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Effect of soil acidity on some soybean varieties

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Abstract

This study aims to determine the mechanism of adaptation and morphophysiology character of soybean genotypes to soil acidity levels. Research using randomized block design with four replications, the first factor consists of soybean varieties: Tanggamus varieties, Detam 2, Anjasmoro and Detam 1, while the second factor is the media's treatment consisted of medium acid soils and limed soil. The results showed that the low level acidity of planting medium will affect the growth and development of plants. There are different mechanisms of adaptation to acidity on soybean varieties. Avoidance mechanism is indicated by an increase in pH around the roots on Tanggamus varieties, Detam2, Anjasmoro and Detam1. Tolerant mechanism is indicated by the maturation age and high production on Tanggamus varieties

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Introduction

Soybeans have become one of the strategic commodities after rice and corn. Domestic soybean demand continues to increase, but domestic soybean production has not been able to offset demand growth. Efforts to improve the production of national soybean could be pursued with three approaches: increased productivity, the increased intensity cropping and the expansion of acreage land cropping into sub optimal.Sub optimal land covering dry land, tidal land and rainfed land. The problems faced in soybean cultivation in dry land among others are less fertile land, drought because the rainfall erratic, the use of local varieties (not superior varieties), weeds, disorder pests and plant diseases (Arsyad *et al.* 2007; Rachman *et al.* 2007). According to Sopandie (2006), the development of plants on marginal land (sub optimal) very requires an understanding of the mechanism that role in increasing the potential outcome (with potential yield) and adaptation plants against various abiotic environmental stresses.

Dry land has great potential for agricultural development in the face of challenges, especially for the improvement of agricultural production and support the national food security program. In general, dry land can be divided into dry acid soil and non acid soil. Dry acid soil dominated land in indonesia especially in temperate areas as in 3 large islands Sumatra, Borneo and Papua which is as large as 102.817.113 ha (69,4 %) and non acid land of 45.256.511 ha (30,6 %) (Mulyani 2006). Dry acid soil generally characterized by land of the nature of reaction acid (low ph <5.5) relating to levels of high aluminum, high fixation of P, the content of a base and the level of exchange rate cation low, the content of iron and manganese that closer to the poison and sensitive erosion (Mulyani 2006).

Environment stress or sub-optimal land is land that naturally has a relatively low productivity as a result of internal and external stress factors. Internal factors for plant growth include physical, chemical, and biological properties of soil, while external factors include eratic rainfall (low and not patterned), flooding or extreme drought. However, this land can be managed into productive land if the factors that the problem can be modified or controlled. Land considered suboptimal include dry acid land, rainfed and swamp land.

Abiotic stresses not applicable as only a single factor, for example, only acidity stress alone, but interacting with other stress factors such as drought. It occurs on dry acid soil generally that found in Indonesia, so it needs to known about physiology mechanism adaptation of soybean to both the abiotic stresses. Based on previous research conducted by Hanafiah *et al.* (2012), there is a different adaptation mechanisms in some soybean varieties were tested against drought. Tolerant mechanism is shown by the low rate evapotranspiration and avoidance mechanism is shown by the large volume of the roots were observed of soybean varieties. Furthermore, it needs to know the mechanisms of plant adaptation to soil acidity stress so that it can be understood on double stress soil acidity and drought stress.

This research aims to investigated the mechanism adaptation soybean response and the difference in the character of morphology and physiology between varieties of soybeans on the level of soil acidity medium planting. Plant morphophysiology relationship in the face of an abiotic stresses can be used for the selection characters. The characters that represent avoidance and tolerant mechanism can be selected as a selection character in a large population to obtain high yielding varieties.

Materials and methods

The experiment was conducted at kassa house. The experiment was conducted using a randomized block design with four replications, the first factor consists of soybean varieties: Tanggamus, Detam2, Anjasmoro and Detam1 varieties, while the second factor is the media's treatment consisted of acid soil medium and limed soil medium.

Planting preparation

Planting done by using the media in polybags with using dried soil media, and then sieved with a sieve diameter ± 6 mm and cleared of debris and dirt..Then the soil mixed evenly and put into plastic sacks and tied closely to keep the moisture content . Soil analysis was conducted to determine characteristics of the physical and chemical of soil .The treatment of sulphur to lower the soil pH and giving dolomite lime given before planting with an incubation period of 2 weeks before planting. Then followed by measuring the pH of the soil to determine the desired pH. Soil are put into polybag size 10 kg .Polybag arranged by the distance between experimental unit by 25 cm. The day before planting, the soil was given basic fertilizer Nitrogen ($[NH_2]_2CO$), Phosfat ($Ca[H_2PO_4]_2$), and Kalium (KNO_3) in accordance with the results of soil analysis.

Planting and maintenance

Seeds planted four seeds per polybag at a depth of 2.0 cm and then given active insecticide carbofuran 3% by 5-10 grains. 7 day old plants thinning down to two plants per polybag. The second thinning is done at the age of two weeks, leaving only one plant per polybag which selected the best plant growth. Plant maintenance carried out in accordance with the conditions of the plant.

Observation

Observations included several variables, namely: dry weight of plant, root length, the number of root nodules, the age of flowering, the age of harvesting and analysis of soil pH at the end of the study. The data obtained were analyzed by F test. The data obtained were analyzed by F test. When treatment varieties and planting media give significant effect, statistical analysis followed by Duncan's multiple range test at level α = 5%.

Results and discussion

Dry weight of plant

Analysis of variance showed that there is a significant effect of varieties and planting media treatment, but the interaction of the two treatments did not significantly affect dry weight of plant. In Table 1 shows that the Anjasmoro variety have the heaviest plant dry weight and significantly different than the dry weight of plants of Tanggamus variety. Table 1 also shows that the treatment given planting medium also showed significant effect on dry weight of plant, in the treatment of lime, the plant has a significant plant dry weight heavier than the dry weight of plants in treatment provision of sulfur (acid soil)

Table 1. Dry weight of plant character of soybean varieties in planting medium treatment.

Variety	Media's treatment		Average
	M1	M2	
	.....g.....		
Tanggamus	0,6	0,9	0,7 B
Detam 2	0,8	0,9	0,9 AB
Anjasmoro	1,0	1,2	1,1 A
Detam1	0,9	1,1	1,0 AB
Rataan	0,8 B	1,0 A	

Note : numbers followed by similar letter in the same row and column are not significantly different according to DMRT test at alpha level 5 %.

Decreased dry weight of plant at acid soils associated with The development growth of the root of each variety tested (Hanum *et al*. 2007). Soil with pH below 5.6 will affect the absorption and translocation of nutrients from the soil to the plant so that it will cause a decrease in dry weight of plant than at soil pH 6.8 (soil that was given lime). The other adverse effects of acid soils is occurs impaired absorption of mineral nutrients, the incorporation of aluminium with cell wall and inhibitory of cell division (Prasetiyono and Tasliah 2003).

Root length

Analysis of variance showed that there was no significant effect on root length varieties. Each of these varieties have genetic differences in root length growth, but statistical tests have not shown a significant difference.

Table 2. Root length character of soybean varieties in planting medium treatment.

Variety	Media's treatment		Average
	M1	M2	
	.....cm.....		
Tanggamus	27,4	31,6	29,5
Detam 2	29,9	28,9	29,4
Anjasmoro	28,6	24,6	26,6
Detam1	31,9	31,4	31,7
Rataan	29,5	29,1	

Note : numbers followed by similar letter in the same row and column are not significantly different according to DMRT test at alpha level 5 %.

Table 2 also shows that the planting medium treatment has not given the difference in root length of each varieties tested. Several studies of soil acidity is due to the Al toxicity especially affects the plant roots cause shortened and thickened root growth and will affect the growth of root length (Ekawaty 2007; Prasetiyono and Tasliah, 2003). Hakim, *et al* (1986) concluded that Al toxicity inhibits elongation and primary root growth, and prevents the formation of lateral roots and root hairs.

The number of root nodules

Analysis of variance showed that there was no significant effect on the number of varieties of root nodules. Table 3 explains that the planting medium treatment with lime giving showed plant growth have root nodules significant number more than the number of root nodules on planting medium treatment by giving sulfur (acid soil).

The low of soil pH can affect the growth of soybean plants or nuts and within certain limits also affect the process of nitrogen fixation. Rhizobium growth and initiation of root nodule formation can be stopped, inhibited nodulation and the growth of plants is delayed (Gandanegara *et al*. 1989).

Table 3. The number of root nodules character of soybean varieties in planting medium treatment.

Variety	Media's treatment		Average
	M1	M2	
	.....		
Tanggamus	0,8	1,3	1,0
Detam 2	0,5	2,0	1,3
Anjasmoro	2,0	4,0	3,0
Detam1	1,3	4,8	3,0
Rataan	1,1 B	3,0 A	

Note : numbers followed by similar letter in the same row and column are not significantly different according to DMRT test at alpha level 5 %.

The age of flowering

Analysis of variance showed that there is significantly effect of varieties, but the media's treatment and the interaction of both treatments did not significantly affect flowering age. In Table 4 shows that Tanggamus variety have the significant longest flowering age than Detam1 and Anjasmoro varieties. Table 4 also shows that media's treatment has not given significant difference to the age of flowering. The age of flowering is influenced by genetic factors of each variety of plant growth and environmental factors (Arsyad *et al.* 2007).

Table 4. The age of flowering character of soybean varieties in planting medium treatment.

Variety	Media's treatment		Average
	M1	M2	
	.....Day after planting.....		
Tanggamus	35,4	32,1	33,8 A
Detam 2	32,9	30,5	31,7 AB
Anjasmoro	29,9	29,6	29,8 BC
Detam1	28,1	27,9	28,0 C
Rataan	31,6	30,0	

Note : numbers followed by similar letter in the same row and column are not significantly different according to DMRT test at alpha level 5 %.

The age of harvesting

Analysis of variance showed that there is significantly effect of varieties, but the media's treatment plant and the interaction of both treatments did not significantly affect harvesting age. In Table 5 shows that Tanggamus variety have the significant longest harvesting age than Detam2, Anjasmoro and Detam1. Table 5 also shows that media's treatment plant has not given significant difference to the character of harvesting age.

The longest harvesting age shows that Tanggamus variety able to adapt to the planting medium treatment which acidic (giving sulfur). Plants can develop metabolic system that can function in the potential toxic concentrations, maybe related with the enzyme molecule (Fitter and Hay, 1981)

Table 5. The age of harvesting character of soybean varieties in planting medium treatment.

Variety	Media's treatment		Average
	M1	M2	
	.....Day after planting.....		
Tanggamus	117,8	117,1	117,4 A
Detam 2	107,9	105,6	106,8 B
Anjasmoro	101,8	106,0	103,9 B
Detam1	107,5	104,6	106,1 B
Rataan	108,72	108,35	

Note : numbers followed by similar letter in the same row and column are not significantly different according to DMRT test at alpha level 5 %.

Medium pH treatment

Analysis of variance showed that there was no significant effect of varieties to soil pH. Table 6 shows that the planting medium treatment with sulfur giving causes an increase in the average pH of the soil, from the initial pH 4.3 to pH 4.9. Treatment planting medium with lime giving caused an average decrease in soil pH from the initial pH 6.8 to pH 5.7.

One of the plant's ability to adapt to acid soils is creating less acidic conditions in the root zone by releasing the organic acid compounds into the rhizosphere (Prasetiyono and Tasliah, 2003). Levels of organic acids released into the rhizosphere of soybean is determined by the type of organic acids and soybean genotypes. Organic acids released by the roots is useful to chelate Al (aluminium) or Fe (iron) to then release the bound P (phosfor) (Bolan *et al.* 1994; Hocking 2001) and thus may increase the absorption of nutrients that plants need (Bertham and Nusantara 2011).

Table 6. pH of the soil in planting medium treatment.

Variety	Media's treatment		Average
	M1	M2	
	.....		
Tanggamus	4,8	6,1	5,5
Detam 2	4,3	5,9	5,1
Anjasmoro	5,2	5,5	5,3
Detam1	5,1	5,3	5,2
Rataan	4,9 B	5,7 A	

Note : numbers followed by similar letter in the same row and column are not significantly different according to DMRT test at alpha level 5 %.

Conclusion

1. There are different mechanisms of adaptation to acidity on soybean varieties.

2. Avoidance mechanism (escape from stress) is indicated by an increase in pH around the roots on Tanggamus, Detam2, Anjasmoro and Detam1 varieties.

3. Tolerant Mechanism (tolerant of stress) is indicated by the harvesting age and high production on Tanggamus variety.

4. Each adaptation mechanisms cooperate with each other in influencing the growth and development of plants.

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