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Effect of Some Factors on Air Dry Moisture Content and Specific Gravity of Torem Wood (Manilkara *kanosiensis*)

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Abstract:
The physical properties of the wood especially moisture content and specific gravity are the factors that are associated with the strength of the wood, they are necessary to know before the wood material is used for the certain needs. The purpose of this study was to determine the effect of trunk position, wind direction and the radial direction on air dry moisture content and specific gravity of Torem wood. The experimental design used was completely randomized design with three factors and three replications. Factor A (trunk position) with five levels, factor B (wind direction) with four levels, and factor C (radial direction) with two levels, so there are 5 x 4 x 2 x 3 = 120 experimental unit. Results of the analysis showed that all single factors and their interactions give significant to high significant effect on air dry moisture content, with determination coefficient 88.06%. On the other hand the three factors studied, as well as all interactions give significant to high significant effect on specific gravity, with determination coefficient 89.01%.

Keywords: *Trunk Position, wind direction, radial direction, the moisture content, specific gravity*

1. Introduction

According to estimates, in Indonesia there are about 4000 wood species, 400 species of which are considered important because they have been used, but only a few of them was known its properties and usefulness (Martawijaya *et al.* 1981). Wood can be processed into semi-finished and finished materials such as paper and others. (Dumanauw, 1982; Frick and Koesmartadi, 1999; Kewilaa, 2012).
The use of wood is ultimately required extensive knowledge about its properties (Dumanauw, 1982), because of the nature of wood of different species has different properties, even from one tree can have different properties (Brown, *et al*. (1952).
One species usually used by the people MTB (Maluku Tenggara Barat) is Torem wood (*Manilkara kanosiensis)*, this species is generally used as building materials, furniture and to craft statue (Soselisa, 2011). Utilization of this species by local people, not yet pay attention to the factors that affect the properties of wood, especially the moisture content and specific gravity, in which the basic properties that determine the strength of the wood.
Brown *et al.* (1952); Skaar, (1972) and Oey Djoen Seng (1990) suggested that variations in moisture content and specific gravity of wood caused by differences in the trunk position and the radial direction. Wibowo and Setiawan (2014) suggests that wind direction affect the ability of roots to absorb water, allegedly, will affect the moisture content and specific gravity.
Based on that problems then planned to research " Effect of some Factors on Air Dry Moisture Content and Specific Gravity of Torem Wood (*Manilkara kanosiensis)*".
The purpose of this study was to determine the effect of the trunk position, wind direction and radial direction on air dry moisture content and specific gravity of Torem.

2. Materials and Methods

2.1. Materials and Equipment

2.1.1. Material

The material used was one tree of *manilkara kanosiensis*, which comes from natural forest at Selu Island, MTB District. Equipments used include: chain saw, phi band, meter roller, hand saw, caliper, plastic, compass, stationery, oven, analytical balance and desiccator.

2.1.2. Preparation of Test Sample

Samples taken from one tree with 7 meters' height and a diameter base of 54 cm. Marking the wind direction on the tree before felled and after that tree is divided into five sections according to the axial direction. Making the sample following the standard ASTM D 143-52 (Annual Book of ASTM Standards, 1981). From each section molded disc 20 cm thick and from a disc is made test samples by a measurement of 5 x 5 x 2.5 cm in the axial direction, wind direction and radial direction.
Measurement of moisture content and specific gravity

2.1.3. Drying and Measurement Activity

Drying and measurement activity of sample test carried out in the laboratory of Forest Products Technology, Department of Forestry, Agriculture Faculty, Pattimura University.
Weighing test sample was first carried out in wet conditions and expressed as wet weight. To the air dry wood condition, the test sample dried to constant weighed and expressed as the air dry weight after 34 days of observation.
Samples were dried in an oven at a temperature of 103 ± 2 ° C, after that it was removed and conditioned in a desiccant for 15 minutes and weighed. Drying and weighing performed continuously until its weight is constant, and it is expressed as oven dry weight.
The moisture content and specific gravity are calculated based on the formula proposed by Brown *et al.* (1952), Skaar (1972), Bodig and Jayne (1982) as follows:

$$M = 100\frac{Wa - Wo}{Wo} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where:
M = moisture content
Wa = weight of a sample at a specific moisture content condition (g)
Wo = kiln dry weight (grams)

$$\text{Specific gravity} = \frac{\text{weight of specimen in grams}}{\text{cc of water (or gram) equivalent to the volume of the specimen}} \quad \ldots\ldots\ldots \text{(2)}$$

$$= \frac{Wo}{V} = \frac{D}{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where:
Wo or D = the weight of the oven dry wood
V = weight equivalent of an equal volume of water

2.1.4. Statistical Analysis Design

The statistical analysis design used in this study is completely randomized design with three factors and three replications. Factor A is the trunk position with five levels, namely: a height of 125 cm (A1); 268.75 cm (A2); 412.5 cm (A3); 556.25 cm (A4); and 700 cm (A5). Factor B is the wind direction with four levels, namely: the north (B1), the south (B2), the east (B3) and the west (B4). Factor C is radial direction with two levels, namely: the sapwood (C1) and heartwood (C2), thus there are 5 x 4 x 2 x 3 = 120 experimental unit. The values obtained from the measurements and calculations were tabulated and analyzed using a completely randomized design. The mathematical models according to Steel and Torrie (1981) as follows:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \alpha\beta_{ij} + \beta\gamma_{jk} + \alpha\gamma_{ik} + \alpha\beta\gamma_{ijk} + \epsilon_{ijk}$$

Where:
Y_{ijk} = response (moisture content and specific gravity)
μ = General Mean
α_i = Effect of trunk position (A)
β_j = Effect of wind direction (B)
γ_k = Effect of radial direction (C)
$\alpha\beta_{ij}$ = Effect of the interaction between factor A and factor B
$\alpha\gamma_{ik}$ = Effect of the interaction between factor A and factor C
$\beta\gamma_{jk}$ = Effect of the interaction between factors B and factor C
$\alpha\beta\gamma_{ijk}$ = Effect of the interaction between factors A, B and C
ϵ_{ijk} = Error

If the F test showed that there factors which give significant effect to the observed parameters, then continued with Tukey Pairwise Comparisons (Steel and Torrie, 1981), where the formula is:

$$W = Q\,(p, fe)\,Sy \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

$Sy = \sqrt{MS\ error/r}$

Where:
W = critical value (applying it to differences between all pairs of mean)
Q = Upper percentage points of the studentized range (Tabel A.8)
p = number of treatment
fe = error degrees of freedom
Sy = standard deviation mean value
MS Error = mean squared error
r = replication

2.1.5. Processing data using Minitab 17 software.

3. Results and Discussion

3.1. Analysis of Variance

Analysis variance the effect of the three factors and their interactions on air dry moisture content and specific gravity of Torem wood presented in Table 1.

Source	P (Moisture content)	P (Specific gravity)
Truk position (A)	0.000	0.000
Wind direction (B)	0.000	0.000
Radial direction (C)	0.000	0.000
Interaction AB	0.000	0.000
Interaction AC	0.000	0.013
Interaction BC	0.023	0.026
Interaction ABC	0.001	0.000
R-Sq	88.06%	89.01%

Table 1: Anova the effect of single factors and their interactions on air dry moisture content

Table 1 shows that single factors and their interactions give significant to high significant effect on air dry moisture content and specific gravity, thus, continued with Tukey Pairwise Comparisons.

3.2. Air Dry Moisture Content

3.2.1. The effect of trunk position, wind direction and radial direction on air dry moisture content

- Grouping Information Using Tukey Method and 95% Confidence

Trunk Position			Wind Direction			Radial Direction		
A	N	Mean	B	N	Mean	C	N	Mean
A5	24	18.3058 a	B2	30	18.0077 a	C2	60	17.9408 a
A4	24	17.7396 b	B4	30	17.9610 a	C1	60	17.5515 b
A3	24	17.6496 b	B3	30	17.8400 a			
A1	24	17.6429 b	B1	30	17.1760 b			
A2	24	17.3929 b						

Table 2: Tukey Pairwise Comparisons: Response = Moisture Content, Term = Trunk Position, Wind Direction and Radial Direction

Means that do not share a letter are significantly different

Data in Table 2 reveals that the average moisture content in the treatment the end of trunk (A5) was the highest and significantly different from all other treatments value; the average moisture content of South (B2) is the highest and significant different to the average moisture content of North region (B1) of wood; average moisture content of heartwood (C2) is higher than moisture content of sapwood and significantly different to the average moisture content of sapwood. This result agree with statement of Brown *et al.* (1952) that the moisture content of wood can vary because of differences in the position of the trunk and radial direction (sapwood and heartwood) of wood. Furthermore it said that the existence of such variation because of variations in the anatomical structure, extractive content and organic materials. Here we can see that the end of trunk (A5) was the young cell and it has a big pore contain water and the radial direction especially heartwood (C2) was buried many elements of cellulose and hemi-cellulose are capable of absorption water, resulting in moisture content is greater than the moisture content of sapwood. Skaar (1972) stated that the

percentage of cellulose and hemi-cellulose in wood is associated with absorption. Presumably, on the heartwood buried many elements of cellulose and hemi-cellulose is capable of absorbing water, resulted in moisture content is greater than the moisture content of sapwood.
Wibowo and Setiawan (2014) suggested that the wind direction affects the ability of roots to absorb water, allegedly it affects the moisture content. Results of analysis of variance (Table 1) shows that wind direction give high significant effect on air dry moisture content.

3.2.2. The Effect of interaction treatments on air dry moisture content

- Grouping Information Using the Tukey Method and 95% Confidence

Factor	**Factor**	**Factor**	**Factor**	**Factor**	**Factor**
B and C	A1	A2	A3	A4	A5
B1	16.3800 h	17.2733 defh	18.1417 bcde	16.6150 gh	17.4700 cdefg
B2	18.2017 bed	18.1167 bcde	17.1000 fgh	18.2600 bc	18.3600 bc
B3	18.7833 b	16.5233 h	17.7400 cdef	19.0133 b	17.1400 efgh
B4	17.2067 efgh	17.6583 cdef	17.6167 cdef	17.0700 fgh	20.2533 a
C1	17.5167 bc	17.0758 c	17.5942 bc	17.8158 b	17.7550 b
C2	17.7692 b	17.7100 b	17.7050 b	17.6633 b	18.8567 a

Position Wind Direction and Trunk Position* Radial Direction*
Table 3: Tukey Pairwise Comparisons: Response = Moisture Content, Term = Trunk

Means that do not share a letter are significantly different.
Data in Table 3 shows that the average moisture content treatment A5B4 (end of trunk, west) is the highest and significantly different to the value of other treatments; average moisture content A5C2 (the end of trunk, heartwood) was the highest and significantly different to the value of the other treatments.
Brown *et al.* (1952) suggested that the moisture content of wood can vary because of differences in the trunk position and radial direction. Furthermore it said that the existence of such variation because of variations in the anatomical structure, extractive content and organic materials. Here we can see that the end of trunk (A5) was the young cell and it has a big pore and the radial direction especially heartwood (C2) was buried many elements of cellulose and hemi-cellulose are capable of absorption water, resulting in moisture content is greater than the moisture content of sapwood.
Wibowo and Setiawan (2014) suggested that the wind direction affects the ability of roots to absorb water. Results of analysis of variance (Table 1) shows that the wind direction and its interaction with trunk position give high significantly affect on moisture content.
According Skaar (1972), there has been research on Eucalyptus species, where the cellulose content of 47%, hemi-cellulose 37% and lignin 16%. The percentage of cellulose and hemi-cellulose in wood is associated with absorption. In the wood had higher levels of cellulose and hemi-cellulose that has a high absorption anyway. Presumably, on the heartwood buried many elements of cellulose and hemi-cellulose are capable of absorbing water, resulted in water level is greater than the moisture content of sapwood.

- Grouping Information Using the Tukey Method and 95% Confidence

Factor		**F a c t o r B**		
C	B1	B2	B3	B4
C1	17.0993 e	17.7593 bcd	17.7707 bc	17.5767 cde
C2	17.2527 de	18.2560 ab	17.9093 abc	18.3453 a

*Table 4: Tukey Pairwise Comparisons: Response = Moisture Content, Term = Wind Direction*Radial Direction*

Means that do not share a letter are significantly different

Data in Table 4 shows that the average moisture content B4C2 (west*heartwood) treatment was the highest value and significantly different to the value of the other treatments. The highest levels of value in interaction B4C2, allegedly, there was accumulation of cellulose and hemi-cellulose that has water absorbing properties (Skaar, (1972)
Wibowo and Setiawan (2014) argued that wind direction affects the ability of roots to absorb water, allegedly it can affect the moisture content. Analysis of variance (Table 1) shows that interaction between wind direction and radial direction give significant effect on the air dry moisture content. Moisture content of wood can vary due to different radial positions (heartwood and sapwood). Allegedly, on the west region of wood and heartwood contains cellulose and hemi-cellulose elements are able to bind water cause the higher moisture content (Brown *et all*. 1952).

- Grouping Information Using the Tukey Method and 95% Confidence

Fac	tor			Factor A		
B	C	A1	A2	A3	A4	A5
B1	C1	16.1033 mn	17.0967 ghijklmn	18.4333 bcdefg	16.4167 klmn	17.4467 efghijklm
	C2	16.6567 jklmn	17.4500 efghijklm	17.8500 cdefghijkl	16.8133 ijklmn	17.4933 defghijklm
B2	C1	18.0500 cdefhij	17.8733 cdefghijkl	16.8900 hijklmn	18.0833 cdefghij	17.9000 cdefghijk
	C2	18.3533 cdefgh	18.3600 bcdefgh	17.3100 fghijklmn	18.4367 bcdefg	18.8200 bcde
B3	C1	18.9433 bcd	15.9267 n	17.7500 defghijkl	19.8467 ab	16.3867 klmn
	C2	17.6233 bcde	17.1200 ghijklmn	17.7300 defghijklm	18.1800 cdefghi	17.8933 cdefghijk
B4	C1	16.9700 ghijklmn	17.4067 efghijklmn	17.3033 fghijklmn	16.9167 hijklmn	19.2867 bc
	C2	17.4433 efhijklmn	17.9100 cdefghij	17.9300 cdefghij	17.2233 fghijklmn	21.2200 a

*Table 5: Tukey Pairwise Comparisons: Response = Moisture Content, Term = Trunk Position*Wind Direction*Radial Direction*

Means that do not share a letter are significantly different

Data on Table 5 showed that the average moisture content of treatment A5B4C2 was the highest value and significantly different to other value of treatments. Brown *et al*. (1952); Skaar, (1972) and Oey Djoen Seng (1990) suggested that variations in the moisture content of the wood caused by different position of the trunk and the radial direction. Here we can see that the end of the trunk (a5) was the young cell and it has a big pore, contain water and the radial direction especially heartwood (C2) are more dominant in determining the moisture content in the treatment A5B4C2. Wibowo and Setiawan (2014) suggested that effect of wind direction on the ability of roots to absorb water. Analysis of variance in Table 1 showed that the interaction of these three factors give high significant to the moisture content.

The effect of all single factor and their various interactions to the average value of the air-dry moisture content can be seen in Figure 1.

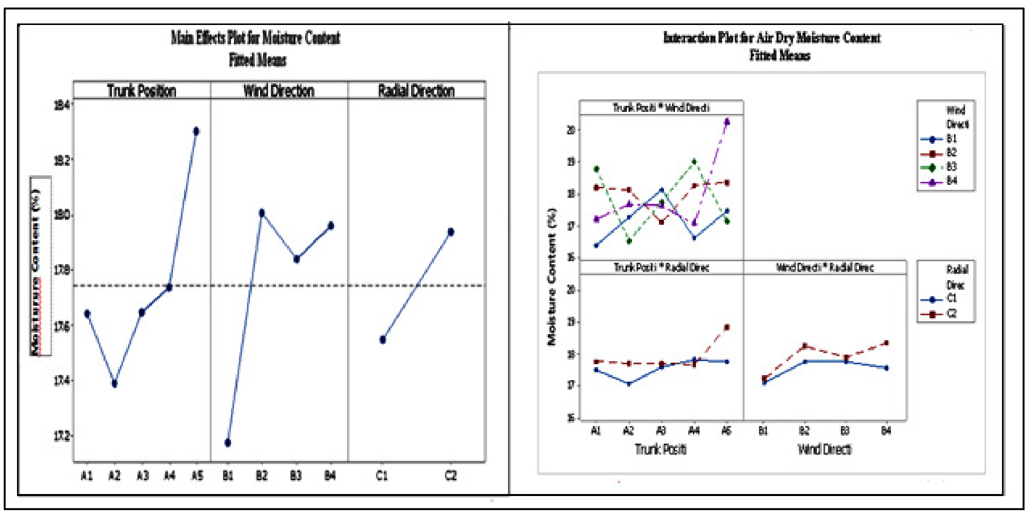

Figure 1: Graph of the influence of all single factors and their interactions factors on air dry moisture content

The average air dry moisture content as a whole amounted to 17.75%, it is consistent with Haygreen and Bowyer (1982) and Oey Djoen Seng, (1990) that the moisture content of air dried wood ranged from 12% to 20%.

3.3. Air Dry Specific Gravity

3.3.1. Tukey Pairwise Comparisons, the effect of a single factor on Air Dry Specific Gravity

- Grouping Information Using Tukey Method and 95% Confidence

	Trunk	Position		Wind	Direction		Radial	Direction
A	N	Mean	B	N	Mean	C	N	Mean
A1	24	0.895417 a	B1	30	0.890333 a	C2	60	0.8815 a
A2	24	0.881667 b	B3	30	0.874000 b	C1	60	0.8665 b
A3	24	0.877083 b	B4	30	0.868333 bc			
A4	24	0.862017 c	B2	30	0.863333 c			
A5	24	0.852917 d						

Table 6: Tukey Pairwise Comparisons: Response = Specific Gravity, Term = Trunk Position, Wind Direction and Radial Direction

Means that do not share a letter are significantly different

The data in Table 6 shows that air dry specific gravity generated by the base of trunk (A1) was the highest and significantly different to the value of other treatments, This result agree with Kollmann and Cote (1968) that in general, the specific gravity at the base of trunk was greater than at the end. It also said that the specific gravity of the wood is gradually reduced from the base to the end of the trunk.

Data in Table 6 also shows that the average specific gravity B1 treatment (north region) was the highest and significantly different with the average specific gravity of other treatments.

This result agree with Wibowo and Setiawan (2014), that the ability of roots to absorb water in the direction of the wind, lowest in the north. Allegedly, the cell wood at the north region has a thick cell wall and specific gravity is biggest value as well as accumulation of extractive substance causing its specific gravity is highest than other treatments value (Frick and Moerdiatianto, 2004). Analysis of variance (Table 1) shows that wind direction gives high significant effect on air dry specific gravity.

Data in Table 6 also shows that the specific gravity of the heartwood (C2) was higher than the specific gravity of sapwood and significantly different to the specific gravity of sapwood (C1). This result agree with statement of Frick and Moediartianto (2004), that the hardwood is old cells so that the cell wall thick and cell contains extractive substances, resulting its specific gravity greater than the specific gravity of sapwood.

3.3.2. Tukey Pairwise Comparisons, the Effect of various interactions on air dry specific gravity

- Grouping Information Using Tukey Method and 95% Confidence

Factor	**F a c t o r A**				
B and C	A1	A2	A3	A4	A5
B1	0.901667 a	0.890000 ab	0.891667 ab	0.878333 abcde	0.890000 ab
B2	0.885000 abcd	0.868333 bcdef	0.863333 cdefg	0.843333 fgh	0.856667 efg
B3	0.900000 a	0.890000 ab	0.891667 ab	0.841667 gh	0.846667 fg
B4	0.895000 a	0.878333 abcde	0.861667 defg	0.888333 abc	0.818333 h
C1	0.890833 a	0.872500 b	0.863333 bc	0.855000 c	0.855000 c
C2	0.900000 a	0.890833 a	0.890833 a	0.870833 b	0.855000 c

Table 7: Tukey Pairwise Comparisons: Response = Specific Gravity, Term = Trunk Position Wind Direction and Trunk Position* Wind Direction*

Means that do not share a letter are significantly different

Data in Table 7 reveals that the average specific gravity of treatment A1B1 (base of trunk* the north) was the highest value and significant different with other reminder treatments except A1B3 (base of trunk*east region) and A1B4 (base of trunk*west).

Allegedly, the cell wood at the base and in the north region have a thick cell wall and specific gravity of cell wall is bigger as well as the accumulation of extractive substances causing its specific gravity is greater than other treatments (Frick and Moerdiartianto, 2004). Wibowo and Setiawan (2014) suggested that the wind direction affect the ability of roots to absorb water, allegedly it can affect specific gravity Analysis of variance (Table 1) shows that the interaction between position of trunk and wind direction give high significant effect on specific gravity.

Data in Table 7 also reveals that the average specific gravity of treatment A1C2 (base of trunk* heartwood) was the highest value and significant different with other reminder treatments except, A1C1, A2C2 and A3C2, allegedly, the wood at the base and the heartwood was accumulation of extractive substances causing specific gravity greater than other treatments values. This result agrees with Kollmann and Cote (1968) that the specific gravity of the wood decrease from the base to the end of trunk, while the radial direction specific gravity of heartwood is greater than sapwood.

- Grouping Information Using Tukey Method and 95% Confidence

Factor	**F a c t o r B**			
C	B1	B2	B3	B4
C1	0.880000 b	0.860667 d	0.868000 bcd	0.857333 d
C2	0.900667 a	0.866000 cd	0.880000 b	0.879333 bc

*Table 8: Tukey Pairwise Comparisons: Response = Specific Gravity, Term = Wind Direction*Radial Direction*

Means that do not share a letter are significantly different

Data in Table 8 revealed that the average specific gravity of treatment B1C2 (north*heartwood) was the highest and significantly different with all the value of other treatments. Wibowo and Setiawan (2014) argued that the ability of roots to absorb water, the highest in the east and lowest in the north. This means that in the north occurred a slow growth, as a sign there was annually growth ring more to dense, it impact on high specific gravity. Analysis of variance (Table 1) shows that the interaction between wind direction and radial direction give significant on specific gravity. Brown *et al.* (1952) suggested that the specific gravity of the wood can vary due to differences in the radial direction, where the highest specific gravity on the heartwood and the lowest in the sapwood.

- Gouping Information Using Tukey Method and 95% Confidence

Fac	tor			**F a c t o r A**		
B	C	A1	A2	A3	A4	A5
B1	C1	0.903333 abc	0.890000 abcdefg	0.863333 defghij	0.870000 cdefghij	0.873333 bcdefhi
	C2	0.900000 abcd	0.890000 abcdefg	0.920000 a	0.886667 abcdefgh	0.906667 abc
B2	C1	0.883333 abcdefgh	0.850000 hij	0.840000 ijkl	0.836667 hijk	0.893333 abcdef
	C2	0.886667 abcdefgh	0.886667 abcdefgh	0.88667 abcdefgh	0.850000 hijk	0.820000 kl
B3	C1	0.896667 abcde	0.893333 abcdef	0.896667 abcde	0.820000 kl	0.833333 jkl
	C2	0.903333 abc	0.886667 abcdefgh	0.886667 abcdefgh	0.863333 defghij	0.860000 efghij
B4	C1	0.880000 bcdefgh	0.856667 fghijk	0.853333 ghijk	0.893333 abcdef	0.803333 l
	C2	0.910000 ab	0.900000 abcd	0.870000 cdefghij	0.883333 abcdefgh	0.833333 jkl

Table 9: Tukey Pairwise Comparisons: Response = Specific Gravity, Term = Trunk Position Wind Direction*Radial Direction*

Means that do not share a letter are significantly different

Data in Table 9 reveals that the average specific gravity of treatment A3B1C2 (middle of trunk* the north* the heartwood) was the highest value and significantly different with the value of other treatments.

Brown *et al.* (1952) suggested that the specific gravity of the wood can vary because of differences in the position of the trunk and the radial direction. Wibowo and Setiawan (2014) suggests that the direction of the wind affects the ability of roots to absorb water, the highest in the east and lowest in the north. This means that on the north has the slow growth of the wood, thus there occurs a narrow its growth ring as a sign of the high specific gravity. Analysis of variance (Table 1) shows that the wind direction and its interactions give significant to high significant effect on specific gravity.

All interaction treatments effect on specific gravity can be seen in Figure 2.

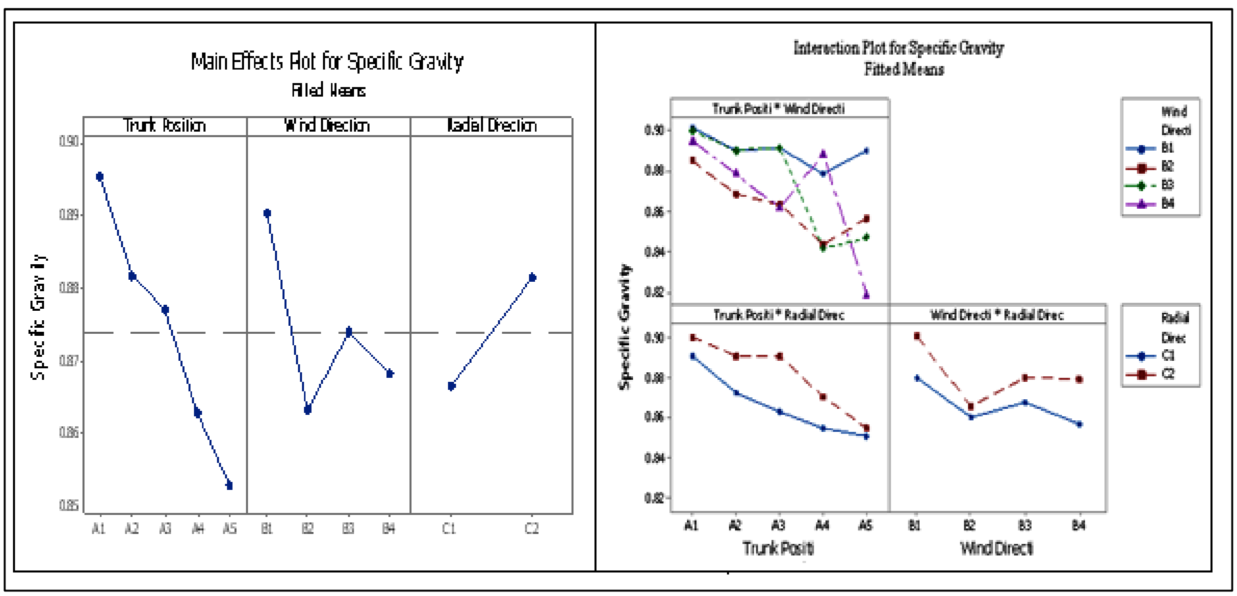

Figure 2: Effect of all single factors and their interaction on air dry specific gravity

The result of research show that the average specific gravity of Torem about 0.874. According to Yap, (1984); Frick and Moerdiartianto, (2004) this species classified as the heavy weight species and it is categorized to strength class of II, because its air dry specific gravity is in the range 0.75 to 0.90.

4. Conclusion

Analysis of variance showed that the position of the trunk (A), wind direction (B), the radial direction (C) and all interactions give significant to high significant effect on the moisture content, with determination coefficient of 88.06%. On the other hand all single factors and all interactions give significant to high significant effect on the air dry specific gravity, with determination coefficient of 89.01%. Results of the study revealed that the highest moisture content of wood at the end of the trunk (A5) that is equal to 18.31% and the lowest at the base (A2) that is equal to 17.39%, otherwise the highest specific gravity at the base (A1) that is equal to 0.895 and the lowest at the end of the trunk (A5) is equal to 0.853, Differences in the wind direction also cause differences in moisture content, the highest at the south region (B2) that is equal to 18.01% and the lowest at the north (B1) region of wood is equal to 17.18%, otherwise the highest specific gravity in the north (B1) that is equal to 0.890 and lowest in the south (B2) that is equal to 0.863. Differences in the radial direction cause the difference of water content and specific gravity, where in the moisture content and specific gravity, the higher is in the hardwood.

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Appendix 1. Air dry moisture content

Factor			Replication			Total	Average
A	B	C	1	2	3		
	b_1	c1	15.69	16.07	16.55	48.31	16.10
A1		c2	16.03	16.95	16.99	49.97	16.66
	b2	c1	17.71	18.09	18.35	54.15	18.05
		c2	18.16	18.41	18.49	55.06	18.35
	b3	c1	18.32	19.14	19.37	56.83	18.94
		c2	18.55	18.79	18.53	55.87	18.62
	b4	c1	16.44	17.16	17.31	50.91	16.97
		c2	16.82	17.65	17.86	52.33	17.44
A2	b_1	c1	16.93	17.13	17.23	51.29	17.10
		c2	17.21	17.53	17.61	52.35	17.45
	b2	c1	17.85	18.02	17.75	53.62	17.87
		c2	18.12	18.52	18.44	55.08	18.36
	b3	c1	15.51	16.02	16.25	47.78	15.93
		c2	16.88	17.31	17.17	51.36	17.12
	b4	c1	17.13	17.56	17.53	52.22	17.41
		c2	17.76	18.08	17.89	53.73	17.91
A3	b_1	c1	18.18	18.02	19.10	55.30	18.43
		c2	17.24	18.29	18.02	53.55	17.85
	b2	c1	16.57	17.12	16.98	50.67	16.89
		c2	17.11	17.32	17.50	51.93	17.31
	b3	c1	17.30	17.94	18.01	53.25	17.75
		c2	17.48	17.75	17.96	53.19	17.73
	b4	c1	16.79	17.61	17.51	51.91	17.30
		c2	17.65	18.10	18.04	53.79	17.93
A4	b1	c1	15.63	16.78	16.84	49.25	16.42
		c2	16.22	16.94	17.28	50.44	16.81
	b2	c1	17.61	18.22	18.42	54.25	18.08
		c2	18.04	18.46	18.81	55.31	18.44
	b3	c1	19.19	20.06	20.29	59.54	19.85
		c2	17.65	18.09	18.80	54.54	18.18
	b4	c1	16.53	17.09	17.13	50.75	16.92
		c2	16.72	17.61	17.34	51.67	17.22
A5	b1	c1	16.92	17.78	17.64	52.34	17.45
		c2	16.91	17.50	18.07	52.48	17.49
	b2	c1	17.58	17.98	18.14	53.70	17.90
		c2	18.57	18.98	18.91	56.46	18.82
	b3	c1	16.04	16.34	16.78	49.16	16.39
		c2	17.68	17.76	18.24	53.68	17.89
	b4	c1	18.15	20.11	19.60	57.86	19.29
		c2	21.36	22.16	20.14	63.66	21.22
Total						2130	710
Average						17.75	17.75

Appendix 2. Air dry specific gravity

Factor			Replications			Total	Average
A	B	C	1	2	3		
	b_1	c1	0.90	0.91	0.90	2.71	0.9033
A1		c2	0.91	0.92	0.87	2.70	0.9000
	b2	c1	0.89	0.88	0.88	2.65	0.8833
		c2	0.90	0.88	0.88	2.66	0.8867
	b3	c1	0.90	0.89	0.90	2.69	0.8967
		c2	0.92	0.91	0.88	2.71	0.9033
	b4	c1	0.88	0.88	0.88	2.64	0.8800
		c2	0.92	0.91	0.90	2.73	0.9100
A2	b_1	c1	0.89	0.89	0.89	2.67	0.8900
		c2	0.89	0.89	0.89	2.67	0.8900
	b2	c1	0.83	0.84	0.88	2.55	0.8500
		c2	0.89	0.87	0.90	2.66	0.8867
	b3	c1	0.89	0.90	0.89	2.68	0.8933
		c2	0.90	0.90	0.86	2.66	0.8867
	b4	c1	0.86	0.86	0.85	2.57	0.8567
		c2	0.90	0.90	0.90	2.70	0.9000
A3	b_1	c1	0.87	0.86	0.86	2.59	0.8633
		c2	0.92	0.91	0.93	2.76	0.9200
	b2	c1	0.84	0.84	0.84	2.52	0.8400
		c2	0.88	0.89	0.89	2.66	0.8867
	b3	c1	0.90	0.90	0.89	2.69	0.8967
		c2	0.88	0.89	0.89	2.66	0.8867
	b4	c1	0.85	0.86	0.85	2.56	0.8533
		c2	0.87	0.87	0.87	2.61	0.8700
A4	b1	c1	0.87	0.87	0.87	2.61	0.8700
		c2	0.89	0.89	0.88	2.66	0.8867
	b2	c1	0.84	0.84	0.83	2.51	0.8367
		c2	0.86	0.85	0.84	2.55	0.8500
	b3	c1	0.83	0.81	0.82	2.46	0.8200
		c2	0.88	0.85	0.86	2.59	0.8633
	b4	c1	0.91	0.89	0.88	2.68	0.8933
		c2	0.89	0.88	0.88	2.65	0.8833
A5	b1	c1	0.88	0.87	0.87	2.62	0.8733
		c2	0.91	0.91	0.90	2.72	0.9067
	b2	c1	0.90	0.89	0.89	2.68	0.8933
		c2	0.81	0.83	0.82	2.46	0.8200
	b3	c1	0.84	0.82	0.84	2.50	0.8333
		c2	0.87	0.87	0.84	2.58	0.8600
	b4	c1	0.81	0.80	0.80	2.41	0.8033
		c2	0.80	0.86	0.84	2.50	0.8333
Gr. Total						104.88	34.9600
Average						0.874	0.8740