The Bido variety is an essential genetic material for coconut breeding

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Abstract. Several tall dwarf and hybrid types coconut were released by IPCRI-IAARD as commercial varieties since more than 40 years ago. Bido is a recently release tall coconut variety having many excellent traits such as early flowering, low height increments, and high yielding. With good cultivation practices, Bido tall variety could flower as early as three years and the first harvest was in 4 years after planting. Bido tall variety yield potential could reach up to 120 nuts/palm/year. As germplasm collections, Bido tall variety was planted in 2017 at Mapanget Experimental Garden. Subsequently, Bido tall variety seed garden was planted in 2018 at Kayuwatu Experimental Garden, North Sulawesi Province. The Bido tall coconut was recently used as parent to generate progenies derived from self- and cross-pollinations. Moreover, the Bido tall variety has been used as male parent and hybridized with some Dwarf coconut varieties to develop hybrid coconut varieties in the future.

1. Introduction
Coconut plantations exist in most of the 34 provinces in Indonesia. The three largest hectarages of coconut plantation (75% of the total coconut plantations) are located in Sumatera (32.0%), Java (27.0%) and Sulawesi (21.0%). The major export of coconut products are coconut oil, desiccated coconut, and copra meal. Increasing demand for coconut products as the healthy food and drink and also for non-food products. Indonesia have exported coconut products, such as VCO, nata de coco, coconut water, coco fiber and dust, bricked, and other products.

One of the major constrains in coconut production is low productivity due to the old and senile palms, without any implementation of replanting program. At the farmers level, the average copra yield is one ton/ha/year. Another essential problem is limited numbers of available seed nuts for replanting programs because of lack of the well maintain coconut seed gardens.

Coconut breeding program in Indonesia has successfully released many coconut varieties having high nuts and copra yield, such as Tall, Dwarf, and Hybrid coconut varieties. The yield potential of those varieties are 3.0 - 3.5 tons copra/ha/year (Tall varieties), 4.0-5.0 ton copra/ha/year (Hybrid varieties). For Dwarf varieties, nut yield may reached up to 120 nuts/palm/year.

Selection and hybridization among coconut varieties have been initiated based on morphological characters, inflorescence, production, and fruit component analysis, copra and oil content [1]; on the kopyor endosperm [2, 3], and on the Virgin Coconut Oil and fatty acids [4, 5]. Molecular marker [6, 7] in ex situ [8, 9], and in situ germplasm collection have also been initiated by coconut farmers.
2. The new direction for coconut breeding

In early 1970, decline in the coconut productivity has occurred, while the demand for cooking oil have increased. To overcome this problem, government of Republic of Indonesia has implemented many programs to increase the copra production through replanting and opening new coconut plantations. The government also introduced hybrid coconut variety by importing large quantity seeds of a hybrid coconut (PB121 hybrid) from Cote d’Ivoire. Moreover, hybrid coconut seed gardens have also been established in 11 provinces, with total planting areas reached up to 1.856 hectares [10]. The introduced hybrid variety were originally generated by crossing between Nias Yellow Dwarf x West Africa Tall. In addition to hybrid coconut importations, the Indonesian Agency for Agricultural Research and Development (IAARD) has assembled coconut hybrids using local coconut germplam.

Production of better coconut seedlings is required to support and accelerate the coconut replanting program. Objectives of coconut breeding programs in Indonesia during the period of 1970-1990 were to provide large scale planting material having the following characteristics, such as: high copra yield and early bearing [11]. The applied breeding methods including intra parental selection and hybrid production to develop hybrid coconut (Dwarf x Tall hybridization) [12].

2.1 Past coconut breeding in Indonesia

The coconut hybridization programs in Indonesia were conducted since 1975. IAARD have successfully released three coconut hybrid types, such as KHINA 1 (Nias Yellow Dwarf x Tenga Tall), KHINA 2 (Nias Yellow Dwarf x Bali Tall), and KHINA 3 (Nias Yellow Dwarf x Palu Tall) coconut varieties in 1984. With high inputs, the KHINA hybrid coconuts produced 4 - 5 tons copra/ha/year [13]. The introduce PB121 hybrid coconut from Cote d’Ivoire has previously failed because of low productivity and bud rot disease susceptibility because of Phytophthora palmivora [14,15]. PB121 hybrid was also sensitive drought stress [16]. KHINA hybrids were better than PB121 hybrid since it is high yield and disease resistance. However, the PB121 coconut hybrid failure has made Indonesian coconut farmers loss interest in coconut replanting using locally developed coconut hybrid variety.

Survey results conducted in the North Sulawesi showed that 98% of coconut farmers preferred Tall coconut types for replanting [17]. Other survey reported that 94.44% of Indonesian coconut farmers preferred high yielding local tall and local hybrid coconut variety for their plantation [18]. Such survey results was correlated with the real coconut plantation in Indonesia, consisting of 93% or coconut plantations grew Tall coconut types. The reasons why Indonesian coconut farmers prefer tall coconut since Tall coconut (1) require less maintenance, (2) more tolerant to drought and bud rot disease and (3) cheaper seedling cost than the hybrid variety. The bad reputation of the introduced coconut hybrid also affect farmers preferences.

2.2. Future coconut breeding in Indonesia

2.2.1. Dwarf coconut variety. The coconut palm consists of two types, namely the Tall coconut type and the Dwarf Coconut type. The morphological, generative, and fruit characteristics of the two types of coconut are very different, mainly due to the pattern of cross-pollination of the Tall type coconut and generally self-pollinating on the Dwarf coconut type. Utilization of these two types of coconut is somewhat different from one another, where the coconut fruit of Tall type is more widely used for the coconut industry with a variety of alternative coconut products. In contrast, the Dwarf coconut have been using as a drink of tender coconut, ornamental, coconut sugar, and religious ceremonies in Bali. In Indonesia especially in Bali Island, the Dwarf coconut has been using as part of religious ceremonies. So that this Dwarf coconut which early bearing to be at the age of 2-3 years, has a large
number of fruits per bunch, has a short stem, and is slower to become tall, very suitable for planting and developing by the people in Bali. Coconut as a multipurpose fruit is one of the essential elements of *Pawitra* (eternal water/lamertha), the symbol of the universe in *Daksina*. This Dwarf coconut variety has a variety of fruit colors, such as Green, Yellow, Red, Brown, Orange, small to medium-size fruit, the various such as shape of the fruit: round, egg-shaped, pear-shaped, and elliptic, and plenty of fruit per bunch and per palm, it is very suitable to grow in people’s yards.

The dwarf coconuts are increasingly popular since farmers and other stakeholders have begun to look for short-stemmed coconuts and bear fruit quickly. The utilization of early maturing coconuts is intended primarily for coconut sugar production. National coconut sugar needs around 400,000 tons per year and an increase of 10% every year. Utilization of coconut sugar, especially for raw soy sauce, sweetener, and other food ingredients. Market demand for coconut sugar products is even greater, since the issue of coconut sugar which has the lowest IG, which is 35 compared to other types of sugar, so it is healthier to consume, especially for diet.

The research of IPCRI collaborated with PT. UNILEVER found that the Waingapu Red Dwarf, Nias Yellow Dwarf, Bali Yellow Dwarf, and Salak Green Dwarf are the highest coconut sugar production compare to other dwarfs coconut. The seedlings of these suitable varieties have been distributed, and planted to coconut farmers in Pangandaran, Sukabumi regency, West Java Province and East Lampung regency, Lampung Province in 2016-2017.

2.2.2. High yielding tall coconut variety. From 2004 to 2021, 28 superior varieties of tall coconut were successfully released, consisting of 11 varieties selected from SMP (Selected Mother Palms) in the experimental garden, the Indonesian Palma Crops Research Institute (IPCRI), and the remaining 8 tall coconut varieties collaboration from regional governments, and, or district. The ten superior varieties of coconut in SMP selection at the IPCRI, namely: (1) Mapanget tall, (2) Tenga tall, (3) Bali tall, (4) Palu tall (PUT’), (5) Sawarna tall, (6) Kima Atas tall, (7) Banyuwangi tall, (8) Jepara tall, (9) Lubuk Pakam tall, (10) Takome tall, and (11) Rennel tall. The coconut tall varieties released by observation method of HYB (High Yielding Block) and SMP in most coconut producing of Regencies and Provinces, namely: Sikka tall, BojongBulat tall, Kramat tall, Molowahu tall, Adonara tall, Panua tall, Mastutin tall, Buol ST1 tall, Sri Gemilang tall, Lampana tall, Cyngap Merah tall, Selayar tall, Babasal tall, NiuSua tall, Zabak tall, Gambut tall, OdeskaLobu tall, and Bido Tall. The potential production of these tall varieties is around 3.0-4.0 ton copra/ha/year, and they have a good quality of meat, copra, oil, and lauric acid.

2.2.3. The Bido Tall variety is a good genetic material for coconut breeding. In the 1940s, the late Mr. Bosu Labaka found a coconut seedling floating in the sea while fishing in Morotai island. The coconut seedling was then brought back to Bido village and planted in his yard. After growing and developing, it turns out that the coconut palm bears fruit very quickly, produces much fruit and the size of the fruit is quite large. Since then, Bido coconuts have been planting by the people of Bido village in their yards and have grown into a population of Bido coconuts. The Bido Tall are famous for being short, fruitful, slow to grow tall, fast bearing fruit with large and abundant fruit production [19].

Coconut farmers need coconut varieties that have a short stem and slow to be grow tall. The specific of this character found in Bido coconut, which has a length of stem 11 leaf scars only 51 cm and is closed with several of Dwarf coconut varieties such as Nias Yellow Dwarf (55 cm), Raja Brown Dwarf (41 cm), and Bali Yellow Dwarf (44 cm). On the Tall coconut varieties derived stem length of 11 leaf scars are generally above 100 cm, such as Mapanget Tall (118 cm), Tenga Tall (104 cm), Bali Tall (109 cm), Palu Tall (125 cm), Sawarna Tall (116 cm), Kima Atas Tall (135 cm), Adonara Tall (114 cm), even hybrid coconut KHINA-1 and KHINA-2 has a stem length of 11 leaf scars around 100 cm. Speed high-growth Bido coconut was less than 50% compared to Talls and Hybrids coconut, included some Dwarf varieties. Bido coconut has the character of a short stem and stems height increment (Tabel 1).
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Table 1. Characteristic of Bido coconut compared to varieties of high yielding talls, dwarfs, and hybrids.\(^{12}\)

| Varieties          | First flowering (years) | First harvest (years) | Stem length of 11 leaf scars (cm) | Number of bunch/ palm/year | Fruit/palm (nuts) | Copra/ha/year (ton) |
|--------------------|-------------------------|-----------------------|---------------------------------|-----------------------------|-------------------|--------------------|
| Bido Tall          | 3.0                     | 4.0                   | 51                              | 14                          | 124               | 4.0                |
| Mapanget Tall      | 5.0                     | 6.0                   | 118                             | 13                          | 90                | 3.3                |
| Tenga Tall         | 5.0                     | 6.0                   | 104                             | 13                          | 75                | 3.0                |
| Bali Tall          | 5.0                     | 6.0                   | 109                             | 13                          | 75                | 3.0                |
| Palu Tall          | 5.0                     | 6.0                   | 125                             | 13                          | 75                | 2.8                |
| Sawarna Tall       | 4.0                     | 5.0                   | 116                             | 14                          | 75                | 3.5                |
| Lubuk Pakam Tall   | 5.0                     | 6.0                   | 91                              | 14                          | 75                | 2.8                |
| Kima Atas Tall     | 5.0                     | 6.0                   | 135                             | 15                          | 95                | 3.2                |
| Kramat Tall        | 4.5                     | 5.5                   | 93                              | 13                          | 102               | 2.8                |
| Adonara Tall       | 5.0                     | 6.0                   | 114                             | 13                          | 94                | 3.0                |
| Buol ST-1 Tall     | 3.5                     | 4.5                   | 99                              | 14                          | 139               | 3.5                |
| Salak Green Dwarf  | 2.0                     | 3.0                   | 61                              | 14                          | 100               | 20,500*            |
| Nias Yellow Dwarf  | 3.4                     | 4.0                   | 55                              | 14                          | 90                | 17,500*            |
| Raja Brown Dwarf   | 3.4                     | 4.0                   | 41                              | 14                          | 95                | 13,500*            |
| Bali Yellow Dwarf  | 3.0                     | 4.0                   | 44                              | 14                          | 85                | 17,500*            |
| KHINA-1 Hybrid     | 3.0                     | 4.0                   | 100                             | 13                          | 80                | 4.0                |
| KHINA-2 Hybrid     | 3.0                     | 4.0                   | 100                             | 13                          | 75                | 4.0                |
| KHINA-3 Hybrid     | 3.0                     | 4.0                   | 90                              | 11                          | 75                | 4.0                |
| KHINA-4 Hybrid     | 3.8                     | 4.10                  | 82                              | 13                          | 104               | 3.5                |
| KHINA-5            |                         |                       |                                 |                             |                   |                    |

Note: *) Nuts

Furthermore, Table 1 showed the character of production components like the number of bunches and number of fruit per palm, as well as copra production estimates, which turned out to be quite high. In the character number of bunches/palm can be seen that the Bido coconut produces an average of 14 bunches/palm/year. This number is equal to generally of coconut Dwarf varieties, Sawarna Tall, Lubuk Pakam Tall, Buol ST-1 semi-tall, and KHINA-5 hybrid, while yield Kima Atas Tall produces 15 bunches/palm/year. For fruit production, Buol ST-1 was obtained the highest that produced 139 nuts/palm/year, while Bido coconut produced 115 nuts/palm/year. Other superior coconut varieties between 75-104 nuts/palm/year. Based on observations of the character number of bunches, fruit number, weight of the fruit components to the weight of fresh nut, it can be analyzed estimates the potential copra production of Bido coconut is 4 ton/ha/year. This result is as same as with hybrid coconut KHINA-1, KHINA-2, and KHINA-3 comparison, other Tall varieties, in general, can produce copra around 2.8-3.5 tonnes/ha/year [12].

The results of observations of the components of Bido coconut fruit obtained that the average weight of whole fruit was 3,158 g/fruit, the weight of fruit without husk was 1,125 g/nut. The results showed that the weight of husk was relatively high, which was around 1,985 g/fruit, while the weight of the shell was 359 g, the volume of fruit juice was 492 ml, the weight of fresh coconut meat was on average 477 g, and the thickness of the flesh was about 1.28 cm. The weight of this fresh fruit flesh, in made copra, will be obtained at least about 60% of the weight of fresh coconut meat, or 286 g of copra/Bido coconut with a standard moisture content of about 5% [20].

The Bido Tall variety had very high expectations as one of the coconut variety future to be more productive, early bearing, and especially having short trunk character and stem height is slowly to grow. These characteristics possessed Bido Tall variety is very suitable for coconut farmers in order to easier to harvest, tapping sap for palm sugar, and high yielding. Why the Bido Tall variety Miracle coconut, because as a Tall coconut type, the Bido Tall variety has the same character with Dwarf coconut type,
such as early bearing, short trunk, and slowly to become higher, plenty of nuts, and compare to other tall type coconut, he has the exact size of fruit medium to more considerable, good quality of meat, copra, oil and fatty acids component, such as medium-chain triglycerides.

2.2.4. Dwarf x Bido Tall Hybrids. Hybridization between Dwarf x Bido Tall coconut was done in two periods. The first period were to evaluate three Dwarf x Bido Tall hybrids in 2016 and KHINA-1 hybrid as a control. The second period were to evaluate five Dwarf varieties x Bido Tall in 2017. The Dwarf x Bido Tall coconut hybrid at one year after planting showing the largest stem girth and highest plant height was Waingapu Red Dwarf x Bido Tall hybrid. For hybrids having the highest number of leaves was Aromatic Green Dwarf x Bido Tall.

Table 2. The results of observations of eight hybrid coconut dwarfs x Bido Tall at 1-2 years after planting at Kayuwatu Experimental Garden.

| Crossing  | Variable | Stem girth (cm) | Plant height (cm) | Number of leaves/6 months |
|-----------|----------|-----------------|-------------------|---------------------------|
|           |          | Ages (year)     | Ages (year)       | Ages (year)               |
| RBD x Bido Tall | Average | 17.60 | 30.15 | 150 | 267 | 2.85 | 3.60 |
|           | SD       | 1.88 | 8.28 | 25.92 | 68.61 | 0.49 | 0.99 |
|           | CV (%)   | 10.68 | 27.46 | 17.28 | 25.70 | 17.19 | 27.63 |
| BYD x Bido Tall | Average | 16.55 | 30.30 | 127 | 210 | 2.45 | 3.79 |
|           | SD       | 3.52 | 10.45 | 27.97 | 47.04 | 0.69 | 0.79 |
|           | CV (%)   | 21.27 | 34.48 | 22.02 | 22.40 | 28.16 | 20.78 |
| NYD x Bido Tall | Average | 16.80 | 31.35 | 133 | 241 | 3.0 | 4.26 |
|           | SD       | 2.61 | 7.71 | 28.36 | 51.67 | 0.39 | 0.56 |
|           | CV (%)   | 15.54 | 24.58 | 21.38 | 21.47 | 13.22 | 13.18 |
| KHINA-1  | Average | 17.0 | 31.00 | 143.18 | 227 | 2.36 | 4.00 |
|           | SD       | 2.17 | 7.78 | 21.32 | 66.26 | 0.50 | 0.58 |
|           | CV (%)   | 12.83 | 25.09 | 14.89 | 29.18 | 21.19 | 14.43 |
| TTD x Bido Tall | Average | 20.55 | - | 169 | - | 3.45 | - |
|           | SD       | 3.60 | - | 37.25 | - | 0.83 | - |
|           | CV (%)   | 17.54 | - | 21.99 | - | 23.93 | - |
| WRD x Bido Tall | Average | 25.35 | - | 232 | - | 4.0 | - |
|           | SD       | 2.96 | - | 21.62 | - | 0.62 | - |
|           | CV (%)   | 11.68 | - | 9.34 | - | 15.74 | - |
| JGD x Bido Tall | Average | 21.65 | - | 189 | - | 3.35 | - |
|           | SD       | 3.01 | - | 25.14 | - | 0.59 | - |
|           | CV (%)   | 13.92 | - | 13.30 | - | 17.53 | - |
| SGD x Bido Tall | Average | 19.40 | - | 182 | - | 3.10 | - |
|           | SD       | 3.70 | - | 37.12 | - | 0.55 | - |
|           | CV (%)   | 19.10 | - | 20.36 | - | 17.82 | - |
| AGD x Bido Tall | Average | 23.05 | - | 208 | - | 4.50 | - |
|           | SD       | 2.93 | - | 31.15 | - | 0.76 | - |
|           | CV (%)   | 12.70 | - | 14.97 | - | 16.91 | - |
At two years after planting, all Dwarf x Bido Tall coconut hybrid showed the same stem girth diameters. For the plant height, the Raja Brown Dwarf x Bido Tall coconut hybrid was the highest. For the leaf numbers, the Nias Yellow Dwarf x Bido Tall coconut hybrid was the highest. The differences of vegetative characters and performance of these coconut hybrids Dwarf x Bido Tall, are expected to affect in early bearing character, high nut yield and sap production [21].

The vegetative character analysis of eight Dwarfs x Bido Tall coconut hybrids and the control KHINA-1 hybrid are summarized in Table 2. At one year after planting, the data showed that the stem girth of WRD x Bido Tall hybrids was 25.35 cm, AGD x Bido Tall – 23.05 cm, JGD x Bido Tall – 21.65 cm) and TTD x Bido Tall - 20.55 cm. On the other hand, the stem girth of standard Khina I hybrid was 17 cm. The stem girth of the other hybrid coconuts at one year after planting were less than 20 cm. The highest plant height was WRD x Bido Tall hybrid (232 cm), followed by AGD x Bido Tall (208 cm). The shortest plant height were BYD x Bido Tall (127 cm) and NYD x Bido Tall (133 cm). The height of standard KHINA-1 hybrid was 143 cm. The leaf number at 6 months after planting for AGD x Bido Tall was 4.5 leaf and WRD x Bido Tall was 4 leaves. Such data indicated that they would have 9 and 8 leaf after one year in the field. The KHINA-1 hybrid leaves was 4.72.

The result of the vegetative character evaluations of four hybrids at two years after planting showed that the stem girth diameters was similar in all hybrids, ranged from 30.15 cm – 31.35 cm. For plant height, the standard KHINA-1 hybrid was 227 cm. The tallest among Bido derived hybrids was of RBD x Bido Tall (267 cm) and NYD x Bido Tall (241 cm). On the other hand, the shortest was BYD x Bido Tall (210 cm). The total leaf number every 6 months in the NYD x Bido Tall hybrid is 4.26, KHINA-1 hybrid was 4 and RBD x Bido Tall and BYD x Bido tall were 3.60 and 3.79 leaves.

A big stem girth, short stem, and many leaves are the expected progeny characters of the best combination of dwarf x Bido Tall coconut hybrids. The differences of these vegetative characters in seedling growth in the field may be associated with early to flowering, high yielding, and the low height increment. However, whether those vegetative growth indicators are a good predictors for superior hybrid characters remain to be seen when they bear their nuts.

2.2.5. Selfing of Bido Tall

The IPCRI-IAARD has planted Bido tall germplasm collection at Mapanget Experimental Garden and Bido tall seed garden at Kayuwatu Experimental Garden in 2017-2018. Those populations were introduced from Bido village, East Morotai district, Morotai Island, North Maluku Province. More than 400 palms of Bido Tall survive, and produce flowers and nuts. In the original location (Bido village) and in the neighboring villages showed segregating progenies derived from original Bido parents. Some of the progenies resemble tall type and differ from the parent. These progenies showed different fruit color, size, and shape than the original Bido. They also showed higher height increment than the original Bido coconut. Such results indicated that there are possible pollen contamination and some of the progenies are no longer Bido variety.

To rectify this potential problem, Bido tall coconut self-pollination program was initiated in 2020-2021, to obtain pure lines of Bido tall coconut. The self-pollination of Bido coconut’s objective is to generate more homozygous and more homogeneous Bido tall progeny populations. Such homozygous and homogeneous Bido population are essential for hybrid production using Bido tall as male parent.

3. Conclusion

Bido Tall coconut is a best coconut variety because of its short stature, low height increment, early bearing, large, and abundant nut yield. Hybrids derived from Waingapu Red Dwarf x Bido Tall, Aromatic Green Dwarf x Bido Tall, Raja Brown Dwarf x Bido Tall, and Nias Yellow Dwarf x Bido Tall showed good performances at vegetative growth stage (1-2 years after planting). The vegetative growth performance affects the subsequent early bearing first characters, nut yield and sap production characters. Self-pollinated Bido tall were conducted to obtain more homozygous and homogeneous Bido tall derived progenies for future hybrid variety development.
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