RESEARCH ARTICLE

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Biodiversity of Indonesian Red Chilli (*Capsicum annuum* var. *longum*) Based on Morphological Characters

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Chilli is one of important economically crop commodity in Indonesia with a large biodiversity, includes red chilli *C. annuum* var. *longum*. Aim of this research was to determine morphological characters of many red chilli cultivars in Indonesia. The morphological characters were determined qualitatively and quantitatively. The results showed there were 6 qualitative characters and 7 quantitative characters could be used to determine inter cultivars diversity. Based on the vegetative performance, Bukittinggi local cultivar had the best performance, which highest plant with dichotomous was near the ground and the widest canopy. Based on the reproductive performance, Gantari or Ciko had better than the others. Gantari had most fruit length and fruit diameter, while Ciko had most fruit diameter and fruit weight.

Keywords: Biodiversity, Chilli, Qualitative Morphology, Quantitative Morphology.

1. INTRODUCTION

Chilli is the major crops in many countries, which the top five chilli producing countries are China, Mexico, Turkey, Indonesia, and Spain.[1] Indonesia is cultivated chilli as an important part of life that consumed daily on all of provinces. In Indonesia, chilli is the second crops (after cabbage) that using 20% of the vegetable land but only produces 12% of the total vegetable. The average yields of chilli crops were 4.7–6.4 ton/ha in 2005, with 62% of the crops were red chilli.[2] The chilli area was increased to 230.000 ha and chilli became the first vegetable commodity which produced 1.450.000 ton chilli in 2013.[1]

Taxonomically, chilli can be classified to many species in genus *Capsicum*, but only five species were domesticated because of their economically values. The five domesticated species were *C. annuum, C. frutescens, C. chinense, C. pubescens*, and *C. baccatum*.[3] The primary diversity center of *C. annuum* is Mexico, with secondary centers are Central America, northern South America, India, the Mediterranean region and Southeast Asia.[4] Red chilli *C. annuum* is the main cultivated species in Indonesia.[5] The wild progenitor of *C. annuum* has red coloured fruit, small size (length of fruits were about 1 cm) but pungent, deciduous and soft-fleshed. The fruit is pungent because of the capsaicin content in the fruit. Mammals do not like chilli because of the pungency. Birds do not have receptors for capsaicin, so the birds can eat chilli without feeling the sting. Birds eat chilli and spread the seeds to many places.[6] Domestication causes selection of many characters, including the shape, colour, flavour or degree of pungency, and fruit wall thickness. Continued selection during domestication has led to elect the larger fruit and non-pungent varieties of chilli.[7]

Indonesia has many cultivars of red chilli, is categorized to big-red chilli and curly-red chilli. There were 87 cultivars of big-red and 86 cultivars of curly-red in 2011 based on Vegetable Varieties List of Indonesian Ministry of Agriculture.[8] Most of cultivated red-chilli was hybrid lines produced by many seed agents and the others were open pollinated or local cultivars. The hybrid cultivars have more preferably than the others because of their productivity, but the seeds usually expensive. The hybrid cultivars were not good to use as progenitor because of their wide variability in the progenies. Open pollinated and local cultivars usually have less performances and productivity but more resistant to disease, cheap seeds, and good to use as progenitor.[9] Megabiodiversity of chilli in Indonesia might be used to develop the open pollinated and local cultivars.

Diversity of plants can be seen morphologically by analysed their qualitative and quantitative morphology. There are some variants of the leaf shape, colour of leave or flower or fruit, fruit length and weight, and so on. The morphological variations are effected by their environment and lead to the genetic relationship among the cultivars. Objective of this research is to determine the biodiversity of red chilli in Indonesia, specifically on open pollinated and local cultivars, based on their morphological characters.

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Table I. Scales for qualitative characters.

No.	Character	Scale			
1	Habit	Erect (1)	Semi-erect (2)	Spreading (3)	Prostrate (4)
2	Leaf shape	Delta (1)	Oval (2)	Lancet (3)	
3	Leaf colour	Dark green (1)	Green (2)	Light green (3)	
4	Leaf edge	Flat (1)	Curved (2)		
5	Leaf tip	Tapered (1)	Pointed (2)		
6	Stem colour	Green (1)	Brownish green (2)		
7	Colour of sepals	White (1)	Cream (2)	Yellow (3)	Purple (4)
8	Colour of petals	Green (1)	Purple (2)		
9	Colour of flower stalk	Green (1)	Purple (2)		
10	Number of sepals	5 (1)	6 (2)		
11	Colour of anther	Purple (1)	Purple-green (2)	Green (3)	
12	Colour of pistil	White (1)	Yellow (2)	Yellow-green (3)	
13	Fruit shape	Cone (1)	Bell (2)	Rounded (3)	
14	Fruit surface	Wrinkle (1)	Smooth (2)		
15	Colour of young fruit	Dark green (1)	Green (2)		
16	Colour of mature fruit	Red (1)			

Table II. Scales for quantitative characters.

No.	Character	Scale			
1	Plant height	>45 cm (1)	40–45 cm (2)	30–40 cm (3)	<30 cm (4)
2	Dichotomous height	>30 cm (1)	20–30 cm (2)	10–20 cm (3)	<10 cm (4)
3	Canopy width	>17.5 cm (1)	16–17.5 cm (2)	14.5–16 cm (3)	<14.5 cm (4)
4	Leaf width	>2 cm (1)	1–2 cm (2)		
5	Fruit length	>10 cm (1)	9–10 cm (2)	8–9 cm (3)	<8 cm (4)
6	Fruit diameter	>1 cm (1)	0.9–1 cm (2)	0.8–0.9 cm (3)	<0.8 cm (4)
7	Fruit weight	>4 g (1)	3–4 g (2)	2–3 g (3)	<2 g (4)

2. EXPERIMENTAL DETAILS

2.1. Plant Materials

Open pollinated cultivars were Lembang-1, Kencana, and Ciko from Indonesian Vegetable Research Centre; Branang and Gantari from Indonesian Breeding Centers; while local cultivars were from Pakem, Yogyakarta and from Bukittinggi, West Sumatra. TM999 was hybrid cultivar produced by PT Seminis, Monsanto, Korea used as comparing cultivar.

Seeds were spread in a tray and grown under plastic canopy, one tray to one cultivar. After 7–10 days the seedlings started to grow. Then the seedlings were planted into small polybag (3×5 cm) contains topsoil and maintained under plastic canopy. On 30 days after planting (dap), each cultivar was grown in 30×30 cm polybag contains topsoil and maintained carefully. Morphological characters were determined since 60 days after planting (dap). Qualitative morphology were descripted according to Bioversity International[11] on 16 characters, included the habit, leaf shape, leaf colour, leaf edge, leaf tip, stem colour, colour of petals, colour of sepals, colour of flower stalk, number of sepals, colour of anther, colour of pistil, fruit shape, fruit surface, colour of young fruit, and colour of mature fruit. Quantitative morphology were descripted according to Bioversity International[8] on 7 characters, included plant height, dichotomous height, canopy width, leaf width, fruit length, fruit diameter, and fruit weight.

3. RESULTS AND DISCUSSION

There were many variances on chilli plant morphology, qualitatively and quantitatively. Table III showed the qualitative morphology of Indonesian red chilli cultivars, while Table IV showed the quantitative morphology.

Based on the qualitative morphology, there were some characters that could be used as a determinant of diversity inter cultivars, i.e., leaf shape, leaf tip, colour of anther, colour of pistil, fruit surface, and colour of young fruit. Leaf shape of red chilli (*C. annuum* var. *longum*) usually is oval to lancet with leaf tip is tapered or pointed.[5] Kencana cultivar had delta leaf shape, it was more similar to bell-pepper leaf (*C. annuum* var. *grossum*). Sepal colours of the all cultivars were white, accordance to the specific character of sepal colour in *C. annuum*.[3] Colour of anther and pistil were specific to the each cultivar and might be used as a specific character of a cultivar. All red chilli cultivars had cone fruit, which confirmed to *C. annuum* var. *longum*. Because of its fruit shape was cone, Kencana was categorized as red chilli and

Table III. Qualitative morphology of Indonesian red chili.

No.	Character	TM999	L-1	Kcn	Gtr	Br	Ciko	Pakem	Bkt
1	Habit	1	1	1	1	1	1	1	1
2	Leaf shape*	3	3	1	2	2	2	2	3
3	Leaf colour	1	1	1	1	1	1	1	1
4	Leaf edge	1	1	1	1	1	1	1	1
5	Leaf tip*	1	1	2	2	1	1	2	1
6	Stem colour	1	1	1	1	1	1	1	1
7	Colour of sepals	1	1	1	1	1	1	1	1
8	Colour of petals	1	1	1	1	1	1	1	1
9	Colour of flower stalk	1	1	1	1	1	1	1	1
10	Number of sepals	1	1	1	1	1	1	1	1
11	Colour of anther*	1	2	2	2	1	2	2	1
12	Colour of pistil*	2	2	1	2	2	3	2	2
13	Fruit shape	1	1	1	1	1	1	1	1
14	Fruit surface*	1	1	1	2	1	2	1	1
15	Colour of young fruit*	1	2	2	2	2	2	2	2
16	Colour of mature fruit	1	1	1	1	1	1	1	1

Note: *Can be used as a determinant of vegetative performance.

Table IV. **Quantitative morphology of Indonesian red chili.**

No.	Character	TM999	L-1	Kcn	Gtr	Br	Ciko	Pakem	Bkt
1	Plant height*	1	3	3	2	3	4	2	1
2	Dichotomous height*	1	2	4	2	3	3	2	4
3	Canopy width*	1	3	4	2	2	4	1	1
4	Leaf width*	1	2	1	1	1	1	2	1
5	Fruit length*^	1	2	4	1	2	3	3	1
6	Fruit diameter*^	3	4	3	1	2	1	4	3
7	Fruit weight*^	4	4	4	2	3	1	4	3

Notes: *Can be used as a determinant of vegetative performance, ^Can be used as a determinant of reproductive diversity.

was not categorized as bell-pepper although its leaf shape was similar to bell-pepper leaf. Fruit surface could be used to differ the big-red chilli and curly-red chilli, which smooth on big-red chilli but wrinkle on curly-red chilli. Based on their fruit surface, just Gantari and Ciko were big-red chilli while the others were curly-red chilli. Colour of young fruit on the red chilli usually green to dark green, but all of Indonesian red chilli had green on their young fruit.

All of the Indonesian red chilli in this research had erect habit with some variances on their height. According to Esbaugh,[3] the plant height usually short to 1.5 m from the ground surface. The plants had a main trunk and branched after reaching a certain point which was called dichotomous. There were differences on the dichotomous height from the ground level. Based on the plant height and dichotomous height, usually the higher the plant habit also the higher dichotomous. TM999, Lembang-1, Gantari, Branang, Ciko, and Pakem had dichotomous far enough from the ground level. But especially to Kencana and Bukittinggi, the dichotomous were near the ground level. The plant height, dichotomous height, canopy width, and leaf width could be used as good characters for selection.[13] The characters affected the performance of each cultivar. For example, the erect plant with normal height which dichotomous was near from the ground would look tough and strong. Plants with wide canopy and wide leaves indicated the plant growth well. The plant habit and canopy also affected the area for each plant to consider the spacing of planting and harvesting, weed control, and the volume of chemical spray.[14] The spacing of planting could be affected the economic value of chilli plant.[15]

Fruit length, fruit diameter, and fruit weight could be used as a determinant of diversity and product performance. Chilli with long, thick, and heavy fruit would be have more economic value and preferred by consumers. Fruit length affected market value which the medium normally to long fruits were preferred.[16] Fruit diameter (fruit width) indicated to greater gains in fruit weight and yield.[17] Fruit weight and length could be optimized by increasing of plant spacing.[14]

4. CONCLUSION

Based on the qualitative and quantitative results, there were 6 qualitative characters and 7 quantitative characters that could be used as good criteria for red chilli cultivar selection. The characters were leaf shape, leaf tip, colour of anther, colour of pistil, fruit surface, colour of young fruit, plant height, dichotomous height, canopy width, fruit length, fruit diameter, and fruit weight. Based on the vegetative performance, Bukittinggi had the best performance, which highest plant with dichotomous was near the ground and the widest canopy. Based on the reproductive performance, Gantari or Ciko had better than the others. Gantari had most fruit length and fruit diameter, while Ciko had most fruit diameter and fruit weight.

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