Short Communication

Intercropping of medicinal plants with cassava (*Manihot esculenta* Crantz) under different row arrangements

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Abstract

A field experiment was conducted during the period from September 2020 to March 2021 at the Department of Agronomy, College of Agriculture, Vellanikkara, to assess the feasibility of intercropping medicinal plants in cassava. Intercropping significantly influenced the growth and yield attributes of both main and intercrops. Shorter cassava plants were observed when *Sida alnifolia* was intercropped as double row (162.84 cm). In general, medicinal plants grown under intercropping system recorded taller plants, except for *Indigofera*, where sole cropping resulted in taller plants. The sole crop of cassava produced higher per plant tuber yield of 3.24kg and was at par with cassava with single row of *Plectranthus* (3.12 kg/plant). The lowest tuber yield was recorded when cassava was intercropped with double row of *Sida* (1.77 kg/plant). The yield of medicinal plants was the highest in sole cropping, followed by single row intercropping and double row intercropping. Same trend was observed for quality parameters of medicinal plants, where higher values of the phytochemical constituents were recorded in sole crops. medicinal plants.

Keywords: Cassava, *Indigofera tinctoria*, Intercropping, *Plectranthus vettiveroides* , Row arrangements, *Sida alnifolia.*

Kerala is considered a treasure house of medicinal and aromatic plants; however, due to indiscriminate harvesting, the existence of most of these plants is under threat. Cultivation is the only option to ensure the continued supply of high quality raw materials without diminishing the natural resources. Due to small holding size and a greater focus on cash crops, the scope for commercial production of medicinal plants as a pure crop in Kerala is restricted. So, the practical alternative is to bring them under intercropping with priority crops such as food and commercial crops. Cassava (*Manihot esculenta* Crantz) is the most important starchy root crop grown in the tropics. The wide spacing, together with slow initial growth and development, makes cassava compatible to intercropping with short duration crops.

A field experiment in Randomized Block Design with 10 treatments and three replications was conducted at the Department of Agronomy, College of Agriculture, Vellanikkara, during September 2020 to April 2021 to assess the feasibility of intercropping medicinal plants *Indigofera tinctoria, Plectranthus vettiveroides* and *Sida alnifolia* with cassava. The treatments were T_1 : sole crop of cassava, T_2 : cassava + single row of *Indigofera tinctori*a, T_3 : cassava + single row of *Plectranthus vettiveroides*, T_4 : cassava + single row of *Sida alnifolia*,T_5 : cassava + double row of *Indigofera tinctoria*, T_6 : cassava + double row of *Plectranthus vettiveroides*, T_7 : cassava + double row of *Sida alnifolia*, T_8 : sole crop of *Indigofera tinctoria*, T_9 : sole crop of *Plectranthus vettiveroides* and T_{10} : sole crop of *Sida alnifolia.*

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Cassava sets of 15 cm length (with three nodes) from high yielding local cultivar were planted on ridges at a spacing of 1m x 1m in plots of size 5 m x 5 m. As intercrops, medicinal plants were planted in single rows and double rows in between cassava. For single row, intercrops were transplanted in the middle of furrows, whereas for double rows, transplanting was done on either sides of furrow at a spacing of 40 cm x 30 cm for *Indigofera* and *Sida*, and 40 cm x 40 cm for *Plectranthus* (Fig.1). Planting materials for medicinal intercrops were procured from AICRP on Medicinal and Aromatic Plants, College of Agriculture, Vellanikkara.

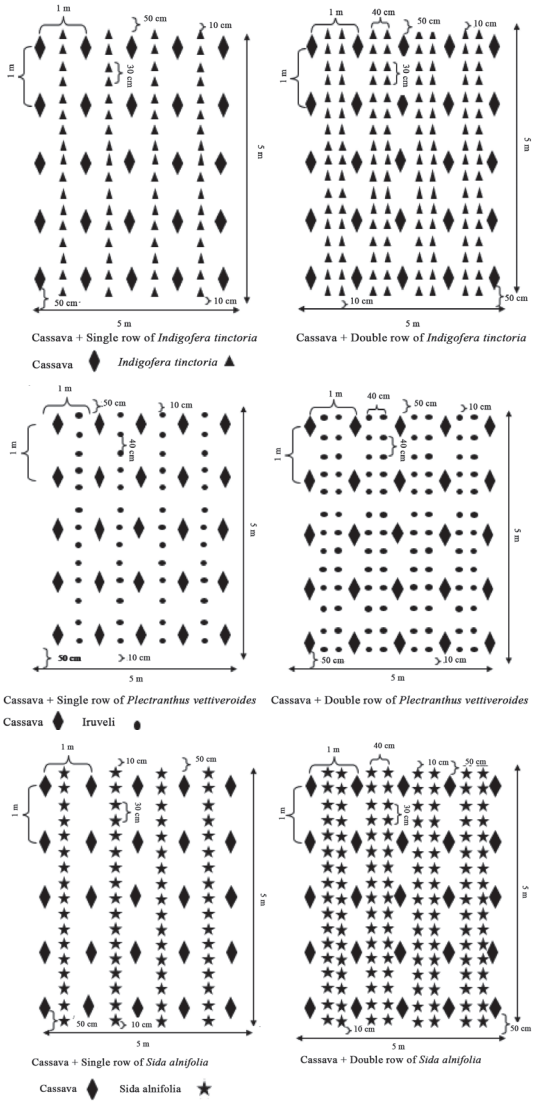


Figure 1. Schematic representation of intercropping system

Manures and fertilizers for main and intercrops were applied as per the package of practices recommendations of Kerala Agricultural University (KAU, 2016). Hand weeding followed by earthing up was done at 30, 60 and 90 days after planting (DAP) for all treatments which included cassava. However, in double row planting of medicinal plants, intercultural practices were not done at 90 DAP. For the sole culture of medicinal plants, hand weeding alone was done at 30 DAT, 60 DAT and 90 DAT.

Cassava tubers were harvested seven months after planting (MAP) when the bottom leaves started to turn yellow. *Plectranthus vettiveroides* and *Sida alnifolia* were harvested three and five months respectively after planting, by uprooting the plants. Leaves of *Indigofera* were harvested one month after planting, and a total of five harvests were done at 30 days. The observations on growth, yield and quality attributes of main and intercrops were recorded at harvest. In *Indigofera*, indican content of leaves at the first cut was analysed spectrophotometrically at 280 nm (Wu et al., 1999). As per AOAC (1975), the essential oil content of *Plectranthus* was estimated by hydro distillation method, using the Clevenger apparatus. Total alkaloid content in roots of *Sida* was estimated using the method of Harborne (1973). The data were analysed statistically using analysis of variance (ANOVA) with statistical package 'WASP-2.0' (Statistical package, ICAR-Central Coastal Agricultural Research Institute, Goa).

At the time of harvest all the treatments, except intercropping with double row of *Sida alnifolia* were on par with respect to plant height (Table 1). Shorter cassava plants were observed when cassava was intercropped with *Sida alnifolia* (162.84 cm). The plant height at harvest ranged from 162.84 cm to 217.79 cm.

Higher tuber yields of 3.24 kg and 3.12 kg per plant

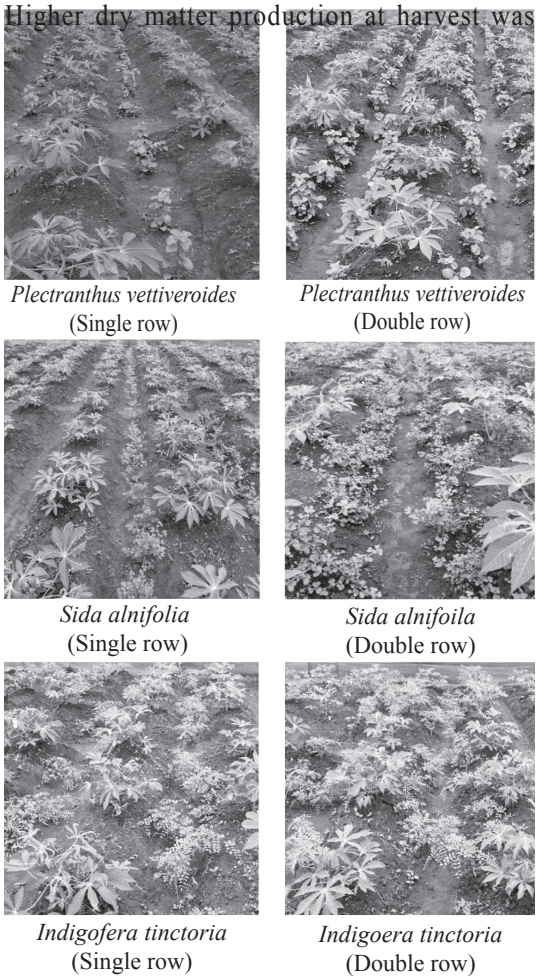
Table 1. Effect of intercropping medicinal plants with cassava on growth parameters of cassava

Treatment	Height at harvest (cm)	Top yield (Fresh) (kg/plant)	Tuber yield (Fresh) (kg/plant)	Total dry matter production (kg/plant)
T_1 Sole crop of cassava	206.62	2.31	3.24	1.98
T_2 Intercropping cassava with *Indigofera tinctoria* (single row)	210.55	2.25	2.83	1.81
T_3 Intercropping cassava with *Plectranthus vettiveroides* (single row)	217.79	2.29	3.12	1.95
T_4 Intercropping cassava with *Sida alnifolia* (single row)	189.29	1.82	2.40	1.51
T_5 Intercropping cassava with *Indigofera tinctoria* (double row)	203.96	2.03	2.45	1.60
T_6 Intercropping cassava with *Plectranthus vettiveroides* (double row)	209.33	2.13	2.56	1.67
T_7 Intercropping cassava with *Sida alnifolia* (double row)	162.84	1.39	1.77	1.13
CD(0.05)	28.81	0.32	0.54	0.26
SE(m)	7.02	0.12	0.18	0.11

was obtained from sole cropping of cassava and cassava intercropped with *Plectranthus vettiveroides* as single row. The reduction in per plant cassava yield between sole crop and single row *Plectranthus* was only 3.59 per cent. *Plectranthus* remained as an intercrop in the field only for three months after which harvesting was done. After harvesting of the intercrop, the field was equivalent to a sole crop of cassava. There was no inter-specific competition for cassava after three months of crop growth. Lack of competition during critical growth stage of cassava might have contributed to better tuber yield in single row intercropping with *Plectranthus*. According to Savithri and Alexander (1995), there was no remarkable difference in yield parameters of cassava when intercropped with suitable short duration crops like cowpea.

Cassava yield reduction was less conspicuous in single row intercropping. However, significant yield reduction was noticed by double row intercropping of medicinal plants. According to Ekwaro et al. (2019), root yield of cassava under low intercrop density was higher than that of higher intercrop density in cassava - maize intercropping. The lowest cassava yield was obtained in cassava intercropping with double row of *Sida alnifolia*. A yield reduction of 45.37 per cent was noticed in this treatment. This reduction could be attributed to the higher competition by *Sida* in the early stages and the resultant effect on the growth and yield parameters. *Sida* persisted as an intercrop in the field up to five months after planting. Growth recommencement of cassava after the removal of *Sida* may not be sufficient to compensate for the earlier growth suppression.

Higher dry matter production at harvest was



Plectranthus vettiveroides (Single row) | *Plectranthus vettiveroides* (Double row)
Sida alnifolia (Single row) | *Sida alnifoila* (Double row)
Indigofera tinctoria (Single row) | *Indigoera tinctoria* (Double row)

Figure 2. Field view of intercropping cassava with medicinal plants

observed in sole crop of cassava (1.98 kg/plant). It was on par with cassava with single row crop of *Plectranthus* (1.95 kg/plant), followed by cassava with single row of *Indigofera* (1.81 kg/plant). This could be attributed to a long time gap between harvesting *Plectranthus* (three months after planting) and cassava (seven months after planting), as well as regular cutting of Indigofera for herbage yield, which opened the path for better dry matter production in the intercropping system. As in the case of tuber yield, the lowest dry matter production (42.92 per cent less than the sole crop of cassava) was in cassava with double row of *Sida*.

Sole cropping of *Indigofera* resulted in the production of taller plants. The plant height of intercropped *Indigofera* was 8.94 per cent (double row) and 10.78 per cent (single row) less than sole crop of *Indigofera* (Table 2). Increased plant height in sole crop of *Indigofera* might have been due to abundant resources with no inter-specific competition, whereas under intercropping, plants might have suffered from competition leading to a reduction in plant height. Sarada (2004) reported higher plant height of *Indigofera* under open conditions than on intercropping in coconut garden. Competition for resource occurs between plants in crop mixtures than when grown as pure crop. Long and lean plants were observed when *Plectranthus* was intercropped with cassava. Taller *Plectranthus* plants were observed in double row intercropping (69.42cm), followed by single row of *Plectranthus* (58.44 cm). The lowest plant height was observed in sole crop of *Plectranthus (45.48* cm). The same trend in plant height was noticed for *Sida*. Intercropped *Sida* plants were taller than sole cropped *Sida*. Taller plants (127.78 cm) were recorded in double row planting, followed by single row planting (106.14 cm) and sole crop (89.93 cm). Priyadarsini et al. (2020) observed taller plants of *Sida* under shade than in open conditions in Kerala. As per Abdel-Mawgoud et al. (1995), plants growing under shade attempt to improve the capture of intercepted light by promoting interception area, eventually leading to escalated plant height. A change in environmental conditions could manipulate plants morphology and adaptation mechanisms (Gong et al., 2015).

Table 2. Effect of intercropping medicinal plants with cassava on growth, yield and quality of medicinal plants

Treatments	Plant height (cm)	Total herbage yield (g/plant)	Indican content (%) at first cut
T_2 Inter cropping cassava with *Indigofera tinctoria* (single row)	95.17	122.73	1.39
T_5 Intercropping cassava with *Indigofera tinctoria* (double row)	97.13	118.84	1.34
T_8 Sole crop of *Indigofera tinctoria*	106.67	185.82	1.40
CD(0.05)	4.27	11.96	0.016
SE(m)	1.49	4.18	0.006
	Plant height (cm)	Root yield (g/plant)	Essential oil content (%) of roots
T_3 Intercropping cassava with *Plectranthus vettiveroides* (single row)	58.44	40.12	0.40
T_6 Intercropping cassava with *Plectranthus vettiveroides* (double row)	69.42	39.23	0.26
T_9 Sole crop of *Plectranthus vettiveroides*	45.48	42.29	0.60
C.D.(0.05)	4.50	1.81	0.017
SE(m)	1.57	0.63	0.006
	Plant height (cm)	Root yield (g/plant)	Total alkaloid content (%) of roots
T_4 Intercropping cassava with *Sida alnifolia* (single row)	106.14	7.50	2.94
T_7 Intercropping cassava with *Sida alnifolia* (double row)	127.78	7.00	2.67
T_{10} Sole crop of *Sida alnifolia*	89.93	9.00	3.07
CD(0.05)	4.20	0.24	0.05
SE(m)	1.47	0.08	0.019

In general, the economic yield of all the three medicinal plants studied *viz., Indigofera*, *Plectranthus* and *Sida* were higher under sole cropping (Table 2). Padma et al. (2018) reported yield reduction of medicinal and aromatic plants when grown as intercrop in coconut garden compared to their mono crop yields. Herbage yield was significantly higher in sole crop of *Indigofera* (185.82 g/plant), followed by single row intercropping (122.73 g/plant) and the lowest was in double row intercropping (118.84 g/plant). The lower herbage yield for *Indigofera tinctoria* under intercropping system might have been due to the shading effect of the tall growing cassava plants. Sole crop of *Plectranthus* recorded highest per plant root yield (42.29 g/plant). Single row and double row intercropping resulted in 2.17 g and 3.06 g less per plant root yield than sole crop. For *Sida alnifolia*, per plant root yield was the highest in sole crop (9.00 g), followed by cassava with single row of *Sida* (7.50 g), and lowest per plant yield was noticed in double row intercropping (7.00 g). Mutual shading due to increased population might have reduced root yield of *Sida* under double row intercropping. Latha and Radhakrishnan (2015) also reported reduction in yield and yield parameters such as the number of roots, root yield per plant and root length under shaded conditions in *Sida*.

Sole crop of *Indigofera* recorded the highest indican content and was on par with single row inter crop. Double row intercropped cassava recorded 4.2 percent less indican content than sole crop. As per Sindhu et al. (2018) indican content in *Indigofera tinctoria* was statistically on par at fully open and 25 per cent shaded conditions, but as the shade intensity increased, the indican content decreased significantly. Sarada (2004) also reported higher indican content for *Indigofera* in open conditions than intercropped in coconut garden.

Growing of *Plectranthus* as sole crop resulted in higher essential oil content than intercropped *Plectranthus*. Single row of intercropped *Plectranthus* yielded 33.33 per cent and double row of intercropped *Plectranthus* yielded 58.33 per cent less essential oil than sole crop of *Plectranthus*. Kumar (2013) observed higher essential oil in open conditions than in shaded conditions for *Plectranthus vettiveroides*. The data analysis on the total alkaloid content of *Sida alnifolia* also showed the significance of sunlight in enhancing quality parameters. The highest alkaloid content was obtained from sole cropping. This was followed by single row intercrop with about 4.23 per cent lower content than sole crop. The lowest alkaloid content was in double row intercropped *Sida*, which was 13.02 per cent less than sole crop of *Sida*. *Low* content of principal components in medicinal plants could be attributed to increased shade level due to higher plant population as in double row planting. Biscoe and Gallagher (1977) suggested that the variation in the principal medicinal constituents in medicinal and aromatic plants between the pure stand and intercrop could be attributed to the role of light on fluctuating photosynthesis and respiration.

From the present study, based on economic yield, *Indigofera tinctoria*, either as a double row or as a single row, could be recommended as the best medicinal intercrop for cassava. Cassava with single row *Plectranthus vettiveroides* was the next best intercrop.

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