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Effects of Time of Weed Removal on Weed Species Composition and Crop Performance of Okra (Abelmoschus esculentus (L.) Moench)

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Abstract
The effect of time of weed removal on weed species composition and crop performance of okra *(Abelmoschus esculentus* (L.) Moench) was assessed in the early and late seasons of 2002 in Ondo (07° 05'N, 04° 55'E). Okra plots weeded at 2, 4. 6, and 8 weeks after planting (WAP) were compared with weed free (WF) and weedy (WY) okra in a randomized complete block design and replicated three times. Weed removal (WR) at 8 WAP was similar to weedy check with regards to crop growth parameters. Plant height, stem girth, nodes per plant, total dry matter, shoot dry matter, mean root length, number of roots, root dry weight, shoot/ total dry weight ratio (SWR) and root/total dry weight ratio (RWR) were superior in the early season to the late season. However number of leaves/plant, number of branches/plant and leaf area/plant were better in the late season than in the early season. Pod number, pod length and fruit yield/plant were also higher in the late season than early season, except weedy throughout and WR at 8 WAP. WR at 4 WAP gave comparable values of plant height, number of leaves per plant, leaf area per plant, mean root length, root dry weight, pod number, pod length and pod yield with WF. The order of pod yield was WF >WR at 4 WAP >WR at 6 WAP >WR at 8 WAP >WY. The critical time of weed removal in okra production under the condition of this experiment was 4 WAP. Uncontrolled weed infestation in okra resulted in 39 % and 84 % reduction in potential okra fruit yield compared with the maximum obtained from the WF okra in the early and late seasons, respectively. It is suggested that plot be weeded early (4 WAP) for optimum growth and yield of okra.
Keywords: weed removal, weedy check, weed species, okra, weed- free

INTRODUCTION

Weed control often constitutes the major cost of producing vegetables crops most especially okra (Biazzo and Masiunas, 2000) in the tropics.

Weed competition is influenced by many biological, cultural and environmental variables, such as weed species composition (Shurrleff and Coble, 1985), weed density (Wyse *et al.,* 1986), row spacing (Burnside 1979; crop cultivars (Burnside, 1979, Bussan *et al.,* 1997); planting date (Oliver, 1979), and tillage system (Banks *et al.,* 1985).

Weed compete for available resources, reduces crop yield and increase production costs because of added costs of weed management (Zimbadh 1980, Mulugeta and Boerboom, 2000). For example, weeds removed as much as 45 kg N ha^{-1} from unweeded and unfertilized maize plots (Sawhney *et al.,* 1977). Maize lost 53 kg N, 18 kg P_2PO_5 and 24 kg K_2O ha^{-1} to weeds under shallow tillage (Bhushan *et al.,* 1979).

Losses in crop yield due to weed may be greater than those due to other plant pests and diseases. Orkwor *et al.,* (1994) worked on the response of yam *(Dioscorea rotundata* Poir) to various periods of weed interference in intercropping with maize *(Zea mays* L.), okra (*A. esculentus*) and sweet potato (*lpomoea batatas* L.) and observed that weed interference with the mixture reduced yam tuber yield by 35%, maize by 60%, okra by 79% and sweet potato by 80%. In Nigeria yield reductions due to weed interference may be as high as 40 — 90% while weeding as a percentage of total farm labor ranges from 22 — 54% (Akobundu and Agyankwa 1987). Nieto *et al.,* (1968) reported that all the time and money spent by the geneticist, entomologist and plant pathologist in improving cultivated plants or raising their productivity can be wasted unless the weeds are controlled in a right manner and at the right moment.

The effect of weed interference varies among weed species and crops (Tollenaar *et al.,*1994), Staniforth, 1965). There could be great variation in the magnitude of the contribution of a given factor because of its dependence on other factor. For instance, the density of weeds could be expected to produce little effect on a crop if the time from weed emergence to maturation was short (Bleasdale, 1959). Weed densities, time of weed emergence, type of weed and growth habit of the weed will also modify weed interference (Moolani *et al.*, (1964) and Okafor and de Delta. 1976).

The period when weeds are most competitive depends to some extent on the growth habit of the weeds. Generally weeds that emerge with crops are more competitive than those that emerge later in the life of the crops.

The stage of crop growth during which yield reductions occur in crops is not fully understood in all crops. Timing of weed removal had been shown to be more critical than the frequency of weeding in crops; (yam/maize/okra/sweet potato intercrop (Orkwor *et* 1994), maize (Ferero *et al.,* 1996), pepper *(Capsicurn frulescens)* (Lagoke *et al.,* 1988).

For every crop there is a need to determine the period of growth when weeds needs to controlled to prevent yield reduction and point beyond which the presence of weeds does not affect the final crop yield. The knowledge of the critical period of weed competition in *Abelrmoschus esculentus* will assist the grower to implement effective and timely weed management practices. However, weed management options for okra are restricted (Biazzo and Masiunas. 2000). The result of few researches conducted on this crop on the effects of weed interference suggest that both crop yield and quality can be negatively affected (Bozsa and Oliver,1993).

The objective of this study therefore was to determine the effect of time of weed removal on the weed species composition crop performance and pod quality of okra in the humid tropical environment.

Materials and Methods

Description of the Experimental Site

Field experiments were conducted in the early and late seasons of 2002 at the Teaching and Research Farm Obafemi Awo1owo University, (Adeyemi College of Education), Ondo (07° 05[1]N, 04° 55[1]E). The location has a bimodal annual rainfall distribution occurring in the early season (April - July) and late season (August to October). The soil belongs to the Ondo series (Iwo Association) and is classified as alfisol (oxic tropudalf) (Harpstead, 1992).

The acidic soil of the experimental site had a pH of 5.8, 2.4% organic matter, Tota1 N. 11.0 mg/kg available P. as well as 0.15. 0.09 and 0.50 (cmolKg^{-1}) exchangeable K, Ca and Mg respectively. Data collected on the distribution of rainfall and temperature for the year 2002 are contained in Table 1.

Treatments and Experimental Design

Okra plants weeded at four different times viz. 2, 4, 6 and 8 weeks after planting (WAP) were compared with those kept weed free and weed infested (weedy) throughout the crop life cycle as controls and checks respectively. Weeding was done by hand hoeing the plot weekly using the West African hoe. The treatments were replicated three times and were arranged in a randomized complete block design (RCBD). The gross and net plot sizes were 8m x 8m and 6m x 6m respectively.

Cultural practice

Before the commencement of the experiment, the land was manually cleared. Okra variety (NHAE 47-4) was planted at three seeds per hill, 2 cm deep and 100 x 30 cm in April 2002 (early season) and August (late season). Emerged crop seedlings (five days after planting) were thinned to one plant per stand. NPK 15-15-15 compound fertilizers was applied 3 weeks after planting at the rate of 200 kg/ha. Okra stands, were sprayed with cvpermethrin weekly at the rate of 30 ml in 10 litres of water beginning from 2 WAP to control leaf eaters. Edible pods were harvested at three-days intervals (Ariyo. 1991).

Data Collection

Weed samples were collected from three random 0.5 m^2 quadrat along a diagonal transect in each plot at 2, 4, 6, 8 WAP for identification by species, plant taxa and growth form. All plants within the quadrat were cut at the soil surface and oven-dried at 80 ° C for 48 h for determination of dry weights.

Weed occurrence was rated visually using a scale of 0-5, where 0 = no weed occurrence and 5 = maximum weed occurrence, and converting scores to percentage values for statistical analysis. Mean weed density for each species in the weed flora was calculated by summing all densities from the three qudrats and dividing by 3. Relative weed density (RD) was determined by dividing the mean density of weed species by the total density multiplied by 100. The percent relative frequency (RF) was calculated from frequency of the individual weed species within each treatment divided by the total frequency of all weed species across the treatments. Relative important values (RIV) were computed as the mean of the percentage relative frequency and relative density for each species (RIV= RD+RF/2) according to Wentworth *et al., (*1984). Weed species diversity was calculated from data on weed density. Diversity index (Shannon's H was obtained from the equation H = Σpilnpi, where pi = number of stands of individual weed species and in natural logarithm, according to Pielou (1969). At 2, 4, 6 and 8 WAP data were taken from 10 randomly selected plants in the two central rows (yield area) of each plot. Plant height was measured from the stem base to the tip of the plant using a meter rule. Stem girth was determined with a pair of calipers 10 cm above the ground. Leaf area was determined using the graphical method. Counts of the number of leaves, nodes and branches were also done. As soon as the first flower opened, the number of plants that flowered were counted every day until 50% of the plants in each plot flowered to determine days to 50% flowering. Okra pods were harvested at three-day intervals over eight times. At final harvest the root systems of plant samples were cut off, for measurement of root length, taken as the longest root per plant root dry weight (oven- drying at 80° C for 48 h.) was then recorded.

Total pod weight per plot was evaluated based on the number of pods accumulated over eight harvests. In order to estimate the yield loss as a function of the weeding regime the yield reduction was computed according to the formula described by Burnside *et al.* (1998).

Yield Reduction = (1 – Experimental plot yield x l00)
Yield in weed- free plot

Pod diameter was determined using the venier calipers while pod length was determined as the length from the base of the pod to the tip.

All data collected were analyzed using the analysis of variance (ANOVA). Data on counts were transformed using square root transformation. Significant treatment were separated using either the Least Significant difference (LSD) or Duncan Multiple Range Test (DMRT) at (P=0.05).

RESULTS AND DISCUSSION

Weed species composition and Diversity

The predominant weed species at the site of the trials were *Euphorbia heterophylla* L., *Tridax procumbens* L., *Commelina diffusa* L., *Asipilia africana* L., *Syndrella nodiflora* Gaertn., *Sida acuta* Burm., *Amaranthus hybridus* L., *Eleusine indica* L., *Cynodon dactylon* (L) Pers., *Dactyloctenium aegvptium* (L.) P Beauv. Willd., *Paspalum conjugatum* L., *Axonopus compressus* (SW) Beauv. *Panicum maximum (*L.) Jacq. and *Cyperus rotundus* L.

Generally the mean species density, RD. RF and RIV were considerably low across treatments both in the early and late seasons (tables 2 and 3). Across treatments *Panicum maxima* and *C. rotundus* were distinctly dominant in the early season. Among treatments mean density RD and RF were very low in WF but very high in WY and WR at 8 WAP both at the early and late seasons

The weed diversity index tends to decrease with increasing delay in time of weed removal up to 4 WAP and later decline at 6 WAP. The implication of this is that species diversity decreases as the magnitude of weed infestation increases. More importantly is the fact that relatively higher weed diversity and least mean density were obtained in the plot weeded 4 WAP in both seasons which implies that the most critical stage of growth of okra is 4 WAP when weed control must be promptly carried out to prevent the yield loss from reaching damaging level.

Specie composition and diversity in weedy check and plot weeded 8 WAP were similar. There was survival of the fittest as the weeds were thinned out. The survivor only shaded and suppressed the growth of the shorter weeds. Thus, there was lower frequency and diversity compared to other weed management treatments namely: plots weeded 2 WAP, 4 WAP and 6 WAP. The dominant weed species in treatment weeded 4 WAP were the ephemerals, which were not able to exert serious competitive advantage over the okra plant. Several authors have adduced differences in specie composition (richness and density) in the above ground weed community and soil bank to climate, soil type, agronomic and weed management (Palmer *et al.,* 1997). The most important weed species in the early season were *Panicum maximum* and *Cyperus rotundus*. Thus, okra was mostly associated with these two weed species in the early cropping season. In the late season *Panicum maxima* was the most important weed specie. *Panicum maxima* had the highest RIV values across seasons and hence could be regarded as the most important weed in terms of density and frequency .This observation supports the findings of Terry (1981) that certain weeds were specific to certain crops. Example of such weeds is *Chromolaena odorata* which is likely to be more successful in the perennial crops because it synchronizes its growth and reproduction with that of the crop. Akobundun *et al.* (1987) reported that *P. maximum* has a rapid growth habit, high seed output and efficient seed dispersal method hence its high wide spread occurrence and uniformly dense infestation. This attribute was responsible for the greater dominance of these weeds.

Effect of time weed removal on the growth parameters of okra

Generally, in the early season the growth parameters such as plant height, number of leaves, number of branches, number of nodes per plant, total dry matter and mean root length were no significantly different (Table 4). In the late season all the growth parameters measured at 8 WAP were significantly affected by time of weed removal except plant height and shoot /root dry weight ratio (Table 5). Okra plants of plots kept weed-free throughout and those of the plots where weeds were removed at 2 WAP had significantly more branches than those kept weedy for longer periods that is 4, 6, and 8 WAP. The reduction in these growth parameters could be as a result of relative low competition from weed for both above and underground materials (Olabode *et al.,* (2010), Lautzeyer *et al.,* (1986), Akobundu and Agyakwa 1987, Ayeni (1991). The increase in weed density in the weedy throughout and plot weeded 8 WAP might have caused significant decrease in okra growth and development. Smith (2000) worked on the comparative response of *Chromoleana* found that close proximity among plant often modified the growth and development of individual stands and this commences immediately the supply of one or more specific growth responses become limiting to the joint survival of close growing stands. The ultimate effect of this interaction is a reduction in both the rate and total amount of growth and sometimes in the survival of competing stands.

Leaf area (LA) was also significantly affected by the time of weed removal in the two seasons. In both seasons keeping plots weed free throughout and weeding plots at 4 WAP resulted in similar maximum leaf areas that were significantly higher than those of the other weed removal treatments including weed infestation throughout. While weed removal at 6 WAP also resulted in higher LA than other stage of removal and weedy check in the early season, both removals at 2 and 6 WAP caused higher LA than removal at 8 WAP and weedy check in the late season.

The vigor of the plant as expressed in the stem girth was also significantly affected at 8 WAP both at the early and late seasons (Tables 4 and 5). Better crop vigor was observed with weed free throughout while the least vigor was obtained in weedy check, plants in plots weeded 8 WAP. Weeding at 4 WAP had comparable stem girth with the weed free plot. The period during which weed interfered with this crop could not be favorably tolerated by the crop; this might have accounted for the average yield loss for weedy check and plants of plot weeded 8 WAP of 61.90 and 58.58% respectively.

The data recorded from the study showed that flowering was generally delayed in the weed free plants and plants of plots weeded 4 WAP while weed infestation (WY) hastens flowering of the crop. The absence of weeds or reduced weed density in weed free-plots and plots weeded 4WAP might have resulted in better utilisation of environmental resources consequently giving the crop enough time for enhanced dry matter partitioning before flowering or fruit setting.

Weed removal generally had significant effect on the number of roots produced by okra plants irrespective of the seasons. Higher number of roots was obtained with plant weeded at 2 and 6 WAP compared with other treatment both in early and late seasons. In both seasons, weed removal at 4 and 8 WAP resulted in significantly lower root numbers than weed free and significantly weed infestations throughout. The least number of roots was produced by okra plants in the late season. Longer roots were also observed in the early season than in the late season. Okra root length was only significantly affected by the time of weed removal during the late season ($p < 05$). Weed removal at 4 WAP and keeping the crop weed free throughout resulted in longer roots than that caused by weed removal at 8 WAP.

In both seasons, weed removal at 6 WAP resulted in higher root dry matter production than all the other treatments except weed removal at 2 WAP in the late season. Similarly, keeping plot weed free throughout crop growth resulted in significantly lower root dry matter than weed removal at various stages of crop growth except that delayed to 8 WAP. In the early season, the plot weeded 4 WAP had similar root dry weight values with that of weed removal at 2 WAP contrasting the relatively lowest values of weed free plots than weed removal at 2 WAP in the late season.There was reduction in the root number and root dry weight in the weedy check, which could possibly be caused by allelopathy. *Cyperus rotundus* for instance possesses allelopathic tendencies against rice and maize which could easily hamper the growth of the crops.

The total dry matter content of okra plant produced as a result of the time of weed removal in okra crop, ranged from 53.3 to 78.33g/plant in the early season and 40.53 - to 63.8-g/plants in the late season. Weed removal at 4 WAP apparently gave the least plant dry matter in both early and late seasons. Comparable values of plant dry matter were recorded for WY and WR at 8 WAP in the early and late seasons indicating that keeping plots weedy for 8 weeks had similar effect as keeping plots weedy throughout crop growth. Although the delay in the time of weed removal did not affect plant dry matter in the early season, late season plant dry matter followed the same trend as shoot dry matter; WF gave the highest and this decreased to a minimum in WR at 4 WAP.

Shoot/root dry weight ratio (S/R) was significantly higher in weed free plants than other treatment irrespective of season. The least S/R was recorded from plants in the plot weeded 6 WAP in the late season while plants in plot weeded 4 WAP had the least in the late season.

The shoot/ total weight ratio (SWR) was consistently low in both seasons being higher in weed free plot than other treatments and lowest in plants weeded 6 WAP in the early season. Similar result was recorded in the late season except the plot weeded 4 WAP which had the least shoot/total dry weight.

In both seasons, time of weed removal affected the root/total dry matter (RWR) critically with plants weeded 6 WAP having the highest root/total dry weight while weed free plot had the least in the early season. In the late season plants in plot weeded 4 WAP resulted into higher root/total dry weight than other treatments while weed removal in 8 WAP had the least.

Crop Yield and Yield Loss Due to Weeds

Generally, the pod fresh weight yield parameters followed the same pattern in all the treatments. Except pod diameter, the observed differences were not significant in the early season (Table 6)

Among the treatments pod yield of plants weeded at 4 WAP (3.63t/ha) was comparable to the maximum of 4.12 t/ha obtained from those kept weed free throughout crop growth.

Weed removal in okra plants at 2. 4 and 6 WAP resulted in significantly higher pod yield than those of plants weed infested throughout. Weed removal at 4 WAP also resulted in higher pod yield than later removals at 6 and 8 WAP.

The pod weights were generally lower in the early season than in the late season. The pod weights were significantly affected by the delay in time of weed removal only in the late season. The WF distinctly gave the longest pod fresh yield while the WY gave the lowest. Comparable pod yield weights were observed in the WY and WR at 8 WAP as well as in both WR at 2 WAP and WR at 6 WAP. The order of pod yield was WF >WR at

4 WAP>WR at 6 WAP >WR at 2 WAP >WR at 8 WAP> WY. The reduction in the number of branches and other growth parameters coupled with high weed infestation might have contributed to the yield reduction recorded in weedy check and WR at 2 WAP.

The yield loss analysis was carried out by comparing the yield of crop weeded at 2. 4. 6 and 8 WAP with those of plots regularly weeded. Higher loss occurred in the late growing season than in the early season. Single weeding at 2 and 6 WAP in the late season gave similar yield loss. Considerable okra yield reduction occurred when weeds were allowed to interfere with the crop till 6 weeks before removal in both the early and late seasons. Weed removal at 8 WAP did not obviate serious loss caused by weed infestation especially in the late season.

Full season weed competition led to a yield reduction of 39.02 and 84.97% in the early and late season respectively. The yield of okra was reduced by 17.1, 0.66, 21.97 and 24.92% when weeds were allowed to compete with the crop for 2, 4, 6 and 8 weeks respectively. In the late season yield reduction were 43.69, 11.89, 49.03 and 82.23% respectively in the early season. Okra yield dropped if weed removal were delayed beyond 4 weeks in both early and late seasons. The high weed density and biomass recorded after 4 weeks after planting could have been bresponsible for high demand for environmental resources such as nutrients, moisture and suppressive tendencies by the weeds (shading and allelopathic influence). This also explains why there was reduction in the pod yield at 6 WAP, 8 WAP as well as WY. This observation further supports the general contention that critical period of weed competition does not usually begin earlier than 4 weeks after crop emergence (Drehnan and Jennings (1977).

Adigun and Lagoke (2003) reported tomato was critically affected by weed interference between 3 and 6 weeks after transplanting and also weed infestation throughout the crop life resulted in about 40-60% reduction in the transplanted tomato fruit yield compared with the appropriate maximum obtained in the trials.

CONCLUSION

The result obtained from this study showed that weed specie composition and pod quality varied significantly with the time of weed removal in okra and significantly affect the growth and yield performance of okra. The critical time of weed removal in okra production was 4 WAP. It is thus concluded that a single weeding at 4 WAP may suffice to minimize the effect of weed infestation and enhance the quality and yield of okra fruits.

REFERENCES

Adigun, J.A. and S.T.O. Lagoke (2003). Critical period of weed interference in rainfed and irrigated tomatoes in Nigerian Savanna. *J. Agric Res & Dev.* 2 pages 32 – 41.

Akobundu, I.O. (1987). *Weed Science in the tropics*. John Wiley and sons.

Akobundu 1.0. and Agyakwa, C.W. (1987) *Handbook of West Africa Weeds*. IITA. Publication. 350Pp.

AOAC (1990). Official method of analysis (15th Ed). Washinghton DC. Association of Official Analytical Chemistry.

Ayeni. A.O; W.B. Duke and I.O. Akobundu (1984): Weed interference in maize, cowpea and maize/cowpea intercrop in a subhumid tropical environment. III Influence of land preparation. Weed Research, 1984, Vol. 24: 439 448.

Ayeni, A.O. (1991). Hand/Mechanical Weed Management as an option in Nigeria Agriculture. *Nigeria Journal of Weed Science*. H: 71-77

.Ariyo, 0. J. (1991). Regression analysis of pod yields components in okra *(Abelrnoschus esculentus)* (L.) Moench. *Journal of Agricultural Science Technology*, 1(1): 72-74.

Banks, P. A,; T.N.Tripp, J.W. Wells and J.E. Hammel !985). Effects of tillage on sicklepod (*Cassia obtusifolia*) interference with soyabeans (*Glycine max*) and soil water use. *Weed Science* 34: 143-149.

Bhushan, L.S, Chauhan, R.S & Chand, S. (1979). Influence of tillage and simazine on weed growth, loss of nutrients and yield of rainfed maize. Journal of Indian Society of Soil Science, 27, 158-160.

Biazzo, J. and J.B. Masiunas (2000): The use of living mulches for Weed management in hot Pepper and Okra. *Journal of Sustainable Agriculture.* Vol. 16. (1): 59— 79.

Bozsa. R. C. and Oliver (1993). Shoot and root interference of common cocklebur *(Xanthium strumarium)* and soyabean (*Glycine max*). *Weed Science* 41: 34-3 7

Bleadsdale, J.K.A. (1959): The yield of onions and red beet as affected by weeds. *Journal of Horticultural Science*. 34:7—13.

Burnside, O C. (1979) Soybean (*Glvcine max*) growth as affected by removal. cultivar and row spacing. Weed Science 27: 562-565.

Burnside. O.C; M.J. Wiens; B.J. Holder; S. Weisberg; E.A. Ristau; M.M. Johnson, J.H. Cameroon (1998): Critical periods for weed control in dry beans (*Phaseolus vulgaris*). *Weed Science*, 301 306.

Busan, A.J;0.C, Burnside. J.H; Orf. E. A. Ristau and K. J Puettmann. (1997). Field evaluation of soyabean (*Glycine max*) genotype for weed competitiveness. *Weed Science*. 45: 3 1-37.

Drenna, D.S.H and Jennings (1977). Weed competition in irrigated cotton *(Gossypium barbadense* L.) and groundnut (*Arachis hypogaea* L.) in the Sudan Gezira. *Weed Research Volume* 17, 3 - 9.

Ferrero, A., Scanzio, M; Acutis, M. Brown. H. (ed) (1996): Critical period of Weed interference in maize. Proceedings of the second International Weed Control congress. Copenhagen. Denmark 25 - 28, Vol. 1 - 4: 171 - 176.

Harpstead.M.J.; (1992): The classification of some Nigerian Soils. *Science.* 116(6) 437 - Molani. M.K.; E.J. Knake and F.W. Slife (1964): Competition of smooth pigweed with cornandsoyabeans. Weeds 12:126— 128.

Lagoke, S. T. O, K. O. Adejonwo, T.T. Nongu, C.E. Uwammah and K. O. Lawal (1988): Studies on weed interference and chenical weed control in chili pepper (*Capsicum frutescens* L.). *Nigerian Journal of Weed Science* 1: 3-10 March 1988

Lutzeyer, H., Akobundu, I.O. and Kodi, W. (1986): Effects of weed crop competition on maize yield IITA Resource and crop management programme, *Annual Report*, P. 20.

Molani, M.K.; E.I. Knake and F.W. Slife (1964): Competition of smooth pigweed with corn and soyabeans. *Weeds* 12: 126 – 128.

Mukhoadhya, S. K. (1974) Increasing fertilizer efficiency through weed control Fertilizer *News* 19(12): 56—58).

Mulugeta D. and Boerboom, C.M. (2000): Critical time of weed removal in glyphosate resistant Glycine max. *Weed Science* 48: 35 42. ‘

Nieto, J.H; M.A. Brondo: and J.T. Gonzalez (1968): Critical periods of the crop growth for competition from weeds, PANS Vol. 14 No 2 159— 166

Okafor, L.T. and S.K. De Datta (1976): Competition between upland rice and purple nutsedge for nitrogen, moisture and light, *Weed Science.* 24: 43 – 46.

Olabode O.S, Adesina G.O, Ajibola A.T (2010). Seasonal effects of the critical period of weed removal and okra performance on *Tithonia diversifolia* (Helms) A. Gray infested field. *Annal of Biological Res*ources 1(4): 67-72

Oliver, LR. (1979). Influence of soyabean (*Glycine max*). Planting date on velvet1eaf) competition. *Weed Science* 27: 183-188.

Orkwor. G.C; Okereke. O.U: Ezedinma. F.O.: Hahn. Ezumah. H.G; Akobundu. 1.0.; Ofori. F. (Ed.): Hahn, S.K (1994): Response of Yam (*Dioscorea rotundata* Poir) to various periods of weed interference in an intercropping with maize (*Zea mays* L.), Okra (*Abelmoschus esculentus* (L.) Moench) and sweet potato (*Ipomoea hatatas* (L) lam); Tropical root crops in a developing economy. Proceedings of the 9th symposium of the international society for Tropical Root crops, held at Accra, Ghana, 20 — 26 October 1991 *Acta Horticultural* 1994. No 380: 349 - 354.

Pielou, E.C. (1969) *Ecological diversity*. Wiley and Sons Inc p. 165

Rochecouste, E. (1956): Observations on nutsedge (*Cyperus rotundata* L.) and its control by chemical method in Mauritius. *Proc.9th Cong*. 1 S.S. T. 1: 319.

Sawhney, J. S; Moolani, M.K & Gill, G.S (1977). Crop weed competition for nitrogen in maize. In: Programme and Abstracts of Papers. Weed Science Conference and Workshop India. Paper No 36: 2 1-22.

Shurrleff. J.L. and H. D. Coble (1985). Interference of certain broadleaf weed species in soyabeans (*Glycine max*). *Weed Science*. 33: 654-657.

Smith, M. A. K (2000). Comparative response of *Chromolaena odorala* and *Corchorus olitorius* to intraspecific competition. *Agricultural Science Digest* 20 (3), 141-145.

Staniforth. D.W. (1962): Responses of soyabean variety to weed competition. *Agronomy . Journal* 54: 11 - 13.

Staniforth. D. W. (1965): Competitive effect of three t1ictaiiI species on soyabeans. *Weeds* 13 (3): 191 — 193.

Terry. P. J(1981). Weeds and their control in the Gambia. *Tropical Pest Management* 27. 44-52.

Tollenaar, M, A. A. Dibo, A. Aguilara, S. F. Weise and C. J. Swanton (1994): Effect of Crop Density on Weed Interference in Maize*, Agronomy Journal*, Vol. 86 No. 4, p. 591-595

Usoroh, N. J. (1979). Assessment of the critical period of weed competition in tomato *(Lycopersicon escullentun* Mill). Proceedings of 7th Annual Conference of Weed Science Society of Nigeria pp 62-65 University of Ile-Ife. Nigeria 2-4 Dec 1977.

Wenthforth. T.R; Conn, J. S. Skroch, W.A. and Mrozek, E. Jr (1984). Gradient analysis and numerical classification of apple orchards weed vegetation. *Agriculture, Ecosystems and Environment* 11, 239-251.

Wyse, D.L; F.L. Young., and R.1. Jones (1986). Influence of Jerusalem artichoke (Helianthus tuberosus) density and duration of interference on soyabean (*Glycine max*) growth and yield. *Weed Science* 34: 243-247.

Zimbadh, R.L. (1980): *Weed crop competition*. A review IPPC Oregon Sitate University. Carvallius, Oregon 195pp.

Table 1: Monthly total rainfall and mean temperature distribution at Ondo in 2002

Month	Rainfall (cm)	Mean Temperature (^{0}C)
January	0.0	27.56
February	11.7	29.27
March	124.3	N.A
April	175.4	27.15
May	98.8	26.98
June	271.6	26.1
July	294.4	25.48
August	237.6	24.48
September	148.4	25.42
October	306.0	25.4
November	172.0	27.63
December	0.0	27.7

Source: Meteorological Station, Ministry of Agric. & Natural Resources, Ondo

Table 2: Weed specie composition as influenced by time of weed removal in the early season

Weed taxa	[1]WF	WY	W12	W14 No./m^2	W16	W18	Mean density (no./m^2)	F (%)	RD (%)	RF (%)	RIV (%)
Chromolaena odorata	0.00	0.00	0.55	1.79	0.00	0.00	0.39	33.33	0.68	2.67	1.67
Euphorbia heterophylla	0.73	7.65	0.00	0.43	4.93	4.04	2.96	83.33	5.18	6.68	5.93
Ageratum conyzoides	0.00	0.00	0.00	0.94	0.00	0.00	0.16	16.67	0.28	1.34	0.81
Tridax procumbens	0.00	0.00	1.21	0.94	4.93	4.04	1.85	66.67	3.24	5.34	4.29
Commelina diffusa	0.00	4.77	1.76	0.43	0.00	2.12	1.51	66.67	2.64	5.34	3.99
Aspilia Africana	2.33	5.04	0.00	0.04	3.79	0.96	2.18	83.33	3.82	6.68	5.25
Syndrella nodiflora	0.00	3.87	0.00	1.79	2.92	0.00	1.43	50.00	2.50	4.01	3.26
Physalis angulata	0.00	0.99	0.00	0.00	0.00	0.99	0.23	33.33	0.40	2.67	1.54
Sida acuta	0.00	1.44	1.21	0.00	0.00	2.11	0.79	50.00	1.38	4.01	2.69
Phyllantus amarus	0.00	0.00	0.00	0.00	0.00	0.96	0.16	16.67	0.28	1.34	0.81
Spigelia anthelmia	0.00	0.00	1.21	1.36	0.00	3.08	0.94	50.00	1.65	4.01	2.83
Amaranthus hybridus	0.00	0.00	0.00	0.00	10.77	2.50	2.21	33.33	3.87	2.67	3.27
Boerhavia diffusa	0.00	0.00	0.55	0.00	0.00	0.00	0.09	16.67	0.16	1.34	0.75
Mitracarpus villosus	0.00	0.99	1.21	0.00	0.00	0.00	0.37	66.67	0.65	2.67	1.66
Laportea aestuans	0.00	0.00	1.76	0.00	0.00	0.00	0.29	16.67	0.51	1.34	0.93
Pouzozia guineensis	0.91	0.45	1.21	0.00	0.91	0.00	0.58	66.67	1.02	2.67	1.85
Acalypha ciliata	0.00	0.00	0.00	0.00	0.91	0.00	0.15	16.70	0.26	4.01	0.80
Sporobolus pyramidalis	0.00	0.00	0.00	2.29	2.01	0.00	0.72	33.33	1.26	2.67	1.97
Eluesine indica	4.31	5.76	0.00	0.00	0.00	10.20	3.38	50.00	5.92	4.01	4.97
Cynodon dactylon	0.00	9.63	2.31	3.15	2.92	3.08	3.52	83.33	6.16	2.68	6.42
Dactylectenium aegyptium	0.00	0.00	2.31	0.00	0.00	6.16	1.41	33.33	2.47	2.67	2.57
Paspalum conjugatum	0.00	5.76	0.00	4.08	4.93	0.00	2.46	50.00	4.31	4.01	4.16
Axonopus compressus	0.00	5.76	1.76	2.72	0.00	0.00	1.71	50.00	2.99	4.01	3.50
Panicum maxima	3.43	47.92	18.52	12.42	4.93	36.96	20.13	100.00	35.22	8.02	21.62
Cyperus rotundus	6.20	5.31	1.76	2.29	8.71	17.52	6.97	100.00	12.19	8.02	10.11
Mariscus alternifolius	0.00	0.99	0.00	0.43	2.01	0.00	0.57	50.00	0.99	4.01	2.50
Mean Density (no./m^2)	0.69	4.09	1.44	1.26	2.29	3.64					
Frequency F (%)	23.1	57.75	53.9	57.75	50.05	53.9					
Relative Density (RD) (%)	5.7	33.7	11.9	10.37	18.84	29.96					
Relative frequency (RF) (%)	7.8	19.6	18.3	19.6	17.0	18.3					
Relative importance (RIV) (%)	6.8	26.7	15.1	17.0	17.92	24.10					
Diversity (H^1)	1.57	2.01	1.99	2.26	2.26	2.02					

[1]WF = Weed Free throughout, WY = Weedy throughout, WI2, WI4, WI6, WI8 Weeded at 2, 4, 6, and 8 weeks after planting, WAP.

Table 3: Weed specie composition as influenced by time of weed removal in the late season

Weed taxa	WF	WC	W12	W14 No./m²	W16	W18	Mean density (no./m²)	F (%)	RD (%)	RF (%)	RIV (%)
Chromoloena odorata	0.00	0.00	2.57	0.00	6.03	0.00	1.43	33.33	1.47	4.02	2.75
Euphorbia heterophylla	0.00	6.71	8.16	2.46	7.54	4.1	4.83	83.33	4.98	10.02	7.50
Ageratum conyzoides	0.74	0.00	0.00	0.00	3.02	0.00	0.63	33.46	0.65	4.02	2.3
Tridax procumbens	0.00	9.80	0.00	4.93	1.51	0.00	2.71	50.00	2.79	6.01	4.40
Commelina diffusa	1.60	0.00	0.00	0.00	0.00	0.00	0.27	16.67	0.28	6.01	4.40
Aspilia Africana	0.74	0.00	4.28	0.00	0.00	4.92	1.62	50.00	1.67	6.01	3.84
Physalis angulata	0.00	0.00	1.71	0.00	0.00	0.00	0.29	16.78	0.29	2.00	1.15
Spigelia anthelmia	0.00	0.00	0.00	0.00	0.00	4.10	0.68	16.78	0.08	2.00	1.04
Amaranthus hybridus	2.11	2.06	0.00	1.41	0.00	5.56	1.86	66.67	1.92	8.02	4.97
Boerhavia diffusa	0.00	0.00	0.00	0.70	12.06	6.56	3.22	33.33	3.32	4.02	3.67
Mitracarpus villosus	0.00	0.52	0.00	0.70	0.00	0.00	0.2	16.78	0.21	2.00	1.11
Laportea aestuans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pouzozia guineensis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acalypha ciliata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sporobolus pyramidalis	0.00	1.03	5.21	0.00	6.03	1.02	2.22	66.67	2.29	8.02	5.16
Eluesine indica	0.00	2.58	0.00	0.35	4.52	21.32	4.79	66.67	4.93	8.02	6.48
Cynodon dactylon	0.00	0.00	0.00	1.06	10.56	0.0	1.94	33.33	1.99	10.02	6.01
Dactylectenium aegyptium	0.00	9.29	0.00	0.00	0.00	4.10	2.23	33.33	2.29	10.02	6.16
Paspalum conjugatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Axonopus compressus	1.86	2.58	11.98	1.06	1.50	0.82	3.3	100.20	3.39	12.02	13.38
Panicum maxima	2.50	36.10	13.69	2.48	10.56	20.5	14.31	100.2	14.74	12.02	13.38
Cyperus rotundus	0.00	0.00	0.00	2.11	0.00	0.00	0.35	16.7	0.36	2.00	1.18
Mariscus alternifolius	0.00	0.00	0.00	1.41	0.00	0.00	0.24	16.7	0.25	2.00	1.13
Mean Density (no./m²)	3.01	2.94	1.98	0.78	2.64	3.04					
Frequency F (%)	25.00	37.50	29.17	45.83	41.70	41.70					
Relative Density (RD) (%)	20.9	20.4	13.8	5.4	18.3	21.1					
Relative frequency (RF) (%)	11.3	16.9	13.2	20.75	18.9	18.9					
Relative importance (RIV) (%)	16.1	16.9	13.5	13.08	18.6	20.00					
Diversity (H[1])	1.8	1.59	1.65	2.21	2.07	1.95					

[1]WF = Weed Free throughout, WY = Weedy throughout, WI2, WI4, WI6, WI8 Weeded at 2, 4, 6, and 8 weeks after planting, WAP.

Table 4: Growth parameters as influenced by time of weed removal at 8 WAP in the early Season

	Time of Weed Removal						
Parameters	**WF**	**WC**	**WI2**	**WI4**	**WI6**	**WI8**	**LSD(0.05)**
Plant Height (cm)	74.73	75.74	73.62	76.06	79.93	82.85	NS
Leaves/plant (no.)	11.54	9.66	9.54	9.68	10.11	10.92	NS
Branch/plant (no)	7.33	7.00	7.17	5.83	6.83	6.83	NS
Stem Girth (cm)	1.93	1.56	1.62	1.92	1.77	1.46	0.14
Nodes/plant (no.)	23.00	19.67	21.33	21.67	21.00	19.83	NS
Days of 50%	55.00	51.00	53.00	54.00	51.00	52.00	1.49
Leaf Area per Plant (Cm²)	420.30	95.64	120.46	406.79	196.43	88.41	31.1
Total Dry Matter (TDM)	78.33	63.33	61.33	53.33	55.00	67.33	NS
Shoot Dry Matter (SDM) (g/plant)	63.53	44.56	42.16	34.16	32.50	42.50	14.52
Mean Root Length (MRL) (cm)	51.67	39.58	48.17	50.15	47.83	39.83	NS
Number of Roots/plant (NR)	24.00	25.00	31.67	22.68	31.00	25.67	1.60
Root Dry weight (RDW) (g/plant)	15.00	18.67	19.17	19.7	22.50	15.83	1.39
Shoot/Root Dry Wt. Ratio	4.20	2.38	2.19	1.78	1.44	2.68	0.56
Shoot/Total Dry wt. Ratio (SWR)	0.81	0.70	0.69	0.64	0.59	0.73	0.25
Root/Total Dry wt. Ratio (RWR)	0.19	0.29	0.31	0.36	0.41	0.27	0.18

[1]WF = Weed Free throughout, WY = Weedy throughout, WI2, W14, WI6, WI8 Weeded at 2, 4, 6, and 8 weeks after planting, WAP.

Table 5: Growth parameters as influenced by time of weed removal at 8 WAP in the late season.

	Time of Weed Removal						
Parameters	**WF**	**WC**	**WI2**	**WI4**	**WI6**	**WI8**	**LSD(0.05)**
Plant Height(cm)	43.53	42.00	47.27	44.97	36.13	24.20	NS
Leaves/plant(no.)	19.87	3.53	14.07	18.27	8.27	5.70	0.92
Branch/plant(no)	11.08	3.09	8.33	8.27	4.57	3.21	0.33
Stem Girth(cm)	1.61	1.08	1.44	1.46	1.42	1.42	0.18
Nodes/plant (no.)	30.20	9.34	24.00	26.01	15.32	8.77	70.47
Days of 50%	56.00	53.00	54.00	55.00	53.00	53.00	1.59
Leaf Area per Plant (cm^2)	406.00	110.96	187.86	389.76	183.76	81.06	17.90
Total Dry Matter (TDM)	63.68	54.25	56.11	40.53	52.70	54.83	0.02
Shoot Dry Matter (SDW) (g/plant)	51.18	38.86	39.07	25.96	32.68	41.90	6.98
Mean Root Length (cm)	44.29	31.94	41.58	42.53	35.82	26.27	15.94
Number of roots/plant (NR)	19.00	20.12	28.07	15.85	32.82	8.14	0.89
Root Dry weight (RDW) (g/plant)	12.50	15.39	17.04	14.57	18.05	12.93	1.45
Shoot/Root Dry Wt. Ratio	4.09	2.503	2.29	1.78	1.92	3.24	NS
Shoot/Total Dry wt. Ratio (SWR)	0.80	0.72	0.69	0.64	0.66	0.76	0.08
Root/Total Dry wt. Ratio (RWR)	0.19	0.28	0.30	0.36	0.34	0.06	0.07

[1]WF = Weed Free throughout, WY = Weedy throughout, W12, W14, W16, W18 Weed removal at 2, 4, 6, and 8 weeks after planting, WAP.

Table 6: Effect of time of weed removal on yield parameters of *okra*

Treatment	**Pod yield parameters**							
	Pod number		**Pod length (cm)**		**Pod (cm)**	**Diameter**	**Pod (t/ha)**	**Weight**
	Early	**Late**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**
Weed free throughout	8.33a	19.83c	6.30a	6.60b	3.65b	3.98a	3.05a	4.12d
Weedy throughout	6.42a	4.92a	5.97a	4.26a	2.00a	2.33b	1.86a	0.64a
Weed removal at 2 WAP[1]	7.83a	12.08b	5.23a	5.87b	2.24a	1.88ab	2.53a	2.32bc
Weed removal at 4 WAP[1]	8.08a	19.17bc	5.50a	6.51b	2.52a	2.35b	2.90a	3.63cd
Weed removal at 6 WAP[1]	7.18a	12.25bc	4.97a	6.19b	2.27a	2.01ab	2.38a	2.10ab
Weed removal at 8 WAP[1]	6.50a	5.75a	5.03a	4.00a	1.97a	1.50a	2.29a	0.73a
SE (+)	**0.19**	**0.31**	**0.59**	**6.72**	**0.23**	**0.22**	**0.459**	**0.46**

1. WAP = Weeks after planting
2. Means followed by the same letter(s) within the same significantly different at 5% level of probability (DMRT).

Table 7: Relationship among weed density, growth and yield characteristics of okra at different times of weed removal.

Parameter	**R-value**	
	Early	**Late**
Plant height	0.625*	-0.574*
No of leaves/plant	-0.321ns	-0.957*
Branches/plant	-0.121ns	-0.940*
Stem girth	-0.829*	-0.695*
No of nodes	-0.988*	-0.937*
Days to 50% flowering	-0.836*	-0.992*
Leaf area	-0.797*	-0.977*
Total Dry Matter	-0.245ns	-0.06ns
Shoot Dry Matter	-0.397ns	-0.824*
Mean Root Length	-0.962*	-0.865*
No. of Roots	0.011ns	0.062ns
Root Dry Weight	0.133ns	0.416ns
Shoot/Root Dry Weight	-0.383ns	-0.325ns
Shoot/ Total Dry weight	-0.236ns	0.220ns
Root/ Total Dry Weight	0.201ns	0.207ns
Pods/plant	-0.971*	-0.939*
Pod length	-0.313ns	-0.791*
Pod diameter	-0.913*	-0.814*
Pod fresh weight	-0.901*	-0.959*

ns= not significantat 5% level of probability
*** = significant at 5% level of probability**