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Impact of various organic manures on yield, yield attributes and economics of cabbage (*Brassica oleracea var. capitata* L.)

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Abstract
An investigation was conducted during *Rabi* 2017-2018 at Student's research farm, Khalsa College Amritsar (Punjab) in Randomized block design having three replications comprising of eleven treatments *viz* T_1- Recommended dose of fertilizers (RDF), T_2-100% N by Vermicompost, T_3- 100% N by Poultry manure, T_4- 100% N by Farmyard manure, T_5- 100% N by Vermicompost + Azotobacter, T_6- 100% N by Poultry manure + Azotobacter, T_7- 100% N by Farmyard manure + Azotobacter, T_8- 75% N by Vermicompost + Azotobacter, T_9- 75% N by Poultry manure + Azotobacter, T_{10}- 75% N by Farmyard manure + Azotobacter, T_{11}- Control. The crop was sown at spacing 45×45 cm and other plant protection measures were followed as recommended by PAU, Ludhiana. The results of the investigation suggested that application of RDF was superior over rest of the treatments in terms of yield and yield attributing characters. % increase in yield for T_1 and T_6 was 77.05% and 70% respectively for over control. % increase in B:C ratio for T_1 and T_6 was 105.70% and 98.96% respectively for over control. Treatments comprising of poultry manure alone or in combination with Azotobacter proved to be beneficial than Vermicompost or Farmyard manure alone or in combination with Azotobacter , as it improved yield attributes as well as yield of cabbage and also gave maximum return as compared to other treatments. Among organic manure treatments T_6 (4 tonnes/ha poultry manure+Azotobacter) was found to be more economical as it serves dual purpose –minimizing inorganic fertilizers and second getting higher returns with higher B:C ratio (4.84).

Keywords: Cabbage, B:C ratio, biofertilizer, organic manures, yield

Introduction
Cabbage (*Brassica oleracea var. capitata* L.) a member of family *Cruciferae* and genus *Brassica* and is a leafy vegetable, which is widely cultivated throughout the globe , which is consumed fresh as well as in processed form in different countries of the world (Haque *et al.*, 2015) [10]. The Food and Agriculture organization has identified cabbage among one of the top twenty vegetables (Olaniyi J O and Akanbi W B, 2008) [19]. In India the area under cabbage cultivation is around 4 lac hectare with 9039000 MT production (Anonymous, 2014a) [2]. Punjab produces 87.19 thousand tonnes from an area of 4.95 thousand ha with an average yield of 17.61 thousand MT/ha (Anonymous, 2014b) [3]. Major cabbage producing districts include Amritsar, Patiala, Jalandhar and Ludhiana. The climatic conditions of Punjab are suitable for cabbage for getting higher yield.

Nutrient management plays a crucial role for the improvement of cabbage yield and production. A remarkable effect on the physiological attributes after the incorporation of organic nutrients especially in the form of vermicompost, farmyard manure, poultry manure and biofertilizer has been noticed in various vegetables. Apparently, inorganic fertilizers impair the crop health due to of residual effect but such kinds of issues are not evident in case of organic fertilizer (Tindal 2000) [21]. The farmers supplement chemical fertilizer as a readily available source for nutrients but they do not apply it in balanced proportion (BARC, 2005) [5]. Despite of the balanced use of sole chemical fertilizer, high yield level could not be attained over years due to deterioration in soil physical, chemical and biological properties (Khan *et al* 2008) [16]. However, some studies have suggested that excessive use of those agrochemicals may actually aggravate pest problem in the long run (Altieri and Nocholls, 2003) [1]. There is a need to minimize the consumption of inorganic fertilizers in agriculture. Thus, strategy of nutrient management is very important in recent days considering the harmful effects of indiscriminate use of chemical fertilizer. Keeping these aspects, the present investigation was planned to find out a suitable alternative of inorganic fertilizers.

Materials and Methods

The field experiment was conducted at an experimental farm area of Department of Horticulture, Khalsa College, Amritsar during 2017-18 located 31º-38´ N latitude and 74 º-52´ E longitude with an elevation of 236 m MSL and represents the sub-tropical climate and humid zone of Punjab region in order to work influence of various source of organic manures for obtaining higher head yield of cabbage. The soil of an experimental plot was sandy loam in texture with pH 8.40, organic carbon (0.40-0.75%), medium in available N (0.28%), available P (16 kg/ha) and available K (175 kg/ha). The experiment was laid in a randomized block design with three replications having 11 treatments comprising different combinations of organic sources and Azotobacter *viz*. 125:62.5:62.5 NPK per hectare through RDF (T_1), 8 tonnes/ha of N through vermicompost (T_2), 4 tonnes/ha of N through poultry manure (T_3), 25 tonnes/ha of N through farmyard manure (T_4), 8 tonnes/ha of N through vermicompost + Azotobacter (T_5), 4 tonnes/ha of N through poultry manure + Azotobacter (T_6), 25 tonnes/ha of N through farmyard manure + Azotobacter (T_7), 6 tonnes/ha of N through vermicompost + Azotobacter (T_8), 3 tonnes/ha of N through poultry manure + Azotobacter (T_9) and 18 tonnes/ha of N through farmyard manure (T_{10}) and control (T_{11}). Cabbage seedling roots were inoculated with *Azotobacter* solution @ 4-5 ml per litre of water. The solution was dissolved in water and the seedlings of cabbage were dipped in the solution for 30 minutes before transplanting. Cabbage (Golden Acre) was transplanted at 45 × 45 cm spacing don 1st of October and harvested at fully matured stage. Selected and tagged plants were left in the field for head production during winter. All other cultural practices were followed as per standard recommendations.

The economics of different cultural practices, input and returns for cabbage variety Golden Acre under each treatment combination was worked out to find the most effective and economical treatment. The benefit:cost ratio was calculated with the help of following formula:

B: C ratio=Gross return÷ Total cost of cultivation

The data were analyzed as per the standard procedure for Analysis of Variance (ANOVA). The difference in the treatment mean was tested by using critical difference (CD) at 5% level of probability.

Result and Discussion

Yield and yield attributes

Head yield is the economic part of the crop, which mirrors the resultant effect of all factors that are influenced by different treatments. Data from Table 1 represents that maximum marketable head yield (30.10 t/ha) was obtained with application of T_1 (RDF) which was statistically similar to the yield obtained with application of T_3 (100% N by PM), T_5 (100% N by VC+AZB), T_6 (100% N by PM+AZB) and T_9 (75% N by VC+AZB). On the other hand, the lowest marketable head yield (17.00 t/ha) was obtained with control treatment (T_{11}). The results were in line with that pointed out by Hasan and Solaiman (2012) [12], Hsieh (2004) [13], Chan *et al.,* (2008) [6], Ijoyah and Sophie (2009) [14]. Kumar *et al.,* (2015) [17] also concluded similar results in their experiment on effect of organic manures and biofertilizers on cabbage. The data from Table 1 reveal that significant variation was observed in head length of cabbage due to application of different treatments comprising of organic manures. Maximum head length of 13.6 cm was recorded in T_1 (RDF) which was statistically at par with T_5 (8t/ha vermicompost + Azotobacter) and T_6 (4t/ha poultry manure + Azotobacter. However, the lowest head length i.e. 10.5 cm was recorded in control treatment (T_{11}). Similar results were also concluded by Moyin-jesu (2015) [18] in their study regarding use of different organic fertilizers in cabbage. Higher head length in T_1 i.e. RDF can be attributed to the rapid availability of nutrients by inorganic sources which promoted rapid growth, increased leaf size and quality. The results summarized above in respect to head length are closely in consonance with findings reported earlier by Parmar *et al.,* (2009) [20] and Jha *et al.,* (2017) [15].

Table 1 describe that the highest value for head diameter of cabbage i.e. 13.7 cm was obtained in T_1 (Recommended practice) which remained statistically similar to with T_3 (4 t/ha poultry manure alone), T_5 (8t/ha vermicompost + Azotobacter) T_6 (4t/ha poultry manure + Azotobacter) and T_9 (3t/ha poultry manure + Azotobacter). Whereas, the lowest head diameter 11.5 cm was observed in T_{11} i.e. control treatment. The results in respect of head diameter are in complete agreement with the findings of Devi *et al* (2017) [9] in cabbage. The use of different organic manures and inorganic manures showed a significant variation for head weight in cabbage has been represented in Table 1 Recommended practice of fertilizer application (T_1) recorded maximum head weight 709.05 g. T_3, T_5 and T_6 are statistically at par to T_1. Haque *et al* (2015) [10], Heish (2004) [13] and Chan *et al.,* (2008) [6] also reported similar research findings in their experiment on cabbage. It is revealed from the Table 1 that the dry matter content was highest i.e. 6.67% in cabbage with recommended doze of nutrients (T_1) application which remained statistically similar to dry matter content of 5.82 % in T_3 (4 t/ha poultry manure alone), 6.02 % in T_5 (8t/ha vermicompost + Azotobacter), 6.11 % in T_6 (4t/ha poultry manure + Azotobacter). However, the lowest dry matter content was obtained in control i.e. 4.47 %. These findings are in conformity with Chaudhary (2005) [8], Haque *et al.,* (2005) [11], Chattoo *et al.,* (1997) [7] and Bahadur *et al.,* (2004) [4]. Higher head yield and yield attributing characters due to RDF can be attributed to easy nutrient availability and uptake by plant. Among organic manures, poultry manure performed best might be because of higher N content.

Economics of experiment was calculated using total input cost, gross returns and net income concept in Rs/ha for year 2017-18. The total input cost consisted of cost of cultivation including the investments on various cultural practices performed and manures and fertilizers used. Net income was estimated by deducting total input cost from gross returns. The presented data from Table 2 revealed that treatment T_1 (RDF) gave maximum returns along with maximum B:C ratio (4.97). Also it was concluded that the treatment T_1 (RDF) yielded maximum head yield as well as other yield characters. The treatments with farmyard manure (FYM) gave minimum returns as compared to poultry manure. The reason behind the minimum net returns in case of farmyard manure is that it is very bulky and is needed in large amount which makes it very costly. Hence, it was clear from the data that the treatment T_1 (RDF) was found more economical. On the other hand, in case of organic manures and biofertilizers combinations, the treatment T_6 (100% N by poultry manure + Azotobacter) was found more economical as it solved the purpose both ways one being changing the trend of using more inorganic fertilizers towards organic manures and second being getting higher returns and B:C ratio (4.84).

Conclusion

From the experiment trial it can be concluded that RDF was found to be better for getting higher yield. On the other hand, in case of organic manures and biofertilizers combinations, the treatment T_6 (100% N by poultry manure + Azotobacter) was found to be more economical as it solved the purpose both ways one being changing the trend of using more inorganic fertilizers towards organic manures and second being getting higher returns and B:C ratio (4.84)

Table 1: Impact of organic manures on yield and yield attributes

Treatments	Head length (cm)	Diameter of head (cm)	Head weight (gm)	Dry matter content (%)	Head Yield (tones/ha)
T_1 RDF	13.6	13.7	709.1	6.64	30.1
T_2 100% N by VC	11.8	12.1	682.5	5.41	24.1
T_3 100% N by PM	12.1	12.8	700.4	5.82	28.0
T_4 100% N by FYM	11.5	11.9	633.3	5.10	23.8
T_5 100% N by VC +Azotobacter	12.3	12.9	700.0	6.02	25.9
T_6 100% N by PM +Azotobacter	12.4	13.1	703.7	6.11	28.9
T_7 100% N by FYM + Azotobacter	11.9	12.1	648.9	5.27	25.3
T_8 75% N by VC +Azotobacter	11.5	12.0	539.1	5.14	23.2
T_9 75% N by PM +Azotobacter	12.0	12.5	653.7	5.37	26.0
T_{10} 75% N by FYM +Azotobacter	10.9	11.8	528.0	4.84	23.0
T_{11} Control	10.5	11.5	423.4	4.50	17.0
	1.41	1.15	14.52	0.93	4.27
VC- Vermicompost , PM- Poultry manure , FYM- Farmyard manure					

Table 2: Impact of organic manures on B:C ratio

Treatments	Net returns (Rs/ha)	Total input cost (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
T_1 RDF	723074	121074	602000.00	4.97
T_2 100% N by VC	645670	163670	482000.00	2.94
T_3 100% N by PM	678870	118870	560000.00	4.71
T_4 100% N by FYM	601670	125670	476000.00	3.78
T_5 100% N by VC +Azotobacter	682050	164050	518000.00	3.15
T_6 100% N by PM +Azotobacter	697250	119250	578000.00	4.84
T_7 100% N by FYM + Azotobacter	632050	126050	506000.00	4.01
T_8 75% N by VC +Azotobacter	616050	152050	464000.00	3.05
T_9 75% N by PM +Azotobacter	638450	118450	520000.00	4.39
T_{10} 75% N by FYM +Azotobacter	583550	123550	460000.00	3.72
T_{11} Control	455670	115670	340000.00	2.93
VC- Vermicompost , PM- Poultry manure , FYM- Farmyard manure				

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