EFFECT OF AZOLLA AS SOURCE OF NITROGEN ON THE GROWTH AND YIELD OF PECHAY (*Brassica napus* L. var. *chinensis*)

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Portion of BS thesis conducted by the senior author at ViSCA.

ABSTRACT

Plants applied with either azolla or inorganic fertilizer performed better than the unfertilized ones. Increasing the rate of azolla application from 120 to 210 kg N/ha correspondingly increased all the parameters measured and the net income during the first cropping. However in the second cropping, all the parameters considered and the net income tremendously decreased. Highest yield and net return in both croppings were obtained from application of 210 kg N/ha from azolla while the unfertilized control showed the lowest values.

Application of the same amounts of nitrogen (165 kg N/ha) from azolla (T_3) and inorganic fertilizer (T_1) did not produce significant differences in all parameters during the first cropping. However during the second cropping, T_3 but not T_1 produced higher average weight per plant and yield than the control.

The soil pH and organic matter, phosphorus and potassium contents increased as the rate of azolla application was raised from 120 kg to 210 kg N/ha.

Ann Trop. Res. 10:85-93

KEY WORDS: Azolla. Pechay. Nitrogen. Organic fertilizer.

INTRODUCTION

Nowadays, inorganic fertilizers are so expensive that their use has become a prohibitive factor in successful crop farming. This necessitates an urgent search for alternative sources of cheap fertilizer materials for agriculture. Azolla, a cryptogamic free floating fern which thrives in ponds, ditches and paddy fields in warm temperate and tropical regions, is a promising

alternative to commercial fertilizer because it is inexpensive and locally available. Its economic importance arises from its capability to fix free atmospheric nitrogen through a strain of blue-green algae, ***Anabaena azollae,*** which is associated only with it and lives symbiotically in it. The amount of nitrogen fixed is about 4-5% dry weight basis, and 0.2 to 0.3% fresh weight basis (Khan, 1983). Moreover with azolla as fertilizer material, early utilization of nitrogen by the plant is possible since N from azolla starts to be mineralized 2 days after its incorporation into the soil (Shi et al., 1980).

Several studies were conducted to determine the effect of azolla on rice, especially lowland rice. Increase in yield was observed in azolla treated plots (Dilag, 1981; Liu, 1979 as cited by Khan (1983); Singh, 1979). Likewise, improvement of some soil properties was also noted (Khan, 1983). However, information on its utilization as organic fertilizer for upland crops is limited, hence this study was conducted.

This investigation presents the effect of azolla as organic fertilizer on the growth and yield of pechay, and on some soil chemical properties; and the comparison of economic returns using azolla and inorganic fertilizer.

MATERIALS AND METHODS

Seedling Preparation

Seed boxes were filled with equal parts of sand, compost and garden soil. Then pechay seeds (var. Black behi) were sown thinly in rows 7-8 cm apart and watered regularly.

When the first pair of true leaves appeared, the seedlings were pricked individually and transferred to the seedbed to enhance seedling development. A week before transplanting, the seedlings were hardened by gradually exposing them to the sun and reducing water supply.

Experimental Design and Field Layout

An area of 232.75 m^2 was plowed and harrowed twice at weekly intervals. After the last harrowing, the experiment was laid out in a randomized complete block design (RCBD) with three replications, each occupying an area of 7.5 x 9.5 m. Plot size was 1.5 x 7.5 m. The different treatments used were as follows:

T_0 – control (without fertilizer)
T_1 – 165-45-45 kg N, P_2O_5, K_2O/ha (inorganic fertilizer)
T_2 – 120 kg N/ha (48,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha
T_3 – 165 kg N/ha (66,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha
T_4 – 210 kg N/ha (84,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha

The rate of inorganic fertilizer applied was based on the average of the recommended fertilizer rates for pechay which ranged from 90-210, 30-60 and 30-60 kg N, P_2O_5 and K_2O, respectively per hectare (PCARR, 1975). On the other hand, the quantity of azolla applied was based on the average of its nitrogen

content which ranges from 0.2 to 0.3% of its fresh weight (Khan, 1983).

Soil Sampling and Analysis

Soil samplings were done before the application of azolla and after the harvest of the second cropping. Soil samples were brought to the Department of Agronomy and Soil Science for analysis of pH and organic matter, phosphorus and potassium contents.

Cultural Management

Fresh azolla was applied 5 days before transplanting following the specified recommended rate. The required amount of azolla was uniformly spread and incorporated 15-20 cm deep into the soil. One half of nitrogen for T_1 and whole amount of phosphorus and potassium for all the inorganic fertilizer treatments (except for T_0) were broadcast on the plots at planting and covered with fine soil to prevent contact of seedlings with the fertilizer. The remaining half of nitrogen was applied around the plants 13 days after transplanting.

A drainage canal was constructed around the area to prevent water logging during heavy rains. Handweeding and cultivation were simultaneously done 10 days after transplanting and were repeated 10 days before harvesting to check weed growth, and improve aeration and waterholding capacity of the soil. Malathion and Benlate were alternately sprayed at the manufacturer's recommended rate when signs and symptoms of pest attack were observed.

Harvesting was done when the plants had 7-10 large expanded leaves, i.e. at about 25-28 days after transplanting. The second crop was planted 2 weeks after harvesting the first crop. The same procedure was followed as in the first cropping except that organic and inorganic fertilizer application was eliminated.

RESULTS AND DISCUSSION

Effect of Azolla on the Growth and Yield of Pechay

The average number of leaves per plant at harvest, total number of leaves produced from transplanting to harvest, average weight per plant and yield of pechay were significantly affected by the rate of azolla application in both the first and second croppings (Table 1). Increasing the rate of azolla application from 120 to 210 kg N/ha resulted in a corresponding increase in all the parameters measured.

During the first cropping, the effect of 120 and 165 kg N/ha from azolla on the average number of leaves at harvest was almost similar to that of inorganic fertilizer. The total number of leaves produced from transplanting to harvest in plants applied with azolla at any rate was comparable to that of inorganic fertilizer treated plants. The response of the plants to T_3 (165 kg N/ha from azolla + 45 kg P_2O_5/ha + 45 kg K_2O/ha) was similar to that of T_1 (165-45-45 kg N, P_2O_5, K_2O/ha inorganic fertilizer). It is probably because the estimated nitrogen in the azolla used in T_3 was equal to the amount of nitrogen in the inorganic

Table 1. Effect of different rates of azolla and inorganic fertilizer application on the growth and yield of pechay.[1]

Treatment	Ave. No. of Leaves per Plant at Harvest		Total No. of Leaves Produced from Transplanting to Harvest		Average Weight per Plant (g)		Yield (tons/ha)	
	Cropping		Cropping		Cropping		Cropping	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
T_0 – control (without fertilizer)	6.68d	7.29b	9.39c	10.37d	35.17d	31.91c	5.86d	5.32c
T_1 – 165-45-45 kg N, P_2O_5, K_2O/ha (inorganic fertilizer)	9.30bc	7.68b	11.40ab	10.95c	117.61ab	36.76bc	19.60ab	6.13bc
T_2 – 120 kg N/ha (48,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	9.04c	7.82b	10.99b	11.20bc	70.81c	38.33bc	11.79c	6.39bc
T_3 – 165 kg N/ha (66,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	10.11ab	8.04b	12.15a	11.55b	110.94b	43.44b	18.43b	7.24b
T_4 – 210 kg N/ha (84,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	10.35a	9.01a	12.39a	12.16a	144.92a	56.35a	24.15a	9.39a
C.V. (%)	4.98	6.23	5.10	2.66	17.83	10.38	17.83	10.42

[1] In a column, means followed by a common letter are not significantly different at 5% level, DMRT.

fertilizer used in T_1. This strongly indicates that the nitrogen content of the former which was organic in form started to mineralize a few days after incorporation. Otherwise, the growth of the plants could have been hampered during the early growth stage. This observation corroborates with the report of Shi et al. (1980) that azolla starts to mineralize a few days after incorporation into the soil.

Table 1 shows that T_4 (210 kg N/ha from azolla + 45 kg P_2O_5/ha + 45 kg K_2O/ha) obtained the highest values in all the parameters measured. However in terms of yield, average weight per plant and total number of leaves; no significant differences existed between T_4 and T_1 during the first cropping.

Except in the control plots, the growth and yield of pechay tremendously decreased ruing the second cropping. In the fertilized plots, the weight per plant and yield per hectare during the first cropping were about 2-3 times heavier and higher than the second cropping. Furthermore, the number of leaves per plant at harvest, average weight per plant at harvest and yield of T_1 and T_2 were just comparable to T_0 (control). However, T_4 was significantly better than the other treatments. The estimated nitrogen of T_4 was higher than that in the inorganic fertilizer treatment, hence it provided more residual nitrogen to the crop during the second cropping.

The considerable decrease in yield and other parameters measured during the second cropping could be attributed to the removal of more nutrients by the first crop and leaching of soil nutrients especially nitrogen, through percolation and run-off during heavy rains which occurred during the experimental period. The occurrence of heavy rains also causes crust formation and ultimate soil compaction which can adversely affect nutrient uptake of the plants because of possible root impedance and poor root aeration. The relatively poor crop performance could be partly attributed to possible reduction in photosynthetic activity of the plant also due to heavy rains and cloudy days. During these periods, temperature and light were limiting.

It is interesting to note that the application of the same amount of nitrogen from azolla (T_3) and inorganic fertilizer (T_1) produced no significant differences in all parameters measured during the first cropping, and both treatments were significantly better than the control. This observation supports the findings of Watanabe (1981 as cited by Khan, 1983) that the use of azolla as fertilizer in rice production gave as good or better results than the equivalent chemical nitrogen fertilizer. Current findings conclusively show that azolla can be a good substitute for commercial fertilizer as source of nitrogen, and has an added advantage since it has longer residual effect aside from increasing nutrient availability; improving structure, aeration and water holding capacity of the soil (Brady, 1974). Inorganic fertilizer is readily dissolved and leached and hence easily lost from the soil whereas organic ones, specifically azolla, gradually release their nutrients

thus provide a continuous supply of nutrients throughout the growing period of the plant.

Effect of Azolla on Soil Chemical Properties

Table 2 presents the initial and final soil pH, and organic matter, phosphorus and potassium contents of the soil. Soil analysis revealed an increase in all the above soil parameters after the second cropping of pechay.

Soil pH increased from 6.0 to 6.5. This can be attributed to the cations released after decomposition of organic materials since organic matter serves as storage of exchangeable cations in the soil (Donahue et al., 1977). However, the slight increase in pH in the control could be ascribed to the heavy rains which caused dilution of the salts accumulated by natural weathering bringing them to the soil surface in the same way that alkaline minerals are raised when evaporation exceeds precipitation (Saigo and Saigo, 1983). On the other hand, the percent organic matter tended to increase as

Table 2. Soil chemical properties as affected by azolla and inorganic fertilizer application.

Treatment	pH	% OM	Available P (ppm)	Extractable K (ppm)
Initial Determination				
Composite sample	6.00	1.29	9.37	201
Final Determination (after second cropping)				
T_0 – control (without fertilizer application)	6.43	1.38	10.87	279
T_1 – 165-45-45 kg N, P_2O_5, K_2O/ ha (inorganic fertilizer)	6.40	1.58	10.94	248
T_2 – 120 kg N/ha (48,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	6.50	1.64	11.39	286
T_3 – 165 kg N/ha (66,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	6.48	1.78	12.32	295
T_4 – 210 kg N/ha (84,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	6.45	1.96	12.75	305

the rate of azolla applied was increased. This could be attributed to the established fact that the soil organic matter content is directly influenced by the amount of organic materials added to the soil.

Likewise, the phosphorus and potassium contents of the soil increased with azolla application, with T_4 giving the highest phosphorus and potassium concentrations. Phosphorus and potassium elements are some of the products of organic matter decomposition hence, their increase.

Finally, the effect of azolla application on the above mentioned soil parameters is generally better than that of inorganic fertilizer application.

Cost and Return Analysis

The cost and return analysis of pechay production under the various treatments studied is presented in Table 3.

During the first cropping; the gross income, expenses and net income increased as the rate of azolla application was raised from 120 to 210 kg N/ha. The increase in expenses was due to the additional cost of labor and materials. The highest rate of azolla application (T_4) incurred the highest production cost but it still came out to be the most profitable treatment. This was followed by the inorganic fertilizer treatment at the rate of 165-45-45 kg N, P_2O_5, K_2O/ha (T_1). The unfertilized plants obtained the lowest net return.

Regardless of the treatments, the net income obtained during the second cropping considerably decreased. The net income from the inorganic fertilizer treated plants was relatively low and ranked fourth among the treatments. However, the combined net income of inorganic fertilizer treated plants ranked next to T_4. This could be explained by the relatively higher yield and net income of the inorganic fertilizer treated plants during the first cropping.

CONCLUSIONS AND RECOMMENDATION

Azolla application promoted vigorous growth and higher yield of pechay hence, azolla is a potential substitute for inorganic nitrogen fertilizer in pechay production. Moreover, it improved the soil chemical and physical properties. Thus, it is recommended that the long term effect of azolla application on the soil properties should be investigated to monitor its residual effects.

Table 3. Cost and return analysis of pechay production using azolla and inorganic fertilizer.

Treatment	First Cropping				Second Cropping				Total Net Income (₱)
	Yield (t/ha)	Gross[1] Income (₱)	Expenses (₱)	Net Income (₱)	Yield (t/ha)	Gross[1] Income (₱)	Expenses (₱)	Net Income (₱)	
T_0 – control (without fertilizer application)	5.86	23,440.00	8,166.00	15,274.00	5.32	21,280.00	6,396.80	14,883.20	30,157.20
T_1 – 165-45-45 kg N, P_2O_5, K_2O/ha (inorganic fertilizer)	19.60	78,400.00	11,984.00	66,416.00	6.13	24,520.00	6,396.80	18,124.00	84,540.00
T_2 – 120 kg N/ha (48,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	11.79	47,160.00	11,763.50	35,396.50	6.39	25,560.00	6,396.80	19,163.20	54,559.70
T_3 – 165 kg N/ha (66,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	18.43	73,720.00	12,678.00	61,042.00	7.24	28,960.00	6,396.80	22,563.20	83,605.20
T_4 – 210 kg N/ha (84,000 kg fresh azolla/ha) + 45 kg P_2O_5/ha + 45 kg K_2O/ha	24.15	96,600.00	13,593.50	83,006.50	9.39	37,560.00	6,396.80	31,163.20	114,169.70

[1] Computed by multiplying yield by ₱4.00/kg (current market price of pechay).

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