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Influence of Nitrogen fertilizer on kenaf performance and weed suppression

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Abstract: *Crop-weed competition may be critical in low fertility soil. A study was conducted at the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan to determine the rate of nitrogen fertilizer for kenaf growth and weeds suppression. The experiment was arranged in Randomized Complete Block Design with six treatments viz. 0 N kg ha^{-1} weed-free, 0 N kgha^{-1} weedy control, 60, 80, 100 and 120 N kg ha^{-1} replicated three times. Results showed that core fibre yield was highest in 60 N kgha^{-1} and 80 N kgha^{-1} plots in 2013 and 2014 respectively. Conversely, weedy control accounted for about 51% and 36% reduction in core fibre yield in 2013 and 2014 respectively. Maximum bast fibre was recorded in plots treated with 120 N kgha^{-1} and 100 N kg ha^{-1} in 2013 and 2014 correspondingly. However, reduction in bast fibre of 46% and 52% were recorded in weedy control plots in 2013 and 2014 respectively. Highest capsule/plant was reported in plot treated with 60 N kgha^{-1} and 80 N kgha^{-1} in 2013 and 2014, respectively. There was about 40% and 55% reduction in capsule/plant in weedy control plots compared to weed-free control and average from N treated plots in both years. 60 N kg.ha^{-1} plots gave the highest seed yield/hectare in both years of the trial. Conversely, weedy control gave the lowest seed yield/ha. Weedy control plots had maximum weed weight at seed harvest in both years of the study. Negative correlation between weed dry weight at 4 WAP and plant height at 12 WAP (-0.54 at $P \leq 0.01$), indicated consequential reduction in kenaf growth and components yields. N fertilizer applied at 60 – 80 kg/ha improved kenaf performance and reduced weed biomass. Anticipation of early weed control in low N sandy soil is vital for kenaf growth. Supplementary mechanism of weed suppression in kenaf may be allelopathy.*

Keyword: *weed weight, weed control, N fertilizer and kenaf components yield*

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I Introduction

Kenaf is a fibre crop that grows on wide range of soil (Dempsey, 1975). Soil nutrient, especially nitrogen is important for crop plant growth and yield. This can be limited in most tropical soil as they are poorly formed and over utilized due to continuous cropping and soil nutrient mining with little or no management practices. The initial interest in kenaf in the U.S.A was as a domestic supply of cordage fibre as a jute substitute in the manufacturing rope, twine, carpet backing and burlap (Webber and Bledsoe, 1993). Kenaf was recognized in Malaysia as a potential alternative fibrous material for the production of panel product such as fibre and particle boards (Abdul-Khalil *et al*., 2010). Core fibre is marketed for animal bedding, cat litter, poultry litter, as an extrusion aid in plastic on industrials absorbent (oil spill cleanouts) a filter medium for fruit juice, as an additive in drilling mud and in "lite" bread dough and for manufacture of acoustic tiles (Ramasivamy and Boyd, 1994; Taylor, 1992). In Nigeria, kenaf leaves form part of diets for the northerners aside cordage production. Recently, it's inclusion as one of the national commodity crops further propelled research into kenaf value addition for foreign earnings.

Kenaf grows better on well drained, fertile soil with a neutral soil pH value, which gives the best result (Dempsey, 1975). However, proper fertility maintenance, especially supplemental nitrogen application may be necessary to optimize kenaf yield. As the result of the inherent differences in soil type with respect to soil fertility, soil texture, organic matter, and pH, there is a wide range of reported responses of kenaf plant to Nitrogen fertilizer applications (Webber, 1996; Adamson *et al*., 1979; Joyner *et al*., 1965; Zainul and Mansur, 2001; Othman *et al*., 2006). However, N application with phosphorus (P) at the rate of 100 N: 200 P kg ha^{-1} showed significant positive effects on yield and growth of kenaf plant (Zainul, 2004).

Weed infestation is one of the major problems in kenaf production. Weed competes with field crops for soil nutrients, water and air. They overtake the crop thereby intercept light, which results into retarded growth and yield reduction. Weed also harbours diseases and pests thereby reducing yield and quality of crops. Kenaf production may be critically reduced by weed infestation when soil nutrients are not sufficient for rapid initial plant establishment and fast growth for weed smothering. Control of weeds may take different forms with attendant shortcomings. This study aimed at ameliorating soil fertility with nitrogen fertilizer for remunerative cultivation of kenaf and season-long weed control.

II Methodology

The experiment was carried out on the Research Farm of the Institute of Agricultural Research and Training (latitude 7^0 22` N and longitude $3^0$ 05` E), Moor Plantation, Ibadan in 2013 and 2014 rainy seasons. Weed flora composition of the site was determined by taking five quadrant samples randomly. The weeds were identified before land preparation.

Land preparation and planting

The experiment was established on sandy soil of gentle slope of about ten years of continuous cropping activities. The land was ploughed and harrowed. Ten soil samples were taken randomly from the field at a depth of 30 cm; aggregated and subjected to physico-chemical analysis. The plot size was 3 x 3 m. Kenaf variety- Ifeken DI 400 was planted using a spacing of 50 x 10 cm at 2-plants/stand. NPK (20:10:10) fertilizer was applied 4 weeks After planting (WAP) at the rates of 0 kg N ha^{-1} (weedy and weed-free control treatments), 60 kg N ha^{-1}, 80 kg N ha^{-1}, 100 kg N ha^{-1} and 120 kg N ha^{-1}. These were replicated three times and arranged in Randomized Complete Block Design (RCBD).

Data collection

Five kenaf plants were randomly tagged per plot for data collection. Data were collected on kenaf agronomic traits and weed growth. Plant height was measured using graduated meter rule from the butt to the plant tip (cm) at 4, 6, 8, 10 and 12 WAP and at seed harvest using the meter rule. Kenaf stem butt (cm) was taken at 6, 8, 10 and 12 WAP with Venier caliper. Number of leaves at 6, 8, 10 and 12 WAP was determined by counting the leaves on five tagged plants. Kenaf core and bast fibre yields (kg ha^{-1}) were determined after retting and drying at 12 WAP by weighing with sensitive weighing scale. Kenaf capsules/plant was taken at maturity by counting the number of kenaf capsules on five tagged plants. 100-seed weight was determined by weighing with sensitive scale Model AND 2000. Weed dry weight (4 WAP and kenaf seed harvest) was determined with quadrant (1 m^2) sample placed in each plot. The weeds were identified and weed fresh biomass was oven dry at 80^0C for 48 hrs. Data were subjected to Analysis of variance and means were separated using the Least Significant Difference (LSD). The relationship between parameters was determined.

III Results

Tectonia diversifolia, *Panicum maximum*, *Maricus* spp., *Axonopus compressus*, *Talinum fruticosum* and *Tridax procumbens* were identified as predominant weed spp before land preparation. The result from the initial soil physical and chemical analyses revealed that the soil is sandy with low nitrogen level (0.021 N $mgkg^{-1}$), hence there was need for N fertilization to enhance sustainable crop production (Table 1).

Tallest kenaf plants were found in plots treated with 120 N kg ha^{-1} and 60 N kg ha^{-1} in 2013 and 2014 respectively. There were comparable plant height across fertilizer treated plots in both years of the study. However, weedy control plots gave the shortest plants in both years of the trial. Kenaf had thickest butt in plots treated with 60 N kg ha^{-1} in both years of the study with similarity across fertilizer treated plots. Although, weed-free plots produced thick butt similar to 100 and 120 N kg ha^{-1} in 2013 and 100 N kg ha^{-1} in 2014. However, weedy control plots had the thinnest butt girth in 2013 and 2014. Kenaf leaf number was highest in the plot treated with 100 N $Kgha^{-1}$ in both years of the trial. This was similar to the number of kenaf leaves in other N fertilized plots. However, lowest number of leaves was recorded in weedy control plots in both years of the trial (Table 2).

Core fibre yield was highest in 60 N $kgha^{-1}$ and 80 N $kgha^{-1}$ plots in 2013 and 2014, respectively. This was comparable with core fibre yields across the fertilizer treated plots in both years of the trial. Although weed-free plot had comparable core yield with 80 N $kgha^{-1}$ plot in 2013; 60 N $kgha^{-1}$ and 120 N kg ha^{-1} in 2014. However, there was significant reduction in core fibre yield in weedy control as the lowest was recorded in 2013 and 2014, respectively. Maximum bast fibre was recorded in plots treated with 120 N $kgha^{-1}$ and 100 N kg ha^{-1} in 2013 and 2014 respectively. These were similar across fertilizer treated plots in both years of the experiment. Weed-free control plots produced comparable bast fibre with plots treated with 80 N kg ha^{-1} and 60 N kg ha^{-1} in 2013 and 2014 correspondingly. Weedy control gave the minimum bast fibre in both years of the study. Highest number of capsule/plant was reported in plot treated with 60 N kg ha^{-1} and 80 N kg ha^{-1} in 2013 and 2014 respectively. On the other hand, weedy control plots had the lowest number of capsule/plant in both years of the study. 100-seed weight was similar across the treatments in both years of the study (Table 3).

Figure.1 shows the seed yield/hectare as influenced by the N rates. 60 N $kgha^{-1}$ gave the highest in both years. Conversely, weedy control gave the lowest seed yield/ha. Figure 2 and 3 show the weed weight at 4 WAP and at kenaf seed harvest in both years of the experiment. There was more weed in 2014 than 2013 at 4 WAP (Fig 2). Weedy control plots had the maximum weed weight at seed harvest in both years of the study.

There was significant negative correlation between weed dry weight at 4 WAP and plant height at 12 WAP (-0.54 at $P \leq 0.05$). Butt girth had significant negative correlation with weed dry weight at harvest (-0.58 at $P \leq 0.01$). On the other hand, plant height had significant positive relation with butt girth (0.65 at $P \leq 0.01$), kenaf capsule (0.60 at $P \leq 0.01$) and seed yield/ha (0.71 at $P \leq 0.001$). Increase in butt girth had a significant and direct relationship with bast fibre (0.73 at $P \leq 0.001$), core fibre yield (0.52 at $P \leq 0.05$), kenaf capsule (0.83 at $P \leq 0.001$) and seed yield (0.60 at $P \leq 0.001$) (Table 4).

The predominant weed species at the experimental site were the broad leaf weeds with few grasses and sedges. These were mostly annual weeds. *Maricus* spp., *Talinum fruticosum*, *Oldenlandia corymbosa*, *Panicum maximum*, *Physalis micrantha* and *Tridax procumbens* were the dominant weed spp found in all the treated plots except weed-free control (Table 5).

IV Discussion

The nitrogen content of the experimental site revealed that N was critically low and cannot support optimum crop productivity. This resulted from poor soil fertility amelioration, continuous crop and vegetation nutrient uptake over the years. Nevertheless, kenaf has been found to thrive on wide range of soils. Weed infestation was inadequately investigated as a barrier to kenaf production in such low nutrient soils. The reduction in crop performance is not limited to depleted soil nutrients, but weed infestation is found to reduce crop growth and yield through soil nutrient and space competitions. According to Sweeney *et al*., (2008) and Khan *et al*., (2012), topdressing with N is associated with efficient weed management because higher growth of rice provides better weed control. Hence, N applied at different rates in the study gave kenaf plant better relative growth and components yield than either weed-free or weedy controls. This is in line with the positive response of kenaf to N fertilizer as reported by Adamson *et al*., (1979) and Joyner *et al*., (1965) on sandy soil. This might have enhanced biomass accumulation and better weed smothering. In crop - weed competition, taller crop plant spp intercept light and smother weed spp in competition. N application was found to enhance growth of kenaf plants. This evidently reduced weed competition across the N fertilizer treated plots.

Cultural practices such as plant spacing, fertilizer application, and pest management have been reported to enhance kenaf performance (Agbaje *et al*., 2008). Hence, N application in the study gave higher kenaf plant height and stem butt which are indices for components yields such as fibre and seed yield. Plant height was found to have significant positive correlation with bast fibre yield, core fibre yield, capsule number/plant, and kenaf seed yield. Negative correlation between weed dry weight at 4 weeks after planting (WAP) and plant height at 12 WAP indicated a critical interaction of weeds with kenaf growth at early stage. Invariably, negative correlation of weed dry weight at 4 WAP to plant height at 12 WAP had inverse relation with kenaf components yield.

Higher weed incidence at 4 WAP and seed harvest in 2014 evidently reflected higher accrual of weed biomass from N applied than previous year. Burgos *et al*., (2006) stated that N availability for use by rice cultivars is further reduced by competition with weedy rice, which has been observed to accumulate N fertilizer and efficiently transform it into biomass production. This further confirmed the fact that competition for soil nutrients in crop-weed competition may shift at the detriment of economic crop production.

On the other hand, comparatively high weed dry weight in weedy control plots indicated better adaptation of weeds to low soil nutrients and competition with kenaf plant for the marginally available soil nutrients. Akobundu (1987) mentioned this as an adaptive trait for weed survival in marginal soils. Hence, reduction in kenaf agronomic traits measured in weedy control plot was an indication of critical weed competition with kenaf plant relative to weed-free control plots. According to Agbaje *et al*., (2008), management practices rather than variety influenced total dry matter yield, bast fibre and core yields. This also accounted for marked reduction in kenaf seed yield.

The predominant weeds were the broad leaves with few grasses and sedges. These were identified mostly as annual weeds. Cultural practices might have influenced the shift in weed flora composition in favour of annual weeds as observed in the study. Continuous cultivation prevents the survival of perennial weeds. The weedy control had the highest number of weed flora composition and weed biomass. The emergence and frequency of *Maricus* spp., *Talinum triangulare Oldenlandia corymbosa, Panicum maximum, Physalis micrantha* and *Tridax procumbens* throughout the study is indicative of their dominance in the agroecology. This may be due to their dispersal mechanisms and relatively high seed density in seed bank. Cultural practices especially tillage, weeding methods and soil fertility status might have influenced their survival and frequency (Akobundu, 1987).

V Conclusion

Weed infestation in critically low N sandy soil may account for kenaf yield reduction of about 49% in bast fibre yield, 43.50% in core fibre yield and 51.50% in seed yield. Weed control should be anticipated in low N soils earlier than 4 WAP to prevent reduction in kenaf growth and yield. This will prevent weed competition and accrual of weed biomass at the detriment of kenaf productivity. Positive response of kenaf to N fertilizer was evident in the study. 60 - 80 N kg ha^{-1} gave optimum kenaf component yield. Excess N from higher doses on sandy soil may be lost through volatilization, leaching or accumulated as weed biomass.

Table 1: Physicochemical analysis of the soil sample before planting

Property	Value
pH	6.09
Organic carbon (mg kg^{-1})	0.21
Nitrogen (mg kg^{-1})	0.021
Available phosphorus (cmol kg^{-1})	5.63
Exchangeable Na (cmol.kg^{-1}	0.43
Exchangeable K (cmol.kg^{-1})	0.22
Exchangeable Ca (cmol.kg^{-1})	2.87
Exchangeable Mg (cmol.kg^{-1})	2.52
% sand (g/kg)	82.8
% silt (g/kg)	4.8
% clay (g/kg)	12.4

Table 2: Effect of N fertilizer and weed interference on kenaf agronomic traits

Treatments	Plant height 12 WAP (cm)		Butt girth 12 WAP (cm)		No. of leaves 12 WAP	
	2013	2014	2013	2014	2013	2014
Weed-free	184.56b	201.00b	1.85b	1.79b	66.00b	67.00b
Weedycontrol	154.29c	164.80c	1.38c	1.41d	43.00c	48.00c
60 kg N ha^{-1}	216.71a	228.60a	2.29a	2.14a	87.00a	86.00a
80 kg N ha^{-1}	202.14ab	226.47ab	2.18a	2.11a	85.00a	87.00a
100 kg N ha^{-1}	195.80ab	214.73ab	1.99ab	1.97ab	96.00a	91.00a
120 kg N ha^{-1}	217.08a	206.83ab	2.09ab	2.01a	85.00a	89.00a
LSD	27.24	23.03	0.31	0.29	12.24	14.58

Means with the same letters in the same column are not significantly different

Table 3: Effect of Nitrogen fertilizer and weed interference on kenaf yield parameters

Treatments	Core yield (kg ha^{-1}		Bast fibre yield (kg ha^{-1})		Kenaf capsules/plant		100-seed weight	
	2013	2014	2013	2014	2013	2014	2013	2014
Weed-free	6308.45b	6478.54b	4185.50b	4012.76b	18.00bc	21.00b	2.61a	2.74a
Weedy control	3419.54c	4501.59c	2524.34c	2253.65c	11.00c	12.00c	2.56a	2.50a

60 N Kg ha^{-1}	7532.48a	7045.53ab	4656.40a	4454.65ab	31.00a	29.00a	2.71a	2.69a
80 N Kg ha^{-1}	6952.87ab	7293.64a	4589.80ab	4854.87a	28.00a	26.00ab	2.77a	2.79a
100 N Kg ha^{-1}	7152.65a	7212.43a	4760.70a	4921.65a	25.00ab	25.00ab	2.79a	2.88a
120 N Kg ha^{-1}	6989.46a	6932.56ab	4858.20a	4753.75a	26.00ab	25.00ab	2.61a	2.91a
LSD ($P \leq 0.05$)	671.91	676.87	427.38	445.60	7.63	6.74	0.51	0.63

Means with the same letters in the same column are not significantly different

Table 4: Relationship between kenaf traits and weed growth

Traits	Plant height	Stem butt diameter	Leaf number	Bast yield/ha	Core yield/ha	Capsule/plant	Seed/ha	Weed dry weight 4WAP	Weed dry weight at harvest
Plant height 12 WAP	-								
Stem butt diameter	0.65**	-							
Leaf no/plant	0.86***	0.63**	-						
Bast yield/ha	0.75**	0.73 ***	0.56*	-					
Core yield/ha	0.71**	0.52*	0.53*	0.89***	-				
Capsule/plant	0.66**	0.96***	0.59**	Ns	ns	-			
Seed/ha	0.71***	0.84***	0.54*	Ns	0.54*	0.85***	-		
Weed dry weight 4WAP	-0.54*	-0.48	-0.43	-0.48	ns	Ns	ns	-	
Weed dry weight at Harvest	Ns	-0.58 *	ns	Ns	ns	Ns	ns	ns	-

* = P≤0.05, ** - P≤0.01, *** - P≤0.001, ns- not significant

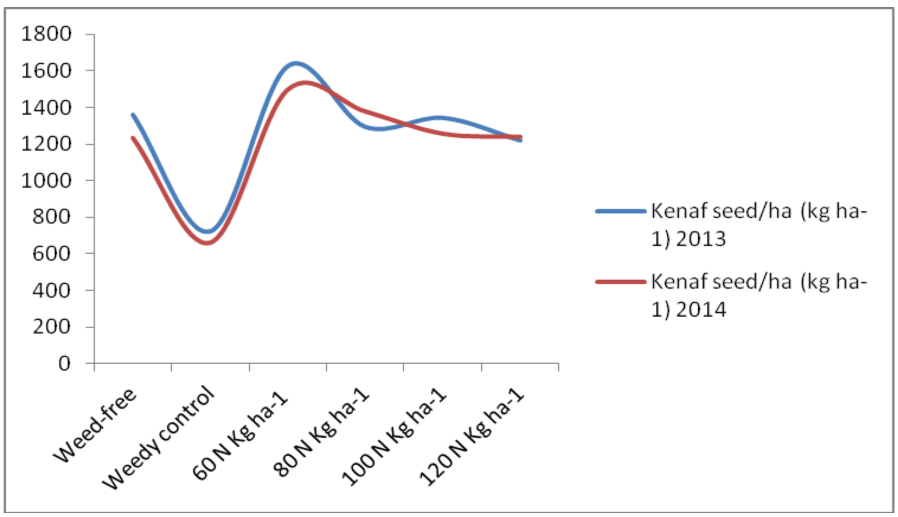

Fig. 1: Kenaf seed yield/ha as influenced by N fertilizer and weed infestation

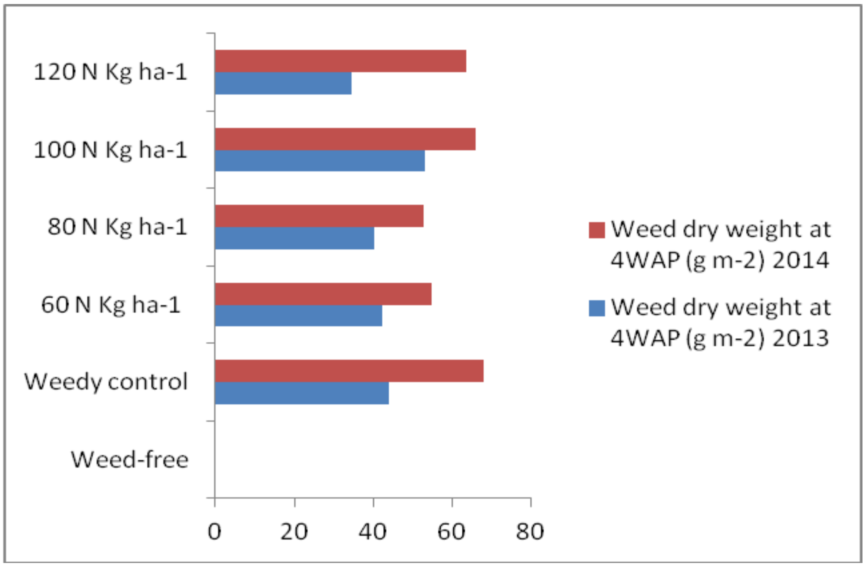

Fig. 2: Weed dry weight at 4 WAP before first weeding

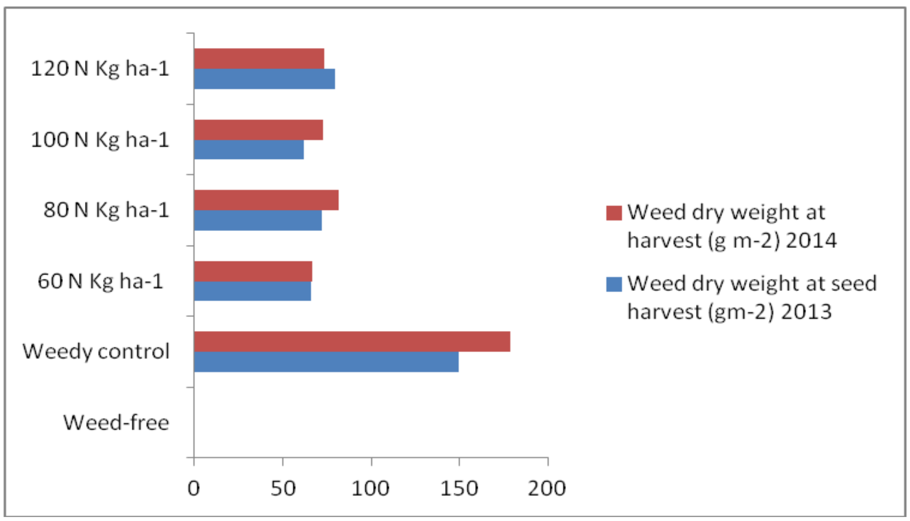

Fig. 3: Treatments effects on weed dry weight at kenaf seed harvest

Table 5: Cumulative weed flora composition of the experimental site

Weed species	Morphology	Lifecycle	4 WAP (Before 1st weeding)						12 WAP (At fibre harvest)					
			0NL (weed free)	0NL (weedy)	60 (kg N ha^{-1})	80	100	120	0NL (weed free)	0NL (weedy)	60 (kg N ha^{-1})	80	100	120
Agerantum conyzoides	Bl	A	-	-	-	-	-	-	-	-	+	-	+	+
Chromoleana odorata	Bl	P	-	+	+	+	-	-	-	-	-	-	-	+
Commelina spp.	Sp	P	-	+	+	+	-	-	-	+	+	+	-	-
Euphobia heterophylla	Bl	A	-	-	-	-	-	-	-	-	+	+	-	-
Oldenlandia corymbosa	Bl	A	-	-	-	-	-	-	-	+	+	+	+	+
Panicum maximum	G	A/P	-	-	-	-	-	-	-	+	+	+	+	+
Paspalum orbiculare	Bl	B	-	-	-	-	-	-	-	+	+	+	+	-
Pennisetum purpureum	G	P	-	+	+	+	+	+	-	-	-	-	-	-
Physalis micrantha	Bl	B	-	-	-	-	-	-	-	-	+	+	+	+
Pueraria phaseoloides	Bl	A	-	-	-	-	-	-	-	+	-	-	-	-
Mariscus spp.	Sg	P	-	+	+	+	+	+	-	+	+	+	+	+
Talinum fruticosum	Bl	A	-	+	+	+	+	+	-	+	+	+	+	+
Tectonia diversifolia	Bl	A	-	+	+	-	+	-	-	-	-	-	+	-
Tridax procumbens	Bl	A/P	-	+	+	+	+	+	-	+	+	+	+	+

Legends: 0NL - zero level of nitrogen, Bl - Broad leaf, Sp - Spiderwort, G - Grass, Sg - Sedges A - Annual, B - Biennial, P - Perennial, A/P- Annual/Perennial, +ve- Presence of weed, --ve - Absence of weed.

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