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Interference of *Euphorbia heterophylla* Linn. on the Growth and Reproductive Yield of Soybean (*Glycine max* (Linn.) Merrill

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Abstract: Soybean was subjected to weed stress employing *Euphorbia heterophylla*. The number of leaflets, pods, flowers, length of pods, plant height, leaf area, hundred seed weight, harvest index and number of pods and seeds were determined. There was no significant difference at $p>0.05$ in number of leaflets, flowers and plant height. Length of pods showed significant difference at $p>0.05$ among period but showed no significant difference among regimes. The critical weed free period fell between 28 and 38 days in this study. This period witnessed increase in the number of leaflets, number of flowers, number of pods, length of pods and plant height. After the critical period soybean suppressed the weed due to increase in crop height, leaf area and deeper and much branched root system. Soybean in monoculture regime reached physiological maturity earlier than plants in the mixed culture. Reproductive yield of soybean was better in the mixed culture.

Key words: Competition stress, *Euphorbia heterophylla*, *Glycine max*, mixed culture monoculture

Introduction

Soybean has been used to a large extent for soil management and agro forestry practices as a nitrogen fixing plant. Apart from cereals, soybean is the most important of all economic plants. It is employed in various types of foods as well as forage. The seed contain high protein and edible oil and the leaves are rich in protein. Soybean and other legumes are in high demand for pasture, hay and fodder, soil stabilization or reclamation and as industrial raw material. As a free biological nitrogen fixer it could be employed in improving soil status for the purpose of agriculture (Awodoyin, 1986). Competition, which may be intraspecific or interspecific, is a reciprocal negative interaction between organisms at the same trophic level brought about by shared requirement for a resource that is in limited supply. It is therefore important in both natural and agricultural communities (Wilson, 1988). Weed infestation seems to be the most important of all the multiple factors that limits crop yield (Pal and Singh, 1990).

Euphorbia heterophylla among other weeds has been found to be a cosmopolitan weed in the southern part of Nigeria and one of the noxious weeds (Eniola and Fawusi, 1989). It has been identified as a common weed of wastelands and cultivated fields in forest zone of West Africa, a serious problem in soybean and cowpea cultivation (Akobundu and Agyaka, 1987).

In soybean, flowering can begin with as few as four nodes or as many as eighteen nodes on the main stem (Fehr *et al.*, 1971). It is strongly responsive to photoperiod and is a short day plant (Langer and Hill, 1991).

Weed competition is known to reduce crop yield (Cousens, 1985) and the advantage of intercropping depends on the extent to which the competing components are compatible

(Jensen, 1978). Soybean is known to experience both intraspecific and interspecific competition when placed alongside weeds and these weeds have significant effects on their performance as well as grain yield (Imrie and Butler, 1983; Baten *et al.*, 1992).

It would be interesting to study both the growth parameters as well as reproductive yield of soybean in response to weed infestation. *Euphorbia heterophylla* was particularly chosen because it is ubiquitous in the South Western part of Nigeria and is known to occur in soybean plantation.

Materials and Methods

The experiment was carried out at Obafemi Awolowo University, Ile-Ife latitude $7^{\circ}26'N$ - $7^{\circ}32'N$ and longitude $4^{\circ}31'E$ - $4^{\circ}35'E$ between 2000 and 2003.

Seeds of *Euphorbia heterophylla* Linn. were collected from natural stands, from a cassava farm adjacent to Chemical Engineering Department of the Obafemi Awolowo University, Ile-Ife. Seeds of soybean variety TGX 1485-ID were obtained from the Department of Plant Science, Obafemi Awolowo University, Ile-Ife.

Topsoil was collected from a fallow land opposite the Department of Botany, Obafemi Awolowo University Ile-Ife. This was dried and thoroughly mixed. The soil was put in 40 plastic pots of approximately 18.5 cm diameter, 16.5 cm depth and 4 L capacity with four holes bored at the bottom to allow for drainage. The 40 plastic pots were divided into four lots, with 10 pots in each lot. The pots were watered a day before planting to allow for a moist environment in the soil. Ten soybean seeds were planted in each of the 40 pots. The first lot was weed free and this served as the control as it contained soybean monoculture. At zero day, 10 seeds of spurge weed, *Euphorbia heterophylla* were planted in each pot in the 2nd lot. A week from the onset of the experiment 10 seeds each of *Euphorbia heterophylla* were planted in each pot in the 3rd lot while two weeks from the onset of the experiment, 10 seeds each of *Euphorbia heterophylla* were planted in each pot in the 4th lot.

Two hundred milliliter of tap water was supplied to each pot in the morning and this was repeated in the evening. Twenty eight days after planting the soybean, the seedlings as well as the weed spurge weed were thinned to 4 per pot with a 50:50 soybean-weed ratio in the mixed culture. The density of 4 per pot was chosen to reduce the total number of seedlings and weed plants to carrying capacity of the plastic pots. Total density of 4 was also chosen per pot in the soybean monoculture. The soybean monoculture was used as the weed free control.

Analysis started on day 28 after planting and at 7 days interval thereafter. Number of pods and flower per plant were recorded every 7 days from the initiation period. Number of leaflets was counted every 7 days. Leaf area was determined by measuring the length and width of the terminal leaflets and leaf area was determined according to the following formula: $L \times W \times 0.75$ and the total values from all terminal leaflets multiplied by 3 according to Nangji and Wanki (1980) where L = length of the terminal leaflet, W = width of the terminal leaflet at the widest point, 0.75 = correction factor for converting terminal leaflet values into leaf area per plant.

Leaf Area Index (LAI) was determined according to the formula S/AGB (Olowe, 1989) where, S = total leaf area and AGB = above ground biomass (shoot dry weight) in $cm^2 g^{-1}$. Leaf Area Ratio (LAR) was determined according to the formula S/W (West *et al.*, 1920), where, S = total leaf area and W = plant dry weight. LAR was determined in $cm^2 g^{-1}$.

Plant height was determined by measuring in centimeters the height of each plant from the soil level to the apex of each of the plant. Number of flowers and number of pods were counted from the point of initiation till day 70 when the sampling ended. The length of each pod was measured and measurements recorded in centimeters.

Reproductive yield was determined as the mean number of pods per plant, mean number of seeds per plant, hundred seed weight as well as harvest index. Harvest index was calculated using the formula

$HI = \text{Economic yield} / \text{Biological yield} \times 100$ (Beadle, 1985), where the economic yield = weight of seeds and biological yield is above ground biomass.

Results

All the plants received approximately 8 h of sunlight and a mean monthly radiation of between 49.28 to 49.36 Wm^{-2} and mean monthly maximum and minimum temperature of 33.10 ± 0.35 and 22.80 ± 0.30 , respectively. Plants were exposed to the same set of conditions except that some were exposed to weed infestation at various intervals of one week, two weeks and three weeks after planting soybean.

Plant height was higher in soybean plants in which *Euphorbia heterophylla* were introduced at the onset of the experiment, followed by the control plants which were not stressed while the height of plants in which weeds were introduced two weeks after the onset of the experiment were lowest throughout the experimental period (Fig. 1). At the end of the experiment the height of soybean plants, which were stressed on the zero day and those that were stressed one week after the onset of the experiment were the same. Plant heights in all treatment were not significantly different.

Leaf number was approximately the same in the control and plants that were stressed one week and two weeks after the onset of the experiment in the first 21 days of the experiment (Fig. 2). Leaf number was highest in plants that were stressed one week after the onset of the experiment followed by the plants that were stressed on the zero day and plants that were stressed two weeks after the onset of the experiment while the number of leaves in the control were lowest. Leaf number was significantly different at week interval as well as among the different treatments.

Number of flowers increased in both the control and the other treatments apart from the plants that were stressed on the zero day (Fig. 3). The control plants and the plants that were stressed at zero day attained physiological maturity earlier than those that were stressed one week and two weeks after

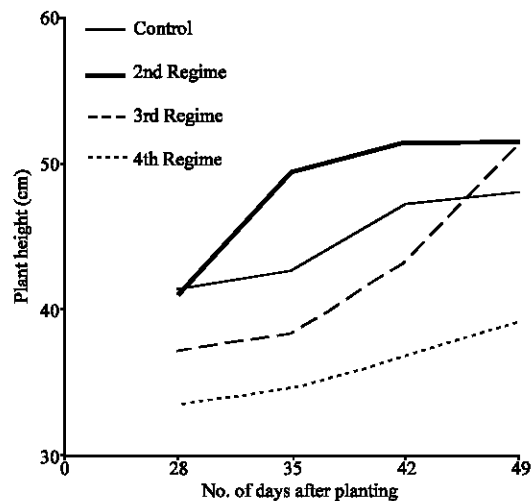


Fig. 1: Heights of soybean (*Glycine max*) plants as influenced by competition stress

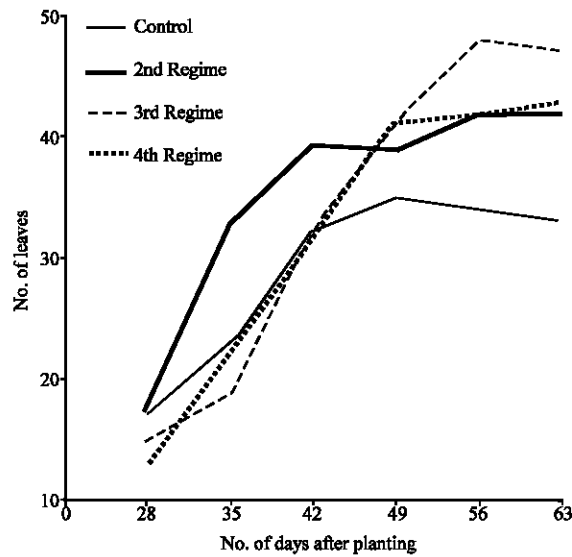


Fig. 2: Number of leaves of soybean (*Glycine max*) plants as influenced by competition stress

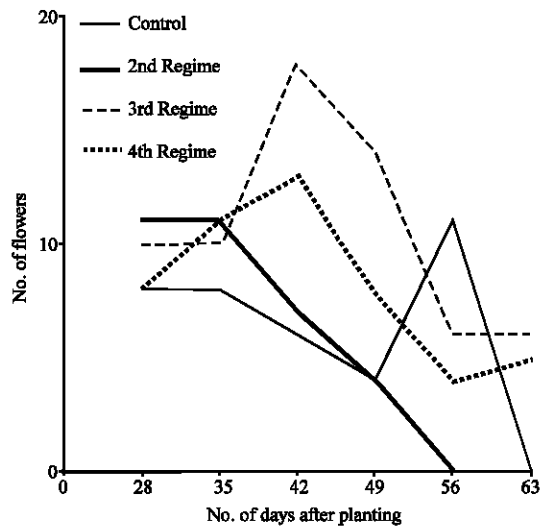


Fig. 3: Number of flowers of soybean (*Glycine max*) plants as influenced by competition stress

the onset of the experiment. The number of flowers that matured to become pods became constant in the control plants and plants that were stressed on zero day while those plants that were stressed one and two weeks after respectively were still increasing in number of flowers. There was no significant difference in the number of flowers in the different treatments as well as intervals.

As from day 56 the number of pods were constant in both the control and the plants that were stressed from zero day signifying early maturity as compared to plants that were stressed one week

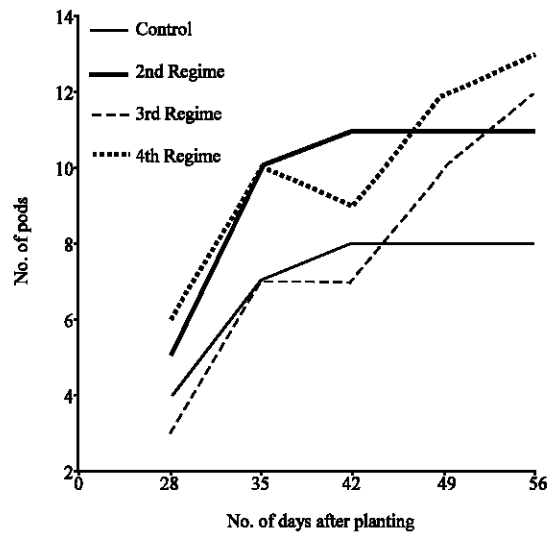


Fig. 4: Number of pods of soybean (*Glycine max*) plants as influenced by competition stress

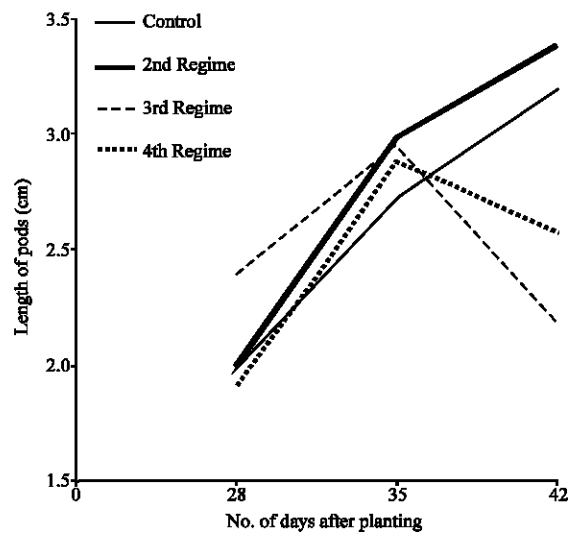


Fig. 5: Lengths of pods of Soybean (*Glycine max*) plants as influenced by competition stress

and two weeks after the onset of the experiment, which continued to increase in number of pods (Fig. 4). At the end of the experiment the plants that were stressed two weeks after the onset of the experiment had the highest number of pods followed by the plants that were stressed one week after the onset of the experiment while the control plants had the least number of pods. There was significant difference in number of pods at $p < 0.05$ among treatments as well as intervals.

Increase in the length of pods was recorded in the control treatments and the plants that were stressed on the zero day throughout the period the experiment lasted (Fig. 5). In the treatments that

Table 1: Reproductive yield as shown by mean number of pods, mean number of seeds, weight of 100 seeds (HSW) and harvest index

Treatments	Mean no of pods	Mean no of seeds	Weight of 100 seeds (HSW)	Harvest index
Control	8	41	7.09	24.80
Stressed 1	11	38	8.74	33.98
Stressed 2	12	32	5.27	13.76
Stressed 3	14	47	6.23	29.43

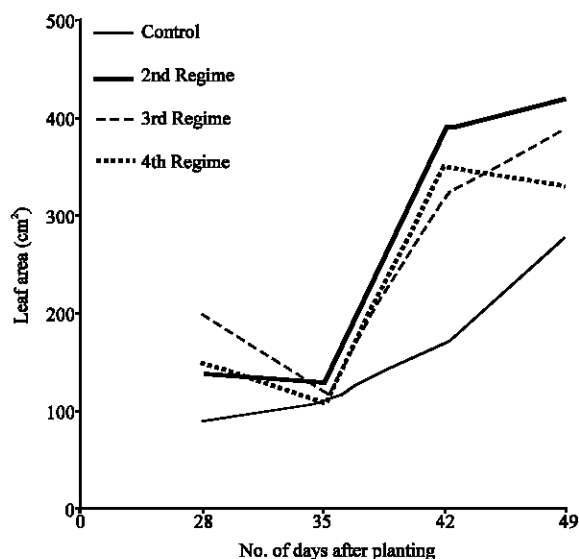


Fig. 6: Leaf area of Soybean (*Glycine max*) plant as influenced by competition stress

were stressed one week and two weeks after the onset of the experiment, an increase was recorded till the 52nd day after which there was a decrease that lasted till the end of the experiment. The decrease in length of pods must have been due to continuity in the production of pods in these two treatments. There was significant difference at $p < 0.05$ in the length of pods over the period as measured in weeks but there was no significant difference among the treatments.

There was an initial decrease in leaf area followed by an increase that lasted till the end of the experiment (Fig. 6). Leaf area was approximately the same throughout the period of the experiment in the plants that were stressed on the zero day, one week and two weeks, respectively after the onset of the experiment. The control plants had the lowest leaf area throughout the experiment.

Leaf area ratio and leaf area index responded the same way throughout the experimental period (Fig. 7 and 8). There was first an initial decrease in all treatments followed by an increase till the end of the end of the experiment. All the stressed treatments were approximately equal throughout the experiment.

The reproductive yields as shown by mean number of pods, mean number of seeds weight of 100 seeds (HSW) and harvest index is shown in the Table 1. Mean number of pods was highest in plants that were stressed 2 weeks after the onset of the experiment. This was followed by those that were stressed one week after the onset of the experiment while the number of pods was lowest in the control. Mean number of seeds was highest in the plants that were stressed two weeks after the onset of the experiment followed by the control while this was lowest in plants that were stressed one week

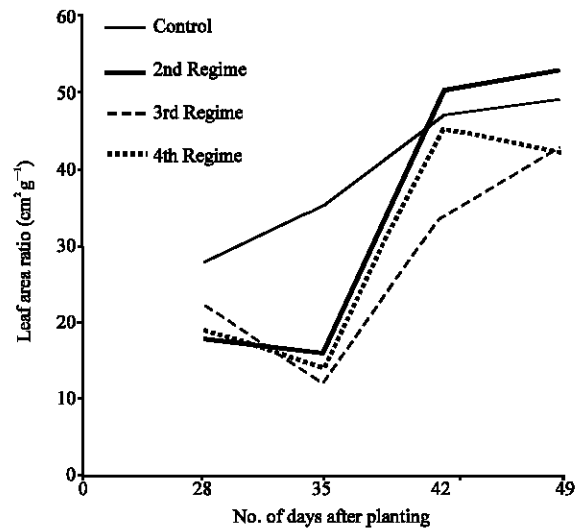


Fig. 7: Leaf Area Ratio (LAR) of Soybean (*Glycine max*) plants as influenced by Competition Stress

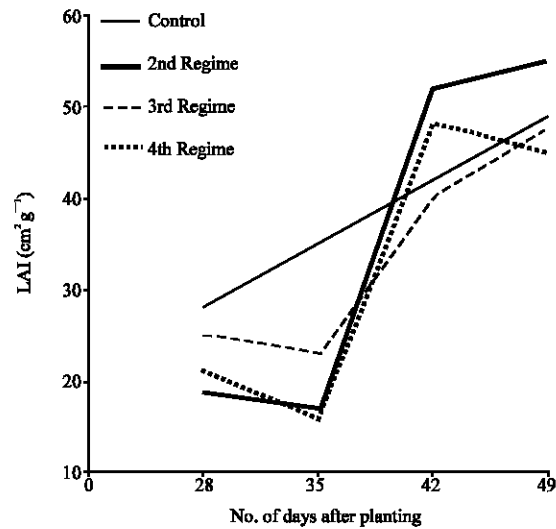


Fig. 8: Leaf Area Index (LAI) of Soybean (*Glycine max*) plants as influenced by competition Stress

after the onset of the experiment. The hundred seed weight was highest in plants that were stressed on the zero days followed by the control plants while plants that were stressed one week after the onset of the experiment had the lowest hundred seed weight. Harvest index as recorded was highest in plants that were stressed on the zero day followed by plants that were stressed two weeks after the onset of the experiment while the plants that were stressed a week after the onset of the experiment had the lowest harvest index (Table 1).

Discussion

Glycine max showed an increase in plant height as a result of an early stress that was introduced on the zero day. Stresses that were applied later did not result in a gain in height as the *Glycine max* had an initial advantage and hence there was not enough reason for gaining height to be able to be exposed to light. All that the plant had to contend with was the competition for water and mineral nutrients.

Weed competition was observed to reduce the growth of *Glycine max* between 28th and 35th day after which it resulted in increase in growth and productivity of the control plants. The above agrees with the findings of Ahuama and Adelusi (1998). The control which was weed free throughout the duration of the experiment had the lowest number of pods even though the seed weight ranked second. The third lot that had a higher weed free period than the third lot had a low dry matter production.

The decrease in the leaf area up till day 35 agrees with the findings of Ahuama and Adelusi (1998) who discovered that there was 25% reduction in leaf area up till day 35 and thereafter an 8% increase.

The Leaf Area Index (LAI) and Leaf Area Ratio (LAR) were enhanced for a greater part of the experimental period. The control plants had the lowest LAI while the plants infested with weeds on day zero had the highest LAI. Those that were infested with weeds in the second and first week were rated second and third respectively. The above did not agree with the findings of Unama and Akobundu (1987) who observed that LAI was highest in weed free plots and that lowest values of LAI were observed in plots with full weed interference. Reduced leaf area index leads into reducing the crops capacity to produce assimilates necessary for food storage during pod filling and this invariably reduced seed yield.

The percentage reductions in shoot biomass in the mixed culture of about 21.27% must have resulted from interspecific competition between the weed and soybean. This was also confirmed by Unama and Akobundu (1987).

Percentage reduction in dry matter yield in mixed culture ranged from 11 to 28%. Reduction in soybean yield has been found to be between 12 to 80% under weed stress (Stoller and Woolley, 1985). It has generally been observed that soybean will suppress weed growth once a complete canopy is achieved (Gallenger, 1978). After the critical period of 28-35 days after planting the crop acquired a high biomass to significantly suppress the weed (*Euphorbia heterophylla*) due to increase in crop height, leaf area and deeper and much branched root system.

From the number of pods and number of flowers, the plant grown in monoculture reached physiological maturity earlier than plants in mixed culture. In dense soybean canopy leaf and flowers are lost and pods turn brown earlier due to accumulation of ethylene above soil level which leads to high abscission rate of both vegetative and reproductive structures as observed in the control plants, showing the intensity of intraspecific competition over that of interspecific competition (Bolhar-Nordenkamp, 1985). Unless the appropriate population density or spacing is employed in *Glycine max* fields, planned programme of weed management and control strategies would be a worthless venture (Ahuama and Adelusi, 1998). The critical growth period of weed interference in a crop therefore depends on the growing conditions (Fadayomi and Abayomi, 1988). The introduction of weed one week after the germination of *Glycine max* had the lowest Harvest Index (HI). The low HI may not be unconnected with a higher vegetative yield at the expense of grain production. The number of soybean seeds does not increase proportionately to the increase in plant dry weight. This is in agreement with the report of Ahuama and Adelusi (1998), who found that seed yield is an

extremely complex character and a function of leaf photosynthetic capacity as well as translocation of photosynthates to the seed. Seed yield therefore may not be correlated with dry matter production (Faluyi, 1987).

Seed yield of soybean was found to be better in mixed cropping than when planted in monoculture. The above assertion is supported by the findings of Olowe (1989) and Summerfield *et al.* (1985) in cowpea. However Baten *et al.* (1992), found that soybean did better in monoculture. The observed low reproductive yield in soybean monoculture may be as a result of the plant trying to outgrow each other thereby utilizing energy which otherwise might have gone to the economically important plant parts like the flowers, fruits and seeds. It may be concluded that intraspecific competition is very pronounced in soybean and that this may be worse than the interference of annual weeds like *Euphorbia heterophylla*.

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