# Biomass Productivity of Different Intercropping Systems with Arecanut†

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### Abstract

*The biomass productivity of 12 cropping systems comprising 19 intercrops grown under arecanut is reported vis-a-vis their sole cropping systems. The productivity of all intercrops was inferior when compared to their respective sole crops. This reduction varied from 18 per cent under beans to 88 per cent under fodder sorghum. Arrow root and banana suffered less than 50 per cent reduction in their productivity as intercrops, while ginger, chilli, colocasia, paddy, turmeric, yam and Dioscorea had productivity rates ranging only between one - third to one - half of their sole crops. The remaining crops suffered severely under intercropping. Intercropping had a positive effect on the productivity of arecanut except with hybrid napier and arrow root. The biomass productivity of all the intercropping systems was greater than that of the sole cropping system of arecanut.*

## Introduction

Biomass productivity of crop lands is gaining importance in recent years due to the rapid growth of human population and the dwindling supply of fossil energy. Apart from providing the largest source of food, fibre, fuel and shelter plant biomass can conserve the cheapest source of renewable energy. Green plants under favourable conditions can fix two to three per cent of the solar energy into chemical energy through photosynthetic bioconversion. Since agricultural land is becoming limited due to the rapid urbanisation and improper land use it is inevitable to develop highly productive and ecologically desirable cropping systems to harvest more from every unit of available crop land.

According to Nichiporovich (1954) the average productivity of a crop may be 80 - 150 kg/ha/day, in a period of rapid growth, but may reach as high as 500 kg/ha/day depending on the leaf area and photosynthetic efficiency. Loomis and Williams (1963) estimated a potential productivity of 77 $g/m^2/day$ at a total radiation of 550 $cal/cm^2/day$. If the net productivity rate could be held constant at this rate for 100 days a yield of about 85 t/dry matter/ha must result. However, as reported by Loomis and Gerakis (1975), careful studies of primary productivity in agricultural fields are rare and seldom represent maximum production situations. Moss (1976) reported that the yearly biomass productivity is a function of two factors, the rate of dry matter production

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and the length of the time the system functions. Nelliat et al., (1974) computed the total dry matter production of a pure stand of coconut at near optimum management as 17.1 t/ha representing hardly 6.1 per cent of the potential productivity estimate of Loomis and Williams (1963). As per the estimates of area and production by Velappan and Paulose (1974) the annual yield of arecanut is less than one t/ha but this does not account for the biomass present in other parts of the palm. Additional production through intercropping in arecanut has been reported by some workers (Abraham, 1974; Bhat, 1974; Roy, 1974 and Muralidharan and Nayar, 1979) but the information is limited to the yield of economic parts only. The present investigations were taken up to study the biomass productivity of different intercropping systems in arecanut *Vis-a-vis* their sole cropping systems.

## Materials and Methods

The studies were undertaken at the Central Plantation Crops Research Institute (CPCRI), Regional Station, Vittal, Karnataka, situated at 200 m above MSL and at 12.57°N latitude with typical monsoon climate. The field experiments comprised 12 cropping systems involving 20 crops including the main crop, arecanut as shown in Table 1, laid out in a 12×3 randomised block design.

An existing 12-year-old arecanut garden planted during 1965 with a spacing of 2.4m×2.4m was used for the intercropping experiment. Each net plot of the intercropping experiment consisted 8 palms in a gross plot size of 12m×7.2m (86.4m$^2$) with common borders of arecanut between treatments. The sole cropping systems were tested in an adjacent but open field without arecanut. A plot size of 5.4m× 2.7m was chosen for this experiment due to shortage of land. The soil of the experimental site was texturally classified as sandy clay loam (Mohapatra, 1977) of lateritic origin and was moderately deep and well drained.

The crops were raised as per the package of practices recommended by the University of Agricultural Sciences, Bangalore

**Table 1. Cropping systems**

| Treatment | Cropping system |
|---|---|
| $T_1$ | Upland paddy [Apr. 15 - Aug. 15] - Finger millet [Aug. 20 - Dec. 5] - Groundnut [Dec. 15 - March 30] |
| $T_2$ | Yam [Apr. 15 - Dec. 10] - Sorghum [Dec. 15 - Mar. 30] |
| $T_3$ | Arrow root [Apr. 15 - Feb. 14] - Beans [Feb. 15 - Apr. 14] |
| $T_4$ | Dioscorea [Apr. 15 - Dec. 5] - Maize [Dec. 10 - Apr. 10] |
| $T_5$ | Ginger [Apr. 15 - Sep. 15] - Chilli [Sept. 20 - Apr. 10] |
| $T_6$ | Turmeric [Apr. 15 - Jan. 14] - Cowpea [Jan. 15 - Apr. 10] |
| $T_7$ | Colocasia [Apr. 15 - Dec. 14] - Dolichos [Dec. 15 - Apr. 10] |
| $T_8$ | Fodder Sorghum [Apr. 15 - Oct. 15] - Sweet potato [Oct. 20 - Mar. 30] |
| $T_9$ | Fodder napier [Apr. 15 - Two years] |
| $T_{10}$ | Cavendish banana [Apr. 15 - Two years] |
| $T_{11}$ | Arecanut only with frequent tillage for arecanut |
| $T_{12}$ | Arecanut only with usual tillage [control] |

Note : $T_1$ to $T_{10}$ under arecanut for intercropping systems and no arecanut for sole cropping systems

(Iyer and Khan, 1975 and Iyer, 1976) for sorghum, maize, finger millet, hybrid napier, ground nut, cowpea, *Dolichos*, beans, banana and chilli; CPCRI (Pamphlet No. 2E) for arecanut and Kerala Agricultural University (Package of practices, 1976) for the remaining crops, except arrow root which was raised as per the package of practices for giner since no separate recommendations were available for the same. The crops were irrigated during summer months (December-March). The intercropping systems were studied for two years (1977 - '79) while the sole cropping systems were studied for one year (1978 - '79).

The biological yield of all the 19 crops grown as inter and sole crops was estimated from samples of above ground portions (including tubers or rhizomes of crop like yams, ginger etc.) and dried to constant weight in hot air oven. The bioproductivity of arecanut was obtained by adding together the dry matter present in all the plant parts removed from the palm and an estimated dry matter present in the trunk formed during the experimental period using the regression equation y=0.01435 l+0.3442 g-1.0017, where l = length of the trunk formed during the period and g=girth of the trunk (Muralidharan, 1980). The total biomass productivity of the cropping systems were worked out by summation of the productivity of the component crops under each system.

## Results

### Biomass productivity of intercrops

Biomass productivity of different intercrops ranged from 2.7 $g/m^2/day$ in hybrid napier to 0.16 $g/m^2/day$ in beans (Table 2). The productivity of the intercrops exceeded at least 2 $g/m^2/day$ only in three more crops viz., arrow root (2.33 g), maize (2.21 g) and sorghum (2.10g). In the sole cropping experiment sorghum recorded the highest biomass productivity (10.85 $g/m^2/day$) followed by maize (10.76 $g/m^2/day$). As under intercropping, beans had the lowest productivity (0.2 $g/m^2/day$) under the sole cropping also. The total biomass production during the year was, however, different from the daily rate of production due to the differences in duration of the crops (Table 2). Eventhough, under sole crop condition, sorghum had a higher rate of biomass production it could yield only 10,633 kg/ha as against 31,360 kg / ha under hybrid napier due to its shorter growing period. Similarly, yam and *Dioscorea* also had greater total production than sorghum and maize either as intercrop or as sole crop. The various intercrops recorded 12.2 to 80.0 per cent of their respective sole crop biomass productivity. Arrow root and beans produced more than two-thirds of their respective sole crops but the productivity of beans was equally poor under both the environments. Crops like banana, ginger, chilli, *Colocasia*, paddy, turmeric, yam and *Dioscorea* could produce at least one third of their respective sole crop biomass, while the remaining nine crops suffered severely under intercropping.

### Biomass productivity of arecanut

More than half of the biomass produced in arecanut was accounted for by the leaves while the nuts had only lesser proportion of the assimilates (Table 3). The trunk had accumulated only less than 10 per cent of the total biomass produced. The cropping systems significantly influenced the productivity of arecanut which was highest when intercropped with the crop sequence of giner followed by chilli and lowest when intercropped with arrowroot and beans.

### Total biomass productivity

The cropping system consisting of arecanut with hybrid napier recorded the highest biomass productivity (22.55 t / ha / year) followed by arecanut with banana (20.64 t/ha/year) (Table 4). In all the intercropping systems arecanut remained as the major component in contributing to the total biomass productivity. However, the biomass productivity of the four sole cropping systems $T_2$, $T_4$, $T_8$ and $T_9$ exceeded the productivity of all the intercropping systems. Hybrid napier as a sole crop ($T_9$) recorded the highest biomass productivity (31.36 t/ha/year) followed by yam-sorghum (24.38 t/ha/year).

Table 2. Biomass productivity of different intercrops vis-a-vis their sole crops

| Crop | Biomass Productivity: g / $m^2$ day — Intercrop (IC) Mean of two years | g / $m^2$ day — Sole crop 1978-'79 | Kg / ha / crop — Intercrop Mean | Kg / ha / crop — Solecrop 1978-'79 | Kg / ha / crop — IC (%) / SC 1978-'79 |
|---|---|---|---|---|---|
| Paddy | 1.20 | 3.66 | 1231 | 3691** | 38.5 |
| Fingermillet | 1.11 | 8.52 | 859 | 6560** | 16.4 |
| Groundnut | 1.37 | 4.55 | 1468 | 4776** | 29.2 |
| Yam | 1.90 | 5.85 | 4537 | 13750** | 36.5 |
| Sorghum | 2.10 | 10.85 | 2186 | 10633** | 19.2 |
| Arrowroot | 2.33 | 3.65 | 6583 | 9852* | 66.8 |
| Beans | 0.16 | 0.20 | 96 | 128 | 80.0 |
| Dioscorea | 1.53 | 5.21 | 3654 | 12241** | 33.3 |
| Maize | 2.21 | 10.76 | 2266 | 10546** | 25.6 |
| Ginger | 1.36 | 2.78 | 2429 | 5498** | 47.5 |
| Chilli | 0.55 | 1.44 | 985 | 2281** | 44.4 |
| Turmeric | 1.38 | 3.63 | 3464 | 8682** | 38.0 |
| Cowpea | 0.92 | 3.53 | 642 | 2403** | 29.2 |
| Colocasia | 1.06 | 3.51 | 1973 | 5647** | 38.7 |
| Dolichos | 1.11 | 3.41 | 1162 | 3370** | 31.9 |
| Fodder Sorghum | 0.86 | 6.63 | 1301 | 9616** | 12.2 |
| Sweet potato | 1.48 | 8.77 | 1814 | 9904** | 18.3 |
| Hybrid napier | 2.70 | 8.59 | 9891 | 31360** | 30.1 |
| Banana | 1.63 | 2.78 | 5956 | 19137** | 58.6 |
| CD (0.05) | 0.43 | 1.05 | — | — | — |

** Significant at 1 per cent  * Significant at 5 per cent only

Table 3. Biomass productivity of arecanut under different cropping systems (Mean of two years)

| Cropping systems* | Biomass (kg / palm) | | | | | |
|---|---|---|---|---|---|---|
| | Nuts | Leaf | Bunch stalk | Spadix cover | Trunk (estimated) | Total |
| $T_1$ | 2.28 | 4.55 | 0.22 | 0.13 | 0.76 | 7.94 |
| $T_2$ | 2.11 | 4.47 | 0.20 | 0.14 | 0.73 | 7.65 |
| $T_3$ | 1.47 | 4.32 | 0.19 | 0.12 | 0.66 | 6.76 |
| $T_4$ | 1.99 | 4.45 | 0.21 | 0.14 | 0.72 | 7.51 |
| $T_5$ | 2.24 | 5.40 | 0.24 | 0.14 | 0.85 | 8.87 |
| $T_6$ | 1.79 | 4.79 | 0.21 | 0.13 | 0.68 | 7.60 |
| $T_7$ | 1.80 | 4.80 | 0.22 | 0.13 | 0.75 | 7.70 |
| $T_8$ | 2.02 | 4.84 | 0.20 | 0.14 | 0.73 | 7.93 |
| $T_9$ | 1.64 | 4.67 | 0.19 | 0.13 | 0.73 | 7.36 |
| $T_{10}$ | 2.19 | 5.07 | 0.23 | 0.15 | 0.82 | 8.46 |
| $T_{11}$ | 1.82 | 4.54 | 0.20 | 0.13 | 0.64 | 7.33 |
| $T_{12}$ | 1.66 | 4.29 | 0.19 | 0.11 | 0.60 | 6.85 |
| CD (0.05) | 0.20 | 0.52 | 0.02 | 0.02 | 0.09 | 0.58 |
| CV (%) | 2.1 | 2.0 | 1.6 | 2.5 | 2.1 | 4.4 |

* Details as in Table 1.

Table 4. Biomass productivity of different cropping systems

| Cropping Systems | Biomass (t / ha / yr) (Mean of 2 years) | | | Sole cropping |
|---|---|---|---|---|
| | Intercrops | Arecanut | Total | |
| $T_1$ | 3.32 | 13.78 | 17.10 | 15.03 |
| $T_2$ | 6.73 | 13.28 | 20 01 | 24.38 |
| $T_3$ | 7.59 | 11.76 | 19.36 | 9.98 |
| $T_4$ | 5.92 | 13.11 | 19.03 | 22.79 |
| $T_5$ | 3.42 | 15.43 | 18.85 | 7.78 |
| $T_6$ | 4.02 | 13.19 | 17.21 | 11.08 |
| $T_7$ | 3.14 | 13.38 | 16.52 | 9.02 |
| $T_8$ | 3.12 | 13.76 | 16.88 | 19.52 |
| $T_9$ | 9.89 | 12.66 | 22.55 | 31.36 |
| $T_{10}$ | 5.96 | 14.68 | 20.64 | 10.14 |
| $T_{11}$ | 0.00 | 12.75 | 12.75 | 12.29 |
| $T_{12}$ | 0.00 | 11.88 | 11.88 | 10.82 |
| CD (0.05) | — | — | — | 2.59 |
| CV (%) | — | — | — | 9.95 |

## Discussion

The results on the biomass productivity of 19 crops grown as intercrops in arecanut and as sole crops under 12 different cropping systems enabled to identify the level of productivity of each crop under normal conditions of cultivation (sole cropping) and under intercropping. Some information has been reported on the possibilities of growing certain crops like yam, arrow root, banana etc. under arecanut (Bhat, 1978; Muralidharan and Nayar, 1979). The present investigation has thrown further light on the capability of arecanut to allow a wide range of crop species which may be a cereal ($C_3$ or $C_4$), a root crop, a legume or a fodder crop to be grown in association with it.

Arecanut being widely planted to maximise economic yield may not be able to utilize the resources in all the dimensions and should spare part of its environment for other crop species. In a perennial crop like arecanut the combination of crops that may best fit into an annual sequence for intercropping deserves careful consideration. They have to be carefully fitted into a suitable rotation so that they are not only grown in ideal season but also compete least with arecanut for growth factors and maintain soil fertility in the long run. Also the proportion of total biomass in each system that contributes to practical use either for direct human and cattle consumption, for industrial raw material or for recycling into the soil demands critical consideration.

In the present state of diminishing resources of fossil energy the world over, the concept of biomass as an alternate energy source is gaining importance, though food production will continue to be most important tasks of human society. Practically all the plant biomass produced by the farmers is a potential source of energy though crop residues may pose difficulties in their conversion to some form of transportable energy. However, until such a time the additional biomass can be put into effective use, the yield of economic parts will outweigh any other consideration to the farmer. The results of the present studies emphasised the scope offered by introducing intercropping systems not only for increasing the biomass productivity from the additional crops but also for increasing the biomass productivity of the main crop, arecanut itself.

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