SOLOMON ISLANDS BREADFRUIT



PHENOTYPIC VARIATION STUDY

This booklet is for farmers, students and researchers who are interested in understanding the intraspecific (tree-to-tree) variation in breadfruit population in Solomon Islands.

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Authored by: Dr. Richard L. Pauku, Maraghoto Holdings Company Limited, Honiara, Solomon Islands.

Photographs: Dr. Richard L. Pauku

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1.0 INTRODUCTION

Breadfruit is one of the multi-purpose and traditionally important trees in the Pacific, and has long been an important staple crop and an integral part of agroforestry systems the people have been practicing. Like other Pacific Island nations, breadfruit tree is significant as a source of food and nutritional security in Solomon Islands, particularly mostly valued by the people of the Temotu province. This was evidenced from an outcome of a national survey conducted in 2000, whereby people in Temotu province prioritized breadfruit over ngali nut (*Canarium* spp.) as number one crop (Lepping, 2000). The other provinces prioritized ngali nut as their number one crop.

There are three species of breadfruit known in Solomon Islands - these are; *Artocarpus camansi*, *Artocarpus mariannensis, and Artocarpus altilis*. Breadfruit trees can grow to heights of 15 to 20m or more, and have trunks as large as 2m at base diameter at full maturity. The origin of breadfruit is thought to be in the Pacific, although the wild form of breadfruit (*A. camansi*) is native to New Guinea and Moluccas (Indonesia) and Philippines (Diane Ragone, 2006). Ragone (2006) reported that the first domestication of breadfruit in the western Pacific region occurred some 3,000 years ago.

Breadfruit is known by different names in the Pacific, for example, *beta* in Vanuatu, *kapiak* in PNG, *meduu* in Palau, *kuru* in Cook Islands, and *uto* / *buco* in Fiji, *ulu* in Hawaii, Samoa and Tuvalu, and *mei* / *mai* in FSM, Tonga, Kiribati, Marshalls and Marquesas. In Solomon Islands it is called *bia* / *nimbalu* (Temotu province), *barego* / *bario* (Choiseul province), (Isabel province), (Western province), (Malaita province), and (Guadalcanal province).

To be able to make selection of fruit and nut trees from the wild population, it is necessary to know the extent of variation, through an assessment of phenotypic expression of quantitative traits that are culturally and commercially important. In breadfruit, the situation is quite different because it has been widely domesticated many years ago. However, there is still need to seek the superior phenotypes within the cultivated populations with a combination of desirable traits. Hence, this study which has involved the characterization of intraspecific (tree-to-tree) variation in fruits.

2.0 PURPOSE

This booklet is produced to document intra-specific (tree-to-tree) variation in fruits of breadfruit, which is important for selection and potential cultivar development. Hence, the contents of this booklet are a benchmark for future work on breadfruit to generate new knowledge and improve understanding on intraspecific variation in breadfruit population in Solomon Islands, and provide opportunity for cultivar development for all users.

3.0 APPROACH AND METHODOLOGY

Tree owners have been involved and informed about the importance of the selection of the desirable traits for commercial objectives. At least one fruit is harvested from a tree deemed a different variety to carry out fruit characterization. Twelve villages in Temotu province, and five villages in Western province have participated in the project. In addition, fruits have been purchased from market vendors at Gizo, Western province for characterization.

Desirable traits selected for characterization in this study include: fruit size (circumference, length and width), fruit shape, flesh colour, fruit skin colour, and fruit core length and width, and seed status of the fruits. To determine these traits, 124 fruits were harvested from breadfruit trees in two geographically and distant and isolated populations - i.e. Temotu (population) province, and Western (population) province. Upon harvesting, the fruits were correctly labelled, and brought back to the field station for measurements. To assess the flesh and count the seeds, the fruit was cut open into equal half.

4.0 PHENOTYPIC VARIATION OF BREADFRUIT

4.1 EXTENT OF VARIATION IN FRUIT CIRCUMFERENCE

Tree-to-tree variation in fruit circumference was highly significant ($P < 0.05$) within and between the two populations (Fig 1, 2, 3 and 4). The largest fruit across the two populations was harvested from a tree of *Bia Banore* variety at Manoputi village in Tempotu province. Within Temotu population, the fruit from variety *Bia Banore* remained the largest. By contrast, the largest fruit in the Western population was from a tree at Obobulu village in Ranogga Island. The mean difference between the two populations in various fruit traits is given in Table 1.

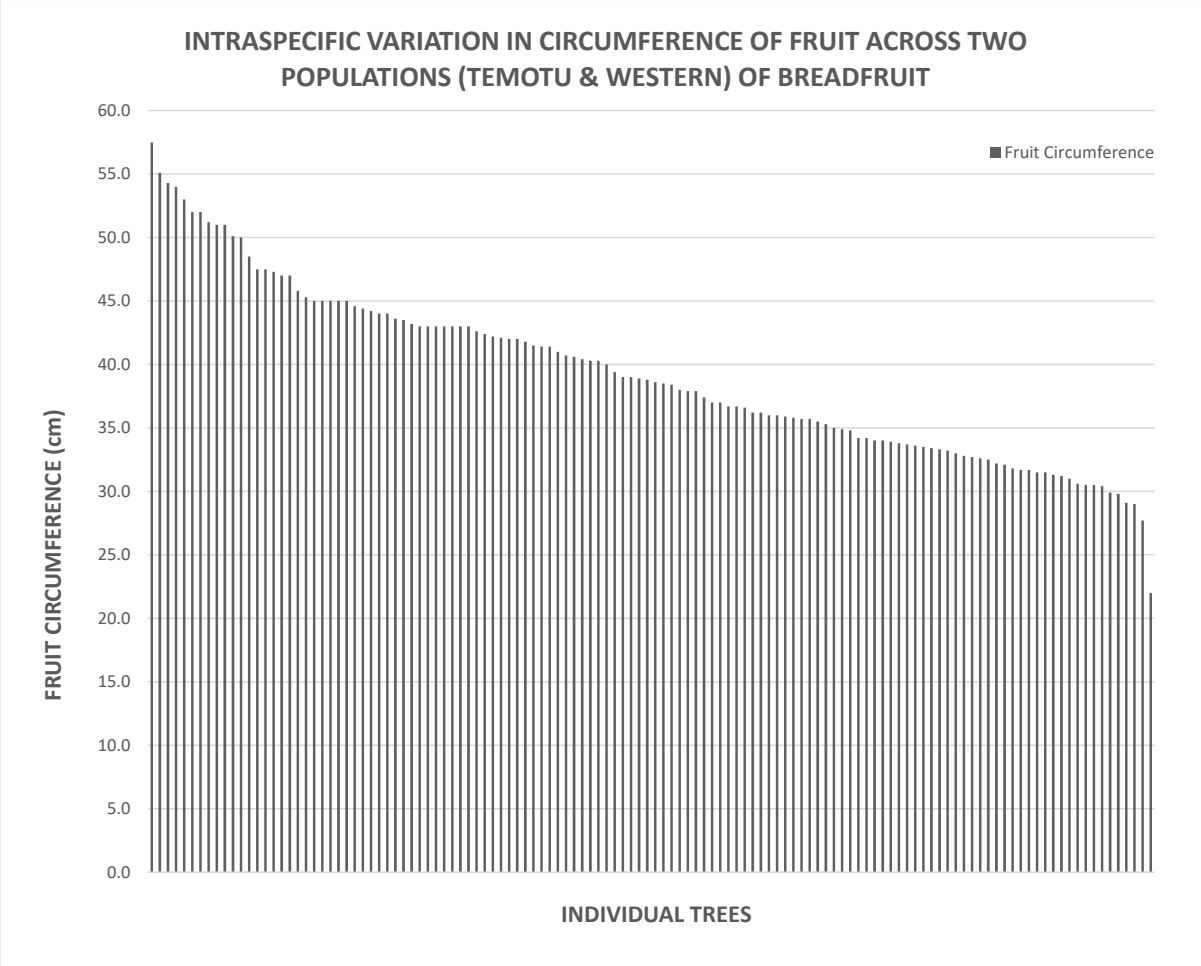

Fig 1: Intraspecific variation in fruit circumference across Temotu and Western population

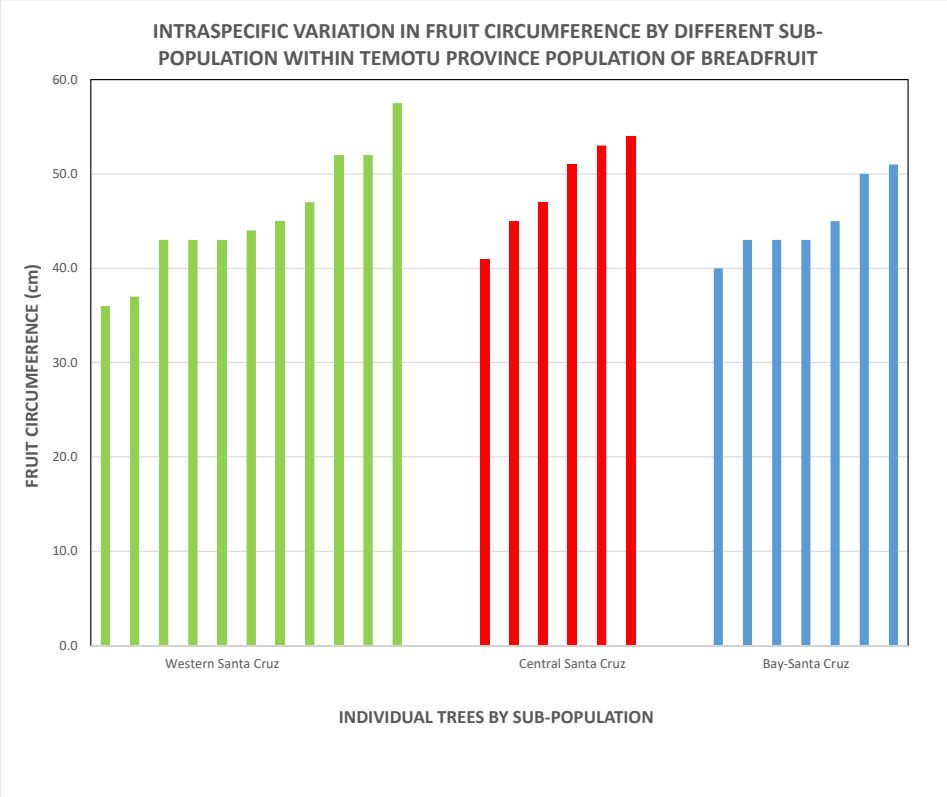

Fig 2: Intraspecific variation in fruit circumference within Temotu population

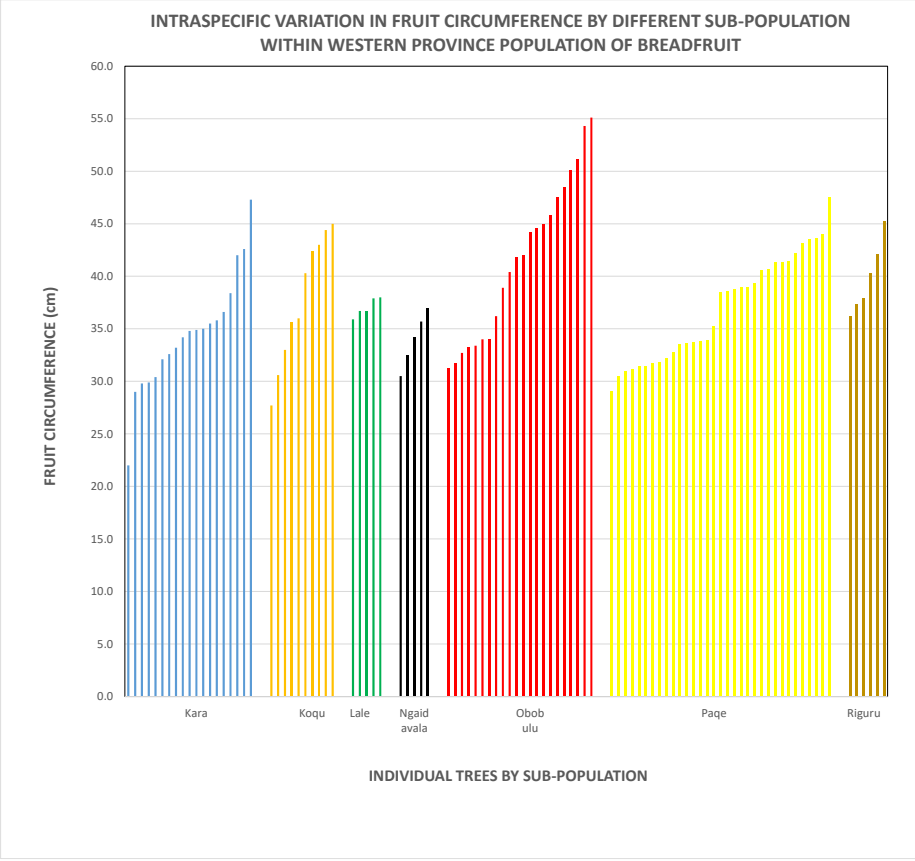

Fig 3: Intraspecific variation in fruit circumference within Western population



Fig 4: Variation in fruit size (circumference, length and width)

Table 1: Morphological characteristics of fruits selected from 124 breadfruit trees.

Population / Sub-population	Fruit Traits				
	Circumference	Length	Width	Core-length	Core-Width
Temotu Population	**46.1 ± 1.75**	**14.3 ± 5.21**	**13.7 ± 5.26**	**7.4 ± 6.01**	**4.0 ± 4.23**
West Santa Cruz	45.4 ± 1.00	14.3 ± 3.48	14.0 ± 3.45	7.3 ± 3.49	4.0 ± 3.34
Central Santa Cruz	48.5 ± 0.37	15.4 ± 2.34	14.1 ± 2.31	7.9 ± 1.91	4.2 ± 1.04
Bay Santa Cruz	45.0 ± 0.84	13.0 ± 1.61	12.7 ± 1.90	7.0 ± 1.17	3.7 ± 1.58
Western Population	**37.6 ± 7.30**	**13.4 ± 26.8**	**10.7 ± 7.30**	**37.6 ± 13.2**	**2.9 ± 19.9**
Obobulu, Ranogga	41.6 ± 0.93	14.1 ± 0.93	11.3 ± 6.61	7.8 ± 5.56	3.2 ± 6.59
Kara, Ranogga	34.5 ± 2.04	11.8 ± 5.13	9.9 ± 5.73	6.4 ± 3.44	2.7 ± 5.55
Koqu, Ranogga	37.8 ± 0.58	13.9 ± 3.20	11.5 ± 2.26	7.5 ± 2.89	2.9 ± 2.45
Paqe, Ranogga	37.0 ± 1.82	13.3 ± 9.75	10.5 ± 9.44	8.2 ± 9.31	2.9 ± 9.46
Lale, Ranogga	37.0 ± 0.54	18.1 ± 1.82	10.2 ± 1.33	10.5 ± 1.76	3.1 ± 1.55
Ngaidavala, Ranogga	34.0 ± 0.15	11.9 ± 1.79	10.1 ± 1.78	7.2 ± 1.77	2.6 ± 1.61
Riguru, Simbo	39.9 ± 0.49	12.4 ± 1.96	10.8 ± 2.09	6.2 ± 1.17	3.2 ± 1.72

NB: *Mean values are expressed in centimeter*

4.2 EXTENT OF VARIATION IN FRUIT LENGTH AND WIDTH

Tree-to-tree variation in fruit length and width was highly significant ($P < 0.05$) across the two populations (Fig 5). However, within population the variation is highly significant from tree-to-tree in the Western population, but not significantly different in the Temotu population (Fig 6).

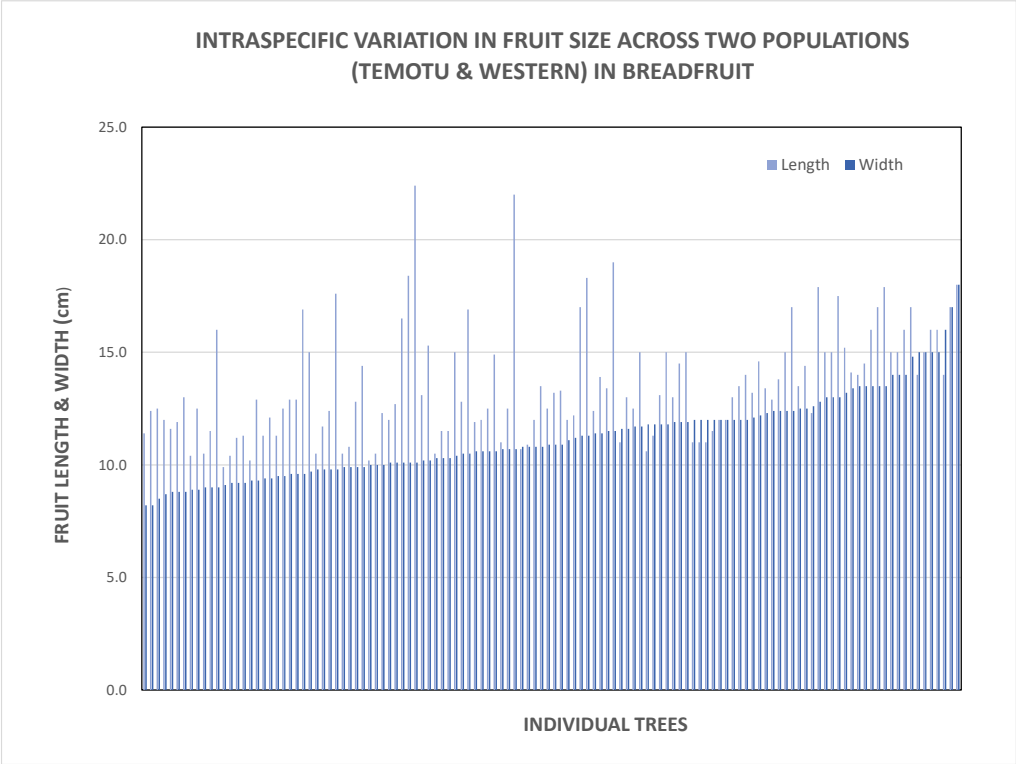

Fig 5: Intraspecific variation in fruit length and width across population

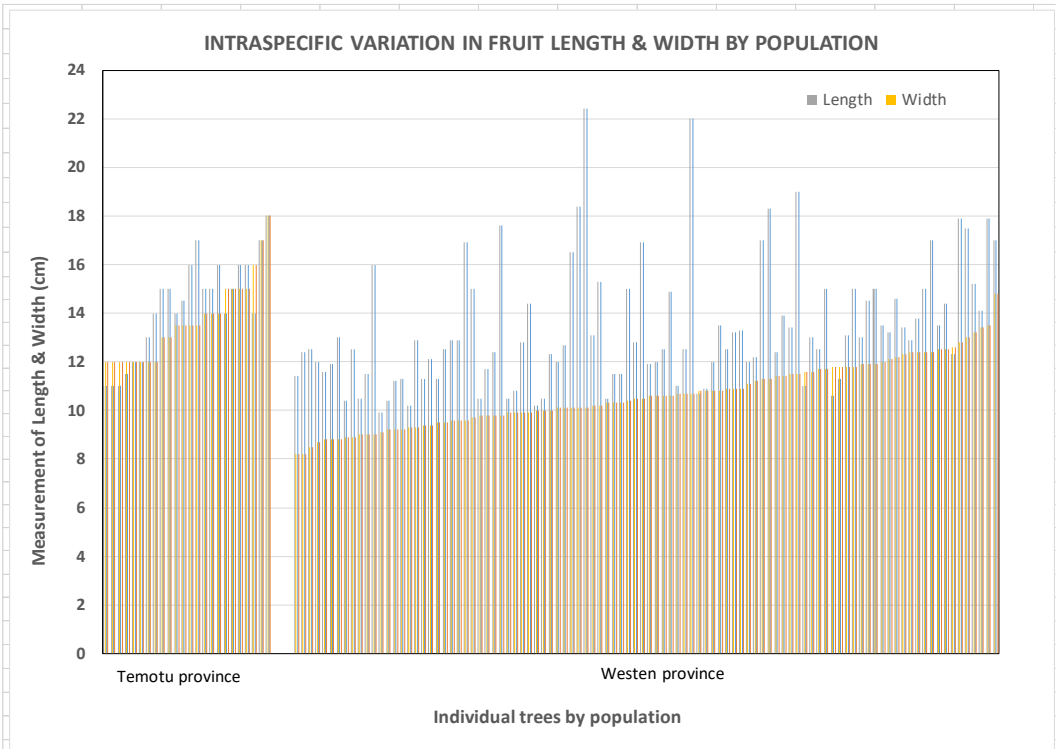

Fig 6: Intraspecific variation in fruit length and width by population

4.3 EXTENT OF VARIATION IN FRUIT CORE LENGTH AND WIDTH

The botanical term for fruit core is **receptacle** - this is the spongy, central axis or stalk to which all individual flowers were originally attached (Fig 7). It is typically pale yellow or whitish, cylindrical, and visibly more fibrous and tougher than the surrounding edible starchy pulp of the fruit. Tree-to-tree variation in fruit core length and width were highly significant ($P < 0.05$) across the two populations (Fig 8), with mean of 7.6cm (length) and 3.1cm (width). Intraspecific variation was also highly significant between and within population.

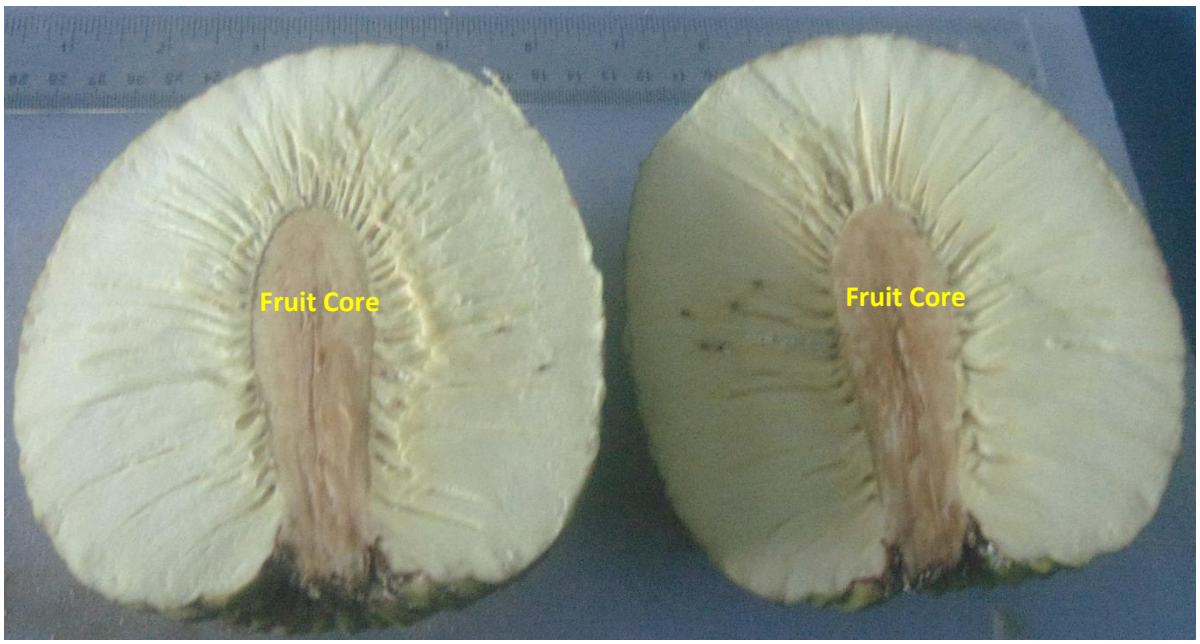

Fig 7: Photo showing fruit core (receptacle) of breadfruit

4.4 EXTENT OF VARIATION IN FRUIT SHAPE

Fruits of breadfruit varied in shape. This study has observed two main variations in shape of the fruit - i.e. i) fruits with oblong shape, and ii) fruits with spherical shape (Fig 9). It was observed also that there was variation within these two shapes, which may not entirely be due to genetic make-up, but perhaps due to environmental factors within which it grows.

Of the 124 fruits being assessed across the two populations, 43.5% had oblong shape, and 56.5% had spherical shape. The fruit shape differs within population. In Temotu population, fruits were predominantly had spherical shape. By contrast, fruits in Western population, however, had exhibited mostly spherical shape (Fig 10).

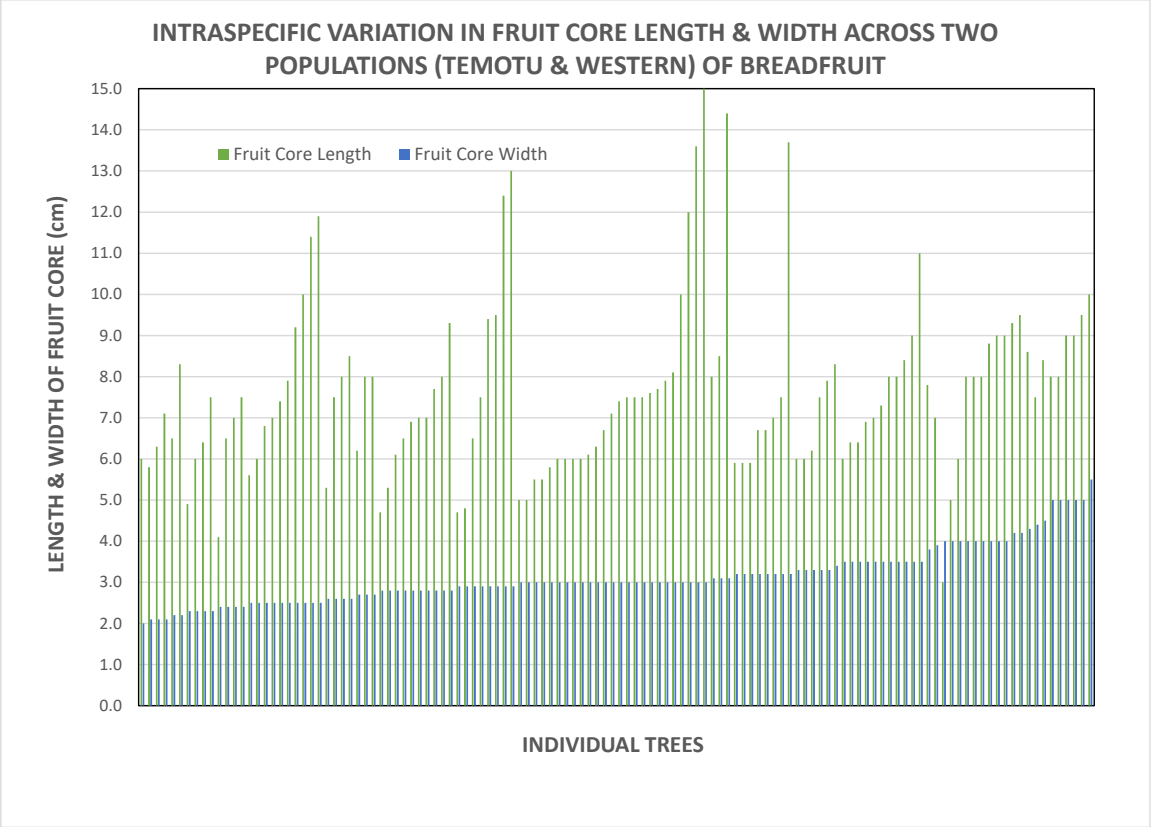

Fig 8: Intraspecific variation in fruit core length and width across population

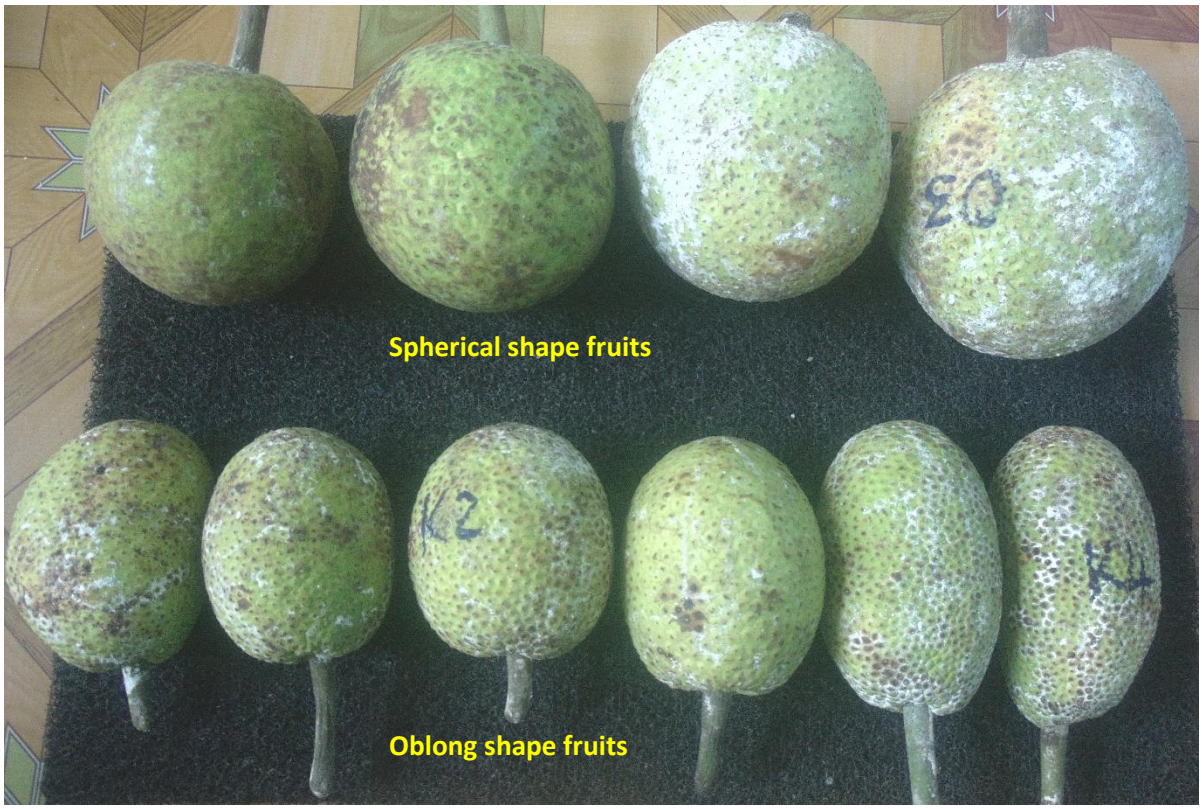

Fig 9: Variation in fruit shape of breadfruit

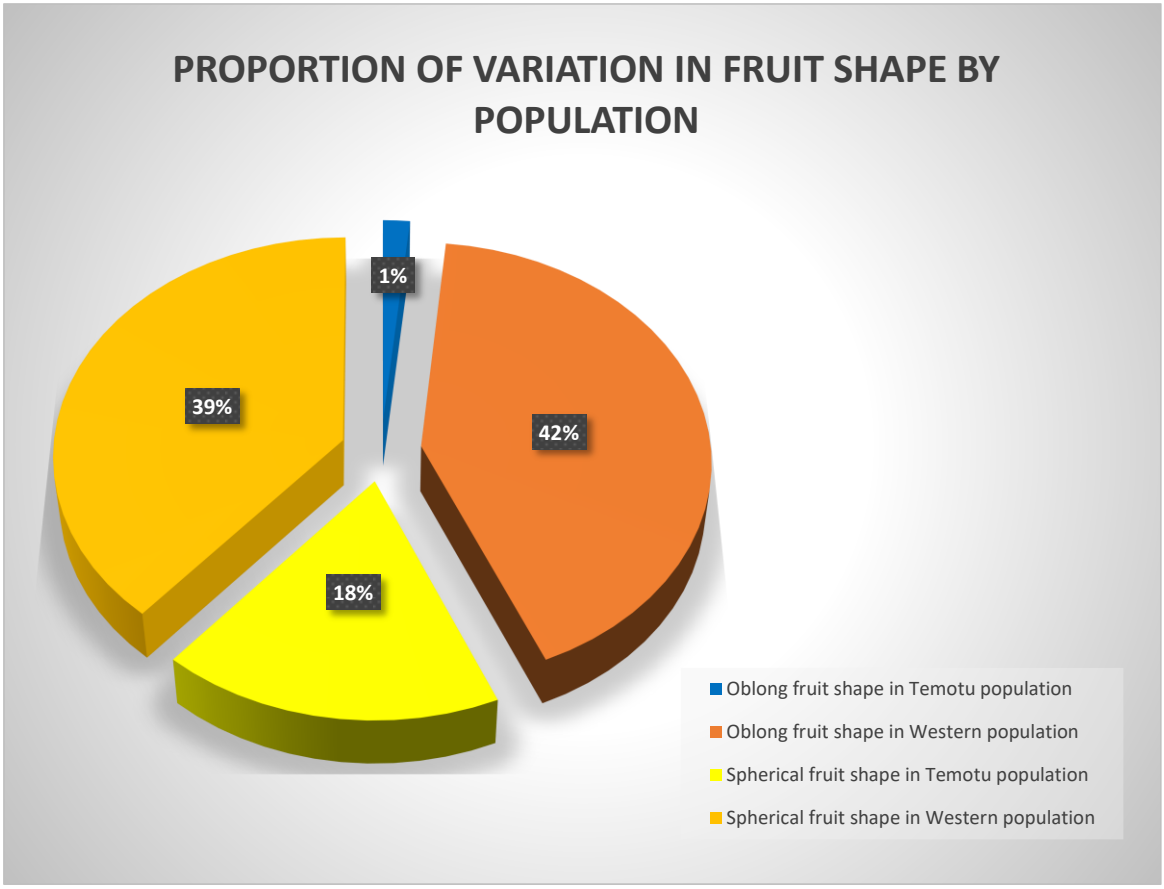

Fig 10: Variation in fruit shape by population

4.5 EXTENT OF VARIATION IN FRUIT FLESH COLOUR

Flesh refers to the edible starchy pulp of the fruit, and the study was focussed on the colour of the flesh, revealed when the fruit is cut open into equal half. This study has observed two main variations in fruit flesh colouration - i.e. i) fruits with white flesh, and ii) fruits with yellow flesh (Fig 11). It was observed also that there was variation within these two colouration, for example, yellow creamy and pale whitish creamy which may not entirely be due to genetic make-up, but perhaps due to environment factors within which it grows.

Colouration of the flesh is an important trait people use to identity desirable variety. A particular variety in the Temotu population, not captured in this study because it was off-season during the field visit, has a purple flesh, and it was deemed good for nambo (a traditional valued added product of breadfruit).

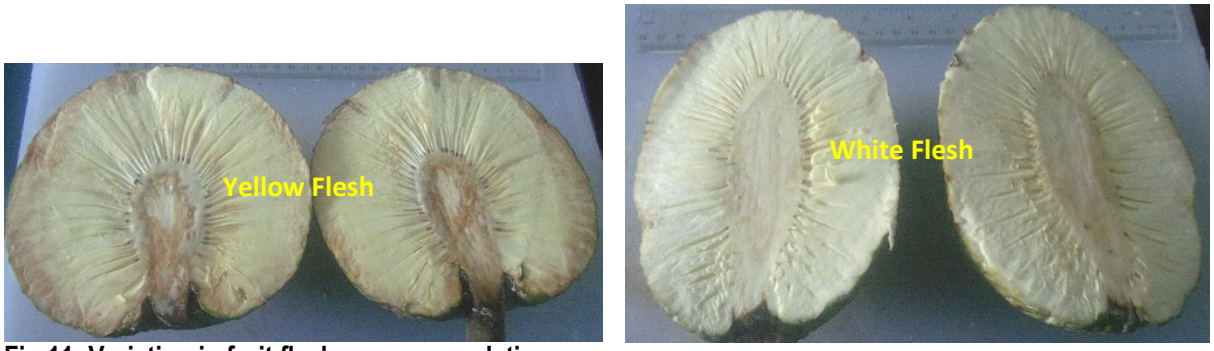

Fig 11: Variation in fruit flesh across population

The study observed that across the two populations, about 90% of the fruits being assessed have yellow flesh, compared to only 9% with white flesh (Fig 12). The study did not conduct organoleptic analysis of the flesh to determine the relationship between the colour and the eating quality of the flesh.

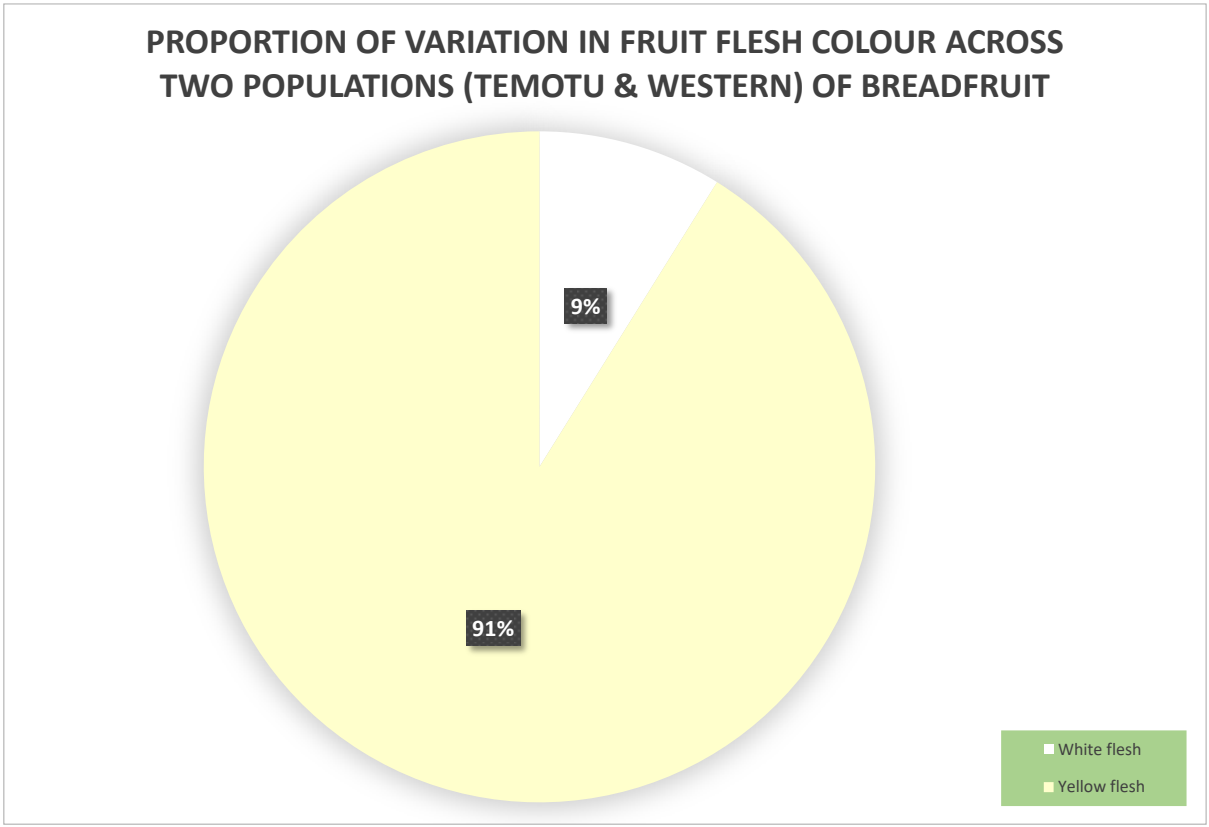

Fig 12: Variation in fruit flesh across population

4.6 EXTENT OF VARIATION IN FRUIT SKIN COLOUR

Like fruit shape and flesh, the colour of skin of the fruit was also varied. The study observed three main colours - i) bright green, light green, and iii) light yellow (Fig 13 and Fig 14). However, there were variations slightly deviating from these three main colours.

Interestingly, farmers and the locals have expressed that the colour of fruit skin also changed over time, apparently a phenomenon they said it was associated with the maturity of the fruit. When the fruit is immature, the fruit colour appears bright green, and as the fruit is mature, and beginning to ripe, the colour appears to change, from light green to light yellow. However, this was not always the case for all fruits, suggesting that it could relate to the specific genetic make-up of the fruit.



Fig 13: Variation in fruit skin colour across population

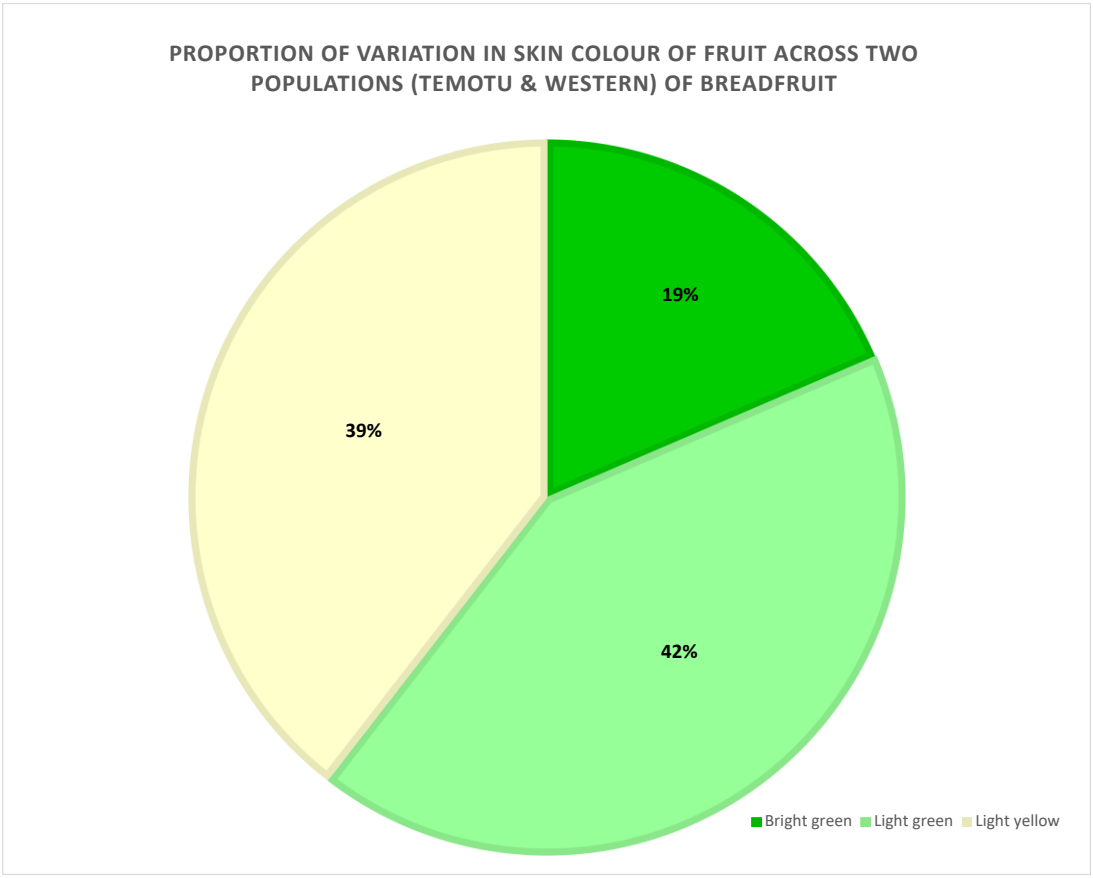

Fig 14: Variation in fruit colour across population

4.7 EXTENT OF VARIATION IN FRUIT SKIN SURFACE

The study observed two main variations in the skin surface of the fruit. The fruits either have a smooth skin surface or a spiny skin surface (Fig 15). Interestingly, the locals have expressed that they have also observed some varieties of breadfruit that have fruits with a spiny skin surface when immature. However, as the fruits grow into maturity, they gradually have a smooth skin surface. Generally, young immature fruits have a spiny skin surface.

Across the two populations, the assessed fruits have equal proportion of smooth and spiny skin surface. On the contrary, observation within each population differed. For example, in Temotu population about 70% of fruits have a smooth skin surface, while 30% have a spiny skin surface. The opposite was observed in Western population, with 45% of fruits have a smooth skin surface and 55% with a spiny skin surface.

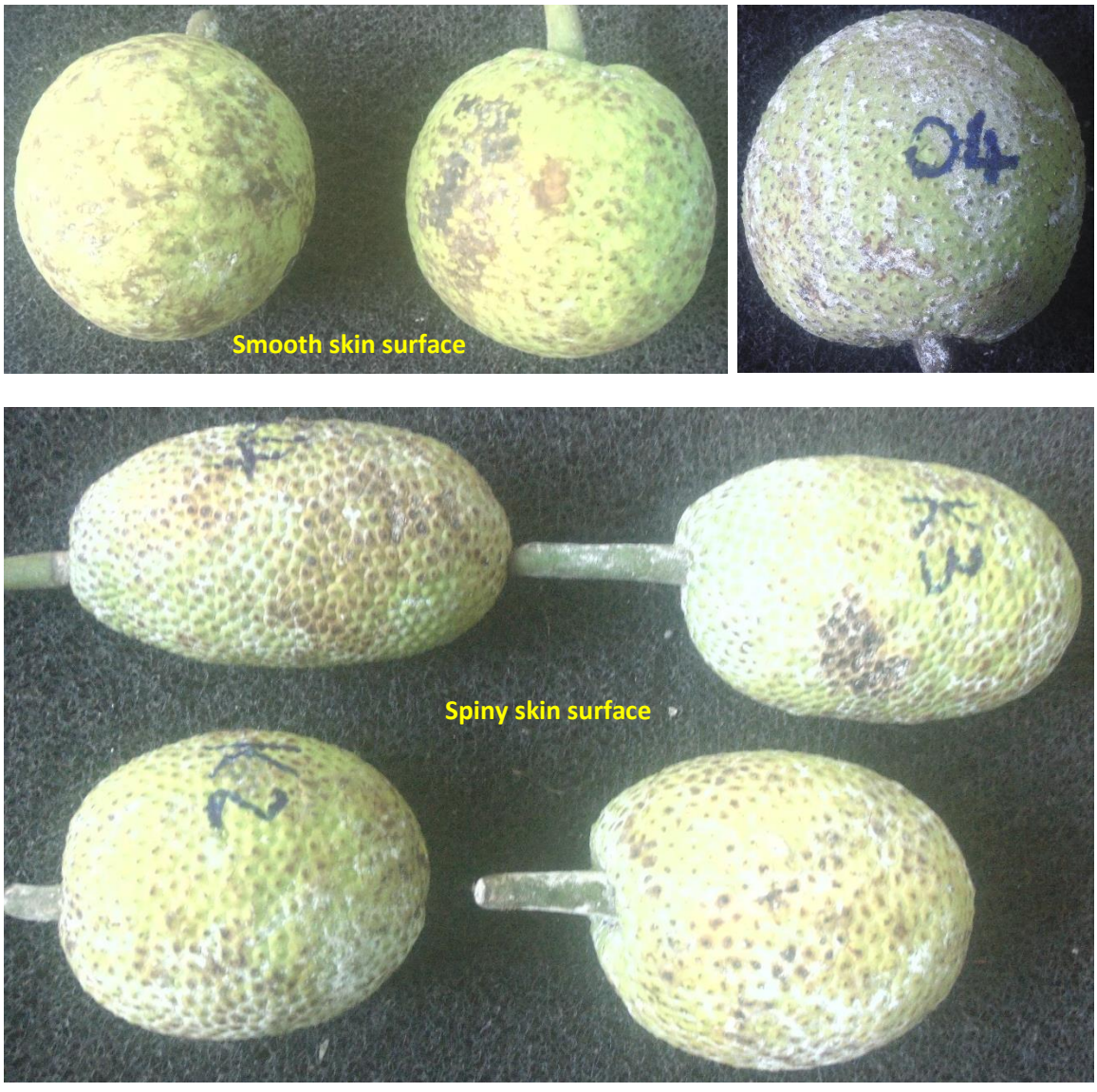

Fig 15: Variation in fruit skin surface population

4.8 EXTENT OF VARIATION IN FRUIT SEED CONTENT

Not all the fruits have seed in them. The study showed significant variation across the two populations, with high number of fruits without seed (Fig 16). The presence or absence of seeds in a fruit is unlikely to be associated with other traits such as fruit size, shape or fruit skin colour (see Fig 17 and Fig 18).

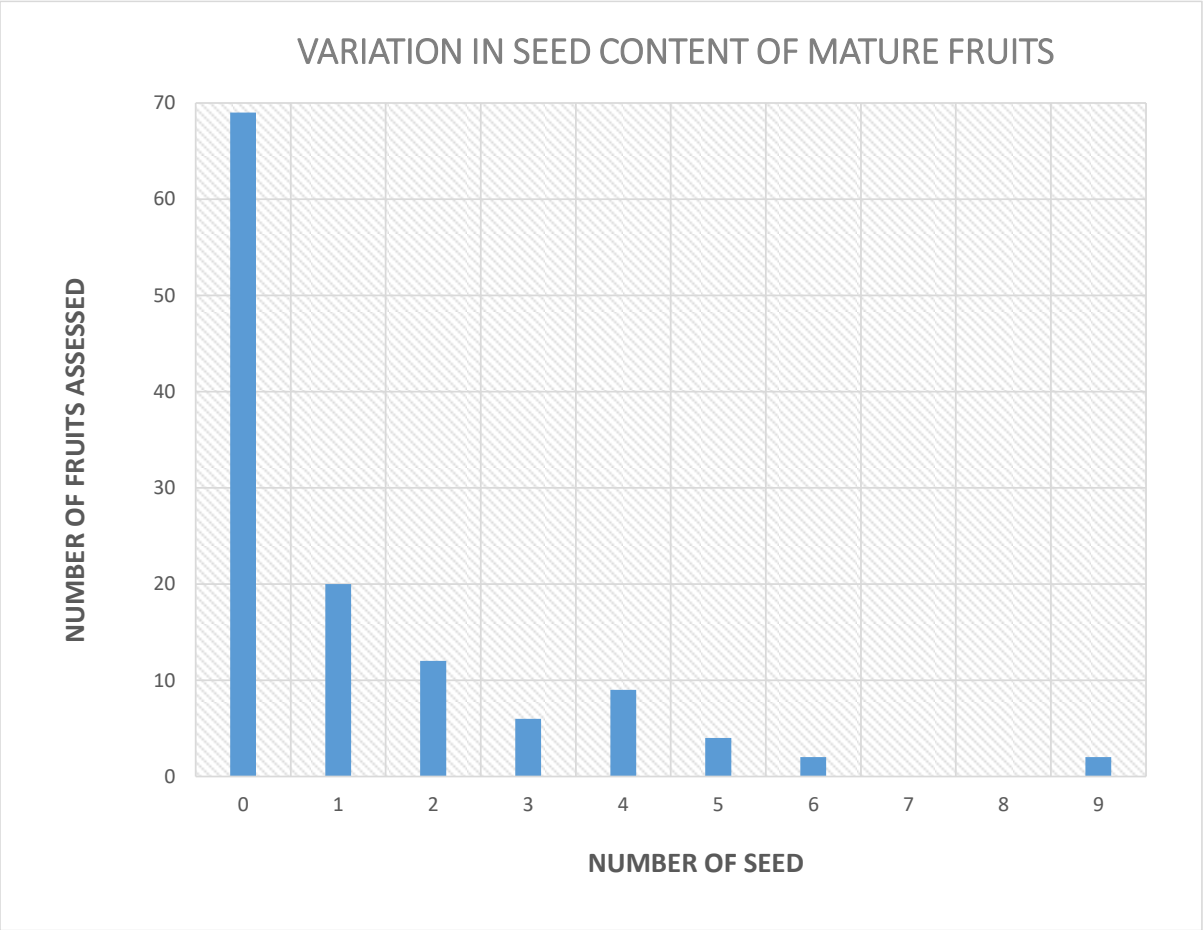

Fig 16: Variation in seed content of a fruit across population



Fig 17: Variation in seed content - fruit oblong, spiny, and seed (L), and seedless (R)



Fig 18: Variation in seed content - fruit spherical, spiny, and seed (L), and seedless (R)

5.0 GENERAL DISCUSSION

Fruit is the most important product of *A. altilis* for food and nutritional security as well as for income generation, although the seed is edible and the tree itself is a source of traditional medicines. Thus, characterization of fruit traits are essential for the selection and cultivation of breadfruit as an agroforestry tree. In Solomon Islands, there has never been any quantitative description of tree-to-tree variation of any of the important traits of the fruit.

This study is the first to provide such information. However, the work is limited to achieving a comprehensive result on desirable traits of breadfruit for commercial objectives in Solomon Islands. There is need to investigate further including, but limited to topics such as intraspecific variation in fruit mass, the relationship between characteristics such as tree height versus diameter, fruit and seed (kernel), relationship between fruit flesh and core, variation in the frequency distribution of fruit and seed (kernel) traits, and organoleptic variation in fruit flesh taste.

Importantly, this study showed considerable phenotypic variation in breadfruit, in all the traits measured and observed. This is typical for an outbreeding tree species like breadfruit. The continuous variation found in the fruit traits questions the validity of the recognition of many 'varieties' by farmers; suggesting that it is just their description of particular traits within the normal range of phenotypic variation.

Furthermore, this study has indicated that in indigenous fruits and nuts the main source of variation are between trees and within population. This is very beneficial to the development of participatory domestication strategies to develop new breadfruit cultivars in the light of competition and narrowing of genetic basis of the crop. Notably, people move planting materials from one place to another - this supports the observation that sometimes the intraspecific variation between populations is not statistically significant.

6.0 CONCLUSIONS

This booklet is the first of its kind, and it documents information on intraspecific variation in a number of fruit traits of breadfruit. The study based its investigation from two geographically distant and isolated

populations of breadfruit in Temotu and Western provinces. The study showed significant phenotypic variation between trees and within population. Furthermore, the study revealed the extent of variation in shape, colour and skin surface of the fruit.

Further work is recommended to expand knowledge and create a better understanding of the extent of variation in other desirable traits of the breadfruit. Essentially, such work should generate more technical information for future commercialisation of breadfruit in Solomon Islands.