https://dx.doi.org/10.4314/ijs.v26i3.7

PLANTING DENSITY EFFECT ON GROWTH, DRY MATTER ACCUMULATION AND WEED CONTROL EFFICIENCY OF *Indigofera hirsuta* Linn. IN IBADAN NIGERIA

Adelere, Y. M. and Awodoyin, R. O.*

Department of Crop Protection and Environmental Biology, Faculty of Agriculture,
University of Ibadan, Nigeria.
*Corresponding Author's Email: frawodoyin@gmail.com

(Received: 25th April, 2024; Accepted: 25th November, 2024)

ABSTRACT

A field experiment was conducted at the Crop Garden, Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria to investigate the effect of planting density on the performance of *Indigofera hirsuta* and its ability to suppress weeds. Seeds sown at 1 cm soil depth were spaced at 20 cm inter-row and varying intra-row spacings: 10, 20, 40, 80 and 160 cm to have densities 50, 25, 12.5, 6.25 and 3.13 plants/m^2, which are equivalent to 500,000, 250,000, 125,000, 62,500 and 31,250 plants/ha, respectively. Plots where *I. hirsuta* were not planted served as control. The experiment was conducted in two trials in a randomised complete block design replicated three times with the five densities and control randomly allocated to plots in each block. The plant height (PH) in cm, stem diameter (SD) in cm, shoot dry weight (SDW) in kg and weed dry weight in kg were measured at 14 weeks after planting and the treatments compared using one-way ANOVA. The PH of *I. hirsuta* at density 50 plants/m^2 (105.0 – first trial and 107.0 – second trial) were significantly higher than the heights recorded in other test densities. The SD and SDW at density 3.13 plants/m^2 (0.97 cm and 0.38 kg – first trial; 0.93 cm and 0.38 kg – second trial) were significantly higher than the SD and SDW recorded in other test densities. The weed dry weight on 50 plants/m^2 plot (0.55 kg and 0.59 kg in the first and second trial, respectively) was significantly lower than those on the other plots. *Indigofera hirsuta* proved effective in suppressing other weeds, which increased with increasing density (WCE = 23.37 and 22.51% at 3.13 plants/m^2; 70.11 and 69.11 at 50 plants/m^2 in the first and second trial, respectively). The weed suppressive ability of *Indigofera hirsuta* is attributed to competition for light due to its rapid growth and spreading habit.

Keywords: Live mulch, cover crop, sown fallow, spacing, weed control, *Indigofera hirsuta*.

INTRODUCTION

Weeds are among the most detrimental threats to crop production especially in agricultural systems that make use of little or no chemicals. Cover crops may be relatively effective in suppressing weeds in such agricultural systems (Uchino *et al*., 2011). Some cover crops have been successfully utilized to suppress weeds, which include *Secale cereal* L., *Hordeum bulbosum* L., *Trifolium repens* L., *Mucuna pruriens* (L.) DC and *Vigna unguiculata* (L.) Walp. (Ross *et al*., 2001; Adeniji *et al*., 2022a). Cover crops do not only provide cover over the soil, they are also usually grown for various ecological reasons including weed control (Caamal-Maldonado *et al*., 2001; Sarrantonio and Gallandt, 2003; Adeniji *et al*., 2022b). Leguminous cover crops also play important role in suppressing weeds and, if nodulating, fix atmospheric nitrogen into the soil (Egberongbe *et al*., 2017). They provide various benefits to an agricultural system when cultivated as live mulches, including nutrients recycling, enhancing soil structure, and controlling weeds and pests (Hartwig and Ammon, 2002).

The mechanism of suppressing weeds by cover crops is by competing for resources with the weeds and inhibiting the growth of weeds through allelopathic interactions (Dorgra *et al.,* 2010). Cover crops are vigorous and fast-growing, thus competing strongly with weeds for space, light, nutrients and water to effectively suppress growth of weeds. The canopy closure created by cover crops prevents the growth of emergent weeds by putting them in the shade (Hartiwig and Ammon, 2002), and may suppress the growth of weeds by 80-100%. Another technique of suppressing weeds by cover crops is the release of chemicals that have the potential to inhibit the growing process of other plants, a process called allelopathy (Adeniji *et al*., 2023). The substances called allelochemicals may be in the form of exudates secreted by the living plant roots, leaves and shoot or release from plants decaying residues. The allelochemicals that are strong enough to be considered as natural herbicides can retard seeds germination, seedlings growth and young plants growth. It can also cause damage to roots and may even cause death of plants. Allelopathy has been documented to be strong enough to control weeds in agricultural systems (Boydston and Hang, 1995).

Cover crops made up of legumes also have a significant consequence on soil conservation and planting them may serve as soil management technique. *Indigofera hirsuta* is a leguminous cover crop that has been reported to grow rapidly and closely to form very thick canopy that could prevent rain from dislodging soil particles (Hartwig and Ammon, 2002). Zaman *et al.* (2020) posited that *I. hirsuta* as a cover crop for sustainable agriculture, had several advantages including high biomass production, improved soil fertility, and weed suppression. Garhwal *et al.* (2018) in their evaluation of the potential of *I. hirsuta* as a green manure crop in the Indian Himalayan region found that the crop had high nutrient content and could improve soil fertility, thus recommended it as a useful addition to crop rotations. Also, Ali *et al.* (2019) reported that *I. hirsuta* had high biomass production and could effectively suppress weeds, making it a promising option for sustainable agriculture. Being indigenous legume cover crop, *I. hirsuta* will readily form root nodules to fix atmospheric nitrogen, thus reducing dependence on synthetic nitrogen fertilisers by the farmers. It has many ethnomedicinal uses that vary among tribes, such as anti-snake venom (Muhammad *et al.* 2023). Also, the decoction of leaves and roots are traditionally used to treat gastro-intestinal disorders, inflammation, pain, skin, respiratory and infectious diseases (Germetta *et al.*, 2020).

Planting density is among the most vital elements of production that have an impact on growth of plant and its yield to the greatest extent (Moria *et al.*, 2018). An increase in plant density may result in a reduction in production of individual plants but may increase the yield per unit area and result in rapid cover of the soil. This study investigated the effect of varying plant density on the growth, biomass production and weed suppression efficiency of *Indigofera hirsuta* in Ibadan, Nigeria with the aim of using it in sown fallow for sustainable crop production.

MATERIALS and methods

Study Area

The study was conducted at the Crop Garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. Ibadan is positioned on latitude of 7°26′ N of the Equator, longitude of 3° 54′ E of the Greenwich Meridian, in the forest-savanna transition ecology of Southwestern Nigeria (Awodoyin and Ogunyemi, 2005). The main rock types in Ibadan are basement complex rocks of pre-Cambrian age (Gbadegesin and Olabode, 2000). The height above sea level (a.s.l) ranges from 160 to 275 m. Ibadan is characterised by the West African monsoon, indicating a noticeable seasonal change in wind patterns. Ibadan has an annual average temperature of 27°C while rainfall ranges from 1270 to 1505 mm with 60-80% relative humidity (Gbadegesin and Olabode, 2000; Raheem and Adeboyejo, 2016). The soils of Ibadan are mainly those derived from underlying complex rocks. The soils have more of Egbeda, Iwo, Okemesi and several other series (Smyth and Montgomery, 1962). The vegetation of Ibadan consists of secondary forests and forest-savanna transition, and the land uses include farmlands and bush fallows. Previous areas covered with high forest plant species are now dominated by secondary regrowth and invasive herbaceous species. The invasive weed species include *Andropogon tectorum* Schumach (savanna grass), *Imperata cylindrica* (L.) P. Beauv. in younger fallows and the presence of surviving forest species such as the *Elaeis guineensis* Jacq. in older fallow regrowth (Egbinola *et al.*, 2014).

Planting density effect on the performance and weed-suppressing ability of *I. hirsuta*

The field study was conducted in two trials, with the first trial carried out from June to September 2017 and second trial from October, 2017 to January 2018. There was no need for irrigation during the second trial because the plants had established well before the rain stopped in 2017. An area of land covering 16.5 m × 10 m was marked out. The land was prepared and five test densities were randomly allocated to plots measuring 2 m × 2 m each. Adjacent plots and blocks were separated by 0.5 and 1 m, respectively. The experiment was set up in a randomized complete block design replicated three times. Planting densities were generated based on previous study established that the plant density ranged from 4 to16 plants/m^2. Seeds (n=2) of *I. hirsuta* were sown manually at 1 cm soil depth and 20 cm inter-row spacing, while intra-row spacing varied (10, 20, 40, 80 and 160 cm). A plot in each block without *I. hirsuta* seedlings served as control. The treatments were as follows:

D0 = 0 plants/ha (Control).
D1 = 31,250 plants/ha (3.13 plants/m^2; 20 cm × 160 cm)
D2 = 62,500 plants/ha (6.25 plants/m^2; 20 cm × 80 cm)
D3 = 125,000 plants/ha (12.5 plants/m^2; 20 cm × 40 cm)
D4 = 250,000 plants/ha (25 plants/m^2; 20 cm × 20 cm)
D5 = 500,000 plants/ha (50 plants/m^2; 20 cm × 10 cm)

Plants were thinned to one per hill at 2 weeks after planting (WAP), while weeds in all the plots were removed at 4 WAP by manual hand-pulling. At 14 WAP, five plants were selected randomly from each plot for assessment. The height of the plants was assessed by taking measurement of the main stem from ground to the tip using a meter rule. The diameter of the stem was determined at 2-cm height, using a Vernier caliper. The numbers of branches and leaves were visually counted and recorded. Shoot dry weight was measured using weighing balance. Shoot dry weight was estimated by clipping the plants with secateurs at the soil surface and oven-dried at 80°C to a constant weight. The oven-dried shoots were weighed on a top loading mettler balance (model P1210).

Assessment of weed spectrum

Weed spectrum was assessed by laying one 50 cm x 50 cm quadrat at the centre of each plot, including the control plots, at 14 WAP for assessment and enumeration of weeds to species level using some flora compiled for Nigeria and West Africa (Akobundu *et al*., 2016). All weeds that rooted within the quadrat were identified, counted and clipped at the surface of the soil. The weeds were oven-dried at 80°C to constant weight; and the weight was measured to determine the dry matter. The frequency, density and relative importance value for each weed species were estimated according to previous procedures as highlighted below:

The number of plants of each species recorded in each quadrat was used to calculate the Relative Importance Value (RIV) as:

[(RD + RF)/2] x 100 (Kent and Coker, 1992; Das, 2011; Awodoyin *et al*., 2013),

where RD=Relative Density and RF= Relative Frequency

Absolute Density (D) is the number of individuals of a particular species per unit area.

Relative Density (RD) is the percentage value of density of a weed species relative to the total density of all species.

RD = [(d/D) X 100], where d = the density of a species; D = total density of all species.

Absolute Frequency (F) is the measure of the chance of finding a species within a quadrat. That is, the percentage of number of quadrats that has a particular species in relation to the total number of quadrats laid.

Relative Frequency (RF): The frequency of a species relative to the total frequency of all species.

RF = [(f/F) X 100], where f = frequency of a species; F = total frequency of all species.

The community structure was studied by determining for each route the Shannon-Wiener and Equitability Indices. Also, the ecosystems were compared in pairs based on species composition by determining the Jaccard index of similarity.

The Shannon-Wiener index of species diversity (H^1) was calculated as;

$H^1 = -\sum pi.I\textit{n}pi$; where pi = n/N (Kent and Coker, 1992),

where pi is proportion which is the number of individuals in a species (n) in relation to the total number of all individuals in the community (N), I*n* (natural logarithm) = 2.303 x $\log_{10.}$ The equitability index (J) measures even representation of all species encountered in a community. The value ranges from 0 to 1. The value tends towards one if all species are evenly distributed within the community, that is, H = lnS. Low J values indicate unequal representation (dissimilar abundance) of the species. The species equitability index (J^1) was calculated as:

$$J = H^I/lnS,$$

where H^I is Shannon-Wiener index and S is total number of species in the community.

The Jaccard index of community similarity (SCj) was calculated as;

$$Scj = [w/(A+B)-w] \times 100\ \%,$$

(Spellerberg, 1993)

where; w is the number of common species; A is the number of species in community A and B is the number of species in community B. The value ranges from 0 % (no similarity) to 100% (maximum similarity; same species are in the two communities compared) (Spellerberg, 1993).

Weed control efficiency (%) =

$$\frac{\textit{weed dry weight of untreated plot} - \textit{weed dry weight of treated plot}}{\textit{weed dry weight of untreated plot}} \times 100$$

Das (2011)

RESULTS

Effects of planting densities of *Indigofera hirsuta* on growth and its ability to suppress weeds

The effect of varying densities on the performance of *I. hirsuta* showed that only the plant height was directly related to the density while the stem diameter, number of branches, number of leaves, shoot dry weight and weight of associated weeds were inversely related to the density.

The difference among the mean height of plants at the various densities was significant except between densities 3.13 plants/m^2 and 6.25 plants/m^2, where the plants were shorter than plants in other densities. At density 50 plants/m^2, plant height was the greatest and considerably ($p = 0.05$) higher than plants in other densities. The second trial followed the same trend (Table 1).

Stem diameter decreased as plant densities increased. The stem diameter of the plants also varied among the densities but variations were only significant ($p = 0.05$) among densities 3.13 plants/m^2, 25 plants/m^2 and 50 plants/m^2. The stem diameter of plants at density 3.13 plants/m^2 was considerably ($p = 0.05$) higher than in the other plant densities except density 6.25 plants/m^2. The SD at 25 plants/m^2 and 50 plants/m^2 were significantly lower than other plant density. In the second trial, the stem diameter of plants at densities 3.13 plants/m^2 was considerably ($p = 0.05$) higher, compared to those at other densities except density 6.25 plants/m^2. However, the stem diameter of plants at density 50 plants/m^2 was considerably ($p = 0.05$) lower than plants diameter at other densities (Table 1).

For the first and second trials, the branch number varied significantly ($p = 0.05$) among the plant densities except between densities 6.25 plants/m^2 and 12.5 plants/m^2. The highest number of branch was obtained at density 3.13 plants/m^2, while the least was obtained at density 50 plants/m^2 (Table 1).

In the first trial, the number of leaves at densities 3.13 plants/m^2 and 6.25 plants/m^2 were similar but significantly better than other densities that were also similar (Table 1). However, in the second trial, the leaf number varied considerably ($p = 0.05$) among the densities. Density 3.13 plants/m^2 gave highest number of leaves while density 50 plants/m^2 gave the lowest number of leaves (Table 1).

The variation in the shoot dry weight among the densities was significant in both first and second trials. At density 3.13 plants/m^2, the shoot dry weight was considerably ($p = 0.05$) greater than other densities while the shoot dry weight was the lowest at density 50 plants/m^2 for both first and second trials (Table 1).

The planting density of *I. hirsuta* affected the growth of the associated weeds and yield of *I. hirsuta*. The highest density for weed suppression was D5 (50 plants/m^2) (Table 2). The dry weight of the weeds decreased as the density of *I. hirsuta* increased. The control plots gave the highest weed dry weight in both trials, which were considerably higher than the dry weight of weeds encountered at the varying densities. In the first trial, the dry weight of weeds at densities 3.13 plants/m^2, 6.25

plants/m^2 and 12.5 plants/m^2 were not significantly different. The weed dry weight at 25 plants/m^2 was significantly lower than at other densities except 50 plants/m^2 (Table 2). The weed control efficiency increased with increasing density (Table 2). The weed control efficiency was the highest at density 50 plants/m^2 (70.11% and 69.11% in the first and second trials, respectively) and least at density 3.13 plants/m^2 (23.37% and 22.51% in the first and second trials, respectively). From the survey carried out on associated weeds in the treated and control plots, a total of 16 weed species were enumerated and identified. In all the treated and control plots, the most important weed species were *Chromolaena odorata* and *Ageratum conyzoides* while the least important species were *Meremia aegyptia* and *Spilanthes costata*, as indicated by their relative importance values (RIV) (Table 3).

Table 1.: Effect of planting density of *I. hirsuta* on its growth and dry matter accumulation at 14 weeks after planting

Density (plants/m^2)	Plant Height (cm)	Stem Diameter (cm)	Number of Branches	Number of Leaves	Shoot Dry Weight (kg)
			First trial		
D0 (0)	-	-	-	-	-
D1 (3.13)	81.17 ± 0.92*	0.97 ± 0.07	21.67 ± 1.20	182.67 ± 13.48	0.38 ± 0.00
D2 (6.25)	81.60 ± 1.77	0.87 ± 0.03	18.67 ± 0.33	164.67 ± 9.96	0.31 ± 0.00
D3 (12.5)	87.67 ± 1.33	0.80 ± 0.00	17.67 ± 0.33	155.00 ± 4.04	0.26 ± 0.00
D4 (25)	93.57 ± 0.30	0.63 ± 0.03	12.67 ± 0.88	149.67 ± 0.88	0.23 ± 0.00
D5 (50)	105.00 ± 1.73	0.53 ± 0.03	8.67 ± 1.33	141.67 ± 2.33	0.20 ± 0.00
LSD (p = 0.05)	4.19	0.12	2.90	24.55	0.01
			Second trial		
D0 (0)	-	-	-	-	-
D1 (3.13)	77.30 ± 3.79	0.93 ± 0.03	22.00 ± 0.58	185.33 ± 3.53	0.38 ± 0.00
D2 (6.25)	81.77 ± 0.63	0.90 ± 0.00	19.00 ± 0.00	170.33 ± 2.40	0.31 ± 0.00
D3 (12.5)	88.00 ± 0.91	0.80 ± 0.00	17.67 ± 0.33	160.67 ± 1.20	0.27 ± 0.00
D4 (25)	93.57 ± 0.83	0.67 ±0.03	12.00 ± 0.58	151.00 ± 0.58	0.23 ± 0.00
D5 (50)	107.00 ± 3.06	0.57 ± 0.03	7.67 ± 0.88	142.67 ± 1.76	0.20 ± 0.00
LSD (p = 0.05)	7.13	0.08	1.78	6.77	0.01

Values are means ± standard error (n=3). D0 = 0 plants/ha (Control); D1 = 31,250 plants/ha; D2 = 62,500 plants/ha; D3 = 125,000 plants/ha; D4 = 250,000 plants/ha; D5 = 500,000 plants/ha.

Table 2: Effect of planting density of *I. hirsuta* on weed dry matter accumulation and weed control efficiency

Density (plants/m^2)	Weed Dry Weight (kg/quadrat*)	Weed Control Efficiency (WCE %)
	FIRST TRIAL	
D0 (0)	1.84 ± 0.04	-
D1 (3.13)	1.41 ± 0.01	23.37
D2 (6.25)	1.37 ± 0.01	25.54
D3 (12.5)	1.34 ± 0.01	27.17
D4 (25)	0.98 ± 0.03	46.74
D5 (50)	0.55 ± 0.04	70.11
LSD (p = 0.05)	0.08	
	SECOND TRIAL	
D0 (0)	1.91 ± 0.02	-
D1 (3.13)	1.48 ± 0.01	22.51
D2 (6.25)	1.37 ± 0.02	28.27
D3 (12.5)	1.33 ± 0.01	30.37
D4 (25)	1.04 ± 0.03	45.55
D5 (50)	0.59 ± 0.01	69.11
LSD (p = 0.05)	0.06	

* quadrat size is 50 cm x 50 cm

Values are means ± standard error (n=3). D0 = 0 plants/ha (Control); D1 = 31,250 plants/ha; D2 = 62,500 plants/ha; D3 = 125,000 plants/ha; D4 = 250,000 plants/ha; D5 = 500,000 plants/ha.

Table 3: Relative Importance Values (%) of associated weeds encountered across *Indigofera hirsuta* planting density.

Species	*D0	D1	D2	D3	D4	D5
Ageratum conyzoides L.	10.92	24.52	17.21	20.59	16.49	12.76
Asystasia gigentica (L.) T. Anders	3.06	0.00	0.00	0.00	0.00	0.00
Alternanthera brasiliana (L.) Kuntze	2.60	0.00	0.00	0.00	0.00	0.00
Celosia leptostachya Benth.	4.73	0.00	0.00	4.61	4.16	4.11
Chromolaena odorata (L.) R.M. King	22.95	29.45	14.86	15.37	17.78	16.65
Commelina benghalensis L.	0.00	1.60	6.61	6.79	4.91	7.36
Ipomoea involucrata P. Beauv.	2.89	2.03	16.99	9.42	4.70	4.98
Leptochloa filiformis (Lam.) P. Beauv.	10.23	0.00	6.22	6.18	8.80	12.60
Mariscus alternifolius Vahl.	2.35	6.83	5.48	7.84	5.66	3.66
Merremia aegyptia (L.) Urban	2.81	0.00	0.00	2.28	1.50	1.76
Oldenlandia corymbosa L.	0.00	9.29	16.38	9.78	10.30	5.00
Passiflora foetida L.	4.90	0.00	0.00	0.71	4.70	5.02
Spilanthes costata Benth.	2.81	0.00	0.00	0.00	2.25	4.68
Talinum fruticosum (L.) Juss.	2.35	10.02	4.89	3.84	4.64	3.08
Tithonia diversifolia (Hemsl.) A. Gray	12.39	1.60	2.82	5.11	8.73	13.03
Tridax procumbens L.	13.92	14.66	8.55	7.49	5.39	5.30

*D0 = 0 plants/ha (Control); D1 = 31,250 plants/ha; D2 = 62,500 plants/ha; D3 = 125,000 plants/ha; D4 = 250,000 plants/ha; D5 = 500,000 plants/ha.

Asystasia gigentica and *Alternanthera brasiliana* were found only on the control plots. Fourteen out of the total sixteen species of weeds were found on the control, 25 plants/m^2 and 50 plants/m^2 plots, and the lowest of nine species were enumerated on 6.25 plants/m^2 plot (Table 4). Plots with the lowest *I. hirsuta* density (D1; 6.25 plants/m^2) had the lowest Shannon-Wiener Index (1.641). The highest Shannon-Wiener (2.270) and Equitability (0.860) indices were recorded from 50 plants/m^2 (Table 4).

Table 4: Weed diversity at varying planting densities of *Indigofera hirsute.*

	Planting Density					
	Control	D1*	D2	D3	D4	D5
Species Richness	14	9	10	13	14	14
Shannon-Wiener Index (*H'*)	2.019	1.641	1.976	2.121	2.219	2.270
Equitability Index (J)	0.745	0.747	0.858	0.827	0.840	0.860

*D1 = 3.13 plants/m^2, D2= 6.25 plant/m^2, D3 = 12.5 plants/m^2, D4= 25 plants/m^2, D5= 50 plants/m^2 and Control = 0 plant/m^2.

DISCUSSION

One of the most crucial aspects of agronomic management to maximize growth and yield is planting crops at appropriate density (Rasekh *et al.*, 2010). Generally, at mature stage in the natural habitat the density of *I. hirsuta* ranged from 4 to 6 plants/m^2. Increasing the density to 50 plants/m^2 reduced other weed species significantly. However, varying the density of *I. hirsuta* affected its height, stem diameter, number of leaves and branches, shoot dry weight and weight of other weed species encountered. The development of greater height, weaker stem, fewer leaves and branches by *I. hirsuta* planted at high density are indications of etiolation as a result of overcrowding (Etiban and Tiwari, 2015). Etiolation occurs in flowering plants growing under reduced or complete absence of light.

Also, at low densities, the plants were shorter, thicker and produced more leaves. These might have resulted from wider gap among the adjacent plants which could have reduced competition for growth resources such as sunlight and soil nutrients among the plants in addition to reduced canopy expansion from the shoots (Rehman *et al.*, 2013). The stronger stem growth in *I. hirsuta* at low population may be ascribed to decreased plant competition, increased light penetration as a result of open canopy and better soil moisture and nutrients-uptake and use (Ahmed *et al.*, 2010). The decrease in stem diameter of the plants as the plant density increased was likewise reported by Awodoyin and Ogunyemi (2005) in growth studies on *S. obtusifolia*. Bitew *et al.* (2014) reported similar results in *Pisum sativum*. These results were, however, in contrast with the results of Naim and Eldouma (2011), in the instance of *Arachis hypogaea*, which may be due its decumbent habit.

Indigofera hirsuta proved effective in suppressing other weeds. If planted as sown fallow or green manure, it will effectively manage weeds. Anderson (2005) reported that, to decrease weed development in the spring, some farmers experimented with cultivating legumes like dry pea or lentils over a period of approximately six to eight weeks during the fallow. The weed suppressive ability of *I. hirsuta* is attributed to high competition for light due to the spreading of its crown. The touching crowns formed a close canopy that cuts off light from reaching the soil surface, thus presenting *I. hirsuta* as an ideal cover crop. Lawley *et al.* (2011) reported that, resulting from the heavily-shading characteristics, cover crops enhance biological weed suppression. Several researches have reported the potential of cover crops cultivation, including *I. hirsuta*, in suppressing weeds (Lawley *et al.*, 2011; Lawley *et al.*, 2012; Rueda-Ayala *et al.*, 2015; Ali *et al.*, 2019; Zaman *et al.,* 2020). They interfere with the life cycle of weeds due to high level of competition for nutrients, water, light and space, thereby inhibiting germination, growth and seed production (Awodoyin and Ogunyemi, 2005; Rueda-Ayala *et al.*, 2015).

The noticed decrease in weed density as the population of *I. hirsuta* increased may be attributed to rise in inter-specific competition for light and other resources (Hall *et al.*, 2014). For effective weed suppression, planting *I. hirsuta* at 50 plants/m^2 may be the best growing density. As cover crops suppress weeds, they also have a number of advantages for agricultural systems, such as nutrient recycling, increased soil organic matter and improved soil structure (Carof *et al.*, 2007).

CONCLUSIONS

Indigofera hirsuta suppressed other weed species when planted at high density. It could be used to cut down on the use of herbicides to manage weeds during the fallow period, and therefore used in sown fallow. The weed suppressive ability of *I. hirsuta* is attributed to its high competition for light due to its rapid growth and spreading habit. *Indigofera hirsuta* can be used to suppress weeds and reduce the need for herbicides.

ACKNOWLEDGMENTS

The authors are grateful for the supports given on the field and laboratory by Dr. Omotanwa Tanimola, Mr. Sheriff Adeniji and other members of Ecology Team in the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria.

SOURCE OF FUNDING

This project was fully self-funded.

DISCLOSURE OF CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTIONS

A.Y. M.: Investigation, Methodology, Data collection, collation and analysis, Writing of original draft; A. R. O.: Conceptualization; Supervision; Validation; Writing, review and editing of manuscript.

REFERENCES

Adeniji, A. O. and Awodoyin, R. O. 2022a. Growth and rate of Biomass accumulation study of *Mucuna pruriens* (L.) DC (Velvet bean) in Ibadan, Nigeria. *Nigerian Journal of Ecology* 18(1): 65-72.

Adeniji, A. O., Olalagba, A. O., Osuolale, R. A. and Awodoyin, R. O. 2022b. Innovative Use of Two Varieties of Cowpea (*Vigna unguiculata* (L.) Walp.), Akidi and Fuampea-2 as Green Manure in Low Input Production of *Celosia argentea* L. and *Amaranthus cruentus* L. in Ibadan, Nigeria. *International Journal of Advanced Agriculture and Food Technology*, 3(3). Retrieved from https://amcs-press.com/index.php/ijafat/article/view/39 31/3/2024

Adeniji, A. O., Awodoyin, R. O. and Orimoloye, J. R. 2023. Green manure potential of *Mucuna pruriens* (L.) DC (Velvet Bean) and its effect on growth of *Amaranthus cruentus* L. in Ibadan, Nigeria. *African Journal of Organic Agriculture and Ecology,* 6: 41-45.

Ahmed, M. E., Entisar, M. E. and Awad, A. A. 2010. Effect of plant density on the performance of some Sesame (*Sesamum indicum* L.) cultivars under rain fed. *Research Journal of Agriculture and Biological Sciences,* 6(4): 498-504.

Akobundu, I. O., Ekeleme, F., Agyakwa, C. W. and Ogazie, C. A. 2016. *A handbook of West African Weeds.* International Institute of Tropical Agriculture. 3rd edition, 381 pp.

Ali, S., Hossain, M. B., Datta, A. and Hossain, M. A. 2019. Evaluation of *Indigofera hirsuta* as a cover crop in the tropics for sustainable agricultural production. *Sustainability*, 11(17): 4629.

Anderson, R. L. 2005. A multi-tactic approach to manage weed population dynamics in crop rotations. *Agronomy Journal,* 97:1579–1583.

Awodoyin, R. O. and Ogunyemi, S. 2005. Stocking effect on the performance of weed smothering ability of an annual legume, *Senna obtusifolia* (L) Irwin and Berneby. *Ibadan Journal of Agricultural Research,* 1(1):30-38.

Awodoyin, R. O., C. Y. Akinyemi, O. O. Bolanle and I. C. Antiabong 2013: Spatial Distribution and abundance of *Solanecio biafrae* (Olive & Heirne) C. Jeffrey and structure of weed communities in some cocoa plots in Ekiti, Oyo and Cross River States, Nigeria. *Ife Journal of Science,* 15(3): 661-676.

Bitew, Y., Asargew, F. and Beshir, O. 2014. Effect of plant spacing on the yield and yield component of field pea (*Pisum sativum* L.) at Adet, North Western Ethiopia. *Agriculture, Forestry and Fisheries,* 3(5): 368-373.

Boydston, R. A., and Hang, A. 1995. Rape seed (*Brassica napus*) green manure suppresses weeds in potato *(Solanum tuberosum)*. *Weed Technology,* 9: 669–675.

Caamal-Maldonado, J. A., Jimenez-Osornio, J. J., Torre-Barragain, A. and Anaya, A. L. 2001. Allelopathic legume cover and mulch for weed control. *Agronomy Journal* 93:27-36.

Carof, M., Tourdonnet, S., Saulas, P., Floch, D. and Roger-Estrade, J. 2007. Undersowing wheat with different living mulches in a no-till system. II. Competition for light and nitrogen. *Agronomy Sustainable Development* 27:357–365.

Das, T.K. 2011. *Weed science*. Basics and Application. Jain brothers publishers pp. 910.

Dorgra, K. S., Sood, S. K., Dobhal, P. K. and Sharma, S. 2010. Alien plant invasion and their impact on indigenous species diversity at global. *Journal of Ecology and the Natural Environment* 2(9): 175 – 186.

Egberongbe, R. K., Awodoyin, R. O. and Olubode, O. S. 2017. Fallow management potentials of *Sesbania pachycarpa* DC.: The green manure effects on *Amaranthus cruentus* L. in Ibadan, South Western Nigeria. *Agricultural Science Research Journal,* 7(4): 171-176.

Egbinola, C. N., Amanambu, A. C. and Taiwo, M. E. 2014. Impact of farming on riparian vegetation along Ona and Orogun rivers, Ibadan, Oyo State, Nigeria. *Geografia* (*Londrina*) 23(1):127-150.

Etiban, L. and Tiwari, B. K. 2015. Effect of plant density on growth and yield of *Thysanolaena maxima*: An important non-timber forest product of Meghalaya. *International Journal of Current Research,* 7.7:18193-18197.

Gbadegesin, A. and Olabode, M. A. 2000. Soil properties in the metropolitan region of Ibadan, Nigeria: Implications for the management of urban environment of developing countries. *The Environmentalist,* 20(3): 205-214.

Gerometta, E., Grondina, I., Smadjaa, J., Frederichb, M. and Gauvin-Bialeckia, A. (2020). A review of traditional uses, phytochemistry and pharmacology of the genus *Indigofera*. Elsevier. https://www.elsevier.com/open-access/userlicense/1.0/. Accessed 23 November, 2024.

Hall, J., Bhattarai, S. P. and Midmore, D. J. 2014. Effect of Industrial hemp (*Cannabis sativa* L.) planting density on weed suppression, crop growth, physiological responses and fibre yield in the subtropics. *Renewable Bioresources,* 2: 1-7.

Hartwig, N. L. and Ammon, H. U. 2002. Cover crops and living mulches. *Weed Science,* 50:688–699.

Kent, M. and Coker, P. 1992. Vegetation description and Analysis: a practical approach. Johnn Wiley and Sons, Chichester. 363pp

Lawley, Y. E., Weil, R. R. and Teasdale, J. R. 2011. Forage radish cover crop suppresses winter annual weeds in fall and before corn planting. *Agronomy Journal* 103:137–144.

Lawley, Teasdale, J. R and Weil, R. R. 2012. The mechanism for weed suppression by a forage radish cover crop. *Agronomy Journal* 104: 205–214.

Moria, F. D., Giayetto, O., Fernandez, E. M., Cerioni, G. A. and Cerliani, C. 2018. Plant density and peanut crop yield (*Arachis hypogaea*) in the peanut growing region of Cordoba (Argentina). *Peanut Science,* 45(2): 82-86.

Muhammad, M. U., Gayari, M. S., Idris, B. Bello, M. and Boyi, M. Y. 2023. Anti-Snake Venom Activity of *Indigofera hirsuta* extracts against *Naja nigricollis* venom. *European Journal of Theoretical and Applied Sciences*, 1(2): 20.

Murányi, E. 2015. Effect of plant density and row spacing on maize (*Zea mays* L.) grain yield in different crop year. *Journal of Agriculture and Environmental Sciences* 2.1:57-63.

Naim, E. A. M. and Eldouma, M. A. 2011. Influence of weeding frequency and plant population on yield and yield components of Groundnut (*Arachis hypogaea* L.) in North Kordofan of Sudan. *Bioresearch Bulletin,* 5: 322-328.

Raheem, W. M. and Adeboyejo, A. T. 2016. Urban greening and city sustainability in Ibadan metropolis, Nigeria. *Ethiopian Journal of Environmental Studies and Management,* 9(3): 287-302.

Rasekh, H., Asghari, J., Massoumi, S. L. and Zakerinejad, R. 2010. Effect of planting pattern and plant density on physiological characteristics and yield of peanut (*Arachis hypogaea* L.) in Iran. *Research Journal of Biological Science,* 5: 542-547.

Rehman, A. U., Ehsanullah, A. R. and Jabbar, A. 2013. Interactive study of row spacings and foliar application of macro and micro-nutrients on growth, yield and quality of sugar cane (*Saccharum officinarum*). *Pakistan Journal of Botany,* 45: 427-433.

Ross, S. M., King, J. R., Izaurralde, R. C. and O'Donovan, J. T. 2001.Weed suppression by seven clover species. *Agronomy Journal,* 93: 820-827.

Rueda-Ayala, V., Jaeck, O. and Gerhards, R. 2015. Investigation of biochemical and competitive effects of cover crops on crops and weeds. *Crop Protection,* 71: 79–87.

Sarrantonio, M. and Gallandt, E., 2003. The role of cover crops in North American cropping systems. *Journal of Crop Production* 8: 53-74.

Smyth, S. J. and Montgomery, R. F. 1962. Soils and land use in central western Nigeria. The Government of Western Nigeria Press, Ibadan. 265Pp.

Spellerberg, I. F. 1993. Monitoring ecological change. Cambridge University Press P 334.

Uchino, H., Iwama, K., Jitsuyama, Y., Ichiyama, K., Sugiura, E.and Yudate, T. 2011. Stable characteristics of cover crops for weed suppression in organic farming systems. *Plant Production Science* 14(1): 75-85.

Zaman, M. and Mishra, P. P. 2020. *Indigofera hirsuta*, a cover crop for sustainable agriculture. *Plant Cell, Tissue and Organ Culture*, 141(2): 201-211.