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Identifying the Potential Yield of Soybean Genotype in Tidal Land Type C

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Abstract

Identification of soybean genotypes including potential yield character is a base to understand soybean growth, development, and productivity on potential lands. The purpose of this research is to determine the potential yield of soybean genotype and their supporting components in tidal land type C. Four soybean genotypes and two comparative varieties Anjasmoro and Lawit (adaptive tidal land) were tested on tidal land type C at four locations (three locations in Jambi Province and one location in South Kalimantan Province), July 2017. The research was conducted using a randomized design and repeated four times in each location. The plot size was 12 m^2, spacing row 40 cm x 15 cm, two plants for each hole. GH_KR_13, GH_GR_1 and GH_GR_5 productivity equal with Lawit, the adaptive variety for tidal land type C. While, Anjasmoro showed more than 2.20 t/ha in seeds productivity, 54 filled pod for each plant, with large seeds (15.84 gram/100 seeds). Anjasmoro had higher seed productivity than all of genotypes including Lawit. Anjasmoro with it's potential yield and productivity, can cofarmer preferences and deserve to be developed in tidal land type C.

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INTRODUCTION

The management of potential lands (sub-optimal) for agriculture has great opportunity, and one of the strategic choices to support national food security, including in tidal swamps type C (Surahman et al., 2018). Tides have never flooded the land, but the tides have an effect on groundwater, and the depth of the groundwater level is less than 50 cm. Tidal land type C has water acidity (pH) 4.7, with soil C-organic content 4.5%, N-total 0.2% and P-total 40.8 mg/100 g P_2O_5. Average P content is 21.8 ppm, K content is 0.9 cmol(+)/kg, Ca content is very low 1.2 cmol(+)/kg and Mg is 1.2 cmol(+)/kg), therefore the land is considered infertile (Mukhlis and Indrayati, 2012). However, it has potential ability to be planted with soybeans by promoting efficient cultivation management techniques (Wijanarko and Taufiq, 2016), including using adaptive genotype/varieties (Kuswantoro et al., 2010; Sagala et al., 2018). According to Pujiwati et al. (2016), tidal swamp land type C was able to show the productivity of soybean yields compared to type B, due to excess levels of Al and Fe in the soil.

Stability test for seed yield is required to determine soybean genotype that appropriate with the targeted environment characteristics. According to various research concepts, including by Rasyad and Idwar (2010), Ghiday (2016), Pacheco, et al. (2017), Silveira, et al. (2018), Ilker, et al. (2018), that stability of seed yield degree is an assessment of the ability of soybean genotypes to maintain or adjust returns in various environments.

Identification of soybean genotypes is a basis for knowing the ability of plants to produce on potential lands with various non-conformities for their continued development and growth. The effects of genotype and its environment, as well as their interactions determined plant resistance. The interaction between genotypes and environment has always been an important and essential issue for plant breeders in developing the desired varieties. Determination of genotype and environment is prevailing in breeding programs because it helps to know genotypes that have specific adaptability in various environmental conditions (Aslim and Idwar. 2010; Chaudhary and Wu, 2012). Based on this concept, it is necessary to understand and identify the potential yield of soybean genotypes under tidal land type C environment.

METHODS

In July 2017, four soybean lines (Table 1) and two varieties i.e. Anjasmoro and Lawit (adaptive tidal land), were tested in tidal swamps type C at four locations i.e. Bandar Jaya Village (L1), Sepunding Village (L2), Rantau Makmur Village (L3), and Sido Makmur Village (L4). L1, L2, and L3 located at Tanjung Jabung Timur, Jambi, while L4 located at Barito Kuala, South Kalimantan. The research was conducted using a randomized design and repeated four times in each location. The plot size is 12 m^2, spacing of 40 cm x 15 cm, two plants per hole. The land used without tillage. Drainage canal was made before planting (40 cm wide and 20 cm deep). In order to prevent excessive weeds, chemical weeding is done at 2-4 weeks after sowing (WAS). Seed treatment was done using carbosulfan insecticide. Fertilizer i.e. 250 kg Phonska/ha + 100 kg SP 36 and 1 t/ha organic fertilizer were given at the time of sowing. Harvesting was conducted at physiological maturation pods which were indicated by yellow/brown pods colouring and leaves have fallen. Observations on plant population per plot i.e. flowering age, age of mature pods, weight of 100 seeds, yield of seeds/plot, and qualitative characteristics (flower colour, leaf shape, hilum colour, seed coat colour); while observations based on 5 sample plants were plant height, number of nodes, number of pods, and seed weight of 5 plants.

Table 1. Characteristics of genotypes used in the research

Genotype/ Variety	Soybean line (GH) identification
GH _Gen_8	Soybean line for water-saturated land
GH_KR_13	Soybean line for salinity land
GH_GR_1	Soybean line for armyworm tolerant
GH_GR_5	Soybean line for armyworm tolerant
Lawit	Adaptive tidal land
Anjasmoro	Improved variety

RESULTS AND DISCUSSION

Climate types at Tanjung Jabung Timur locations in Jambi and Barito Kuala in South Kalimantan according to Oldeman climate classification are classified as having sufficient wet months for soybean. Soybean required 300-450 mm of water or 2.5-3.3 mm/day during it growth (85-100 days) (Taufiq and Sundari, 2012). The type of soil at location was organosol soil, which is forms from organic materials decomposition, with water-saturated soil conditions. The research location was classified as tidal land type C.

Soil chemical properties are presented in Table 2. The results of soil analysis in each location showed that the soil pH was low, especially at L4. The optimal soil pH value is 5.5-7.5 and low soil pH (pH <6) generally caused by high Al content. Low pH and high Al soil conditions affect the availability of nutrients for the plants (Taufiq and Sundari, 2010). Soybean limit tolerance to Al saturation is 20% (Taufiq and Sundari, 2012), and it exceeds this limit in L3 and L4 locations. There are no saturation in L1 and L2. The effect of Al on nutrient absorption occurs due to disruption of the root system (Pujiwati et al., 2016). Likewise, what happens in the location was, higher cation exchange capacity (CEC), at lower pH of the soil. Total N content in the research location was medium. Fertilization with a dose of 23-35 kg N/ha was necessary if N content is lower than 0.1%, especially in immature/young plant (Taufiq and Sundari, 2010). The L1 had sufficient availability of P elements in the soil, while the L2, L3 and L4 were low (<20 ppm). It's necessary to keep P element between 15 to 35 ppm to maintain soybean needs (Mike Staton, 2014). P element deficiency can reduce root nodules formation in soybean (Servani et al., 2014). Interaction between phosphorus (P) and Al also causes nutrient absorption disturbance so that P becomes unavailable to plants (Pujiwati et al., 2016).

The Na content in the location was medium. High pressure of Na content increases plant growth reduction, reduces water balance and plant ion absorption mechanism (Shereen and Ansari, 2001), also disruption of photosynthetic activity which results in leaf shedding (Li et al., 2016). Ca content of 0.7–2.0% in young leaves that are fully exposed when forming pods is considered sufficient. The critical limit for Mg-dd is 50 ppm (Taufiq and Sundari, 2012). The optimum Mg-dd content for soybean is 1.4 me/100 g (Fegeria, 2009). L4 location showed the lowest Mg-dd content. The range of values for soybeans on young leaves is 0.3-1.0% (Taufiq and Sundari, 2012). High level content of Al-dd in the soil is 22 ppm or around 0.24 me Al/100 g, while 1.5 and 11.7 me 100/g are relatively low (Pujiwati et al., 2016). Critical limit of K-dd content for soybean is 0.2-0.3 me/100 g (Franzen, 2013). The research location showed the diversity of nutrient availability for soybean. The fulfilment of the elements needed by soybean was essential to improve soil fertility.

Table 2. Soil chemical characteristics in four research locations

Characteristic	Research location			
	L1	L2	L3	L4
pH	5.1	5.2	4.9	3.9
N (%)	0.2	0.2	0.2	0.2
P_2O_5 (ppm)	35.1	20.8	19.2	15.9
K (Cmol/100 g)	0.4	0.3	0.2	0.4
Na (Cmol/100 g)	0.6	0.4	0.4	0.7
Ca (Cmol/100 g)	2.6	2.9	2.8	0.8
Mg (Cmol/ 100 g)	0.9	0.9	0.9	0.6
Al-dd (Cmol/100 g)	0.6	1.3	2.3	13.2
H-dd (Cmol/100 g)	1.7	1.2	0.0	3.1
C-Org (%)	2.4	1.6	2.3	3.0
Effective CEC (%)	6.8	6.9	6.5	18.8
Al saturation (%)	8.9	18.7	35.4	70.4

Pay attention to the characteristics of yield components that have a role in assessing soybean potential yield is important to selection of soybean line in tidal land (Kuswanto, 2017). Flowering age characters showed diversity among genotypes. Genotypes and environment interaction was significantly different on a level of 1% (Table 3). It indicated that environment determined flowering age. Genotypes in L3 location tended to show a more extended flowering period than in other location. It was considered that the soil moisture level at L3 was higher than others. Maturity age follows the flowering age. It is meant that earlier flowering age was followed by earlier maturity age. Research locations had a significant role in maturity age determination (Table 3). Genotypes in L3 showed longer maturity age (> 89 DAS/very late) than in other locations. It was suspected that P element availability in the soil determined maturity age (Table 2). GH_Gen_8 had early maturity age (< 80 DAS) relatively, GR_1 was classified as intermediate maturity age (80-85 DAS), while GR_5, KR_13, Lawit and Anjasmoro were classified as late maturity age (> 85- 90 DAS) (Table 3).

A high and erect stem were one of selection criteria for soybean line. Lawit variety had a highest stem (72-107 cm), while GR_1, GR_5 and Gen_8 had a short stem (31-58 cm) in every location. Based on the analysis of variance, location influenced the height of soybean plant (Table 4). According to Chauhan dan Opena (2013)

Table 3. Flowering and maturity age of six soybean genotypes tested in four locations, July 2017

Genotype	Flowering age (DAS*)								Maturity age (DAS)							
	L1		L2		L3		L4		L1		L2		L3		L4	
GH _Gen_8	28	d	28	c	32	b	33	a	75	d	75	c	75	d	84	a
GH_KR_13	38	a	37	a	45	a	34	a	88	a	88	a	96	a	85	a
GH_GR_1	34	c	34	b	33	b	34	a	83	c	83	b	87	c	84	a
GH_GR_5	36	b	33	b	35	b	34	a	85	ab	83	b	90	b	86	a
Lawit	36	b	36	a	45	a	35	a	84	bc	83	b	94	a	83	a
Anjasmoro	33	c	34	b	35	b	33	a	82	c	83	b	94	a	84	a
Combined Test	(Pr > F)															
Genotype (G)	: <0.0001															
L x G	: <0.0001															

Note: The data obtained from plot population; DAS: the day after sowing; numbers followed by same letters showed that there were no significant differences

Table 4. Plant height of six soybean genotypes tested in four locations, July 2017

Genotype code	Plant height (cm)									
	L1		L2		L3		L4		Average	
GH _Gen_8	55	d	50	d	58	bc	38	c	50	d
GH_KR_13	87	b	93	b	64	ab	56	b	75	b
GH_GR_1	46	d	49	d	42	de	31	c	42	e
GH_GR_5	56	d	58	d	37	e	34	c	46	de
Lawit	104	a	107	a	73	a	72	a	89	a
Anjasmoro	75	c	74	c	50	cd	56	b	64	c
Combined Test	(Pr > F)									
Genotype (G)	: <0.0001									
L x G	: 0.0002									

Note: The data obtained from the average of five sample plants; number followed by same letters showed that there were no significant differences

the height of soybean plant could be affected by space rows, since the closer (20 cm x 5 cm) had higher plants compared to 40 cm x 10 cm. It was related to the sunlight intensity for the plants, due to not all soybean genotypes were resistant to low sunlight intensity. If soybean plants were lack of sunlight intensity, it could cause etiolation which the plant would grow higher than usual. It probably happened to genotypes in L1 and L2 which exceeded their stem character.

The environment did not influence the number of branches. Average number of branches were four branches, and it was normal for soybean with 40 cm x 15 cm row spacing (Table 5). The number of branches of both line and variety in L3 and among the locations was not different. It showed that the number of branches did not determine by the environment.

Genetic factor determined the number of nodes on each genotype. (Table 5). Stem nodes were place for the pods created. Lawit variety had largest quantity of pods, while GH_KR_13 produced the least number of pods compared to other genotypes. The nodes formed both in the stem and branch has the same path with number of pods. It showed that number of nodes was equivalent to the number of pods and vice versa. Table 6 showed the number of pods per plant.

Soybean potential yield can be assessed from seed yield per plant. Tested genotypes have a variety of potential seed yields (Table 7). Genotypes in L1 and L2 showed the higher seed potential compared to L3 and L4. It means that seeds productivity in L1 and L2 are also higher with the average more than 2.0 t/ha, followed by L4 and L3. Environment influences both parameters. It showed that research location determined the level of seeds yield. In L3 and L4, there was no line reached productivity level more than 2.0 t/ha, except Anjasmoro in L4. Kuswanto et al. (2017) reported that Menyapa variety showed highest productivity of 1.6 t / ha at the same

Table 5. Number of branches and nodes of six soybean genotypes tested in four locations, July 2017

Genotype code	Number of branches								Number of nodes							
	L1		L2		L3		L4		L1		L2		L3		L4	
GH _Gen_8	4	b	5	a	4	a	2	a	26	ab	25	ab	26	a	9	a
GH_KR_13	4	b	3	b	4	a	2	a	18	c	16	d	21	a	10	a
GH_GR_1	4	ab	4	a	4	a	2	a	21	bc	19	cd	21	a	10	a
GH_GR_5	5	ab	4	a	4	a	3	a	22	bc	21	bc	20	a	11	a
Lawit	6	a	5	a	4	a	2	ab	29	a	29	a	26	a	12	a
Anjasmoro	5	ab	4	a	4	a	2	b	21	bc	20	bcd	21	a	12	a
Combined Test (Pr > F)																
Genotype (G)	: <0.0001								<0.0001							
L x G	: <0.0001								0.3218							

Note: The data obtained from the average of five sample plants; number followed by same letters showed that there were no significant differences

Table 6. Number of filled pods per plant of six soybean genotypes tested in four locations, July 2017

Genotype code	Number of filled pods per plant									
	L1		L2		L3		L4		Average	
GH _Gen_8	74	ab	52	b	58	a	21	b	51	bc
GH_KR_13	49	c	44	b	50	a	25	ab	42	c
GH_GR_1	53	c	46	b	54	a	24	ab	44	c
GH_GR_5	59	bc	58	ab	50	a	31	ab	49	bc
Lawit	79	c	78	a	69	a	32	a	65	a
Anjasmoro	62	bc	60	ab	64	a	31	ab	54	b
Combined Test (Pr > F)										
Genotype (G)	: 0.0002									
L x G	: 0.6014									

Note: The data obtained from the average of five sample plants; numbers followed by the same letter indicate no significant difference

Table 7. Seeds weight (g) and yield (t/ha) of six soybean genotypes tested in four locations, July 2017

Genotype code	Seed weight (g) per plant								Seed yield (t/ha)							
	L1		L2		L3		L4		L1		L2		L3		L4	
GH _Gen_8	12.4	c	10.2	d	10.9	a	6.5	ab	1.9	bc	1.6	d	1.1	c	1.7	abc
GH_KR_13	29.3	a	23.8	a	12.8	a	9.9	a	2.3	ab	2.4	ab	1.5	b	1.3	c
GH_GR_1	14.9	bc	14.8	bc	11.1	a	6.2	b	2.4	a	2.2	abc	1.6	ab	1.4	bc
GH_GR_5	14.2	bc	12.6	cd	11.9	a	6.2	b	2.3	ab	2.0	bcd	1.3	bc	1.8	ab
Lawit	11.5	c	13.8	cd	15.3	a	5.6	b	1.8	c	1.9	dc	1.6	b	1.9	a
Anjasmoro	20.7	b	19.3	ab	14.1	a	7.4	ab	2.7	a	2.5	a	1.9	a	1.9	ab
Combined Test (Pr > F)																
Genotypes (G)	: <0.0001								<0.0001							
L x G	: <0.0001								0.0023							

Note: The data obtained from the average of five sample plants; numbers followed by the same letter indicate no significant difference

location (L4) but at different times. Soil acidity (pH) in both of that location is low, and caused unavailability of nutrients due to nutrient toxicity. High soil aluminum content caused soybean growth inhibition (Taufiq dan Sundari, 2010; Bachtiar et al., 2016; Kopittke, et al., 2016), especially in the root (Zhang et al., 2007; Pujiwati et al., 2016). Furthermore, even though N content

Table 8. Weight of 100 seeds (g) of of six soybean genotypes tested in four locations, July 2017

Genotype code	Weight of 100 seeds (g)									
	L1		L2		L3		L4		Average	
GH _Gen_8	22.4	a	20.8	a	18.6	e	21.2	a	20.4	a
GH_KR_13	16.1	c	16.9	ab	14.5	c	15.7	b	15.8	b
GH_GR_1	13.6	d	15.2	bc	11.1	a	13.9	bc	13.5	c
GH_GR_5	12.7	d	13.2	bc	16.2	b	12.0	cd	13.5	c
Lawit	9.8	e	10.6	c	12.5	de	9.4	d	10.6	d
Anjasmoro	17.9	b	17.6	ab	13.9	cd	13.8	bc	15.8	b
Combined Test	(Pr > F)									
Genotypes (G)	: <0.0001									
L x G	: <0.0001									

Note: The data obtained from plot results; numbers followed by the same letter indicate no significant difference

in the research location are classified as medium, but the availability is low because N element existing generally is in organic form (Bachtiar et al., 2016). These conditions disrupted seed yields in soybean plants (Bachtiar et al., 2016). According to the results of the study of Budianta et al., (2018) adding lime can increase land productivity and soybean yields in tidal land. Wijanarko and Taufiq (2016) concluded that it is equivalent to 10% of aluminum saturation by inserting it 20 cm into the soil in depth.

GH_KR_13 showed higher seed yield potential compared to Lawit and Anjasmoro. The lowest level of productivity is caused by number of filled pods that is not contributed by plant populations (plots). Anjasmoro showed the higher potentials of seeds yield except with GH_KR_13. Meanwhile, Anjasmoro has seeds productivity more than 2.2 t/ha and higher than other genotypes. It showed that Anjasmoro is considered more potential to be developed in tidal land type C. The genotypes of GH_KR_13, GH_GR_1 and GH_GR_5 have equivalent seed productivity with Lawit (1.8 t/ha) for tidal land type C.

GH_Gen_8 has an average weight of 100 seeds, 20.7 g, and classified as large seed size (> 14 g/100 seeds). GH_KR_13 also classified as a large seed and is equivalent to Anjasmoro (Table 8). Large seed size with the contribution of large quantity of filled pods can reach high level of productivity.

The results of this study were able to identify the potential and productivity of soybeans in tidal land type C. It assumes that genotypes that have 40, 36, or 32 pods/plants with seed sizes of 16, 18, and 20 g/100 seeds and about 330,000 plants per population are predicted could achieve seed productivity > 3.0 t/ha (with limits on the correction value). For this reason, this research is important to be developed by examining gene sources that show soybean seed productivity as described above, according to the characteristics of tidal land type C.

CONCLUSION

GH_KR_13, GH_GR_ and GH_GR_5 genotypes have equivalent seed productivity to Lawit in tidal land type C, there are around 1.82 t / ha. Anjasmoro variety has higher seeds productivity than other genotypes, more than 2.2 t/ha with about 54 filled pods and large seed size (15.8 grams/100 seeds). Anjasmoro with it's potential yield and productivity, can become farmer preferences and deserve to be developed in tidal land type C.

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