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Seed Production, Germination, Emergence and Growth of *Tithonia diversifolia* (Hemsl.) A. Gray as Influenced by Different Sowing Depths and Soil Types

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Abstract

Seed production, germination, emergence and the influence of planting depths and soil types on growth of *T. diversifolia* were determined from the harvest made in 2013 fruiting season. Natural population of *Tithonia diversifolia* stands growing on a clay soil was used for the study. Number of capitulum heads per plant was in the range of 35-212 with each capitulum head carrying seeds in the range of 32-62. Depending on the size and number of capitulum heads number of seeds per plant ranged from 1120-13,144 with average of 897,342 seeds per square meter. The seeds were small and light in weight as indicated by 100-seed weight (0.51-0.72 g) with 93% viability. The seedlings that emerged from soil showed greater growth efficiency and vigour compared to seedlings obtained from seeds plated in petri-dishes. The young seedlings emerged at all depths studied with seeds sown on soil surface having 76.76 % germination while those at the depth of 3.5 cm showing 5%. Growth parameters such as root length, shoot length, leaf area, leaf number and dry matter accumulation increased significantly ($p \leq 0.05$) with decrease in sowing depth. The plant grew in all types of soils investigated with maximum growth in loamy followed by clayey and sandy soil. The foregoing results could be used to account for the aggressive nature of this plant.

Keywords: Capitulum, dry matter, germination, loamy soil, viability

1. Introduction

Tithonia diversifolia, Asteraceae, is a perennial shrub which is native to North and Central America but has become an invasive species in Africa [8]. In West Africa, the plant has established itself as a noxious weed of arable crops. It is an aggressive colonizer of new sites, inhabiting every available sunny space with high water table. It has also been reported to be alloptric never found growing in mixed population [8]. In Nigeria, the weed has become predominant in waste lands, railway banks, building sites, fallowed land and cultivated farm lands. It is a serious weed species in cowpea, groundnut, guinea corn, maize and cassava.in southern Guinea savanna ecological zone of Nigeria, like *Chromolaena odorata.*

The effect of weeds on crop in terms of yield losses, reduction in available nutrients, light, space and carbon dioxide that are necessary for plant growth have been variously reported [5, 9 2, 3, 7 and 4]. As an invasive plant that readily thrives virtually in all ecological habitats, a clear understanding of the behavioral pattern of this plant needs to be investigated. This will provide a platform for the development of effective control measures. In Zambia, reproductive strategies, seed germination in the field as well as allocation of dry matter to different structural parts of this plant have been documented [8]. However, there is little or no information on the growth of this plant under different sowing depths and soil types. This study therefore examines the seed production, germination, emergence and growth *T. diversifolia* at various soil depths and soil types with the aim of providing evidence on the depth that promotes the emergence of the plant and the soil type that favour its luxuriant growth for its invasive characteristics.

2. Materials and Methods

2.1. Seed production and viability test

Natural population of *Tithonia diversifolia* stands growing on a clay soil opposite University of Ilorin, Zoological garden was used for the study. Ten $1m^2$ quadrats were randomly marked out in zig-zag manner with each quadrat containing at least eight

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stands of the *T. diversifolia* plants. Five individual plants within each quadrat were tagged and left until anthesis and subsequent fruiting. In December 2013, matured and dried captilum heads per plant were manually counted and carefully removed by cutting the flower stalk with the aid of sharp knife for each of the tagged plants within the quadrat. The capitulum heads per plant were bagged in separate envelope and labeled appropriately. In each of the five plants that were sampled per quadrat, the number of seeds per capitulum were counted and this was used to determine number of seeds per plants as well as average number of seeds per square meter. The seeds were air-dried for one week and cleaned to remove foreign particles and weight of 100 and 1000- seed weight were then evaluated. The harvested seeds were stored in plastic bottles at room temperature (27-28^{o}C) until they were used for study. Seed viability was determined using floatation methods by soaking seeds in 500 ml beakers containing water and left to stand for fifteen minutes. The number of floated seeds and those that sank at the bottom were counted. Five replicates with 150 seeds per replicate were used. Thereafter, percentage viability was determined using the formula below.

$$\% \text{ Viablity} = \frac{\text{Total number of soaked seeds} - \text{Number of floatec seeds}}{\text{Total number of soaked seeds}} \text{ x100}$$

It should be noted that seeds that were considered viable, air-dried for one week and stored in a stopper bottle at room temperature were used for subsequent studies.

2.2. Germination, emergence and growth

Seed germination efficiency of *T. diversifolia* was compared in Petri-dishes and pots. In Petri-dishes of 9 cm in diameter, 20 seeds were plated after they have been surface sterilized using 0.1g mercury chloride and rinsed with several changes of distilled water. In the pots experiment, 20 seeds were also planted on soil surface and irrigated both in the morning and evening. Both treatments were in five replications. The emergence of radicle was used as criterion to score germination in Petri-dishes whereas in pots experiment germination was scored when cotyledon has emerged above the soil surface. The effect of sowing depth on seed emergence growth of *T. diversifolia* was determined by sowing 20 cleaned seeds in pots (17 cm x14 cm) at depth of 0, 0.5, 1.5, 2.5 and 3.5 cm. The depth was determined by inserting a graduated stick from the soil surface. The pots were arranged following a complete randomized block design with each depth having four replicates. The germination counts were made on daily basis for 10 days and the index of germination was protrusion of the cotyledon from the soil surface. After 10 days, the seedlings were thinned down one per hole within each sowing depth. The growth of *T. diversifolia* at various depths in terms of plant height, number of leaves, length of petiole, root length, leaf area, fresh and dry weight were determined at eight weeks after planting. It should be noted that the dry weight was obtained after oven-dried at 80^{o}C for 24 hours.

2.3. Growth of T. diversifolia under different soil types

In separate experiment, the effect of three soil types- loamy, sandy and clayey soils on growth of *T. diversifolia* were monitored for 12 weeks. In each soil type, twelve plastic of dimension 17 cm by 14 cm were used. The pots were filled with different soil types and arranged in complete randomized block design with four replications. Growth parameters that were determined were plant height, number of leaves and total leaf area at interval of two weeks till the end of the experiment.

2.4 Data analysis

Data were analysed using simple percentage range and Analysis of Variance Using Gent Start Statistical Package. Graphs were plotted using Origin 7.0 for window. Means were separated using Duncan Multiple range Test at 0.05 level of significance.

3. Results

3.1 Reproductive behaviour

The reproductive behaviors of T. diversifolia are shown in Table 1. The number of capitulum heads per plant and number of seeds per capitulum as obtained from the ten quadrates ranged from 35-212 and 32-62 respectively. Depending on the number of capitulum head per plant, number of seeds was between 1,120-13,144. The weight of 100 and 1000 seeds had values that ranged from 0-51-0.72 and 6.42-7.50 g respectively which indicated that the seeds of *Tithonia diversifolia* are very light. Mean number of seeds per square meter was 897,342±31,054.03.

Table 1. Reproductive behavior of *T. diversifolia*

S/N	Parameters	Range of values (1-5)
1	Number of capitulum head per plant	35-212
2	Number of seeds per capitulum head	32-62
3	Number of seeds per plant	1120-13,144
4	100-seed weight (g)	0.51-0.72
5	1000-seed weight (g)	6.42-7.5
6	Mean number of seeds per square meter	897,342±31054.03

3.2. Germination efficiency and effect of sowing depth on percentage germination.

Seeds sown in pots germinated better that those in Petri-dishes (Table 2). Significance difference was recorded in percentage germination of the plant at various showing depths (Table 3). *Tithonia diversifolia* germinated readily from soil surface as indicated by significantly ($p \leq 0.05$) highest percentage germination of 76.76. Lowest percentage germination was recorded at the highest soil depth (5.00%). As observed in this study, seedlings from the soil surface emerged five days after planting while seedlings from 0.5-2.5cm and 3.5cm emerged six and seven days after planting respectively. Generally, percentage germination increased with decrease in planting depth (Table 3).

Table 2: Germination efficiency of *T. diversifolia* in petri-dishes and pots

Experiment	Number of seed planted	Number of seeds germinated	Percentage germination
Petri-dishes	100	19	19
Pots	100	81	81

Table 3: Effect of various sowing depth on percentage germination of *T. diversifolia*

Depth of sowing (cm)	Percentage germination
0	76.76^{a}
0.5	53.33^{b}
1.5	53.33^{b}
2.5	23.3^{c}
3.5	5.00^{c}
p-value	<0.001
SEM	7.19

Within column mean values followed by the same superscripts are statistically similar at $p<0.05$

Different sowing depths significantly ($p \leq 0.05$) affect all the growth characters that were assessed (Table 4). The increased in height of the plant was significantly highest when seeds were planted on the soil surface (24.90 cm) and followed in decreasing order at planting depth of 0.5cm (18.63cm), 1.5 cm (16.23cm), 2.5 cm (12.51 cm) and 3.5 (8.20 cm). Number of leaves followed the same trend as plant height. However, significantly highest numbers of leaves were recorded from the soil surface (35.33 cm^2) and depth of 0.5 cm (32.67cm^2) whose values are statistically similar. Statistical difference in number of leaves was not recorded at sowing depth of 1.5─2.5cm. Significantly lowest number of leaves was obtained in *T. diversifolia* at the highest sowing depth of 3.5cm. Petiole length and root length of the plant showed similar trend. The parameters increased significantly with decrease in depth of sowing (Table 4). The leaf area, fresh and dry weight of *T. diversifolia* significantly increased proportionately with decrease in sowing

depth. In all the aforementioned parameters significantly lowest values of the parameters were recorded from highest depth of sowing (Table 4).

Table 4: Effect of sowing depth on Morphological characters of *T. diversifolia*

Depth of sowing	Plant height (cm)	Number of leaves (n/p)	Petiole length (cm)	Root length (cm)	Leaf area (cm^2)	Fresh weight (g)	Dry weight (g)
0.0	24.90^{a}	35.33^{a}	3.83^{a}	16.93^{a}	840.45^{a}	11.43^{a}	2.43^{a}
0.5	18.63^{b}	32.67^{a}	3.50^{ab}	13.37^{ab}	684.86^{b}	$8,23^{b}$	1.69^{b}
1.5	16.23^{c}	30.67^{ab}	3.09^{bc}	10.53^{bc}	590.58^{c}	6.73^{c}	1.43^{bc}
2.5	12.51^{d}	26.67^{ab}	2.84^{c}	10.20^{c}	405.38^{d}	5.53^{d}	1.29^{cd}
3.5	8.20^{e}	22.00^{c}	1.87^{d}	5.97^{d}	283.80^{e}	4.71^{d}	1.09^{d}
p-value	<0.001	0.04	<0.001	<0.001	<0.001	<0.001	<0.001
SEM	1.53	1.66	0.74	0.99	53.73	0.64	0.13

Within column mean values followed by the same superscripts are statistically similar at $p \leq 0.05$

3.3. Effect of soil types on growth

The results of the effect of three soil types on plant height, number of leaves and leaf area are presented in Figs. 1, 2 and 3. In Fig. 1, plant height of *T. diversifolia* increased linearly in all the soil types till final sampling (12^{th} week after planting). Loamy soil was found to significantly increase the height of the plant followed by clayey soil. Least height increment was recorded in *T. diversifolia* grown in sandy soil in all the sampling periods. The number of leaves and leaf area of *T. diversifolia* as shown in Figs. 2 and 3 followed the same trend as plant height except that at 4 and 6 WAP, *T. diversifolia* grown in loamy and clayey soil showed leaf development that was statistically the same.

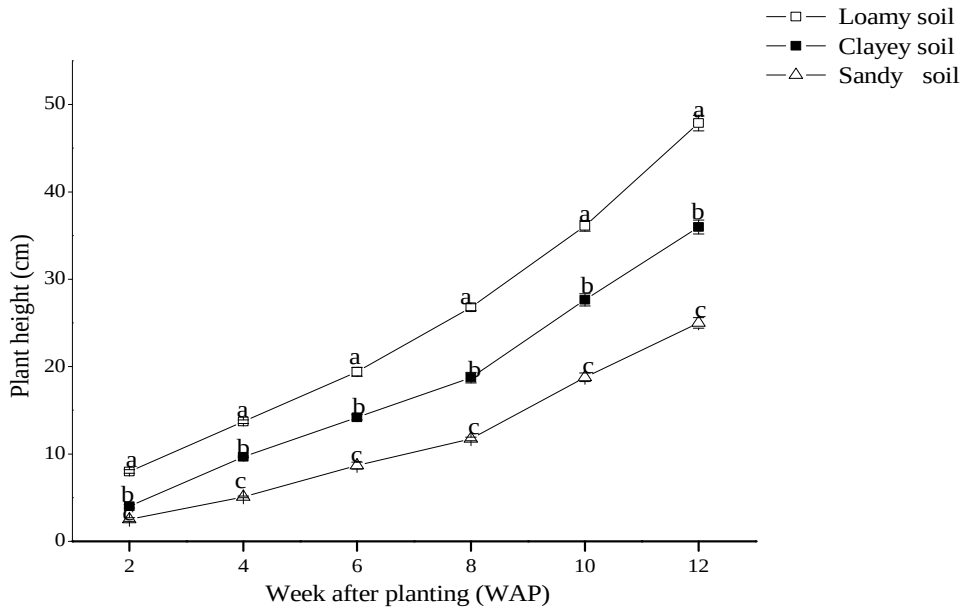

Figure 1. Mean plant height of *T. diversifolia* as affected by different soil types

Mean followed by the same letter during each sampling period are statistically similar at 0.05 level of significance. Bars represent standard error (SE±) of means.

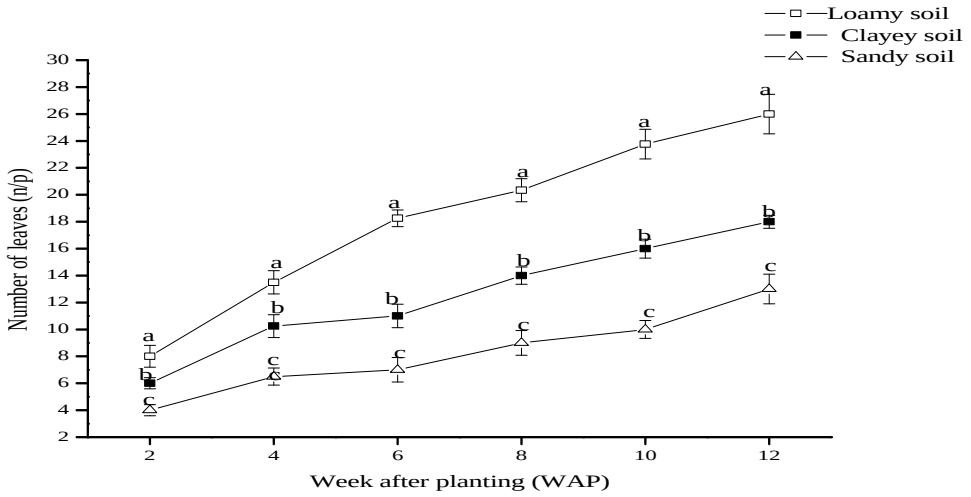

Figure 2. Mean number of leaves of *T. diversifolia* as affected by different soil types

Mean followed by the same letter during each sampling period are statistically similar at 0.05 level of significance. Bars represent standard error (SE±) of means.

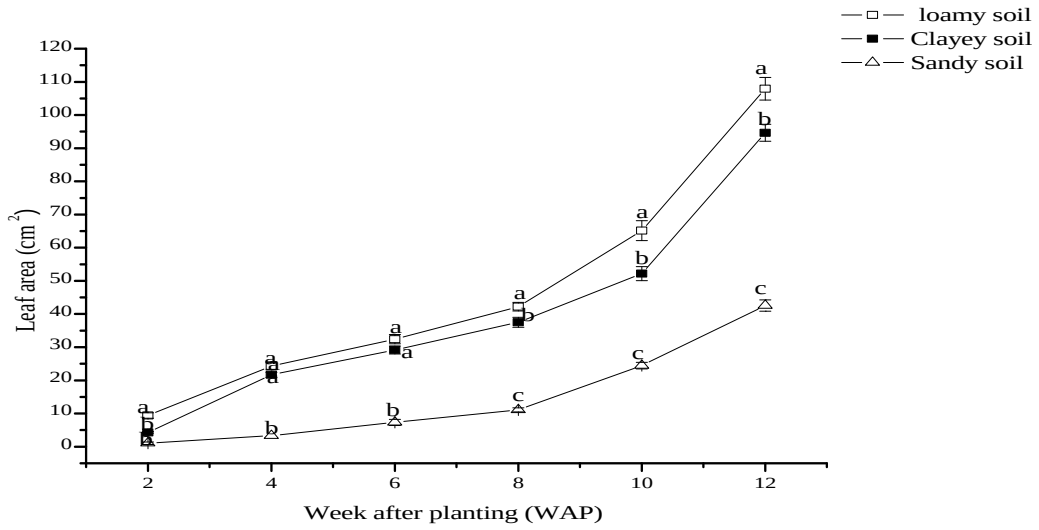

Figure 3. Mean leaf area of *T. diversifolia* as affected by different soil types.

Mean followed by the same letter during each sampling period are statistically similar at 0.05 level of significance. Vertical bars represent standard errors (SE±) of means

3. Discussion

Tithonia diversifolia, whose behavioural pattern was investigated, produced greater number of capitulum heads per plant with each capitulum carrying enormous number of seeds. The number of seeds per plant could be as high as ten thousand even more. As indicated by 100 and 1000-seed weight *T. diversifolia* seeds are smaller in size and light weight with structural adaptation known as pappus which aids their floatation in air. The foregoing reproductive attributes could account for its wide spread, ability to cluster along the borders of major roads and rapid colonization of sites. Similar findings had been reported by [8] in their comparative studies of seed germination and reproductive strategies of *T. diversifolia and T. rotundifolia*. In the study, it has been shown that within a square meter number of seeds released from dried capitulum heads and deposited in the soil seed bank could be as high as eight hundred thousand. The preponderant of the seeds in thesoil seeds bank coupled with 81 percent germination efficeincy when planted in soil could explain its prolific growth in areas where it become invasive. This could also be used to explain why the plants grow in dense populations with heavily clustered stands with closed canopies. Their closed

canopies and dense populations completely shade out other weeds and neighboring crops [1], and made them to stabilize as single or near single species stands[8].

The seeds of *T. diversifolia* were found to germinate readily from the soil surface and percentage germination increased significantly with decrease in planting depth. Similar findings had been reported on *Euphorbia heterophylla* weed where it was posited that the plant emerged very readily on the soil surface [5]. The ability of the seeds to germinate very readily on the soil surface and emergence of this plant with further increase in depth may probably explain why the plant is able to compete with a wide range of crops [5]. In crop-weed competition, weeds have been found to emerge faster and grow readily compared to the crop they are competing with [6].

The growth and dry matter accumulation of *T. diversifolia* at various soil depths which was fastest when seeds were planted on the soil surface could further be used to explain the ability of this plant to compete and colonize every available sites. *T. diversifolia* was found to thrive in all the soil types studied. This further explains the ability of this plant to grow on a wide variety of ecological habitats. The enhancement of growth in loamy soil compared to other soils is quite understood as the soil is rich in organic matter which the plant was able to utilize to maximize growth. Similarly, better growth in clayey soil than sandy soil could be attributed to retention of moisture within soil pores which would have been otherwise drained in sandy soil due to its porous nature.

4. Conclusion

The behavioural pattern of this plant in terms of production of light weight and numerous viable seeds as well as high ability of the seedlings to emerge from the soil at various depths are some of the factors responsible for the aggressiveness and successful nature of this plant on a wide variety of ecological habitats.

5. References

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