Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2022, Volume 35, Issue 2, Page 06-12

Studies on Weed Diversity and Phytosociology in Maize crop

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ARTICLE INFO

Article history:
Received: 31 May, 2022
Revision: 10 August, 2022
Accepted: 31 October, 2022

Key words: *Weed interference, Weed density, Weed diversity, Importance Value, Diversity indices.*

DOI: 10.56678/iahf-2022.35.02.2

ABSTRACT

A field experiment was conducted during the *Kharif* season in the year 2021 to identify dominant weed species and their diversity indices along with their importance in maize, with 14 treatments arranged in Randomized Block Design which were replicated thrice. Two sets of seven treatments each were used, the first being a weedy treatment (plots were left weedy for 10, 20, 30, 40, 50, and 60 DAS), and the second being a weed-free treatment (plots were left weed-free for 10, 20, 30, 40, 50, and 60 DAS). Weed samples for their density and diversity analysis were collected using the standard quadrant approach. Further, diversity commonly used diversity indices viz. Shannon Wiener Index and Simpson's Index were calculated and interpreted as per standard protocols. The research findings revealed that the field was overrun by 15 different weed species from six different families. And weeds belonging to family Asteraceae and Poaceae were most dominant. However, *Eleusine indica*, *Ageratum houstonianum*, *Bidens alba*, *Cressocephalum crepidiodes*, and *Gallinsoga parviflora* were the most dominant species with higher importance value. The higher the importancevalue of a weed, the greater its competitiveness. Additionally, the Shannon Wiener Diversity Index values were calculated for each treatment, and W_5, WF_0, WF_1, and WF_6 gave the highest values (2.7), whereas W_1 had the least diversity (1.56). While W_1 had the highest value of 0.2 when the Simpsons index values for various treatments were determined.

1. Introduction

Cereals are the most important portion of our diet all over the world, and they play an important role in our food security. Maize (*Zea mays* L.) is among the most important cereal crops in the world. Maize is cultivated in an area of about 150 m ha worldwide with average productivity of 5 t ha^{-1}. Globally, the USA ranks first in maize production followed by other countries like China, Brazil, Argentina, and India (FAOSTAT, 2019). India is ranked seventh in terms of production and fourth in terms of area among the nations that grow maize. Although maize may be produced year-round because it is a photo-insensitive plant, its cultivation is mostly concentrated during the *Kharif* season. Of the total area under maize cultivation, *Kharif* maize covers around 83 percent and the rest 17 percent is occupied by Rabi maize. *Kharif* maize is grown under the rain-fed condition which tends to suffer from different types of stresses that reduce Productivity (2.2 t ha^{-1}) in contrast to *Rabi* maize (4 t ha^{-1}), which is generally grown under protected condition (https://iimr.icar.gov.in/).

In India's North Eastern Himalayan Region (NEHR), maize is the second-most important crop after rice. It is grown largely under rain-fed mountainous upland environments. Maize cultivation plays an important part in providing food security in India's North Eastern Region (NER), where it is used for both direct consumption as well as for piggery and poultry feed. Maize is cultivated predominantly on jhum land and terraced areas of NER, covering a total area of 239 thousand hectares which adds up to 2.6 percent of the national average, according to the GOI for 2014-15 (Singh *et al.*, 2018[a]). However, in Meghalaya, maize is cultivated under 18000 ha with average productivity of 2.1 t ha^{-1} (Subhash *et al.*, 2019) which falls below the national average. Both abiotic and biotic stresses are

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responsible for the reduction in the yield of maize in rain-fed conditions. Among biotic stresses, the threat posed by weeds is a cause of concern for all maize growers. Weed infestation had been linked to a 35-80 percent reduction in maize output. The type of weed flora infesting the maize field, weed emergence, weed density, stage of crop growth relative to keen active competition period, and duration of weed infestation in the field are some of the major factors influencing yield losses (Singh *et al.*, 2018[b]). Furthermore, the cumulative impacts of genotypic efficiencies with various environmental combinations influence its productive potential. Weed competition is a serious problem for maize. The timing of weed emergence concerning the crop determines the severity of production losses, and it is evident that earlier emerging weeds cause more harm. Given that maize has a low level of competition when still in the early phases of growth, the critical period for weed control (CPWC) of the crop is crucial. The CPWC, according to Swanton and Weise (1991), is the crucial time frame when the field must be weed-free to prevent yield loss. Therefore, with the objectives of calculating weed density, diversity, and its importance value at weedy and weed-free stages in *Kharif* maize, a field study was conducted in the experimental field of the College of Post Graduate Studies in Agricultural Sciences (CAU-Imphal) Umiam, Meghalaya.

2. Material and Methods

1. Site details and experimental setup

The experiment was conducted at the Experimental field of College of Post Graduate Studies in Agricultural Sciences (CAU-Imphal), Umiam, Meghalaya, India. The experimental site is located at 25°68.157' N latitude, 91°91.203' E longitude, and 951 m above mean sea level. The soil of the experimental field is ideally clayey sand with a pH of 5.0-5.5. The climate of the region is defined as humid subtropical with heavy rainfall and cold winters. Monsoon season begins around the first week of June and lasts until the end of September. Monsoon withdrawal occurs in the first week of October, following a downward trend in rainfall from September onwards. During the cropping season, the experimental site received cumulative rainfall of 230.14 cm, and the mean weekly maximum and minimum temperatures were 26.54 °C and 18.03 °C, respectively **(Fig.1)**.

Standard techniques for growing maize were used to prepare the experimental field. The experiment was arranged in a randomized block design with three replications for 14 treatments*. The treatments were divided into two categories of seven treatments each, the first one as weedy treatment (plots were left weedy for 10,20,30,40,50, and 60 DAS) and the second one as weed-free treatment (plots) were left weed-free for 10, 20,30,40,50, and 60 DAS). Sowing was done with the spacing of 60 cm x 20 cm and the variety Vivek maize-45 was used.

2. Data collection and analysis

Weed samples were collected at every stage (10, 20, 30, 40, 50, 60, and 90 DAS and at harvest stage) using a 1 m^2 quadrant at five places from each plot, and weed species were separated and counted. Afterward, the following calculations were carried out for different parameters.

Relative frequency, which is expressed as a percentage, represents the degree of target species dispersion within the sampling unit in relation to the total number of all the species that occurred, whereas relative density describes the numerical strength of a target species in relation to the total number of individuals of all the species that occurred (Booth *et al.*, 2003).

$$\text{Relative Weed Frequency (RWF)} = \frac{\text{Number of quadrates in which a given species occured}}{\text{Total number of quadrates thrown}} \times 100$$

$$\text{Relative Weed Density (RWD)} = \frac{\text{Number of weeds of a given species in a quadrate}}{\text{Total number of weeds in that quadrate}} \times 100$$

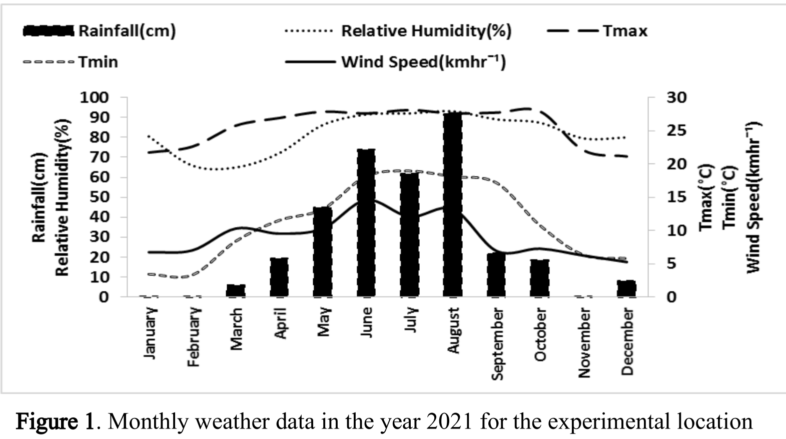

Figure 1. Monthly weather data in the year 2021 for the experimental location

*W_0-Weed free throughout growing season, W_1-Weedy up to 10 DAS, W_2-Weedy up to 20 DAS, W_3-Weedy up to 30 DAS, W_4-Weedy up to 40 DAS, W_5-Weedy up to 50 DAS, W_6-Weedy up to 60 DAS, WF_0-Weedy throughout the growing season, WF_1-Weed free up to 10 DAS, WF_2-Weed free up to 20 DAS, WF_3-Weed free up to 30 DAS, WF_4-Weed free up to 40 DAS, WF_5-Weed free up to 50 DAS, WF_6-Weed free up to 60 DAS.

the growth and development of the crop, which can be calculated using the following formula:

$$\text{Importance value (IV\%)} = \frac{\text{Relative Weed Density+Relative Weed Frequency}}{2}$$

A diversity index is a numerical representation of how many different species exist in a community, along with the relationships among the individuals distributed throughout those types, such as divergence, evenness, and richness. To study biological diversity, the following indices are commonly used.

Shannon-Wiener Index (H') = $-\sum_{N=1}^{S} pi(\ln pi)$ (Shannon and Weaver, 1963)

Simpson's Index (λ) = $\sum_{N=1}^{S} pi^2$ (Simpson, 1949)

Where,

pi: Proportion of individuals belonging to the i^{th} species

S: Number of weed species observed in the sample

N: Number of individuals in the sample

3. Results and Discussion

Avoiding yield loss and maximizing yield are two of the most crucial objectives in the maize production. However, this is not always simple owing to several aspects in the environment that affects crop growth. Along with other factors, weed competition can have a significant negative impact on maize yield losses up to 90% (Vrbničanin *et al.*, 2017). The degree of weed competition is influenced by soil characteristics, environmental factors, and weed abundance (Chikoye *et al.*, 2005; Soltani *et al.*, 2016). The reduction in yield can also be influenced by the diversity of weed species. However, crop yield reduction per unit of weed population or biomass is a common way to measure the competitiveness of weeds (Teasdale and Mohler, 2000; Kumar and Sundari, 2002).

Many weed species compete with maize plants, and it has been discovered that yield reductions of up to 65% occur when weed management is put off. Up to 83% of the grain yield in maize can be lost due to weeding after the critical period for weed removal (Ehsas *et al.*, 2016).

Weed flora

Weed flora of maize comprise varying plant species, ranging from grasses to broadleaf weeds and sedges, and they significantly reduce the yield (18–85%) (Jagadish and Prashant, 2016). Research data revealed that the field was infested by *Eleusine indica*, *Ageratum houstonianum*, *Cressocephalum crepidiodes*, *Bidens alba*, *Gallinsoga parviflora*, *Dichanthelium clandestinum*, *Digitaria ciliaris*, *Mimosa pudica*, *Acmella oleracea*, *Emilia sonchifolia*, *Cyperus distans*, *Echinohloa crusgalli*, *Eragrostis unioloides*, being problematic and reducing maize yield. The largest portion of the crop's weed flora (15%) belongs to the Asteraceae family, followed by Poaceae (8%), Amaranthaceae (6%), Euphorbiaceae (6%), and Fabaceae (6%). While other researchers discovered different weed species dominating maize fields. The most prevalent weeds in the maize field, according to Singh *et al.* (2015)[c], were *Chenopodium album*, *Medicago denticulata*, *Avenaludo viciana*, and *Phalaris minor*. Furthermore, according to Wiqar *et al.* (2019), *Digitaria marginata*, *Echinochloa spp.*, *Cynodon dactylon*, *Cyperus rotundus*, *Alhajica melorum*, *Convolvulus arvensis* and *Amaranthus spp.* are important weed species. The main weed species in the experimental field during the *kharif* season included *Xanthium strumarium*, *Tridax procumbens*, *Digera arvensis*, *Euphorbia geniculata*, *Euphorbia hirta*, *Cyperus rotundus*, *Parthenium hysterophorus*, *Amaranthis viridis*, *Cynodon dactylon*, *Panicum spp*, *Celosia argentea*, *Phyllanthus niruri*, *Alternanathera triandra*, *Dinebra arabica*, and *Commelina benghalensis* (Kakade *et al.*, 2020).

Weed Density

The highest weed density was found at 90 DAS in plots that had been kept weedy throughout the growing season, followed by density at the harvest stage, 60 DAS, and 50 DAS in the same plots. Also, there was a substantial difference in density between the 60 DAS and 90 DAS stages in the same plot, with a subsequent drop in density. At the same time, the plots kept weedy for 10 DAS had the lowest density. There is no significant difference between the densities at 90 DAS and the harvest stage in the plots that were kept weed-free up to 60 DAS **(Fig.2)**. These results are consistent with those of Waqir *et al.* (2019), who asserted that different herbicide treatments significantly affected the total number of weeds at every stage of the maize crop. While weedy check recorded a fairly higher number of weeds, the sequential application of atrazine @ 1.5 kg/ ha (pre-emergence) followed by tembotrione 0.12 kg/ha (post emergence) at 25 DAS documented a significantly lower number of weeds compared to the other treatments. Additionally, when the weeds were allowed to interfere the growth of maize for longer period the number of weed species competing with the crop increased (Imoloame and Omolaiya, 2017).

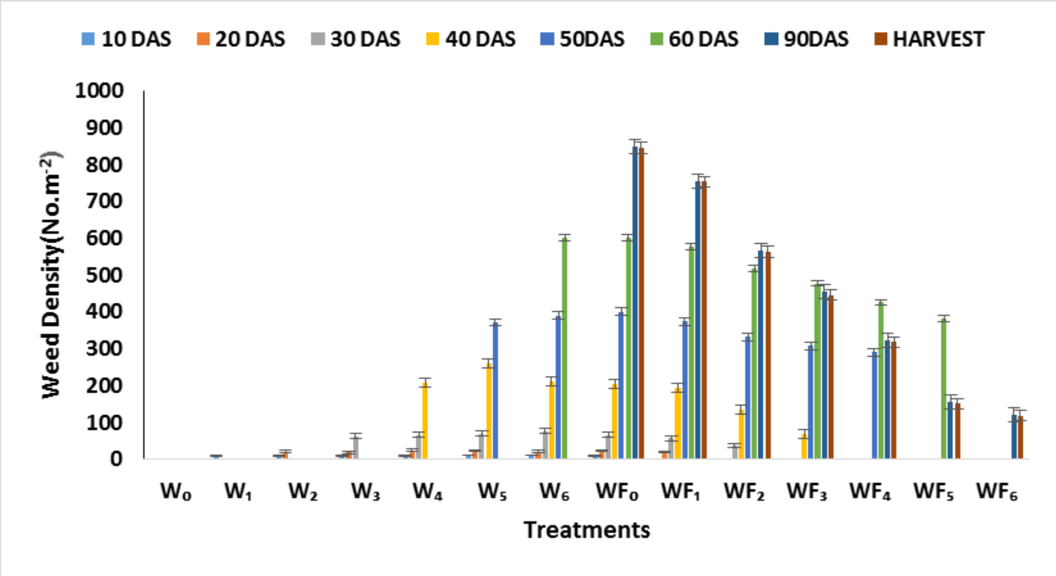

Figure 2. Density of weeds in maize as influenced periodically by different stages of weedy and weed free treatments

Relative weed density (RWD%) and Relative weed frequency(RWF%):

The data analysis revealed that the field was infested with weeds from six different families. Weeds belonging to the Asteraceae family were most dominant, followed by the Poaceae family. *Eleusine indica*, however, had the highest relative density and frequency (12.1%, 13.4% respectively), followed by *Ageratum houstonianum*, *Bidens alba*, and so on. Further, *Alternanthera sessili*, had the lowest relative density as well frequency (4.3%and 3.8% respectively). It was observed during the study that the maize field was mostly predominated by broad leaf weeds, grasses, and sedge sequentially **(Table 1)**. And the result confers with the findings of Imoloame and Omolaiya (2017). Even so, Williams and Lagoke (2018), reported the order of occurrence and weed flora composition to be broadleaf > sedge > grass.

Importance value:

Regardless of weedy and weed-free treatment combinations, the most significant weed species infesting the field include *Eleusine indica*, *Ageratum houstonianum*, *Bidens alba*, *Cressocephalum crepidiodes*, and *Gallinsoga parviflora*. The plots with weeds for 10 DAS had the highest important value for *Eleusine indica* (40%) while the plots with weeds for 30 DAS had the lowest importance value for *Eragrostis unioloides* (0.6%) **(Table 2)**. Additionally, the importance value for different weed species when calculated for all treatments combined showed that *Eleusine indica* ranked first (12.9%), followed by *Ageratum houstonianum* (10.4%), *Bidens alba* (9.5%), and so on. While *Paspalum scobuculatum* (22.8%) and *Digitaria horizontalis* (10.6%), according to Imoloame and Omolaiya (2017), had the highest importance value in maize weed interference.

Table 1. Relative weed density (RWD%) and Relative weed frequency (RWF%) of the weed species of Maize during *Kharif* season, 2021

WEED	FAMILY	COMMON NAME	RWD %	RWF%
Eleusine indica	Poaceae	Goosegrass	12.15	13.41
Ageratum houstonianum	Asteraceae	Goatweed	9.96	10.79
Bidens alba	Asteraceae	Spanish needle	9.82	9.14
Gallinsoga parviflora	Asteraceae	Gallant soldier	9.34	8.47
Digitaria ciliaris	Poaceae	Crab grass	8.27	7.84
Cressocephalum crepidiodes	Asteraceae	Redflower ragleaf	7.25	7.25
Mimosa pudica	Fabaceae	Touch me not	5.12	5.52
Dichanthelium clandestinum	Poaceae	Deer Tongue	5.09	5.36
Echinohloa crusgalli	Poaceae	Barnyardgrass	4.93	5.31
Acmella oleracea	Asteraceae	Toothache plant	4.91	4.99
Eragrostis inioloides	Poaceae	Canegrass	4.85	4.96

Cyperus distans	Cyperaceae	Slender cyperus	4.75	4.59
Spermacoce alata	Rubiaceae	Buttonweed	4.64	4.45
Emilia sonchifolia	Asteraceae	Liliac tassel flower	4.60	4.21
Alternanthera sessilis	Amarantheceae	Joyweed	4.33	3.73

Weed diversity:

When the Shannon Wiener Diversity Index values were calculated for the different treatments, W_5, WF_0, WF_1, and WF_6 gave the highest value (2.7), suggesting the most diversity followed by WF_2, WF_3, WF_5, WF_4, and W_4. W_1 had the least diversity (1.56).Similarly, when the Simpsons index values for several treatments were calculated, W_1 had the highest value of 0.2, indicating that a few species were dominant. W_5, W_6, WF_0, WF_1, WF_2, WF_3, WF_4, WF_5, and WF_6 had the same value (0.07), showing that the weed species had equal dominance in these treatments. Diversity indices used in the experiment provide a far more detailed description of the composition of the weed species as compared to just species richness (Sawicka *et al.*, 2020). The higher value of the Shannon-Wiener index represents the higher diversity prevalent in the specific area. Conversely, a higher Simpson's index score indicates less diversity. Furthermore, the result also revealed a similar result. The highest value of the Shannon Wiener Index (2.70) corresponded well with the least value of Simpson's Index (0.07) **(Fig.3)**.

4. Conclusion

According to the experimental results, the maize-based cropping system in Meghalaya is seriously threatened by weed species from the families Poaceae and Asteraceae. Among the various weed species, *Eleusine indica*, *Ageratum houstonianum*, *Bidens alba*, *Cressocephalum crepidiodes*, and *Gallinsoga parviflora* are the most important weeds in the cropping system, and weed density increases with weedy duration up to 90 DAS after which, then values declines substantially. Management tactics should be altered so that species with higher importance values receive the majority of attention from the start in order to minimise their population and lower cultivation expenses without sacrificing yield.

5. Acknowledgement

The authors are highly grateful to the CPGS-AS, CAU(I), Umiam, Meghalaya for providing all the required facilities, and constant support for conducting the experiment.

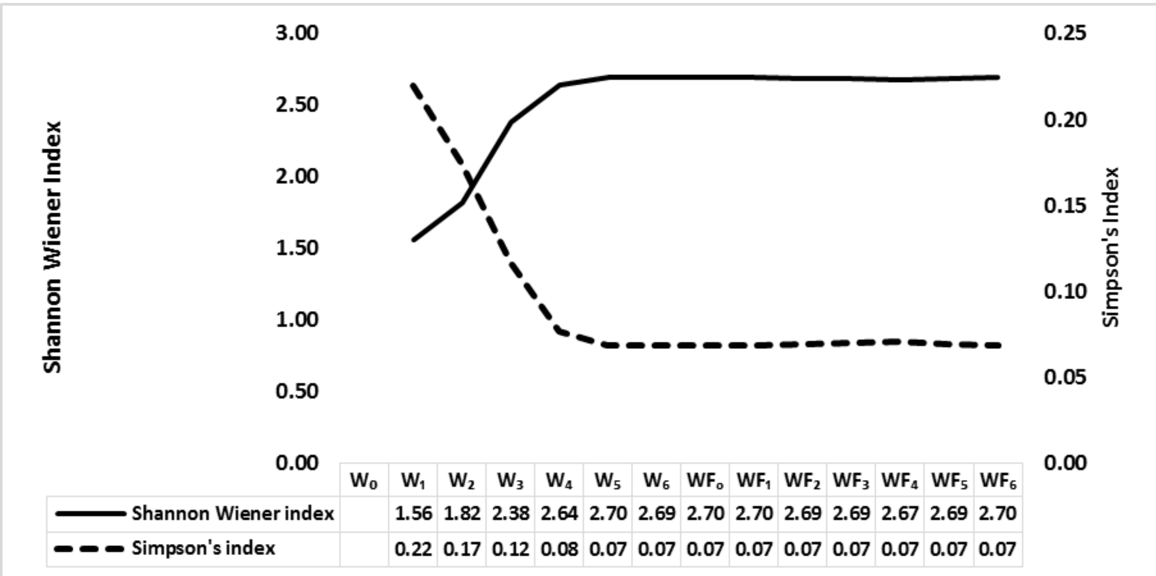

Figure 3. Shannon Wiener Index and Simpson's index as influenced periodically by different stages of weedy and weed free treatments

Table 2. Importance value of different weed species of maize under different weedy and weed-free treatments

Importance value %	W_0	W_1	W_2	W_3	W_4	W_5	W_6	WF_0	WF_1	WF_2	WF_3	WF_4	WF_5	WF_6	Total %	Rank
Eleusine indica	-	40.00	19.38	18.15	12.38	12.25	7.91	7.55	8.05	8.42	8.97	7.18	7.95	7.94	12.78	1
Ageratum houstonianum	-	22.50	13.25	12.92	12.58	12.42	8.08	7.27	7.65	7.67	8.02	7.63	8.33	6.51	10.37	2
Bidens alba	-	10.00	16.38	12.72	11.86	9.56	8.07	7.66	7.87	7.65	8.19	7.88	7.70	7.66	9.48	3
Gallinsoga parviflora	-	-	21.38	5.08	9.54	9.86	8.12	7.59	7.76	6.98	7.77	8.51	7.57	8.64	8.37	4
Cressocephalum crepidiodes	-	5.00	15.25	9.00	10.75	3.86	7.98	7.41	8.03	7.94	8.45	8.54	9.21	6.37	8.29	5
Digitaria ciliaris	-	22.50	9.25	6.05	8.74	5.89	5.71	6.75	5.96	5.56	5.72	4.81	5.68	5.53	7.55	6
Mimosa pudica	-	-	-	3.34	4.99	5.68	7.27	6.70	5.38	6.18	7.13	8.41	5.93	7.94	5.30	7
Dichanthelium clandestinum	-	-	5.13	5.32	4.75	8.65	5.86	5.51	7.24	4.33	5.98	6.06	3.78	5.53	5.24	8
Acmella oleracea	-	-	-	3.53	2.06	8.32	5.57	6.47	5.75	6.97	5.72	6.71	7.57	5.67	4.95	9
Echinohloa crusgalli	-	-	-	3.53	4.84	5.76	5.76	6.45	6.76	6.48	6.99	4.93	5.77	7.09	4.95	9
Eragrostis inioloides	-	-	-	0.58	4.96	3.17	6.98	6.52	6.86	6.27	5.57	6.68	6.91	7.94	4.80	10
Spermacoce alata	-	-	-	8.42	2.68	2.88	5.25	6.22	6.36	5.82	5.21	4.63	6.56	6.93	4.69	11
Cyperus distans	-	-	-	7.06	4.86	3.17	5.65	6.47	5.50	6.55	5.62	4.88	5.30	5.67	4.67	12
Emilia sonchifolia	-	-	-	1.16	2.84	5.63	5.41	6.43	5.50	6.73	7.00	8.01	5.93	4.24	4.53	13
Alternanthera sessilis	-	-	-	3.14	2.17	2.93	6.38	5.02	5.33	6.46	3.66	5.13	5.80	6.37	4.03	14

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