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Impact of organic manures on growth, yield and quality of pak-choi (*Brassica rapa* var. *chinensis*)

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Abstract
The research was conducted at Student's Research Farm of Department of Agriculture, Khalsa College, Amritsar to study the impact of organic manures on growth, yield and quality of Pak-choi (*Brassica rapa* var. *chinensis*). Eleven treatments were evaluated in randomized block design with three replications. Among various treatments T_{10} (100% Recommended Dose of Fertilizers (RDF)) proved to be significant over rest of the treatments as it registered maximum growth parameters. It was followed by T_5 (100% Nitrogen by poultry manure + azotobacter). Among the organic manures, T_5 (100% Nitrogen by poultry manure + azotobacter) proved to be beneficial than other treatments, as it improved the growth and yield of pak-choi under Punjab conditions.

Keywords: pak-choi, RDF, poultry manure, azotobacter, growth, yield

Introduction
Pak-choi is a type of Chinese cabbage (*Brassica rapa* or *Brassica campestris*) of the *chinensis* group, called *Brassica chinensis.* It is a loose leaf, non-heading type of Chinese cabbage with thick white leaf stalks with green leaves that form in cluster (Stephens 2015) [1]. It is a cool-season leafy vegetable belongs to the brassicaceae (cabbage and cauliflower) family with chromosome number 2n=20. It was originated in China and has been cultivated for thousands of year (Tay and Toxopeus 1984) [2].

At present, soil management practices have recently changed dramatically including an increased use in synthetic fertilizers and pesticides to help crop yields. However, some studies have suggested that the excessive use of these agrochemicals may actually increase pest problems in the long run (Altieri and Nicholls 2003) [3]. Organic manures are considered helpful in improving the physical and nutritional status of the soil and also enhance the activity of soil microflora. They also add considerable amount of major nutrients in the soil besides improving the soil properties. Further, decomposition of organics in the soil leads to different types of biological reactions which are helpful in preventing various diseases causing pathogens (Ramesh *et al.* 2010) [4].

A remarkable effect on the physiological attributes after the incorporation of organic nutrients especially in the form of vermicompost, FYM, poultry manure and biofertilizers has been noticed. Apparantly, inorganic fertilizers impair the crop health due to residual effect but such kinds of issues are not evident in case of organic fertilizer (Tindal 2000) [5].

Biofertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of vegetable produce. Further, they also increase the productivity of the soil and control many harmful pathogens and microorganisms (Asokan *et al*. 2000) [6]. Commonly used biofertilizer is azotobacter, a free living bacteria, whose inoculation saves nitrogenous fertilizer by 10 to 20% (Verma *et al.* 1997) [7].

Organic farming of another *Brassica* spp. was successfully done. A considerable scientific data have been generated, which shows that combined and sole application of organic amendments and biofertilizers increased yield, influenced quality attributes and soil health in several vegetables (Worthington 2001) [8]. However, information on the effect of different organic manures on performance of Pak-choi is lacking. Keeping these points in view, the present investigation entitled "Impact of organic manures on growth, yield and quality of Pak-choi (*Brassica rapa* var. *chinensis*)" was carried out.

Material and Methods

The present investigation on "Impact of organic manures on growth, yield and quality of Pak-choi (*Brassica rapa* var. *chinensis*)" was carried out in an experimental field of Department of Agriculture, Khalsa College, Amritsar during 2019-2020. Seedlings of the cultivar of pak-choi were procured from Centre of Excellence for Vegetables, Kartarpur. The seeds of cultivar sown in the plastic plug trays by using cocopeat, perlite and vermiculite in ratio 3:1:1 respectively inside the automatic ventilated polyhouse to get healthy and disease free seedlings of pak-choi. The experiment was laid out in Randomised Block Design (RBD) comprising of 11 treatments replicated thrice.

Treatment of pak-choi plants with different combinations of organic manures has been done in this experiment. Total 11 treatments *viz;* T_1 (100% N by vermicompost), T_2 (100% N by poultry manure), T_3 (100% N by FYM), T_4 (100% N by vermicompost + azotobactor),T_5 (100% N by poultry manure + azotobactor), T_6 (100% N by FYM + azotobactor), T_7 (75% N by vermicompost + azotobactor), T_8 (75% N by poultry manure + azotobactor), T_9 (75% N by FYM + azotobactor), T_{10} (100% RDF), T_{11} (Control). The land was brought to a fine tilth by repeated ploughing and harrowing. All the weeds and stubbles of previous crop removed from the field completely. Application of manures and fertilizers were applied as per treatment. Seedlings were inoculated in *azotobacter* solution @ 4-5 ml/ litre of water. The solution was dissolved in water and seedlings of pak-choi were dipped in the solution for 30 minutes before transplanting. Healthy and uniform seedlings were transplanted on ridges at a spacing of 45 cm between rows and 30 cm between plants. Transplanting was done in evening hours. The observations were recorded on five plants taken randomly for the characters *viz;* plant height (cm), leaf length (cm), leaf thickness (mm), leaf area (cm^2), number of leaves, weight per plant (g), yield per plot (Kg), total yield (q/ha), ascorbic acid (mg/100 g), moisture content (%), dry matter (%). The pertaining to the present investigation were statistically analysed using the standard procedures of the Randomised Block Design (RBD). The treatments effects were tested at 5% level of significance.

Results and Discussions

The organic manures had a significant effect on growth, yield and quality of pak-choi. Table 1 depicted that the plants under treatment T_{10} showed maximum plant height, leaf length, leaf area and number of leaves. The enhancement of plant height with higher application of inorganic may be due to the direct effect of higher amount of inorganic nitrogen, which is an integral part of protein and chlorophyll molecules which might have increased the foliage of the plant and thereby enhanced the photosynthesis. These results are in agreement with the findings of Hasan and Solaiman (2012) [9] in cabbage. The maximum leaf length and number of leaves with application of inorganic nutrient may be due to the direct availability of adequate supply of the three major nutrients *viz.* NPK which resulted in an increase in vegetative growth of pak-choi. The results are in congruence with findings of Kiran *et al.* (2016) [10] in radish. Maximum leaf area might be due the fact that quick supply of nutrients leads to increased growth and higher the expansion of leaves which leads to increased leaf area. Higher the leaf length correlates with maximum leaf area. The results are in line with findings of Arshpreet (2020) [11] in cabbage. No significant variation was observed for leaf thickness with application of different organic manures.

Yield attributing parameters like weight per plant, yield per plot and total yield were maximum under treatment T_{10}. The application of 100% RDF favoured the metabolic and auxin activities in plant, helped in the expansion of leaf area, increased plant height, leaf length, number of leaves and chlorophyll content which together might have accelerated the photosynthetic rates and in turn increased the supply of carbohydrates to plants and ultimately resulted in increasing all the yield attributes. The results of Islam *et al.* (2020) [12] in knol-khol are in the conformity with the results of present study.

The highest value for ascorbic acid was observed in treatment T_5. There is general observation that organically managed crop have usually higher ascorbic acid content than the conventionally fertilized crops because when the plant is exposed to more nitrogen, it increases protein production and reduces carbohydrates synthesis. Since ascorbic acid is made from carbohydrate, hence the synthesis of ascorbic acid might have reduced. Results are in congruence with findings of Shree *et al.* (2014) [13] in cauliflower. Maximum values for moisture content and dry matter were recorded under treatment T_{10}. Results for moisture content corroborates with findings of Kumar *et al.* (2015) [14]. Higher value for dry matter % might be due to availability of significant amount of nutrients by process of mineralization at constant level that gave higher dry matter because of increased growth parameters *i.e.* plant height, leaf number and leaf area etc. The results corroborate with findings of Chaudhary (2005) [15].

Table 1: Impact of organic manures on growth, yield and quality of Pak-choi

Treatments	Plant height (cm)	Leaf length (cm)	Leaf thickness (mm)	Leaf area (cm^2)	Number of leaves	Weight per plant(g)	Yield per plot (Kg)	Total yield (q/ha)	Ascorbic acid (mg/100 g)	Moisture content (%)	Dry matter (%)
T1	26.82	12.53	0.31	215.66	13.09	148.94	6.88	110.11	33.67	90.61	5.57
T2	27.43	13.05	0.35	217.85	13.49	156.54	7.21	115.12	33.82	90.97	5.70
T3	26.30	11.97	0.31	211.93	12.59	146.90	6.70	107.22	32.52	90.13	5.53
T4	27.58	13.78	0.36	222.45	14.03	158.05	7.27	116.30	31.57	91.14	6.02
T5	29.80	14.71	0.38	224.65	14.78	160.08	7.35	117.51	35.22	91.54	6.53
T6	26.47	11.78	0.30	210.45	12.24	141.46	6.57	105.03	32.39	89.89	5.37
T7	25.91	11.48	0.28	208.86	11.89	137.76	6.35	101.65	32.29	89.69	5.30
T8	25.46	11.10	0.27	208.28	11.60	126.42	5.83	93.18	32.32	89.70	5.25
T9	25.33	10.84	0.24	207.11	11.17	124.92	5.73	91.53	31.68	89.59	5.20
T10	30.31	16.01	0.40	238.70	16.44	168.84	7.80	124.55	31.49	92.96	6.91
T11	24.50	6.57	0.22	198.60	6.78	116.99	5.38	86.38	29.26	89.52	3.20
CD (5%)	1.93	1.57	NS	13.11	1.69	4.46	0.62	2.05	1.47	1.67	0.67

Conclusion

The plant characteristics in terms of plant height, leaf length, leaf area, number of leaves and yield characteristics *viz.* weight per plant, yield per plot, total yield recorded maximum values when plants were treated with T_{10} (100% RDF). T_5 (100% N by poultry manure + azotobacter) was at par with T_{10} (100% RDF).

The maximum values for quality characteristics were obtained by application of (100% RDF) *viz.* dry matter and moisture content except for ascorbic acid which was recorded highest in T_5 (100% N by poultry manure + azotobacter).

The total yield obtained by application of T_5 (100% N by poultry manure + azotobacter) *i.e.* 117.51 q/ha nearly 7-8 q/ha less as obtained by 100% RDF *i.e.* 124.54 q/ha. Moreover, organically raised crop with biofertilizers combination was found to solve the purpose in both ways one being changing the trend of using inorganic fertilizers towards organic manures as manures improve and maintain the soil health second being, getting higher yields and quality. So, it was concluded that among organic manures application of 100% N by poultry manure + azotobacter was witnessed to be the best for growth of vegetative and quality parameters of pak-choi under Punjab conditions.

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