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Effect of Intercropping on Yield Attributes and Yield of Taro (*Colocasia esculenta* Schott.) under the Sloppy Foot Hills of Manipur

Taro (*Colocasia esculenta* Schott.) commonly called as eddoe or arvi is an important perennial tuberous vegetable belongs to the family Araceae. It is believed to have originated in the Indo-Malayan region and is the staple food in small isolated communities of the tropics. It is used as secondary staple food in Pacific islands and as a vegetable in Africa, India, and other South East Asian countries. About 88% of the total world acreage under taro is in Africa which produces about 80% of total production (Onwueme, 1978). In India, it is mainly cultivated in Eastern and Southern states *viz.* Andhra Pradesh, West Bengal, Uttar Pradesh, Bihar, Kerala, Orissa and Tamil Nadu. North-Eastern region of India has many cultivated and feral forms of taro. It is widely grown as a rainfed crop in the valley and Jhum area in entire North Eastern States of India. In Manipur taro is grown since time immemorial. It is cultivated for domestic consumption and market.

Intercropping can be seen as the practical application of diversity, competition and facilitation in arable cropping systems. The system of intercropping is to a great extent practiced in various ways based on the extent of spatial arrangement of the crops on the field (Oguzor, 2007). For subsistence farmers, greater stability in the production of food crops in intercropping systems is particularly meaningful, since this characteristic of the production system tends to ensure their sustainability and reduces the risk of total crop loss substantially.

Taro attains maturity after 6 months. It is planted at the spacing of 60 cm x 45 cm. It takes more than 3 to 4 months to develop enough canopies. Since taro is a long duration crop, the available sunlight, water and nutrients between rows can be efficiently utilized for short duration intercrops production. Keeping in view the present investigation has been taken up to study the yield of taro and assessing yield advantage of intercropping.

An experiment was conducted in the Horticultural Research Farm (HRF), Central Agricultural University, Imphal, during 2013-2014. The soil type is clay loam with a pH of 4.48. The experiment consisting of thirteen treatments and was laid out in randomized block design with three replications. The treatment consisted of sole and intercropping *viz*., T_1-Taro (sole), T_2- Taro + cowpea (1:1) ,T_3-Taro + cowpea (1:2), T_4-Taro+ French bean (1:1), T_5-Taro + French bean(1:2), T_6- Taro + turmeric (1:1), T_7-Taro + turmeric (1:2) , T_8-Taro + ginger (1:1), T_9 - Taro + ginger (1:2) , T_{10} - cowpea (sole), T_{11} - French bean (sole), T_{12}-turmeric (Sole), T_{13}- ginger (sole). It is planted at inter row spacing of 60cm x 45 cm(sole crop), 30cm x 15 cm (cowpea and french bean) and 35 cm x 20 cm (ginger and turmeric). The yield attributes and yield were recorded at harvest.

For assessing yield advantage, Taro Equivalent Yield and Land Equivalent Ratio were studied as given below.

1. Crop Equivalent Yield (CEY) was calculated as described by Reddy and Reddi (2008)

   $$CEY = \sum_{i=1}^{n} (Y1, ei)$$

   Where "Yi" is yield of component 'i' and "ei" is equivalent factor of component 'i' or price of crop 'i'.

2. Land Equivalent Ratio (LER) was calculated by the formula proposed by Willey and Osiru (1972)

   $$LER = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Yab is yield of species "a" in association with species "b" and Yba is the yield of species "b" in association with species "a". Yaa and Ybb represents the pure stand yield of species "a" and "b", respectively.

The findings of the experiment indicated that intercropping significantly influenced the yield attributes and yield of taro (Table 1 and 2). Data on yield attributes

Table 1. Effect of intercropping on yield attributes of taro at harvest

Treat-ments	Weight of corm per plant(g)	Weight of corms per plant(g)	Diameter of the corm (cm)	Diameter of the cormels (cm)	Whole plant fresh weight (g)	Whole plant dry weight (g)	Yield (t ha^{-1})
T_1	174.40 (13.22)	470.82 (21.71)	6.86	4.00	600.84 (24.51)	151.56 (12.32)	23.90 (4.94)
T_2	103.17 (10.18)	406.90 (20.14)	5.84	3.59	518.07 (22.76)	129.51 (11.40)	19.20 (4.44)
T_3	62.55 (7.93)	194.01 (13.93)	5.75	3.39	254.28 (15.95)	63.57 (8.00)	9.50 (3.16)
T_4	83.75 (9.14)	316.24 (17.79)	5.68	3.42	399.98 (20.00)	99.99 (10.02)	14.80 (3.90)
T_5	56.88 (7.57)	173.92 (13.14)	5.79	3.58	230.99 (15.15)	57.74 (7.60)	8.56 (3.00)
T_6	119.10 (10.91)	292.15 (17.10)	6.02	3.24	411.25 (20.28)	102.81 (10.16)	15.21 (3.96)
T_7	62.88 (7.94)	104.79 (10.21)	5.76	3.47	167.66 (12.67)	41.91 (6.49)	6.21 (2.58)
T_8	133.50 (11.56)	336.10 (18.34)	6.40	3.59	469.50 (21.67)	117.37 (10.85)	17.33 (4.22)
T_9	142.41 (11.88)	284.02 (16.86)	5.69	3.44	426.39 (20.64)	106.56 (10.34)	16.08 (4.07)
S.Ed (±)	0.67	0.84	0.18	0.17	0.86	0.44	0.16
CD (0.05)	1.42	1.79	0.38	0.36	1.83	0.93	0.34

Value in parenthesis are square root transformed values.

Table 2. Sole and intercrop yields, taro equivalent yield and land equivalent ratio under taro intercropping system

Treat-ments	Taro/Sole crop yield (t ha^{-1})	Intercrops yield (t ha^{-1})	Taro equivalent yield (t ha^{-1})	Land equivalent ratio
T_1	23.90	_	23.90	1.00
T_2	19.20	1.13	23.05	1.04
T_3	9.50	1.72	15.53	0.76
T_4	14.80	0.99	18.75	1.14
T_5	8.56	0.32	9.84	0.53
T_6	15.21	7.57	20.88	0.82
T_7	6.21	17.20	19.11	0.66
T_8	17.15	15.13	32.26	1.15
T_9	16.08	30.17	46.25	1.53
T_{10}	4.83	_	4.83	1.00
T_{11}	1.90	_	1.90	1.00
T_{12}	35.16	_	35.16	1.00
T_{13}	43.11	_	43.11	1.00
SD±	1.20	4.72	1.21	0.05
CD	2.48	9.74	2.50	0.10

of taro at harvest were found significant among the treatments (Table 1). Highest weight of corm per plant, cormel per plant, diameter of the corm, diameter of the cormels, whole plant fresh weight, whole plant dry weight at harvest were recorded from the taro sole crop. Maximum corm yield was recorded from taro sole crop which was significantly higher than the rest of the treatments. Among the intercropped treatments maximum intercrop yield was recorded from taro with single row of ginger. These results are in conformity with the finding of Amanullah et al. (2006) and Zarate et al. (2007). Thirumdasu et al. (2015) reported that poor yield performance in intercropping may be due to simultaneous structural growth and corm development for long period and thus demands simultaneous supply of assimilates to both sink and source, which may lead to intensive competition resulting in less translocation of food material for developing corm.

The present study has also shown significant differences among the treatments in respect to total taro equivalent

Table 3. Effect of intercropping on benefit cost ratio in taro cultivation

Treatments	Gross returns (₹)	Total cost of cultivation (₹)	Net returns (₹)	B:C ratio
T_1	478000.00	77031	400967	5.2
T_2	463101.13	84781	378320.13	4.46
T_3	310401.72	92531	217870.72	2.35
T_4	375200.99	78351	296849.99	3.78
T_5	196800.32	80031	116769.32	1.45
T_6	417757.57	80781	336976.57	4.17
T_7	382217.20	84531	297686.2	3.5
T_8	649215.13	89031	560184.13	6.29
T_9	925030.17	101031	823999.17	8.1
T_{10}	338100.00	67948	270152	3.97
T_{11}	152000.00	41414	110586	2.67
T_{12}	527550.00	106079	389486.40	3.9
T_{13}	646650.00	111865	534785	4.78

yield and land equivalent ratio as given in Table 2. The maximum total taro equivalent yield was recorded from taro with double row of ginger (46.25 t ha^{-1}). It could be due to combined effect of yield and price of both the crops whereas the minimum total taro equivalent yield was recorded from the treatment french bean as sole crop (1.90 t ha^{-1}). It indicated that intercropping of taro and ginger with optimum plant population ensured more efficient use of the natural and applied resources *viz.* soil, moisture, nutrients, solar energy and space leading to higher total taro equivalent yield. The results are in conformity with the finding of Islam et al. (2012). In similarity to the above results, the maximum land equivalent ratio (1.53) was also recorded from the taro with double row of ginger whereas the minimum land equivalent ratio (0.53) was recorded from taro with double row french bean. The results were in conformity with the finding of Adeyemi (1999) indicating high yield advantages and efficient land use. Similar findings were also reported by Sagos et al. (2004).

In the present study higher benefit cost ratio was recorded from taro with double row of ginger and followed by taro with single row of ginger (Table 3). However, the lowest benefit cost ratio was recorded from the treatment taro with double row of French bean (Table 3). These findings were in agreement with Seran and Brintha (2009). They viewed that yield and market value, plays important role than the number of crops that determine the economic returns.

From the study it can be concluded that to achieve higher yield and monetary advantage as well as efficient resource utilization, taro can be intercropped with ginger at 1:2 ratio.

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