EFFECT OF PAIRED ROW PLANTING OF RADISH (*Raphanus sativus* L.) INTERCROPPED WITH VEGETABLE AMARANTHUS (*Amaranthus tricolor* L.) ON YIELD COMPONENTS OF RADISH IN SANDY REGOSOL

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ABSTRACT

This study was aimed to evaluate the effect of paired row planting of radish (Raphanus sativus L.) intercropped with vegetable amaranthus (Amaranthus tricolor L.) on yield components of radish in sandy regosol at Agronomy farm, Eastern University, Sri Lanka in Yala 2007. This experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicates and six treatments. Base crop (T1) and intercrop (T2) were grown in pure stands and other treatments were 20/50 cm paired row planting of radish with three (T3) or four (T4) rows of vegetable amaranthus in between paired rows of radish and 25/40 cm paired row planting of radish with three (T5) or two (T6) rows of vegetable amaranthus in between paired rows of radish. Growth parameters were recorded at regular intervals. The results showed that land equivalent ratio was superior in all tested intercropping treatments. In T3, radish yield was high (37.8 tons/ha) and most of the yield components exhibited high average values as compared with other intercropping treatments. The present study revealed that 20/50 cm paired row planting of radish with three rows of vegetable amaranthus in between paired rows of radish (T3) would be the most suitable planting system in sandy regosol.

Key words: *Base crop, inter crop, land equivalent ratio, paired row planting, yield.*

INTRODUCTION

Intercropping is an agricultural practice of cultivating two or more crops in the same land area at the same time. In intercropping, there is often one main crop intercropped with one or more added crops where the main crop is of primary importance because of economic or food production reasons. Intercropping leads to be effective utilization of sun light, nutrient and water, as well as, minimizing risk of pests and diseases. Intercropping can increase light interception by as much as 30-40% (Chatterjee *et al*, 1993). By intercropping, dependence on one crop is avoided and also different varieties of products can be produced throughout the year.

The technique of paired row planting in intercropping system is one way of accommodating the whole population of the base crop and creating interspaces wide enough to accommodate one or two rows of intercrop. Therefore, two adjustion-rows of the base crops are paired to reduce the inter row space to create some space between pairs of base crop rows but wide enough to minimize undue competition among plants of the base crop (Sivaraman and Palaniappan, 1996). Several experiments conducted all over India clearly showed that paired row planting of sorghum gave similar yield as normal spaced planting (Palaniappan *et al*., 1975). Development of a feasible and economically viable intercropping system largely depends on the adaptation of planting pattern and selection of compatible crops. The choice of compatible crops for an intercropping

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system can vary depending on growth habit, land, solar radiation, water and fertilizer utilization.

Raphanus sativus (Radish) is an edible root vegetable consumed throughout the world. Radish is a popular choice for cultivation, as they are fairly easy to grow and is a rapidly maturing crop with many varieties, and reach maturity within 60 days. The most popular eating part of radish is the tuberous root (swollen portion of root) although the entire plant is edible and the tops can be used as a leafy vegetable. Radish is useful in the treatment of liver, gall bladder troubles, sleepleness, chronic diaria, neuralgic headaches, urinary complaints, piles and gastrodynia (Sadhu, 1993).

In intercropping, yield advantages occur because component crops differ in their use of resource so that in combination, they are able to complement each other and obtain better overall use of resources than grown separately. Radish and leafy vegetable are compatible crops for fertilizer management. Radish needs higher amounts of potassium for tuberous root formation. On the other hand, nitrogen is vital for leafy vegetable production. Intercropping radish with vegetable amaranthus makes efficient use of fertilizer, and the vegetable amaranthus can be harvested 25 days after sowing, while radish can be harvested 45 – 60 days after sowing, leading to the reduction of competition for resources at peak production. Complementarity occurs when the growth pattern of the component crop differs in time, so that the crops make their major demands on resource at different times. This type of complementarity is termed as temporal (Trenbath, 1974). Therefore, radish and vegetable amaranthus are compatible crops for intercropping. Radish could be grown in polyculture with lettuce, cauliflower, carrot, potato, leeks, cabbage and coriander. In Sri Lanka, intercropping radish with leafy vegetable has been worked out by many researches. However, there is no evidence on radish and vegetable amaranthus intercropping. Therefore this attempt was aimed to study the effect of paired row planting of radish intercropped with vegetable amaranthus on yield components of radish and also select a suitable cropping system in the sandy regosol of Sri Lanka.

MATERIALS AND METHODS

A field study was conducted at the Agronomy farm, Eastern University, Sri Lanka to evaluate the effect of paired row planting of radish intercropped with vegetable amaranths on yield components of radish in sandy regosol in Yala 2007. This area belongs to the agro ecological region of low country dry zone in Sri Lanka where the temperature ranges from 28 °C to 32 °C and the annual rainfall is about 1600 mm. The soil at the experimental area is sandy regosol. Vegetable amaranthus seeds (*Amaranthus tricolor*, red variety) and radish seeds (Japanese ball variety) were used in this study. This experiment layout was a Randomized Complete Block Design with four replicates and six treatments as follows:

T1: Radish as a sole crop with the spacing of 30 cm × 10 cm (Figure 1).

T2: Vegetable amaranthus as a sole crop with the spacing of 10 cm × 5 cm (Figure 2).

T3: 20/50 cm paired row planting of radish and three rows of vegetable amaranthus in between paired rows of radish (Figure 3).

T4: 20/50 cm paired row planting of radish and four rows of vegetable amaranthus in between paired rows of radish (Figure 4).

T5: 25/40 cm paired row planting of radish and three rows of vegetable amaranthus in between paired rows of radish (Figure 5).

T6: 25/40 cm paired row planting of radish and two rows of vegetable amaranthus in between paired rows of radish (Figure 6).

Monocropping

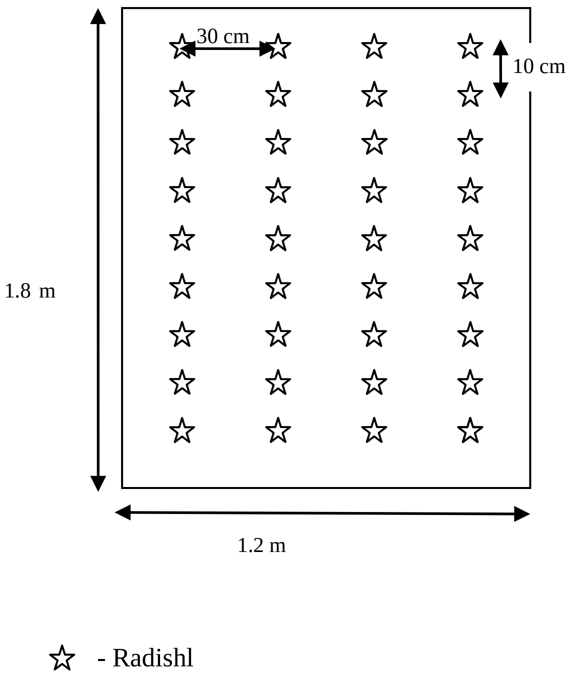


Figure 01: Radish as a sole crop with the spacing of 30 cm × 10 cm

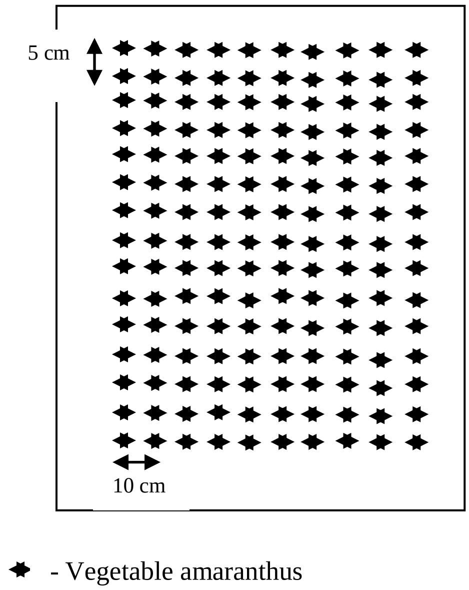
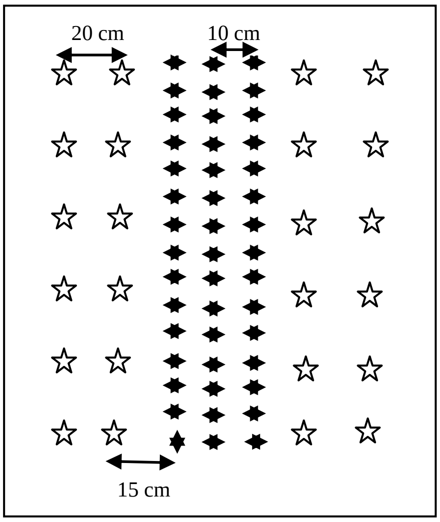


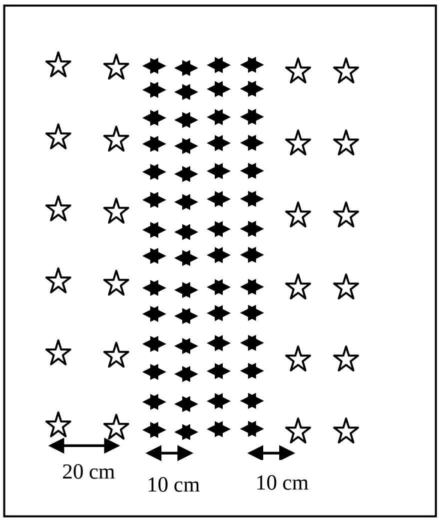
Figure 02: Vegetable amaranthus as a sole crop with the spacing of 10 cm × 5 cm

Intercropping



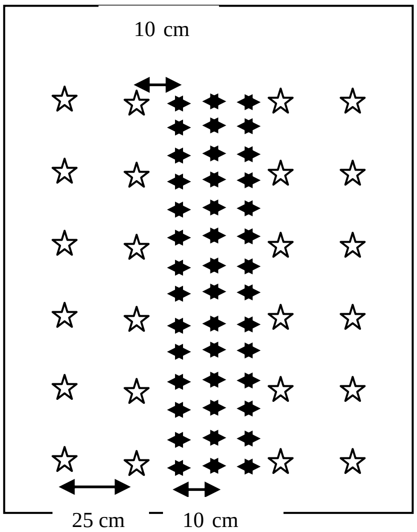
☆ - Radish ✱ - Vegetable amaranthus

Figure 03: 20/50 cm paired row planting of radish and three rows of vegetable amaranthus in between paired rows of radish



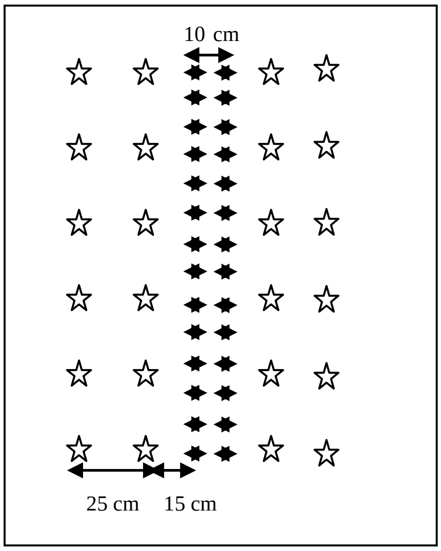
☆ - Radish ✱ - Vegetable amaranthus

Figure 04: 20/50 cm paired row planting of radish and four rows of vegetable amaranthus in between paired rows of radish



☆ - Radish ✱ - Vegetable amaranthus

Figure 05: 25/40 cm paired row planting of radish and three rows of vegetable amaranthus in between paired rows of radish



☆ -Radish ✱ - Vegetable amaranthus

Figure 06: 25/40 cm paired row planting of radish and two rows of vegetable amaranthus in between paired rows of radish

The size of each plot was 1.2 m × 1.8 m, and all treatments had four replicates. The total number of plots was twenty four. A spacing of 0.5 m separated the plots and the blocks were separated with a space of 1 m.

Prior to sowing, germination test was carried out and the germination percentages of radish and vegetable amaranthus seed stocks were 85% and 89% respectively. During land preparation, considerable amount of cattle manure was added. After land preparation, furrows were made to the depths of 0.5 cm-1 cm and radish seeds were sown in rows. After five days of sowing, they were thinned out at 10 cm spacings within the plants and one plant per hill maintained. Five days after sowing of radish furrows (1 cm) were made according to field plan and seeds of vegetable amaranthus were sown in rows and covered with soil. After one week they were thinned out at 5 cm spacing to allow one plant per hill. Agronomic practices were done as recommended by the Department of Agriculture, Sri Lanka (2006). Leaf area was measured at two weeks intervals by a portable leaf area meter **(**Li – Cor, LA 3000A**)** and at harvest, tuberous root diameter and length of tuberous root and total root, fresh and dry weight of leaf and tuberous root were taken in radish. While taking data, border plants were avoided to reduce the border effects. Collected data were analyzed by the SAS program. The means were compared using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Leaf area index

Leaf area index of a canopy is important for predicting crop growth and yields (Xinyou *et al*, 2003). A reasonable leaf area index (LAI) is critical to maintain high photosynthetic rates and the yield (Xiaolei and Zhifeng, 2002). LAI allows for optimum photosynthesis of the plant as a whole. If index is too low, not enough light will be absorbed. If too high, lower leaves will not receive enough light and will thus be a liability (Frank and Cleon, 1992). In the present study, the average leaf area index of radish planted as base crop ranged from 0.11 to 0.22 at 2nd week after sowing and the LAI of radish significantly varied ($P<0.05$) among the treatments (Table 1). The difference in leaf area among the treatments may be due to the spacing between rows, light interception and other complementary effects. All the intercropping treatments had higher leaf area index when compared with monocropping. Leaf area index at the 8th week was significantly different ($P<0.01$) among treatments. In monocropping, leaf area index was lower (4.61) compared to that in intercropping at 8th week. Leaf area index varies between 1 and 8 according to species and the habitat of the plant (Fogg, 1976). In this experiment LAI of radish in all treatments attained a range of 1 to 8 except T4. T4 had a higher (9.03) LAI, it may due to the higher density of vegetable amaranthus, leading to produce more radish leaves per unit land to compete with vegetable amaranthus for seeking more interception of solar radiation. Productivity rates increased with LAI because of increased total light interception, but larger LAI values often cause no more increases and then decreases on a ground area basis, probably because of respiratory CO_2 loss from heavily shaded leaves and stems (Frank and Cleon, 1992).

Table 01: Leaf area index of radish at two week intervals.

Treatments	Leaf area index			
	At 2nd week	At 4th week	At 6th week	At 8th week
T1	0.11 ± 0.01 d	1.81 ± 0.02 d	3.19 ± 0.03 d	4.61 ± 0.04 e
T3	0.22 ± 0.01 a	3.62 ± 0.02 a	6.08 ± 0.22 a	7.91 ± 0.06 c
T4	0.19 ± 0.01 b	3.12 ± 0.01 b	5.42 ± 0.01 b	9.03 ± 0.04 a
T5	0.19 ± 0.01 b	3.13 ± 0.01 b	5.22 ± 0.17 b	7.89 ± 0.06 b
T6	0.17 ± 0.01 c	2.74 ± 0.02 c	4.71 ± 0.01 c	6.82 ± 0.03 d
F test	*	*	*	**

Value represents mean ± standard error of three replicates.

F test: - ** : P<0.01; *: P<0.05

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5 % level.

Root formation

As reported by Panwar *et al.* (2003) yield correlated with root length and tuber diameter of radish. In this experiment, diameter of radish tuberous root significantly varied (P<0.05) among the treatments (Table 2). Average tuberous root diameter of radish intercropped with vegetable amaranthus ranged from 5.89 cm (T3) to 6.17 cm (T4) at harvest. Radish in monoculture (T1) had significantly higher level of tuberous root diameter (6.34 cm) than that in intercropping, except T4. However, tuberous root length of radish was not significantly different (P > 0.05) among the planting systems. Hence it could be suggested that tuberous root length of plant was not influenced by the planting pattern. Further, it was observed that total root length significantly varied (P<0.05) among the treatments (Table 2). The average total root length of radish ranged from 17.74 cm (T5) to 18.56 cm (T6) at harvest. T1 did not significantly differ (P>0.05) from other treatments. Low density of the intercrop (vegetable amaranthus) between paired rows of radish may allow radish roots to penetrate deeply. It may be the reason for longer roots in T6 followed by those in T3. Theoretically longer roots are advantageous to extract water and nutrients in the soil at greater depths and would be useful for tolerance to drought. As reported by Singh *et al.* (1978), the paired row system of planting of pearlmillet proved to be more efficient for the utilization of moisture from deeper layers of the soil profile than the conventional system, besides exhibiting higher moisture use efficiency. Table 2 results suggest that when root length increases, area for food storage is increased longitudinally and it may lead to reduce the diameter of tuberous root by store food throughout the length.

Fresh weight of plant

The result exhibited that there was no significant reduction (P>0.05) in tuberous root yield or plant weight of radish when intercropped with vegetable amaranthus relative to monoculture (Table 3). Keeping the plant population of base crop constant may be the reason for no deviation in its yield compared with monocropping. This is supported by similar yields obtained from potato seed tubers (Ranalli *et.al.*, 1994) and sorghum when planted intercropping combination (Palaniappan *et.al.*, 1975). Fresh weight of radish leaves was significantly different (P<0.05) among treatments (Table 3). Average leaf weight ranged from 45 g in T4 to 55 g in T6.

Fresh weight of leaves was high in T6, where intercrop density is lower when compared with other treatments. This might be explained as lower competition for resources when the density of intercrop is lower, leading to produce more leaf weight of radish (base crop). The opposite situation exists in T4 has formed a lower leaf fresh weight. In all treatments, leaf fresh weight was lower than the tuberous root weight. It may suggest that all planting systems were good in terms of the balance between fresh weight of leaf and tuber.

Table 02: Root formation of radish at harvest.

Treatments	Tuberous root diameter (cm)	Tuberous root length(cm)	Total root length (cm)
T1	6.34 ± 0.12 [a]	7.59 ± 0.18	17.96 ± 0.30 [ab]
T3	5.89 ± 0.11 [c]	7.31 ± 0.10	18.49 ± 0.15 [a]
T4	6.17 ± 0.08 [ab]	7.27 ± 0.25	18.08 ± 0.16 [ab]
T5	6.01 ± 0.02 [bc]	7.39 ± 0.04	17.74 ± 0.25 [b]
T6	6.02 ± 0.05 [bc]	7.32 ± 0.12	18.56 ± 0.06 [a]
F test	*	ns	*

Value represents mean ± standard error of three replicates.

F test: - *: P<0.05; ns: not significant

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5 % level.

Table 03: Fresh weight of radish at harvest.

Treatments	Plant weight (g)	Tuberous root weight (g)	Leaf weight (g)
T1	132.5 ± 4.79	82.5 ± 4.79	50.0 ± 0.01 [ab]
T3	127.5 ± 4.79	77.5 ± 4.79	50.0 ± 0.01 [ab]
T4	117.5 ± 4.79	72.5 ± 4.79	45.0 ± 2.89 [b]
T5	120.0 ± 4.08	70.0 ± 4.08	50.0 ± 0.01 [ab]
T6	125.0 ± 6.45	70.0 ± 4.08	55.0 ± 2.89 [a]
F test	ns	ns	*

Value represents mean ± standard error of three replicates.

F test: - *: P<0.05; ns: not significant

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5 % level.

Dry weight of plant

In the tuberous root and leaf dry weights, there were not significantly different (P>0.05) among treatments. This may be attributed by the favorable plant architecture of radish to intercept sufficient light for uniform dry matter production in all the treatments. The efficiency of agricultural production depends on the utilization of sunshine for photosynthesis by crop plants. Dry matter production is at an optimum when nearly all the solar radiation is intercepted (Chatterjee *et al*., 1993). Mandal (1993) reported that dry matter is accumulated more in leaves during the first 3 to 4 months of growth and afterwards accumulated more in the tuberous root crops of cassava. In the present study, dry weight of tuberous root was comparatively higher than that of leaf in each treatment (Figure 7). Hence, dry matter accumulated in radish leaves in all treatments appeared to be efficiently transformed to tuberous roots.

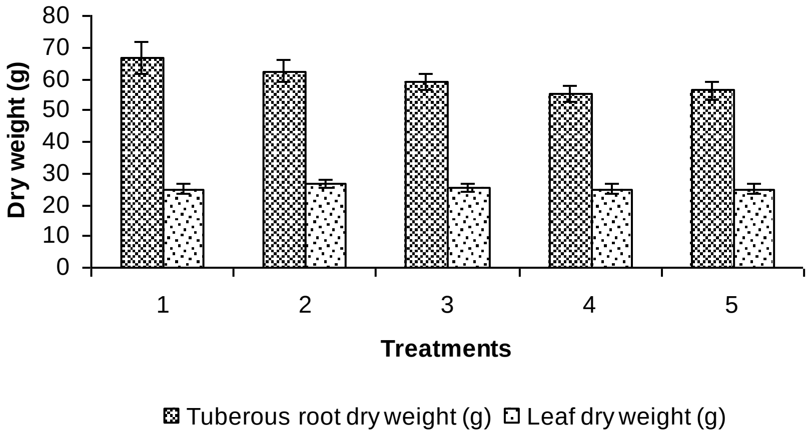


Figure 07: Dry weight of tuberous root and leaf of radish at harvest

Yield of radish and vegetable amaranthus

There was no significant effect on radish yield by planting patterns (Table 4). Radish yield (39.3 tons/ha) was high in monocropping as compared that of intercropping. Average yield ranged from 34.8 to 39.3 (tons/ha). This yield data suggests that paired row planting did not affect the yield of radish. It may be due to constant plant density in all tested treatments. In case of vegetable amaranthus, there was significant difference ($P<0.01$) among treatments and the average ranged from 24.3 to 46.0 (tons/ha) in intercropping. The highest was in T4 while lowest in T6. It varies according to the plant density of vegetable amaranthus. Land equivalent ratio (LER) is an index of intercropping advantage. LER greater than 1.0 usually shows that intercropping is advantageous and less than 1.0 shows a disadvantage. In this experiment LER performed well in all intercropping combinations.

Table 04: Yield (tons/ha) of radish and vegetable amaranthus.

Treatments	Radish yield	Vegetable amaranthus
T1	39.3 ± 1.42	-
T2	-	107.8 ± 1.34 [a]
T3	37.8 ± 1.42	38.0 ± 0.40 [c]
T4	34.8 ± 1.42	46.0 ± 0.67 [b]
T5	35.6 ± 1.21	30.5 ± 1.19 [d]
T6	37.0 ± 1.91	24.3 ± 0.56 [e]
F test	ns	**

Value represents mean ± standard error of three replicates.

F test:-**: $P<0.01$; ns: not significant

Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5 % level.

CONCLUSION

The present study concluded that by reduced inter row spacing of radish, the radish yield did not change significantly. The yield of radish was slightly high (39.3 tons/ha) in T1 followed by T3 (37.8 tons/ha). A low radish yield (34.8 tons/ha) was obtained in T4 compared with other treatments. It may be due to resource depletion. Leaf area index was within the optimum range (1 - 8) in T3, T5 and T6. It indicated that intercropped vegetable amaranthus influences leaf area index of radish. In T4, leaf area index of radish (9.03) exceeds the optimum range created by dense arrangement of vegetable amaranthus (4 rows) between 20/50 cm paired rows of radish. A further 2-3 row of vegetable amaranthus between paired rows of radish would be suitable to allow high photosynthesis of radish. Land equivalent ratio was high in all intercropping treatments. In T3, base crop yield was high (37.8 tons/ha) and also most of the yield components were good as compared with other intercropping treatments. In the present study, 20/50 cm paired row planting of radish intercropped with three rows vegetable amaranthus in between paired rows of radish would be the most suitable planting system in sandy regosol.

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