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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 (Muehlbauer 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 hilium, 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

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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 (Akinyemiju, 1987; Akinyemiju 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 geocarpa* 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 geocarpa* 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 R_1, R_2 and R_3 and space between each replicates being 1 m. Each replicate was divided into six representing:

Weed+Nitrogen control (WN_0)
Weed+Nitrogen dose 1 (WN_1)
Weed+Nitrogen dose 2 (WN_2)
Nitrogen Control (N_0)
Nitrogen dose 1 (N_1)
Nitrogen dose 2 (N_2)
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 geocarpa* 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):

$$Cb = \log. \left\{\frac{Wab}{Wba} \times \frac{Waa}{Wbb}\right\}$$

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)

$$RYT = \frac{Wab}{Waa} + \frac{Wba}{Wbb}$$

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

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} X100$$

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 N_0 and N_1 while N_2 had the highest competitive balance index on the zero day. From the 7th day till the 21st day N_0 had the highest Cb, followed by N_1 while N_2 had the lowest Cb, but on the 28th day Cb was highest in N_0 followed by N_1 and N_2 was lowest. At the end of the experiment, there was a reduction of 8.3% in N_0 and 21.5% in N_1 plants as compared to N_2 plants. There was variation in the Cb of the three treatments (Table 1).

The Relative Yield Total (RYT) was initially highest in N_1 plants at zero day, followed by N_0 plants, while this was lowest in N_2 plants. There were fluctuations as the experiment progressed but at the end of the experiment RYT was highest in N_0 followed by N_2 while it was lowest in N_1. There was variation in RYT in the treatments (Table 2).

The Relative Yield of the Mixture (RYM) was highest in N_2 followed by N_1 while N_0 was lowest. This was followed by fluctuations and at the end of the experiment N_0 plants had the highest RYM followed by N_1, while N_2 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 N_1 plants followed by WN_1, WN_0, N_0 and N_2, respectively while the lowest number was recorded in WN_2. The highest number of buds/plant was recorded in WN_1 followed by WN_0, N_0, N_1 and N_2, respectively while the lowest number was recorded in WN_2 plants. Flowers/plant was highest in N2 followed by WN_1, N_1, N_0 and WN_0 while WN_2 had the lowest number. Seeds plant^{-1} was highest in N_1 followed by WN_1, WN_0, NO, N_2 and WN_2, respectively. Hundred seed weight (HSW) was highest in N_1 followed by WN_1, WN_0, N_2, WN_2 and N_0, respectively. Harvest index was highest in WN_0, followed by WN_1, N_0, WN_2, N_1 and N_2, respectively (Table 4).

Table 1: The competitive balance index at five different harvest periods of *Macrotyloma geocarpa* treated with different levels of nitrogen fertilizer and weed (values are means)

	Harvest period				
Treatments	0	7	14	21	28
N_2	0.187	0.338	0.331	0.38	0.0087
N_1	0.181	0.131	0.275	0.256	0.023
N_0	0.304	0.074	0.026	0.048	0.107

Table 2: The relative yield total at five different harvest periods of *Macrotyloma geocarpa* treated with different levels of nitrogen fertilizer and weed (values are means)

	Harvest period				
Treatments	0	7	14	21	28
N_2	1.921	1.246	1.47	3.094	2.059
N_1	2.269	1.674	2.232	1.894	1.387
N_0	1.287	1.672	1.654	1.637	1.7

Table 3: The relative yield mixture at five different harvest periods of *Macrotyloma geocarpa* treated with different levels of nitrogen fertilizer and weed (values are means)

	Harvest period				
Treatments	0	7	14	21	28
N_2	1.928	1.269	1.497	3.019	2.041
N_1	2.252	1.678	1.642	1.855	1.607
N_0	1.428	1.857	1.490	1.858	1.569

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 geocarpa*. 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 (N_0-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

Table 4: Effect of weed competition and fertilizer application on the reproductive characters of *Macrotyloma geocarpa*

Parameters	N_0	N_1	N_2	WN_0	WN_1	WN_2
Mean No. of pods/plant	4.50	8.83	3.50	4.15	8.20	2.40
No. of flower buds/plant	49.25	48.42	44.17	51.30	53.00	40.60
No. of flowers/ plant	37.42	41.32	43.37	33.40	42.83	30.48
Mean no of seeds/plant	4.17	9.55	3.67	4.35	9.20	3.00
Weight of seeds (100) HSW	11.77	13.90	12.27	12.49	12.97	12.20
Harvest Index	244.19	237.20	196.95	266.30	260.18	239.69

lower than that in which there was application at the end of the experiment. This agrees with Ezedinma (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. Ezedinma (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 C_4 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 *Macrotyloma 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 *Macrotyloma geocarpa* is grown in the mixture or intercropped with C_4 plants. Also the high seed protein obtained under the various environmental conditions and the ability to suppress this notorious weed make *Macrotyloma 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. Faluyi (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 (H1) obtained in the control and low fertilized crops (such as N_0 and N_1 plants). The seed yields obtained in the WN_0, WN_1 and WN_2 was not significantly different from that obtain in N_1 and N_2 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 *Macrotyloma 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 *Macrotyloma geocarpa* fields may be inter-specific suppression of the weed by *Macrotyloma 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 *Macrotyloma uniflorum, Vigna subterranes, Vigna poisseniii*(L.) Verde (Bambara groundnuts) 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

Akinyemiju, O.A., 1987. Weed species, densities and control in control in cowpea (*Vignia unguiculata* L. Walp) using pre-emergence herbicides under different tillage practices. Ife J. Sci. 1: 43-49.

Akinyemiju, O.A. and T.N.C. Echendu, 1987. Influence of different tillage methods and pre-emergence herbicides on weed control in cowpea (*Vignia unguiculata* L. Walp) Crop Prot., 6: 229-291.

Ayeni, A.O., W.B. Dduke and R.O. Akobundu, 1984. Weed interference in maize, cowpea and maize/cowpea intercrop. Weed Res., 24: 287-290.

Bandyopadhyay, S.K. and R. De, 1986. Nigerian relationship in a legume/non-legume association grown in an intercropping system. Fert. Res. (In Press).

Baten, M.A., A.A. Agboola and H.J.W. Mutsaers, 1992. All Exploratory Survey of Soybeans Production in Ayepe, Nigeria. In: Mulongoy, K., M. Gueye and D.S.L. Spencer (Eds.). Biological Nitrogen Fixation and Sustainability of Tropical Agriculture, pp: 333-342.

Beadle, C.L., 1985. Plant growth analysis. In: Techniques in Bio-productivity and Photosynthesis 2nd Edn. J. Combs J., D.o. Hall, S.p. Long and J.m.o. Scurlock (Eds.). Pergamon Press, Oxford, pp: 20-25

Ezedinma, F.O.C., 1961. Research on cowpea (*Vigna unguiculata*) in Nigeria before s1960. Nig. Fed. Dept. Agric. Res. Memo. No. 80.

Ezedinma, F.O.C., 1964. Effects of inoculation with local isolates of cowpea rhizobium and application of nitrate nitrogen on the development of cowpeas. Trop. Agric., 41: 243-249.

Fadayomi, O., 1979. Effects of crop spacing on weed competition and seed yield in cowpea (*Vigna unguiculata* L. Walp) e.v. 'Ife Brown' Ife J. Agric., 1: 46-50.

Faluyi, M.A., 1987. Investigation on the relationship between grain yield and vegetative traits of cowpea in a tropical rain forest environment, Nig. J. Agron., 2: 55-60

Fennel, M.A., 1962. USAID Terminal Report No. A-61.

Hepper, F.N., 1963. Plants of the 1957-58 W.A. Expedition. The bambarra groundnut (*Voadzeia subterraneal*) and kerstings groundnut (*Kerstigiella geocarpa*) Wild. Kew Bull., 16: 395-407.

Johansen, C., B. Balder, J.B. Brouwer, W. Erskine, W.A. Jermyn and L. Li-Juan, 1992. Biotic and Abiotic Stresses Constraining Productivity of Cool Season Food Legume in Asia, Africa and Oceanic. Production and use of Cool Season Food Legumes Kluwer, Dordrecht, pp: 175-194.

Monti, L., A.T. Biddle, M.T. Moreno and P. Planequaert, 1992. Biotic and Abiotic Stresses of Pulse Crops in Europe. In: Expanding the production and use of Cool Season Food Legumes. Muchlbauer, F.J. and W.J. Kaiser Eds., Kluwer, Dordrecht, pp: 204-218.

Moudy, K., 1973. Weed control in cowpea. Proceeding 3rd Nigerian Weed Science Group Meeting, pp: 14-32.

Muehlbauer, F.J. and W.J. Kaiser, 1992. Expanding the Production and Use of Cool Season Food Legumes. Kluwer Academic Press, Dordrecht, The Netherlands, pp: 195-203.

Osiname, O.A., 1978. The fertilizer (N.P.K.) requirement of Ife-Brown cowpea (*Vigna unguiculata* (L.) Walp.). Institute of Agricultural Research and Training, University of Ife, P.M.B. 5029, Moor Plantation, Ibadan. IITA J., 12: 13-15.

Pike, D.R., E.W. Stoller and L.M.Wax, 1990. Modelling soybean growth and canopy appointment in weed-soybean (*Glycine max*) competition, Weed Sci., 38: 522-532.

Remison, S.U., 1978. Performance of cowpea (*Vigna unguiculata* (L.) Walp.) as influenced by weed competition J. Agric. Sci. Cambridge, 90: 523-530

Sheehy, J.F., F. Gastal, P.L. Mitochell, J.L. Durand, G. Lemaire and F.L. Woodward, 1996. A nitrogen led model of grass growth. Ann. Bot., 77: 167-177.

Silvertown, J.W., 1987. Introduction to Plant Ecology 2nd Edn., Longman Science and Technical Essex, England, pp: 75-76.

Summerfield, R.J., P.J. Dart, R.A. Huxley, A.R.J. Eaglesham, F.R. Minchin and J.M. Day, 1977. Nitrogen nutrition of cowpea (*Vigna unguiculata*). Effect of applied nitrogen and symbiotic nitrogen fixation on growth and seed yield. Exp. Agric., 13: 129-142.

Trenbath, B.R., 1974. Biomass productivity of mixtures. Adv. Agron., 26: 177-210.

Wilson, J.B., 1988. Shoot competition and Root competition. J. Applied Ecol., 25: 279-296.