MANIPULATING TREE ARCHITECTURE TO INCREASE DURIAN PRODUCTIVITY AND TO IMPROVE TREE FORM

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INTRODUCTION

Background

- In Indonesia, durian is usually planted in home gardens (pekarangan) and small scale farms with low productivity (6.2-13.5 ton/ha).
- Durian potential productivity up to 25 ton/ha (Verheij dan Coronel, 1992)
- Field observation at some durian farms around Bogor showed following characters:

  (1) complex crown structures,

  (2) small angle branches,

(3) very tall trees (up to 40 m) due to gradual self-pruning at the basal crown,

(4) alternate bearing,

(5) simultaneous flushing and reproductive organ formation,

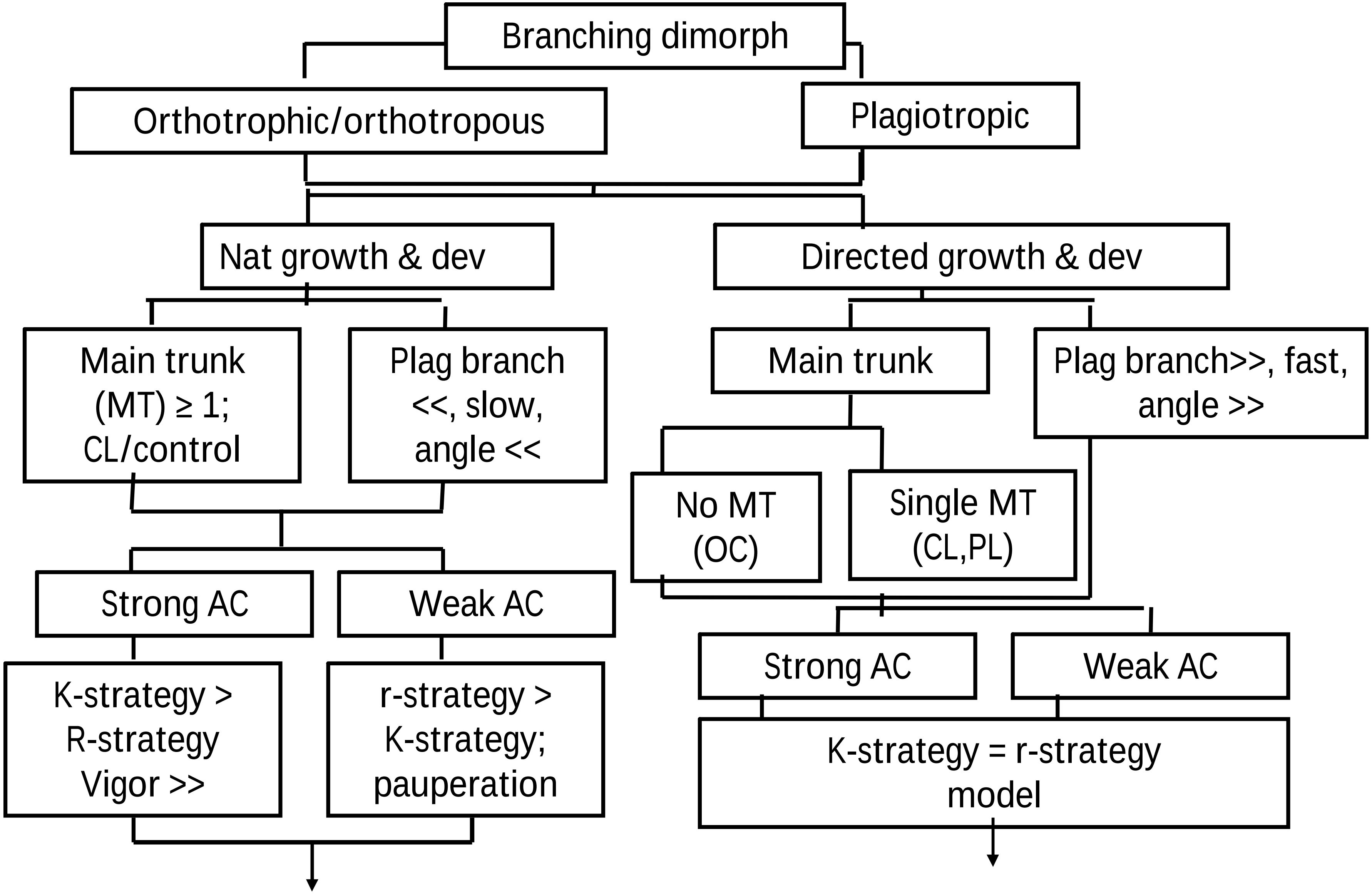
(6) in shaded condition, infant developed reproductive organs dedifferentiate into vegetative organ

Some durian farms were opened as agro-tourism objects

- Less effective orchard management

Directing plant growth and development → pruning and training;

Fig 1. Frame work



- unbalanced partition of assimilate
- Ø branch <<
- over flushing
- reiteration

- Self pruning and alternate bearing (low stock of assimilate)
- Ineffective orchard management

Low productivity

- Balanced partition of assimilate
- Ø branch >>
- proporsional flushing
- No reiteration

- No self pruning and no alternate bearing (abundant stock of assimilate)
- Effective orchard management

Higher and sustainable productivity

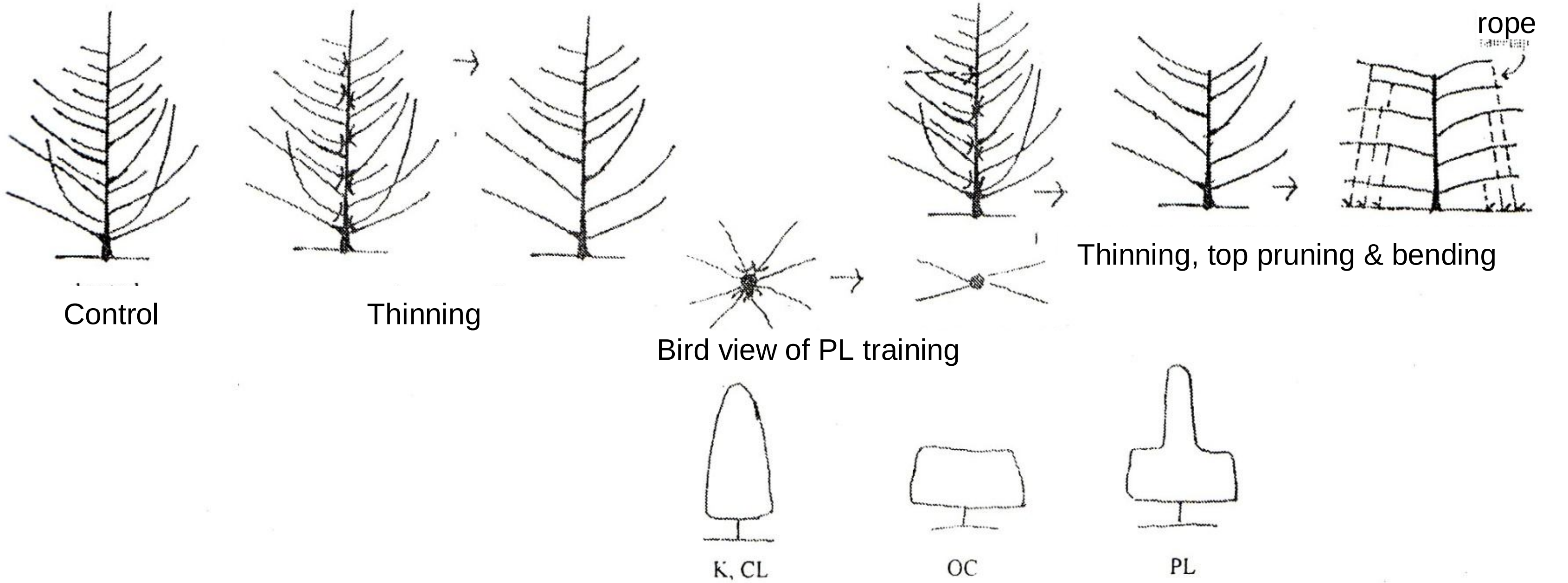
Objectives

1. Studying branching habit (apical control and dimorphism), crown form and morphometric aspect,
2. Studying the effect of pruning and training to plant growth and development
3. Studying source-sink physiology or dynamic of sugars in some different growth development, training type and branch structure.

METHODOLOGY

Basic experimental design

- **Two durian clones:**
  - Matahari conical crown), and
  - Monthong (columnar-to-rounded crown)
- **Four training types**
  - Central leader, control (K)
  - Central leader (CL)
  - Palmette/palmetto leader (PL)
  - Open center (OC)
- **Practices following training**: top pruning, thinning and bending



Training type and following plant direction
(thinning, bending and top pruning

Crown Model, Branching Habit and Morphometric Aspect

Experiments and surveys

to quantify crown form and model at seedling and mature trees,
to study the effect of pruning and training to apical control, and crown model, and
to study morphometric aspect and branch dimorphism.

Variables

Crown model (representing apical control) → gradient model (break point regression of Littell, 1989)
Physical crown was defined by Cook's approach (Cook et al., 1999)
Crown structures were described by method of Norman and Campbell (1989) and Halle *et al*. (1978).

- Branch angle
- Procumbent index
- Number of plagiotropic/plagiotropous branches (%)
- Reiteration form

Effect of Pruning and Training to Plant Growth

Objective:

- To study assimilate (dry weight partition)

Variables:

- Total dry weight (DW in kg) – by non-destructive method
- Branch/trunk DW ratio
- Leaf area index (LAI)

Source-sink **Physiology**

Objectives:

- To study sugars and sugar fraction (reductive and non-reductive sugars (g-red and g-nonred) in:
  - *sink* tissues (young leaves)
  - *source* tissues(mature leaves and phloem tissues)
- To study sugar dynamic → defoliation of plagiotropic branches
  - Sugar transfers from source to sink tissues

Variables:

- tissue samples for sugar analysis → sampled in the morning (8:00-9:00 am), processed by method of Keller dan Loescher (1989) and analyzed by method of Stute and Martin (1986)

RESULT AND DISCUSSION

Crown Model, Branching Habit and Morphometric Aspect

1. **Crown model** (table 1)

- Two and three phase (Matahari clone)
- Two phase (Monthong clone) models
- Matahari > Monthong crown gradient
- conclusion

(1) different basal branches growth of the two clones and such growths were controlled by apical control mechanism,

(2) no ontogeny factors affected apical control of durian.

These knowledge will be useful to predict earlier crown model of mature tree by observing crown model of seedling and what type of training needed.

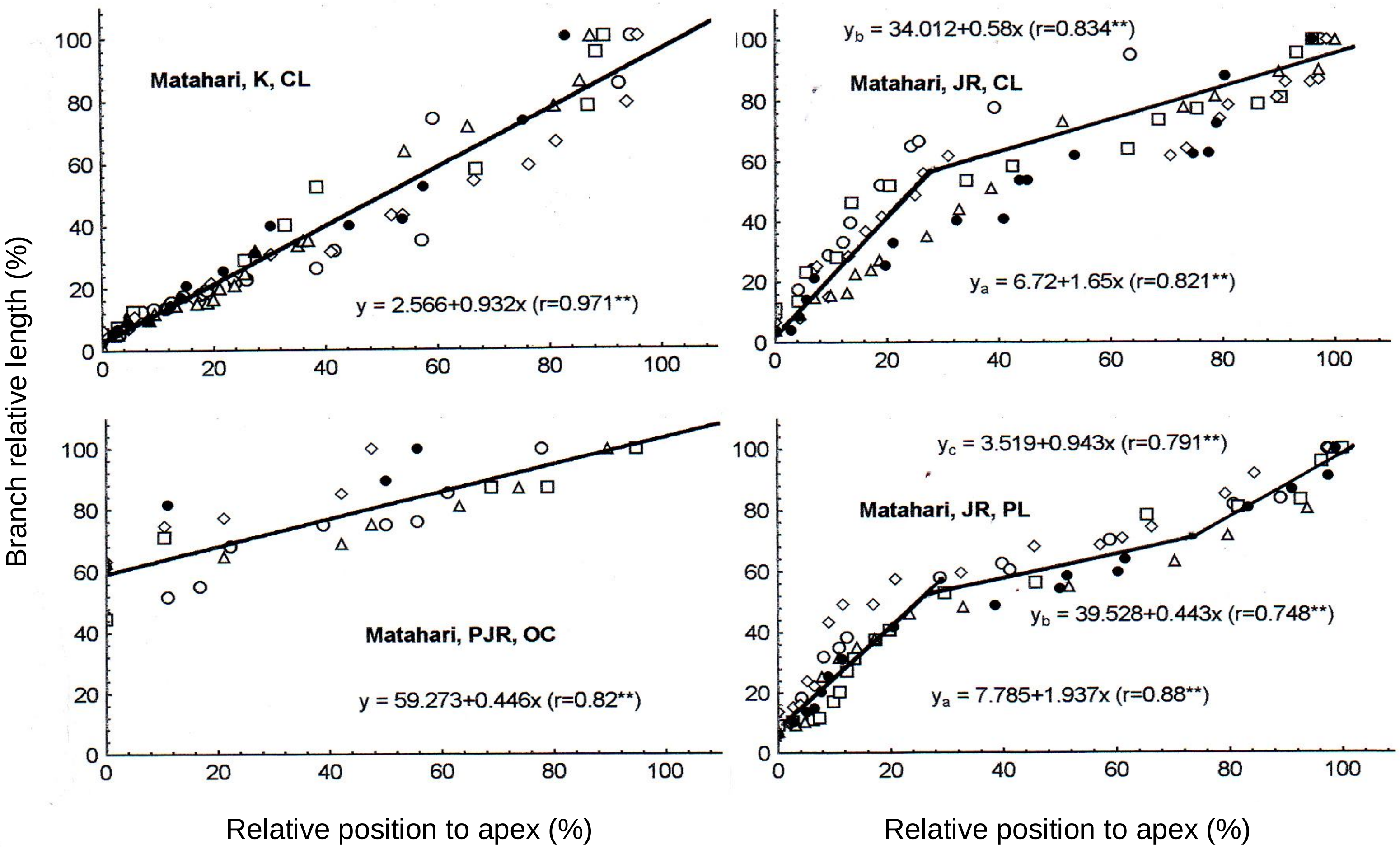


Figure 2 Relation of branch relative position to apex (%) with branch relative length (%) of pruned and trained Matahari durian

(CL = *central leader*, OC = *open center*, PL = *palmette leader*; treatment T =thinning, B = bending, P = top pruning; J or T = thinned, R or B = bended and P = top pruned)

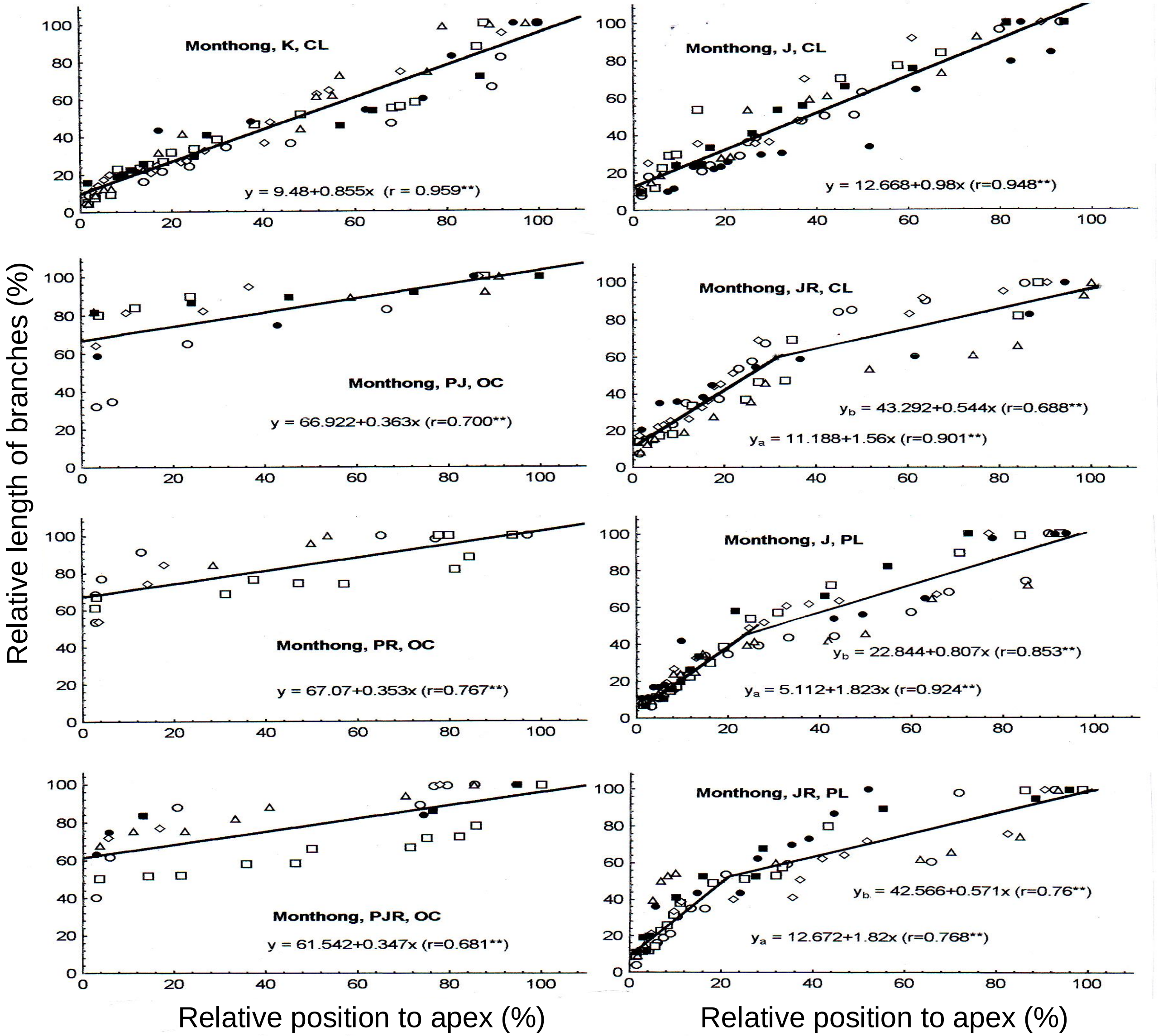


Figure 3 Relation of branch relative position to apex (%) with branch relative length (%) of pruned and trained Monthong durian

(CL = *central leader*, OC = *open center*, PL = *palmette leader*; treatment T =thinning, B = bending, P = top pruning; J or T = thinned, R or B = bended and P = top pruned)

2. Branching habit and morphometric aspects

Table 1 Effect of pruning and training on branch diameter quartile distribution, branch angle, procumbent index, number of plagiotropic branches and number of reiteration form of mature (3.5 years) durian Matahari tree.

Treatment/ training type	Branch dia (cm)						Branch angle	Procum-bent index	Plag. Branch %	Rei-teration form
	Mean & SD	Q0	Q1	Q2	Q3	Q4				
Control/CL	1.3 ±1.2	0.3	0.5	0.9	1.8	5.8	52.1±9.0	0.64±0.16	90.2±9.8	0.6±0.5
TB/CL	1.6 ±1.0	0.2	0.8	2.0	2.4	4.2	76.0±10.5	0.30±0.11	99.0±1.4	-
PTB/OC	3.1 ±0.8	1.3	2.7	3.1	3.5	5.0	78.1±8.4	0.24±0.07	100.0±0.0	-
TB/PL	2.1 ±1.1	0.3	1.0	2.1	3.0	4.5	78.3±9.8	0.28±0.08	90.2±10.3	-

Training type: CL = *central leader*, OC = *open center*, PL = *palmette leader*; treatment T =thinning, B = bending, P = top pruning; plag. = cabang plagiotrop. Number of branches of Control to TB/PL plants were 68,50, 17 and 38 respectively.

Finding

a. Pruned and trained durian had (Table 1).

- better quartile distribution of their branches,
- bigger branch angle and
- bigger total number of plagiotropic branches

b. Early thinned-bended (TB or JR) and pruned-thinned-bended (PTB or PJR) plants had (Table 2):

- more plagiotropic branch numbers and such branches were more procumbent, trailing along (low procumbent index) or bending.
- No reiteration was found.

Finding (continue)

Such good performances might be caused by:

- Lesser apical dominant (Ryugo, 1988 and Wilson, 2000),
- Lesser apical control (Wilson, 2000), and
- Lesser inter-organ competition (Borchert, 1976).

c. Naturally growing durian

- Matahari > Monthong reiteration

d. Thinning and bending:

- Better branch/trunk DW and total DW (Fig 4a-b)
- Better LAI (Fig 4c)
- Protecting self pruning (Fig 4d)

Table 2. Characters of durian crown of non-trained tree (5 year old) in Mekarsari Agroturism, Cileungsi, Bogor

Crown character	Monthong clone (n=8)	Matahari clone (n=8)
Branch angle (^{o})	50,9 ± 12,3	53,9 ± 16,6
Number of primary branches	31,4 ± 16,4	35,5 ± 8,6
Number of reiteration form	0,4 ± 0,7	1,6 ± 2,3

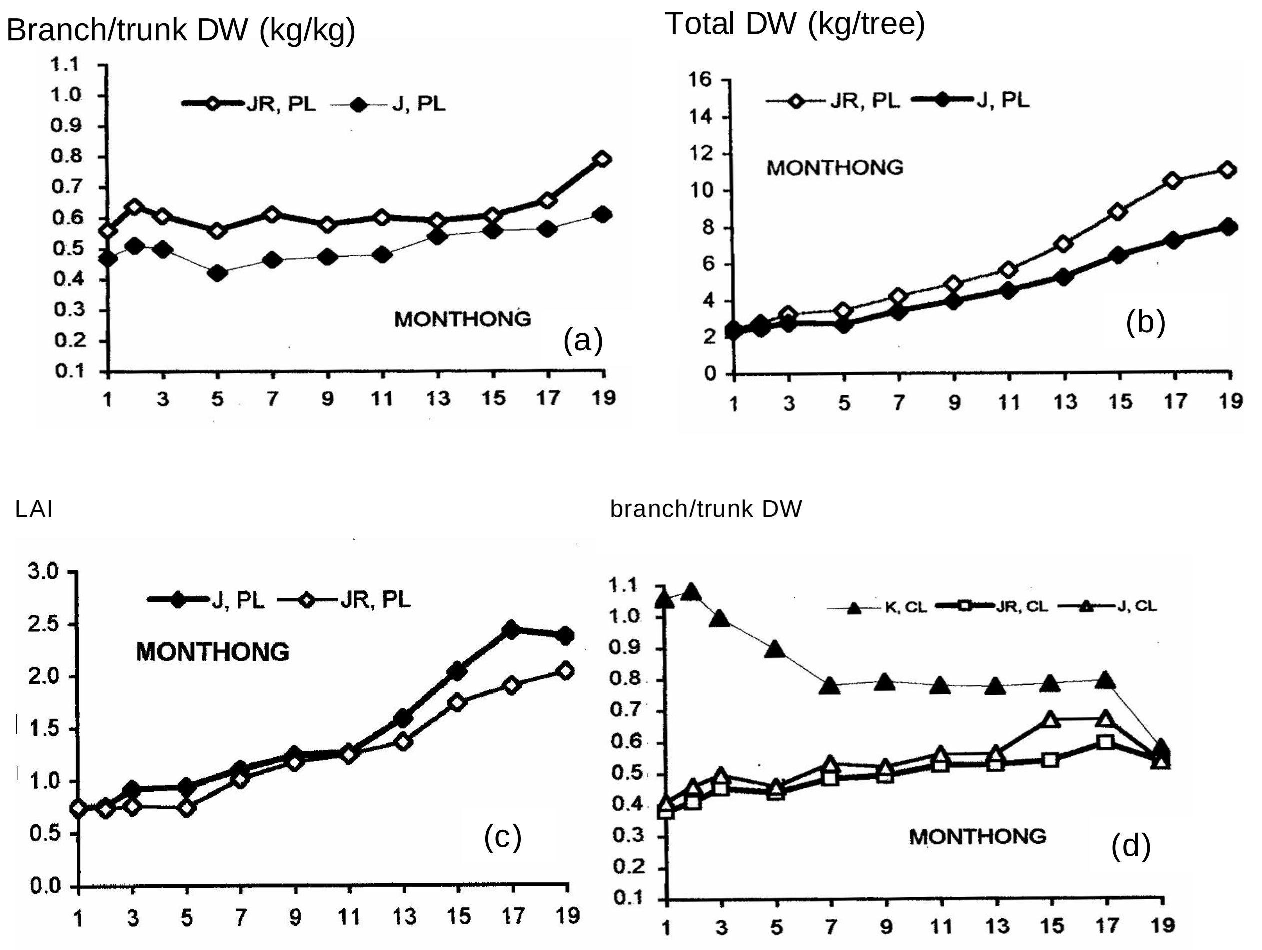


Figure 4 Effect of thinning (J) and bending (R) applied to training type to branch/trunk dry weight (DW) ratio, total DW and LAI of Monthong clone (K = control, CL = central leader, PL = palmette leader)

Finding:

1. Sucrose and oligosaccharide (stachiose) were found abundant either in source or sink tissues.
2. The two non-reductive sugar content achieved 8-10% and 4.0-7.2% of their phloem and old leaf tissues recpectively, 2-3 times higher than that of reductive sugars (Figure 5 and 6)
3. Sugar dynamic

a. Effect of strong sink-to-source of young leaf to phloem tissues sugar

   - either reductive or non-reductive sugars depleted in flush of 2 WAD, but in 4 and 6 WAD such sugars content increase (Figure 5): depletion followed by recovery (parallel with chlorophyll content development)

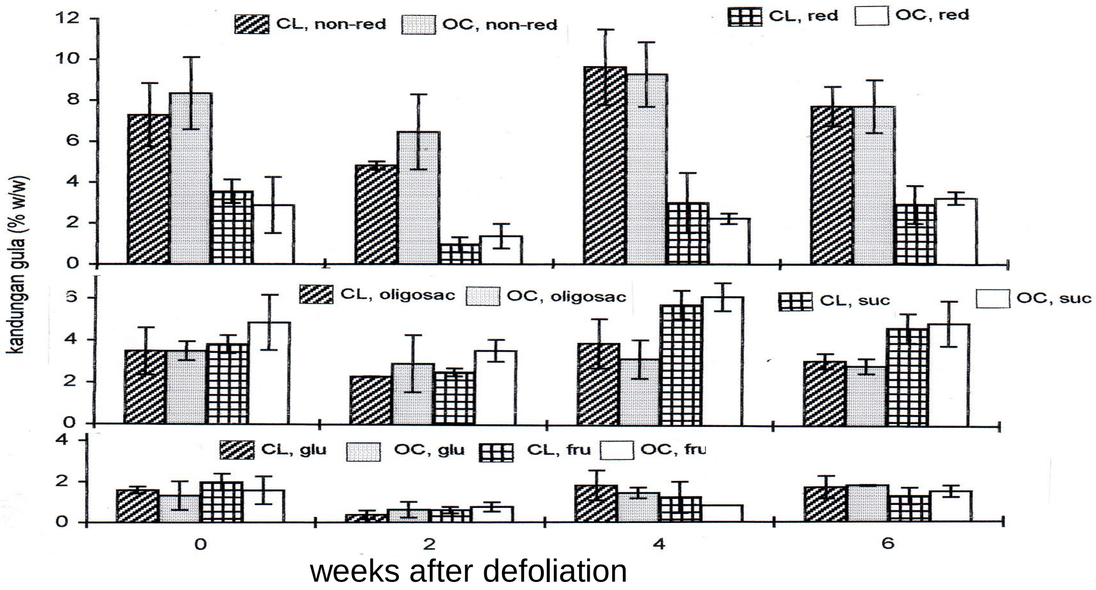


Figure 5. Effect of training typeand flush sink (WAD) to phloem tissues sugars

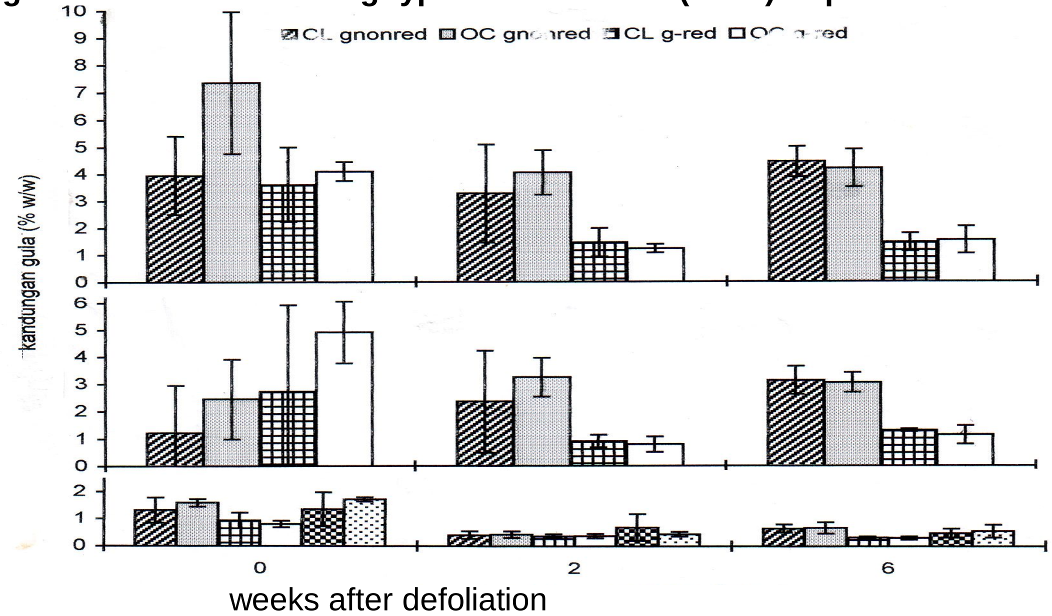


Figure 5. Effect of trainng typeand flush sink (WAD) to mature leaf sugars

b. At strong sink (2 WAD):

- sucrose content decreased but not for oligo-saccharide (sucrose were instanly convert into oligo-saccharide and transiently stored) → abundant phenomena (Iglesias dan Podesta, 1997) ~ analog to polymorphism for Rauh model
- It was caused by starch-non reductive sugar interconversion and sugar fractionation at intercellular level of leaf (Dietz dan Keller, 1997) during strong sink (Wright, 1989) that was intensively occurred.
- reductive sugars as glucose (glc), galactose (gal) and fructose (fru) also increased → with glycocidic linkage (Salisbury and Ross, 1992) or polymerization and through a series of enzymatic reaction (Dietz and Keller, 1997) could form stachiose.

CONCLUSION

1. Apical control on durian is clone-specific and it does not depends on ontogeny.

2. Strong apical control clone (Monthong) should be pruned and trained in open center, but the weaker one (Matahari) should be in open center, palmette leader or in central leader followed by bending.

3. Pruning and training could direct the plant toward "model" strategy that support high "potential" productivity and tree longevity as reflected by morphometric aspect and assimilate (dry weight) partition.

CONCLUSION

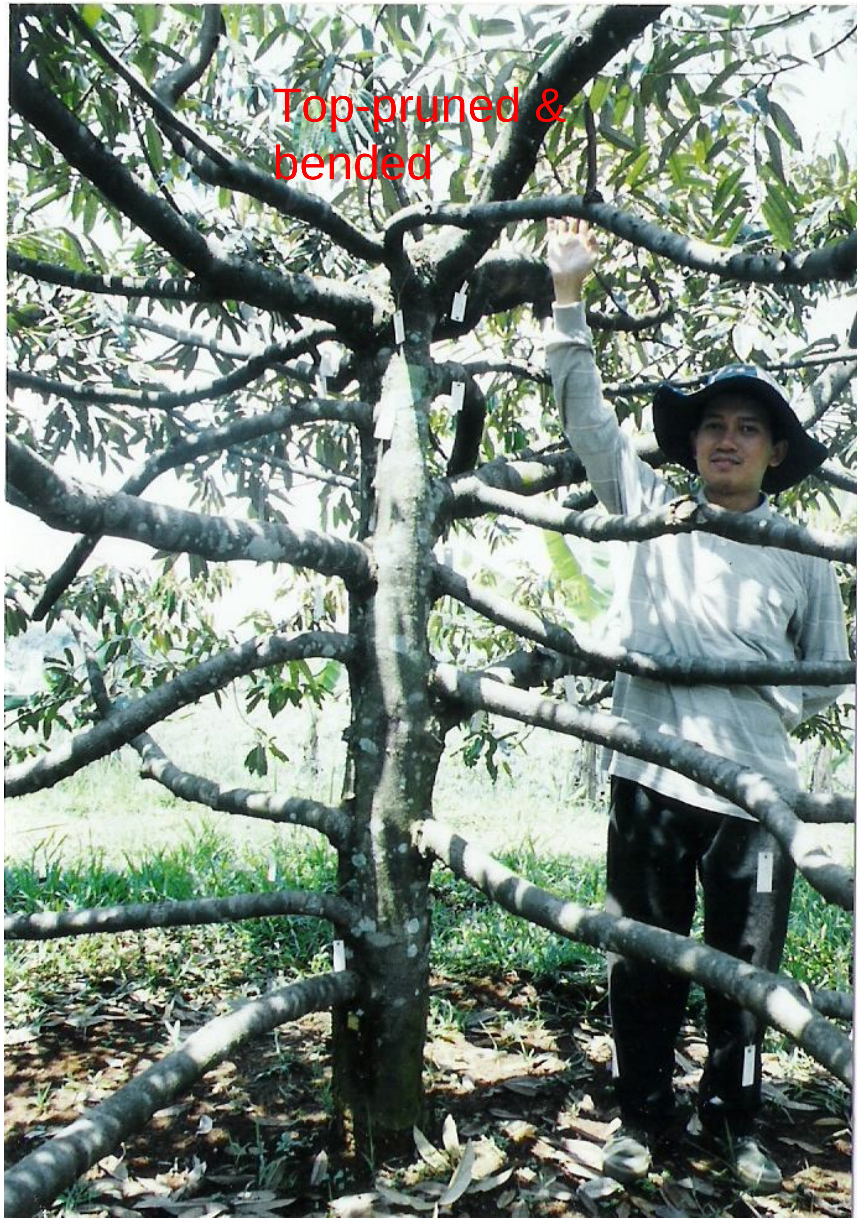
4. Non-reductive sugars sucrose and oligosaccharide (supposed as stachyose) were mobile sugars found abundant in plagiotrophic branches that play important role in source-sink physiology of durian, can be used to predict the productivity of trained and pruned durian.

5. Further study is needed to explore the oligosaccharides mobilization, the activity of enzyme that interconvert the storage of that sugar, and the control mechanism of the release from storage compartments, which can be beneficial for other practical application, such as micro-element foliar fertilizer application.


Flower at bending
('procumbent')
branches


Flowers at secondary
branches
'96 9 14

CL training



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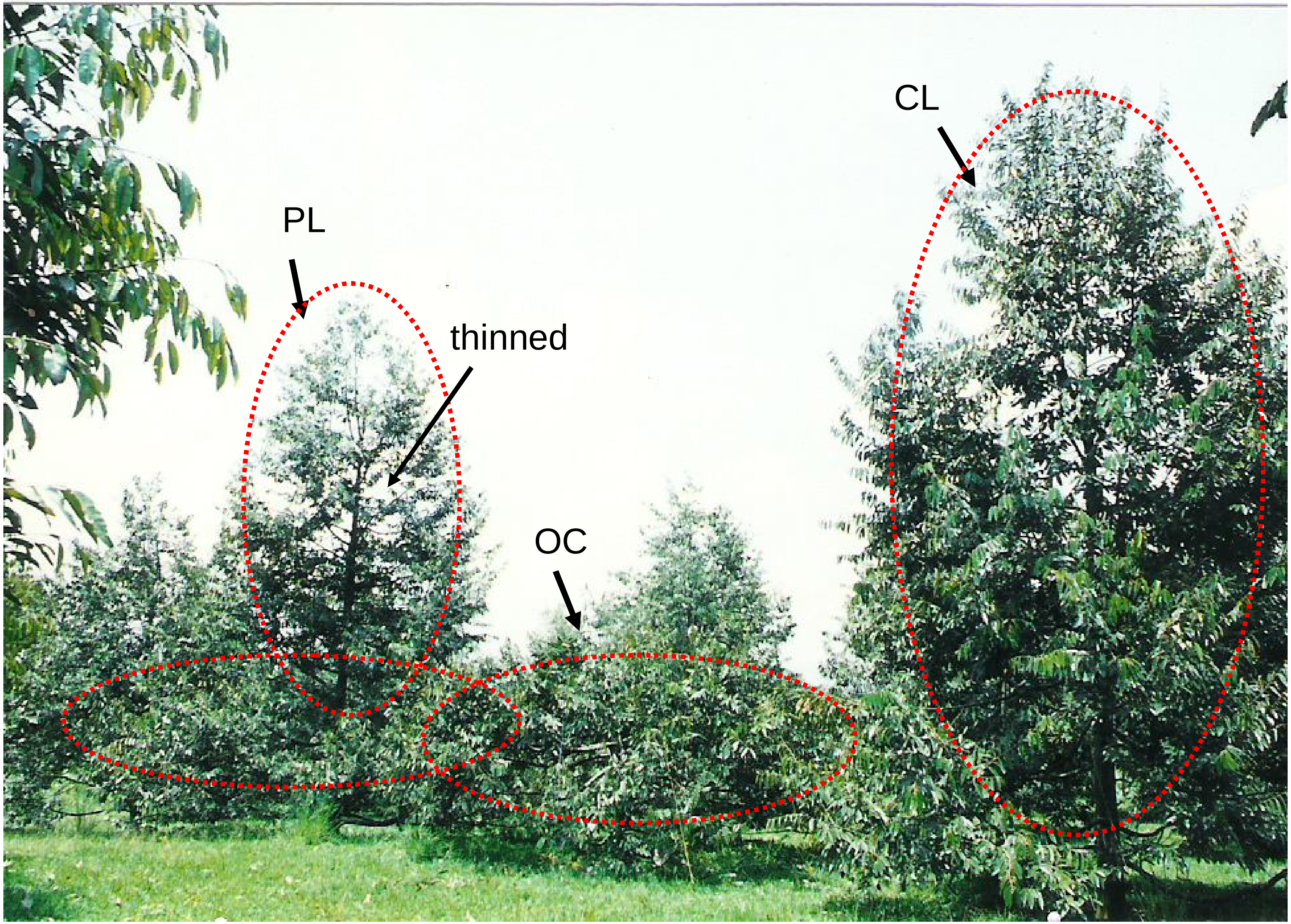

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Glossary

Apical control

growing of a certain branches controlled by autonomy of the upper branches of the same apical dominant level

Dimorphism

meristem (shoot) development that orient to be orthotropous and plagiotropous

Pauperation

lessening the vigor and dimension so that tree architecture expressed minimum

K-strategy

species mechanism to preserve its genotype or its self by sacrificing its reproductive capability

r-strategy

species mechanism to preserve its genotype or its self by maintaining high reproductive rate but sacrificing individual longevity