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# EFFECT OF THE TIME OF INTRODUCTION OF COMPONENT CROPS AND OF FERTILIZER-N APPLICATION ON MAIZE AND VEGETABLE COWPEA GROWN IN MIXTURES UNDER THE HUMID TROPICAL CONDITIONS

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## ABSTRACT

*Field experiments were carried out during 1998 and 1999 cropping seasons at Umudike, south eastern Nigeria, to evaluate the yield performance of maize intercropped with vegetable cowpea under different planting schedules. Treatments comprised vegetable cowpea planted 4 weeks before, same day as, 4 and 8 weeks after maize and nitrogen levels of 0, 50 and 100kgN/ha.*

*The results showed that plant height, leaf area index, dry matter and pod yield in vegetable cowpea as well as seed yield in maize decreased significantly following delay in the introduction of either crop in mixture. Usually the component crop that was planted earlier in the mixture gave a stiffer competition against the component that was planted later as demonstrated by growth and yield values. Cases of applied N increased growth and yields in the intercrops. On the average, planting vegetable cowpea at 4 weeks before, same day as, 4 and 8 weeks after maize gave yield advantages of 98, 93, 64 and 97% respectively, over sole cropping. The yield advantages due to intercropping at 0, 50 and 100kgN/ha were 131, 81 and 74% respectively. Planting the mixture the same day produced more satisfactory yields of the intercrops than other planting schedules while fertilizer use was optimized by applying 50kg N/ha.*

**Key words:** *Maize, Vegetable cowpea, Mixture, Time of introduction, Fertilizer N, Land equivalent ratio.*

## INTRODUCTION

Intercropping maize (*Zea mays*) and vegetable cowpea (*Vigna unguiculata* sub species *sesquipedalis*) provides one of the common crop combinations in the intercrop system adopted by local farmers in the forest zone of south eastern Nigeria. While maize is grown through out the country, vegetable cowpea is restricted, in cultivation and use, to the derived savannah and forest belts (Uguru, 1996). The produce from both crops contributes substantially to the dietary carbohydrates and proteins of the rural populace during one half of the year, from May to October (Uzo, 1983).

Modifications in time, technique and pattern of planting crops grown in association can enhance the compatibility of mixtures and make intercropping a more feasible practice (Singh and Anyaneyulu, 1979). A combination of tall and short crops gave a good performance, especially if the tall crop was planted a little later (Crookston and Kent, 1976). In the traditional farming systems of the tropics, the component crops may be sown at the same or different times, depending on the farmers preference (Remison, 1982; Ofori and Sterm, 1987). Research information is scanty on the competition between maize and vegetable cowpea in mixture. Information is also limited on the fertilizer needs of the maize and vegetable cowpea intercrops in the

zone. Nitrogen is often in short supply for most crops grown in the area, especially because of leaching from high rainfall and the sandy nature and low organic matter content of the soil (Asiegbu, 1989). As maize is a high nitrogen-demanding crop, there may be need to augment the nitrogen supply from the vegetable cowpea with inorganic nitrogen fertilizer. The vegetable cowpea may also require some fertilizer nitrogen especially for early growth.

The objectives of this paper were to examine the effects of time of introducing vegetable cowpea into maize/cowpea mixtures, and the effects of nitrogen fertilizer on maize/vegetable cowpea intercrops in the forest zone of south eastern Nigeria.

## MATERIALS AND METHODS

The experiment was conducted in 1998 and repeated in 1999 at the Research Farm of the Michael Okpara University of Agriculture, Umudike, south eastern Nigeria. Umudike lies on Latitude 5° 28'N, Longitude 7°33'E and at altitude 122m above sea level. The total rainfall at Umudike during the study period (March to October) were 1901.0mm in 1998 and 2507.2mm in 1999. The soil of the location was characterized as sandy loam ultisol.

In the first year (1998), a 3 x 3 factorial experiment in randomised complete block design with three replications was used. The factors consisted of three periods of introducing vegetable cowpea of same day as maize (May 14), 4 weeks after planting maize (June 11) and 8 weeks after planting maize (July 9) and three nitrogen levels of 0, 50 and 100kg/ha). In 1999, a 4 x3 factorial experiment was conducted. There were four periods of vegetable cowpea introduction of 4 weeks before planting maize (April 17), same day as maize (May 14), 4 weeks after maize (June 11) and 8 weeks after maize (July 9). The three nitrogen levels were 0, 50 and 100kg/ha as urea. Each plot measured 4mx4m.

Land previously planted to cassava but under a one year fallow at the commencement of the experiment, was disc ploughed, harrowed and rigded 1m apart. FARZ-23-yellow and a local vegetable cowpea variety, Isuochi Black, were used. The crops were hand sown at two seeds per hole and later thinned down to one plant per stand two weeks after planting (WAP). A spacing of 1m x 0.25m and a density of 40,000 plants/ha were maintained for each crop. Maize occupied one-half of the ridges while vegetable cowpea occupied the second-half. Sole crops of maize and vegetable cowpea were included to ensure computation of land equivalent ratio (LER). Each plot was given blanket application of 40kg$P_2O_5$ and 40kg$K_2O$ per hectare as single super phos-

**Table 1:** Soil and rainfall data of the site during the experimental periods

| | Soil physical characteristics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sand (%) | | Clay (%) | | Silt (%) | | | | |
| 1998 | 67.0 | | | | | | | | |
| 1999 | 64.8 | | 30.8 | | 4.4 | | | | |
| | Soil chemical characteristics | | | | | | | | |
| | OM (%) | N(%) | Total P (PPM) | Exch.K (meq/100 g soil) | Soil pH | | | | |
| 1998 | 3.2 | 0.18 | 25.0 | 0.46 | 4.81 | | | | |
| 1999 | 2.2 | 0.16 | 24.0 | 0.38 | 5.8 | | | | |
| | Rainfall (mm) | | | | | | | | |
| | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. |
| 1998 | 35.6 | 114.2 | 311.3 | 402.6 | 243.2 | 310.7 | 287.6 | 195.8 | 70.1 |
| 1999 | 203.4 | 192.0 | 319.9 | 296.6 | 284.4 | 382.2 | 395.3 | 433.7 | 50.1 |

**Table 2:** Effect of time of introducing vegetable cowpea and cowpea and nitrogen fertilizer on growth of the component crops at 7WAP in 1998

| | Plant height (cm) | | Leaf area index | | Shoot dry weight (g/plant) | |
|---|---|---|---|---|---|---|
| | Maize | Vegetable Cowpea | Maize | Vegetable Cowpea | Maize | Vegetable Cowpea |
| **Time of introducing vegetable cowpea** | | | | | | |
| Same day as maize | 251.9 | 204.8 | 3.7 | 3.1 | 101.7 | 16.4 |
| 4 weeks after maize | 241.7 | 124.9 | 3.1 | 0.8 | 102.7 | 4.7 |
| 8 weeks after maize | 226.8 | 72.1 | 3.7 | 0.6 | 100.0 | 3.6 |
| LSD (0.05) | 17.4 | 29.8 | NS | 0.7 | NS | 3.0 |
| **Nitrogen rate (K/ha)** | | | | | | |
| 0kgN/h | 201.8 | 98.3 | 3.0 | 1.5 | 76.2 | 5.9 |
| 50 | 260.8 | 139.4 | 3.2 | 1.2 | 101.4 | 8.2 |
| 100 | 258.6 | 164.0 | 4.3 | 1.8 | 126.8 | 10.6 |
| LSD (0.05) | 17.4 | 29.8 | 0.7 | NS | 21.9 | 3.0 |
| **Time of introduction x Nitrogen rate** | | | | | | |
| Same day as maize x | 219.9 | 160.5 | 3.9 | 3.5 | 92.2 | 11.2 |
| 0kgN/ha | 275.0 | 229.4 | 3.0 | 2.3 | 102.7 | 16.4 |
| x | 260.8 | 224.5 | 4.1 | 3.5 | 110.1 | 21.6 |
| 50kg/N/ha | | | | | | |
| x | | | | | | |
| 100kgN/ha | | | | | | |
| 4 weeks after maize x | 207.2 | 87.0 | 2.6 | 0.5 | 74.8 | |
| 0kgN/ha | | | | | | |
| x | 254.7 | 124.3 | 2.9 | 0.8 | 99.9 | |
| 50kgN/ha | | | | | | |
| x | 263.3 | 163.3 | 3.9 | 1.0 | 133.5 | |
| 100kgN/ha | | | | | | |
| 8 weeks after maize x | 178.2 | 47.5 | 2.6 | 0.5 | 61.7 | |
| 0kgN/ha | | | | | | |
| x | 250.6 | 64.4 | 3.7 | 0.5 | 101.6 | |
| 50kgN/ha | | | | | | |
| x | 251.6 | 104.3 | 4.8 | 0.8 | 136.7 | |
| 100kgN/ha | | | | | | |
| LSD (0.05) NS | NS | NS | NS | NS | NS | NS |

**Table 3:** Effect of time of introducing vegetable cowpea and nitrogen on yield and yield components of maize

| | Number of grains Per cob | | 100-grain weight(g) | | Grain yield (kg/ha) | |
|---|---|---|---|---|---|---|
| | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| **Time of introducing vegetable cowpea** | | | | | | |
| 4 weeks before maize | | 110.2 | | 15.1 | | 0.68 |
| Same day as maize | 358.5 | 161.7 | 23.0 | 16.0 | 3.31 | 1.03 |
| 4 weeks after maize | 343.2 | 197.3 | 21.7 | 15.1 | 2.97 | 1.31 |
| 8 weeks after maize | 315.0 | 205.1 | 12.9 | 18.9 | 1.74 | 1.57 |
| LSD (0.05) | NS | 44.2 | 2.4 | 2.5 | 0.41 | 0.38 |
| **Nitrogen rate (k/ha)** | | | | | | |
| 0 | 272.0 | 116.2 | 17.3 | 16.1 | 2.03 | 0.76 |
| 50 | 370.2 | 202.2 | 19.8 | 15.7 | 2.94 | 1.31 |
| 100 | 374.4 | 187.4 | 20.5 | 17.8 | 3.05 | 1.37 |
| LSD (0.05) | 42.5 | 38.3 | 2.4 | NS | 0.41 | 0.33 |
| **Time of introducing x Nitrogen rate** | | | | | | |
| 4 weeks before maize x 0kgN/ha | | 85.8 | | 14.8 | | 0.51 |
| x 50kgN/ha | | 113.5 | | 15.3 | | 0.69 |
| x 100kgN/ha | | 131.2 | | 15.2 | | 0.82 |
| Same day as maize x 0kgN/ha | 302.8 | 153.1 | 21.8 | 17.3 | 2.61 | 1.07 |
| x 50kg/N/ha | 398.6 | 158.6 | 23.9 | 14.4 | 3.80 | 0.90 |
| x 100kgN/ha | 373.7 | 173.4 | 23.4 | 16.4 | 3.53 | 1.12 |
| 4 weeks after maize x 0kgN/ha | 344.1 | 120.0 | 20.7 | 15.4 | 2.83 | 0.74 |
| x 50kgN/ha | 335.3 | 217.7 | 21.0 | 14.4 | 2.81 | 1.25 |
| x 100kgN/ha | 350.3 | 254.1 | 23.4 | 18.5 | 3.27 | 1.93 |
| 8 weeks after maize x 0kgN/ha | 169.0 | 105.7 | 9.3 | 17.0 | 0.65 | 0.72 |
| x 50kgN/ha | 376.7 | 319.0 | 14.6 | 18.6 | 2.20 | 2.39 |
| x 100kgN/ha | 399.2 | 190.7 | 14.7 | 21.1 | 2.36 | 1.61 |
| LSD (0.05) | 73.5 | 76.5 | NS | NS | 0.71 | 0.66 |

phate and muriate of potash respectively. The appropriate fertilizer rates were applied by banding one week after planting maize. Plots were hoe-weeded three times at 3-week intervals after sowing the first crop, sprayed thrice with karate at 100ml in 20L water at 3-week intervals after sowing to protect them against insect pests.

Data were collected on plant height, leaf area index and shoot dry weight in 1998 only. Data on number of pods/plant, pod weight (g), pod yield (kg/ha), number of seeds/pod and cob, 100-seed weight (g) and seed yield (kg/ha) were obtained in 1998 and 1999. Leaf area of maize was determined using Elsahookie's (1977) formula while that of vegetable cowpea was computed with the formula by Osei-Yeboah *et al* (1983). Data obtained were statistically analysed using the procedures of Steele and Torrie (1980) for randomised complete block design (RCBD). Land equivalent ratio and competition coefficient (C) were calculated using the formulae of Fisher (1977) and Okigbo (1979) respectively.

## RESULTS

Delay in introducing vegetable cowpea in maize significantly reduced plant height in both crops, and, also depressed the leaf area index and dry weight of shoot in vegetable cowpea at 7WAP (Table 2). Nitrogen fertilizer application at 100kgN/ha significantly increased height and dry matter accumulation in maize and vegetable cowpea. Interaction of time of introducing vegetable cowpea x nitrogen did not significantly affect the growth attributes at 7WAP.

Maize grain yields were, on the average, significantly greater where the mixture was planted the same day or vegetable cowpea was introduced 4 weeks after maize compared with where vegetable cowpea was introduced 4 weeks before or 8 weeks after maize (Table 3). Nitrogen fertilizer application increased seed yields significantly compared with where no N fertilizer was applied.

The highest maize grain yields occurred where the mixture was planted the same day or where vegetable cowpea was introduced 4 and 8 weeks after maize and nitrogen applied at 50 or 100kgN/ha while the least yield occurred where vegetable cowpea was planted 4 weeks before maize, regardless of nitrogen levels applied. Maize grain yields in 1998 were much higher than in 1999.

On the other hand, vegetable cowpea pod yields were significantly greater when the crop was planted 4 weeks before maize than when the mixture was planted the same day or where vegetable cowpea was introduced 4 or 8 weeks after maize (Table 4). Planting the mixture the same day gave a significantly higher pod yield than planting maize earlier and introducing vegetable cowpea later. Successive increments in the rate of nitrogen fertilizer application significantly increased pod yeilds within the range of fertilizer used. Seed yield and number of pods/plant were similarly increased by nitrogen application. Interaction of time of introducing vegetable cowpea and nitrogen on pod yield was significant in 1999. The greatest pod yields were obtained where vegetable cowpea was planted 4 weeks before maize and nitrogen was applied at 100kgN/ha, while the least pod yield occurred where vegetable cowpea was planted 8 weeks after maize, regardless of nitrogen levels applied.

Except for where vegetable cowpea was introduced at 4 weeks after maize, the land equivalent ratios were similar for all planting schedules (Table 5). The advantages of intercropping were 131, 81 and 74% for the 0, 50 and 100kgN/ha treatments, respectively. Maize had competition coefficient greater than 0.5 where both crops were planted the same day or where the vegetable cowpea was introduced at 4 weeks after maize and nitrogen applied at 0 or 50kgN/ha in 1998. In 1999, however, competition coefficient was in favour of maize (C>0.5) where vegetable cowpea was introduced at 4 and 8 weeks after maize and nitrogen was applied at 100kgN/ha.

Competition coefficient favoured vegetable cowpea in cases where the crop was introduced 8 weeks after maize in 1998 and where the mixture was planted the same day or where vegetable cowpea was planted 4 weeks before maize in 1999, regardless of the nitrogen levels.

**Table 4:** Effective of time of introducing vegetable cowpea in mixture with maize and nitrogen fertilizer on yield and yield components of vegetable

| | Number of pod per plant | | Pod weight (g) | | Fresh pod yield (t/ha) | | Number of seeds per plot | | 100-seed weight [g] | | Dry grain yield [t/ha] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| **Time of introducing vegetable cowpea** | | | | | | | | | | | | |
| 4 weeks before maize | | | | | 6.78 | | | | | | 1.64 | |
| Same day as maize | 19.3 | 29.3 | 3.9 | 2.1 | 2.95 | 2.33 | 13.6 | 16.3 | 6.7 | 7.2 | 0.69 | 1.39 |
| 4 weeks after maize | 7.6 | 4.6 | 2.9 | 3.9 | 0.88 | 0.72 | 14.0 | 12.8 | 6.1 | 6.4 | 0.25 | 0.16 |
| 8 weeks after maize | 8.1 | 0.7 | 2.7 | 2.2 | 0.88 | 0.06 | 0.36 | 0.02 | 5.7 | 6.2 | 0.36 | 0.02 |
| LSD (0.5) | 3.7 | 2.5 | 0.3 | 2.5 | 0.64 | 0.53 | 1.8 | 1.1 | 0.5 | 0.9 | 0.16 | 0.17 |
| **Nitrogen rate (kg/ha)** | | | | | | | | | | | | |
| 0 | 13.2 | 15.1 | 2.0 | 3.3 | 1.55 | 2.29 | 13.1 | 13.7 | 5.9 | 6.8 | 0.40 | 0.61 |
| 50 | 11.9 | 18.8 | 3.4 | 3.1 | 1.64 | 2.36 | 12.8 | 14.3 | 6.2 | 6.9 | 0.39 | 0.83 |
| 100 | 16.0 | 19.3 | 3.7 | 3.3 | 2.39 | 2.77 | 13.8 | 15.0 | 6.4 | 7.2 | 0.52 | 0.97 |
| LSD (0.05) | NS | 2.2 | 0.3 | NS | 0.64 | NS | 1.8 | 1.0 | 0.5 | NS | 0.16 | 0.14 |
| **Time of introducing x Nitrogen rate** | | | | | | | | | | | | |
| 4 weeks before maize x 0kgN/ha | | 31.4 | | 4.8 | | 6.03 | | 14. 4 | | 7.3 | | 1.33 |
| x 50kgN/ha | | 36.0 | | 4.5 | | 6.54 | | 14.5 | | 8.0 | | 1.68 |
| x 100kgN/ha | | 41.1 | | 4.7 | | 7.76 | | 14.0 | | 8.3 | | 1.91 |
| Same day as maize x 0kgN/ha | 24.0 | 23.9 | 3.3 | 2.6 | 3.24 | 2.38 | 12.8 | 15.1 | 5.9 | 7.0 | 0.73 | 0.99 |
| x 50kgN/ha | 14.6 | 32.7 | 4.0 | 1.7 | 2.36 | 1.98 | 13.2 | 16.1 | 7.4 | 6.7 | 0.57 | 1.41 |
| x 100kgN/ha | 18.9 | 31.4 | 4.3 | 2.1 | 3.26 | 2.63 | 14.8 | 14.8 | 6.9 | 7.9 | 0.77 | 1.78 |
| 4 weeks after maize x 0kgN/ha | 6.1 | 4.2 | 2.6 | 3.9 | 0.63 | 0.67 | 14.0 | 11.8 | 6.0 | 6.0 | 0.20 | 0.12 |
| x 50kgN/ha | 9.2 | 5.7 | 2.8 | 3.8 | 1.03 | 0.88 | 13.0 | 12.9 | 5.3 | 6.9 | 0.25 | 0.21 |
| x 100kgN/ha | 7.5 | 3.8 | 3.3 | 4.0 | 0.98 | 0.60 | 15.0 | 13.8 | 7.0 | 6.4 | 0.31 | 0.14 |
| 8 weeks after maize x 0kgN/ha | 9.1 | 0.7 | 3.0 | 2.0 | 0.11 | 0.06 | 12.5 | 13.4 | 5.7 | 6.8 | 0.26 | 0.03 |
| x 50kgN/ha | 11.8 | 0.6 | 3.3 | 2.4 | 1.54 | 0.06 | 12.3 | 13.6 | 6.0 | 5.9 | 0.34 | 0.02 |
| x 100kgN/ha | 21.7 | 0.8 | 3.4 | 2.3 | 2.92 | 0.07 | 11.7 | 14.1 | 5.4 | 6.0 | 0.49 | 0.03 |
| LSD (0.05) | NS | 4.4 | NS | NS | NS | 0.92 | NS | NS | NS | NS | NS | 0.29 |

## DISCUSSION

Introducing vegetable cowpea 4 or 8 weeks after maize had been planted resulted in significant reductions in height, leaf area index and dry matter in the vegetable cowpea, compared with where the mixture was planted the same day. In the study reported here, maize was taller and produced more leaf area and was therefore at an advantage over vegetable cowpea. The general conclusion from experiments involving competition for light is that the component with its leaf area higher in the canopy is at an advantage (Stern and Donald, 1962; Donald, 1963; Remison, 1982; Adelana, 1981; Muoneke *et al*, 1997).

This study showed that the yield of each component of the mixture decreased when sown later than the other component. Ofori and Stern (1987) and Remison (1982) had similarly observed that when component crops in mixture were sown at different times, the earlier sown component often had an initial competitive advantage over the later one. On the average, maize grain yields were depressed by 69% when maize was sown 4 weeks after planting vegetable cowpea while pod yields in vegetable cowpea were reduced by 70 and 82% when it was introduced into maize plots 4 and 8 weeks after, respectively compared to where the mixture was planted at the same time. Planting maize 4 weeks after vegetable cowpea seemed undesirable not only because the desired protein-energy balance as given by May (1982) may not be achieved but also because maize seedlings stand very high risk of being smothered by the trailing vegetable cowpea vines. For the soil of this investigation, nitrogen fertilizer application at 50kgN/ha appeared satisfactory for achieving high yields of maize and vegetable cowpea in mixture. Results did not show any evidence that higher fertilization could be utilized to advantage in the planting schedules. The yields of both crops illustrate the trade-off that occurred between maize and vegetable cowpea. The yield of each crop decreased as the competitiveness of the other crop increased, a finding that is corroborated by other observations (Willey, 1979; Freyman and Venkateswarly, 1979; May, 1982). Increasing competitive ability of maize consistently depressed vegetable cowpea yields and number of pods/plant while increasing competitive ability of vegetable cowpea was evident in depressing the grain yield of maize.

The mixtures had, on the average, land equivalent ratios above 1.0, indicating that higher productivity per unit area was achieved by intercropping maize with vegetable cowpea than by growing either of the two crops separately. Although the land equivalent ratios for the 50 and 100kgN/ha treatments were lower than the zero nitrogen treatment, the total absolute yield was, in most cases, far greater in the 50 and 100kgN/ha treatments than where no fertilizer N was applied. Yields were much lower for maize in 1999, probably owing to heavier rainfall which might have caused leaching of nutrients, water logging of some plots and cloud cover. Undoubtedly, maize, a C4-plant characterized by high efficiency of light utilization (Uzo, 1983) was more disadvantaged photosynthetically under the cool, dull conditions of the 1999 cropping season. Milthorpe and Moorby (1975) had reported that $C_3$-species have a photosynthetic advantage over $C_4$-species under cool, dull conditions.

## CONCLUSION

The results indicated that maize and vegetable cowpea can be successfully intercropped. From overall consideration of the yield values, it is concluded that fertilizer use can be optimized by applying 50kgN/ha. Planting the mixture the same day not only gave higher LER values but also produced more satisfactory yields of the intercrops than the other planting schedules, which drastically reduced the yields of either the maize or vegetable cowpea component.

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