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Land Suitability Study in Ultisols for Soybean Based on Soil Fauna

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ABSTRACT

Evaluation of land suitability for soybean by involving the presence and biodiversity of soil fauna has been conducted. The research was done on thecenter of soybean plantations in Ultisols soils in Banten, Lampung, and Lahat (south Sumatera) Provinces. The objective of research was to determine the interaction between soil fauna diversity in Ultisols soil and productivity of soybean. The research used a Survey Method. Every location was divided into three categories of vegetation performance, such as, less vegetation, average vegetation, and very fertile vegetation with two replicates. The chemical, physical, and biological properties of soils from every unit sampling were analyzed. The results showed that nutrient and chemical properties of soil which directly influenced the growth and production of soybean was P-potential, P-available, K-available, B (Boron), Ca and pH; the physical properties were pores drainage, pores rapid drainage, soil water content, and soil permeability. The presence of earthworm did not have direct effect to soybean, except as the 3th between variables, meaning that the presence of earthworms affected soil physical properties, soil physical properties affected nutrient availability, nutrient availability affected the biomass and yield of soybean.

Keywords: Earthworm, land suitability, soil fauna, soybeans, Ultisol

INTRODUCTION

Soil is a complex living system containing different types of organisms with different functions to perform various vital processes for terrestrial life. Microbial soil fauna commonly carries various metabolic called soil biological activity (Kilowasid *et al*. 2011) . Important role in the overhaul of organic matter and biological soil nutrient cycling put as a central factor in maintaining soil fertility and productivity (Alexander 1977; Rao 1994). Each soil type has different properties which are influenced by the physical, chemical and biological properties. Identify the role of each component of natural resources and their interactions can determine the parameters of an effective choice for the development of agriculture is expected to suit the needs of the target and does not interfere with existing subsystems (Subowo *et al.* 2002)

Synchronization empowerment soil biological resources to improve soil productivity by providing soil media as a place to grow plants that are appropriate to support the activities of each of the target organisms will improve the efficiency of land and resource management can take place in a sustainable manner in an effort to support the development of environmentally sustainable agriculture determining the suitability of land for farming systems becomes very important (Giller *et al*. 1997)

So far, evaluating the suitability of land or land rehabilitation that has been done did not involve the role of soil biodiversity (Djaenudin *et al.* 2003; Subowo 2010). Thus, determining the land suitability for a crop-specific may not be suitable and causes planting failure because it does not take into account the biological function of soil which can increase soil fertility (such as earthworms) (Anwar *et al.* 2010; Edwards 1977). On the other hand, there is a biological soil harmful parasitic in soil that can reduce the soil productivity like some kind of nematode that is biologically important in soil, and Fusarium (fungi) that spread through the soil-born disease and other organisms (Giller *et al.* 1997; Lal 1995; Zangarle *et al*. 2011). Therefore, the interaction between biological soil populations and other factors such as soil nutrient content and soil physical properties were needed to know to get the optimum soil productivity (Ayuke *et al.* 2011).

The objective of this research was to determine relationship between soil fauna and land suitability as well as soil chemical and physical properties of Ultisols soils that were planted with soybean.

MATERIALS AND METHODS

Study Sites and Sampling

The research was conducted in three locations of central soybean production *i.e.* Banten, Lampung, and South Sumatra Provinces.The research was started from January to April 2011. The research was conducted by survey methods. The first locatian was Subdistrict Cibaliung, Banten Province; the second was Rejobinangun Village, North Lampung regency, Lampung province, and the third was Banjarsari village of Lahat regency, South Sumatra province. Every location was choiced by a vegetation performance, such as, less fertile, average fertile and very fertile with the covered wide area of each location was1.0 ha. Every site were sampling by two replications. Soil samplings from each site were analyzed for soil chemical and physical properties as well as soil fauna. Soil fauna data were correlated with others parameter for measuring land suitability for soybean.

Soil Fauna Survey

Soils macrofauna were extracted according to Biological Soil Analysis Methods (ICALRRD, 2007), by handsorting method using the soil monolith with an area of 1 m × 1 m to a depth of 30 cm. Intake for the soil chemical analysis was done by taking composite top soil samples (0-20 cm), then it was analyzed in the Soil Research Institute in the laboratory of Chemical Technical Analysis Soil, Water and Plant Fertilizer (Balai Penelitian Tanah 2005). While sampling for soil physics used ring samples, then the soil was analyzed in the soil physics laboratory of Research Institute and refers to the Physical Properties Soil and Analysis Methods (ILALRRD 2006). Soil samplings were done when soybeans plants in vegetattif active phase (50% flowering) and soybean agronomic parameters were measured at harvest.

Data Analysis

Data were analysed by correlation between obsevation data (data of soil biology, soil chemistry, soil physics and agronomic parameters). Data were compiled and produced a correlation matrix. Significant Correlation between the value of the parameter was tabulated (Table 4). Then, it was tested followed by regression equation (Drapper *et al.* 1976) to obtain the optimum value, maximum value and the constant (x = 0) (Table 5). With parameter constraints that produce maximum Y in equation considered the best, and the parameters under constant (x = 0) is considered not suitable for development of soybean-farming system.

Land suitability criteria set out in the 3 criteria with benchmark results (yield) is obtained, which is very suitable, appropriate and not appropriate. Very appropriate when the independent variables affect the results above the maximum value (maximum y) (Subowo 2011). Appropriate when the independent variables affect the outcome on a constant value. Not appropriate when the independent variable affect the results under a constant value that is the value of y at x = 0, and a very appropriate definition is when the development efforts will benefit soybean farmers carried out on the land, as is the development of soybean-farming will favorable done on the land with a certain effort, while not appropriate is the development of soybean-farming will not be done on the land profitable even with a certain effort (Subowo 2010).

RESULTS AND DISCUSSION

The observations of soil organisms, soil chemical and physical properties of the three locations were listed in Table 1, 2 and 3. Parameter types observed (n) were 42 units, including soybean agronomic properties, soil chemical status and soil physical properties and the diversity and populations of fauna. The table shows the value of the properties of agronomic, chemical, physical and biological properties and the diversity of fauna populations each different location. Results of soybean seed yield from Cibaliung-Banten 65.2 g m^{-1}, Rejobinangun-Lampung was 305 g m^{-1}, Banjarsari South Sumatera was 81.3 g m^{-1}.

In accordance with the results of correlation-regression models there were significantly correlation between soil biological populations and the growth of soybean on Ultisols soil, both positive and negative effects.

Fertile soil with views of vegetation, had a higher population density and relative amount of soil fauna than fertile soil with a view of less vegetation. Soil with a view of vegetation Medium had a higher population density and relative amount of soil fauna than soil with a view of less vegetation.

Early identification to determine the land suitability used correlation test between the observed factors (Dayan 1979). Factors that had a close relationship were indicated by the significant correlation values and followed by regression analysis (Drapper and Smith 1976). The value of a constant was determined a y value when x = 0; x = the value of the independent variable was value that affects the dependent variable. The main dependent

Table 1. Soybean production and selected soil properties from three observations at Cibaliung, Banten Province.

Parameter	Soil fertility grade						Average
	Fertile		Medium		Less		
	I	II	I	II	I	II	
Soybean yield (g m^{-2})	108.8	104.4	24.9	62.8	29.9	60.4	65.20
Plant biomass (g m^{-2})	97.04	96.25	30.67	60.40	33.00	37.11	59.08
Pods (g m^{-2})	65.32	68.67	30	39.31	17.34	22.4	40.51
Root weight (g $plant^{-1}$)	0.63	0.63	0.20	0.40	0.22	0.24	0,39
Nodule number ($plant^{-1}$)	75	12	60	27	39	16	38.17
Nodule weight (g $plant^{-1}$)	0.114	0.012	0.063	0.084	0.035	0.064	0.060
pH (H_2O)	4.84	6.02	4.71	6.19	4.97	6.35	5.51
Total-N (%)	0.43	0.34	0.19	0.39	0.38	0.15	0.31
Total-C (%)	1.47	2.51	1.56	2.39	1.45	2.23	1.94
Ratio C:N	3.4	7.4	8.2	6.1	3.8	14.9	7.30
Available-P (Bray I) (mg kg^{-1})	3.95	1099	4.66	1.98	3.68	4.96	186.4
Available K (mg kg^{-1})	77	245	107	183	88	246	157.67
Potential P (HCl) (mg100g^{-1})	254	354	252	341	222	268	281.83
Potential K (HCl) (mg100g^{-1})	157	463	163	481	135	484	313.83
B (mg kg^{-1})	90.7	92.3	64.4	97.6	58.5	78.7	80.4
Mg (cmol (+) kg^{-1})	2.78	5.96	2.35	8.65	2.45	9.57	5.29
Ca (cmol (+) kg^{-1})	12.34	15.89	10.26	20.97	11.21	18.59	14.88
Bulk density (g ml^{-1})	1.24	1.17	1.19	1.2	1.26	1.1	1.19
Particle density (g ml^{-1})	2.36	2.19	2.33	2.19	2.34	2.18	2.27
Pore rapid drainage (% vol)	11.6	10.1	9.9	5.3	14.7	8.1	9.95
Pore slow drainage (% vol)	3.2	3.7	3.7	3.3	4.9	4.8	3.93
Total pore space (% vol)	47.3	46.9	48.8	45.2	46.2	49.4	47.30
Available water (% vol)	7.9	8.9	10.4	9.6	6.8	10.4	9.00
Permeability (cm hr^{-1})	0.7	0.98	1.19	2.11	1.2	1.82	1.34
Water content (% vol)	24.7	27.3	22.4	33.4	24.7	25.5	26.33
Earthworm (ind. m^{-2})	32	31	21	2	73	0	26.50
Cocoon (ind. m^{-2})	29	1	4	0	18	0	8.67
Milipeds (ind. m^{-2})	0	0	0	0	0	0	0
Centipeds (ind. m^{-2})	1	0	0	0	0	0	0.17
Ants (ind. m^{-2})	31	2	2	0	3	0	6.33
Termites (ind. m^{-2})	0	0	0	0	0	0	0
Snails /mollusc (ind. m^{-2})	1	0	0	2	0	0	0.50
Soil insect (ind. m^{-2})	3	0	4	0	0	3	1.67

variables determined soybean production the (yield). While, the factor x (independent variable) and the main independent variable were correlated among the agronomic traits other than yield, like soil physical and chemical properties, as well as soil fauna where soybeans grow. Table 4 and 5 show the soybean results yields were correlated with other factors such as weight biomass, weight of pods, soil potential P, pori drainage, soil insects etc. Soil chemical factors that affect the formation of peas skin such as elements of Ca, B (boron), available P and P potential. Soil fauna, especially earthworms, was significantly correlated with cocoons (earthworm eggs). In the upland conditions, earthworms were rarely discovered, there were only found traces of worms and cocoons. Cocoons correlated to a variety of factors such as root nodules, pH, C, N, C/N, available K, K and P potentials and Mg. So indirect factors had influence or be influenced by earthworms.

Table 2. Soybean production and selected soil properties from three observations at Rejobinangun, North Lampung, Lampung Province.

Parameter	Soil fertility grade						Average
	Fertile		Medium		Less		
	I	II	I	II	I	II	
Soybean yield (g m^{-2})	400	350	450	300	200	130	305
Plant biomass (g m^{-2})	1,300.0	116.05	1,350.0	112.25	1,000.0	32.58	651.81
Pods (g m^{-2})	839	74.9	871	72.5	645	21.0	420.8
Root weight (g $plant^{-1}$)	4.9	7.33	1.82	7.2	1.25	3.25	4.29
Nodule number ($plant^{-1}$)	62	76	18	44	35	17	42
Nodule weight (g $plant^{-1}$)	0.093	1.146	0.178	0.66	0.053	0.267	0.40
pH (H_2O)	4.31	5.07	4.18	4.4	4.33	4.69	4.50
Total-N (%)	0.1	0.24	0.17	0.21	0.21	0.14	0.18
Total-C (%)	1.14	2.13	1.13	1.27	1.15	1.56	1.40
Ratio C:N	11.4	8.9	6.6	6.0	5.5	11.1	8.3
Available-P (Bray I) (mg kg^{-1})	69.36	298.27	183.24	76.31	192.43	174.3	165.65
Available K (mg kg^{-1})	65	215	14	19	12	15	56.67
Potential P (HCl) (mg $100g^{-1}$)	558	892	694	606	751	733	705.67
Potential K (HCl) ($mg100g^{-1}$)	77	180	27	27	22	27	60.00
B (mg kg^{-1})	41.47	37.2	32.85	31.21	32.75	32	34.58
Mg (cmol (+) kg^{-1})	0.4	0.99	0.4	0.44	0.34	0.64	0.54
Ca (cmol (+) kg^{-1})	2.09	4.44	1.79	2.18	1.74	3.14	2.56
Bulk density (g ml^{-1})	1.26	1.37	1.32	1.35	1.34	1.32	1.33
Particle density (g ml^{-1})	2.48	2.4	2.46	2.4	2.38	2.4	2.42
Pore rapid drainage (% vol)	6.7	12.4	17.1	7.1	17.9	11.7	12.15
Pore slow drainage (% vol)	4.2	5.5	5.3	5.5	5.2	4.7	5.07
Total pore space (% vol)	49.4	42.8	46.4	43.8	43.8	43.8	45.00
Available water (% vol)	10	8.7	9.7	9.3	10.3	10.7	9.78
Permeability (cm hr^{-1})	0.14	1.19	0.92	4.23	0.37	1.41	1.38
Water content(% vol)	22.8	15.9	20.7	7.7	22.8	29.7	19.93
Earthworm (ind. m^{-2})	1	0	0	2	0	0	0.50
Cocoon (ind. m^{-2})	0	0	0	0	0	0	0.00
Milipeds (ind. m^{-2})	0	1	1	1	0	0	0.50
Centipeds (ind. m^{-2})	1	0	1	1	0	0	0.50
Ants (ind. m^{-2})	0	0	2	2	7	8	3.17
Termites (ind. m^{-2})	6	0	1	0	2	1	1.67
Snails /mollusc (ind. m^{-2})	3	0	2	1	0	0	1.00
Soil insect (ind. m^{-2})	1	4	1	1	0	0	1.17

The main variables were the variables that significantly correlated with yield; the variable between 1st were variables that significantly correlated with main variables; the variables between the 2nd were the variables that correlated significantly with the variable 1st; the variable between 3rd were variables that correlated significantly with the variables between the 2nd, and so on.

Land suitability criteria are divided into three criterias, *i.e.* does not suitable, suitable and very suitable (Soil Survey Staff 1998; Dajenudin *et al.* 2003a). Based on the presence of soil fauna, land suitability were not appropriate when independent variable affected the yields (the value of the equation y = dependent variable) under a constant value which was the value of x = 0 (Table 6). Land suitability was appropriate when independent variable affected

Table 3. Soybean production and selected soil properties from three observation at Lahat, South Sumatera.

Parameter	Soil fertility grade						
	Fertile		Medium		Less		Average
Soybean yield (g m^{-2})	50	190	48	120	20	60	81.33
Plant biomass (g m^{-2})	3.21	8.05	7.3	8.2	1.3	2.9	1.91
Pods (g m^{-2})	2.1	5.20	0.4	5.0	1.0	2.0	2.6
Root weight (g $plant^{-1}$)	1.96	1.80	3.01	4.61	2.92	0.64	2.49
Nodule number ($plant^{-1}$)	58	24	26	51	2	6	27.83
Nodule weight (g $plant^{-1}$)	1.02	0.21	0.35	1.12	0	0.06	0.46
pH (H_2O)	4.9	5.3	4.9	6	4.8	8.4	5.72
Total-N (%)	0.16	0.09	0.13	0.03	0.14	0.07	0.10
Total-C (%)	2.16	1.1	1.77	0.35	1.93	0.84	1.36
Ratio C:N	13.5	12.2	13.6	11.7	13.8	12.0	12.8
Available-P (Bray I) (mg kg^{-1})	8.5	11.8	3.4	4	5.9	4.4	6.33
Available K (mg kg^{-1})	432	79	261	63	309	79	203.83
Potential P (HCl) (mg $100g^{-1}$)	30	66	24	41	23	42	37.67
Potential K (HCl) ($mg100g^{-1}$)	57	21	36	16	45	19	32.33
B (mg kg^{-1})	50.3	41.4	33.4	49.3	39.1	42.8	42.72
Mg (cmol (+) kg^{-1})	2.39	3.44	2.16	3.36	2.18	3.15	2.78
Ca (cmol (+) kg^{-1})	3.68	9.28	3.88	11.43	3.38	10.16	6.97
Bulk density (g ml^{-1})	1.05	1.06	0.95	1.18	1.1	1.33	1.11
Particle density (g ml^{-1})	2.14	2.27	2.16	2.33	2.13	2.37	2.23
Pore rapid drainage (% vol)	14.9	22.6	23.7	16.5	16.9	12.2	17.80
Pore slow drainage (% vol)	5.5	4.8	5.4	4.5	4.2	5.0	4.90
Total pore space (% vol)	50.8	53.5	55.9	49.4	48.2	44.1	50.32
Available water (% vol)	7.3	5.1	6.1	8.5	6.4	7.2	6.77
Permeability (cm hr^{-1})	1.78	4.56	3.48	2.06	2.92	1.57	2.73
Water content (% vol)	44	39.8	39.8	35.4	39.8	37	39.30
Earthworm (ind. m^{-2})	12	20	12	1	7	2	9.00
Cocoon (ind. m^{-2})	0	0	0	0	0	0	0
Milipeds (ind. m^{-2})	0	0	0	0	0	0	0
Centipeds (ind. m^{-2})	0	0	0	0	0	0	0
Ants (ind. m^{-2})	0	0	2	2	7	8	3.17
Termites (ind. m^{-2})	82	0	0	0	0	0	13.67
Snails /mollusc (ind. m^{-2})	0	0	0	0	0	0	0
Soil insect (ind. m^{-2})	1	0	0	0	0	0	0.17

the yields above a constant value. While, land suitability was very appropriate when independent variable affected the yields above the maximum (maximum y), x the maximum was obtained by the first descent of the quadratic equation: y = 0, y = $0.0001x^2$ for example - 0.207x + 77.99 first descendant (forms ignored curve) was 2 x 0.0001 x - 0207 = 0, simplified 0.0002x = 0207 (negative values were due to the change of position which was turned positive) (Drapper and Smith 1976), or x = 0.207/0.0002 = 1035. If the maximum value of x was inserted into the equation, y value would be the maximum, while the optimum value obtained from the maximum value ±5% interaction relationship with biomass resulted very closely with the correlation value was 0.88. In Table 6, biomass is the main independent variable means variable that directly affected and related to soybean yield. It can be seen that quadratic equation soybean biomass yield showed the maximum value of y suspicion was

Table 4. Correlations between agronomy caharacteristics of soybean, soil properties, and soil fauna.

Agronomy characteristics of soybean	Value of correlation (r)	Soil properties	Value of correlation (r)
Soybean production	**0**	**pH(H_2O)**	**0**
Plant biomass	0.9121	Cocoon	-0.7064
Pods	0.9046	Ca	0.6231
Potential P	0.7070	Mg	0.6050
Particle density	0.7049	Soil insect	0.5368
Soil insect	-0.7426	Centipeds	-0.5279
Milipeds	0.6579		
Centipeds	0.5630	**Total-N**	**0**
Available K	-0.5407	B	0.6669
		Cocoon	0.5902
Plant Biomass	**0**	Earthworm	0.5699
Pods	0.9722	Potential K	0.5432
Particle density	0.5845	C	0.5044
Potential P	0.5509		
Soil insect	-0.5250	**Total-C**	**0**
Snails /mollusc	0.5012	Cocoon	-0.7757
		Available K	0.7238
Pods	**0**	Potential K	0.7226
Ca	1	Soil insect	0.6777
Centipeds	-1	Particle density	-0.6215
Snails /mollusc	-1	Centipeds	-0.6087
Pore slow drainage	-0.7387	Termites	0.6036
B (Boron)	0.7303	B	0.5053
Available-P	0.6313	Mg	0.5004
Potential P	0.5545		
Permeability	-0.5266	**Ratio C:N**	**0**
Ants	0.5013	Cocoon	-0.6777
		Water content	0.5980
Roots weight	**0**	Bulk density	-0.5800
Soil insects	0.6826	Total pore space	0.5508
Water content	-0.6403	Termites	0.5464
Potential K	0.5881	Available K	0.5002
Weight nodule	0.5660		
Ants	-0.5500	**Available-P**	**0**
Pore rapid drainage	-0.5336	Snails / mollusc	-0.5688
Nodule number	**0**	**Available K**	**0**
Centipeds	1	Termites	0.8794
Snails /mollusc	-1	Particle density	-0.8326
Cocoon	0.7558	Cocoon	-0.7918
pH (H_2O)	-0.5013	Soil insect	0.7826
		Bulk density	-0.6668
Nodule weight	**0**	Water content	0.5101
Milipeds	0.7146		
Cocoon	0.6225		
Termites	0.5139		

292.2 with a constant value of 77.99 means 77.99 minimum biomass gm^{-2} to get the maximum 292.2 g m^{-2}, or equivalent to 2.92 Mg ha^{-1} as the average value to be potential for the highest attainable soybean, whereas if the produced biomass was less than 77.99 g m^{-2} the soybean crop will not produce.

Interactions between earthworm and cocoons were very closely with the correlation value was 0.85. While in the field observations cocoon were predominantly found than an earthworm, because earthworms can move during sampling processed, earthworms stir into the lower layer or escape to another place, so that the cocoon was easily found (Subowo *et al*. 2002). In Table 6 earthworms are the 3rd variable, meaning that earthworms did not directly affect soybean yield, but affected the previous variable physical and chemical properties and other agronomic properties. In Table 6, it appears quadratic equation with earthworm cocoons indicate suspicion y maximum value was 200.2 with a constant of 5.28, meaning that on a population level 200.2 earthworms m^{-2} soybean yield value would be the maximum, while the value constant value of 5.28 indicated the lowest total earthworm population that could affect the increasing in soybean yields.

Soil fauna is variable between 3rd, meaning not directly affected the results, but the effect on soil physical properties (variables between the 2nd), then the variables between the 2ndvariables affect between 1st (the chemical properties of the soil) which in turn affected the production of soybeans. Soil fauna was most closely correlated with earthworms (R^2 = 0.85), with the model equation Y = -0.237 + 7.845 X + X^2 and constant value was 5.28. Constant value of 5.28, meaning that the land could still produce soybean in Ultisol if there was a minimum of 5.28 earthworms m^{-2} with a mean maximum value of 200.02 on earthworm population 200 ind. m^2 expected soybean production could reach a maximum.

Soil fauna that directly affected soybean yield was soil insects with a correlation value of -0.7426. Soil insects identified were asprey (predator), other soil fauna (earthworms, etc.), the higher the predator population decreased soybean yield, whereas the lower predator the higher soybean yield obtained. Retrieved equation was Y=-47.45+103.8X, with a constant value of 284.2 means soybean yield when there was no soil insects (predators) population reached 227.4 ind. m^{-2} and the population every square meter was the highest predator population to obtain the highest soybean yield, assuming the

Table 5. Correlations between soil properties and soil fauna.

Parameters	Equation	Y max	Constant	R^2
The main variables				
Yields vs Biomass	$y = 0.0001x^2 - 0.207x + 77.99$	292.2	77.99	$R^2 = 0.882$
Yields vs pods	$y = 0.019x^2 - 0.214x + 35.02$	65.53	35.02	$R^2 = 0.837$
Yields vs potential P	$y = 0.0001x^2 - 0.038x + 65.26$	72.48	65.26	$R^2 = 0.556$
Yields vs particle density	$y = 5{,}924.x^2 – 26{,}363x + 29{,}358$	27.8	29.358	$R^2 = 0.743$
Yields vs soil insect	$y = -47.45x^2 + 103.8x + 284.2$	227.4	284.2	$R^2 = 0.719$
Variable between 1				
Pods vs pore slow drainage	$y = -6.062x^2 + 27.81x + 27.63$	59.53	27.63	$R^2 = 0.551$
Pods vs B	$y = -0.008x^2 + 2.320x - 89.12$	79.08	89.12	$R^2 = 0.536$
Pods vs permeability	$y = 72.81x^2 - 232.5x + 204.7$	19.09	204.7	$R^2 = 0.694$
Variable between 2				
Potential P vs BD	$y = 4{,}513x^2 – 8{,}847x + 4375$	17,379.3	4,375	$R^2 = 0.616$
Potential P vs cocoon	$y = 0.319x^2 - 11.40x + 317.6$	215.75	317.6	$R^2 = 0.580$
Variable between 3				
Earth worms vs cocoon	$y = -0.237x^2 + 7.845x + 5.280$	200.02	5.28	$R^2 = 0.853$

Description = bold: observation object, independent variable: 2, degree of freedom (df): 2, total observation (n): 18, df total: 17, df error: 16, regression (r) of 5% significantly: 0.545, and regression of 1% significantly: 0.647.

Table 6. Value of factor regression observations.

Parameter	Equation	Y max	Constant	R^2
The main variables				
Yields x Biomass	$y = 0.0001x^2 - 0.207x + 77.99$	292.2	77.99	$R^2 = 0.882$
Yields x Leather pods	$y = 0.019x^2 - 0.214x + 35.02$	65.53	35.02	$R^2 = 0.837$
Yields x P potential	$y = 0.0001x^2 - 0.038x + 65.26$	72.48	65.26	$R^2 = 0.556$
Yields x PD	$y = 5924.x^2 - 26363x + 29358$	27.8	29358	$R^2 = 0.743$
Yields x SRG Land	$y = -47.45x^2 + 103.8x + 284.2$	227.4	284.2	$R^2 = 0.719$
Variable between 1				
K pods X PD Slow	$y = -6.062x^2 + 27.81x + 27.63$	59.53	27.63	$R^2 = 0.551$
K pods x B	$y = -0.008x^2 + 2.320x - 89.12$	79.08	89.12	$R^2 = 0.536$
K pods x Permeability	$y = 72.81x^2 - 232.5x + 204.7$	19.09	204.7	$R^2 = 0.694$
Variable between 2				
P Potential x BD	$y = 4513.x^2 - 8847.x + 4375$	17379.3	4375	$R^2 = 0.616$
P Potential x cocoon	$y = 0.319x^2 - 11.40x + 317.6$	215.75	317.6	$R^2 = 0.580$
Variable between 3				
Earthworms x Cocoon	$y = -0.237x^2 + 7.845x + 5.280$	200.02	5.28	$R^2 = 0.853$

lower of 227.4 ind. m^{-2} higher the chances to obtain maximum results.

CONCLUSIONS

The soybean yields planted on the Ultisols soil could result in maximum of 2.92 Mg ha^{-1} with the optimum input. Earthworms did not directly influence the soybean crop, but it was is the 3^{th} variable between, meaning that the presence of earthworms affected soil physical properties, soil physical properties affected nutrient availability, nutrient availability affected the biomass and yield of soybean.

Nutrients and chemical properties which directly influenced the growth and production of soybean were a potential P, available P, available K, B (Boron), Ca and soil pH. Physical properties that directly influenced the growth and production of soybean were Drainage Pore (DP), Rapid Drainage Pore, soil water content and permeability.

Based on soil biology indicators, soil fauna that directly influence (negativeor positive) the growth and production of soybean was the presence of soil insects, miliped, centiped, ants and molluscs.

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