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Ankit Patyal
Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

T Chamroy
Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
T Chamroy
Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Effect of organic and inorganic fertilizers on growth and yield parameters of broccoli (*Brassica oleracea* var. Italica) cv - Palam Samridhi

Ankit Patyal and T Chamroy

Abstract
An investigation was carried out to study the Effect of organic and inorganic fertilizers on broccoli (*Brassica oleracea* var. italica) cv- Palam Samridhi at vegetable research farm of Lovely Professional University, Phagwara, Punjab during winter season 2019-2020. The experiment was laid out at RBD (Randomized Block Design) with three replications and nine treatments having different combination of organic and inorganic fertilizer. Treatments used were: T_0 (Control), T_1-100% RDF through chemical fertilizer 125:62.5:62.5 kg NPK/ha, T_2-Vermicompost @2.5t/ha, T_3-Poultry manure @5.0t/ha, T_4-75% RDF through chemical fertilizer + vermicompost @0.3t/ha + poultry manure @0.63t/ha, T_5-50% RDF through chemical fertilizer + vermicompost @1.25t/ha + poultry manure @2.5t/ha, T_6- Poultry manure @5.0t/ha + Vermicompost @1.25t/ha, T_7-40% RDF through chemical fertilizer + vermicompost @0.75 t/ha + poultry manure @1.5t/ha, T_8- 60% RDF through chemical fertilizer + vermicompost @0.5t/ha + poultry manure @1 t/ha The experiment showed that inorganic fertilizer treatments i.e., T_1- 100% RDF i.e. N:P:K @125:62.5:62.5 kg/ha, was significantly superior over all the other treatments, recording maximum plant height (35.96cm), number of leaves/plant (15), leaf chlorophyll content (66.13mg/100g), weight of head (224.33g), yield/hectare (149.36 q/ha), total chlorophyll content (8.85mg/100g) of broccoli head, total soluble Solid (9.53^0 Brix), ascorbic acid (224.33mg/100g), total cost of cultivation (1, 20, 600 Rs/ha), gross income (6, 72, 120 Rs/ha), net income (5, 51, 520 Rs/ha) and Benefit cost ratio (4.57).

Keywords: Broccoli, economics, growth, inorganic, organic, quality and yield

Introduction
Cole crops are important vegetable crops in the world. They can be eaten as leaves (cabbage), flowers/inflorescence (broccoli), stems (khol rabi) and roots (rutabaga). *Brassica oleracea* (Cole or cabbage group) and oriental types (Chinese cabbage and its relatives) are of immense importance in the human diet, because of their medicinal properties (Masarirambi *et al.*, 2011). Among various cole crops, broccoli occupies fourth position after cauliflower, cabbage and knolkhol (Dev 2014).

Broccoli (*Brassica oleracea* L. var. italica) is a native of the Mediterranean region and derived from the Latin word Brachium which means an arm or branch (Dixon 2007). USA is the largest producer of broccoli in the world. In India, its cultivation started in the second half of the 20th century (Dev 2014). Its production is increasing at a steady rate on account of awareness about its medicinal values among educated masses of metropolitan cities of India (Dev 2014). It is a rich source of vitamin A, B1, B2, C and calcium. It also possesses anti-cancerous properties due to the presence of indols, isocyanates and phytochemicals. The sulforaphane present in broccoli prevents the growth of tumours and reduces the risk of cancer (Singh *et al.*, 2015). It also kills *Helicobacter pylori*, the causal organism of ulcer disease (Fahey *et al*., 2002).

Broccoli is a cool-season crop. The optimum temperature requirement is 15-25 ^{0}C. When the plants are small and delicate, they are responsive to cold injury. In northern India, it is generally planted in September and October and is ready for harvest from late November to early December and may continue till early February. Broccoli requires fertile soil and the soil moisture demands to be maintained properly to evade the hollowness of the stalk. The hollowness of the stalk progresses with abundant nitrogen applications also (Anonymous, 2014).

In the recent past, broccoli cultivation has been taken up favorably by some farmers around Nasik, Pune and Thane. The state of Punjab gives an adequate opportunity for the successful

cultivation of broccoli. Over the last few years, there has been an increased demand for this vegetable among the city dwellers in the state. A few ambitious farmers in the state have already started growing broccoli which are obtaining premium prices in local markets as well as in markets of appending states. Nutrient management is one of the most significant methods for effective cultivation of any vegetable crop. Brassica are heavy feeders that can grow on a variety of soils, which provides adequate nutrients and moisture and are well-drained. The soil is the Centre where plant life originates and ends. Healthy soil will have a more prominent capacity to uptake the composts and will provide a more symmetrical uptake of nutrients, generating a healthy plant that is less attractive to pest and more resistant to pest damage. Sustainable soil management maintains soil health and productivity by taking care of and improving the soil organic matter.

Cultural practices like the application of manure and compost are the most effective method to accomplish the maximum yield. Several researches have been carried out to illustrate the role of different major and micronutrients in broccoli (Wang *et al.*, 1997) [15]. Recommendation on fertilizer application in broccoli has also been made from different parts of the country (Kumar and Sharma, 2001; Singh and Singh, 2000; Brahma *et al*., 2002) [3, 13] with different portions of different nutrients depending upon the soil fertility status under different regions. The interactive benefits of blending organic and inorganic sources of nutrients generally will secure long term soil fertility and provide a higher level of productivity (Pillai *et al*., 1985) [9].

Material and Methods

The present investigation was carried out at Vegetable Research Farm of the Department of Horticulture, Lovely Professional University, Phagwara during 2019-2020. The cultivar Palam Samridhi was taken for investigation, the experiment was laid in a randomized block design with three replications. The seeds of broccoli were sown in nursery beds on 15th September and transplanted on 25th October 2019 at a spacing of 60 cm × 45 cm. The experiment comprised of various combinations of organic and inorganic fertilizers, *viz*., T_0 (Control), T_1-100% RDF through chemical fertilizer (125:62.5:62.5 kg NPK/ha) T_2-vermicompost @2.5t/ha, T_3-Poultry manure @5.0 t/ha, T_4-75% RDF through chemical fertilizer + vermicompost @0.3t/ha + poultry manure @0.63 t/ha, T5-50% RDF through chemical fertilizer + vermicompost @1.25 t/ha + poultry manure @2.5 t/ha, T_6-Poultry manure @5.0t/ha + Vermicompost @1.25 t/ha, T_7-40% RDF through chemical fertilizer + vermicompost @0.75 t/ha + poultry manure @1.5t/ha, T_8- 60% RDF through chemical fertilizer + (vermicompost @0.5t/ha + poultry manure @1 t/ha. Growth, yield and quality Parameters such as plant height, number of leaves/plant, leaf chlorophyll content, the weight of the head, yield/plot, yield/hectare, chlorophyll content of broccoli head, total soluble solids and ascorbic acid were recorded. The Economics of the experiment was worked out on basis of prevailing market prices of input and output.

Results and Discussions

The plant height (cm) at 30 days after transplanting was recorded maximum i.e. 20.53cm in T1 (100% RDF through chemical fertilizer) followed by T6 (19.53cm) and T8 (19.40cm) while the minimum plant height i.e. 14.60cm was observed in T0 control. The plant height (cm) at 60 days after transplanting was recorded in the treatment in T1 (100% RDF through chemical fertilizer) i.e. 35.96cm followed by T4 (33.33cm). The minimum height of 19.54cm was observed in T0 control. This result might be due to the application of 100% RDF helps in providing a better nutrition environment in the root zone for the growth and development of the plant because nitrogen plays important role in plant metabolism which helps in providing growth to the plants. These results are similar to the findings by (Sharhidhara, *et al.*, 1998) [11] and (Choudhary *et al.*, 2012).

The number of leaves per plant at 30 days after transplanting was recorded maximum in the treatment T_1 (100% RDF through chemical fertilizer) i.e. 9.00 number of leaves per plant which was at par with treatment T_6 (8.40), T_7 (8.20), T_8 (8.40) followed by T_2 and T_3 (7.66 leaves each). While the minimum number of leaves i.e. 6.13 was observed in T_0 Control. The number of leaves per plant at 60 days after transplanting was recorded maximum i.e.15.00 in T_1 (100% RDF through chemical fertilizer), followed by T_4 (12.80) while the minimum 8.75 number of leaves per plant was observed in T_0 Control. These results might be due to the application of 100% RDF through chemical fertilizer which had increased the soil nutrients and enhanced availability of nutrients present in the soil to help in attributing growth characteristics. This result is similar to the findings by (Sharhidhara, *et al*., 1998) [11] and (Choudhary *et al*., 2011).

The leaf chlorophyll content (mg/100g) after harvesting was recorded maximum in the treatment T_1 (100% RDF through chemical fertilizer) i.e. 66.13mg/100g which was significantly superior over than other treatments followed by T_7 (62.80mg) and a minimum of 49.96 mg was observed in T_0 (Control). These results might be due to increased soil nutrients and enhanced availability of nutrients present in the soil, which helps in more photosynthetic activities. Nitrogen is the main constituent of all amino acids in proteins and lipids acting as a structural compound of the chloroplast activity in plants that leads to higher chlorophyll content in leaf (Chaurasia *et al*., 2008), (Kandil Hala 2009) and (Shree *et al.*, 2014) [10].

The weight of head (g) and yield per hectare (q/ha) was recorded maximum in the treatment T_1 (100% RDF) i.e. 224.33 g and 149.36 q/ha, followed by T_4 (174.33 g and 116.03 q/ha) and the minimum i.e., 75 g and 49.94 q/ha yield was observed in T_0 (control) respectively. These results might be due to increased NPK levels and better uptake of nutrients by plant that leads to good chlorophyll content, which accelerates photosynthetic rates and increased supply of carbohydrates to plants and automatically resulted in increasing in head weight and as well as total yield per plot and total yield per hectare. These results might be due to the application of T_1 (100% RDF through chemical fertilizer) because the application of increased NPK levels helped in the uptake of nutrients to plant that leads to good chlorophyll content which accelerates photosynthetic rates and increased supply of carbohydrates to plants and automatically resulted in increasing in curd weight and total yield per hectare. These results are similar to the finding by (Brahma *et al*., 2002) [3], (Singh, 2004) [12], (Chaurasia *et al*., 2008) and (Ouda, *et al.*, 2008) [8].

The total Chlorophyll content in the broccoli head after harvesting was recorded maximum i.e. 8.85mg/100g in the treatment T_1 (100% RDF through chemical fertilizer) followed by T_2 and minimum was observed in treatment T_8 (vermicompost @0.5t/ha + poultry manure @1 t/ha + 60%

RDF through chemical fertilizer). These results might be due to the application of T1 because the application of increased NPK levels helped in the uptake of nutrients to plant, which leads to good chlorophyll content in the curd due to acceleration of photosynthetic activity. These results are similar to the finding by (Brahma *et al.*, 2002) [3], (Singh A.K. 2004) [12], (Kandil and Nadia 2009), and (Wani *et al.* 2011) [14].

TSS content (^{0} B) after harvesting was recorded maximum i.e. 9.53^0 B in the treatment T_1 (100% RDF through chemical fertilizer) followed by T_4 and the minimum 6.02 ^{0} Brix. TSS was observed in treatment T_3 Poultry manure @ 5.0t/ha. These results might be due to the application of T_1 (100% RDF through chemical fertilizer) where the inorganic manures provide nutrients to plant, helps in improving the physical, chemical and biological changes in the plant which helps in improving the vegetative growth as well as quality parameters. These results might be due to the application of T_1 (100% RDF through chemical fertilizer) where the inorganic manures provide nutrients to plants, helps in improving the physical, chemical and biological changes in the plant which helped in improving vegetative growth as well as quality parameters. These results are similar to the finding by (Singh A.K. 2004) [12], (Ouda, *et al*. 2008) [8] and (Shree *et al*., 2014) [10].

The vitamin 'C' content in curd (mg/100g) after harvesting was maximum recorded i.e. 224.33 mg/100g in treatment T_1, (100% RDF through chemical fertilizer) which was significantly higher than the rest of the treatments followed by T4 treatment. And the minimum vitamin C content in curd was recorded 75.00mg/100g, which was recorded in T0. These results might be due to the application of T_1 (100% RDF through chemical fertilizer) where the inorganic manures provide nutrients to plants and can supply the plant hormones which improved the quality of broccoli and enhanced good ascorbic acid content. These results might be due to the application of T1 (100% RDF through chemical fertilizer) where the inorganic manures provide nutrients to plants and can supply the plant hormones, which improved the quality of broccoli and enhanced good ascorbic acid content. These results are similar to the finding by (Singh A.K. 2004) [12], (Ouda, *et al.* 2008) [8] and (Shree *et al*. 2014) [10].

The economic analysis of broccoli per ha was worked out for one season. The result revealed that, the maximum cost of cultivation, gross income, net income and B: C ratio from one hectare was obtained in the treatment T_1 (100% RDF through chemical fertilizer) i.e., Rs.120600, Rs.672120, Rs.551520 and 4.57 respectively and minimum values were obtained in T_0 control Rs.84000, Rs.224730, Rs.140730 and 1.67 respectively. The total cost of cultivation under the combined application of organic manure was higher as compare to RDF. However, due to higher yield, the gross and net income was also greater with the B: C ratio in 100% RDF through chemical fertilizer application.

Table 1: Effect of organic and inorganic nutrient sources on growth and yield parameters on broccoli (*Brassica oleracea* var. italica)

Treatment	Plant height (cm)		Number of leaves per plant		Leaf chlorophyll content (mg/100g)	Weight of head (g)	Yield Per Ha. (q)
	30 Days	60 Days	30 Days	60 Days			
T_0 (Control)	14.60	19.54	6.13	8.75	49.96	75.00	49.94
$T_1$100% RDF through chemical fertilizer (125:62.5:62.5 kg NPK)	20.53	35.96	9.00	15.00	66.13	224.33	149.36
T_2 Vermicompost @2.5t/ha	17.46	31.49	7.66	12.20	56.83	164.00	109.16
T_3 Poultry manure @5.0t/ha	18.90	27.73	7.66	12.73	58.70	163.66	108.93
T_4 75% RDF through chemical fertilizer + (Vermicompost @0.3t/ha + poultry manure @0.63t/ha)	17.76	33.33	7.73	12.80	61.00	174.33	116.03
T_5 50% RDF through chemical fertilizer + (Vermicompost @1.25t/ha + poultry manure @2.5t/ha	18.66	31.06	6.93	12.73	54.26	135.66	90.34
T_6 Poultry manure @5.0t/ha +Vermicompost @1.25t/ha	19.53	27.30	8.40	11.73	51.96	142.00	94.79
T_7 40% RDF through chemical fertilizer + vermicompost @0.75 t/ha + poultry manure @1.5t/ha)	18.90	30.40	8.20	12.33	62.80	95.33	63.45
T_8 60% RDF through chemical fertilizer + (vermicompost @0.5t/ha + poultry manure @1 t/ha	19.40	28.53	8.40	12.53	73.80	136.00	90.56
C.D.	2.67	4.62	1.09	1.50	2.48	4.93	3.35
SE (m)	0.88	1.53	0.36	0.49	0.82	1.63	1.10

Table 2: Effect of organic and inorganic sources of nutrients on quality parameters and economics of broccoli (*Brassica oleracea* var. italica)

Treatment	Total chlorophyll in head (mg/100 g)	TSS (◦B)	Ascorbic acid (mg/100g)	Total cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C
T_0 (Control)	5.41	6.46	75.00	84,000	2,24,730	1,40,730	1.67
$T_1$100% RDF through chemical fertilizer (125:62.5:62.5 kg NPK)	8.85	9.53	224.33	1,20,600	6,72,120	5,51,520	4.57
T_2 Vermicompost @2.5t/ha	7.72	6.76	164.00	1,15,700	4,91,220	3,75,520	3.24
T_3 Poultry manure @5.0t/ha	7.14	6.06	163.66	1,07,280	4,90,185	3,82,905	3.56
$T_4$75% RDF + vermicompost @0.3t/ha + poultry manure @0.63t/ha	7.00	7.66	174.33	1,08,520	5,22,135	4,13,615	3.81
T_5 50%RDF + vermicompost @1.25t/ha + poultry manure @2.5t/ha	6.72	6.66	135.66	1,00,680	4,06,530	3,05,850	3.03
T_6 Poultry manure @5.0t/ha +Vermicompost @1.25t/ha	6.49	6.20	142.00	1,06,363	4,26,555	3,20,192	3.01
T_7 40%RDF + vermicompost @0.75 t/ha + poultry manure @1.5t/ha	5.52	7.46	95.33	84,472	2,85,525	2,01,053	2.38
T_8 60% RDF + vermicompost @0.5t/ha +	3.85	7.47	136.00	98,640	4,07,520	3,08,880	3.13

poultry manure @1 t/ha							
C.D.	0.97	0.41	4.93	-	-	-	-
SE(m)	0.32	0.13	1.63				

Conclusion

It was concluded from the results obtained that, the treatment T_1 (100% RDF through chemical fertilizer) was the most superior treatment for growth, yield and quality parameters and is most profitable for production of broccoli.

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