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Growth and Yield performance of *Pandanus amaryllifolius* Roxb. Accessions under Andaman Padauk plantation in Andaman and Nicobar Islands, India.

I.Jaisankar*, Prabhu Pari, Abhilash, B. Augustine Jerard, T. Subramani, E. B. Chakurkar, and Arthi, N
ICAR-Central Island Agricultural Research Institute, Port Blair- 744 105 Andaman and Nicobar Islands, India.
***Corresponding author's E-mail:**- ijaisankar78@gmail.com*

Abstract

This study evaluated the growth, yield, and chemical composition of *P. amaryllifolius* collected from three geographical locations in the Andaman and Nicobar Islands under the Andaman Padauk (*Pterocarpus dalbergioides*) plantation system. The experiment was conducted at ICAR-CIARI, Port Blair, in a randomized block design with three replications. Results showed that, intercropping with Andaman Padauk significantly enhanced the growth parameters of *P. amaryllifolius*, including plant height (65.11 cm vs. 54.67 cm in monocrop), number of leaves (63 vs. 58), and leaf length (80.53 cm vs. 65.67 cm). Among the accessions, accession 3 (IC-0646223) exhibited the best performance with the highest plant height (67.17 cm), number of leaves (67.83), and leaf length (84.92 cm). Yield parameters such as total fresh leaf weight were also higher in the intercrop system (404.86 g/plant vs. 374.89 g/plant in monocrop). Chemical analysis revealed higher total chlorophyll content (8.56 vs. 7.82), water content (79.44% vs. 74.56%), and fiber content (3.62% vs. 3.45%) in the intercrop system. Micro-nutrient content, including zinc, manganese, magnesium, and iron, was also higher in the intercrop system. Accession 3 (IC-0646223) showed superior quality in terms of leaf chemical composition and micro-nutrient content. The study concludes that intercropping *P. amaryllifolius* under Andaman Padauk significantly enhances growth and yield, with accession 3 being the most promising for cultivation.

Key words: *Pandanus amaryllifolius; Intercropping; Andaman Padauk; Growth performance; Yield enhancement; Chemical composition.*

Introduction

The genus *Pandanus* from the family Pandanaceae comprises approximately 600 species that are widely distributed in tropical and subtropical regions (Takayama *et al*., 2002). Nineteen species of *Pandanus* are recorded in India (Karthikeyan *et al*., 1989), out of which *Pandanus tectorious* Parkinson, J. Voy, S. Seas and *Pandanus amaryllifolius* Roxb. are exploited commercially by flavour industry. In *P. tectorious*, the flowers are scented, while, in *P. amaryllifolius*, the leaves are scented (Keller, 2001; Bhattacharjee *et al*., 2005). *P. amaryllifolius* is a short shrub of about 1.2-1.5 m in height and 60 – 90 cm in width with a stout stem, often branched low down and has uniquely fragranced leaves of about 80 cm long and 5 cm wide. Flowering is rare and mostly male whereas, female flowers are unknown. The plant has aerial roots that are distinct not only in growth forms but also have root caps at the apex. Owing to the aromatic properties of leaves, the plant is cultivated as a spice in tropical peninsular countries and in certain coastal regions of India. The fragrance and aroma of leaves are due to the presence of 2-acetyl-pyrroline (2AP) which is the principal aromatic compound in basmati and other scented rice varieties. The epidermal papillae are bag-like structures present under the leaf surface that serve as a sink for 2-AP. Besides, the leaves are widely used as a flavouring agent in Southeast Asian foods such as bakery products (Wakte *et al.,* 2009) sweets, biryani and home cooking and natural food colour due to their increased chlorophyll content. The Pandan protein in the leaves is known to have magnificent potential for a healthy body also the Pandan leaf consists of several alkaloids like Norpandamarilactonine-A, -B, Pandamarilactone-1, Pandamarilactonine-A, -B, -C, Pandamarine, and Pandanamine. The juice extracted from the leaves is used for colouring cakes. The dried leaf powder is used for preparing traditional pandan-flavoured rice and Pandan flavoured coconut jam called 'Kaya' in Malaysia. The leaves have excellent health benefits when used in food and hence are exploited well in the flavour

industries. Besides its fragrant usage, it is also used medicinally as a diuretic, cardio-tonic and anti-diabetic. It is also used as a potential natural anti-oxidant.

Andaman padauk (*Pterocarpus dalbergioides* Roxb.), is an endemic tree belonging to the family Fabaceae. It is a large deciduous tree, mostly found in sedimentary soil consisting of sandstone and conglomerate in natural habitats. The mature trees have tall stature of about 80–127 ft, and buttress roots, and the species has been designated as the state tree of Andaman and Nicobar Islands. Andaman padauk wood is used for innumerable purposes; it varies in colour and is highly valued1. It is used for ornamental and decorative work and has emerged as the principal timber tree of the Andamans, triggering economic revolution in the Island (Rao, 2000). However, padauk tree population is affected by logging operations on the one hand and poor regeneration status on the other. The tree has been declared as a reserved tree due to the threat of extinction with poor natural seed germination status. FAO has also prioritized the conservation efforts considering the limited pattern of distribution and economic importance of the species (Rama Chandra Prasad *et al*., 2008). There is a need to identify the suitable crop combination under Padauk plantation to increase the productivity of the plantation as well as to obtain the intermittent yield from the long term plantations.

Sequential cropping is the growing of two or more crops in sequence on the same piece of land in a farming year, depending upon the number of crop grown in a year, it is called double, triple and quadruple cropping involving two, three and four crops respectively. Growing two or more crops in sequence on the same piece of field per year (one farming year is assumed to be 12 months except in very arid areas where one crop can be grown every 2 years) is known as sequential cropping (Andrews and Kassam, 1976). It is practiced in high rainfall area (>,750 mm) (ICRISAT, 1980). The research gap identified from the previous studies indicated that there is very little work reported on the cultivation as an intercrop. Considering unravels and the health benefits of this plant for society, our present research was designed to study the growth, yield, physical and chemical composition of *P. amaryllifolius* collected from three geographical locations of Andaman and Nicobar Islands, India under the Andaman Padauk plantation.

Material and Methods

The trial was conducted at ICAR- Central Island Agricultural Research Institute, Port Blair, India in 2022-24. Similar to most of the tropical islands, Andaman Islands have tropical to humid tropical climate with distinct dry and wet season. The islands receive copious amounts of annual rainfall averaging 2900–3100 mm with the mean maximum and mean minimum temperature of 32°C and 22°C, respectively. The relative humidity varies from 68 to 86%. The experiment was laid out in randomized block design with three replications. The intercrop of *P. amaryllifolius* collected from various part of Andaman and Nicobar Islands (Table. 1) were planted as an intercrop in the existing four years old Andaman Padauk plantation with the spacing of 60 cm x 60 cm, mono crop as a control for all three accessions. The mean height of the padauk tree was 3.8 m with 6.2 cm DBH. Soil nutrient of the intercropped area was available nitrogen 87 kg/ha, phosphorous 37.60 kg/ha, potassium 67.50 kg/ha, PH 6.25, EC ranged 0.3 (ds/m) and OC 1.20 (%).

The growth and yield parameters viz., height if the plant, number of leaves, length of the leaf (cm), width of the leaf (cm) and total fresh weight of the leaves (g) were recorded similarly the leaf physical and chemical properties like total chlorophyll content (Kavitha & Indira, 2016), water % and fibre % were also recorded. The micronutrients *viz.* zinc, manganese, magnesium, potassium, iron and copper were analysed by atomic absorption spectrophotometer (Shimandzu Scientific Instruments, Inc. Columbia, USA). 10 g of sample was converted to ash using muffle furnace and dissolved in Millipore water for dilution and the diluted samples were then read on the AAS (Singh *et al*., 2011). Growth, yield parameters and analytical data recorded in the study were subjected to statistical analysis (Panse and Sukhatme, 1985).

Table1. Details of Pandan Accessions collected from Andaman and Nicobar Islands

Accession numbers and place of collection	Island group	Latitude (N)	Longitude (E)	Altitude (mMSL)
Acc. 1 Rangat	Middle Andaman	12º35´17.01´´	92º57´32.06´´	7
Acc. 2 Garacharma	South Andaman	11º37´51.36´´	92 º 44´02.82´´	10
Acc. 3 Malacca (IC-0646223)	Nicobar	9º10´11.14´´	92º49´45.46´´	6

Results and Discussion

Growth and Yield Performance

The growth and yield parameters of *P. amaryllifolius* under different cropping systems were analyzed, and significant variations were observed among the accessions and cropping systems.

The leaf fresh weight of *Pandanus amaryllifolius* varied significantly between different cropping systems and accessions over the two years (2022-2024). In the first year (2022-23), (Table 2.) the highest fresh weight was recorded for the mono crop of accession 3 (T_3C_3) at 370.42 g/plant, followed by the intercrop of accession 3 (T_6C_3) at 378.00 g/plant. The intercrop of accession 2 (T_5C_2) and accession 1 (T_4C_1) showed moderate fresh weights of 272.00 g/plant and 257.33 g/plant, respectively, while the mono crops of accession 1 (T_1C_1) and accession 2 (T_2C_2) had the lowest fresh weights at 259.00 g/plant and 254.00 g/plant, respectively. In the second year (2023-24), the trend remained consistent, with the intercrop of accession 3 (T_6C_3) showing the highest fresh weight at 430.00 g/plant, followed by the mono crop of accession 3 (T_3C_3) at 412.00 g/plant. The intercrop of accession 2 (T_5C_2) and accession 1 (T_4C_1) had fresh weights of 399.00 g/plant and 386.00 g/plant, respectively. The mono crops of accession 2 (T_2C_2) and accession 1 (T_1C_1) had the lowest fresh weights at 363.00 g/plant and 350.00 g/plant, respectively. The statistical analysis indicated that the differences in leaf fresh weights between treatments were significant, with critical difference (CD) values of 73.475 g/plant for 2022-23 and 49.133 g/plant for 2023-24. The standard error of the mean (SE(m)) was 23.02 g/plant for 2022-23 and 15.394 g/plant for 2023-24, with coefficients of variation (C.V.) of 13.362% and 6.838%, respectively. These results suggest that the intercrop system, particularly with accession 3, significantly enhances the leaf fresh weight of *P. amaryllifolius* compared to the mono cropping system.

Table 2. Leaf fresh weight of *P. amaryllifolius* under different cropping system

Treatments	Leaf fresh weight (2022-23) (g/plant/year)	Leaf fresh weight (2023-24) (g/plant/year)
T_1C_1	259.00	350.00
T_2C_2	254.00	363.00
T_3C_3	370.42	412.00
T_4C_1	257.33	386.00
T_5C_2	272.00	399.00
T_6C_3	378.00	430.00
CD	73.475	49.133
SE(m)	23.02	15.394
C.V.	13.362	6.838

T_1C_1: Mono crop acc. 1, T_2C_2: Mono crop acc. 2, T_3C_3: Mono crop acc. 3, T_4C_1: Inter crop acc. 1, T_5C_2: Inter crop acc. 2, T_6C_3: Inter crop acc. 3

The height of plants grown as intercrop under Andaman Padauk plantation was significantly higher (65.11 cm) compared to those grown as a mono crop (54.67 cm) (Table 3). Similarly, the number of leaves per plant and leaf length were greater in the intercrop system, with values of 63 leaves and 80.53 cm respectively, compared to 58 leaves and 65.67 cm in the mono cropping system. The width of the leaves was slightly higher in the intercrop system (4.42 cm) compared to the mono crop (4.31 cm), though this difference was not statistically significant.

Among the accessions, accession 3 (IC-0646223) exhibited the highest plant height (67.17 cm), number of leaves (67.83), and leaf length (84.92 cm), indicating superior growth performance. The width of leaves in accession 3 (IC-0646223) was also the highest (4.57 cm), which contributed to its overall better performance.

Fig.1a. Leaf characters of *P. amaryllifolius* accessions 1.b Performance of *P. amaryllifolius* accessions under Andaman Padauk

Table 3. Growth and yield parameters of *P. amaryllifolius* accessions under different cropping system

Parameter	Height	No of leaves	Leaf length	Leaf width	Single leaf weight	Total fresh weight/ plant
Cropping						
Open	54.67	58.22	65.67	4.31	6.67	374.89
Intercrop	65.11	63.44	80.53	4.42	9.18	404.86
C.D.	**N/A**	**4.20**	**10.345**	**N/A**	**1.349**	**28.367**
SE(d)	**6.043**	**1.862**	**4.584**	**0.083**	**0.598**	**12.569**
SE(m)	**4.273**	**1.317**	**3.241**	**0.058**	**0.423**	**8.887**
Accession						
Acc 1	56.17	58.33	63.85	4.23	7.10	368.00
Acc 2	56.33	56.33	70.53	4.30	7.10	380.67
Acc 3	67.17	67.83	84.92	4.57	9.54	421.00
C.D.	**N/A**	**5.147**	**12.67**	**0.228**	**1.652**	**34.742**
SE(d)	**7.402**	**2.28**	**5.614**	**0.101**	**0.732**	**15.394**
SE(m)	**5.234**	**1.612**	**3.97**	**0.071**	**0.517**	**10.885**
Interaction (Cropping X Accession)						
C.D.	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
SE(d)	**10.47**	**3.225**	**7.939**	**0.143**	**1.035**	**21.77**
SE(m)	**7.402**	**2.28**	**5.614**	**0.101**	**0.732**	**15.394**

Leaf Chemical Composition

The leaf chemical composition varied significantly between cropping systems and among the accessions. The total chlorophyll content was higher in plants grown as intercrop (8.56) compared to mono crop (7.82) (Table 4). The water content was also higher in the intercrop system (79.44%) compared to the mono crop (74.56%). Fibre content showed a marginal increase in the intercrop system (3.62%) compared to the mono crop (3.45%). Among the accessions, accession 3 (IC-0646223) had the highest water content (81.00%), fibre content (3.82%), and total chlorophyll content (8.75), indicating its superior quality in terms of leaf chemical composition.

Table 4. Leaf chemical parameters of *P. amaryllifolius* accessions under different cropping system

Parameter	Water %	Fibre %	Total chlorophyll
Cropping			
Open	74.56	3.45	7.82
Intercrop	79.44	3.62	8.56
C.D.	**N/A**	**N/A**	**0.505**
SE(d)	**2.463**	**0.282**	**0.224**
SE(m)	**1.742**	**0.2**	**0.158**
Accession			
Acc 1	75.00	3.46	7.82
Acc 2	75.00	3.33	8.00
Acc 3	81.00	3.82	8.75
C.D.	**N/A**	**N/A**	**0.619**
SE(d)	**3.017**	**0.346**	**0.274**
SE(m)	**2.133**	**0.245**	**0.194**
Interaction (Cropping X Accession)			
C.D.	**N/A**	**N/A**	**N/A**
SE(d)	**4.266**	**0.489**	**0.388**
SE(m)	**3.017**	**0.346**	**0.274**

Micro-Nutrient Analysis

The micro-nutrient content of the leaves also showed significant variations between cropping systems and among accessions. The zinc (Zn) content was higher in the intercrop system (13.56 mg/kg) compared to the mono crop (11.82 mg/kg). (Table 4.) Similar observation for manganese (Mn), magnesium (Mg), iron (Fe), and copper (Cu), with higher values in the intercrop system. Among the accessions, Accession 3 (IC-0646223) showed the highest levels of all analyzed micro-nutrients, including zinc (13.85 mg/kg), manganese (18.52 mg/kg), magnesium (948.17 mg/kg), potassium (411.00 mg/kg), iron (80.07 mg/kg), and copper (26.47 mg/kg). (Table 5.)

Table 5.Micro nutrients of *P. amaryllifolius* accessions under different cropping system

Parameter	Zn	Mn	Mg	K	Fe	Cu
Cropping						
Open	11.82	15.71	741.11	379.56	70.67	21.44
Intercrop	13.56	17.43	947.83	379.22	77.62	27.78
C.D.	**0.84**	**N/A**	**90.4**	**N/A**	**N/A**	**2.715**
SE(d)	**0.372**	**0.979**	**40.054**	**20.478**	**5.257**	**1.203**
SE(m)	**0.263**	**0.692**	**28.323**	**14.48**	**3.717**	**0.851**
Accession						
Acc 1	11.67	15.32	795.17	353.83	71.83	24
Acc 2	12.57	15.87	790.08	373.33	70.53	23.38
Acc 3	13.85	18.52	948.17	411	80.07	26.47
C.D.	**1.029**	**N/A**	**110.717**	**N/A**	**N/A**	**N/A**
SE(d)	**0.456**	**1.199**	**49.056**	**25.08**	**6.438**	**1.474**
SE(m)	**0.322**	**0.848**	**34.688**	**17.734**	**4.553**	**1.042**
Interaction (Cropping X Accession)						
C.D.	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
SE(d)	**0.645**	**1.696**	**69.376**	**35.469**	**9.105**	**2.084**
SE(m)	**0.456**	**1.199**	**49.056**	**25.08**	**6.438**	**1.474**

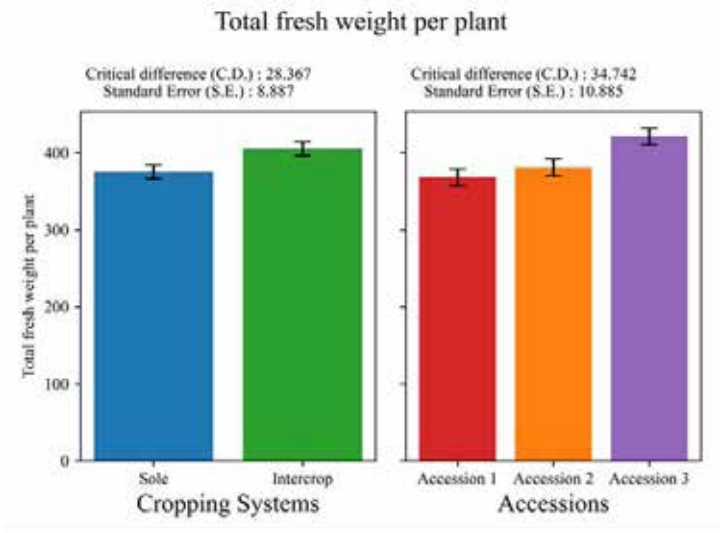

Figure 2. Total leaf fresh weight of *P. amaryllifolius* under different cropping system

The statistical analysis indicated that significant differences in growth, yield, and chemical composition parameters between the cropping systems and among the accessions. (Figure 2.) The intercrop system significantly enhanced the growth and yield parameters, indicating a beneficial effect of the Andaman Padauk shade. The intercrop system with Andaman Padauk having positive effect in growth of the *P. amaryllifolius*. similar observations were noticed by(Zhong et al.2022). The soil microbial diversity of arecanut and panadan intercrop system were significantly increased. The superior performance of accession 3 (IC-0646223) in terms of growth, yield, and leaf quality parameters suggests its potential as the most promising accession for cultivation under Andaman Padauk plantations.

Conclusion

The study demonstrated that intercropping *P. amaryllifolius* under Andaman Padauk plantations significantly enhances its growth and yield performance. Among the accessions, Accession 3 (IC-0646223) exhibited the best performance, making it a suitable candidate for cultivation in the Andaman and Nicobar Islands. The intercrop system not only improved the quantitative yield but also enhanced the qualitative traits of the leaves, making it a viable agronomic practice for sustainable production.

Declarations

Ethical approval: This article contains no studies on human or animal objects

Competing Interests: The authors declare that they have no competing interests.

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