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Seasonal Effects on the Critical Period for Weed Removal and Okra Performance on *Tithonia diversifolia* (Helmsl) A. Gray Infested Field

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Abstract: Field experiments were conducted during dry and rainy reasons at the Ladoke Akintola of Technology Ogbomoso to understudy the effects of seasons on okra performance and the critical period for weed removal in Okra on *Tithonia diversifolia* infested fields. The randomised complete block experiment had ten weeding regimes (treatments) throughout the experimental period. Results of the experiments showed that better growth and yield of Okra occurred during the rainy season than the dry season. Okra performance was not significantly (P=0.05) affected during the rainy seasons when *Tithonia* weed competition did not exceed 4 WAP. However, during the dry season, okra performance was only comparable to the control when infestation did not exceed 2 weeks after planting (WAP). During the rainy season, weeding beyond the 4th WAP was luxurious while in the dry season luxurious weeding occurred beyond 2 WAP. Similarly, one single weeding that kepts the crop weed free for the first 2 WAP was as inadequate as not weeding at all during the rainy season while in the dry season delayed weeding beyond 2 WAP led to damages that could not be reversed by subsequent clean weeding.

Key words: Season · Critical period · Weed removal · *Tithonia*

INTRODUCTION

The significance of weed in agriculture in general and crop production in particular had over the years been highlighted by various researchers. The cumulative effects of weeds on crop production eventually lead to crop losses due to weed activities including competition, allelopathy, acting as alternate and / or alternative hosts to pests and pathogens, adulteration of farm produce etc [1-4] uncontrolled weed growth had resulted in yield losses ranging from 40% [1] to 97% [4] in maize, 91% in sweet potato [1] and 35%, 60%, 75% and 80% respectively in a yam/maize/okra/sweet potato intercropping systems [5]. Thus, the need for adequate weed control for good crop yield can not be over emphasized. However, since the bulk of labour requirement in crop production goes into weed control [1] it implies that the bulk of the total cost of production is gulped by weeding. Usoroh [6] reported that weeding alone accounted for 30-45% of the total cost of production in Nigeria, while in India, the cost of weeding alone in pineapple production line stands at 40% of the total cost of production [7].

The frequency and hence the cost of weeding is influenced by a number of factors ranging from the weed type, crop grown, cultivation practices and farming system to season of the year. It is however significant to note that the response of plants (weed/crop) to season is a direct consequence of available water and length of daylight. Thus, competition for water and space is likely to be severe during the dry season than the rainy season. It is also likely that the competitive ability of the plants (crop/weed) during the dry season will be lower compared to the rainy season. Against this background, there is the suspicion that the blanket recommendations as per the critical period of weed removal in crops may not hold across the seasons. This suspicion becomes stronger when considering competition between a water loving crop like Okra and a water loving weed like *Tithonia*. Okra is a prominent fruit and leafy vegetable grown for domestic consumption of the highly nutritious immature leaves and fruits in Nigeria [8]. Most of the cultivation is done during the dry season either as a follow up crop to early maize or in fadama cultivation, especially in the south west Nigeria. *Tithonia diversifolia*, family Asteracase and native to Mexico and Central America [9] is an alien invasive weed in Tropical Africa. Characterized with an aggressive growth and high biomass accumulation, *Tithonia* is a very successful competitor on most crop field [10].

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Against a crop like okra, with a very slow juvenile development, Olabode [10] reported yield loss of over 95% and 99% loss in seed viability in an uncontrolled Tithonia/Okra competiton. In the earlier reported study Olabode, [10] fixed the critical period for the weed removal in okra at 2-4 weeks after planting (WAP). However, this recommendation did not take the effect of season into consideration. The aim of the experiment therefore is to understudy the influence of season on okra/*Tithonia* competition with a view to determine the critical period of Tithonia removal in dry season Okra production.

MATERIALS AND METHODS

Field experiments were conducted at the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso during the rainy and dry seasons of 2006 and 2007. The experiments were sited on *Tithonia diversifolia* dominated plots [11]. The sites were adjudged heavily infested by Tithonia having being found that the weed accounted for more than 90% of the total weed population obtained from 20 randomly placed 1 m^2 quadrat. Routine analysis of the soil of the experimental site shows that it contains 2.3% organic carbon, 0.31% nitrogen, 6.48 ppm. available phosphorus, 0.41meq/100 g Exchangeable K, pH 6.20 and sandy loan textures. The mean annual rainfall was 1677 mm while the mean annual temperature was 30.1°C.

The experimental design was a randomized complete block with three replications. Each replicate was measured 19 m X 9 m with a space of 1 m separating the replicates while each plot measured 3 m x 4 m with an alley of 1 m separating the plots. There were ten (10) plots representing ten (10) treatments divided into 2 schemes (Table 1). In the first scheme were: weed free conditions for only the first 2, 4, 6 and 8 weeks after planting (WAP) each followed by weed infestation till harvesting. The control treatment for this scheme is clean weeding (no weed infestation). In the second scheme, the treatments were; Tithonia weed infestation for only the first 2, 4, 6 and 8 WAP each followed by clean weeding till harvesting. The control of the scheme is no weeding. Weeding was done manually such that one hoe weeding provided 1 week weed freeness [12].

Plantings were done on flat on June, 18 and 21 respectively for 2006 and 2007 rainy season trials and October 5 and 9 respectively for 2006 and 2007 dry season trials after manual land preparation. The okra variety V35, an early maturing cultivar obtained from the National Institute for Horticultural Research and Training (NIHORT) Ibadan, was used for the experiment.

Table 1: Experimental Treatments

Treatments	Acronyms
SCHEME I	
Weed free for the first 2 WAP* followed by weed infestation	T1
Weed free for the first 4 WAP followed by weed infestation	T2
Weed free for the first 6 WAP followed by weed infestation	T3
Weed free for the first 8 WAP followed by weed infestation	T4
Weed free life	T5
SCHEME II	
Weed Infestation for the first 2 WAP followed by weed freeness	T6
Weed Infestation for the first 4 WAP followed by weed freeness	T7
Weed Infestation for the first 6 WAP followed by weed freeness	T8
Weed Infestation for the first 8 WAP followed by weed freeness	T9
Weed Infestation for life	T10

* WAP - Weeks After Planting

Planting was done at a spacing of 0.6 m x 0.5 m. Three seeds were planted/hole and the seedlings were later thinned to 2 plants/stand to give a plant population density of 66, 666 plant/ha. Cypermethrin was used to control insect pests' attack from the 10th days after planting at 5 days interval.

Data were collected for the growth and yield parameters of okra including plant height by measuring with metre rule, stem diameter using the Venier calipers, leaf area following Olasantan [13] and Numbers of branches/plant, days to 50% flowering and cumulative fruit yield / plant harvested at 5 days interval. The cumulative fruit weight was also recorded from which the fruit yield (t/ha) was estimated. Data were also collected for *Tithonia* weed population density and dry matter yield. The density was determined using the quadrat method while the dry matter yield was measured using the oven drying method at 80°C for 72 hours. Data means over the two years were subjected to analysis of variance and means were compared using the least significant difference (LSD) as outlined by Steel and Torrie [14].

RESULTS

The influence of season on the growth performance of okra under the various weeding regimes is presented in Table 2. There were significant (P = 0.05) seasonal effects on the parameters measured. Except for flowering, all the parameters measured were better in the rainy season than the dry season across the weeding regimes, okra plant height stem diameter, leaf area and number of branches increased with decreasing period of *Tithonia* infestation (T2, T3, T4 and T5). Also, when infestation was not more than the first two weeks of life (T6), okra growth

Table 2: Effects of season and period of *Tithonia* infestation on the growth of okra

Period of Infestation	Plant Height (cm)		Stem Diameter (cm)		Number of branches (cm^2)		Leaf area (cm^2)		No of Days to 50% Flowering	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
T1	35.2	24.4	0.70	0.59	0.0	0.5	31.3	21.9	74.0	48.0
T2	66.2	35.7	1.10	0.62	2.5	1.5	940.7	658.5	60.0	48.0
T3	66.2	35.5	1.06	0.63	3.8	2.5	1047.9	732.9	60.0	49.0
T4	71.0	38.0	1.23	0.56	3.8	3.0	1167.2	805.4	56.0	50.0
T5	72.5	39.2	1.20	0.60	3.7	3.0	1257.8	860.5	58.0	50.0
T6	72.2	39.0	1.15	0.61	5.2	3.0	1094.6	766.2	61.0	48.0
T7	67.2	25.5	0.94	0.34	5.0	1.0	529.3	370.5	59.0	69.0
T8	34.5	18.7	0.56	0.27	1.8	0.0	109.5	75.0	74.0	0.0
T9	35.2	19.0	0.60	0.22	1.8	0.5	23.0	14.8	74.0	0.00
T10	33.7	18.0	0.52	0.26	0.0	0.0	27.0	14.5	78.0	00.0
LSD 5%	8.29		0.21		1.38		257.40		10.44	

Table 3: Effects of season and period of Tithonia infestation on the yield and yield Parameters of okra

Period of Infestation	No of Fruit/Plant		Fruit Yield (kg/ha)		Number of Seeds/Pod		100-Seed Weight (g)	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
T1	0.5	2.4	0.2	1.3	780.0	17.0	17.9	2.7
T2	5.0	4.6	3.1	1.9	97.0	39.0	20.1	2.9
T3	6.6	4.8	4.9	2.5	103.0	52.0	20.3	2.9
T4	6.5	4.5	5.4	2.5	107.0	54.0	19.1	3.0
T5	6.5	5.0	5.4	2.8	121.0	55.0	18.3	3.1
T6	6.8	4.7	5.3	2.8	124.0	54.0	20.7	3.2
T7	2.6	3.0	1.2	1.5	114.0	50.0	19.3	2.6
T8	1.4	0.0	0.3	0.0	85.0	10.0	19.7	2.4
T9	0.0	0.0	0.0	0.0	86.0	2.0	16.8	0.2
T10	0.0	0.0	0.0	0.0	16.0	0.0	14.5	0.0
LSD (5%)	2.21		2.72		18.70		2.10	

Table 4: The Effects of season and period of weed infestation on the density and dry matter yield of *Tithonia diversifolia* on okra plots

Period of Infestation	Weed Density/m^2		Weed Dry Matter Yield (Kg/m^2)	
	Rainy Season	Dry Season	Rainy Season	Dry Season
T1	76	48	3.80	2.31
T2	70	24	0.96	0.55
T3	47	19	0.21	0.14
T4	50	20	0.21	0.16
T5	31	19	0.11	0.09
T6	49	34	0.94	0.56
T7	90	54	1.25	0.97
T8	69	42	2.92	1.78
T9	74	44	3.24	1.94
T10	82	49	3.29	1,97
LSD (5%)	20.00		1.04	

•For Scheme (in creasing weed freeness i.e. T1-T5), data were collected at flowering

•For scheme 2 (increasing period of infestation i.e. T6 - T9), data were collected at point of weed removal

parameters were similar to those of T2 - T5. There were no significant difference (P= 0.05) in all these parameters among the listed treatments i.e. (T2 - T6). Conversely, okra plants subjected to treatment T1, T7-T10, which represented increasing period of *Tithonia* interference, were inferior to the other treatments and control in these parameters (p = 0.05). Flowering was significantly earlier and more uniform in okra during the dry season than the wet season. The mean number of days to 50 % flowering in okra during the wet season was 65.4 as against 51.7 in the dry season. There were no significant difference (P=0.05) in the attainment of 50 % flowering in okra plant subjected to weed freeness for the first 4, 6 and 8 WAP as well as those subjected to weed infestation for only the first four weeks of live (T2-T7) when compared to the control during the rainy season. During the dry season however, only T2 - T6 were significantly (P = 0.05) comparable in the attainment of 50% flowering. Beyond infestation for 4 WAP and 2 WAP in rainy and dry seasons respectively, flowering was as badly delayed as in no weeding.

In general, considering okra growth performance, during the rainy season, weed free period of only 2 WAP was as in adequate as not weeding at all while weeding to provide weed freeness beyond 4 WAP was a luxury. Conversely when *Tithonia* infestation extends beyond 4 WAP, crop performance was as bad as not weeding at all. In the dry season however, infestation beyond 2 WAP led to a non-redeemable damage to crop growth.

Okra yield and yield parameters were better during the rainy season than the dry season (Table 3). The number of fruit per plant and total yield of okra were significantly (P=0.05) better during the rainy season than the dry season. The highest number of fruits produced per plant were 6.8 and 5.0 during the rainy season and dry season respectively while the highest estimated yields were 5.4 t/ha and 2.8 t/ha for the rainy and dry seasons respectively. Similarly, more and heavier seeds were produced during the rainy season than the dry season. During the rainy season, yield and yield parameters were only comparable to the weed free control (P = 0.05) when the plots were kept weed free for at least 4 WAP (T2) or weed infested for only 2 WAP (T6). Weed free condition for only 2 WAP (T1) or weed infestations for up to 4 WAP and above (T7-T9) gave yield that were as bad as not weeding at all. During the dry season however, weed freeness of 2 WAP induced fruit yield comparable to the control. Beyond 4 WAP, *Tithonia* weed interference resulted in no yield at all. For both seasons, weeding beyond 4 WAP did not result in any significant yield increase (P = 0.05). The effect of season on the competitive ability of *Tithonia diversifolia* as measured by the density and dry matter yield of the weed is presented in Table 4. There was a strong seasonal influence on *Tithona* density and dry matter yield (P = 0.05). Higher density and dry matter yield occurred during the rainy season than the dry season. Furthermore, *Tithonia* density and dry matter yield was significantly (P = 0.05) affected by period (length) of weed infestation. Higher weed density than the control were recorded when infestation commenced from 2 WAP (T1) and 4 WAP (T2) as well as when infestation lasted for at least, 4 WAP (T7 - T10) (P = 0.05) during the rainy season. The dry matter yield of *Tithonia* reduced with increasing length of weed freeness. In the dry season however, though the trend is similar to those of the rainy season, the values were lower. Highest values of weed density and dry matter yield across the seasons were recorded in the unweeded control, while the lowest values were obtained in the clean weeded control.

DISCUSSIONS

The competition of *Tithonia diversifolia*, a fast growing annual weed with okra (*Abelmoschus esculentus*) had a debilitating effect on both okra growth and yield parameters when the period of competition was prolonged. This is due largely to the fact that the weed is an aggressive broad leafed weed species which forms canopy quickly thereby easily out-competing accompanying plants [15,16,4]. Close canopy formation by the weed shut out insolation from okra plants growing underneath, thereby reducing photosynthetic activities of the crop. Expectedly, the detrimental effects of *Tithonia* interference was more pronounced on okra during the dry season than the rainy season. This may be due to greater water stress in the dry season. Okra being, highly, a water loving crop [17] could hardly tolerate competition from an equally exertive and high water demanding plant like *Tithonia diversifolia*. Furthermore, since seedling recruitment in *Tithonia* is both rapid and in great numbers, the competition is sure to favour the weed more than okra. Fullick [18] had reported that competition is directly proportional to plant population.

Better performance of the crop was obtained in the rainy season than the dry season due to ready water availability [17]. Hence, higher seed production and heavier seeds during the rainy season were the result of better nourishment than in the dry season. The variation in the period during which *Tithonia* interference was debilitating over the season could be attributed to weather. During the rainy season, interference for up to 4 WAP was detrimental to yield performance while weed-freeness for more than 4 WAP did not result in a substantial yield increase thus fixing the critical period for *Tithonia diversifolia* in okra at 2-4 WAP. In the dry season however, *Tithonia* interference for more than 2 WAP reduced yield substantially, while continued weeding beyond 2 WAP did not lead to a statistically higher yield thereby fixing the critical period at 2 WAP. As in okra, the variation in the growth performance of *Tithonia diversifolia* across the season is strongly attributable to weather factors.

Recommendations: For a profitable okra production during the rainy season, following the critical period fixed above, 2 weedings is recommended i.e. at 2 and 4 WAP respectively. During the dry season however one good weeding at 2 WAP is adequate for optimum production of okra on *Tithonia diversifolia* infested plots.

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