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BALANCED FERTILIZATION STRATEGY OF CABBAGE IN THE HIGHLANDS, NORTHERN PHILIPPINES

ABSTRACT

Balanced fertilization strategy for cabbage was studied at the Soil Science Experimental Area, College of Agriculture, Benguet State University, La Trinidad, Benguet from December, 2005 – March, 2006 (on station trial) and at Paoay, Atok, Benguet from February, 2006 – June, 2006 (on farm trial). The objectives of the study aimed to determine balanced fertil-ization for cabbage in the two areas, determine the effect on the growth of cabbage and its effect on the soil properties.

Application of farmer's rate (250-100-100 kg/ha N-P2O5-K2O + 7 tons/ha chicken manure) and recommended rate + 5 tons/ha chicken manure produced the heaviest yield of cabbage in the on-station trial. An increase on the pH value, organic matter and nitrogen content of the soil was noted from farmer's rate.

Likewise in the on farm trial, application of 50% recommended rate + 50% chicken manure + boron registered the highest yield per plot but not significantly different from recommended rate + 5 tons/ha chicken manure. However, application of 25% recommended rate + 75% chicken manure had the highest increase of soil pH from the initial value. For organic mat-ter and nitrogen content, application of 25% recommended rate + 75% chicken manure + boron registered also the highest in the soil. Lastly, ap-plication of 75% recommended rate + 25% chicken manure increased the phosphorous content of the soil while other treatments decreased its phos-phorous content.

INTRODUCTION

Cabbage is one of the leading leafy vegetables grown in the high-lands of northern Philippines. It is continuously cultivated through out the year that led to serious soil fertility depletion and soil acidification. Due to these soil conditions, timely correction of deficiencies of all nutrients is vital to sustain high crop yields that can be solved by adopting the balanced fertilization through integrated nutrient management, judicious and com-bined use of all nutrient sources. In this case, optimum use of organic and inorganic fertilizers with proper grade and amounts to supply the correct ra-tio of plant nutrients which ensure the soil to sustain high crop yield known as balanced fertilization strategy is encouraged. This is primarily designed to supplement limiting nutrients.

Presently BFS technology was developed and adopted only for rice. No published reports were made on BFS technology specifically for cab-bage while BFS for corn is on-going.

Objectives of the Study

The study was composed of two trials. The on station trial was con-ducted at the Soil Science Experimental Area, College of Agriculture, Ben-guet State University from December 2005-March 2006 while the on farm trial was conducted at Paoay, Atok, Benguet from February 2006-June 2006 to determine the balanced fertilization strategy for cabbage in the two areas, determine the effect on the growth parameters of cabbage and determine the effect on the soil chemical properties of soil.

MATERIALS AND METHODS

Materials

The materials used in the study were cabbage seeds, formulated compost of BSU, chicken manure, complete fertilizer (14-14-14), urea, and labeling materials.

Methods

Soil samples were collected from the experimental area for initial analysis of pH, OM, N, and P. An area measuring 360 m2 was thoroughly prepared and was divided into three blocks with two rows measuring 1 m x 5 m. The experiment was laid out in a randomized complete block design (RCBD) with three replications.

Two kinds of organic fertilizers were applied three days earlier before planting. One half of the recommended rate of inorganic fertilizers was incorporated into the soil during planting and hilling-up. Boron was applied as foliar once a week, four weeks after transplanting until one month before harvesting.

All cultural practices such as watering, spraying, weeding and others were strictly followed.

Originally the study was composed of twenty-four treatments, and was reduced to eight treatments which were selected to be the better treatments. The treatments were as follows:

T1 250-100-100 kg/ha N-P_2O_5-K_2O + 7 tons/ha chicken manure (farmer's practice)
T2 Recommended Rate (250-100-100 kg/ha N-P_2O_5-K_2O) + 5 tons/ha chicken manure
T3 75% RR + 25% CM
T4 25% RR + 75% CM
T5 50% RR + 50% CM + B
T6 25% RR + 75% CM + B
T7 100% RR + formulated organic fertilizer (FOF) + B
T8 75% RR + 25% FOF + B

The data gathered were as follows:

Agronomic Parameters

1. **Average head solidity (g/cc)**. This was done by dipping the harvested head of cabbage in a basin filled with water. Then the volume of water displaced was measured using a graduated cylinder. The solidity was cal-

culated as follows:

solidity of the head = Weight of the head (g) / [redacted]

2. **Average head circumference (cm)**. This was done by using tape measure.

3. **Total yield (kg/5 m2 plot)**. This was the weight of marketable heads har-vested per plot only since there was no non-marketable gathered.

4. **Non-marketable weights (kg/ plot)**. This was done by separating and weighing cabbage heads that did not form head and with damage of insects and diseases. This data was only present in the on farm trial.

Some Soil Chemical Properties
(Before and after the conduct of the study)

1. **pH**. The soil pH was analyzed using the 1:2.5 soil and CaCl2 ratio. The pH was obtained using the Electrometric pH meter.

2. **Organic Matter.** The organic matter content of the soil was analyzed us-ing the Walkley-Black Method.

3. **Nitrogen content.** This was computed based on the organic matter content of the soil. The formula was:

$$\%N = (\%OM)(0.05)$$

where:
%OM = the computed organic matter value of the soil
0.05 = constant value

4. **Phosphorous content.** The phosphorous content of the soil was analyzed using Bray No. 2 method and was obtained using the spectrophotom-eter.

RESULT S AND DISCUSSION

On Station Trial

Agronomic Parameters

Average Head Solidity. Table 1 shows the agronomic parameters as affected by the treatments of balanced fertilization. Head solidity of the dif-ferent treated plants had relative differences from each other however statis-tically, there was no significant difference among the treatments. Moreover, the result shows that plants applied with recommended rate (250-100-100 kg/ha N-P2O5-K2O) + 5 tons/ha chicken manure produced the hardest and most compact heads (3.37 g/cc).

Average Head Circumference. The different treatments gave no significant effect on the head circumference of cabbage plants. However, the smallest heads were obtained from treatment 6 (25% recommended rate + 75% chicken manure + boron). This could be attributed by low supply of N wherein formation of small cells of the leaves, thick walls, harsh and fibrous leaves was observed. As a result, the cabbage heads were small. Fur-thermore, the result of the study revealed that application of 100% recom-mended rate + 5 tons/ha formulated organic fertilizer + boron produced the biggest heads apparently, the nutrient requirement for head formation was sufficiently supplied by this treatment.

Total yield per plot. The result shows that application of farmer's rate gave the highest yield per plot and was significantly different from oth-er treatments except for the application of recommended rate (250-100-100 kg/ha N-P2O5- K2O) + 5 tons/ha chicken manure. This could be due to the amount of N applied to the cabbage plant wherein N alone can account for most of the increase in yield of cabbage (Burleson, 1958). The lowest yield per plot was obtained from plants applied with 75% recommended rate + 25 % formulated organic fertilizer + boron.

Non-marketable Yield per Plot. Application of recommended rate + 5 tons/ha chicken manure and 75% recommended rate + 2 5 % chicken manure gave high non-marketable yield values. Statistically, these were significantly differed from other treatments. The result further re vealed that application of 50% recommended rate + 50% chicken manure +

boron gave the lowest non-marketable yield which is utmost importance.

Table 1. Average Head Solidity

TREATMENT	HEAD YIELD KETABLE (g/cc)	HEAD FERENCE (cm)	TOTAL NON-MAR-SOLIDITY (kg)	CIRCUM- YIELD (kg)
T1, farmer's practice	3.33$_{a}$	49.03$_{a}$	25.50$_{a}$	0.78$_{b}$
T2, 100% recommended rate (RR)	3.37$_{a}$	49.70$_{a}$	23.67$_{ab}$	3.00$_{a}$
T3, 75% (RR) + 25 % (CM)	3.13$_{a}$	48.23$_{ab}$	19.18$_{cd}$	3.09$_{a}$
T4, 25% (RR) + 75 % (CM)	3.23$_{a}$	46.83$_{ab}$	18.32$_{cd}$	0.40$_{b}$
T5, 50% (CM) + 50 % (CM) + B	3.23$_{a}$	49.63$_{a}$	17.88$_{cd}$	0.30$_{b}$
T6, 25% (RR) + 75 % (CM) + B	3.13$_{a}$	34.30$_{b}$	18.05$_{cd}$	1.13$_{b}$
T7, 100% (RR) + 5 tons/ha (FOF)+ B	3.07$_{a}$	49.77$_{a}$	19.25$_{cd}$	0.83$_{b}$
T8, 75% (RR) + 25 % (FOF) + B	3.00$_{a}$	49.25$_{a}$	16.25$_{d}$	0.57$_{b}$

Mean with the same letter are not significantly different at 5% level DMRT.

Some Soil Chemical Properties

Soil pH. Table 2 shows some of the chemical properties of soil as af-fected by the different treatments. There was an increase in soil pH in all treat ments applied with varied combination of organic and inorganic fertilizers except for treatment 4 and 5 compared with the initial value of 6.2.This might be due to lime like materials present in the manure such as calcium and magnesium. Result further shows that application of farmer's practice had the highest increase of the final pH of the soil to 6.67 which signifi-cantly differed from treatment 4, 5, and 6. On the other hand, treatment 4 and 5 lowered the pH of the soil.

Organic Matter Content of the Soil. Soil treated with 100% rec-ommended rate + 5 tons/ha formulated organic fertilizer + boron and farm-er's practice registered higher organic matter content of the soil at harvest compared to other treatments. The lowest mean (2.32%) was obtained from

plots treated with recommended rate + 5 tons/ha chicken manure.

Nitrogen Content of the Soil. The nitrogen content of the soil after harvest was significantly affected by the balanced fertilization treatments. The results further show an increase in the nitrogen content of the soil from the initial value of 0.11%. Application of 100% recommended rate + 5tons/ ha formulated organic fertilizer + boron gave the highest mean of nitrogen content of the soil which could be due to slow rate of mineralization in the soil where cabbage plants did not utilized much of the N content of the soil.

Phosphorous Content of the Soil. Significant differences on the fi-nal phosphorous contents of the soil were observed as affected by balanced fertilization treatments. An initial value of 286 ppm greatly decreased. This indicated that phosphorous utilization was enhanced by the increased of pH of the soil.

Table 2. Some Soil Chemical Properties

TREATMENT	SOIL pH	ORGANIC MATTER (%)	NITROGEN (%)	PHOSPHO-ROUS (ppm)
T1, farmer's practice	3.33$_{a}$	49.03$_{a}$	25.50$_{a}$	0.78$_{b}$
T2, 100% recommended rate (RR)	3.37$_{a}$	49.70$_{a}$	23.67$_{ab}$	3.00$_{a}$
T3, 75% (RR) + 25 % (CM)	3.13$_{a}$	48.23$_{ab}$	19.18$_{cd}$	3.09$_{a}$
T4, 25% (RR) + 75 % (CM)	3.23$_{a}$	46.83$_{ab}$	18.32$_{cd}$	0.40$_{b}$
T5, 50% (CM) + 50 % (CM) + B	3.23$_{a}$	49.63$_{a}$	17.88$_{cd}$	0.30$_{b}$
T6, 25% (RR) + 75 % (CM) + B	3.13$_{a}$	34.30$_{b}$	18.05$_{cd}$	1.13$_{b}$
T7, 100% (RR) + 5 tons/ha (FOF)+ B	3.07$_{a}$	49.77$_{a}$	19.25$_{cd}$	0.83$_{b}$
T8, 75% (RR) + 25 % (FOF) + B	3.00$_{a}$	49.25$_{a}$	16.25$_{d}$	0.57$_{b}$

Mean with the same letter are not significantly different at 5% level DMRT.

On Farm Trial

Agronomic Parameters

Average Head Solidity. Table 3 shows the agronomic parameters of cabbage planted in Paoay, Atok. The response of cabbage plants to different treatments of balanced fertilization in terms of average head solidity was observed. The result shows that no significant difference among the treated plants was observed. However, plants applied with 100% recommended rate + 5 tons/ha formulated organic fertilizer + boron produced loose puffy heads.

Average Head Circumference. The different treatments show no significant effect on the average head circumference. However, treated plants with recommended rate + 5 tons/ha chicken manure produced the largest cabbage head. The result further reveals that application of 75% rec-ommended rate + 25% chicken manure registered the lowest average head circumference.

Average Total Yield per Plot. Significant differences existed among the treatments as affected by the different treatments. Application of 25% recommended rate + 75% chicken manure + boron gave low yield per plot. This result confirmed the report of Kinoshita in 1972 that cabbage does not form hard head of good quality when N fertilizer is inadequate to meet its requirement. Furthermore, the result revealed that plants treated with 50% recommended rate + 50% chicken manure + boron produced the highest yield per plot however it is not significant from treatment 1, 2, 3, 7, and 8.

Soil Chemical Properties

Soil pH. Table 4 shows some chemical properties of soil planted with cabbage as affected by the different treatments. The soil pH after harvest was significantly affected by the different treatments. Application of 25% recommended rate + 75% chicken manure had the highest soil pH that could be the effect of unutilized organic matter whereas it served as buffer, making the soil to increase its value from the initial (5.80).

Organic Matter Content of the Soil. The organic matter content of the soil was not affected by the different treatments of balanced fertiliza-

tion for cabbage. However, application of 25% recommended rate + 75% chicken manure + boron greatly increased the organic matter content of the soil after harvest that could be due to low consumption of the plant for nitrogen as reflected by its low yield. On the other hand, recommended rate + 5 tons/ha chicken manure slightly increased the organic matter of the soil.

Nitrogen Content of the Soil. Soil treated with 25% recommended rate + 75% chicken manure + boron registered the highest nitrogen content of the soil and differed significantly from other treated soil. Application of rec-ommended rate + 5 tons/ha chicken manure had the lowest mean of nitrogen content but it slightly increased from the initial value of 0.09%. This result could be due to absorption by the plant of nitrogen for it s growth and development.

Phosphorous Content of the Soil. The phosphorous content of the soil was significantly affected by the different treatments. As can be seen from the result, there is a general decrease in the final P content of the soil. Apparently, the original P content was utilized by the plants even with added fertilization. Soil treated with 75% recommended rate + 25% chicken manure greatly increased the P content of the soil from the initial value of 286 ppm which differed significantly with all the other treatments.

Table 3. Agronomic Parameters of Cabbage

TREATMENT	HEAD SOLIDITY (g/cc)	HEAD CIRCUMFERENCE (cm)	TOTAL YIELD (kg)
T1, farmer's practice	4_{a}	45.33_{a}	25.99_{abc}
T2, 100% recommended rate (RR)	4^{a}	45.67_{a}	29.15_{ab}
T3, 75% (RR) + 25 % (CM)	4_{a}	42.00_{a}	22.03_{abc}
T4, 25% (RR) + 75 % (CM)	4_{a}	43.11_{a}	15.98_{bc}
T5, 50% (CM) + 50 % (CM) + B	4_{a}	43.00_{a}	34.32_{a}
T6, 25% (RR) + 75 % (CM) + B	4_{a}	45.00_{a}	12.54_{c}
T7, 100% (RR) + 5 tons/ha (FOF)+ B	4_{a}	44.00_{a}	27.06_{ab}
T8, 75% (RR) + 25 % (FOF) + B	4_{a}	42.11_{a}	22.77_{abc}

Means with the same letter are not significantly different at 5% level DMRT.

Table 4. Soil Chemical Properties Planted with Cabbage

TREATMENT	SOIL pH	ORGANIC MATTER (%)	NITROGEN (%)	PHOSPHO-ROUS (ppm)
T1, farmer's practice	5.93$_{b}$	3.07$_{b}$	0.15$_{b}$	109.60$_{b}$
T2, 100% recommended rate (RR)	5.82$_{d}$	2.01$_{bc}$	0.10$_{bc}$	12.65$_{d}$
T3, 75% (RR) + 25 % (CM)	5.90$_{bc}$	2.57$_{bc}$	0.13$_{bc}$	584.60$_{a}$
T4, 25% (RR) + 75 % (CM)	6.03$_{a}$	2.75$_{bc}$	0.14$_{bc}$	8.35$_{d}$
T5, 50% (CM) + 50 % (CM) + B	5.91$_{bc}$	2.92$_{bc}$	0.15$_{b}$	9.20$_{d}$
T6, 25% (RR) + 75 % (CM) + B	5.83$_{d}$	4.55$_{a}$	0.23$_{a}$	11.30$_{d}$
T7, 100% (RR) + 5 tons/ha (FOF)+ B	5.86$_{cd}$	2.49$_{bc}$	0.12$_{bc}$	8.80$_{d}$
T8, 75% (RR) + 25 % (FOF) + B	5.90$_{bc}$	2.56$_{bc}$	0.13$_{bc}$	7.50$_{d}$
Initial Value	**5.80**	**1.89**	**0.09**	**286.00**

Mean with the same letter are not significantly different at 5% level DMRT.

SUMMARY, CONCLUSION AND RECOMMENDATION Summary

Balanced fertilization for cabbage was conducted at the Soil Science Experimental Area, College of Agriculture, Benguet State University, La Trinidad, Benguet for the on station trial from December, 2006 to March, 2006. An on farm trial was conducted at Paoay, Atok, Benguet from February, 2006 to June 2006. The study aimed to determine the balanced fertilization strategy for cabbage from the two areas.

Application of farmer's practice registered the highest yield and was determined to be the best treatment in terms of yield. The lowest yield was obtained from plants treated with 75% recommended rate + 25% formu-lated organic fertilizer + boron.

There was a significant increase on the value of pH from the initial

value as compared to the final pH values obtained from the plots treated with 50% recommended rate + 50% chicken manure + boron and 75% rec-ommended rate + 25% formulated organic fertilizer + boron.

Application of the different treatments of balanced fertilization significantly affected the final organic matter and nitrogen content of the soil. The highest final organic matter and nitrogen content of the soil was obtained from the application of 100% recommended rate + 5 tons/ha formulated organic fertilizer + boron. Application of farmer's practice registered the lowest organic matter and nitrogen content of the soil that could be utilized by the plants.

Lastly, the final phosphorous content of the soil was affected by the treatments of balanced fertilization showing depletion of phosphorous in the soil. Results further show that application of 75% recommended rate + 25% formulated organic fertilizer + boron and farmer's practice greatly decreased the P content as affected by high pH value.

Second Trial (On Farm Trial)

Based on the findings, no significant difference was recorded on the average head solidity and circumference of cabbage. However, the total yield was significantly affected by the treatments where application of 50% recommended rate + 50% chicken manure + boron registered higher total yield per plot.

A significant increased on the value of pH from the initial value was observed. Results further show that application of 25% recommended rate + 75% chicken manure had the highest soil pH that favored plant growth.

A significant increase of the final organic matter and nitrogen content of the soil was observed among the treatments. Soil treated with 25% recommended rate + 75% chicken manure + boron registered the highest organic matter and nitrogen content of the soil. In contrast with the applica-tion of recommended rate + 5 tons/ha chicken manure, low organic matter and nitrogen content was retained.

Lastly, the phosphorous content of the different treated soil significantly decreased from the initial value except from the application of

75% recommended rate + 25% chicken manure where great increase on the phosphorous content was obtained.

Conclusion

The results of the study in the first trial have shown that among the treatments of balanced fertilization, treatment 1 (farmer's practice) and treatment 2 (recommended rate + 5 tons/ha chicken manure) had higher cabbage yield. However, farmer's practice had good effect on the soil condition where soil pH, organic matter and nitrogen content of the soil had higher increase that could be utilized by the next cropping. For phosphorous content of the soil, farmer's practice still retained higher amount in the soil although, it decreased from the initial value.

In the on farm trial, application of 50% recommended rate + 50% chicken manure + boron produced the highest yield but not significantly dif-ferent from farmer's practice. The lowest yield was obtained from treated plants with 25% recommended rate + boron.

The application of different treatments significantly increases the soil pH, organic matter and nitrogen content of the soil from the initial value. Furthermore, application of 25% recommended rate + 75% chicken manure had the highest soil pH value that significantly differed from farmer's prac-tice. For the organic matter and nitrogen content, application of 25% recom-mended rate + 75% chicken manure + boron registered the highest amount retained in the soil and was significantly different from farmer's practice. On the other hand, there was decreased on the phosphorous content of the soil among the treatments except for treatment 3 (75% recommended rate + 25% chicken manure).

Recommendation

Based on the result of this study, fertilizer rate of 250-100-100 kg NPK/ha + 7 tons/ha chicken manure is recommended for cabbage production under La Trinidad condition or similar areas.

Under Paoay, Atok condition, application of 50% recommended rate + 50% chicken manure + boron is recommended to substitute farmer's practice of applying 250-100-100 kg NPK/ha + 7 tons/ha chicken manure.

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