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# Performance of carrot as intercrop in multistrata sissoo woodlot

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**Abstract**: The experiment was conducted at the existing multistrata sissoo woodlot of the Horticulture Farm, Bangladesh Agricultural University, Mymensingh, to investigate the performance of carrot as intercrop in sissoo based multistrata Agroforestry system (MAF) and also to observe the effect of different spacing of upper and middle layer trees on carrot yield during the period of October 2005 to March 2007. The experiment was laid out in randomized complete block design with three replications. There were seven treatments in this experiment viz. $T_1$= sissoo (spacing 4m x 4m) + guava (spacing 2m x 2m) + carrot; $T_2$= sissoo ( spacing 4m x 4m) + lemon (spacing 2m x 2m) + carrot; $T_3$= sissoo (spacing 5m x 5m) + guava (spacing 2.5m x 2.5m) + carrot; $T_4$= sissoo (spacing 5m x 5m) + lemon (spacing 2.5m x 2.5m) + carrot; $T_5$= sissoo (spacing 6m x 6m ) + guava ( 3m x 3m )+ carrot; $T_6$= sissoo (spacing 6m x 6m) + lemon (spacing 3m x 3m ) + carrot and $T_7$= sole cropping of carrot. From the treatments $T_1$ to $T_6$ were three layered woodlot consisted of sissoo at the top layer, guava and lemon at the middle layer; and carrot was at the ground layer and $T_7$ were in open condition. In the open condition $T_7$ received 100% sunlight; while sissoo+ guava based Agroforestry system ($T_1$, $T_3$ and $T_5$) and sissoo +lemon based Agroforestry system ($T_2$, $T_4$ and $T_6$) allowed, respectively 33 to 54% and 45 to 69% sunlight for the growth of carrot. The Experimental results revealed that multistrata agroforestry systems with different tree spacing were found to significantly influence on the root yield of carrot. The highest carrot root yield (29.87 t/ha in 2005 and 29.24 t/ha in 2006) was recorded under sole cropping, which was followed by the wider and intermediate spacing of sissoo+lemon based MAF. The reduction in yield of carrot compared to sole cropping was more at closer spacing of multistrata agroforestry systems. Significantly, the lowest yield (17.84 t/ha in 2005 and 18.65 t/ha in 2006) was recorded in narrower spacing of sissoo+guava based MAF. This yield reduction was 40.27 % in 2005 and 36.22 % in 2006 over the sole cropping. But, it was found that the highest benefit-cost ratio of 4.74 was recorded from intermediate spacing of sissoo+guava based MAF followed by $T_4$, $T_5$, $T_1$, $T_2$ and $T_6$ treatments. The lowest benefit-cost ratio of 3.48 was observed in sole cropping of carrot.
**Key words**: Multistrata, sissoo, lemon, guava, carrot, agroforestry system, woodlot

## Introduction

The existing land use systems of Bangladesh with separate allocation to agriculture and forest are insufficient to meet the demands for food, fuel, fodder, timber and other minor products in the 21st century. One should follow effective and compatible cultivation approaches where fruits, vegetables, spices, medicinal plants and timber can be grown combined in the limited land. In this link, the multistrata agroforestry system may be the best substitute cultivation approach. By practicing this cultivation arrangement, one can efficiently amplify the production of fruits, vegetables, spices, medicinal plants and timber vertically. Consequently, multistrata agroforestry is considered a panacea for overcoming most of the problems related to the alleviation of poverty, socio-economic instability and lessening ill effects of the global warming. The increasing demand and high prices of wood (fuel, timber, pulp) unlike the agriculture crops is a foremost reason for farmers to plant more trees in association with cereals, pulses, vegetables and spices. Peasants of this republic integrate fast growing trees on there farmland in close alliance with agricultural crops. The potential benefits of growing trees in blend with annual and perennial crops are to uphold and sustain soil productivity and fertility (Nair, 1984; Singh *et al*., 1989; Chauhan *et al.*, 1997). But there is practically no information available on the probability of growing vegetables like carrot in a multistrata sissoo woodlot. So, much research efforts are needed in this field to identify suitable vegetables to be integrated with sissoo tree species to develop potential, diversified and profitable multistrata agroforestry system. Therefore, keeping this view in mind the study has been conducted to evaluate the performance of carrot under sissoo based multistrata agroforestry systems.

## Materials and Methods

The experiment was conducted in the existing multistrata sissoo woodlot of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh throughout the growing seasons of 2005-2007. Geographically it is located about $22.03^0$ North latitudes and $90.26^0$ East longitudes. The experimental area is under sub-tropical climate characterized by heavy rainfall during the months from April to September and scanty rainfall during the rest period of the year. The soil of the experimental area is silty loam in texture. It is a medium high land and fertile well drained. The experiment was conducted a single factor Randomized Complete Block Design (RCBD) with three replication for each treatment. There were seven treatments in this experiment viz. $T_1$= sissoo (spacing 4m x 4m ) + guava (spacing 2m x 2m) + carrot; $T_2$= sissoo (spacing 4m x 4m) + lemon (spacing 2m x 2m) + carrot; $T_3$= sissoo (spacing 5m x 5m) + guava (spacing 2.5m x 2.5m) + carrot; $T_4$= sissoo (spacing 5m x 5m) + lemon (spacing 2.5m x 2.5m) + carrot; $T_5$= = sissoo ( spacing 6m x 6m ) + guava ( 3m x 3m )+ carrot; $T_6$= sissoo (spacing 6m x 6m) + lemon ( spacing 3m x 3m ) + carrot and $T_7$= sole cropping of carrot. From the treatments $T_1$ to $T_6$ were three layered woodlot consisted of sissoo at the top layer, guava and lemon at the middle layer; and carrot was at the ground layer and $T_7$ was in open condition. In the open condition $T_7$ received 100% sunlight; while sissoo + guava based Agroforestry system ($T_1$, $T_3$ and $T_5$) and sissoo + lemon based Agroforestry system ($T_2$, $T_4$ and $T_6$) allowed, respectively 33 to 54% and 45 to 69% sunlight for the growth of carrot. The upper layer sissoo tree was planted eight years ago i.e. July 1997. As the middle layer plant, guava and lemon both were five years old and were in full bearing condition. Standard pruning techniques for sissoo, guava and lemon tree were followed and the pruned materials were not added into the

plot. Sissoo, guava and lemon tree were not dressed with fertilizer. But as the ground layer crop carrot was fertilized with recommended doses of fertilizers and the doses for carrot was 4 ton-120 kg-25kg-90kg kg as cowdung, N, P and K per hectare, respectively (BARC, 1999). Carrot seeds cultivar NK (New Kuroda) was sown in lines continuously 25 cm apart. After emergence, carrot plants were thinned out by maintaining 10cm distance from plant to plant. The carrot seeds were sown on 19 November 2005 and 20 November 2006.The experimental plots were kept weeds free by weeding frequently. The plots were irrigated whenever needed by using hose pipe and watering cane. Carrot harvesting was started at 90 days after planting and continued up to 125 days. Economics of various treatments was calculated taking into account the current costs of inputs and produce. The data on various growth and yield performance characters of the carrot was statistically analyzed to examine the significant variation of the results due to different shading condition as well as different tree-crop associations. The mean differences were evaluated by Least Significant Difference (LSD) test (Freed, 1992).

## Results and Discussion

**Growth and yield contributing characters of carrot as influenced by the multistrata sissoo woodlot:** The differences of plant height of carrot due to the influence of sissoo based multistrata agroforestry systems (MAF) were noteworthy in both the seasons. The tallest plant (68.96 cm in 2005 and 70.08 cm in 2006) was experienced in narrower spacing of the sissoo + guava alliance ($T_1$). The corresponding figures for wider spacing of sissoo + guava ($T_3$ and $T_5$) were 65.34 and 64.63 cm in 2005 but 66.92 and 63.71 cm in 2006, in that order. The intermediate plant height (64.10 in 2005 while 68.04 cm in 2006) was measured in the narrower spacing of sissoo + lemon based MAF ($T_3$). The corresponding values for wider spacing of sissoo + lemon based MAF ($T_4$ and T6) were 62.20 and 58.55 cm in 2005 and 64.52 and 62.65 cm in 2006, respectively. On the other hand, the dwarf plant (51.62 in 2005 and 53.69 cm in 2006) was recorded in the open conditions. Numbers of leaves per plant of carrot were also significantly disposed by the diverse agroforestry systems. The maximum number of leaves (13.42 in 2005 and 14.63 in 2006) was found in wider spacing of sissoo+lemon based MAF ($T_6$) followed by intermediate spacing of sissoo+lemon based MAF ($T_4$). Significantly, the lowest number of leaves (7.24 in 2005 and 7.84 in 2006) were found in narrower spacing of sissoo+guava based MAF ($T_1$). Similar testimonies were also cited by Ali (1999) and Wadud (1999). Leaf length of carrot was increased gradually with the increase of shade level i.e. in the narrower spacing of MAF. This might be attributed due to the situation of cellular expansion and cell division of leaves under shaded condition (Schoch, 1972). Root length of carrot per plant differed significantly under different treatments. It is clear from the Table 1 and Table 2 that the longest root (17.24 cm in 2005 and 18.73cm in 2006) was recorded in open conditions ($T_7$). The reduction of the root length was observed in carrot comparatively more at closer spacing than that at wider spacing of MAF. Among the MAF, sissoo+guava based MAF produced shorter carrot root than that of from sissoo+lemon based MAF.

**Table 1.** Growth and yield of carrot as influenced by the sissoo based multistrata agroforestry systems during November 2005 to February 2006

| Treatments | Plant height (cm) | No. of leaves /plant | Length of leaves (cm) | Length of root (cm) | Diameter of root (cm) | Fresh wt. of root (g) | Dry wt. of root (g) | Yield (t/ha) |
|---|---|---|---|---|---|---|---|---|
| $S_1$+$G_1$+Carrot ($T_1$) | 68.96 | 7.24 | 56.78 | 12.90 | 2.69 | 56.14 | 7.39 | 17.84 |
| $S_1$+$L_1$+Carrot ($T_2$) | 64.10 | 11.60 | 49.70 | 14.38 | 3.20 | 70.87 | 10.23 | 22.35 |
| $S_2$+$G_2$+Carrot ($T_3$) | 65.34 | 7.84 | 51.32 | 13.77 | 2.92 | 68.91 | 9.58 | 19.24 |
| $S_2$+$L_2$+Carrot ($T_4$) | 62.20 | 12.17 | 42.63 | 15.84 | 3.39 | 86.53 | 12.70 | 24.71 |
| $S_3$+$G_3$+Carrot ($T_5$) | 64.63 | 10.93 | 45.18 | 15.59 | 3.32 | 78.54 | 11.04 | 24.16 |
| $S_3$+$L_3$+Carrot ($T_6$) | 58.55 | 13.42 | 38.90 | 16.81 | 3.70 | 83.65 | 12.59 | 26.13 |
| Open ($T_7$) | 51.62 | 11.07 | 36.80 | 17.24 | 4.10 | 104.21 | 15.91 | 29.87 |
| Lsd $_{0.01}$ | 19.18 | 2.58 | 17.16 | 3.97 | 1.05 | 21.90 | 2.73 | 5.26 |
| Level of signi. | ** | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 13.28 | 9.74 | 14.99 | 10.45 | 12.67 | 11.20 | 9.65 | 8.99 |

** Significant at 0.01 level

Careful study of data reveals a noteworthy effect caused by the multistrata agroforestry system on the root diameter of carrot. The maximum root diameter (4.10 cm in 2005 and 4.30 cm in 2006) was observed in sole cropping, which were followed by that in wider spacing of sissoo+lemon based MAF ($T_6$). With the decrease in spacing of sisoo+guava based MAF, the corresponding figures of root diameter had decreased. The minimum root diameter (2.69cm in 2005 and 3.19cm in 2006) of carrot was observed in plants grown under narrower spacing of sisoo+guava based MAF ($T_1$) in both the seasons. Individual fresh root weight of carrot was also decreased as the light interception decreased. The maximum fresh root weight (104.2g in 2005 and 106.1g in 2006) was observed in sole cropping ($T_7$). Significantly, the minimum fresh root weight (56.14 g in 2005 and 64.47 g in 2006) was produced under narrower spacing of sisoo+guava based MAF ($T_1$) in both the seasons. The

root dry weight of carrot in multistrata agroforestry systems was observed lesser under different spacing ($T_1$-$T_6$) than sole cropping ($T_7$). The pattern of root dry weight observed was as $T_7>T_4>T_6>T_5>T_2>T_3>T_1$ during the year 2005. Similar was the trend during the second year i.e. in 2006.

**Table 2.** Growth and yield of carrot as influenced by the sissoo based multistrata agroforestry systems during November, 2006 to February, 2007

| Treatments | Plant height (cm) | No. of leaves plant | Length of leaves (cm) | Length of root (cm) | Diameter of root (cm) | Fresh wt. of root (g) | Dry wt. of root (g) | Yield (t/ha) |
|---|---|---|---|---|---|---|---|---|
| $S_1+G_1$+Carrot ($T_1$) | 70.08 | 7.84 | 62.70 | 14.19 | 3.19 | 64.47 | 7.56 | 18.65 |
| $S_1+L_1$+Carrot ($T_2$) | 68.04 | 12.58 | 54.93 | 15.46 | 3.43 | 75.53 | 9.92 | 22.42 |
| $S_2+G_2$+Carrot ($T_3$) | 66.92 | 8.39 | 56.02 | 16.49 | 3.31 | 75.69 | 9.41 | 20.27 |
| $S_2+L_2$+Carrot ($T_4$) | 64.52 | 13.22 | 47.20 | 15.81 | 3.83 | 94.71 | 11.54 | 25.93 |
| $S_3+G_3$+Carrot ($T_5$) | 63.70 | 11.82 | 49.81 | 16.92 | 3.80 | 87.19 | 10.893 | 25.7 |
| $S_3+L_3$+Carrot ($T_6$) | 62.65 | 14.63 | 43.24 | 18.02 | 4.17 | 91.34 | 11.78 | 27.36 |
| Open ($T_7$) | 53.69 | 10.68 | 39.38 | 18.73 | 4.31 | 106.08 | 16.21 | 29.24 |
| Lsd $_{0.01}$ | 13.29 | 2.18 | 6.49 | 2.09 | 0.86 | 11.70 | 2.05 | 6.74 |
| Level of signi. | ** | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 8.30 | 7.71 | 5.16 | 5.09 | 9.31 | 5.52 | 7.44 | 11.16 |

** Significant at 0.01 level

**Yield (t/ha) of carrot as influenced by the multistrata sissoo woodlot:** Multistrata sissoo woodlot with different tree spacing were found to significantly influence on the root yield of carrot during both years of experimentation (Tables 1 and Table.2). The highest yield (29.87 t/ha in 2005 and 29.24 t/ha in 2006) was recorded under sole cropping ($T_7$), which was statistically similar to that of the treatments $T_6$ and $T_4$. The reduction in yield of carrot compared to sole cropping was more at closer spacing of multistrata agroforestry systems. Significantly, the lowest yield (17.84 t/ha in 2005 and 18.65 t/ha in 2006) was recorded in narrower spacing of sissoo+guava based MAF ($T_1$) in the both seasons. This yield reduction was 40.27 per cent in 2005 and 36.22 per cent in 2006 over the sole cropping. The reason of maximum yield reduction in closer spacing of MAF might be that close spacing of upper and middle later trees canopy densely covered almost the entire ground layer plots, consequently shading effect on carrot was higher. As a result, root yield of carrot was low. This result also collaborates with the findings of Miah (2001).

**Economic analysis:** Profitability of growing carrot as ground layer crop in sissoo based multistrata agroforestry system was calculated on the basis of local market rate prevailed during experimentation. The cost of production of carrot include the cost of production of tree plantation and management of middle and upper layer trees as well as the return of produce and the profit per taka i.e. Benefit Cost Ratio (BCR) have been presented in Table 3. The total cost of production was the highest (79790 Tk./ha) in narrower spacing of sissoo+guava based MAF ($T_1$) followed by the narrower spacing of sissoo+lemon based MAF (76004 Tk./ha) ($T_2$). The lowest cost of production (56985 Tk./ha) was recorded from the sole cropping of carrot ($T_7$).

**Table 3.** Economics of carrot production under sissoo based multistrata cropping system (average of two years)

| Treatments | Return (Tk./ha) | | | | Gross Return (Tk./ha) | Total cost of Production (Tk./ha) | Net Return (Tk./ha) | BCR |
|---|---|---|---|---|---|---|---|---|
| | Carrot | Guava | Lemon | Sissoo | | | | |
| $S_1+G_1$+Carrot ($T_1$) | 54735 | 157081 | -------- | 153904 | 365720 | 79790 | 285930 | 4.58 |
| $S_1+L_1$+Carrot ($T_2$) | 67155 | -------- | 115002 | 153904 | 336061 | 76005 | 260056 | 4.42 |
| $S_2+G_2$+Carrot ($T_3$) | 71118 | 118706 | --------- | 140500 | 330324 | 69636 | 260688 | 4.74 |
| $S_2+L_2$+Carrot ($T_4$) | 91152 | ------- | 83201 | 140500 | 314853 | 67207 | 247646 | 4.68 |
| $S_3+G_3$+Carrot ($T_5$) | 79771 | 74193 | -------- | 113592 | 267556 | 58326 | 209230 | 4.59 |
| $S_3+L_3$+Carrot ($T_6$) | 85579 | ------- | 49499 | 113592 | 248669.7 | 56985 | 191685 | 4.36 |
| Open ($T_7$) | 177330 | ------- | -------- | --------- | 177330 | 50916 | 126414 | 3.48 |

Note: Carrot 6 tk./kg, Guava 6 Tk./kg; Lemon 1 Tk./piece, Sissoo ($T_1$ & $T_2$) 179 Tk./tree/year, Sissoo ($T_3$ & $T_4$ ) 250 Tk./tree/year, Sissoo ($T_5$ & $T_6$) 358 Tk./tree/year.

Higher cost of production was found in the narrower spacing of sissoo+lemon based MAF due to higher plantation and management cost of sissoo and guava trees. Again, the highest value of gross return (365720 Tk. /ha) was obtained from the narrower spacing of sissoo+guava based MAF) ($T_1$). On the other hand, the lowest value of gross return (177330 Tk. /ha) was obtained from the sole cropping of carrot ($T_7$). The highest gross return was obtained due to higher fruit yield of guava along with the value of sissoo trees. Among the treatments, it was found that the highest benefit-cost ratio of 4.74 was recorded from intermediate spacing of sissoo+guava based MAF ($T_3$) followed by $T_4$, $T_5$, $T_1$, $T_2$ and $T_6$ treatments. The lowest benefit-cost ratio of 3.48 was observed in $T_7$ treatment i.e. in sole cropping of carrot. So, carrot can profitably be cultivated in multistrata sissoo woodlot.

The findings of the present investigation indicate that diversification of farming system and growing vegetables like carrot as ground layers crops in mutistrata sissoo woodlot is a viable option for increasing income of farmers. Carrot has been grown successfully as intercrops in the floor of sissoo woodlot plantations. The presence of tree canopies did not influence growth and yield of carrot although some adverse effect of trees was obvious in plants growing nearer to the tree rows. Despite some negative effects of upper layer trees on the growth, yield and physiological attributes, particularly at closer distance to the tree rows, a multistrata agroforestry is still beneficial as it ensure higher returns because of diversified products in comparison to sole cropping. Out of the three tree spacing, wider spacing i.e sissoo planted at 6m x 6m and guava or lemon planted at 3m x 3m proved to be the best tree spacing for little adverse effect on the growth and yield of carrot. So, this spacing may be adopted as suitable spacing in woodlot based MAF to cultivate ground layer crops for diversification and boosting economy of farmers in land scare Bangladesh circumstances.

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