Research Journal of Agriculture and Forestry Sciences ISSN 2320-6063
Vol. **3(2),** 16-19, February **(2015)** *Res. J. Agriculture and Forestry Sci.*

Effect of different spatial arrangements on the growth and yield of Maize (*Zea mays* L.) and Groundnut (*Arachis hypogaea* L.) intercrop in the Sandy Regosol of Eastern region of Sri Lanka

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Available online at: www.isca.in, www.isca.me
Received 11th December 2014, revised 6th January 2015, accepted 3rd February 2015

Abstract

A study was carried out at the Crop Farm of the Eastern University, Sri Lanka to evaluate the effects of different spatial arrangements on the growth and yield of maize and groundnut in an intercropping system. Nine treatments were defined and experimental arrangement was randomized complete block design (RCBD) with four replicates. The results revealed that compared to monocropping of maize yield, T8 and T9 (paired row planting of maize with two rows of groundnut in between paired rows) provided 13% and 6% increased yield, respectively. Highest Land Equivalent Ratio was recorded in T8 (1.86) followed by T9 (1.81). Therefore, it could be concluded that 45/30 cm paired row planting of maize with two rows of groundnut in between paired rows, is the best spatial arrangement to maximize yield advantage of maize groundnut intercropping in the sandy regosol of Eastern region of Sri Lanka.

Keywords: Biomass, land equivalent ratio, leaf area, spatial arrangement.

Introduction

Intercropping is growing two or more crops at the same time on the same land area during the growing season[1]. It is a potential way of increasing total yield per unit area and time, especially for small holding farmers. The main concept of intercropping is to increase productivity and reliability of production. Furthermore, intercropping gives yield stability over monocropping[2] and ensures greater resource use efficiency[3]. In intercropping system, component crops use natural resources differently and utilization of natural resources are better than grown separately[4]. The main intercropping cropping systems are legumes/legumes, root and tuber crops/cereals and cereals/legumes [5].

Spatial arrangements of crops is another method of intercropping when two or more crops are planted in separate rows or alternating rows on the same piece of land. In spatial arrangements, component crops compete for resources such as light, water, carbon dioxide and nutrients[5]. Competition for resources is a main factor which can cause a significant impact on yield of crop mixtures compared to pure stands[6]. Increased yields have been recorded when competition between two species in intercropping have lower competition than within the same species[7].

Intercropping a non-legume with legume crop is a judicious practice, where nitrogen is the most limiting plant nutrient in most of the soils. The most obvious gain from intercropping legumes and non-legumes is the chance for nitrogen use complementarities[8]. Farmers in the dry zone of Sri Lanka show an interest in cultivating maize and groundnut. Maize is a popular coarse grain crop in Sri Lanka, grown in the second highest extent of land next to rice. Maize is used as a raw material in various industries and the demand is increasing continuously. Maize has demand in foreign countries too and hence there are possibilities to export maize from Sri Lanka. Groundnut is one of the major oilseed crops cultivated in Sri Lanka under family Leguminaceae. Groundnut, soya bean and cowpea are good nitrogen fixers and are able to fix up to 280 kg/ha[9]. Maize and groundnut intercropping would furnish several benefits to the farmers in the dry zone of Sri Lanka.
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However, the effects of different spatial arrangements of component crop on the growth and productivity of cereal/legume intercropping systems has not been adequately studied in the sandy regosol of Batticaloa district, Sri Lanka. Therefore, this experiment was carried out with the objectives of; to study the effect of different spatial arrangements on the growth and yield of maize and groundnut intercropping in sandy regosol of Batticaloa district and to find out suitable spatial arrangement for maize-groundnut intercropping system in the sandy regosol of Eastern region of Sri Lanka to increase crop productivity and profitability.

Material and Methods

This research was conducted at the Crop Farm, Eastern University, Sri Lanka during *Yala* 2014. The experimental arrangement was Randomized Complete Block Design (RCBD) with nine treatments and four replications. An experimental unit consisted of one plant. In this study, maize (cv. Pacific 984) and groundnut (cv. *Indi*) were used.

Treatments were defined as follows: T1- Maize as mono crop with the spacing of 60 cm × 30 cm (one plant per hill), T2- Maize as mono crop with the spacing of 60 cm × 60 cm (two plants per hill), T3- Groundnut as mono crop with the spacing of 45 cm × 15 cm (one plant per hill), T4 – Alternative planting of groundnut (60 cm × 15 cm) and maize (60 cm × 30 cm), T5 – Alternative planting of groundnut (60 cm × 15 cm) and maize (60 cm × 60 cm), T6 - 45/15 cm paired row planting of groundnut with one row of maize (60 cm × 30 cm) in between paired rows, T7 - 45/15 cm paired row planting of groundnut with one row of maize (60 cm × 60 cm) in between paired rows, T8- 45/30 cm paired row planting of maize (within row spacing 30 cm) with two rows of groundnut in between paired rows, T9- 45/30 cm paired row planting of maize (within row spacing 60 cm) with two rows of groundnut in between paired rows

Agronomic practices were followed in accordance with the recommendations of Department of Agriculture, Sri Lanka.

Destructive sampling method was practiced and samples were selected randomly for measurements. Leaf area and plant biomass were measured at monthly interval. Seed yield of maize and groundnut were measured at the harvest. Analysis of variance was performed using SAS software to determine the significant differences among treatments ($P < 0.05$). Land Equivalent Ratio (LER) was calculated using the following equation.

$$LER = \frac{\text{Yield of intercrop maize}}{\text{Yield of monocrop maize}} \quad \frac{\text{Yield of monocrop groundnut}}{\text{Yield of intercrop groundnut}}$$

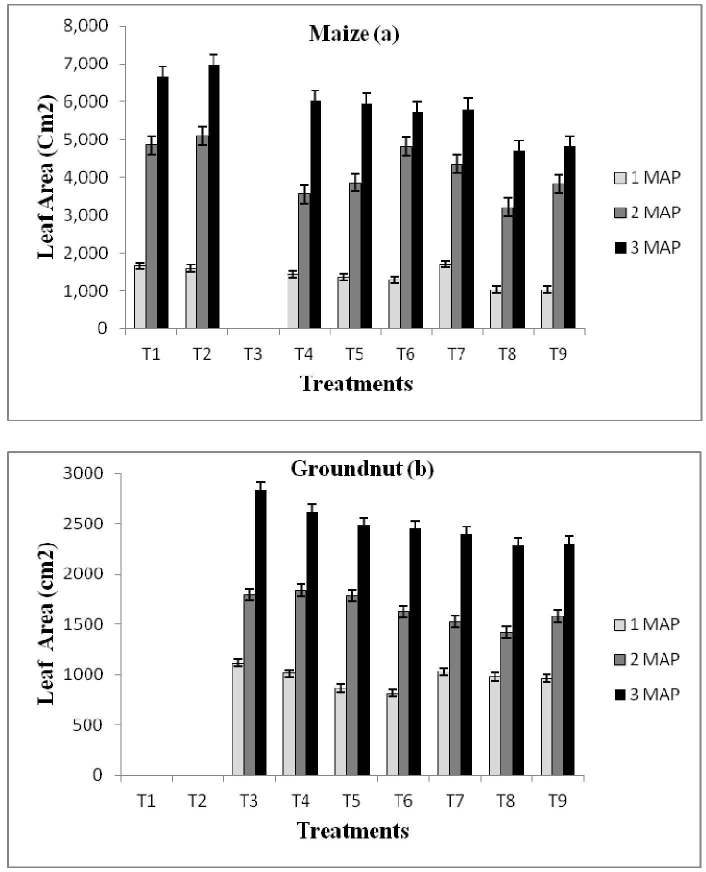

Figure-1
Effect of different spatial arrangements of maize (a) and groundnut (b) intercropping on leaf area per plant of maize and groundnut (n=3)

Results and discussion

Leaf area per plant: Leaf area per plant (LA) of maize and groundnut were significantly ($p<0.05$) influenced by different treatments (figure-1). Highest and lowest LA were measured in sole crop and intercropped treatments of maize and groundnut, respectively at 3 months after planting (MAP).

In this experiment, plant biomass decreased with increasing plant density in intercropping treatments**.** Reduced light availability and decreased LA would have limited the biomass production of maize and groundnut in intercropping. Growth of crops is related to the quantity of solar radiation received during the growth period[13].

Dry matter production decreases with the decrease of leaf area index[14]. Dry matter accumulation decreased due to decrease in number of leaves, leaf area index and acceleration of leaf senescence[15]. Hence, lower irradiation and LA would have caused reduction in photosynthesis and thereby reduced dry matter accumulation in the intercropping systems. Further, it could also be stated that, biomass production followed the pattern of LA development in sole as well as intercroped plants.

The results revealed that LA decreased with increasing plant density in intercropping treatments**.** It was reported that, increasing plant density decreased leaves per plant in both sole and intercropped cowpea[10]. Light availability has a great effect on leaf area. It was found that, 30% of shade has a significant effect on LA of tomato[11]. Reduced light availability in the higher plant densities would have decreased the LA of maize and groundnut under the intercropping system. Plants tend to grow taller and to have lower leaf areas if the light infiltration into the canopy is lower [12]. This might be the reason for the lowest LA measured in the treatments of intercropping.

Plant biomass: Significant ($p<0.05$) differences were observed between different treatments in plant biomass (figure-2). Highest and lowest plant biomass was measured in sole crop and intercropped treatments of maize and groundnut, respectively at 3 MAP.

Yield: Intercropping significantly ($p<0.05$) influenced the yield of maize and groundnut (figure-3). The highest yield of intercropped maize and groundnut were recorded in T8 and T9.

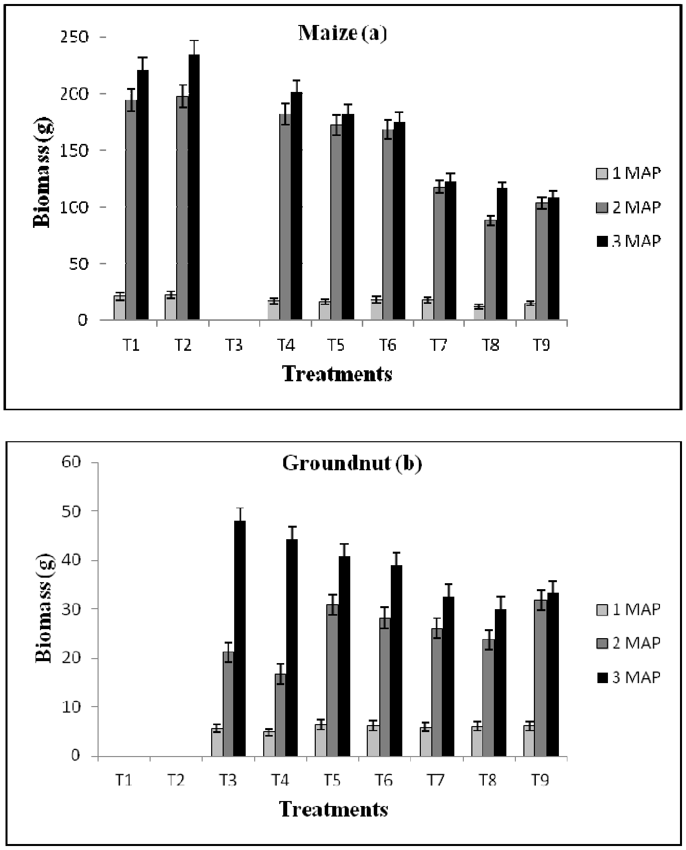

Figure-2
Effect of different spatial arrangements of maize (a) and groundnut (b) intercropping on plant biomass (n=3)

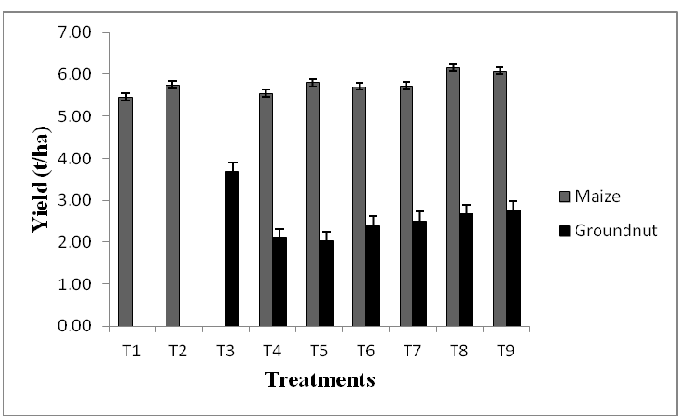

Figure-3
Effect of different spatial arrangements of maize and groundnut intercropping on the yield of maize and groundnut (n=10)

Intercropping significantly reduced the yield of groundnut. Yield of groundnut was lower when intercropped with brinjal[16]. Similar trend was observed in this experiment where ground nut was intercropped with maize. This may be due to shading effect of the maize and subsequent interruption in the photosynthesis process. It was pointed out that intercropping groundnut with cereals reduced nodulation and nitrogen fixation due to shading of groundnut by the cereals and the resulting decrease in photosynthesis[17]. However there was an increase in the seed yield of groundnut with increasing plant density in intercropping treatments.

There were no significant differences in the yield of sole and intercropped maize. It was observed that an increase in grain yield with increasing plant population density. When compared to the recommended level of plant population (55,555 plants ha^{-1}) in sole cropped maize (T1 and T2), a 13% (one plant/hill) and 6% (two plants/hill) yield increases were recorded under 88,888 plants ha^{-1} (T8 and T9) intercropped maize. It was reported that it is economical to increase maize plant population up to 88,888 plants ha^{-1} when hybrid maize is grown for grains[12]. It was found that grain yield of maize increased as number of cobs were higher in increased plant density[18].

Increased yield of maize would also have been resulted due to the nitrogen fixing ability of groundnut. Nitrogen fixed by the groundnut would have contributed for the increased yield of intercropped maize over sole cropping. It was in agreement where brinjal yield increased when intercropped with French bean[19]. Legume intercrops increase the yield of maize by increasing NO_3 and NH_4 concentrations and populations of beneficial active bacteria in the maize rhizosphere[20]. These may be the reasons for the increased yield of maize in intercropped treatments of T8 and T9.

Land Equivalent ratio (LER): The **v**alues of LERs expressed better land use in all intercrop treatments (table-1). The Highest (86%) and lowest (56%) yield advantages were obtained in T8 and T5 respectively.

Table-1
Land equivalent ratio in intercropping treatments

Treatments	LER
T4	1.59
T5	1.56
T6	1.70
T7	1.68
T8	1.86
T9	1.81

Land was effectively utilized and yield was improved in intercropping systems[21]. In this experiment all the intercropped treatments were advantageous as the LER was above 1.5. Leguminous crops improves yield of component crops in intercropping[22]. It was reported that, higher LER can be obtained in Groundnut maize intercropping[23]. Therefore, 45/30 cm paired row planting of maize with two rows of groundnut in between paired rows is the best spatial arrangement as it maximized the yield advantage of maize groundnut intercropping.

Conclusion

This study revealed that intercropping maize and groundnut may increase or decrease yields of maize and groundnut, depending on the spatial arrangements of the intercrops. However, growing maize and groundnut in intercrop increases total yield and land use efficiency. From the findings it was observed that, treatments T8 and T9 had a well-balanced yield compensation for both maize and groundnut, which provide reasonably good yields for both crop and expressed the best land use efficiency. Therefore 45/30 cm paired row planting of maize with two rows of groundnut in between paired rows is the best spatial arrangement to maximize the yield advantage of maize groundnut intercropping system in the sandy regosol of Eastern region of Sri Lanka.

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