The Combined Effects of *Euphorbia heterophylla* Linn. and Nitrogen Fertilizer on the Reproductive Yield and Competitive Ability of *Macrotyloma geocarpa* (Harms) Marechal and Beaudet

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**Abstract:** Kersting’s groundbean (*Macrotyloma geocarpa* (Harms) Marechal and Baudet), a grain legume was subjected to different nitrogen levels and spurge weed (*Euphorbia heterophylla* L.) competition to study the combined effects of these factors on its growth. Weed competition was achieved by growing Kersting’s groundbean with spurge weed, while fertilizer stress was imposed by planting Kersting’s groundbean without fertilizer treatments. There was another treatment, which was a combination of the two stresses. Fertilizer application of the crops was achieved by broadcasting NPK fertilizers at 0, 15 and 30 kg N ha\(^{-1}\) in the Kersting’s groundbean seedlings plots. The results showed that 15 kg N ha\(^{-1}\) was adequate for good yield. In the present investigation, the level of nitrogen in fertilizer at a lower dose of 15 kg N ha\(^{-1}\) improved growth and yield overt and above those of double dose of 30 kg N ha\(^{-1}\) and the zero fertilizer application. Analysis of yield showed that the crop became more competitive than the weed from the beginning to the end of the experiment in all treatments. Relative yield of the mixture was greater than 1.0 indicating that the yield of the mixed culture was greater than the mean of the two monocultures.

**Key words:** Weed, fertilizer, reproductive yield, competition, *Macrotyloma geocarpa*

**INTRODUCTION**

The introduction of legumes generally has helped a great deal to solve the problem of balanced diet particularly in developing countries where it’s consumption has increased terribly due to increase in population.

*Macrotyloma geocarpa* is an indigenous grain legume cultivated in parts of Tropical Africa for food. It produces its seeds underground (Hepper, 1963). Its cultivation is not as widespread as cowpea and other legumes. The leaves are sometimes eaten in soup. Dried seeds of approximately 100 g can yield 348 calories and contains 9.7% moisture, 19.4 g proteins, 1.1 g fat, 66.6 g total carbohydrate, 5.5 g fibre, 3.2 g ash, 100 mg calcium etc.

The agronomic problems associated with pulse differ between geographical areas. In Asia, Africa and oceanic regions (Johansen *et al.*, 1992), North America (Muehlauber and Kaiser, 1992) and Europe (Monti *et al.*, 1992), drought and biotic stresses appear to be the major limiting factor while other stresses such as extreme temperature and nutrient deficiencies have less frequent impact. Crop management and plant breeding are among the various ways by which stresses could be alleviated.

The pods mature underground and are indehiscent usually divided by 1 or 2 constrictions into 2 or 3 joints seeds are oblong to oblong-ovoid, about 0.6-1.3 cm long, kidney-shaped with a white hilum, white, red, black, or mottled in colour. The seeds resemble the seeds of *Phaseolus vulgaris* but smaller and very hard when dried. Since the seeds are buried in the soil they are safe from attacks by flying insects that severely limit or destroy pulses like soybeans whose pods are remain in the air. It takes between 4-5 months to mature. Seeds ripen, as leaves turn yellow. Plants are later dug up and lefty on the ground to dry and later beaten with sticks or in a mortar to remove seeds. These are later dusted with insecticide to prevent attack by weevils. The protein is rich in essential amino acids, such as lysine 6.2% and methionine 1.4%.

The roots grow well in fine sand or silt where phosphorus and nitrogen are available but roots do not move into regions of moist gravel or coarse sand easily even when fertilizer is applied. The extent of the root system is related to texture and structure of soils as well as available nutrients. Some grain legumes such as varieties of cowpea will do well with about 20 kg N ha\(^{-1}\) and 8 kg ha\(^{-1}\) (Ezedinma, 1961; Fennel, 1962). Optimum response to fertilizer as well as overall yield levels depends on timely sowing (Bandyopadhyay and De, 1986). Nitrogen deficiency is known to cause a reduction in the photosynthetic capacity of plants. The quantum yield for CO\(_2\) uptake decreased heavily with leaf nitrogen content. The critical nitrogen
concentration of a plant can be defined as the minimum nitrogen concentration required for maximum growth rate at any time (Sheehy et al., 1996), leaching and erosion have been the cause of low levels of nutrients particularly nitrogen in cultivated soils.

Weeds are known to constitute a major limiting factor to grain legumes production and probably the most important yield depressing factor to grain legumes in Nigeria (Fadayomi, 1979). Weeds compete for nutrients, moisture, light and space. Weeds with good competitive ability show a faster rate of root elongation and development than the crop (Ayeni et al., 1984). Such weeds cause yield losses ranging from 50 to 86% (Moudy, 1973; Remison, 1978). Weed competition is most serious when crop is young and the critical time for weeding has been reported to be between 4 and 6 weeks after planting (Fadayomi, 1979; Ayeni et al., 1984). Weeds may also serve as a host for insects, pests and pathogens (Akinremi, 1987; Akinremi and Echendu, 1987).

In the present study nitrogen as a fertilizer and Euphorbia heterophylla that has been identified as a common weed in grain legume fields were applied to Macrotyloma geoscarpa and the growth and yield responses followed over a period of time.

**MATERIALS AND METHODS**

The site of the experiment is situated in the Biological Gardens unit of Obafemi Awolowo University Ile-Ife, Nigeria. Soil samples were tested for pH and found to be 6.8, which is still ideal for the growth of legumes, which ranges between 6.5-7.0. Seeds of Macrotyloma geoscarpa were collected from Plant Science Department, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife. The site was cleared and ridges were made. This was divided into three replicates R1, R2, and R3, and space between each replicate being 1 m. Each replicate was divided into six representing:

- Weed+Nitrogen control (WNc)
- Weed+Nitrogen dose 1 (WN1)
- Weed+Nitrogen dose 2 (WN2)
- Nitrogen Control (Nc)
- Nitrogen dose 1 (N1)
- Nitrogen dose 2 (N2)

with a space of 60 cm between each one which was 3x2.4 m.

Analysis started on the of fertilizer application that is zero day and at 7 day intervals thereafter.

Seeds of Macrotyloma geoscarpa were planted in a space of 60x60 cm. NPK fertilizer was applied 18 days after germination. Application was at 15 kg and 30 kg N ha^{-1}.

Competition between two samples (Ground Bean and Spurge Weed).

From the result of dry weight got earlier, the total yield in both monocultures and mixed cultures, with different nitrogen fertilizer doses were related to derive the following competitive indices.

**Competitive Balance Index (Cb) is as follows (Wilson, 1988):**

\[
Cb = \log \frac{Wba}{Wbb}
\]

Where, \(w\) = dry weight plant^{-1}, \(a\) and \(b\) were the two components investigated.

Waa = wt. of species a in monoculture
Wab = wt. of species a in mixed culture
Wbb = wt. of species b in monoculture
Wba = wt. of species b in mixed culture.

The index is a measure of the relative competitive ability of the components of the mixture.

Relative Yield Total (RYT) was derived using the formula (Wilson, 1988)

\[
RYT = \frac{Wab}{Wba} + \frac{Waa}{Wbb}
\]

Relative Yield of the Mixture (RYM) was calculated using the formula (Trentham, 1974):

\[
RYM = \frac{(Wab + Wba)}{(Waa + Wbb)/2}
\]

This determines whether the yield of the mixture is greater than the means of the monoculture.

The seed yield and the yield components were determined as follows:

Mean number of flower buds plant^{-1}.
Mean number of flower plant^{-1}.
Mean number of pods plant^{-1}.
Mean number of seeds plant^{-1}.
Weight of 100 seeds (HSW).

The Harvest Index (HI) was calculated using the formula (Beadle, 1985):

\[
HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100
\]

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Where:
Economic yield = wt. of seeds
Biological yield = Above ground biomass

RESULTS

The Competitive Balance (Cb) index was approximately the same in the control that is N0 and N1 while N2 had the highest competitive balance index on the zero day. From the 7th day till the 21st day N2 had the highest Cb, followed by N1 while N0 had the lowest Cb, but on the 28th day Cb was highest in N0 followed by N1 and N2 was lowest. At the end of the experiment, there was a reduction of 8.3% in N0 and 21.5% in N1 plants as compared to N2 plants. There was variation in the Cb of the three treatments (Table 1).

The Relative Yield Total (RYT) was initially highest in N1 plants at zero day, followed by N0 plants, while this was lowest in N2 plants. There were fluctuations as the experiment progressed but at the end of the experiment RYT was highest in N1 followed by N0 while it was lowest in N2. There was variation in RYT in the treatments (Table 2).

The Relative Yield of the Mixture (RYM) was highest in N1 followed by N2 while N0 was lowest. This was followed by fluctuations and at the end of the experiment N0 plants had the highest RYM followed by N2, while N1 had the lowest RYM. There was variation in RYM values in all the treatments (Table 3).

The reproductive yield showed that the highest mean number of pods/plants was recorded in N1 plants followed by WN1, WN5, N0 and N2, respectively while the lowest number was recorded in WN5. The highest number of buds/plant was recorded in WN5 followed by WN5, N0, N1 and N2, respectively while the lowest number was recorded in WN1 plants. Flowers/plant was highest in N2 followed by WN1, N0, and WN5 while WN2 had the lowest number. Seeds plant\(^{-1}\) was highest in N0 followed by WN1, WN5, NO, N1 and WN2, respectively. Hundred seed weight (HSW) was highest in N1 followed by WN1, WN5, N0, WN5, N1 and N2, respectively (Table 4).

DISCUSSION

This study sets out to highlight, the effects of interspecific competition, nitrogen fertilizer application and effects of the two (weed + fertilizer) treatments combined on the overall growth, performance and reproductive yield of *Macrotyloma uniflorum*. All the investigations were carried out under the same experimental and environmental conditions, except for the variation in the doses of nitrogen fertilizers and weed interference. Any observed differences therefore in the growth, yield and photosynthetic pigments of the crop, that is the control experiment (N0-no weed and no fertilizer) and other treatments were due to the effects of the applied treatments. The high significant differences obtained in the overall growth and yield of the crop between nitrogen fertilizer treatments at different levels imply that crop grain yield performance is predominantly determined by a constant ratio of growth rate to relative nitrogen uptake as the productivity in the control was
lower than that in which there was application at the end of the experiment. This agrees with Ezedirna (1964) that there is a linear relationship between growth rate of a crop and the relative nitrogen uptake. Nitrogen fertilizer will affect the rate of this process only when the nitrogen fertilizer increases the external (soil) concentration of nitrogen. This declines with crop age. Growth response to nitrogen application was observed throughout. Ezedirna (1964) cited by Osiname (1978) noted that nitrogen application to cowpea at planting eliminated any retardation in growth and development, which might follow the loss of cotyledons shortly after emergence and before the nodules become functional.

The total biomass accumulation, which reflects on a summation of effects throughout the growth period, is one of the best parameters for evaluating as well as comparing competitive abilities among plants (Pike et al., 1990). Comparative Balance index (Cb) values different from zero indicate that one species was more competitive than the other (Wilson, 1988) and the results of the Relative Yield (RY) show that the crop became more competitive than the weed immediately after zero day throughout the experimental period. Wilson (1988) reported that crops are more competitive than the associated annual weeds in open fields.

The observable results on RYT showed that, the values greater than one means that the two species use partially different resources, due to the fact that crop is a legume and partly due to the C₄ photosynthetic pathway of the weed. Differences in leaf canopy structure may also contribute to it. These led to the relative yield of the two monocultures at different nitrogen levels being lower than the yield of the mixed cultures. The above reports are in agreement with Silvertown (1987) that a mixed culture of plants with different mineral requirement, leaf canopy structure or developmental time to maturity tend to have a high RYM.

The better reproductive yield of *Macrotlyoma geocarpa* in mixed cultures observed in the study is not in agreement with the report Baten et al. (1992) that soybean does better under monoculture. It however, justifies the observation that in favourable but disturbed environments, plants tend to minimize their reproductive yield. The RYM of more than one also indicates that a higher economic return would be obtained when *Macrotlyoma geocarpa* is grown in the mixture or intercropped with C₄ plants. Also the high seed protein obtained under the various environmental conditions and the ability to suppress this notorious weed make *Macrotlyoma geocarpa* a treasure of diversity and versatility.

It is reported that seed yield is an extremely complex trait and a function of leaf photosynthetic capacity and translocation of photosynthates to the seed. Seed yield therefore, may not be correlated with dry matter production. Falthyi (1987) reported further that low yields are attributed to high vegetative yield at the expense of grain production in cowpea. This was no doubt, responsible for the low Harvest Indices (HI) obtained in the control and low fertilized crops (such as N₀ and N₁ plants). The seed yields obtained in the WN₀, WN₁ and WN₂ was not significantly different from that obtain in N₁ and N₀ plants this therefore supports Summerfield et al. (1977) that effectively nodulated cowpea can produce very high seed yields per plant under tropical conditions.

The significantly low growth and yield of the crop in the unfertilized crops especially control experiment, implies that nitrogen fertilizer is more detrimental to *Macrotlyoma geocarpa* than weed competition stress. It is observed that the plant responded to a small dose (15 kg N ha⁻¹), which stands as dose 1 of nitrogen fertilizer and generally performed better than the larger dose II (30 kg N ha⁻¹) fertilizer. The conclusion from these investigations was that about 15 kg N ha⁻¹ was adequate for good yield. It is believed that higher doses of N application resulted in higher vegetative growth and lower grain yield. So higher dose of nitrogen fertilizer applied at planting adequately acted primarily as a growth booster, though still with significant effect on yield.

The natural means of controlling *Euphorbia heterophylla* and related weed species in *Macrotlyoma geocarpa* fields may be inter-specific suppression of the weed by *Macrotlyoma geocarpa* due to its spreading ability. The improvement of these crops will further increase the protein base of the poor people who cannot afford animal protein. This is needed with other ground bean varieties such as *Macrotlyoma uniflorum, Vigna subterranes, Vigna poissonii*(L.) Verde (Bambara groundnats) and weed species with other types of fertilizers at different levels to widen scope of this investigation of the effects of weed competition and fertilizer application on ground beans.

REFERENCES


