Journal of Coastal Development
Vol. 1, No. 2, February 1998: 121-138

ISSN : 1410-5217

THE APPLICATION OF CALCIUM AND POTASSIUM FERTILIZER TO DECREASE SODIUM TOXICITY ON PLANT IN COASTAL AREA *)

Karno

Faculty of Animal Science, Diponegoro University, Semarang, Indonesia

ABSTRACT

This research was carried out in April to July 1996 in the coastal area of Semarang in order to evaluate the effects of calcium and potassium fertilizer to plant growth and production of setaria grass and to observe sodium toxicity on the grass.

The experiment was arranged in a two factor split-plot design with three replication. The main factor was the application of $CaCO_3$ which was divided into three levels : 0, 4 and 8 ton $CaCO_3$ /ha and the sub factor was the application of KCl which was divided into three levels: 0, 40 and 80 kg K_2O/ha.

Eight parameters were observed in this experiment : Total Dissolved Salts (TDS), Soil Electrical Conductivity (ECe), level of death plant, plant height, leaves number, fresh yield, dry yield and protein content.

The results show that the application of $CaCO_3$ and KCl created inverse effects to Total Dissolved Salts (TDS) and Soil Electrical Conductivity (ECe). On one hand, $CaCO_3$ decreased TDS and ECe and on the other hand. KCl increased TDS and ECe. There were interactions between $CaCO_3$ and KCl in influencing TDS and ECe. However, $CaCO_3$ and KCl brought about similar effects to plant performance. Both $CaCO_3$ and KCl decreased the level of died plant and increased plant height, leaves number, fresh yield, dry yield and protein content of setaria grass. $CaCO_3$ and KCl did not interact each other in increasing plant performance.

The application of $CaCO_3$ increased plant height significantly at week 3, week 4 and week 5, and increased dry yield and protein content significantly, but did not increase fresh yield significantly.

The application of KCl increased dry yield and protein content significantly, but did not increased plant height, leaves number and fresh significantly.

Key words : calcium, potassium, fertilizer, sodium-toxicity

---

*) Funded by UNDIP-McMASTER Collaboration Project

I. INTRODUCTION

It is known that salinity leads to many agricultural problems around the world because saline soils are abundant in the world, especially in countries which have huge coastal areas such as Indonesia. Besides, saline soils occur in semiarid and arid regions because of insufficient rainfall for salt leaching and in non-irrigated croplands as a result of evaporation and transpiration processes so that salts are left in the soils.

The accumulation of a number of salts such as chlorides, sulfates, sodium salts, calcium salts, and magnesium salt result in saline soils; however, sodium salts (NaCl) is dominant in saline soils in coastal areas.

The high concentration of sodium in coastal area creates negatives effect on plant growth and production in various ways. First, the present of sodium in high concentration in soil leads to dispersion of soil particle. As a consequence, soil has no structure so that it has poor draination and aeration. Eventually, plants cannot grow well in this condition. Secondly, the high concentration of sodium increases osmotic potential of water in soil. As a result, plants have difficulties absorbing soil water. This decreases the rate of photosynthesis and plant production. Finally, the presence of sodium in high concentration often causes toxicity problems. Sodium toxicity occurs when plant absorbs sodium in excessive amount so that the sodium accumulation reaches toxic concentrations. In short, all the negative effect caused by sodium disturb plant growth and production. These often reduce yield and bring about crop failure.

Many efforts have been made to cope with salinity problems in agricultural activities. For instance, increased leaching fraction, periodic leaching, land grading, profile modification and artificial drainage are employed to decrease salinity problems. Besides, amandement such as gypsum and sulfuric acid and salt tolerant plant are used to solve the salinity problem. However, there is little information about the use of calcium carbonate ($CaCO_3$) and potassium chloride (KCl) to minimize sodium toxicity on plant.

This research was conducted to evaluate the application of calcium and potassium fertilizers in order to decrease sodium toxicity on plant in saline soil. There are several reasons for choosing calcium and potassium as treatment. Firstly, Ca ion and K ion can be used to decrease sodium percentage in the soil solution. Israelsen and Hansen (1962) explain the relationship among Na, Ca, K and Mg in the soil solution. They formulate sodium percentage as follow :

Sodium percentage =

$$= \frac{Na}{Ca + K + Mg + Na} \times 100\%$$

From this formula, combination of Ca, K and Mg decreases sodium percentage. The decrease of sodium percentage in the soil solution will decrease sodium absorption and negative effects of sodium on plant growth and production.

Secondly, Ca and Na create opposite effect on soil structure. The present of Na in soil leads to dispersion of soil particle. As a consequence, soil has no structure and has bad aeration and bad draination. Eventually, plant cannot grow well in this kind of soil. On the other hand, the present of Ca creates flocculation in the soil. Ca will join soil particles to create soil structure. This will improve soil condition that supports plant growth and development. In other words, the presence of Ca in soil will decrease the negative effect of Na on plant growth and production

II. LITERATURE REVIEW

Many researchers have observed the negative effects of salinity to plant growth and development. O'Leary (1969 cit. Greenway, 1973) and Devlin and Witham (1983) stated that salinity decreases the permeability of cell to water and nutrient so that plant has difficulty to absorb them. As a result, the activity of stomata is disturbed so that photosynthesis activity is very low. Eventually, plant production is very low. Richardson and McCree (1985) added the information that high concentration of salt pursues cell development including leaf cells so that the rate of photosynthesis decreases sharply.

Other researchers, Terry and Waldron (1986) observed the effect of salinity to plant photosynthesis and growth. They found that increase in salinity decrease leaves expansion so that the total leaf area decreased sharply. This resulted in the decrease of the rate of photosynthesis. In term of plant production, low level of salinity as 25 mM NaCl decreased total dry matter of sugar-beets and the increase of salinity up to 500 nM NaCl decreased plant growth and production progressively.

Devitt and Stolzy (1986) investigated the response of sorghum to saline condition and found that sodium concentration controlled the root elongation of sorghum. The increase on sodium concentration brought about the decrease of root growth rate. Other researchers, Sutcliffe and Baker (1974) found that plant growing on saline soil showed the symptom of potassium deficiency because Na ion disturbs the absorption of K ion.

The level of salinity also influences the uptake of nutrients such as nitrate (NO_3^-)and ammonium (NH_4^+). At 100 mM salt the absorption of nutrient was little affected, but the uptake of nitrate and ammonium went down sharply at the higher level of salt up to 200 mM salt (Huffaker and Rains, 1986). Furthermore, they showed that high concentration of NaCl reduced fresh yield of barley. However, The absorption of nutrient of plant growing in the saline condition can be improved by the addition of calcium (Ca^{++}). The application of calcium increased nitrate uptake, assimilation and seedling growth. This improvement resulted from the stabilization of the cell membrane.

Finally, Kristanto et al. (1993) applied KCl and $CaCO_3$ on saline soil with corn as an indicator plant. This research project was conducted in a glasshouse. The results showed that the application of KCl and $CaCO_3$ on saline soil increased plant height, fresh and dry yield of corn (Zeamays) forage and decreased sodium absorption. These results showed that potassium and calcium can be employed to decrease or minimize the negative effect of high concentration of sodium in saline soil from coastal areas.

III. METHODOLOGY

3.1. Experimental Design

The experiment was arranged in a two factor split plot design with three replication. The main factor was the application of $CaCO_3$ which was divided into 3 levels :

C1 : 0 ton $CaCO_3$/ha
C2 : 4 ton $CaCO_3$/ha
C3 : 8 ton $CaCO_3$/ha

The sub Factor was the application of KCl which was divided into 3 levels:

K1 : 0 kg K_2O/ha
K2 : 40 kg K_2O/ha
K3 : 80 kg K_2O/ha

Split plot design was chosen as experimental design because by using it, researchers can analyze not only the effects of $CaCO_3$ and KCl separately but also the interaction effects between them as well.

3.2. Research Procedure

The experiment was carried out in coastal area in Semarang. Lay out of experiment plots can be seen in appendix. Seedling of Setaria grass (*Setaria sphacelata*) was prepared in the seedbed for 30 days to create uniform seedling. Setaria Grass is a sort of forage grass usually used to feed goat. This grass is resistant to drought.

$CaCO_3$ and KCl were applied into the plots based on the level of treatments. Urea (50 kg N_2/ha) and Super Phosphate (50 kg P_2O_5/ha) were also applied into all plots as base treatments.

Setaria grass was replanted to the experiment plots one day after the application of fertilizers with planting range 40 X 40 cm. All planted grasses were cut in 15 cm height to make uniform plant material.

Eight parameters were observed in this experiment : plant height, leaves number, fresh yield, dry yield, level of death, soil electrical conductivity (ECe), total dissolved salts (TDS) and forage quality.

Plant height and leaves number were observed weekly and the other parameters were observed at 40 days after planting. Soil electrical conductivity (ECe) and total dissolved salts (TDS) were analyzed according to Hidayat (1978) and forage quality (protein content) was determined by using semi-micro kjeldahl method described by Hidayat (1978).

Data were analyzed by analysis of variance using Costat. The effects of treatment and interaction between them were recognized by analysis of variance (Anova). The differences among means were determined by using Duncan's Multiple Range Test (Gomez and Gomez, 1983).

IV. RESULT AND DISCUSSION

4.1. TDS, ECe and Level of Death

The application of $CaCO_3$ and KCl in saline soil effected Total Dissolved Salts (TDS) and Soil Electrical Conductivity (ECe) significantly and interaction between them occurred in affecting TDS and ECe.

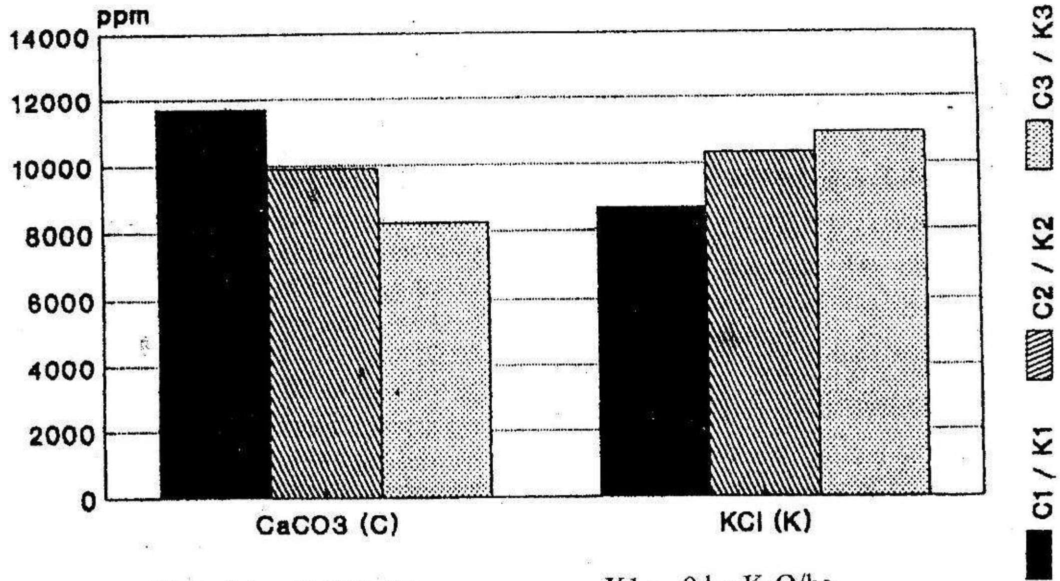
$CaCO_3$ and KCl showed different effect to soil. The application of $CaCO_3$ 0, 4 and 8 ton/ha decreased TDS from 11669.33 ppm to 9902.22 ppm and 8270.22 ppm and decreased ECe from 15.97 mmhos/cm 12.716 mmhos/cm and 11.078 mmhos/cm respectively. On the contrary, the application of KCl 0, 40 and 80 kg K_2O/ha brought about an increase of TDS 8657.78, 10296.89 and 10887.11 ppm respectively and an increase of ECe 11.77, 13.45 and 14.55 mmhos/cm respectively (Figure 1 and 2).

Although $CaCO_3$ and KCl had different effects to TDS and ECe, they showed similar influences to death plant level of Setaria grass. The application of both $_3$ and KCl decreased the level of death plant. This means that the application of calcium and potassium fertilizer create good effects to plant. 4 ton $CaCO_3$ added to soil decreased the level of death plant from 38.89% to 36.80% and an increase of $CaCO_3$ to 8 ton/ha decreased death plant level to 29.17%; however, the decreased were non significantly different (Figure 3).

The level of death plant went down with the application of KCl. Without treatment, the average of death plant was 48.61%. The treatment of KCl of 40 kg K_2O/ha decreased significantly ($p<0.05$) the level of death plant from 48.61% to 33.33%. An increase of dose of KCl up to 80 kg K_2O/ha resulted in a significant decrease of the level of death plant from 48.61% to 22.92% (Figure 3).

All the death plants showed the symptoms as follows : leaf burn and drying tissue occurred at the outer edge of leaf and the burn continued to the leaf center that resulted in scorched leaf and finally, the plant died. Ayers and Wescot (1976) stated that these typical symptoms were caused by sodium toxicity that appears when plant absorbs sodium to concentrations that exceed the tolerance of the crop.

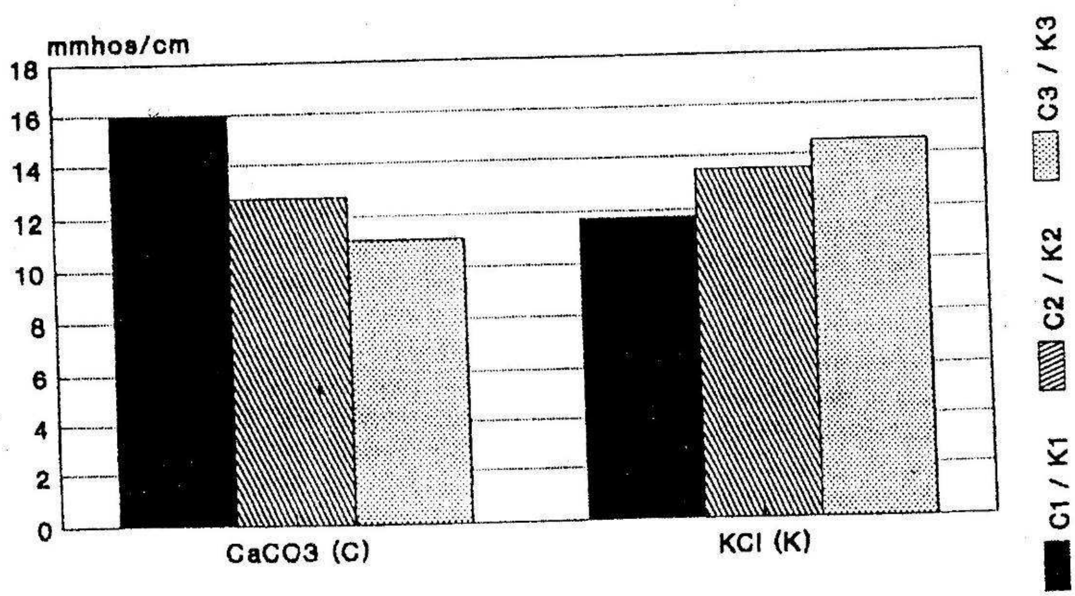
The results above show that calcium and potassium fertilizer can be employed to decrease sodium toxicity on plant. Ayers and Wescot (1976) gave the information that calcium is commonly used as soil amandement to modify or reduced sodium toxicity. They explained that sodium effects on plant depend on both sodium and calcium concentration in soil and they suggested that the application of calcium at moderate amount may reduce sodium toxicity and prevent it at the higher amount.



C1 : 0 ton $CaCO_3$/ha
C2 : 4 ton $CaCO_3$/ha
C3 : 8 ton $CaCO_3$/ha

K1 : 0 kg K_2O/ha
K2 : 40 kg K_2O/ha
K3 : 80 kg K_2O/ha

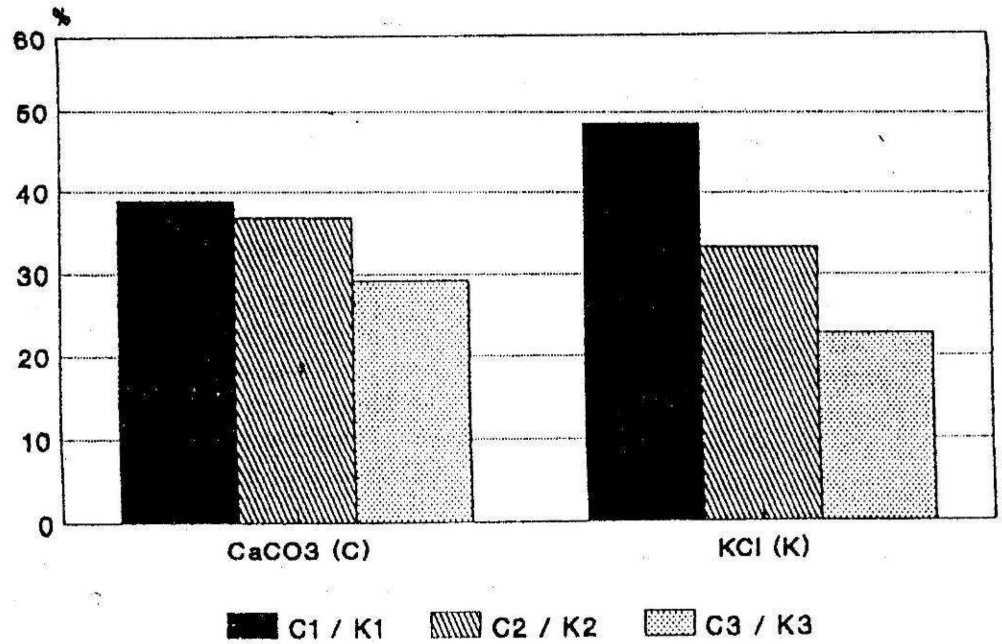
Figure 1. Effects $CaCO_3$ and KCL to Total Dissolved Salts (TDS)



C1 : 0 ton $CaCO_3$/ha
C2 : 4 ton $CaCO_3$/ha
C3 : 8 ton $CaCO_3$/ha

K1 : 0 kg K_2O/ha
K2 : 40 kg K_2O/ha
K3 : 80 kg K_2O/ha

Figure 2. Effects $CaCO_3$ and KCL to Soil Electrical Conductivity (Ece)



C1 : 0 ton $CaCO_3$/ha	K1 : 0 kg K_2O/ha
C2 : 4 ton $CaCO_3$/ha	K2 : 40 kg K_2O/ha
C3 : 8 ton $CaCO_3$/ha	K3 : 80 kg K_2O/ha

Figure 3. Effects $CaCO_3$ and KCL to the Level of Death Plant

Other researchers, Baligar and Duncan (1990) explored the evidence that sodium toxicity can be reduced by the application of calcium. Their citation from Lahaye and Epstein (1971) showed that moderate levels of Ca prevented root necrosis of bush-bean and decreased Na accumulation in leaves. Crammer el al. (1987) cited by Baligar and Duncan (1990) stated that ion absorption, selectivity and retention were essentially affected by ca in the rooting medium and ca reduced the deleterious effects of high Na levels in cotton. They suggested that there was a competition between Na and Ca in the plasmalemma, high concentration of Na displaces Ca in the plasmalemma. Huffaker and Rains (1986) added the information that the application of Ca in saline soil increased nutrient uptake because of the stabilization of the cell membrane by Ca. Finally, Coule et al. (1984) cited by Marschner (1986) reported that application of calcium to saline soil improves soil structure that improves soil aeration and increases the Ca ++/Na+ ratio in the rooting medium that supports the ability of root to restrict Na.

All the evidence above supports the result of this research. The application of calcium to saline soil minimizes the negative effect of sodium. In other words, the application of Ca improves plant performance.

In addition of effect calcium on plant, the application of potassium fertilizer also created good effects on plant growing in the saline condition. The treatment of KCl decreased sodium toxicity to plant. Israelsen and Hansen (1964) explained that the application of K to saline soil decreases sodium absorption. James (1988) cited by Baligar and Duncan (1990) stated that marginal chlorosis of alfalfa leaves as symptoms of sodium toxicity can be eliminated by the application of potassium fertilizer. Application of K increased leaf K and decreased leaf Na to normal levels, about 2% of K and 0.1% of Na. Besides that, the accumulation of K in the root tip encourages the sodium exclusion and K transportation within the plant.

4.2. Plant Height and Leaves Number

4.2.1. Plant Height

The application of $CaCO_3$ improved plant height significantly at week 3, week 4 and week 5 and KCl improved Plant Height non significantly for all weeks. There was no interaction between $CaCO_3$ and KCl in improving the Plant Height.

The treatment of $CaCO_3$ 8 ton/ha increased the Plant Height significantly ($p< 0.05$) at week 3, week 4 and week 5 but not significantly at week 2 and week 6 (Table 1).

Table 1.

Effects of $CaCO_3$ to Plant Height of Setaria Grass at Week 2 to Week 6

Treatment $CaCO_3$	Plant Height (cm)				
	week2	week 3	week 4	week 5	week 6
0 ton/ha	22.04 a	20.08 ab	19.05 b	19.99 ab	16.14 a
4 ton/ha	20.66 a	19.01 b	18.39 b	16.81 b	13.78 a
8 ton/ha	22.54 a	22.20 a	21.68 a	21.20 a	18.39 a

Table 2.
Effects of KCL to Plant Height of Setaria Grass at Week 2 to Week 6

Treatment KCl	Plant Height (cm)				
	week2	week 3	week 4	week 5	week 6
0 kg K_2O/ha	22.33 a	20.89 a	19.83 a	17.90 a	14.95 a
40 kg K_2O/ha	21.83 a	20.39 a	18.96 a	18.98 b	15.57 a
80 kg K_2O/ha	21.09 a	20.02 a	20.33 a	21.13 a	17.78 a

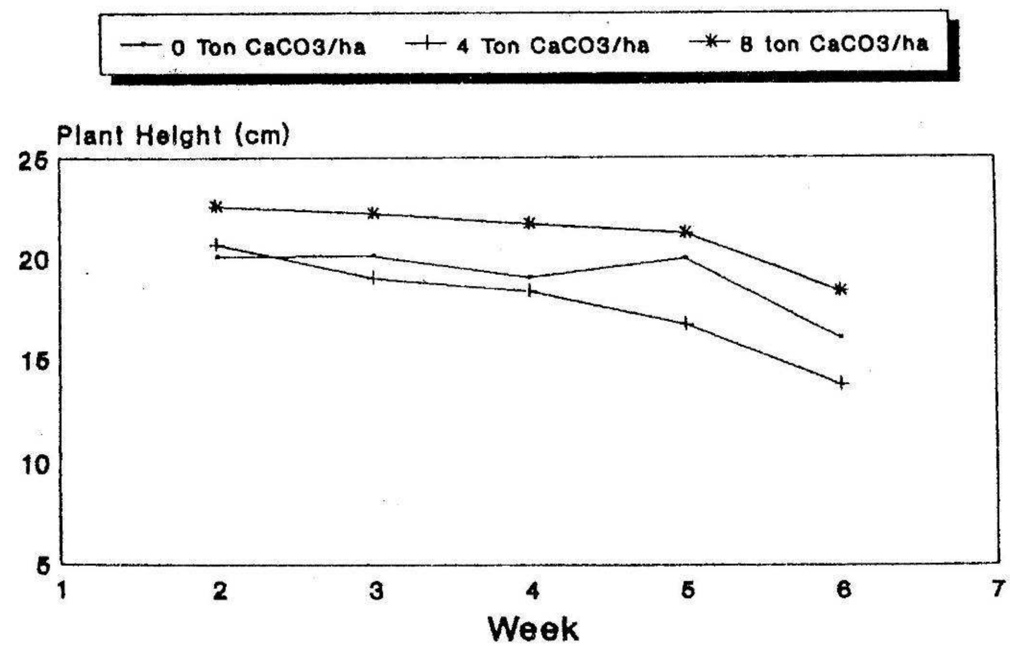


Figure 4. Effects of CaCO3 to Plant Height of Setaria Grass at Week 2 to Week 6

From the Figure 4, it can be seen that all curves, as a result of the treatment of $CaCO_3$ 0, 4 and 8 ton/ha, show similar trend, that is, plant height decreases gradually from week 2 to week 6. This can be discussed from the result of soil electrical conductivity (ECe) above, the application of $CaCO_3$ up to 8 ton/ha decreased the ECe value up to 11.08 mmhos/cm. However, this value is still high and considered severe to plant growth. As stated by Ayers and Wescot (1976), the value of Electrical conductivity more than 3.0 mmhos/cm causes severe problems to plant, but the threshold value of ECe depends on plant species.

Another explanation, plant exposed to saline conditions for short periods faces problems in absorption of soil water so that plant faces water deficit. If the exposure is for long periods, in addition to water deficit, plant faces toxicity problems, especially sodium toxicity, that leads to poor growth of plant and even to death.

The application of KCl did not affect plant height significantly. However, KCl with dose 80 kg K_2O/ha improved plant height better that of KCl with dose 0 kg K_2O/ha or 40 kg K_2O/ha at long duration (week 5 and week 6) (table 2).

The Figure 5 shows that plant height went down gradually from week 2 to week 6 for the treatment of KCl dose 0 kg K_2O/ha and 40 kg K_2O/ha. However, the application of KCl 80 kg K_2O/ha resulted in different curve. Plant height increased at week 4 and reached peak at week 5 and then decreased at week 6. This figure showed that application of KCl up to 80 kg K_2O/ha has good effect to plant height.

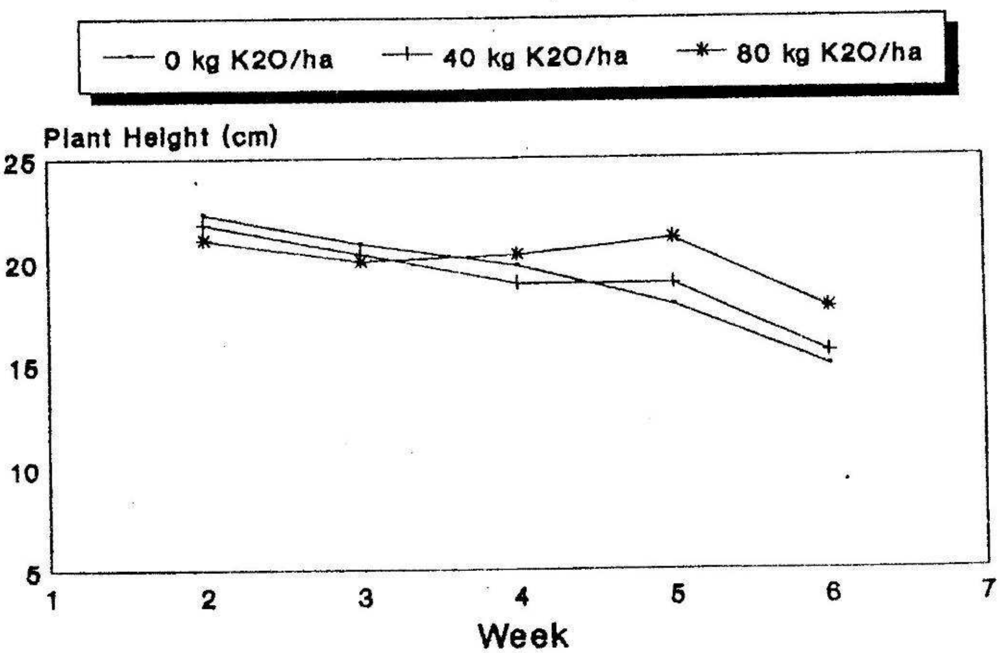


Figure 5. Effects of KCL to Plant Height of Setaria Grass at Week 2 to Week 6

4.2.2. Leaves Number

The application of $CaCO_3$ increased leaves number significantly at week 4 and week 5 and application of KCl increased leaves number non significantly. $CaCO_3$ and KCl did not interact each other in affecting leaves number (Figure 6 and 7).

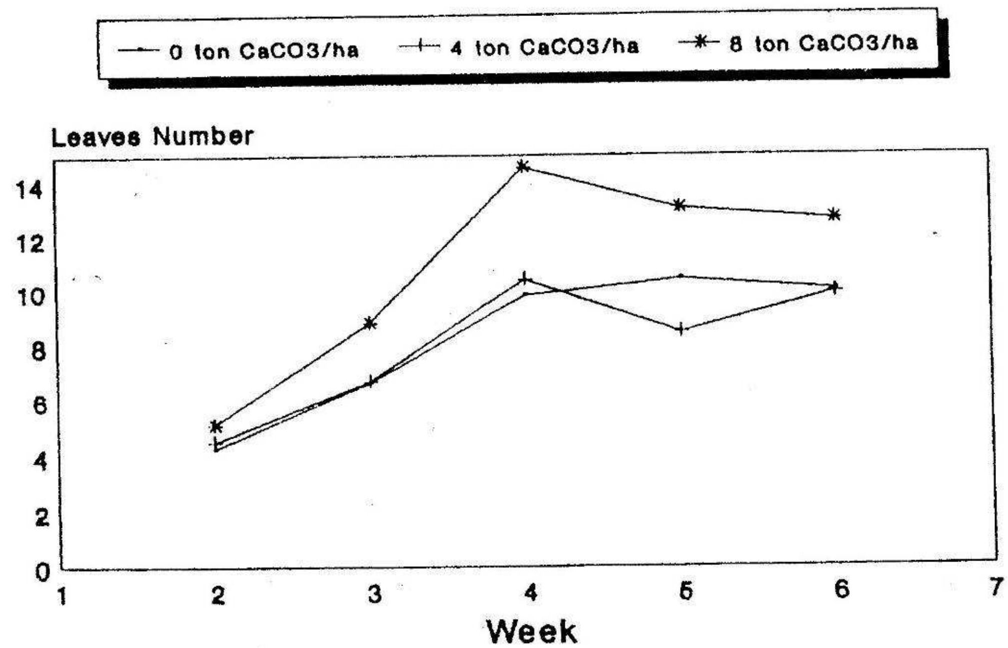


Figure 6. Effects of $CaCO_3$ to Leaves Number of Setaria Grass at Week 2 to Week 6

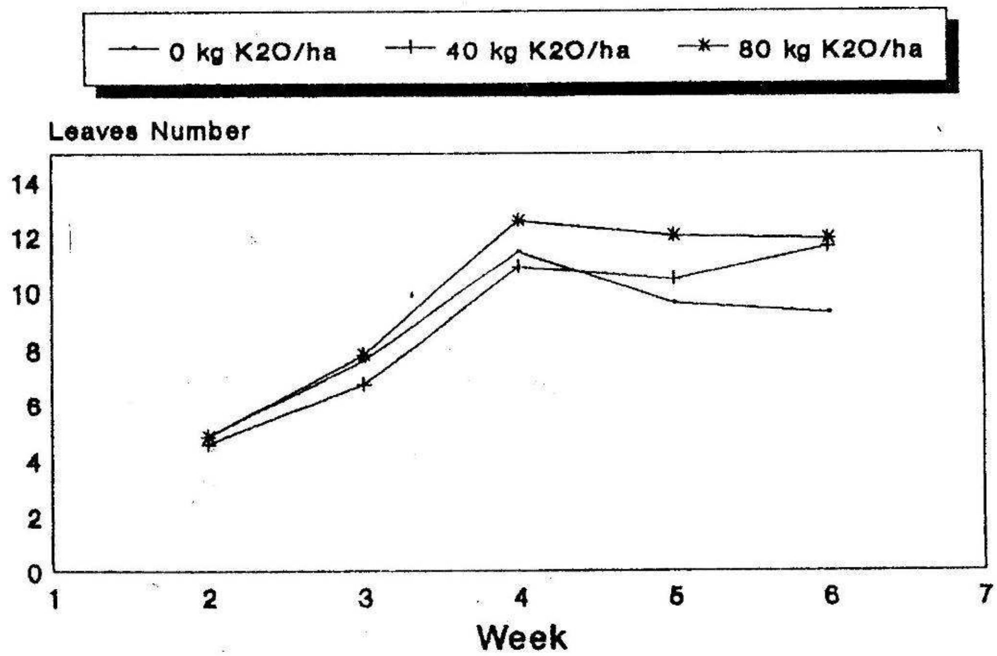


Figure 7. Effects of KCL to Leaves Number of Setaria Grass at Week 2 to Week 6.

Figure 6 shows that leaves number from week 2 to week 6 from parabolic curves. The first curve (0 ton $CaCO_3$ /ha), leaves number increased gradually from 4.25 at week 2 and reached peak at week 5 with leaves number 10.47 and then decreased at week 6. The second curve (4 ton $CaCO_3$/ ha), starts from week 2 with 4.50 leaves, leaves number went up gradually and reached peak at week 4 10.44) and went down at week 5 and week 6. The last curve (8 ton $CaCO_3$ /ha) is similar to the second curve but the value is higher than that of the second curve. Leaves number increased sharply from week 2 (5.11) and reached peak at week 4 (14.56) and then decreased gradually at week 5 and week 6.

Plant growing on saline conditions had difficulties to absorb soil water at the first time. Then plant tried to adapt this condition by osmoregulation process. As a result, plant could grow which was shown by an increase in leaves number. However, in long periods, after 3 weeks, salt absorption increased so that plant suffered from ion toxicity especially sodium toxicity which could be seen from the symptoms such as dry and scorched tissue of leaves. As some leaves died, leaves number decreased until the sixth week and some of the plants died.

In addition to effect of $CaCO_3$ to leaves number, treatment of KCl resulted in the same curves as $CaCO_3$ treatment. All curves (Figure 7) illustrated that leaves number went up gradually from week 2 and reached peak at week 4 and then decreased after that.

Although all curves are similar, the application of KCl 80 kg $\cdot K_2O$/ha resulted in higher leaves number than that of treatment of KCl 40 kg K_2O/ha or 0 kg K_2O/ha.

4.3. Fresh Yield, Dry Yield and Protein Content

The application of $CaCO_3$ and KCl increased fresh yield non significantly and increased dry yield and protein content significantly ($p<0.05$). There was no interaction between $CaCO_3$ and KCl in influencing fresh yield, dry yield and protein content.

The dose of $CaCO_3$ 4 ton/ha applied to saline soil increased fresh yield from 5.49 g/plant (without treatment) to 6.81 g/plant and an increased of $CaCO_3$ up to 8 ton/ha increased fresh yield up to 7.84 g/plant (Figure 8).

Similar to the result above, the application of KCl 40 kg K_2O/ha increased fresh yield from 5.75 g/plant (without treatment) to 6.08 g/plant and fresh yield increased up to 8.31 g/plant when KCl was increased up to 80 kg K_2O/ha (Figure 8).

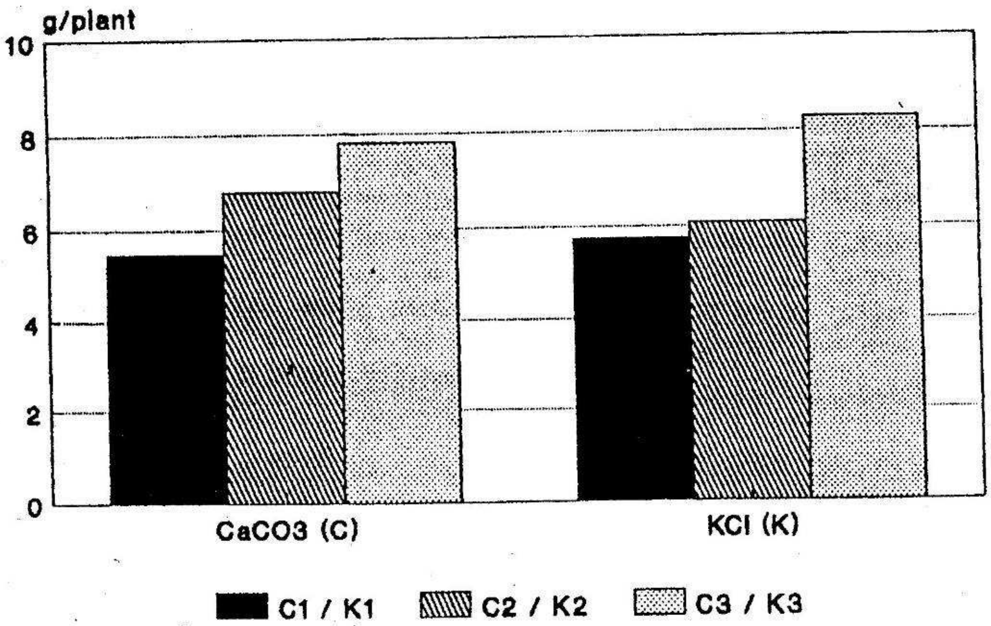
Although the results show non significantly increases in fresh yield, the results suggest that the treatments of $CaCO_3$ and KCl create good effects to fresh yield. $CaCO_3$ decreased ECe and TDS and both $CaCO_3$ and KCl decreased sodium percentage in rooting medium. Through these effects, $CaCO_3$ and KCl increased fresh yield of setaria grass.

Plant production is accurately shown by the accumulation of dry matter products in photosynthesis that results in dry yield of plant. The treatment of $CaCO_3$ and KCl increased dry yield of setaria grass significantly ($p<0.05$) ; however, there was no interaction between them in improving dry yield.

Dry yield increased with increased $CaCO_3$ doses. The application of $CaCO_3$ 4 ton/ha increased dry yield from 1.88 g/plant (without treatment) to 2.40 g/plant and dry yield went up to 2.72 g/plant as $CaCO_3$ was increased to 8 ton/ha (Figure 9).

Masrcher (1986) stated that the levels of salinity affect respiration and photosynthesis. The higher the level of salinity the higher the rate of respiration and the lower the rate of photosynthesis. Therefore, by decreasing the level of salinity, the application of $CaCO_3$ increased the rate of photosynthesis and decreased the rate of respiration that resulted in an increase of dry yield.

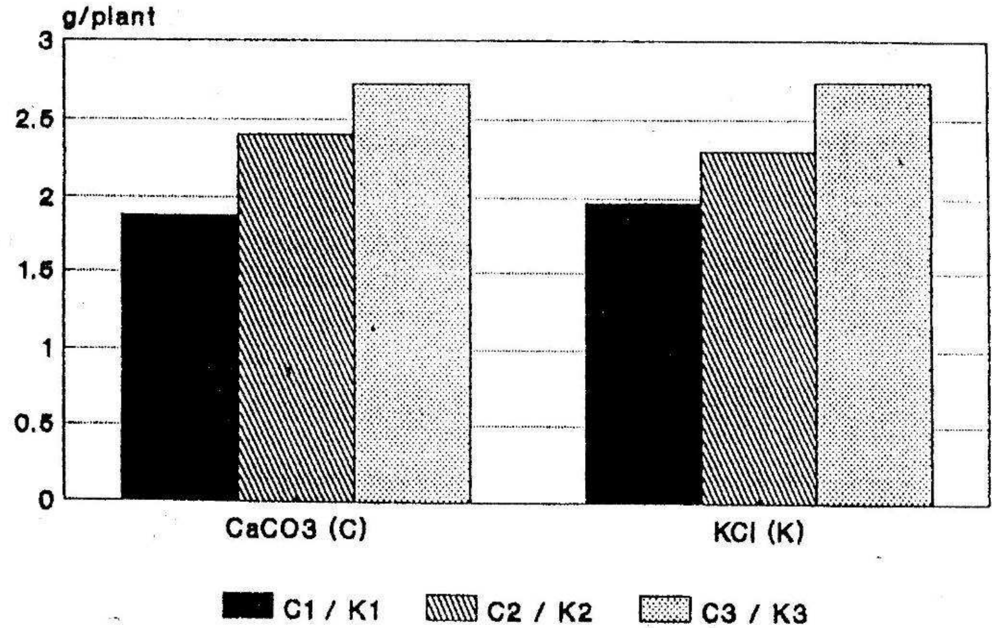
The ability of K to complete with Na in soil solution and plant tissue results in a decrease of sodium absorption by plant in saline soil where potassium fertilizer is applied. As a result, the application of KCl decreases sodium toxicity so that plant can grow better shown by an increase of dry matter production. Dry yield increased significantly with an increase of KCl from 40 kg K_2O/ha to 80 kg K_2O/ha. These result were higher than that without treatment (1.97 g/plant) (Figure 9).



C1 : 0 ton $CaCO_3$ /ha
C2 : 4 ton $CaCO_3$ /ha
C3 : 8 ton $CaCO_3$ /ha

K1 : 0 kg K_2O/ha
K2 : 40 kg K_2O/ha
K3 : 80 kg K_2O/ha

Figure 8. Effects $CaCO_3$ and KCL to Fresh Yield



C1 : 0 ton $CaCO_3$ /ha	K1 : 0 kg K_2O/ha
C2 : 4 ton $CaCO_3$ /ha	K2 : 40 kg K_2O/ha
C3 : 8 ton $CaCO_3$ /ha	K3 : 80 kg K_2O/ha

Figure 9. Effects $CaCO_3$ and KCL to Dry Yield

The application of $CaCO_3$ and KCl also increased protein content of setaria grass significantly, but $CaCO_3$ and KCl did not interact each other in increasing protein content.

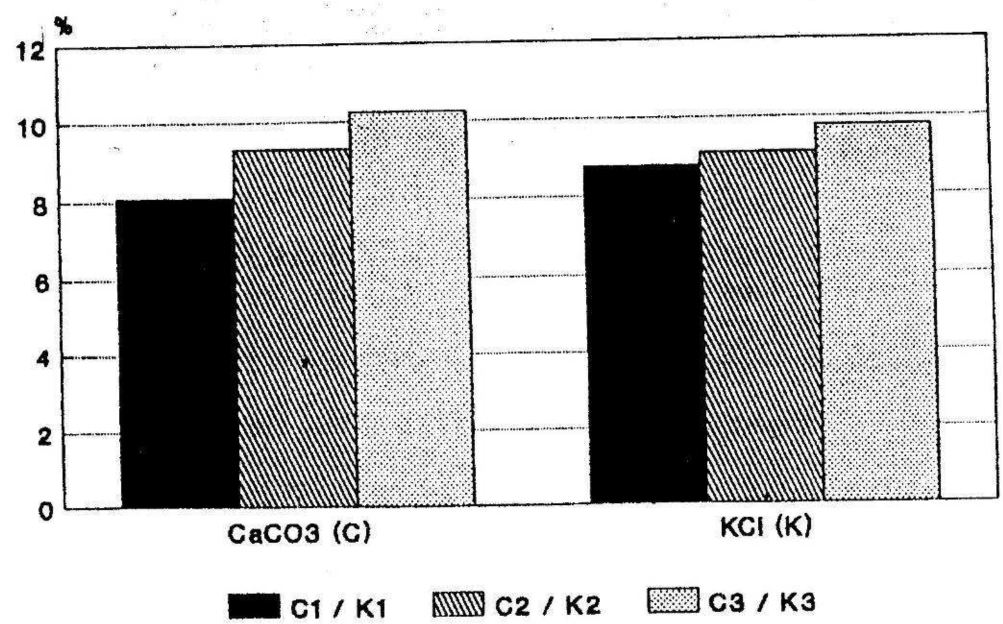
The treatment of $CaCO_3$ in saline soil brought about an increase of protein content significantly. Dose of $CaCO_3$ 4 ton/ha increased protein content from 8.09 % (without treatment) to 9.29 % and protein content increased up to 10.26 % when $CaCO_3$ was increased up to 8 ton/ha (Figure 10).

Huffaker and Rains (1986) observed that the presence of Ca in saline condition protected the nitrate and ammonium transports from sodium injury. In long periods, an increase of Ca concentration increased nitrate assimilation and nitrate reductase activity. As a result, protein synthesis increased that finally would increase protein content, too.

KCl increased protein content in a different way. In the leaves of plant growing in saline condition, protein synthesis decreases because of ion imbalance (Na+/K+ ratio) or sodium toxicity (Marschner, 1986). He stated that protein synthesis in barley can be managed by the application of KCl because the application of KCl decreased sodium absorption.

Application of KCl 40 K_2O/ha and 80 kg K_2O/ha increased protein content of setaria grass to 9.09% and 9.78% respectively from 8.75% (without treatment) (Figure 10).

From the results above, it is clear that calcium and potassium fertilizer can be used to improve plant performance in saline conditions. These results are very important because these would support the improvement of coastal areas for agricultural activities.



C1 : 0 ton $CaCO_3$ /ha
C2 : 4 ton $CaCO_3$ /ha
C3 : 8 ton $CaCO_3$ /ha

K1 : 0 kg K_2O/ha
K2 : 40 kg K_2O/ha
K3 : 80 kg K_2O/ha

Figure 10. Effects $CaCO_3$ and KCL to Protein Content

V. CONCLUSION AND SUGGESTION

5.1. Conclusion

The application of $CaCO_3$ and KCl created inverse effect to Total Dissolved Salts (TDS) and Soil Electrical Conductivity (ECe). On one hand, $CaCO_3$ decreased TDS and ECe and on the other hand, KCl increased TDS and ECe. There were interactions between $CaCO_3$ and KCl in influencing TDS and ECe. However, $CaCO_3$ and KCl brought about similar effects to plant performance. Both $CaCO_3$ and KCl decreased the level of death plant and increased plant height, leaves number, fresh yield, dry yield and protein content of setaria grass. $CaCO_3$ and KCl did not interact each other in increasing plant performance.

The application of $CaCO_3$ increased plant height significantly at week 3, week 4 and week 5, and leaves number significantly at week 4 and week 5, and increased dry yield and protein content significantly, but did not increased fresh yield significantly.

The application of KCl increased dry yield and protein content significantly, but did not increase plant height, leaves number and fresh yield significantly.

5.2. Suggestion

The dose of $CaCO_3$ 8 ton/ha and KCl 80 kg K_2O/ha resulted in the highest results but some effect were non significantly different. Therefore, further research projects should be conducted with the higher doses of $CaCO_3$ and KCl in order to obtain optimal effects to plant growth and production in saline conditions.

REFERENCES

Ayers, R.S. and D.W. Wescot. 1976. Water Quality for Agriculture. Food and Agriculture Organization of the United Nations. Rome.

Baligar, V.C and R.R. Duncan. 1990. Crops as Enhancers of Nutrient Use. Academic Press, Inc. Harcourt Brace Jovanovich, Publishers. San Diego.

Devitt, D.A. and L.H Stolzy. 1986. Plant Response to Na+, K+, and K+/Na+ Ratio Under Saline Conditions. In Kearney Foundation Five-Year Report 1980-1985. Soil and Plant Interactions with Salinity. Agricultural Experiment Station University of California Division of Agriculture and Natural Resources.

Devlin, R.M and F.H. Witham. 1983. Plant Physiology. 4th ed. Wilard Grant Press, London.

Gomez, K.A and A.A Gomez. 1983. Statistical Procedures for Agricultural Research. 2nd ed. John Wiley & Sons. New York.

Greenway, N. 1973. Salinity, Plant Growth and Metabolism. Aust. J. Agric. Sci. 39 : 24-34.

Hidayat, A. 1978. Methods of Soil Chemical Analysis. Japan International Cooperation Agency (JICA) in the Frame Work of the Indonesia-Japan Joint Food Crop Research Program. Bogor.

Huffaker, R.C. and D. W. Rains. 1986. N use Efficiency as Influenced by S Assimilation in Barley Exposed to Salinity. In Kearney Foundation Five-Year Report 1980-1985. Soil and Plant Interactions with Salinity. Agricultural Experiment Station University of California Division of Agriculture and Natural Resources.

Kristanto, B. A., C.I. Sutrisno, Widyati, B. Sulistyanto, Karno and S. Anwar. 1993. The Effects of Irrigation Methods and Fertilizer on the Improvement of Coastal Area Quality. Diponegoro University. Semarang.

Marschner, H. 1986. Mineral Nutrition of Higher Plants. Academic Press Harcourt Brace Jovanovich, Publisher. London.

Richardson, S.N. and K.J. McCee. 1985. Carbon Balance and Water Relation of Sorghum Exposed to Salt and Water Stress. Plant Physiol. 79 : 1015-1020.

Sutcliffe, J.F. and D.A. Baker 1974. Plant and Mineral Salt. Oxford & IBH Pub. Co. New Delhi.

Terry, N and L.JK. Waldron. 1986. Salinity Responses of Crop Plants in Term of Leaf Expansion and Photosynthesis. In Kearney Foundation Five-Year Report 1980-1985. Soil and Plant Interactions with Salinity. Agricultural Experiment Station University of California Division of Agriculture and Natural Resources.