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Biologically Efficient and Productive Okra Intercropped System in a Tropical Environment

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ABSTRACT

A field experiment was carried out at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi from 10th November, 2009 to 31st March, 2010 with the objectives of (1) developing a biologically efficient onion intercropping system for okra production and (2) determining the agronomic productivity of the intercrop systems. There were five treatments arranged in a randomized complete block design. The treatments were (1) two rows okra to one row onion (2+1) (2) three rows okra to one row onion (3+1) and (3) four rows okra to one row onion (4+1) (4) sole okra and (5) sole onion. Intercropped onion did not affect the growth and reproductive parameters of okra. Intercropping okra with onion significantly reduced the leaf damage caused by *Podagrica* spp. The 2+1 intercrop system recorded the least leaf damage, significantly different from the other intercrop systems and the sole okra. Fruits of sole okra were significantly ($p<0.05$) longer (16.3 cm) than those from the 3+1 and 2+1 intercropped okra, although similar to those from the 4+1 intercrop system. Contrarily, the 2+1 intercrop system produced 99% significantly heavier okra fruits with mean weight of 341.3 g than the sole okra with mean weight of 171 g, which produced the lightest. However, for total production, there were no significant differences among the treatments. For yield loss, the 2+1 intercrop system produced the least percentage yield loss of 10.5%. There was significant reduction in the bulb size and yield of the intercropped onion. The 2+1 intercrop system produced the highest agronomic productivity with a land equivalent ratio of 1.36. The study concluded that the most biologically efficient and productive intercrop system for okra+onion was the two rows of okra to one row of onion (2+1 system).

Key words: Okra, intercropping, onion, insect damage, yield

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the vegetable crops extremely popular in West Africa (Norman, 1992). In Ghana, the tender fruits are consumed nearly on a daily basis in stews and soups (Sinnadurai, 1992). Economically, the fruits are a source of cash for rural households in the southern and central parts of most West African countries (Norman, 1992). The yield and fruit quality are however hampered by insect pests that attack either the plant or the fruit, particularly the flea beetle (*Podagrica* spp.) and cotton stainer (*Dysdercus superstitious*) (Boamah, 2002; Obeng-Ofori *et al.*, 2007). To overcome the devastating damage caused by these insects, most farmers rely heavily on the use of insecticides, which inadvertently leads to accumulation of pesticide residues, destruction of beneficial fauna and environmental pollution (Trumper and Holt, 1998). In recent times, interest in the use of edible crops in production systems to either repel or trap these insects is gaining popularity. Moreover, the shift in consumption patterns from conventionally produced fruits to organically produced ones (Magnusson and Cranfield, 2005) has further heightened the need to explore viable pest management alternatives that could keep farmers in profitable production. Earlier studies have shown that intercropping cabbage with tomato repelled the Diamondback moth (*Plutella xylostella*) (Norman, 1992) whereas white flies infestation on tomato was significantly reduced when intercropped with onion (Prasterink, 2000). Currently in okra production, only *Amaranthus* spp. has been recommended as an effective method for the control of the flea beetle (Obeng-Ofori *et al.*, 2007). But *Amaranthus* spp. is not popular across West Africa and therefore other alternatives need to be found to control the flea beetle across West Africa. The objectives of the study therefore were to (1) determine the growth, insect pest control and yield of okra in onion-intercropped systems and (2) determine the agronomic productivity of the okra in the intercropped systems.

MATERIALS AND METHODS

The experimental site: The experiment was carried out at the experimental field of the Horticulture Department of Kwame Nkrumah University of Science and Technology, Kumasi. The site has a bimodal rainfall distribution, with peaks in June and September. The first and second growing seasons typically last from mid-March to mid-July and from mid-August to the end of November, respectively, separated by a short dry spell of about four weeks in July. The major dry season starts in mid-November and lasts to the end of February or middle of March. The predominant soil at the site is Kaolinitic and Typic Kandiudult (Hulugalle and Ndi, 1993).

Experimental procedure: The experiment was conducted from 10th November, 2009 to 31st March, 2010. The field was ploughed on 1st November, 2009 and harrowed on 2nd November, 2009 after 300 kg of cow dung had been spread on it. Each plot measured 5 ×2.1 m. The treatments were arranged in a randomized complete block design with three replications. The treatments were (1) two rows of okra + one row of onion (2+1) (2) three rows of okra + one row of onion (3+1) (3) four rows of okra + one row of onion (4+1) (4) sole okra and (5) sole onion.

The onion seeds were nursed on 25th September, 2009 and transplanted when the seedlings were six weeks old. Transplanting was done at the same time as the direct seeding of the okra cv. Bhindi. Okra plants were spaced 60 cm between rows and 30 cm within rows whereas the spacing of onion was 30 cm between rows and 30 cm within rows. Weeds were manually controlled with a hoe at two weekly intervals. The plants were watered daily since the experiment was conducted in the dry season.

Assessment of major insect pest damage on okra: Damage caused by the flea beetles (*Podagrica* spp.) on okra leaves was based on estimates of defoliation. A leaf each was picked from the top, middle and low canopy levels of 10 randomly selected plants on each plot. All the leaves from the selected plants each plot were put in a collection bag and the damage assessment was made in the laboratory. The collected leaves were compared to the illustration in Fig. 1 and the mean level of defoliation recorded. Data were taken six weeks after planting until fruit set.

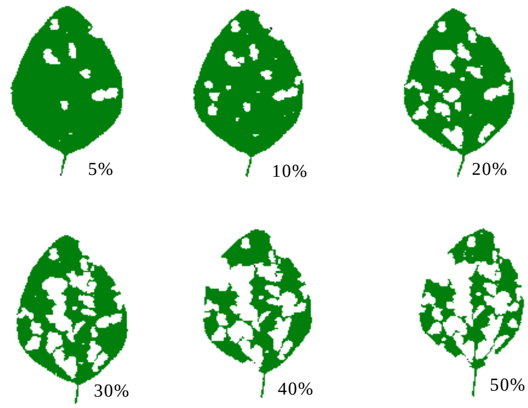

Fig. 1: Various levels of okra leaf defoliation by *Podagrica* spp.

Assessment of growth and yield of okra and onion: Growth measurements on okra were made on the six middle rows of each plot beginning at two weeks after establishment and subsequently at two weekly intervals. The growth parameters taken included plant height, number of branches, number of days to 50% flowering, number of days to 50% fruit set, number of days to maturity, number of fruits per plant, fruit weight per plant and fruit size. The leaf area of okra was derived by tracing 50 leaves of varying growth stages on metric graph papers. The leaf area was derived from the regression equation (Y = -0.211 + 0.6X, r = 0.98**), (Muoneke and Asiegbu, 1997), where Y = leaf area while X was the product of the length and widest breath of each leaf. Yield data on okra and onion were taken at harvest. The data included total yield ha^{-1} of each crop, marketable yield ha^{-1} of each crop and bulb size of onion.

Statistical analyses: Data were analyzed by analysis of variance (ANOVA) using statistix 8 software. The Least Significant Difference (LSD) was calculated and the probability of treatment means being significantly different was set at $p<0.05$.

The Land Equivalent Ratio (LER) was used to determine agronomic productivity of the intercropping systems as follows:

$$\text{LER} = \frac{\text{Yield of intercrop 1}}{\text{Yield of sole 1}} + \frac{\text{Yield of intercrop 2}}{\text{Yield of sole 2}}$$

RESULTS

Growth of okra: There were no significant differences in plant height and number of branches among the sole and intercrops. Intercropping did not also affect the time taken to attain 50% flowering as well as 50% fruiting of okra. Among the okra treatments, it took 35 and 37 days after planting to attain 50% flowering and 50% fruiting, respectively. Similarly, the period to maturity of the okra fruits was not influenced by intercropping.

Leaf area and pest leaf damage on okra: Prior to insect attack, the sole okra had the largest leaf area, significantly different from the intercropped okra plants. Among the intercropped okra, the 2+1 and 3+1 systems had okra leaf area also significantly larger than those of from the 4+1 system (Table 1). In terms of insect damage, intercropping okra with onion significantly reduced the leaf damage caused by *Podagrica* spp. The 2+1 intercrop system recorded the least leaf damage, significantly different from the other intercrop systems and the sole okra. Leaf damage on the sole okra was greatest, yet similar to that from the 4+1 intercrop system. Consequently, available okra leaf area for light interception and subsequently for photosynthetic activity was largest in the 2+1 system and the smallest in the 4+1 system, the difference being significant.

Yield and yield components of okra: Fruits of the sole okra were significantly longer (16.3 cm) than those from the 3+1 (12.4 cm) and 2+1 (12.7 cm) intercropped okra but similar to those from the 4+1 intercropped okra (Table 2). In contrast, the 2+1 intercrop system produced 99% significantly heavier okra fruits than the sole okra, which produced the lightest. In terms of total production, there were no significant differences among the treatments. Yet for yield loss (non-marketable yield), the intercrops recorded less loss of okra than the sole. The sole okra produced the highest yield loss of 12.9% whereas the 2+1 intercrop system producing the least (10.5%) (Table 2).

Yield and yield components of onion: Intercropping reduced both onion bulb yield and bulb size in the okra-based systems. The bulb yield reductions were 55.1, 78.6 and 84.0% in the 2+1, 3+1 and 4+1 okra intercrop systems, respectively (Table 3). Furthermore, there were 33.8, 35.4% and 33.8% reductions in bulb size from the 2+1, 3+1 and 4+1 okra intercrop systems, respectively. Sole onion recorded the highest bulb yield (0.38 t ha^{-1}) and mean bulb size (6.5 cm) whereas the 4+1 intercrop system produced the least bulb yield (0.06 t ha^{-1}) although not the smallest bulb size (4.3 cm) (Table 3).

Productivity of okra intercrop systems (land equivalent ratios): All the intercrop systems of okra were more productive than the sole crop. The 2+1 intercrop system produced the highest agronomic productivity of 1.36, an indication that the intercrop system was 36% more productive than the sole crop (Table 4).

Table 1: Effect of onion intercrop on okra leaf area, percent okra leaf damage by *Podagrica* spp. and available leaf area for light interception

Cropping system	Mean leaf area of okra plant^{-1} (m^2)	Mean percent (%) leaf defoliation plant^{-1}	Mean available leaf area plant^{-1} (m^2) for light interception
2 rows okra+1 row onion	0.1926	5.50	0.1820
3 rows okra+1 row onion	0.1728	15.00	0.1469
4 rows okra+1 row onion	0.1476	23.00	0.1137
Sole okra	0.2646	35.00	0.1719
LSD (5%)	0.0390	12.18	0.0240

Table 2: Effect of onion intercrop on yield and yield components of okra

Cropping system	Mean fruit length (cm)	Mean fruit weight (g)	Marketable fruit yield (t ha^{-1})	Non-marketable fruit yield (t ha^{-1})	Percent yield loss
2 rows okra+1 row onion	12.7	341.3	2.45	0.29	10.5
3 rows okra+1 row onion	12.4	224.7	2.32	0.28	10.8
4 rows okra+1 row onion	14.0	219.8	2.70	0.35	11.5
Sole okra	16.3	171.0	2.63	0.39	12.9
LSD (5%)	3.15	105.6	0.936	0.14	

Table 3: Effect of okra intercrop on onion bulb yield and bulb size

Treatment	Mean bulb yield (t ha^{-1})	Percent reduction in bulb yield (%)	Mean bulb size (cm)	Percent reduction in bulb size (%)
Onion in 2 okra+1	0.17	55.1	4.30	33.8
Onion in 3 okra+1	0.08	78.6	4.20	35.4
Onion in 4 okra+1	0.06	84.0	4.30	33.8
Sole onion	0.38	-	6.50	-
LSD (5%)	0.054		0.43	

Table 4: Agronomic productivity of the okra-based intercrop systems

Cropping system	Land equivalent ratio (LER)
2 rows okra+1 row onion	1.36
3 rows okra+1 row onion	1.07
4 rows okra+1 row onion	1.17

DISCUSSION

Pest damage on productivity of okra in intercropped systems: Intercropping with onion suppressed *Podagrica* spp. of okra irrespective of the system, corroborating earlier results (Broad, 2007; Theunissen, 1994) that intercropping field vegetables with other species or engaging in mixed cropping systems manifest in insect pest suppression. The suppression of the flea beetles (*Podagrica* spp.), in the present study is the first report of the onion repellent effects on *Podagrica* spp. on okra. Onion produces a pungent alliaceous compound, allyl-epropyl-disulphide, which might be responsible for the pest repellent attribute of the crop. Okra leaf damage caused by the flea beetle reduced the photosynthetic capacity of the leaves which was manifested in the light fruits weights obtained from the sole cropping plots that suffered more insect damage. Consequently, the high plant density advantage in the sole crop was eroded which resulted in the similar total marketable yield in this and the intercropped okra systems. The okra fruit yield loss was however higher in the sole crop, probably due to the activities of insect fruit borers, which may not have been present in the intercropped systems. In fact the percentage yield loss decreased as the population of onion in the okra-onion intercrop system increased, an indication of the effect of the repellent action of the onion on fruit borer insects that may have been present.

Intercropping cabbage with mustard also proved effective in controlling the major cabbage pest, *Plutella xylostella* (Srinivasan and Murthy, 1991). Altieri and Nicholls (1999) indicated that intercropping could be an effective approach to the control of insect pests through either the masking of host plants' odour by the production of highly odourous compounds by the second crop or the releases of deterrent chemical by the second crop which are supposed to repel insect pests. The lower pests' pressure on okra/onion systems resulted in reduced leaf damage by *Podagrica* spp. Similar observations were made on cowpea pests in a cowpea/green gram cropping systems (Munyuli *et al*., 2007). Intercropping of vegetables could therefore be seen as on option that fits well into the Non-Pesticide Management (NPM) of crops that is currently gaining popularity among vegetable growers in the world. Non-pesticide management of crops helps to keep crop cultivation costs to a minimum and avoid dependency on manufactured inputs by utilizing materials that are readily available to farmers, in this case, the adoption of vegetable intercropping systems.

Productivity of onion in intercropping systems: Competition among crops (for light, nutrients, space and water) is the main constraint in intercropping systems (Dhima *et al*., 2007).

In the present study, the bulb size and bulb yield were both reduced in the okra-onion intercropping systems. This corroborates the reports of Muoneke and Asiegbu (1997) and Manga *et al.* (2003) that most often there is reduction in growth and yield of some component crops in intercropping mixtures. In further explaining the yield advantage of the okra over the onion, Obasi (1989) and Orkwor *et al.* (1991) observed that height was the most important feature of plants that promoted their competitive ability for light. They concluded that a successful competitor for light is the component that has its foliage at a higher canopy layer. Furthermore, Palaniappan (1985) reported that in an intercropping situation, the taller component crop intercepted the major share of light such that the growth rates of the two crops would be proportional to the quantity of the photosynthetic active radiation they intercepted. In this present study, okra was taller than onion and therefore shaded the onion plants growing between the okra rows. Consequently, it was not surprising that the 2+1 intercrop system was found to be the most productive, being 36% more productive than the sole crop. Additionally, all the other intercrop systems were also more productive than the sole crop. In conclusion, a biologically efficient and productive okra system could be achieved with onion as intercrop in a plant arrangement of two rows of okra to one row of onion (2+1).

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