How Farmers Manage Taro Beetle Infestations in the Perhumid Lowlands of Papua New Guinea

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Abstract: Taro beetle is a serious pest of taro in Papua New Guinea (PNG). Adult feeding renders corms inedible and feeding cavities facilitate secondary fungal rots, and may cause immature plant death. Although it is a serious pest, little is known about farmers' knowledge of the beetle and its control in PNG. We investigated the level of farmers' knowledge and the approaches engaged to manage the pest, using a semi-structured questionnaire. Almost all the farmers are knowledgeable of taro beetle and symptoms of infestations associated with it. Although high proportion (92%) cultivate taro under rain-fed conditions, only 8% of the farmers have abandoned its cultivation due to previous experiences in recurring infestation by the beetle. Many farmers managed beetle infestation by combining non-chemical means such as cultural and agronomic methods, while only 16% integrated non-chemical methods and insecticides, particularly pyrethroid or organophosphate insecticides. The level of training on pest control affected their present practices in controlling taro beetle. Trainings on taro beetle management practices suitable for resource-poor farmers, and their integration to the current practices are necessary for sustainable taro production in PNG.

Keywords: Training-extension · *Colocasia esculenta* · *Papuana woodlarkiana* · Pest Management

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1. INTRODUCTION

Taro, *Colocasia esculenta*, is the third most important root crop cultivated in Papua New Guinea (PNG) for its edible corms primarily and leaves. It has been around in the island of New Guinea for thousands of years (Bourke,2004). The food crop has great cultural significance and contributes to food security in the rural areas of PNG as well as other Pacific Islands (Bourke, 2012; Gendua, 2000; Georgeou, 2022).

Global estimates have reported that PNG is ranked fifth in taro production (FAO , 2022). Domestic cultivation and production, especially in the Morobe province, is uncontestably the highest in PNG, hence large number of taro accessions (19% of total collections from 15 provinces) were collected in this part of PNG under the TaroGen project (Bourke, 2012; Gendua, 2000; Singh, 2001), and current international exports have been initiated from this province[1,2]. In this part of PNG, farmers still maintain the local or farmer taro varieties, as corms from these varieties are in high demand in the local markets (Unpublished data). Taro in PNG is usually grown under rain-fed conditions, principally from huli, the pseudostem from which the corm is cut off, and occasionally from suckers as planting materials (Bourke, 2012; Onwueme, 1999).

Despite many years of research into developing and release of improved taro varieties (Guaf, 2006), almost all of these improved varieties including farmer varieties are equally highly susceptible to the taro beetles, *Papuana* spp. and *Eucopidocaulus* sp. (Coleoptera: Scarabaeidae: Dynastinae) (Lal, 2008; Thistleton, 2001; Yalu, 2009). Adult beetles are black in colour 18±2 mm in length; male adult beetle is easily distinguished by the presence of prominent dorsal horn on head and pronotum, and a pair of short pronotal horns (Macfarlane, 1987). Females visit taro gardens and feed on corms, thereafter attract males for mating and further feeding (Macfarlane, 1987; Thistleton, 1995). Adults feed by creating tunnels and burrows into developing corms, and the cavities produced entry points for fungal secondary infection, resulting in inedible corms and plant death at high infestations (Macfarlane, 1987; Thistleton, 1995). Mated female beetle thereafter flies to nearby heaps of debris, dead stumps and logs, and *Imperata cylindrica* for egg oviposition (Lal, 2008; Thistleton, 2001 ; Yalu, 2009).

The last farmer training to minimize the taro beetle problem occurred in the late 1990s and 2000s in the East New Britain and Morobe provinces, which were conducted by the National Agricultural Research Institute (NARI) under the European Union funding through NARI and the Secretariat of the Pacific Community (Lal, 2008). These trainings were based on farmer-participatory research and taro production, and taro beetle management with the use of insecticides such as Karate® (pyrethroid) and Imidachloprid® (nicotinoid) (Lal, 2008). Individual farmers have indicated that the lack of knowledge to reduce taro beetle infestation now exists, especially in Morobe province (Unpublished data).

This study reports on farmer surveys that were conducted in Morobe province to investigate if taro beetle is still an issue in selected districts, and to explore farmers' different approaches towards managing the beetle infestations.

2. MATERIALS AND METHODS

2.1. Study area descriptions

Three districts (Huon-Gulf, Lae and Nawaeb) of Morobe Province (Fig. 1) were selected for this survey in 2021-2022. These districts were selected out of the 10 provincial districts because constant supply of taro for Lae City local market and distributions into the local markets in the capital city, Port Moresby, originate from these districts. The districts are categorized under the Lowland Perhumid Agro-ecological zone of PNG with characteristic average annual rainfalls of 2000-3500 mm (McAlpine, 1989). Taro in these areas is cultivated under rain-fed conditions all year round. Farming is subsistence and family-oriented, meaning that labour from land preparation to marketing is done by the household head and his/her family members.

[1] https://business.pngfacts.com/2023/11/papua-new-guinea-exports-taros-to.html

[2] https://www.thenational.com.pg/png-taro-for-nz-market/

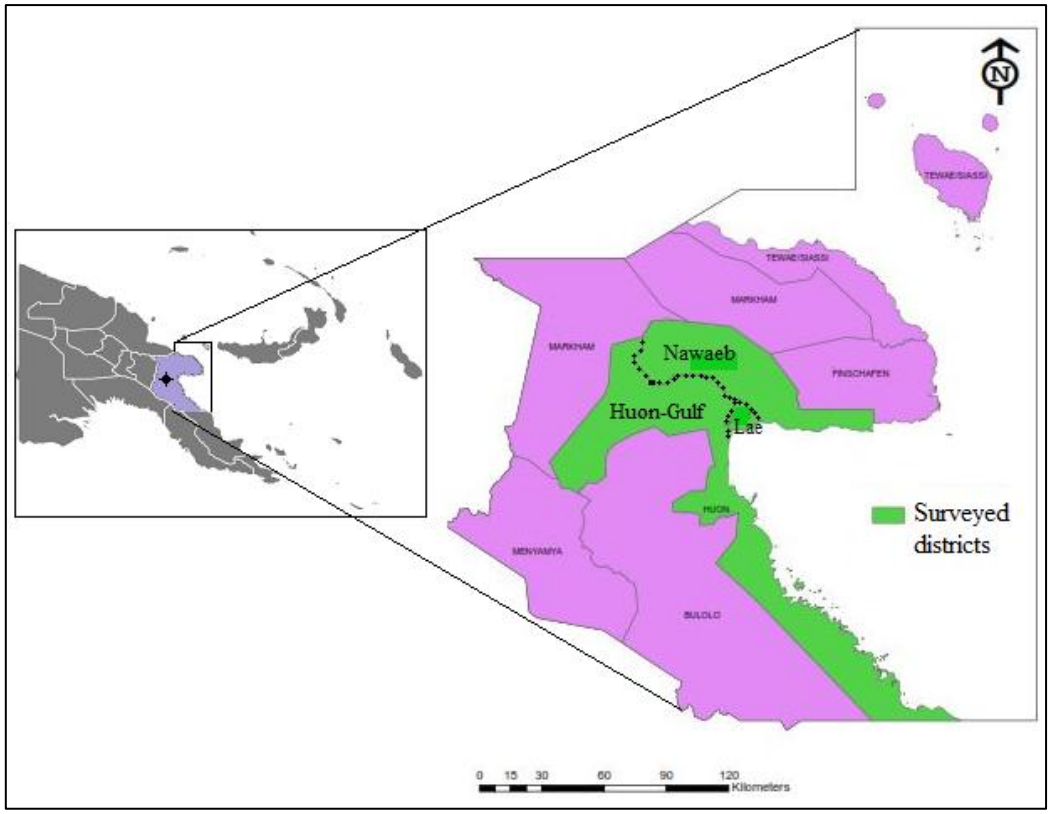

Fig. 1. Map of Papua New Guinea and surveyed districts in the Morobe province.

2.2. Sampling procedures

Initially, informal group discussions (10-15 people), mostly taro sellers, were carried out in the Lae city market twice; primarily to gain better understanding of the production of taro and to develop a survey questionnaire. We interviewed 155 farmers in the 3 districts between November 2021 and July 2022. A semi-structured questionnaire was used to conduct oral interviews and questionnaire using *Tok Pisin*, an English-based creole regarded as one of the 3 national languages in PNG (Kik, 2021). Prior to conducting interviews, the questionnaire was pre-tested with 10 farmers then revised to guarantee that relevant information was collected from taro farmers.

The first section of the questionnaire collected farmer's socio-demographic information that may have potentially influenced perception and practices farmers used to manage taro beetle problem. In the second section, closed- and open-ended questions section were associated with farmers' perception of taro beetle as a pest, and individual experiences on damage and yield loss due to taro beetle infestation.

In the third section, information on farmers' management practices of taro beetle was collected. The last section relates to farmers' knowledge on the use of insecticides, and regulations pertaining to their use. In the Huon-Gulf district, 50 farmers were interviewed at the main city market; another 50 farmers from the Lae district were interviewed in Poahom Station, Division of Agriculture and Livestock; and in the main city market. In the Nawaeb district, 55 farmers were interviewed in Poahom and in the main city market.

2.3. Data collection and analysis

Topics in the questionnaire were in relation to demographic characteristics of respondents, taro beetle knowledge and pest problems, different approaches engaged to control beetle infestation in gardens, and previous trainings attended.

Descriptive statistics were used to analyze data on demographics and farm charactristics. For categorical data, Chi-square tests were performed to determine the associations between training and districts, knowledge of

taro beetle and its control, and knowledge of insecticides. Student *t*-test was used to assess the differences in age for farmers that attended trainings and those who have not attended a training.

Raw data were first collated in Microsoft Windows Excel. All the analyses were performed in Statistical Package for Social Sciences for Windows (v. 13.0, 2004) and Microsoft Windows Excel.

3. RESULTS

3.1. Household demographics, farm characteristics and taro cultivation

Majority of farmers interviewed from the three districts were women (60%) with an average age of 39. Many farmers (83.3%) have completed formal education in primary school level. The average farmer family size is 5 and committed at least 0.5 ha of their land for taro cultivation under rain-fed conditions (Table 1). At the time of the survey, farmers earned an annual average income of PGK935.20 (US$256.00) from taro corm sales at the main city market and local or roadside markets. Aside from taro, farmers also had other sources of income, of which root crops and leafy vegetables were the predominant alternative cash crops (Fig. 2).

All farmers cultivate local taro cultivars (Lae Green, Lae Red, Lae Yellow, Numkowec and Tasma Lae), but sparingly cultivate NT varieties. The predominant local cultivar is the Numkowec with yellowish fresh.The survey revealed that of the 155 farmers interviewed, 92% (142) cultivate taro while 8% (13) ceased its cultivation.

Table 1. Summary of socio-economic background of farmers interviewed in 3 districts of Morobe province.

Socio-economic characteristics	**Summary of responses, *n* = 155**
Sex (% total respondent)	
Male	40.0
Female	60.0
Age (% total respondent)	
20 – 30	21.8
31 – 40	47.3
41 – 50	21.8
51 – 60	7.3
>60	1.8
Level of education (% total respondent)	
Illiterate	3.6
Primary (Grades 1-8)	83.6
High school (9-10)	7.3
Secondary school (11-12)	5.5
Average family size	5.0
Average land holding (ha)	0.51
Average income from taro (PGK)	935.20

3.2. Farmer training, knowledge of taro beetle and its control

In the interviews, individual farmers were asked if they have gained training on taro farming and beetle control. Interestingly, only 19% of the farmers interviewed have attended a training; with high proportion from Huon-Gulf district followed by Nawaeb and Lae districts [($x^2(3) = 8.50$, $P = 0.03$] (Table 2). The training include taro beetle description, damage symptom identification and control measures to limit infestations. There was statistically

significant average age difference between farmers who have attended a training and those who have not (t_{54} = 11.20, $P < 0.01$) (Table 2). On average, farmers who have attended training were older than those who have not attended a training. Since some farmers have ceased taro cultivation, we tested if their decision to cease taro cultivation was influenced by lack of training. There was no association between training on taro beetle and farmers' decision to cease cultivation of taro (x^2 (1) = 0.39, P = 0.73) (Table 2).

Table 2. Farmers' training, knowledge of taro beetle and insecticide use from 3 districts of Morobe province.

Source of data	All districts (%)	Nawaeb (%)	Huon-Gulf (%)	Lae (%)	Significance
Training on taro beetle					
Training		8	9	2	0.03[a]
No training		51	46	49	
Training vs. taro cultivation					
Training+Continued	23				NS[a]
Training+Ceased	5				
No training+Continued	65				
No training+Ceased	8				
Average age					
Training	43				< 0.01[b]
No training	31				
Knowledge of taro beetle					
Strong		8	7	2	< 0.001[a]
Moderate		12	26	27	
Weak		11	3	3	
*Chemical use for taro beetle**					
Non-chemical control		50	22	12	< 0.01[a]
Insecticide		5	9	2	

[a]Significance test using Chi-square test, [b]significance test with Student *t*-test, NS = not significant.
*farmers who have ceased taro cultivation were excluded in this analysis.

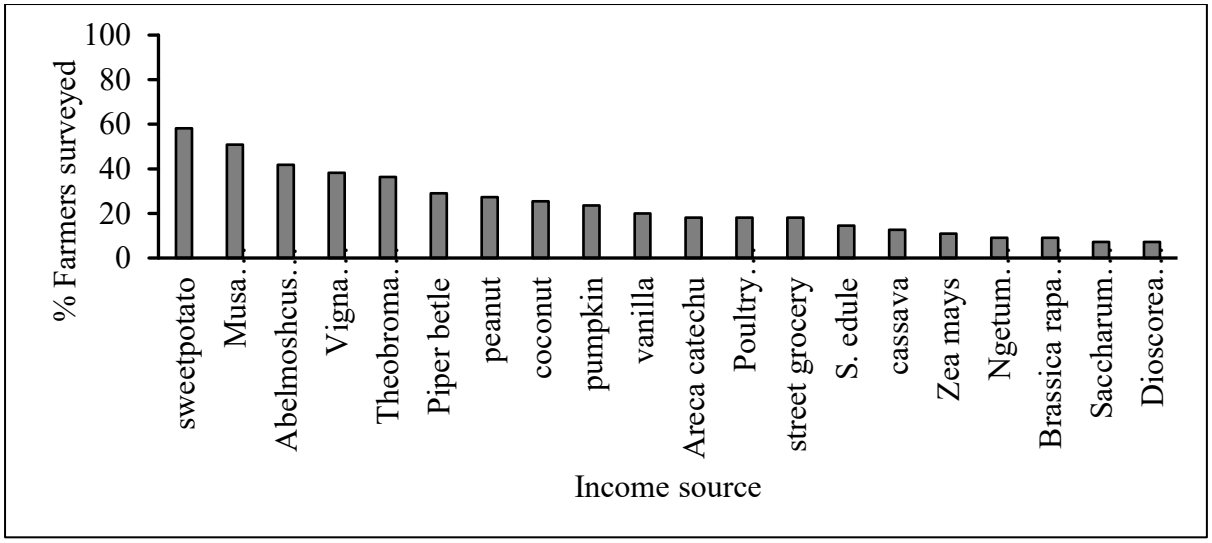

Fig 1. Alternative sources of income by farmers in the districts of Morobe province aside from cultivation of taro. N = 180.

Farmers were asked whether or not they have some knowledge of the beetle pest. Almost all the farmers (65%) indicated that they have moderate knowledge of taro beetle and the infestation symptoms. However, only 17% of the farmers were able to provide brief explanations of the pest; distinguishing male beetle from female beetle by the presence of dorsal horn on males, where the female beetles oviposit, and its alternative host plants which includes bananas, canna lily (*Canna indica*) and betelnut palm (*Areca catechu*) (x^2 (4) = 31.71, $P < 0.001$).

Two types of taro cultivation practices were identified; shifting cultivation whereby taro is grown for 2-3 years on a piece of land before abandoning the site and cutting/clearing of new site, usually primary forest. With continuous cultivation, taro is grown on a piece of land for 2-3 years followed by 1-2 years of fallow or cultivation of crops other than taro. In each case, 55% farmers practiced shifting cultivation and 45% farmers practiced continuous cultivation.

Figure 6 presents beetle control approaches used by farmers in different types of taro cultivation. Cultural practices such as weeding, garden sanitation by tree stump removal and the use of clean planting materials were common practices adopted by farmers in both types of taro cultivation. On the other hand, garden restrictions is mostly used by farmers in shifting cultivation. Crop rotation, followed by fallowing, intercropping and fertilization are primarily used by farmers practicing continuous cultivation. 16% of respondents use insecticides during the crop cycle (Table 2). The use of insecticides during crop cycle was significantly associated with training gained [x^2 (1) = 38.64, $P < 0.001$]. More farmers (53%) who attended a training used insecticides, while only 6% use insecticide without any training (Fig 4). When farmers were asked about the effects of insecticide use, all (100%) responded by indicating the effects on applicator.

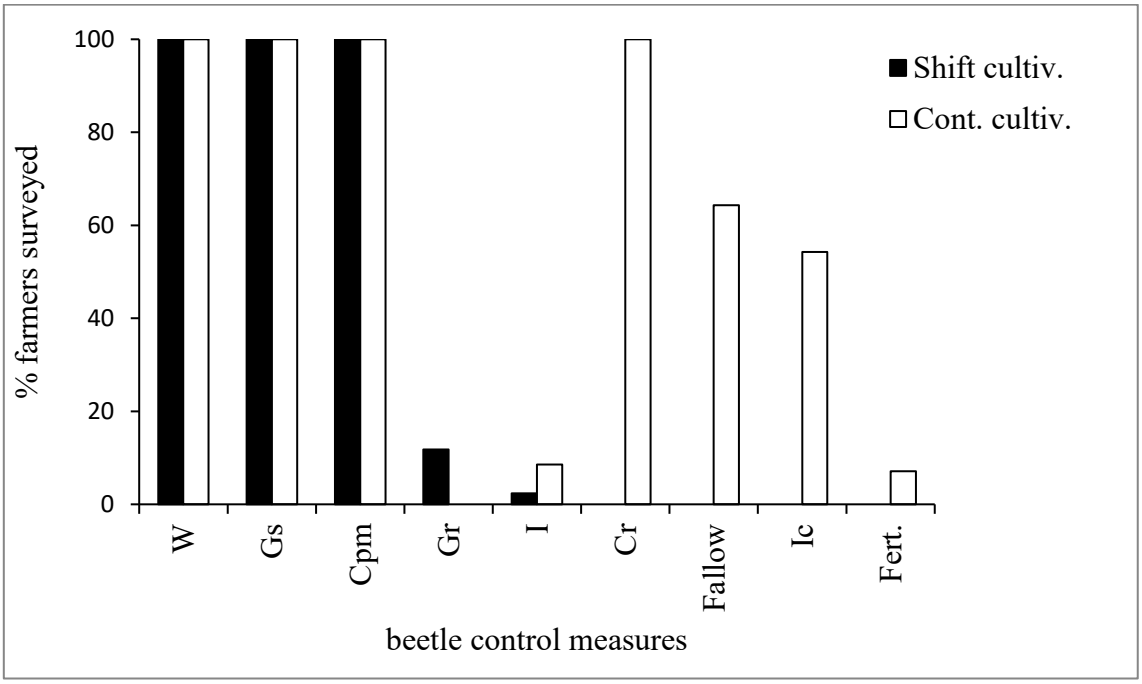

Fig 3. Various control measures taken by Morobe farmers to reduce taro beetle infestations under different taro cultivation styles. The measures include weeding (W), garden sanitation/stump removal (Gs), clean planting material (Cpm), garden restriction (Gr), insecticide (I), crop rotation (Cr), fallowing (Fallow), intercropping (Ic) and fertilization (Fert.).

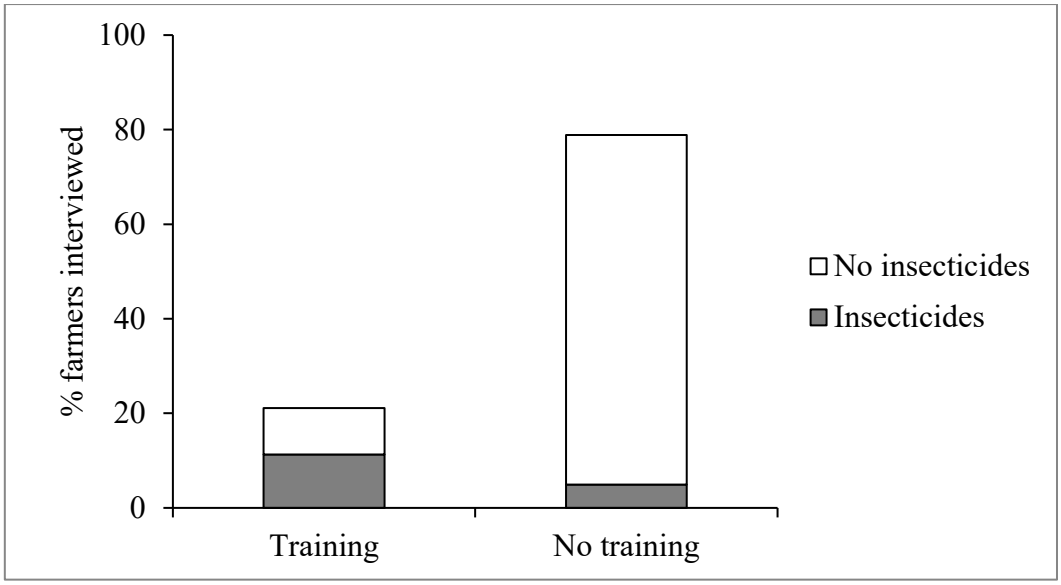

Fig 4. Chemical control of taro beetle by insecticides by taro farmers. Note that farmers who have ceased taro cultivation were excluded in this analysis.

3. DISCUSSION

Taro is the third most important root crop in PNG, and Morobe province is the largest producer and supplier for domestic consumption, and international exports. A farmer survey in 3 districts of Morobe province indicated that most farmers were women with an average age of 39 years. In an impact assessment of adoption of NARI-released taro varieties (NT), Guaf and Komolong [8] have reported similar findings of high proportion of women farmers in 5 districts of Morobe; this includes Huon-Gulf, Nawaeb, and Finschafen, Markham and Tewae-Siassi. Additionally, these researchers indicated high adoption rate of the NT varieties; however, this study reports farmers still maintaining and cultivating the local cultivars and supplying the corms for sale in local city markets, as per the high local demand.

Taro cultivation by farmers is one source of household income and many farmers have diversified their income in various activities. Notably, sale of vegetables have predominated farmer household income. This, in fact, is common for rural PNG where farmers diversify income generating activities. For instance, the cacao farmers in Morobe and East New Britain provinces have diversified income generation by mixed farming apart from the main cash crop (Kerua, 2019). On the other hand, diversification of income generation may have impacted pest control, in this case taro beetle control, based on the unequal time allocation for the upkeep of a particular crop (Kerua, 2019 ; Kerua, 2016). Our study, however, did not compare the time allocation between tending taro gardens and other income generating activities. The problem of taro beetle infestation still remains an issue even though researches have been conducted to manage this pest (e.g. Lal, 2008); as a consequence, some farmers have ceased taro cultivation while others have attempted the combination of available methods of control. Similar findings were reported in Fiji, where farmers abandoned taro cultivation and resorted to other root crops due to heavy *P. uninodis* infestations (Brown, 2014). We report farmers using different types of taro cultivation in shifting cultivation and continuous cultivation as a means to avoid beetle population buildup, thus high infestations. Cultural practices such as sanitation, garden restrictions, and various agronomic practices have been adopted to suppress beetle infestation. Fertilization by applying animal manure had been perceived by farmers to repel beetle infestation; however, this approach remained to be investigated as *Papuana* spp. and their dynastid relatives have been reported to artificially breed in soil-saw dust-animal manure mixes (Bedford, 1980 ; Theunis, 1998). It is worth noting that past trainings positively impacted the use of insecticides with over 50% of farmers adopting insecticides such as Karate® (Pyrethroid) and Orthene® (Organophosphate) during the crop's growth

cycle; nevertheless, farmers knowledge on the effects of insecticides should not only be limited to the effects on applicator but non-target organisms in the environment. This is vital for the responsible use of insecticides and set precedence for the use of soft insecticides such as botanicals.

The factors that undoubtedly impacted farmers dealing with this issue of taro beetle management are literacy and the lack of training attained. As indicated in this study, high proportion of farmers completing primary education only and less farmer training were apparent. The trainings on beetle management were conducted more than 20 years ago, when at least most of the current farmers (47.3%) surveyed were below the age of 20 years.

Farmer trainings on crop protection are vital for improved crop productivity. The current study showed taro farmers in Morobe province are still in the subsistence way of farming, hence sole reliance on basic pest management practices such as cultural and agronomic practices. These practices are notably reported in smallholder farmers in the highlands of PNG for the management of sweetpotato pests and diseases (Gurr, 2016). Our study has provided an understanding of the status of taro beetle management in Morobe province, and has established that many farmers between the ages 20-40 years are motivated to grow taro; however, the level of education attained and lack of training are primary factors that affect their decisions whether or not to cultivate the crop due to taro beetle damage. Furthermore, farmers evidently rely solely on cultural practices to manage the pest; which in this age, combination of various management practices is vital to optimize crop yields (Gurr, 2016 ; Mendesil, 2007 ; Muoni, 2019).

In summary, majority of the farmers are knowledgeable of taro beetle and its impact on taro corm production but lacked improved ways to manage the pest. The use of insecticides in taro gardens, the frequency of their use within the taro season, and the use of soft and readily-available insecticides such as botanicals should be investigated. Undoubtedly, training can motivate younger generation of farmers in the province to suppress beetle infestation and improve taro corm yield, and responsibly incorporate soft insecticides to the present practices.

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REFERENCES

Bedford, G. O. (1980) Observations on the biology of Xylotrupes gideoni (Coleoptera: Scarabaeidae: Dynastinae) in Melanesia. Journal of Australian Entomological Society. 14:213-216.

Bourke, R. M., Vlassak, V. (2004) Estimates of food crop production in Papua New Guinea. Land Management Group, The Australian National University, Canberra. 2004. http://rspas.anu.edu.au/lmg/pubs/estimates_food_crop.pdf.

Bourke, R. M. (2012) The decline of taro and taro irrigation in Papua New Guinea. Senri Enthonological Studies.78:255-264.

Brown, P., Daigneault, A. (2014) Cost-benefit analysis of managing the Papuana uninodis (Coleoptera: Scarabaeidae) taro beetle in Fiji. Journal of Economic Entomology. 107(5):1866-1877. doi:10.1603/EC14212.

FAO Statistical Database [database on the Internet]2022. Available from https://www.fao.org/faostat/en/#data/QCL Accessed: 23 September 2023

Gendua, P. A., Risimeri, J. B., Maima, J. B., editors. (2000) The effect of planting density on the marketable corm yield of taro (Colocasia esculenta (L.) Schott. 764- 767.2000: ACIAR.

Georgeou, N., Hawksley, C., Wali, N., Rowe, E., West, C., Barratt, L. (2022) Food security and small holder farming in the Pacific Island countries and territories: a scoping review PLOS Sustainability and Transformation. 1(4):e0000009. doi:10.1371/journal.pstr.0000009

Guaf, E., Komolong, B. (2006) Impact assessment of three taro (Colocasia esculenta) varieties in the Morobe Province, Papua New Guinea. PNG Journal of Agriculture, Forestry and Fisheries.49(2):19-27.

Gurr, G. M., Liu, J., Johnson, A. C., Woruba, D. N., Kirchhof, G., Fujinuma, R. et al. (2016) Pests, diseases and crop protection practices in the smallholder sweetpotato production system of the highlands of Papua New Guinea. PeerJ. 4(e2703). doi:https://doi.org/10.7717/peerj.2703.

Kerua, W. (2019) Livelihood diversification and its impact on cocoa production and Morobe and East New Britain provinces of Papua New Guinea. International Journal of Agricultural Extension.7(1):117-124.doi:https://doi.org/10.33687/ijae.007.01.2793.

Kerua, W., Glyde, S. (2016) Beyond the cocoa farm: a new look at farmers' choices in livelihood activities and impact on productivity in selected areas of Papua New Guinea. Research, Extension and Innovations Systems Journal. (2016);12(1):1-11.

Kik, A., Adamec, M., Aikhenvald, A. Y., Bajzekova, J., Baro, N., Bowern, C. et al.(2021) Language and ethnolbiological skills decline precipitously in Papua New Guinea, the world's most linguistically diverse nation. Proceedings of the National Academy of Sciences. (2021);118(22). doi:www.doi.org/10.1073/pnas.2100096118.

Lal, S. N. (2008) Taro beetle management in Papua New Guinea and Fiji. Final project report.2008.
Lal, S. N., Moxon, J., Autar, M. L., Milner, R. J., Hunter, D. M., Hazelman, S. et al.(2008) Taro beetle management in Papua New Guinea and Fiji. Fiji2008.

Macfarlane, R. (1987) Papuana Beetles. Pest Advisory Leaflet 21. South Pacific Commission, Noumea, New Caledonia. 4 pp. . Noumea, New Caledonia: South Pacific Commission; 1987. p. 4.

McAlpine, J. R., Keig, G., Falls, R. (1989) Climate of Papua New Guinea. National University Press, Canberra, Australia: Commonwealth Scientific and Industrial Research Organization; 1989.

Mendesil, E., Abdeta, C., Tesfaye, A., Shumeta, Z., Jifar, H. (2007) Farmers' perception and management practices of insect pests on stored sorghum in southwestern Ethiopia. Crop Protection. 26:1817-1825.

Muoni, T., Barnes, A. P., Öborn, I., Watson, C. A., Bergkvist, G., Shiluli, M. et al. (2019) Farmer perceptions of legumes and their functions in smallholder farming systems in east Africa. . International Journal of Agricultural Sustainability. 17(3):205-218.

Onwueme, I. (1999) Taro cultivation in Asia and the Pacific. Bangkok, Thailand: FAO of the United Nations Regional Office; 1999.

Singh, D., Okpul, T., Iramu, E., Wagih, M. E., Sivan, P. (2001) Breeding taro for food security in PNG. In, Food Security for Papua New Guinea. . In: R.M. Bourke, M.G.Allen, J.G. JGS, editors. Papua New Guinea Food and Nutrition 2000 Conference; 26-30 June 2000; PNG University of Technology, Lae.: ACIAR Proceedings No.99; 749-751.

Theunis, W., Aloali'i, I. (1998) Selection of a highly virulent fungal isolate, Metarhizium anisopliae Ma TB 101, for control of taro beetle, Papuana uninodis (Coleoptera:Scarabaeidae). Biocontrol Science and Technology.8:187-195. doi:10.1080/09583159830252.

Thistleton, B. M., Aloali'i, I., Masamdu, R. T. M., Theunis, W. (1995) The biology and control of taro beetles Papuana spp. (Coleoptera: Scarabaeidae) in the South Pacific.

Thistleton, B. M., Masamdu, R. T. M., Theunis, W., Aloali'i, I., Taisau, P., Simbiken, N.(2001) A. A study on taxonomy, biology, and ecology of taro beetles Papuana spp. and Eucopidocaulus spp. (Coleoptera: Scarabaeidae) from the South Pacific and evaluation of measures for their control. EU/SPC Final Project Report2001.

Yalu, A., Singh, D., Yadav, S. S. (2009) Taro improvement and development in Papua New Guinea: a success story. APAARI, FAO Regional Office for Asia-Pacific, Thailand 2009.