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Insect Species Diversity and Abundance in and around Federal University of Agriculture, Makurdi Forestry Nursery, Benue State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors GOY and FSA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FSA and ESA managed the analyses of the study. Author ESA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

With the rapid increase in human population, there has been concomitant increase in anthropogenic activities helping to rise to habitat modification. The change in habitat composition and seasonal variations affect the population of insects. The aim of the study therefore, was to investigate the insect species diversity and abundance in and around the Federal University of Agriculture, Makurdi Forestry Nursery with the view to ensuring healthy seedling production. Line transects were used to survey the three habitats within and around the forestry nursery using handheld sweep nets and pitfall traps from August 2016 to February 2017. Data were analyzed using descriptive statistics, one-way analysis of variance and composition was estimated using diversity indices. A checklist was made comprising a total number of 810 individuals from 8 Orders 25 Families and 50 species were recorded across the three habitats. Out of these, members belonging to order Hemiptera were

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the most dominant (35.8%) according to number of individuals, followed by Lepidoptera (16.91%), and the least were Coleoptera (2.72%) and Dictyoptera (2.60%) respectively. The major insect pest encountered in the nursery was mealybugs. The Swampy part of the Nursery and the URF had similar species composition. Species diversity, evenness and richness varied from habitat to habitat. However there was no significant difference in species composition/richness across the habitat types at 0.05% level of significance. Therefore it was recommended that, measures should be taken to control insect pest infestation in the nursery to ensure healthy production of seedlings.

Keywords: Abundance; diversity; forestry nursery; species; insects.

1. INTRODUCTION

Insect is a word derived from Latin "*insectum"*, meaning "with a notched or divided body", literally "cut into sections" [1]. They are a class of animals within the phylum arthropod. The total number of insect species on earth is estimated to be 1-3 million and the class probably represents more than 80-90% of all animal species [1,2,3,4]. Speight et al. [5] observed that, insects are the most populated organisms in the world, because different species reproduce fast and have enormous numbers of offspring, majority some do not even care for their young.

They can adapt to nearly all environments, but only a few species stay in the oceans [6,7]. They are highly sensitive to changes in climatic factors such as rainfall, temperatures, wind, humidity and altitudes [8,9] as these affect their population dynamics, distribution, abundance, intensity and feeding behavior [10].

Table 1. Some insect abundance by species

S/no	Order	Common names	Number of species
1.	Archeognatha	Bristletails	500
2.	Zygentoma	Silverfish	400
3.	Ephemeroptera	Mayflies	3 100
4.	Odonata dragonflies	Damselflies	5 500
5.	Dermaptera	Earwigs	2 000
6.	Grylloblattodea	ice crawlers	26
7.	Mantophasmatodea	rock crawlers	15
8.	Plecoptera	Stoneflies	2 000
9.	Embiodea	web spinners	500
10.	Zoraptera		32
11.	Phasmatodea	stick insects, leaf insects	3 000
12.	Orthoptera	crickets, grasshoppers	20 000
13.	Mantodea	Mantises	1 800
14	Blattaria	Cockroaches	4 000
15.	Isoptera	Termites	2 900
16.	Psocoptera	bark lice	4 400
17.	Phthiraptera	true lice	4 900
18.	Thysanoptera	Thrips	5 000
19.	Hemiptera	bugs, aphids, scale insects	90 000
20.	Coleoptera	Beetles	350 000
21.	Raphidioptera	Snakeflies	220
22.	Megaloptera	alderflies, dobsonflies	270
23.	Neuroptera	Lacewings	6 000
24.	Hymenoptera	wasps, bees, sawflies, ants	125 000
25.	Mecoptera	Scorpionflies	600
26.	Siphonaptera	Fleas	2 500
27.	Strepsiptera	twisted wings	550
28.	Diptera	true flies	120 000
29.	Trichoptera	Caddisflies	11 000
30	Lepidoptera	butterflies, moths	150 000

Source: Adopted from Nair, [19]; Zrzavý, [22]

Insects are important components in most natural and transformed landscapes. They play crucial functional roles that ensure delivery of various ecosystem services which are important for some aspects of human livelihood such as agriculture, tourism and natural resource use [11,12,13]. They also control populations of other organisms, provide major food source for other taxa [14], bio-indicator of fresh water bodies [7]. However, they are also disease vectors to many other organisms, including humans, and they have the capacity to alter the rates and directions of energy and matter fluxes in an ecosystem [15]. Gbadegesin et al. [16] report that majority of the insects feed on all kinds of plants including forest nursery seedlings, crop plants, forest trees, and weeds on the field, thus modifying the range condition of the ecosystem. Pest problems that originate from insect attack in most nursery establishments are as a result of accumulation of large amount of leaves and branches occupying the ground floor of the nursery site [17].

Nursery establishments generally are faced with one of several such challenges of insect pest attack, though being home to many forest plantations where seedlings are raised. Several regions of the world have their own fair share of insect pest problems. Insect damage can affect both the quality and quantity of seedlings and may affect reforestation plans and plantation programme [18]. Forest tree seedlings are raised generally on nursery beds and later they are planted in the field [19]. Some of the pest species are host specific while others are generalists attacking a wide range of tree species [19]. However, large scale plantation establishment of cash crops as well as indiscriminate bush burning and overgrazing lead to habitat destruction with consequent impact on insect species [20].

Disappearance of insects could lead to extinction of earth's animals because of the disappearance of so much plant life. Today insects are by far the planet's most diverse, abundant and successful species [21,22]. The roles (positive or negative) insects play in nature require proper understanding on how they interact with living and non-living environment and their diversity [21]. The objective of the present investigation is to provide a checklist of insects, identify insect pests in the forestry nursery and determine the composition and diversity pattern of insects' species in the study area.

2. MATERIALS AND METHODS

2.1 Study Area

University of Agriculture, Makurdi Forestry Nursery is located within the University of Agriculture Makurdi campus at the south core part which is situated in the Northern part of Makurdi town within Benue State. It is located within the Guinea Savannah zone between latitudes 8°35E and 8°41E and longitudes 7°45N and 7°52N; it is on the Southern bank of river Benue, close to River Guma in the East and to the West of the (Route A3) Makurdi to Lafia and is about 16.5 kilometers to the North of the Makurdi city [23,24]. Rainfall distribution is bimodal in the area occurring in June and September. Mean annual rainfall is between 1000 mm – 15000 mm. Mean annual temperatures is 29°C - 30°C, relative humidity is between 60% and 80% but decreases in the early months of the dry season [23]. The area is characterized by undulating rolling plain with irregular river valleys and ridges with steep slope. The drainage pattern is dendritic. The surrounding of the area is open savannah woodland which is relatively rich with high diversity of species comprising of a wide variety of woody trees, predominately fewer trees, more shrubs, and a collection of herbs, palms, climbers and predominately tall grasses up to 2 m tall. Forest formations are found in low-land areas and river banks. Some of the species found in the area include: *Daniellia oliverri, Vitelleria paradoxa, Vitex doniana, Hymenocordia acida, Burkia africana, Khaya senegalensis* and *Parkia biglobosa* [23].

2.2 Sampling Procedure

The study area was stratified into two habitats. Insect species were assessed quantitatively across the habitats and the adjacent University research farm (URF) with handheld sweep net and pitfall trap as outlined by [6].

2.3 Method of Data Collection

2.3.1 Monitoring (Line transect)

A 0.23 km line transects was established at every site and attempts were made to catch every insect seen. Similar procedure has been done in the study area by [24]. A total of 6 transect walks were made (i.e two transects on each of the habitats). Each of the transect lay

was slowly traversed at a uniform pace of 30 minutes at each habitat.

2.3.2 Sweep net

Sweep sampling technique was employed a cross the two habitats within the forestry nursery area and the adjacent URF with the use of a handheld sweep net. This method is suitable for sampling insects from ground layer vegetation. The sweeps were done during the morning hours from 6 am to 10 am and evening from 4 pm to 7 pm twice in a week along the predetermined transect. The insects collected were killed using ethyl acetate and temporarily kept in polythene bags and plastic containers and later taken to the laboratory for identification and preservation.

2.3.3 Pitfall traps

A total of 12 traps (4 each) were placed in the various habitats. Pitfall trap each consisted of a single 100 ml capacity plastic container (top diameter =12.5 cm, height =11.5 cm) were buried so that the top was flushed with the ground surface and filled with 2 cm of dishwashing soap and water solution to prevent escape by captured insects.

2.3.4 Insect killing/ preservation

A wide- mouthed jar was used as a killing bottle. The jar has an air-tight lid with the bottom lined with a layer of cotton wool into which ethyl-acetate (a suitable poison) was added as a killing agent. Insect captured were kept in the jar for 10minutes, after which they are removed [25]. The method adopted for preservation was direct pinning and pickled specimens.

a. Direct pinning

The dead insect was removed from the killing bottle and placed on a setting board. The insect was mounted by inserting an entomology pin symmetrically positioned through the thorax, in such a way that three quarter of the pin passes through the insect. The fore and hind wings were then properly sprayed out at 90°. This method was applicable to large insects.

Setting of insect; insect captured were set such that their wings and legs were spread in a horizontal position on a standard setting board and held in position by a setting tape. Then pinned insect was allowed to dry for two days before mounting on the insect box.

b. Pickled specimens

Specimens that cannot be pinned were pickled in tubes containing fluid preservative. In this research a 50% ethanol (alcohol) was prepared as a preservative for pickled specimen.

2.4 Identification of Insects

The collected specimens were taken to the laboratory and identified with the aid of appropriate identification keys provided by Riley [26], Youdeowei [25], Bernard [27], Larsen [28], Tanwar et al. [29] and Terren et al. [30].

2.5 Data Analysis

Data generated from this research were analyzed using descriptive statistics (Frequencies and percentages). Identified insects species were grouped into species, family and order. One- Way analysis of variance was used to determine the difference in Order, Family and Species. Species Diversity and Distribution were computed using diversity indices such as species diversity, species richness and evenness.

3. RESULTS

A total of 810 insect samples were collected during the month from August, 2016 to February, 2017. Altogether 50 species were collected but only 37 were identified belonging to 25 families under 8 orders (Tables 2 and 3).

According to the total number of species, the dominant order was Lepidoptera (11 species), followed by Hemiptera (7 species) and the least was Dictyoptera and Coleoptera with 2 species each (Table 3). Also Fig. 1 indicates the percentage of insects composition by order, the highest order is Lepidoptera (30%), followed by Hemiptera (19%) and least Dictyoptera and Coleoptera (5%) respectively.

Among order Lepidoptera, family Nyphalidae dominated with 6 species represented only in DLA and SWA. Followed by Papilionidae with 2 species, Peridae, Gracillaridae and Eribidae each contain only 1 species. Among order Hemiptera, the family Coreidae dominated with 2 species while Reduviidae, Pyrrhocoridae, Pentatomidae, Pseudococcidae and Aleyrodidae contain only 1 species respectively. The order Orthoptera has a total number of 3 species

belonging to family Acrididae, Gryllidae and Pyrgomorphidae each sharing 1 species. Among order Hymenoptera, family Apidae includes 2 species and family Formicidae and Vespidae includes only 1 species respectively. In order Diptera, it includes 3 families i.e Calliphoridae, Muscidae and Sarcophagidae which shared each only one species. Among order Odonata, the family Libellulidae dominated with 2 species and family Platycnemididae with only 1 species. The order coleopteran had 2 families i.e Coccinellidae and Lagridae which showed each only one species and among order Dictyoptera, family Mantidae contained with only two species.

The sampled species of seedlings identified in the FUAM Forestry nursery were recorded according to the insect pest attack (Table 4). Among the identified seedlings (seed beds) only 11 species were attacked by insect pests. The attack was measured based on the population of insects occupying the seed beds, number of seedlings attacked, number of leaves attacked, the part of plant attacked (terminal bud, apex and root) and the feeding habit.

The result of the study as presented in (Table 5) revealed that the URF area had the highest value for insect diversity, and evenness (H'= 3.20), (J' = 0.67). This was followed by Swampy area for species diversity (H'= 2.87), while DLA for species evenness (J' = 0.47). However, the SWA had the highest value of species richness (D = 6.70).

Table 2. Insects species captures at FUAM Forestry Nursery and the Adjacent University Research Farm

Insect order	Family	S/N	Species	Habitats		
				DLA	SWA	URF
Lepidoptera						
	Nymphalidae	1	*Acraea egina* cram	7	3	0
		2	*Ariadne merione*	2	0	0
		3	*Danaus chrysippus*	6	2	0
		4	*Euphaedra janetta*	1	3	0
		5	*Junonia orithya ocyale*	2	0	0
		6	*Neptis rivularis*	0	1	0
	Pieridae	7	*Eurema hecabe*	22	31	15
	Papilionidae	8	*Graphium sarpedon*	1	0	0
		9	*Papilio demoleus*	9	2	6
	Gracillariidae	10	*Stomphastis thraustica*	22	0	0
	Erebidae	11	*Utetheisa pulchella*	0	0	2
Hemiptera						
	Reduviidae	12	*Assassin bug*	0	4	8
	Coreidae	13	*Cletomorpha lancigera*	6	1	9
		14	*Riptortus linearis*	2	1	4
	Pyrrhocoridae	15	*Dysdercus spp*	2	6	4
	Pseudococcidae	16	*Mealybug spp*	93	61	38
	Pentatomidae	17	*Nezara viridula*	8	0	20
	Aleyrodidae	18	*Trialeurodes spp*	0	11	12
Orthoptera						
	Acrididae	19	*Chorthippus spp*	3	0	3
		20	*Christa compta*	2	1	5
		21	*Dissosteira spp*	6	3	4
	Gryllidae	22	*Acheta domestica*	5	4	7
	Pyrgomorphidae	23	*Zonocerus variegates*	6	3	9
Hymenoptera						
	Apidae	24	*Apis mellifera adansonii*	4	19	22
		25	*Bombus bee*	0	0	1
	Formicidae	26	*Oecophylla smaragdina*	21	31	0
	Vespidae	27	*Ropalidia marginata*	0	2	0
Diptera						
	Calliphoridae	28	*Lucilia sericata*	10	13	4

Insect order	Family	S/N	Species	Habitats		
				DLA	SWA	URF
	Muscidae	29	*Musca domestica*	11	19	3
	Sarcophagidae	30	*Sarcophaga carnaria*	7	19	4
Odonata						
	Platycnemididae	31	*Copera marginipes*	6	6	1
	Libellulidae	32	*Orthetrum pruinosum*	4	14	5
		33	*Sympetrum flaveolum*	2	0	2
Coleoptera						
	Coccinellidae	34	*Harmonia axyridis*	3	0	5
	Lagriidae	35	*Lagria villosa*	2	10	2
Dictyoptera						
	Mantidae	36	*Plistospilota guineensis*	4	1	5
		37	*Sphodromantis lineola*	5	3	3
Others		38		9	17	23
			Total	293	291	226

Key: DLA = Dry land of the Nursery, SWA = Swampy area and URF= University Research Farm

Table 3. Frequency distribution of insect species encountered according to order

S/no	Order	Number of species (%)	Individuals (%)
1.	Lepidoptera	11(30)	137(16.91)
2.	Hemiptera	7(19)	290(35.80)
3.	Orthoptera	5(14)	61(7.53)
4.	Hymenoptera	4(11)	100(12.35)
5.	Diptera	3(8)	90(11.11)
6.	Odonata	3(8)	40(4.94)
7.	Coleoptera	2(5)	22(2.72)
8.	Dictyoptera	2(5)	21(2.60)
		37(100)	810(100)

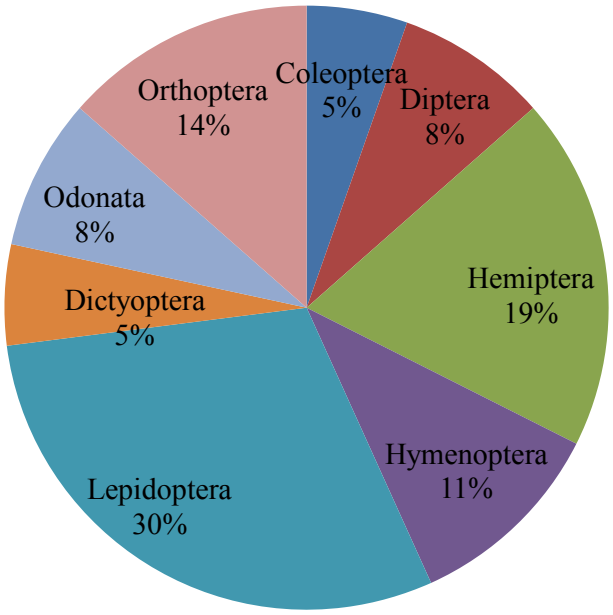

Fig. 1. Insect species distribution by orders in the study area

Table 4. Some insect pests encountered on species of seedlings in the study area

S/N	Seedlings	Insect pest	Pest status	Dryland	Swampy area
1.	*Parkia biglobosa*	*Ferrisia virgata*	Major	+	+
2.	*Jatropha curcus*	*Paracoccus marginatus* stomphastis thraustica	Major	+	_
3.	*Ceiba pentandra*	P. marginatus	Major	+	_
4.	*Khaya senegalensis*	Eurema sp caterpillar	Minor	_	+
		Ferrisia virgata	Major	+	_
5.	*Leuceana leucocephala*	*Ferrisia virgata*	Major	+	_
6.	*Dacryodis edulis*	Defoliators	Minor	_	+
7.	*Mangifera indica*	*Oecophylla smaragdina*	Minor	_	+
8.	*Annona muricata*	None		_	+
9.	*Terminalia catapa*	None		_	+
10.	*Elaeis guineensis*	None		_	+
11.	*Albezia zygia*	*Ferrisia virgata*		+	_
12.	*Irvingia garbonenesis*	None		_	+
13.	*Afzelia africana*	*Ferrisia virgata*		+	_
14.	*Treculia africana*	None		+	_
15.	*Polyalthia longifolia*	None		+	_
16.	*Terminalia mentalis*	None		+	_
17.	*Prosopis africana*	*Ferrisia virgata*		+	_
18	*Citrus jhambiri*	Caterpillar of *Eurema sp*	Minor	+	+

+ Present and _ Absent

Table 5. Species diversity indices of insect species in FUAM Nursery across habitats type

Variables	DLA	SWA	URF
Number of Species	37	39	37
Individuals	293	291	226
Dominance_D	0.11	0.089	0.055
Shannon_H	2.86	2.87	3.20
Species Evenness_	0.47	0.45	0.67
Species richness	6.34	6.70	6.64

Key: DLA = Dry land of the Nursery, SWA = Swampy area of the Nursery and URF= University Research Farm

The Jaccard similarity index showed high similarity for insect species composition between Swampy area and University research farm (URF) 0.65 and the low value between dry-land area and cultivated land 0.50 (Table 6).

Table 6. Similarity index of insect species composition across habitat types

Pairing habitat	Similarity index value
Dry-land area vs Swampy area	0.57
Dry-land area vs University Research Farm	0.50
Swampy area vs University Research Farm	0.65

The result of One-way ANOVA revealed in Table 7 indicates that there was no significant difference in species composition/richness across habitat at 5%.

4. DISCUSSION

The results of this study showed that the Federal University of Agriculture, Makurdi Forestry Nursery has high insect diversity. The rich number of species available in the forest nursery ecosystem could be mainly because of availability of different tree species (ornamental plants/seedlings) and vegetation cover with a forest-like nature and microhabitats against University Research Farm (URF). This agrees with the findings of Yager et al. [24] who reported same for butterfly species in the area.

The result obtained showed that Hemiptera were the most dominant order based on individual species. This finding is in contrast with that of [6] who reported Hymenoptera as the dominant insect Order in Gulbarga District, Karnataka, India, while Adeduntan and Olusola [31] recorded Orthoptera as the most dominated insect Order in different forest vegetation types in Ondo state. This can be attributed to the variation in environmental conditions and maybe the presence of susceptible hosts within the study area. This is substantiated by the view of Khaliq et al. [8] who reported that both

Table 7. One-way ANOVA difference in species composition across habitat

Variables	Sum of square	Df	Mean square	F	p-value
Between groups:	58.12	2	29.06	0.2748	0.7601
Within groups:	15545.9	147	105.754		
Total:	15604	149			

There is no significant difference at 5%

abiotic (temperature, humidity, light) and biotic (host, vegetative biodiversity, crowding and diets) significantly influence the insects and their population dynamics. Order Coleoptera and Dictyoptera had the least number of individuals which disagrees with the findings of Okrikata and Yusuf [32] in Wukari, Taraba State who reported that the Order Coleoptera was the most dominant. The reason for this disparity might be attributed to difference in study location and other environmental factors as reported by Alarapa et al. [9] that the abundance of individual of a species at any given point on a temporal scale was again dependent on abiotic and biotic environmental factors.

The species of Lepidoptera captured were typical of West African taxa and this is in line with Nwosu and Iwu [33] who reported to have captured same order of Lepidoptera such as Pieridae, Nymphalidae, and Papilionidae. These are orders of Lepidoptera common to Africa taxa. More so, the present study revealed that Lepidoptera was the second dominated Order. This could be as a result of presence of several plant, ornamental and seedlings species and also because of the fact that the FUAM Forestry Nursery is a protected area with forest canopy. This agrees with the findings of Nwosu and Iwu [33] who observed more species of butterfly in protected area of Okwu Ogbaku forest reserve in Imo State. The high number of butterfly recorded is an indication that they are attracted by plant species in the area, invariably this may result to an increase in the population of caterpillars which have resulted to leaf defoliation. This finding is in line with that of Braza [34] who recorded attack on *Falcataria moluccana* and *Acacia mangium* by caterpillars of Yellow butterflies (*Eurema* spp) in nurseries in the Philippines.

The major insect pest identified on seedlings in the FUAM Forestry Nursery was mealybugs and these were seen on the leaves and aerial portion of plants because of their slow motility and by the suitable conditions. This is in agreement with the findings of Oliveira et al. [35] and Tanwar et al. [36]. They discovered that heavy clustering can be seen under leaf surface indicating severe infestation. The high population of mealybugs in the study area is an indication that several plant species are attacked by this pest which has led to damage of apical meristems which had resulted to stunted growth and death of seedlings [36,29]. Mealybugs have been reported to have a wide host range of attack e.g *Tectonal grandis, Ceiba pentandra and Jatropha curcas*. They infest growing parts, piercing and sucking of sap of different plant species which may lead to stunted growth, withering, yellowing of leaves, and premature dropping of fruits, defoliation and eventually death of the plant [36,29].

The result of diversity indices across habitats showed that, even though URF area had the higher value of insect species diversity and evenness, the Forestry Nursery habitat was more in species richness put together. This implies that the availability of different plants influences the diversity and abundance of insect species. This agrees with findings of Gaston [37]; Hougen and Rausher [38] and Cheng et al. [39] whose reports substantiated that plants and insects interact by way of mutualism and phytophagy. Also Alarape et al. [9] revealed that the structural complexity of habitat and diversity of vegetation forms have been shown to correlate with animal and insect species diversity.

The SWA and URF habitats were more similar in species composition. However, there was no significant difference in species composition/ richness across habitat types which can be clearly understood from the perspective that both SWA and URF are highly plant and seedlings based and it is believed that plants co-evolve with their insect herbivores as opined by Hougen and Rausher [38]; and Tscharntke and Brand [40]. This can also be attributed to the continuous availability of resources in the habitat and so the environment is conducive for breeding. This finding agrees with the results of Samways [41] and Adeduntan and Olusola [31] who reported that insects are present where there is a favorable condition for their survival.

5. CONCLUSION

The findings of this study underline the diversity and composition of insect's species in protected

area of Federal University of Agriculture forestry nursery and the adjacent University research farm. The study provides baseline information on insects' species in the study area.

From the result obtained, the FUAM Forestry Nursery is rich in insect species composition when compared with the URF. However, seedlings were attacked by major insect pest unless drastic measures are applied to mitigate its infestation in the nursery. This is the first effort in exploring the insect's wealth of University of Agriculture, Makurdi. The present list of insects species is not exhaustive and so further exploration of insects species be continued to update this checklist. It is recommend that management strategies towards conservation of both flora and insects species should be intensified in the campus at large and at the same time device possible ways of curbing the menace posed by these pests in other to achieve the set goal(s) of the establishment, thereby promoting healthy seedling production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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