Note

Comparison of *Azolla mexicana* and N and P fertilization on paddy taro (*Colocasia esculenta*) yield

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The yields of taro intercropped with *Azolla* and under slowly flowing water (F) and taro intercropped with *Azolla* after incorporation of *Azolla* into mud (B) were compared with N and P fertilization and a control in Mangaia, The Cook Islands. Significantly, higher yields were obtained for treatments F and B than for the chemical fertilization treatment, which had a minimal effect on yield. The control produced 53.4 and 64.7% of yield of treatments F and B, respectively.

Keywords: Incorporation; Intercropped; Decomposition; Leaching; Fixation; Inoculation; Canopy

The importance of *Azolla mexicana* as a biofertilizer in paddy rice production in China, Vietnam, and Senegal is well documented. It also serves as fish food and animal fodder (Watanabe *et al.*, 1977; Lumpkin and Plucknett, 1980, 1982; IRRI, 1987; Ventura *et al.*, 1987; FAO, 1989). In the Phillipines, a programme to meet 50% of the N requirement for paddy rice production through the application of *Azolla* as a green manure is in progress (IRRI, 1987).

Less attention has been given to the benefits of *Azolla* in paddy taro production. This trial was therefore undertaken to compare the effect of *Azolla* with chemical fertilization on the yields of paddy taro.

Materials and Methods

The soils of Mangaia are classified as Latosols, Lithosols, Alluvium, and Colluvium. Latosols are the most important group and are widely distributed throughout the island.

The experiment was carried out in a paddy taro field (31.9 m × 10.5 m). The soil is of volcanic origin, reddish-brown weathered from basalt. It has a strongly developed structure, friable, well drained, and deep with low water-holding capacity. The pH was 6.1. Available phosphate was low and cation-exchange capacity of the soil was medium.

The design was a randomised block (RBD) with six treatments and five replications. The treatments were (A) Control (no chemical fertilizer, no *Azolla*); (B) *Azolla* incorporated into mud at 20 t ha^{-1} and also applied to the soil surface at 0.5 kg m^{-2} at planting of taro; (C) 20 kg N ha^{-1} (ammonium sulphate); (D) 40 kg N ha^{-1} (ammonium sulphate); (E) *Azolla* applied to the soil surface at 0.5 kg m^{-2} plus 10 kg P ha^{-1} (triple superphosphate); and (F) *Azolla* intercropped and under slowly flowing water.

The land had been fallowed for six years. At the time of clearing for the trial, it supported a mixture of tall grasses and shrubs. Water was drained from the field and the land was cleared with the help of bush knives (machetes) The seed bed was prepared by trampling (foot), use of a rotary hand-pushed plough, and bamboo sticks.

Taro setts, variety Niue (40–80 g in size), were planted on 23 January 1990. Inter-row and intra-row distances were 1.0 m and 0.7 m, respectively. At planting *Azolla* was incorporated and (or) applied to the surface, and chemical fertilizers were broadcasted at rates indicated above.

During the growing season and at harvest (on four marked plants from each plot) petiole length, leaf area, fresh weight of plant tops, corm fresh weight separated to mother corm and suckers, and economic value of corms were taken.

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Results and Discussion

Plant growth in general

At its juvenile stage (30 days after planting) taro encountered cyclone 'Pani'; however, plant recovery was quick. Later, in the growing season, plots were infested with the notorious weed *Ludwingia ascendens* which had the capacity to depress *Azolla*. Hand weeding was performed twice. Throughout the growing period both height and leaf area were retarded. Harvest was performed 48 weeks after planting (WAP).

Petiole length

Petiole length increased slowly until 28 WAP and decreased thereafter for all treatments. Ezumah and Plucknett (1977), Sivan (1980), and Wilson (1984a) reported the highest shoot growth for *Colocasia* at 16–24 WAP. In this trial differences in height among treatments became evident at 16 WAP. Thereafter treatment B produced significantly taller petioles than other treatments except treatment A (control).

Leaf area

Leaf area throughout the season was small. This might be due to the small (40–80 g) sett size used for planting, cyclone 'Pani,' and weeds. According to Kagbo *et al.* (1979) the optimal sett size for *Colocasia* is 100–120 g.

From 20–40 WAP treatment B produced the highest leaf area. This was significantly higher than the other treatments apart from treatment A which experienced a larger flow of fresh water, the temperature of which might have been lower, and dissolved and eroded nutrients from uplands might have improved the fertility of the soil. *Azolla* absorbs its nutrients from the water in which it grows (Lumpkin and Plucknett, 1982). From about 30 WAP onwards, the new leaves were not as large as the earlier leaves.

Harvest data

Weight of total plant tops, mother corms, and total corms are presented in Table 1. There was a positive relationship between leaf production and corm yield. According to Enyi (1977) and Abit and Alferez (1980) leaf area is closely related to corm and cormel yield. For total corm fresh weight, treatment F produced a significantly higher yield than treatments A, C, D, and E.

Treatment A (control) which received greater quantities of freshwater than treatments B, C, D, and E produced significantly higher plant tops and corm yield than treatments C, D, and E. Because setts of 50–100 g and taro leaves can be sold for planting and for food preparation the production of higher plant tops by treatments A, B, and F has an economic advantage for the farmers.

The yield of treatment A (control) was 53.4% of the total corm fresh weight of treatment F and 64.7% of that of treatment B. This is in agreement with Lumpkin and Plucknett (1982) who reported yield in control plots that were 10–100% of the yield of plots treated with *Azolla*.

At harvest, corms were divided into marketable and nonmarketable corms. All mother corms were marketable while sucker corms for all treatments were unmarketable. Wilson (1984b) indicated that *Colocasia* under flooded conditions in Hawaii gave higher sucker yields. This might be due to the higher fertilizer application. Under upland conditions *Colocasia* does not produce marketable sucker corms.

Weights of marketable and unmarketable corms are presented in Table 2. The rank of both marketable and unmarketable corms were as follows: F > B > A > C > D > E. Therefore, treatments with *Azolla* produced higher sucker yield than without *Azolla* and treatments under chemical fertilizer.

Previous studies indicate that *Azolla* can produce more than 2 kg N ha^{-1} day^{-1}, which is equivalent to more than 10 kg of ammonium sulphate (Lumpkin and Plucknett, 1982). IRRI (1987) reported *Azolla* production of 450 kg N ha^{-1} yr^{-1}.

According to Lumpkin and Plucknett (1982) the range of nutrient composition of *Azolla* on a dry weight basis for N was 1.96–5.3%, P 0.16–0.59%, and K 0.31–5.97%. Comparable N (3.55%), P (0.20%), and K (2.85%) elemen-

Table 1 Total plant tops, mother corm fresh weight, and total corm fresh weight (kg ha^{-1})

Treatments	Total plant tops at harvest	Mother corm fresh wt	Total corm wt
A	2 623.7 a	4 415.8 abc	5 471.9 bc
B	2 514.2 ab	5 790.3 ab	8 445.7 ab
C	729.9 b	3 437.5 bc	4 178.4 c
D	823.8 b	3 036.8 bc	3 651.0 c
E	561.2 c	1 871.3 c	2 102.3 c
F	4 275.9 a	7 185.4 a	10 235.2 a

Means followed by the same letter do not differ significantly by LSD (P = 0.05)

Table 2 Weight of marketable and unmarketable corms at harvest (kg ha^{-1})

Treatments	Marketable	Nonmarketable	Total
A	4 415.8	1 056.1	5 472.0
B	5 790.3	2 655.4	8 445.7
C	3 437.3	740.5	4 178.4
D	3 036.8	614.2	3 651.0
E	1 871.3	230.9	2 102.3
F	7 185.4	3 049.8	10 235.2

tal composition was obtained from *Azolla mexicana* in Mangaia, The Cook Islands.

The N content of *Azolla* (3.5%) was higher than that of alfalfa (*Medicago sativa*; 2.8%) and soya bean (*Glycine max*; 2.9%) (Lumpkin and Plucknett, 1980). *Azolla* also contained high levels of K.

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