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Effects of Dolomite on Growth and Seed Yields of Soybeans *(Glycine max* L.) Grown on Oxic Paleustult Soil in Northeast Thailand

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Abstract
An experiment on the effect of dolomite was carried out at Khon Kaen University, Khon Keen, Thailand to investigate the response on growth and seed yield of soybeans. Three levels of dolomite being used were 0, 937 and 1,875 kg/ha and five soybean cultivars were SJ4, SJ5, Chiang Mai60, KKU1 and KKU2. The experiment was laid in a factorial with four replications.
The results showed that the application of dolomite significantly increased pH of Oxic Paleustult soil, shoot growth, stem plus petiole dry weights, leaf dry weights and leaf areas of the soybean plants but had no effects on seed size and seed yield/ha. Seed yields of the soybean plants were highest with KKU1 followed by KKU2, SJ5, SJ4 and Chiang Mai60, 3,823, 3,324, 3,283, 3,210 and 3,123 kg/ha, respectively. There was some small relationships between seed yield and total shoot dry weights and also between seed yield and leaf areas. Leaf area indices of the soybean plants reached the value of 5. Seed yield was affected by inadequate amount of soil moisture content. Oxic Paleustult soil always requires at least 937 kg/ha of dolomite for good crop yield. It was suggested that dolomite is always needed for most tropical acid soils.

Key words: Soybean cultivars, total shoot dry weights, leaf areas, leaf area indices

Introduction
During the past few decades, soybean cultivation was not widely cultivated in Northeast Thailand. This was due to the poor growth and seed yield as a result of poor soil fertility since most of the soil types are those of sandy loam soils with high level of soil acidity and low amount of nutrients content. Furthermore, there has been a massive amount of soil erosion and leaching annually. Nevertheless, seed yields of soybeans being cultivated in Northeast Thailand during this decade have been improved due to better soil and water management and the improved varieties as reported by Songkanam *et al*. (1990), Susn *et al*. (1990) and Kesawapitak (1993). The need to achieve high amount of annual seed yield is considerably as an urgent need for most Asian countries due to the numerous utilisation of seeds since there are many products derived from soybean seeds such as cooking oil, feed stuffs for both human and animals. Thailand requires a large amount of soybean seeds annually to produce cooking oil and feed stuffs for both man and animals, hence a numerous tons of soybean seeds have been imported to the country even though there has been some large amount of seeds being produced annually. Therefore, it is of tangible value for scientists to search for better technology in order to produce more seeds of this cash crop as to replace the annual imported amount. Soil pH usually plays its significant role in crop production when it comes to a considerable level of soil acidity, hence it improves soil pH value to a workable level where most nutrients are released as stated by Mengel and Kirkby (1987), Miller and Donahue (1990) and others.

Materials and Methods
The experiment was carried out at Khan Kaen University Farm on Oxic Paleustult soil during October 1996. The land was ploughed twice followed by harrowing once and the soil samples were taken for initial soil analysis. The mean values of soil pH (soil : water, 1:2.5), sail nitrogen (micro Kjedahl), soil phosphorous (Bray II plus calorimetric) and soil potassium (NH_4OAC 1 N pH 7 extracted plus Flame Photometry) were: 5.70, 0.028%, 37.40 ppm, 61.53 ppm, respectively. The design of the experiment was a factorial with four replications. The experiment consisted of three rates of dolomite i.e. 0, 937, 1,875 kg/ha and five soybean varieties were SJ4, SJ5, Chiang Mai60, KKU1 and KKU2. Dolomite was added to the soil two weeks before ploughing. The treatments being used were: SJ4 plus nil kg dolomite (T1), SJ4 plus 937 kg dolomite (T2), SJ4 plus 1,875 kg dolomite (T3), SJ5 plus nil kg dolomite (T4), SJ5 plus 937 kg dolomite (T5), SJ5 plus 1,875 kg dolomite (T6), Chiang Mai60 (CM60) plus nil kg dolomite (T7), Chiang Mai60 plus 937 kg dolomite (T8), Chiang Mai60 plus 1,875 kg dolomite (T9) KKU1 plus nil kg dolomite (T10), KKU1 plus 937 kg dolomite (T11), KKU1 plus 1,875 kg dolomite (T12), KKU1 plus nil kg dolomite (T13), KKU2 plus 937 kg dolomite (T14) and KKU2 plus 1,875 kg dolomite (T15). The plot size being used was a 3 x 5 m and a metre wide path was used to separate the plots from each other. Seeds of each cultivar at the rate of 3-4 seeds per hill were sown directly into the soil by hand at the spacing between rows and within the row of 30x20 cm, respectively. Three weeks after emergence, thinning of seedlings was carried out leaving only one seedling per hill and chemical fertiliser 13-13-21 (NPK) at the rate of 312 kg/ha was applied to the soil, a half at the same day of sowing and another half at four weeks after emergence. The soil samples were collected again at the end of the experimental period and tested as that of the initial soil samples. Ten plant samples of each plot were taken at day

63 after emergence when the plants reached approximately maximum growth as stated by Suksri (1992, 1993). The plant samples were used for the determinations of dry weights, leaf areas, leaf area index. Irrigation water was given once a week, each at approximately two hours (56.25 m^3 /hour/ha) during the experimental period. The data obtained were statistically analysed.

Results and Discussion

Dolomite effects on some soil conditions: With the initial soil analysis data, the results showed that there were some small differences in soil pH values in all plots being used and the pH values were ranging from 5.50 to 5.95 (Table 1). The results indicated that the soil requires some certain amount of lime or dolomite to raise the soil pH values up to a workable level i.e. the pH level should be in the range between 6 to 6.5. Soil NPK levels, in most cases were slightly higher than the critical level for high crop yield as stated by Mengel and Kirkby (1987). Therefore, the additional amounts of dolomite must have raised soil pH values in the added plots to a considerable level but unfortunately soil pH was not tested during the experimental period but did at the end of the experiment. It must be possible that soil pH values in the dolomite added plots were raised up and then decreased with time throughout the experimental period. The major decrease must have been attributed to the uptake of calcium by soybean plants and other factors attributed to the decline in soil pH should include the leaching of soluble calcium, plant root respiration, microbial activities and others. The data of soil analysis at the final harvest revealed that there were some small increased in all values except that of K i.e. the exchangeable K value was much lesser than the initial one (Table 2). The results suggested that soybean plants must have taken up some large amount of K for growth and seed development, hence soil K may have been inadequately available particularly during the pod filling stage even though K content was highest in the chemical fertilizer formula. Mengel and Kirkby (1987) reported that, for better crop production, soil exchangeable K should be greater than 60 ppm. It may be possible that the plants required much higher K level since K has its significant effect on electron (e^-) transport i.e. the transport of assimilates must have been assisted by K as stated by Overnell (1975) and Mengel and Kirkby (1987).

Dolomite effects on growth characters: Except that of the control treatments at day 63 after emergence, an increase in the amount of dolomite added to the soil significantly increased total shoot dry weights, leaf dry weights, and leaf areas of the soybean plants (Table 3). The growth of the control plants was similar to those grown with the highest level of dolomite treated plants. This could presumably be attributed to the initial soil pH, soil N and soil exchangeable K. That is their values were, in most cases, greater than those of the dolomite added plots, hence the growth of the soybean plants was similar. The results indicated that the differences in most values could possibly be attributed to the previous history of the plots. That is the plots may have been unevenly distributed with both liming materials and chemical fertilisers. It may also presumably be due to the large amount of growth of the previous crops in the dolomite added plots, where they may have taken up a large amount of calcium. At the same time the plant materials may have been removed from the plots, hence soil pH values became relatively low. Therefore, it is advisable to return all crop residues to the plots in every harvest so that soil organic matter might be improved particularly in most tropical soils where they generally contented less amount of organic matter as stated by Ratnapradipa (1996). Seed yields and a 100 seed weights were unaffected by levels of dolomite added to the soil. This may be attributed to the inadequate amount of soil moisture content. To justify this, it is necessary to provide irrigation water twice a week since the plants were grown without rains.

Table 1: Initial soil pH, nitrogen, phosphorous and potassium contents of Oxic Paleustult soil, Khon Kaen University, Khon Kaen, Thailand

Treatment	pH	N (%)	P (ppm)	K (ppm)
T1	5.65	0.036	40	60
T2	5.50	0.031	39	60
T3	5.50	0.029	37	52
T4	5.70	0.035	48	105
T5	5.75	0.034	39	60
T6	5.80	0.040	32	56
T7	5.70	0.030	34	52
T8	5.60	0.025	38	54
T9	5.80	0.032	37	57
T10	5.60	0.028	36	68
T11	5.70	0.030	36	61
T12	5.80	0.026	37	61
T13	5.95	0.033	37	53
T14	5.70	0.028	34	68
T15	5.90	0.030	37	56

Table 2: Soil pH, nitrogen, phosphorous and potassium contents of Oxic Paleustult soil after the final harvest of soybean plants at Khon Kaen University, Khon Kaen, Thailand

Treatment	pH	N (%)	P (ppm)	K (ppm)
T1	5.60	0.036	47	56
T2	5.80	0.030	39	57
T3	6.00	0.028	43	56
T4	5.75	0.028	50	61
T5	5.80	0.033	38	35
T6	6.00	0.030	37	40
T7	5.60	0.028	37	53
T8	5.65	0.029	42	55
T9	5.80	0.040	38	39
T10	5.70	0.030	42	55
T11	5.60	0.032	41	55
T12	5.90	0.032	37	37
T13	5.60	0.035	43	52
T14	5.90	0.33	43	51
T15	5.80	0.031	42	42

Table 3: Total shoot dry weights, leaf dry weights, leaf areas, seed yield and a 100-seed yield of the soybean cultivars at day 63 after emergence as affected by levels of dolomite grown at Khon Kaen University, Khon Kaen, Thailand

	Dolomite (kg/ha)		
	0	937	1875
Total shoot dry weights (g/plant)	22.79a	20.05b	22.49a
Leaf dry weight (g/plant)	6.92a	5.78b	6.65a
Leaf area (cm^2/plant)	2944.11a	2465.88b	2835.41a
Seed yield (Kg/ha)	3451.00	3304.00	3305.00
100-seed weights (g)	17.15	17.10	17.10

Total 4: Total shoot dry weights, stem plus petiole dry weights, leaf dry weights, leaf areas and seed yields of soybean plants at day 63 after emergence as affected by cultivars grown on Oxic PaleuStult soil at Khon Kaen University, Thailand

	Variety				
	SJ4	SJ5	CM60	KKU1	KKU2
Total shoot dry weights (g/plant)	21.11	22.11	20.44	22.64	22.61
Stem plus petiole dry weights (g/plant)	5.99b	6.11b	5.25c	7.19a	6.81a
Leaf dry weights (g/plant)	6.25bc	6.39bc	5.80c	7.25a	6.56ab
Leaf area (cm^2/plant)	2664.86bc	2724.08bc	2475.36c	3091.23a	2795.14ab
Seed yield (kg/ha)	3210.00bc	3284.00b	3124.00b	3824.00a	3324.00b
LAI	4.44bc	4.54be	4.13c	5.15a	4.66ab

Dolomite effects on cultivars: With total shoot dry weights/plant, leaf areas/plant, leaf area index (L) and seed yield/ha, the results showed that at day 63 after emergence, there were no statistical differences on shoot dry weights found among the five soybean cultivars (Table 4). The similar amounts of growth may be attributed to the inadequate amount of soil moisture content since irrigation water was given only once a week. At this age the plants had already attained a large amount of growth, hence inadequate water supply may have had some effects on photosynthetic activities. Unfortunately soil moisture content was not determined. However, the differences on stem plus petiole dry weights, leaf dry weights, leaf areas, and leaf area index of the five cultivars were found i.e. the highest values were with KKU1 followed by KKU2, SJ5, SJ4 and Chiang Mai60, respectively. This may be attributed to genetic traits of the crop plants. Leaf areas *w*ere much higher than those reported by Suksri (1992) and Songkanam (1996) but similar to those of Suksri (1993). L values were followed a similar pattern as that of leaf areas per plant and reached the highest value for KKU1 followed by KKU2, SJ5, SJ4, and Chiang Mai60, respectively. The soybean plants were not able to attain maximum L reaching only up to 5.15. The results indicated that the spacing between rows and within the row could be adjusted to the distances of 25x20 cm so that L should reach the value of 6 for KKU 1. This L value should provide 90% light interception among the canopies of soybean plants, L value should be in the range of 6-8 for this type of horizontal leaves as stated by Suksri (1993) for tropical zone. The adjusting of plant spacing as such may help increasing seed yield largely. There was some small relationships between seed yields and total shoot dry weights (r^2 = 0.124) and also between seed yield and leaf areas (r^2 = 0.135). Seed yields obviously increased with an increase in both leaf areas and total shoot dry weights provided that adequate amount of soil moisture content and soil nutrients are adequately available particularly soil macro nutrients as reported by Suksri (1993).

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