by the farmers in the agro-ecozones. A survey of speargrass density was carried out with 1 m^2 quadrat sampled randomly over the LGAs of the study by counting the number of speargrass stands/m^2. Mapping of the agro-ecologies was carried out with GIS to determine the geographical coverage of speargrass as major weed identified by the farmers.

GIS Methodology.

Global Positioning System (GPS) was used to sample speargrass in the locations. The delineation of the remotely sensed data (land-use) was used to predict the implications of the spatial distribution of the weed in the study areas. Inverse distance weighted (IDW) interpolation determined the cell values using a linearly weighed combination of the sampled locations. The weight is a function of inverse distance. The surface being interpolated was that of a location dependent variable. The measured values surrounding the prediction location was used to predict a value for any un-sampled location, based on the assumption that things that are close to one another are more alike than those that are farther apart. This method assumes that the variable being mapped decreases in influence with distance from its sampled location. When interpolating a surface, the power of a more distant location will have less influence. IDW assumes that the characteristics of the surface are driven by local variation. The speargrass spatial analysis method applied was the effective integration of the GIS-based Inverse Distance Weighted (IDW) interpolation procedure to estimate the factor values on a grid cell basis across the study areas. Figure 1 shows the survey locations data (Speargrass Data) used in the calculation of each interpolated cell (Study Area Speargrass Grid). These were cells that fall within the specified study area boundary shape (mask feature data).

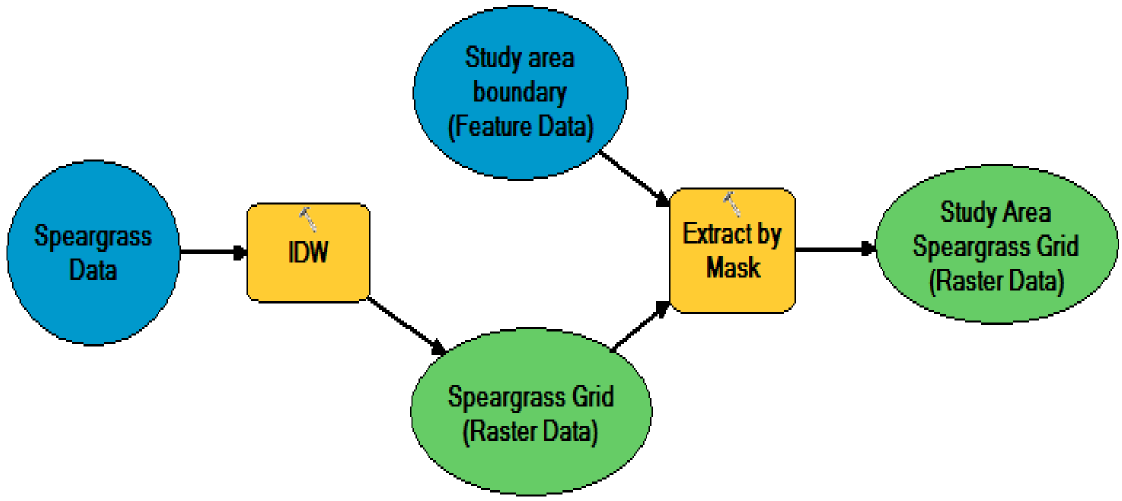

Figure 1: Flow chart of speargrass spatial analysis.

RESULTS

Survey of weeds and weed management methods among farmers in Derived Savanna and Southern Guinea Savanna

According to the survey, 10 problem weeds were identified on farmers' fields in SGS whereas only seven were indentified in the DS. These were made up of 50% grass, 40% broadleaf and 10% sedge. Speargrass (*I. cylindrica*), was identified as the predominant and problematic weed on farmers' fields in both locations. 100 % and 90 % farmers in the DS and SGS respectively had speargrass incidence on their fields. Other weeds identified by the farmers in the two locations were shown in Figure 2.

Weed management practices in Derived savanna and Southern Guinea Savanna agro-ecologies

Figure 3 shows the weed control methods adopted in both agro-ecologies. Manual weeding (MW - slashing and hoe-weeding) was the most common weed control method used among

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respondent farmers. 60% and 50% of the farmers adopted MW in DS and SGS respectively. This was followed by chemical weed control (CW) (DS 30% and SGS 40%) and manual + chemical (MC) was practiced by 10% each of farmers in both agro-ecologies. Frequently used weed control methods followed the order of Manual weeding (MW) > Chemical weeding (CW) > Manual + chemical weeding (MW + CW).

Speargrass invasiveness in study locations

Figure 5 shows that the speargrass density range from <50 stands/m^2 (minimum) to 151 – 200 stands/sq.m (maximum) density range. The mean speargrass density was 39 stands/sq.m in SGS. In table 1, <50 stands/sq.m (very low) speargrass density had the largest coverage area of 79.80% (288066.02 sq.km) of the surveyed area in SGS. This was followed by a density range of 51 100 stands/sq.m covering 18.60% (67153.28 sq.km) of the surveyed area investigated. Highest speargrass density of 151 – 200 stands/sq.m, had smallest coverage of 0.1% (303.85 sq.km) of the survey area in SGS.

Figure 6 shows that speargrass density ranged from 0 - 288 speargrass stands/sq.m with a mean of 140 stands/sq.m at DS. Table 2 shows speargrass density range and covered area. Speargrass density range of 101 – 150 stands/sq.m had the highest coverage of 57.60% (231742.71 sq.km) of the studied area. Speargrass density range of 151 - 200 stands/sq.m covered 29.10% (117075.48 sq.km) of surveyed area, while speargrass density of > 250 stands/sq.m had the lowest coverage of 0.6% (2439.36 sq.km) of the surveyed area in 2016.

DISCUSSION

Naturally-evolving weeds interact with, and are influenced by, cultural practices which invariably determine their survival and dynamism (Al-Kaisi *et al*. 2005; Carter and Ivany, 2006; Sosnoskie *et al*. 2006; Aluko *et al*. 2015; Nichols *et al*. 2015; Ramesh, 2015; Matloob *et al*. 2015). This probably accounts for dominance of annual broadleaf weeds in respondent farmers' fields. The predominance of annual broad leaf weeds might be due to continuous cropping of the land and short life span of the weeds. According to Streit *et al*. (2003), annual broadleaf weed species tend to adapt better to frequently disturbed habitats and are therefore more abundant in conventional tillage systems.

The identification of speargrass as a difficult –to-control weed or noxious weed by farmers in these agro-ecologies confirmed the ranking made by Holm et al. 1977. This might have resulted from the frequency of land cultivation with its attendant fragmentation of speargrass rhizomes, dispersal and re-infestation of the farmlands over other identified annual weeds. Thus, cultural practices in the agro-ecozones under the study contributed to the endemic status of speargrass as 60% and 50% of the farmers in the agro-ecologies (DS and SGS) adopted manual weeding (hoe-weeding and slashing). In many cases, weed endemic status may also arises because of lack of specific parasites or herbivores i.e. 'natural enemies', which gives them an advantage over crops or native flora (Naylor and Lutman, 2002). This is in agreement with the findings of Macak *et al*. (2005), that rich ecological biodiversity prevents the dominance of few problematic weeds. Although, speargrass grows on soils with wide range of nutrients, moisture content and pH, lack of competition from other plant species with speargrass, especially on marginal soils, enhances its dominance (Santoso *et al*. 1997). The presence of few annual weed species (DS 10 weed species and SGS 7 weed species) identified on farmers' fields reduced competitions with speargrass, especially in ecologies that are prone to incessant bush burning.

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Burning of speargrass induces sprouting and flowering, which in turn results in the production of viable seeds and eliminates other weed competitors, thereby consolidating it persistence as most potential competitors are lost to fire. Speargrass is a perennial weed that remains persistent with underground vegetative rhizomes that are less affected by burning. Rhizomes remain vegetative during the dry season after the senescence of other annual weed species, thereby reducing off-season competitions and enhancing it invasiveness.

Manual weeding method generally adopted by farmers in these study areas, consequentially increase the speargrass density and invasiveness in the agro-ecologies. Manual weeding (slashing and hoe weeding) break rhizome apical bud dominance and induces bud regeneration to give auxiliary shoots at stem nodes in speargrass. The frequency of manual weeding thus leads to the sprouting of more auxiliary shoots. This may be implicated for the shift in weed flora composition in respondent farmers' fields in favour of speargrass. This is in line with the fact that cultural practices among other factors influence weed flora dynamics and density in agro-ecologies (Al-Kaisi *et al*. 2005; Carter and Ivany, 2006; Sosnoskie *et al*. 2006; Aluko *et al*. 2015; Nichols *et al*. 2015; Ramesh, 2015; Matloob *et al*. 2015). In the face of increasingly limited farmland and pressure from urbanization, farmers may be restricted to continual cultivation of such infested farmland.

Timely intervention of herbicides for weed management has given positive results especially on large-scale crop production (Chikoye *et al*. 2004). However, the attempt made by farmers in the use of herbicides for speargrass management may not give positive results as it requires regimented herbicide application programme of which farmers lack the technical know-how. This may account for the use of manual weeding among farmers in the agro-ecologies. Suppressing speargrass with herbicides should follow a routine weed management programme with the right choice of herbicide. The low adoption of herbicides for weed control by respondent farmers in the study areas may also be due to limited resources and small farm size. Speargrass invasiveness in farming communities under study might reduce crop yield and threaten farmers' livelihood and food security if not properly managed.

CONCLUSION

Speargrass remain a noxious weed in farmers' in Derived and Southern Guinea savanna agro-ecologies. The manual weed control method (slashing and hoe-weeding) might have influenced speargrass invasiveness in these agro-ecologies. Derived savanna had more speargrass density and geographical range of invasiveness than Southern Guinea savanna. This might be due to differences in locations. Cultural practices and minimal competition from other weed species might have influenced high speargrass density and invasiveness in farmers' field. This may impact negatively on crop productivity, food security and livelihood of the people in the agro-ecologies.

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APPENDIX

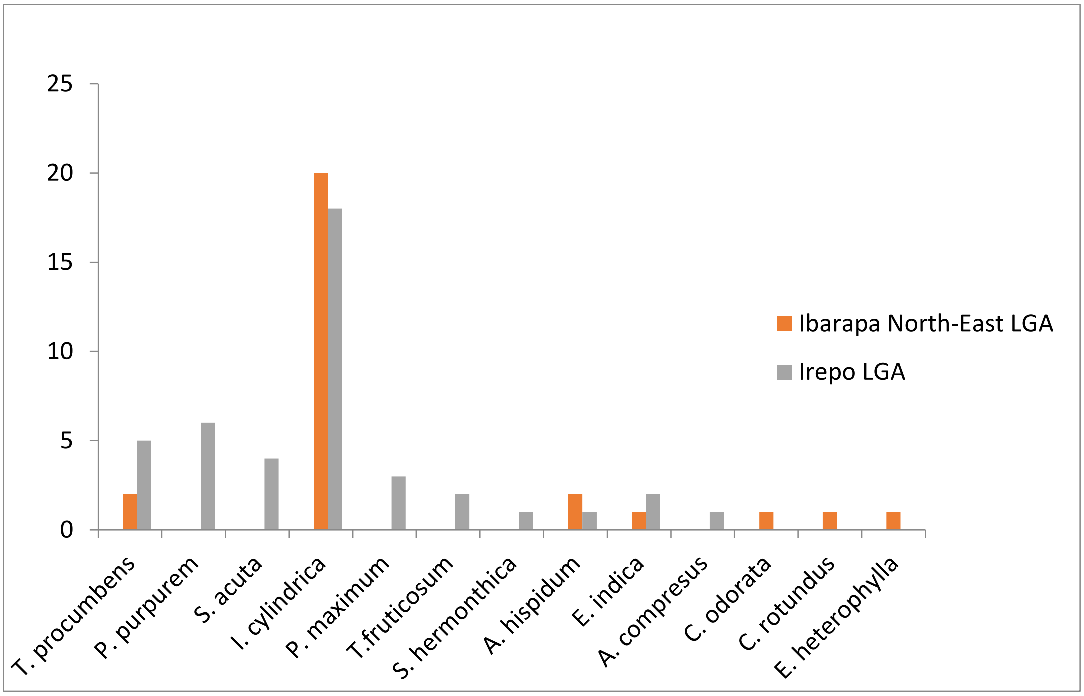

Figure 2: Weed flora composition in respondent farmers' fields in Ibarapa North-East LGA (Derived Savanna) and Irepo LGA (Southern Guinea Savanna)

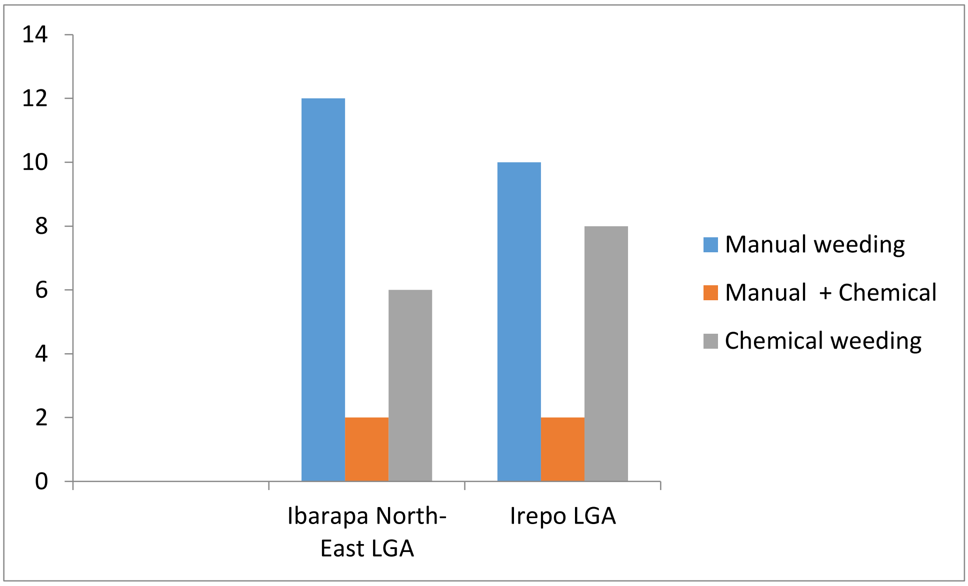

Figure 3: Weed control methods adopted by respondent farmers in Derived savanna and Southern Guinea Savanna.

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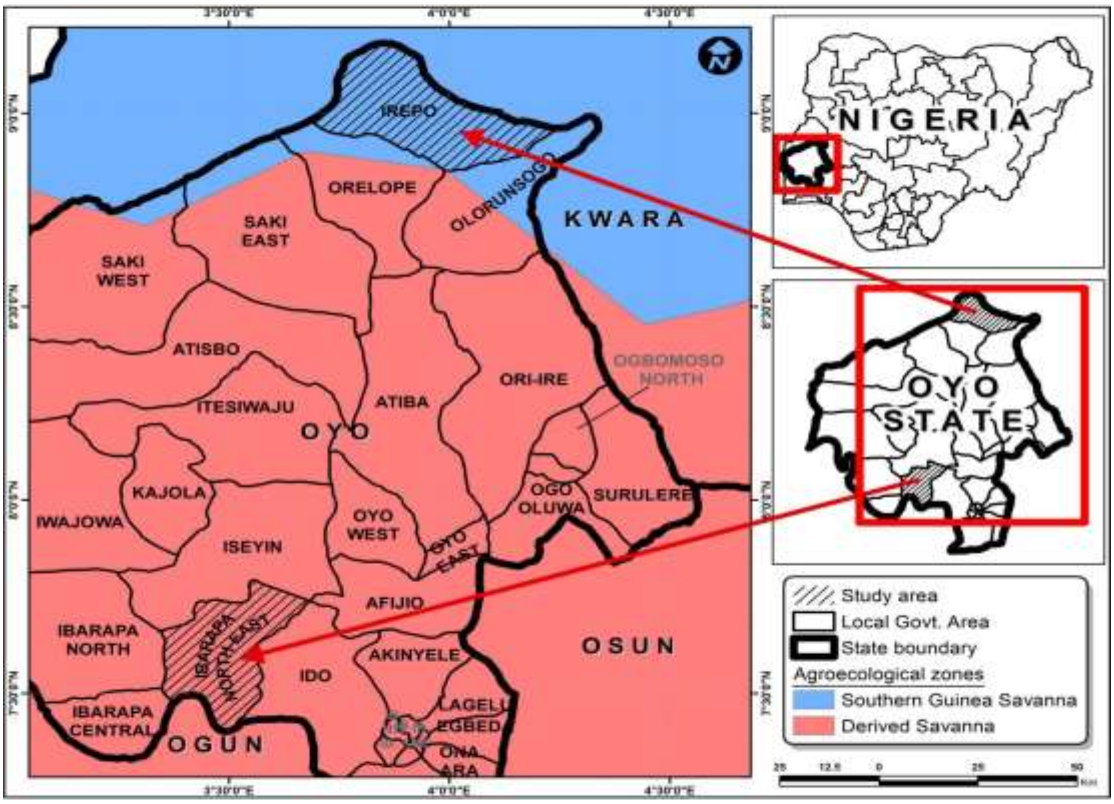

Figure 4: Shaded portions represent the LGAs of study in Oyo State.

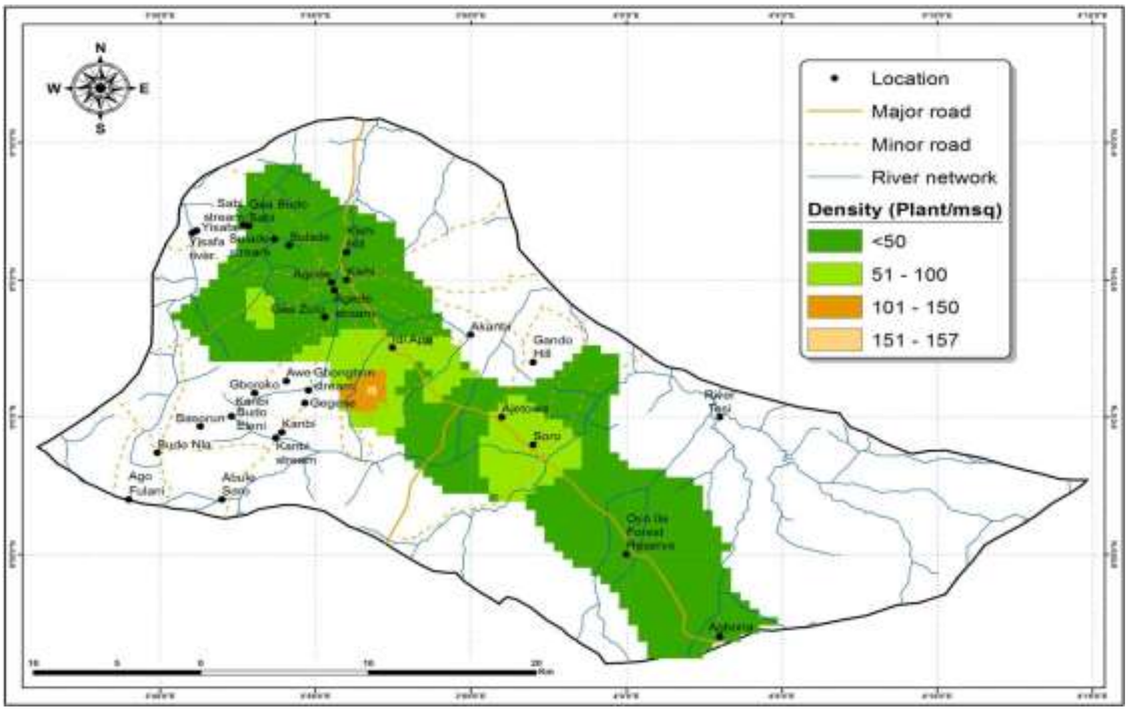

Figure 5: Speargrass density range in Southern Guinea Savanna of Nigeria in a survey conducted in 2016

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Table 1: Speargrass density range and land coverage in SGS

Density	Area (m^2)	% Area covered
<50	288066.02	79.8
51 - 100	67153.28	18.6
101 - 150	5469.28	1.5
151 - 200	303.85	0.1

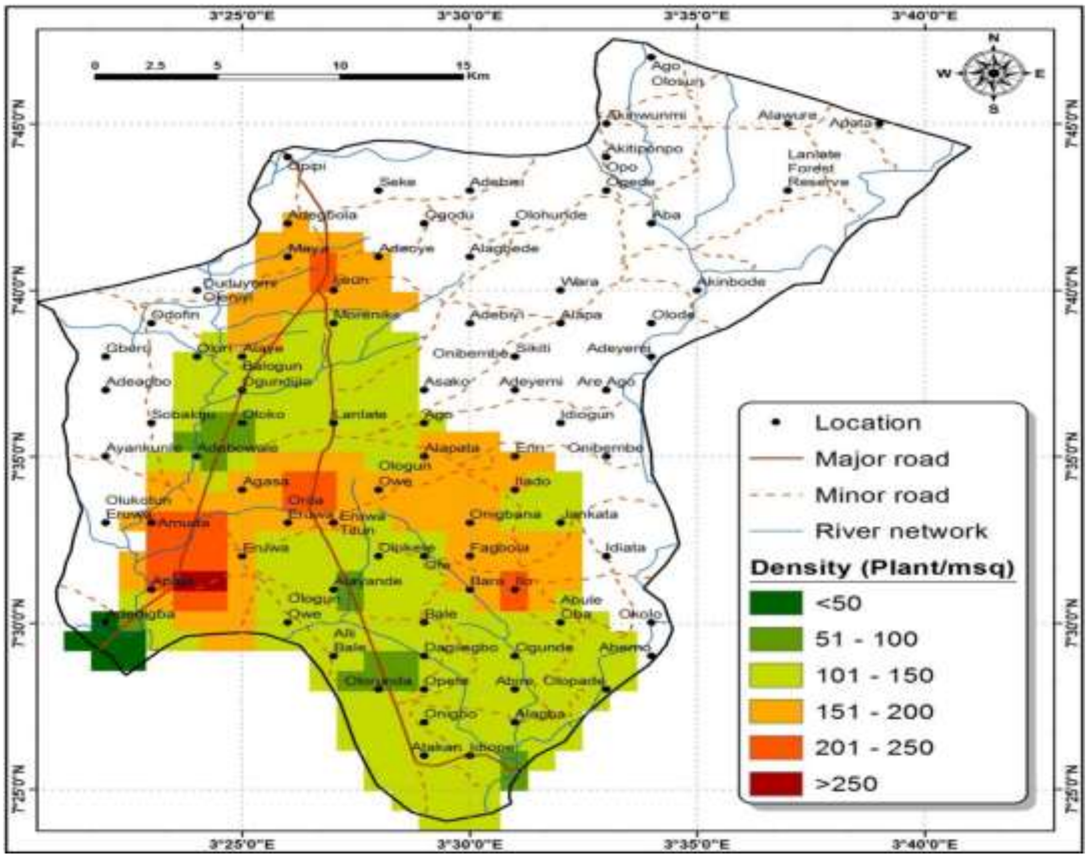

Figure 6: Speargrass density range in Derived savanna in a survey conducted in 2016

Table 2: Speargrass density range and invaded area in Ibarapa North-East LGA (Derived savanna).

Speargrass density range	Area (Sq.km)	Area covered %
<50	7318.54	1.8
51 - 100	19515.14	4.8
101 - 150	231742.71	57.6
151 - 200	117075.48	29.1
201 - 250	24392.04	6.1
>250	2439.36	0.6

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