Yield stability and adaptability of kenaf (*Hibiscus cannabinus* L.) genotypes at different kenaf growing regions in Indonesia

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Abstract. Stability and adaptability analysis is a very important tool for breeders to find out the potentiality of a genotype in various environments. Twenty kenaf genotypes were evaluated in 6 locations, namely Asembagus (Situbondo Regency), Muktiharjo (Pati Regency), Sumberrejo (Bojonegoro Regency), Laren (Lamongan Regency), Wanareja (Cilacap Regency), and Sukolilo (Pati Regency). For Asembagus, Muktiharjo, and Sumberrejo testing was carried out in 2013 for 2 seasons, namely longday and shortday period, while testing in Laren, Wanareja, and Sukolilo carried out in 2014 for one season on a longday period. The study is to determine the effect of the environment on the fiber yield of kenaf genotypes and their adaptation in various environments. The results of variance analysis showed that genotypes, environment, and genotype by environment interactions had a very significant effect on the fiber yield of kenaf. The average fiber yield of kenaf ranges from 0.846 to 3.758 tons per ha. Regression coefficients and mean square of deviation from regressions differ from each other indicating that there are variations in stability and adaptability between genotypes tested.

Keywords: kenaf, GE interaction, stability, adaptability, yield.

1. Introduction
Kenaf (*Hibiscus cannabinus* L.) is a fiber-producing plant belonging to bast fiber crops, which fibers are obtained from bark through a retting process. The natural fiber produced by the kenaf plant has high economic value and has a very wide product diversification such as packaging, carpeting, textile, geotextile, fiber-drain, hardboard, automotive interiors, composites, etc. [1-5]. Kenaf also have high environmental values. According to Aoi, kenaf plants can absorb CO₂ from air to 13.5 tons/ha and kenaf stems are very good for phytoremediation [6]. The fiber produced by kenaf can be used as a good oil absorbent with absorption capacity of 35 times its weight [7]. In an effort to save forest wood, kenaf fiber and its stems have been developed for pulping with good quality [8-11] with energy and material use lower chemicals [12]. Kenaf fiber is biodegradable, thermaldegradable, photodegradable, drappable, hydrophyllic, non-toxic, non-plastic, acidic, anionic, visco-elastic, has a hollow structure so that there is enough space for air, moisture and light through it. With such properties kenaf fibers and their derivatives are believed to be environmentally friendly [13].

In Indonesia, the kenaf growing area is mostly located in the flooded area in Lamongan Regency. The growing of kenaf in flooded area for fiber production is quite competitive because planting other crops on this land has a high risk of crop failure due to flooding. In addition, the growing of kenaf in flooded area is very efficient because enough water is available for the retting process which is part of the production process which consumes the highest cost. The expansion of kenaf growing areas in flooded and other marginal lands is still widely open, both on Java and outside Java Island. The flooded...
area on the of Java Island alone is estimated to be around 6,000 ha spread across several districts, including Bojonegoro, Pati, Cilacap and Banjar Regency.

The use of improved varieties is the most easily adopted and cheapest technology to be applied by farmers. Efforts to obtain high yield kenaf varieties were carried out with two approaches, namely: first, by selecting accessions on existing germplasm; and second, by crossing among accessions to form base population followed by selection. From this activity several promising lines have been obtained with high yield potential (14-18]. Before being released as new improved varieties, these promising lines were tested in several locations in several seasons to find out the potency of its yield and adaptability. Yaghotipoor and Farshafar states that testing a genotype in several environments often has genotypic environment interactions (GEI) where the presence of GEI will make it difficult to choose suitable genotype for a broad environment [19]. To overcome these problems, various statistical procedures have been made by several researchers, one of them by Eberhart and Russel using the regression coefficient $b_i$ and the mean square deviation of the regression $S_{bi}^2$ as the parameters [20]. According to [21], the $b_i$ value describes the adaptability of a genotype, while $S_{bi}^2$ is used to measure the performance stability of a genotype. Fasahat et al. stated that the regression model of Eberhart and Russel can be used to predict the adaptation of a genotype so that it is very useful for breeders [22]. The study is to determine the effect of the environment on the fiber yield of kenaf genotypes and their adaptation in various environments of kenaf growing regions in Indonesia.

2. Material and Method
   2.1. Genetic Material
   Twenty genotypes have been tested, consisting of 4 genotypes results from crosses (85-9-SSH, 9011 / G4-1-4-2 M Blk, 9014 / G4-11-4-2, 85-9-72) ; 14 genotypes from direct selection of germplasm (G51, GT 7-1, PI 267667, PI 329183, PI 329205, Hc 10 / I, Hc 32, Hc 41 / II, Hc G4 USA, IDN-09-HCAN-1272, Hc Tainung, KK 60, PI 468077 (X) green, Hc 42, Hc 48; and 1 cultivated variety (KR 15) as a comparison variety. These genotypes are the result of a series of selections that have been conducted from 2008 to 2012.

   2.2. Field experiment
   Multilocation trial were carried out in 6 locations, namely in Asembagus (Situbondo Regency), Muktiharjo (Pati Regency), Sumberrejo (Bojonegoro Regency), Laren (Lamongan Regency), Wanareja (Cilacap Regency), and Sukolilo (Pati Regency). For Asembagus, Muktiharjo, and Sumberrejo testing was carried out in 2013 for 2 seasons, namely longday and shortday period, while testing in Laren, Wanareja, and Sukolilo carried out in 2014 for one season on a longday period. On longdays period, testing begins in September and finishes in January, while testing on shortdays period begins in April and finishes in August. The characteristics of the testing environment are presented in Table 1. In each location/season (as an environmental representation), the research was carried out using a Randomized Complete Block Design with three replications.

   The size of the plot used is 3 m x 5 m and a spacing of 30 cm x 10 cm with one plant per hole. Maintenance includes fertilizing, thinning, weeding, and controlling pests and diseases carried out according to recommendations and local conditions.

   Observations were made on plant height, stem diameter, and dry fiber yield at harvest. Plant height and stem diameter were observed for 10 sample plants taken randomly. While the dry fiber yield were observed for the entire population in each treatment.
Table 1. Characteristics of the testing environment for the kenaf multilocation trial in the growing area

| No | Location                        | Testing planting season | Year | Type of area | Soil Texture |
|----|---------------------------------|-------------------------|------|--------------|--------------|
| 1  | Asembagus (Situbondo Regency)   | a. Longday              | 2013 | Rainfed      | Sandy        |
|    |                                 | b. Shortday             | 2013 | Irrigated    | Sandy        |
| 2  | Wanareja (Cilacap Regency)      | Longday                 | 2014 | Flooded      | Clay         |
| 3  | Laren (Lamongan Regency)        | Longday                 | 2014 | Flooded      | Clay         |
| 4  | Muktiharjo (Pati Regency)       | a. Longday              | 2013 | Rainfed      | Clay         |
|    |                                 | b. Shortday             | 2013 | Irrigated    | Clay         |
| 5  | Sukolilo (Pati Regency)         | Longday                 | 2014 | Flooded      | Clay         |
| 6  | Sumberrejo (Bojonegoro Regency) | a. Longday              | 2013 | Irrigated    | Clay         |
|    |                                 | b. Shortday             | 2013 | Irrigated    | Clay         |

2.3. Data analysis
Estimation of the genotype environment interactions was carried out by a combined analysis across environments. The stability and adaptability of the tested kenaf genotypes were analyzed using regression models of Eberhart and Russel [20]. A genotype is considered stable if the regression coefficient \( b_i \) is not significantly different from one and the mean square deviation of the regression is not significantly different from zero. Adaptability of a genotype is determined according to Finlay and Wilkinson, based on the value of \( b_i, S^2_{di} \) and the average yield of a genotype [23] (Table 2).

Table 2. Adaptability criteria of a genotype

| \( b_i \) | \( S^2_{di} \) | Yield of genotype | Adaptability               |
|-----------|---------------|-------------------|----------------------------|
| > 1       | = 0           | > average yield of all genotypes | Good in a favorable environment |
| = 1       | = 0           | > average yield of all genotypes | Wide adaptation            |
| < 1       | = 0           | > average yield of all genotypes | Good in an unfavorable environment |
| All value of \( b_i \) = 0 | < average yield of all genotypes | Poor in all environment |
| All value of \( b_i \) ≠ 0 | All yield value of genotype | Adaptability cannot be interpreted |

3. Result and Discussion

3.1. Analysis of Variance
The results of the combined analysis of variance across environment showed that there was a very significant genotype effect on fiber yield, which showed that the potential genotype tested to produce fiber varied greatly. This means that there is an opportunity to make effective selection to get a superior genotype. Genotype and environmental interactions have a significant effect on the fiber yield of kenaf. This shows that the performance of the tested kenaf genotypes is not consistent across the environment. The same results were also found by several kenaf researchers [24, 25].
3.2. Fiber yield of kenaf

The fiber yield of the kenaf genotype tested in several environments is presented in Table 2. In Table 2 it appears that out of the 20 genotypes tested there were two genotypes that had high fiber yields, namely genotype 9011/G4-1-4-2 M Blk and IDN-09-HCAN-1272-1. Genotype 9011/G4-1-4-2 M Blk and IDN-09-HCAN-1272-1 have the highest average fiber yield compared to the other genotypes and are significantly different from check variety (KR 15) with fiber yield of 3.727 tons and 3.521 tons per hectare respectively. In each season in almost all locations the two genotypes tend to produce higher fiber than check varieties. Genotype 9011/G4-1-4-2 M Blk occupies a higher level than KR15 in almost all test environments except in Asembagus on shortday period. Statistically, 9011/G4-1-4-2 M Blk exceeded KR15 significantly in the four test environments, namely in Laren on long days, Muktiharjo on longday period, Muktiharjo on shortday period, and in Sumberrejo on shortday period. Likewise, IDN-09-HCAN-1272-1 ranked higher than KR15 in 8 testing environments and ranked below KR 15 only in Asembagus on shortday period. The genotype IDN-09-HCAN-1272-1 exceeds KR15 significantly in two environments, namely in Laren on longday period and in Sumberrejo on shortday period.

Genotype 9011/G4-1-4-2 M Blk is a pure line improvement from G4 by inserting the fast growth and non-thorny properties of KK 60 through a single cross which is followed by a back cross. While the genotype IDN-09-HCAN-1272-1 was the result of negative mass selection in the base population of accession IDN-09-HCAN-1272 from the kenaf germplasm collection at the ISFCRI. The use of genotype 9011 / G4-1-4-2 M Blk and IDN-09-HCAN-1272-1 is expected to increase fiber yield so that in turn it will increase the income of kenaf farmers.

The higher fiber yield of 9011/G4-1-4-2 M Blk and IDN-09-HCAN-1272-1 is supported by better stem diameter and plant height (Table 4). This fact is in line with the results of previous studies stating that fiber yields have a close relationship with stem diameter and plant height [26, 27]. Genotype 9011/G4-1-4-2 M Blk has significantly higher plant height than KR15 and stem diameter tends to be larger than KR 15. Genotype IDN-09-HCAN-1272-1 has plant height and stem diameter not significantly different with KR 15.

Based on the calculation of the increase in yield over the KR 15 check variety, it was shown that genotype 9011 / G4-1-4-2 M Blk and IDN-09-HCAN-1272-1 increased the yield quite significantly, which were 18.2% and 11.7% respectively (Table 5). The yield increase exceeding 10%, as expected to increase kenaf farmer’s income.

3.3. Variability of environment

In this study, the testing environment represented by location and season or a combination of locations and seasons is quite vary. This is indicated by the environmental index value ($I_j$) which has a fairly wide range, which ranges from −1.995 to 1.525 (Table 3). Environmental index ($I_j$) describes the level of suitability of an environment for plant growth. The higher the value of $I_j$, the more favorable the environment for plant growth. According to [28], the high variation in the testing environment in general will lead to genotype and environment interactions (GEI). The presence of GEI indicates that the tested genotypes respond differently to existing environmental conditions [29]. This is seen in Table 3 that the ranking of the kenaf genotypes tested is inconsistent from one environment to another. This shows that the adaptability of several kenaf genotypes tested is different. However, the genotype 9011/G4-1-4-2 M Blk and IDN-09-HCAN-1272-1 showed a fairly consistent performance.
Table 3. Fiber yield of kenaf genotypes in Asembagus, Wanareja, Laren, Muktiharjo, Sukolilo, and Sumberrejo

| No | Genotypes         | Longday No | Average | Shortday No | Average | Longday Mean | Shortday Mean | CV (%) | Ij | Significance |
|----|-------------------|-------------|---------|-------------|---------|--------------|---------------|--------|---|--------------|
| 1  | G51               | 3.59        | 3.955   | 4.524       | 3.462   | 3.932        | 4.096         |        |   |              |
| 2  | GT 7-1            | 2.97        | 3.321   | 3.916       | 3.652   | 2.734        | 3.671         |        |   |              |
| 3  | PI 269/667        | 2.63        | 3.577   | 3.513       | 3.828   | 2.878        | 3.671         |        |   |              |
| 4  | PI 329/2184       | 2.40        | 3.427   | 3.079       | 3.659   | 2.878        | 3.462         |        |   |              |
| 5  | Hc 10 T       | 1.87        | 3.321   | 2.462       | 3.079   | 2.462        | 2.878         |        |   |              |
| 6  | PI 329/205        | 2.35        | 3.221   | 3.031       | 3.577   | 3.031        | 3.671         |        |   |              |
| 7  | Hc 41 USA        | 2.30        | 3.345   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 8  | PI 328/183        | 2.15        | 3.305   | 2.079       | 3.221   | 2.079        | 2.878         |        |   |              |
| 9  | PI 329/205        | 2.55        | 3.221   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 10 | Hc 42            | 2.07        | 3.748   | 2.750       | 3.828   | 2.750        | 3.671         |        |   |              |
| 11 | Hc 41            | 2.12        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 12 | Hc 41            | 2.24        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 13 | Hc Tainan        | 2.40        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 14 | Hc 32            | 2.30        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 15 | Hc 41 USA        | 2.30        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 16 | Hc 41 USA        | 2.30        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 17 | Hc 41 USA        | 2.30        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 18 | Hc 41 USA        | 2.30        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 19 | Hc 41 USA        | 2.30        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |
| 20 | Hc 41 USA        | 2.30        | 3.321   | 2.236       | 3.221   | 2.236        | 2.878         |        |   |              |

*Numbers in the same column followed by the # sign were significantly different from the check variety KR 15 based on the Dunnet test at the level of 5%.*
Table 4. Average plant height and stem diameter of the kenaf genotypes

| No | Genotypes          | Plant height (cm) \(^a\) | Stem diameter (mm) \(^a\) |
|----|--------------------|--------------------------|--------------------------|
| 1  | G51                | 307.7                    | 18.51                    |
| 2  | GT 7-1             | 297.7                    | 17.37 #                  |
| 3  | PI 267667          | 279.3 #                  | 16.36 #                  |
| 4  | PI 329183          | 280.5 #                  | 16.79 #                  |
| 5  | PI 329205          | 288.9                    | 17.31 #                  |
| 6  | Hc 10/I            | 294.1                    | 17.47 #                  |
| 7  | Hc 32              | 281.1 #                  | 16.58 #                  |
| 8  | Hc 41/II           | 287.3                    | 17.56                    |
| 9  | Hc G4 USA          | 295.5                    | 17.50 #                  |
| 10 | IDN-09-HCAN-1272-1 | 308.2                    | 18.13                    |
| 11 | Hc Tainung         | 284.6 #                  | 16.52 #                  |
| 12 | 85-9-SSH           | 288.2                    | 17.59                    |
| 13 | KK 60              | 283.0 #                  | 16.59 #                  |
| 14 | 9011/G4-1-4-2 M Blk| 311.8                    | 18.67                    |
| 15 | 9014/G4-14-4-2     | 302.0                    | 17.99                    |
| 16 | PI 468077 (X) hijau| 282.7 #                  | 17.36 #                  |
| 17 | Hc 42              | 284.7 #                  | 16.60 #                  |
| 18 | 85-9-72            | 301.0                    | 18.28                    |
| 19 | Hc 48              | 279.7 #                  | 16.43 #                  |
| 20 | KR 15 (check variety) | 298.5                    | 18.14                    |

Average 291.8 17.39
Dunnet (5%) 10.3 0.62
CV (%) 6.6 6.7

\(^a\) numbers followed by the # sign in the same column was significantly different from the check variety KR 15 based on the Dunnet test at the level of 5%
Table 5. Percentage increase in fiber yield of several kenaf genotypes against check variety KR 15

| No | Genotypes         | Fiber increased against KR 15 (%) |
|----|-------------------|----------------------------------|
| 1  | G51               | 5.4                              |
| 2  | GT 7-1            | -8.2                             |
| 3  | PI 267667         | -29.3                            |
| 4  | PI 329183         | -23.7                            |
| 5  | PI 329205         | -13.8                            |
| 6  | Hc 10/I           | -9.1                             |
| 7  | Hc 32             | -16.7                            |
| 8  | Hc 41/II          | -15.4                            |
| 9  | Hc G4 USA         | -10.2                            |
| 10 | IDN-09-HCAN-1272-1| 11.7                             |
| 11 | Hc Tainung        | -18.5                            |
| 12 | 85-9-SSH          | -2.2                             |
| 13 | KK 60             | -26.6                            |
| 14 | 9011/G4-1-4-2 M Blk | 18.2                        |
| 15 | 9014/G4-14-4-2    | 3.8                              |
| 16 | PI 468077 (X) hijau | -19.7                        |
| 17 | Hc 42             | -19.2                            |
| 18 | 85-9-72           | -1.8                             |
| 19 | Hc 48             | -22.4                            |
| 20 | KR 15 (check variety) |                                 |

3.4. Stability and adaptability of genotypes

The results of the stability analysis using the Eberhart and Russel model [20] showed that of the 20 kenaf genotypes tested almost all genotypes had a means square deviation from regression ($s_d^2$) equal to zero except PI 468077 (X) hijau greater than zero; and all genotypes having regression coefficients ($b_r$) are not different from one (Table 6). According to Djaelani et al., if a genotype has a mean square deviation from the regression differs from zero, the regression is not linear and the genotype cannot be explained by its adaptability [30].

According to Finlay and Wilkinson, a genotype that has a high yield and a coefficient of regression equal to one has a wide adaptation and can adapt to all test environments [23]. Based on the stability analysis, the genotype 9011/G4-1-4-2 M Blk and IDN-09-HCAN-1272-1 are classified a widely adapted genotype. Genotype 9011/G4-1-4-2 M Blk is a pure line selected from the results of a cross, while IDN-09-HCAN-1272-1 is a pure line from the result of a negative mass selection from the germplasm population. According to Allard and Bradshaw, pure line that adapt to large environments generally have strong individual buffering [31].
Table 6. Parameters of stability and adaptability of genotypes kenaf

| No. | Genotypes             | $b_i$ | $S_{ai}^2$ | Stability       | Adaptability         |
|-----|-----------------------|-------|------------|-----------------|----------------------|
| 1   | G51                   | 0.94  | 0.0972     | Stable          | Wide                 |
| 2   | GT 7-1                | 0.95  | 0.0228     | Stable          | Wide                 |
| 3   | PI 267667             | 0.83  | 0.0327     | Stable          | Poor in all environment |
| 4   | PI 329183             | 0.94  | -0.0334    | Stable          | Poor in all environment |
| 5   | PI 329205             | 0.94  | 0.0811     | Stable          | Poor in all environment |
| 6   | Hc 10/I               | 0.96  | 0.1002     | Stable          | Wide                 |
| 7   | Hc 32                 | 1.14  | 0.0825     | Stable          | Poor in all environment |
| 8   | Hc 41/II              | 0.98  | 0.1000     | Stable          | Poor in all environment |
| 9   | Hc G4 USA             | 1.02  | 0.0605     | Stable          | Poor in all environment |
| 10  | IDN-09-HCAN-1272-1    | 1.09  | 0.0155     | Stable          | Wide                 |
| 11  | Hc Tainung            | 1.08  | 0.1589     | Stable          | Poor in all environment |
| 12  | 85-9-SSH              | 1.15  | 0.0465     | Stable          | Wide                 |
| 13  | KK 60                 | 0.91  | 0.0634     | Stable          | Poor in all environment |
| 14  | 9011/G4-1-4-2 M Blk   | 1.15  | 0.0278     | Stable          | Wide                 |
| 15  | 9014/G4-14-4-2        | 1.15  | 0.0393     | Stable          | Wide                 |
| 16  | PI 468077 (X) hijau   | 0.86  | 0.4157 b   | Not stable      | Cannot be interpreted |
| 17  | Hc 42                 | 1.02  | -0.0238    | Stable          | Poor in all environment |
| 18  | 85-9-72               | 0.95  | -0.0152    | Stable          | Wide                 |
| 19  | Hc 48                 | 0.99  | -0.0044    | Stable          | Poor in all environment |
| 20  | KR 15 (check variety) | 0.95  | -0.0001    | Stable          | Wide                 |

a Significantly different from 1 according to the t test at the level of 5%
b Significantly different from 0 according to the F test at the level of 5%

4. Conclusions

The results of testing several kenaf genotypes in several growing area obtained 2 genotypes that produce high fiber, namely: genotype 9011/G4-1-4-2 M Block and Strain IDN-09-HCAN-1272-1. The stability and adaptability of the tested kenaf genotypes varies.

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References

[1] Kuroda S, Tian Y and Kubota H 2007. Polymer composites reinforce by kenaf fibre: Modified by novel polymeric coupling agent. Paper presented on the International Symposium of Kenaf and Allied Fibre, 23 August, Xiamen, China.
[2] Abdullahi T, Harun Z, Othman M H D, Aminu N, Gabriel O, Aminu T, Ibrahim S A, Kamarudin N H 2018 Malaysian Journal of Fundamental and Applied Sciences Vol. 14, No. 4 : 397-402
[3] Hassan F, Zulkifli R, Ghazali M J and Azhari C H 2017 International Journal On Advance Science Engineering Information Technology, Vol.7 No. 1: 315-321
[4] Raman Bharath V R, Ramnath B V and Manoharan N 2015 *ARPN Journal of Engineering and Applied Sciences* Vol. 10, No. 13: 5483-5485

[5] Babatunde O E, Yatim J M, Ishak M J, Masoud R, Meisam R 2015 *Journal Teknologi (Sciences & Engineering)* 77:12 (2015) 23–30

[6] Aoi, T 2000 Phytoremediation by kenaf core and production of activated carbon from harvested core. *Proceeding of International Symposium of Bio-Recycle*. Composting in Sapporo. http://www.cvl.gunmact.ac.jp/~ao/aoihtml.kena_6.html , tgl. 3 Maret 2011

[7] Anthony W S 1994 *Applied Engineering in Agriculture* 10 (3): 357-361.

[8] Chen X Y, Chen R S, Zhang Y X, Hu Z X and Xiao A P 1992. *China’s Fibre Crops* 2: 15 – 19.

[9] Sellers T Jr, Miller G D and Fuller M J 1993 *Forest Product Journal* 43, 7-8, 69-71.

[10] Zhang M J and Dick M R 1994. An economic evaluation of U.S. kenaf markets. Research Report Agricultural Experiment Station, Oklahoma State University.

[11] Aimin L 2007 Making paper and pulp form kenaf. A Overview. In: *Proceedings of the First International Workshop on Pulp and Paper Making from Kenaf*, Yuanjiang, China. http://ccgconsultinginc.com/kenaf.aspx , tanggal 3 Maret 2011

[12] Rymszay T A 1998 Creating high value markets for kenaf paper. A Commercial Experience. Presented at the American Annual Kenaf Association. San Antonio, Texas. 4p.

[13] Abdullah A B M 1997 *Jute and Jute Fabrics Bangladesh* 23(4): 3-7

[14] Sudjindro, Heliyanto B, Marjani, Setyo-Budi U, Hadiyani S, Sunardi D, Utari D 2000 Uji daya hasil lanjutan genotipe-genotipe harapan kenaf berbatang halus. Laporan Hasil Penelitian Dana Reboisasi TA. 1999/2000. Balai Penelitian Tembakau dan Tanaman Serat Malang, Indonesia.

[15] Marjani, Sudjindro, Purwati R D dan Setyo-Budi U 2008 Observation for Yield Potency of Early Maturity Kenaf Germplasm. Final report of research cooperation between Indonesian Tobacco and Fibre Crops Research Institute (IToFCRI) with Toyota Boshoku Corporation Japan (TBCJ). Indonesian Tobacco and Fibre Crops Research Institute Malang, Indonesia (Unpublish).

[16] Marjani, Sudjindro, Purwati R D dan Setyo-Budi U 2009 Observation for Yield Potency of Early Maturity Kenaf Germplasm. Final report of research cooperation between Indonesian Tobacco and Fibre Crops Research Institute (IToFCRI) with Toyota Boshoku Corporation Japan (TBCJ). Second Year. Indonesian Tobacco and Fibre Crops Research Institute Malang, Indonesia (Unpublish).

[17] Marjani, Sudjindro, Purwati R D dan Setyo-Budi U 2010 Observation for Yield Potency of Early Maturity Kenaf Germplasm. Final report of research cooperation between Indonesian Tobacco and Fibre Crops Research Institute (IToFCRI) with Toyota Boshoku Corporation Japan (TBCJ). Third Year. Indonesian Tobacco and Fibre Crops Research Institute Malang, Indonesia (Unpublish).

[18] Marjani, Sudjindro, Purwati R D dan Setyo-Budi U 2011 Observation for Yield Potency of Early Maturity Kenaf Germplasm. Final report of research cooperation between Indonesian Tobacco and Fibre Crops Research Institute (IToFCRI) with Toyota Boshoku Corporation Japan (TBCJ). Third Year. Indonesian Tobacco and Fibre Crops Research Institute Malang, Indonesia (Unpublish).

[19] Yaghotipoor A and Ezatollah Farshafar 2007 *Pak J Biol Sci* 10:2646 – 2656

[20] Eberhart S A and Russel W L 1966 *Crop. Sci. (6) : 36 – 40."

[21] Zakir M 2018 *Journal of Biology, Agriculture and Healthcare* Vol.8, No.12: 15-21

[22] Fasahat P, Rajabi A, Mahmoudi S B, Noghabi M A, Rad J M 2015 *Biom Biostat Int J* 2(5): 00043

[23] Finlay K W and Wilkinson G N 1963 *Australian Journal of Agricultural Research* No. 14:742-754.

[24] Ogunniyan D J, Makinde S A and Omikunle S O 2018 *Cercetări Agronomice În Moldovavol*. Vol L1 , No. 1 (173) / 2018: 51-63. Doi: 10.2478/Cerce-2018-0005

[25] Adeniyan O N, Aluko O A, Olanipekun S O, Olasoji J O, Adetumbi J A, Alake C O and Adenekan M O 2014 *Journal of Agricultural Science* Vol. 6, No. 8: 28-34
[26] Golam F, Alamgir M A, Rahman M M, Sbha B, and Motior M R 2011 *Aust J. Crops Sci.* **5**(13): 1882 – 1890
[27] Nurheru, Setiawan A C, Sastrosupadi A 1990 *Jurnal Penelitian Tanaman Tembakau dan Serat* **5**(2):132–138.
[28] Farshafar E, Mahmodi N and Yaghotipoor A 2011 *Aust J Crop Sci* **5**(13): 1837 – 1844
[29] Mohammadi R, Abdullahi A, Haghparast R and Armion M 2007 *Euphytica* **157**: 239 – 251
[30] Djaelani A K, Nasrullah dan Sumartono. 2001. *Zuriat* Vol. **12** No. 1: 27-33
[31] Allard R W and Bradshaw A D 1964 *Crop Sci.* **4**: 503-508