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Effect of FYM, biochar and biofertilizers on growth and yield of kharif cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

Ali Sher and Saket Mishra

Abstract
A field study was conducted at the Horticulture Research Farm in the Department of Horticulture at the Naini Agricultural Institute at the Sam Higginbottom University of Agriculture, Technology, and Sciences (SHUATS), Prayagraj (U.P.), during the academic years 2018-19 and 2019-20. For this study, we employed a Randomized Block Design with 17 treatments (including variations in Inorganic fertilisers, organic manures, and biofertilizers) and 3 replications. The primary objectives of this study were to compare the growth and yield of cabbage grown under different levels of Inorganic fertilisers, organic manures, and biofertilizers. Maximum plant height (34.46 cm, 36.33 cm, and 35.40 cm), number of leaves per plant (21.58, 24.58 and 23.08) and plant spread (50.67 cm, 48.36 cm and 49.52 cm) were all reported in T_9 (FYM 20 t + 75% NPK + Azotobacter + PSB) over both years and also the pooled analysed data. On the other hand, T_{10} (Biochar 30% t+50% N+P+K) had the lowest values for these indicators. In relation to yield attributes maximum diameter of head (16.45 cm, 17.60 cm and 17.03 cm), weight of trimmed head (1054.38 g, 1159.82 g and 1107.10 g), weight of plant without roots (1093.38 g, 1308.38 g and 1200.88 g), head yield per plot (6.33 kg, 6.96 kg and 6.64 kg), and yield per hectare (39.05 t, 42.96 t and 41.00 t) during both the years and pooled were recorded in T_9 (FYM 20 t + 75% NPK + Azotobacter + PSB). Whereas the minimum value regarding these parameters were recorded in T_{10} (Biochar 30 t+50% N+P, K).

Keywords: Cabbage, organic manure, FYM, biochar, inorganic fertilizers, growth, yield, azotobacter and PSB

1. Introduction
Cabbage (*Brassica oleracea* var. *capitata* L.; 2n= 18) is a popular leafy vegetable crop that may be eaten raw, boiled, pickled, or dried (Katyal and Chadha, 1985) [14]. The name "cabbage" comes from the French word "coboche," which means "head". The cabbage is a member of the cruciferae family. It is one of the most popular cole crops in India. The epithet "cole" was used to refer a collection of these plants that descended from a single wild variety, *Brassica oleracea* var. *sylvestris*, often known as colewort or field cabbage. The varietal name capitata comes from the Latin phrase for "having a head." The Mediterranean Sea coast is regarded as the origin of all these crops, from which they spread first in Europe and subsequently to nearly every country on the planet, ranging from temperate regions to tropical regions (Chiang *et al*., 1993) [6].

China, India, and Russia are the top three cabbage growers, and Russia is the top cabbage consumer. India is the second-largest cabbage producer after China (FAOSTAT, 2019) [10]. It's grown on 21.5 million ha, yielding 59.55 million tonnes and 27.7 tonnes per hectare. Average cabbage output and productivity in India are 7,923.89 MT and 22.7 MT/ha (Mishra *et al.*, 2021) [24]. West Bengal is India's major cabbage producer, followed by Odisha, Madhya Pradesh, Assam, Bihar, and Gujarat (NHB, 2020).

Cabbage's flavour comes from glucosinolates, a family of sulphur-containing glucosides that includes anti-cancer sulforaphane (Beecher, 1994) [2]. Cabbage head is a digestible and bioavailable source of protein. It's rich in vitamins A, B_1, B_2, C, K, and minerals but lacks B_6 and folate (Singh *et al.*, 2006) [34]. Cabbage contains potassium (114 mg), phosphorus (44 mg), calcium (40 mg), magnesium (10 mg), sodium (14.1 mg), ascorbic acid (30-65 mg), protein (1.5 g), iron (0.5 mg), fat (0.2 g), water (93 ml), and amino acids, mainly sulphur-containing amino acids. 100 g cabbage leaves provide 103 kJ of energy (Rai *et al.*, 2005) [33].

Cabbage head growth demands additional plant nutrients, notably nitrogen. Straight fertilizers, especially nitrogen-containing ones, are used indiscriminately by farmers to improve

productivity (Ojetayo *et al.*, 2011) [29]. Application of FYM (Farm Yard Manure) to crops is common. Well-decomposed FYM provides plant nutrients and enhances soil. Biochar is a carbon-rich burned substance used to improve soil quality. Also, biochar is made from waste biomass using thermochemical methods. Biochar produces energy, reduces waste, sequesters carbon, conserves water, and improves soil. Using biochar as a soil amendment is a novel and promising strategy for sustainable agriculture (Bhatta *et al.*, 2017) [3], whereas, bio-fertilizers are agriculturally beneficial microorganisms that can change nutritionally significant components from nonstable to useable forms. They enhance agricultural yield and save inorganic fertilisers (Kumar *et al.*, 2011) [17]. Azotobacter fixes atmospheric nitrogen in the plant's root zone. It is a free-living aerobic nitrogen-fixing bacterium that can replace some inorganic fertilizer. Azotobacter inoculation reduces nitrogenous fertilizer use by 10 to 20%. PSB (Phosphorous solubilizing bacteria) are a kind of microbes that can convert insoluble P compounds into accessible forms by secreting organic acids, and they may be employed as inoculants to increase P availability for plants. They can also boost plant growth and development by generating hormones like cytokinin and indole acetic acid (Wang *et al.*, 2014) [39].

Eliminating artificial fertilisers, high-yielding varieties, and cropping intensity reduces crop productivity. These difficulties can be minimised by using an integrated nutrient management plan. Combining inorganic and organic sources is crucial for soil health and productivity. Organic manures increase soil's physical, chemical, and biological properties, boosting fertility, production, and water retention. Bio inoculants like *Azotobacter* sp. and Phosphate solubilizing bacteria (PSB) are a promising nutrient delivery component. By mobilising plant nutrients and producing plant hormones, biofertilizers improve crop growth, yield, and quality. To maintain soil fertility and crop yield, chemical fertilisers, organic manures (FYM/biochar), bio inoculants like Azotobacter and PSB, and other organics can be utilized. No one nutrient source can provide adequate levels of plant nutrients. To maintain soil fertility and productivity and to give plant nutrients in appropriate proportions for optimal crop development yield, quality, and productivity, use inorganic, organic, and biological sources of plant nutrients.

Therefore, in light of the foregoing, the current study, named "Effect of FYM, Biochar and biofertilizers on growth and yield of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India" was carried out at SHUATS, Prayagraj, Uttar Pradesh.

2. Materials and Methods

The current study on Kharif Cabbage cv. Pride of India planted at 60 cm×45 cm was carried out in the years 2018–19 and 2019–20. The experimental field is located about 8 kilometres from Allahabad city, on the left side of the Allahabad-Rewa Road, close to the Yamuna River, at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.).

Randomized block design was used to set up the experiment, with 3 replications for each of the seventeen treatment combinations. Details and combinations of treatments are listed in Table 1. Each treatment received a unique combination of inorganic fertilizers, organic manures (including FYM and Biochar), and biofertilizers (including Azotobacter and PSB). Growth attributes like Plant height (cm), number of leaves per plant & plant spread (cm) and Yield attributes like diameter of head (cm), weight of trimmed head (g), total weight of plant without roots, Head yield per plot (Kg) & Head yield per hectare (t/ha) were all successfully measured to determine the best treatment combination for cabbage cultivation.

Table 1: Treatment Details & Treatment combinations

S. No.	Treatment	Treatment combinations (%)
1	T_1	100% NPK
2	T_2	Biochar 20 t+75% N+P, K (Recommended)
3	T_3	Biochar 20 t+75% N+P, K Azotobacter
4	T_4	Biochar 20 t+75% N+P, K+PSB
5	T_5	Biochar 20 t+75% N+P, K+ Azotobacter+ PSB
6	T_6	FYM 20 t+75% N+P, K
7	T_7	FYM 20 t+75% N+P, K+ Azotobacter
8	T_8	FYM 20 t+75% N+P, K +PSB
9	T_9	FYM 20 t+75% N+P, K+ Azotobacter+ PSB
10	T_{10}	Biochar 30 t+50% N+P, K
11	T_{11}	Biochar 30 t+50% N+P, K+ Azotobacter
12	T_{12}	Biochar 30 t+50% N+P, K+PSB
13	T_{13}	Biochar 30 t+50% N+P, K+PSB+ Azotobacter
14	T_{14}	FYM 30 t+50% N+P, K
15	T_{15}	FYM 30 t+50% N+P, K+ Azotobacter
16	T_{16}	FYM 30 t+50% N+P, K+PSB
17	T_{17}	FYM 30 t+50% N+P, K+PSB+ Azotobacter

3. Results and Discussion

Statistics were used to analyze the observation of Kharif Cabbage (*Brassica oleracea* L. Var. *capitata*) cv. Pride of India's growth and yield characteristics. The analysis of the data reveals that the application of various levels of FYM, Biochar and biofertilizers significantly improved all the attributes. The data shows that the variances were significant since the F Cal value was higher than the F Tab value.

3.1 Growth attributes

The results of the observations regarding plant height (cm) are shown in Table 2; Fig 1. From the data it was observed that plant height increased throughout the period of observation till the harvest stage during both the years (2018-19 and 2019-20) of study. Treatment T_9, which consisted of FYM 20 t+75% N+P, K+ Azotobacter+ PSB, was found to be the most effective and recorded significantly the highest plant height, which was [22.33 cm (2018-19), 22.71 cm (2019-20) and 22.52 cm (Pooled)] at 20 DAT, [30.65 cm (2018-19), 30.45 cm (2019-20) and 30.55 cm (Pooled)] at 40 DAT & [34.46 cm (2018-19), 36.33 cm (2019-20) and 35.40 cm (Pooled)] at harvest, while Treatment T_{10}, which consisted of Biochar 30 t+50% N+P, K, recorded significantly the lowest plant height, which was [16.69 cm (2018-19), 16.76 cm (2019-20) and 16.73 cm (Pooled)] at 20 DAT, [21.12 cm (2018-19), 21.30 cm (2019-20) and 21.21 cm (Pooled)] at 40 DAT & [28.91 cm (2018-19), 29.76 cm (2019-20) and 29.34 cm (Pooled)] at harvest. 75% of Nitrogen and Recommended P, K directly increased inorganic NPK availability to plants, which increased plant height. FYM may have increased the availability of macro- and micronutrients to plants during growth. FYM improves soil texture and structure, improving nutrient availability (Mazumdar *et al.*, 2014) [22]. Azotobacter and PSB bio-inoculants preserve nitrogen and phosphorus

availability. These bio-inoculants release growth-promoting chemicals that promote cell elongation and division. Azotobacter is a free-living microorganism that fixes nitrogen in soil, ensuring plant growth (Baral and Adhikari, 2013) [1]. PSB (Phosphorous Solubilizing Bacteria) solubilizes fixed soil phosphorus, promoting root growth and proliferation (Poonia and Dhaka, 2012) [31]. Similar observations were also reported by Zargar *et al.* (2022) [41] & Narayan *et al.* (2018) [27] while working on cabbage.

The observations regarding Number of leaves per plant are shown in Table 3; Fig 2. From the data it was observed that Number of leaves per plant increased throughout the period of observation till the harvest stage during both the years (2018-19 and 2019-20) of study. Treatment T_9, which consisted of FYM 20 t+75% N+P, K+ Azotobacter+ PSB, was found to be the most effective and recorded significantly the highest Number of leaves per plant, which was [9.24 (2018-19), 9.29 (2019-20) and 9.26 (Pooled)] at 20 DAT, [15.25 (2018-19), 15.30 (2019-20) and 15.28 (Pooled)] at 40 DAT & [21.58 (2018-19), 24.58 (2019-20) and 23.08 (Pooled)] at harvest, while Treatment T_{10}, which consisted of Biochar 30 t+50% N+P, K, recorded significantly the lowest plant height, which was [6.65 (2018-19), 6.70 (2019-20) and 6.68 (Pooled)] at 20 DAT, [11.87 (2018-19), 11.92 (2019-20) and 11.90 (Pooled)] at 40 DAT & [17.31 (2018-19), 18.41 (2019-20) and 17.86 (Pooled)] at harvest. The increase in leaf number is due to inorganic NPK fertilizer's higher Nitrogen availability to plants. Better Nitrogen availability improves plant physiology by creating more phytohormones, proteins, photosynthetic enzymes, and vital chemicals, resulting in higher cell division and differentiation and more leaves per plant **(**Umami *et al.*, 2019) [36]. Bio-inoculants like Azotobacter and PSB fix nitrogen and phosphorus in soil (Zaidi *et al.*, 2009) [40]. FYM solubilizes soil macronutrients (Mostafa, 2011) [25]. As a result, more nutrients are available to the cabbage roots, leading to better vegetative development and more leaves (Ding *et al.*, 2018) [9].

The data regarding Plant spread (cm) is shown in Table 4; Fig 3. From the data it was observed that Plant spread (cm) increased throughout the period of observation till the harvest stage during both the years (2018-19 and 2019-20) of study. Treatment T_9, which consisted of FYM 20 t+75% N+P, K+ Azotobacter+ PSB, was found to be the most effective and recorded significantly the highest Plant spread (cm), which was [33.47 cm (2018-19), 33.77 cm (2019-20) and 33.62 cm (Pooled)] at 20 DAT, [46.48 cm (2018-19), 43.77 cm (2019-20) and 45.13 cm (Pooled)] at 40 DAT & [50.67 cm (2018-19), 48.36 cm (2019-20) and 49.52 cm (Pooled)] at harvest, while Treatment T_{10}, which consisted of Biochar 30 t+50% N+P, K, recorded significantly the lowest Plant spread (cm), which was [28.04 (2018-19), 27.93 (2019-20) and 27.99 (Pooled)] at 20 DAT, [42.74 cm (2018-19), 41.37 cm (2019-20) and 42.06 cm (Pooled)] at 40 DAT & [46.51 (2018-19), 44.20 (2019-20) and 45.36 (Pooled)] at harvest. Plant Spread affects overall vegetative growth. Plant spread increases due to leaf and branch growth (Kumar *et al.*, 2017) [15]. The presence of inorganic nitrogen in fertilizers led to profuse plant growth because nitrogen mobilization led to the synthesis of amino acids, proteins, and plant growth regulators, which increased the macronutrient's availability to younger leaves, leading to growth in leaf area and leaf number due to cell division (Masclaux-Daubresse *et al.*, 2010) [20]. Bio-inoculants like Azotobacter and PSB increase plant nitrogen availability, which was lost owing to macronutrient leaching. These microorganisms release growth-promoting chemicals that help root cells divide and develop **(**Umar *et al.*, 2009) [37]. Root proliferation led to absorption of macro and micronutrients, which create chloroplasts and other plastids. The optimal availability of Nitrogen may have increased chlorophyll production, boosting photosynthetic efficiency. To boost Nitrogen usage efficiency (NUE), plants increase leaf production and leaf area (Lazare *et al.*, 2020) [18], which increases cabbage plant biomass and plant spread.

3.2 Yield attributes

Table 5; Fig 4 displays the collected data in terms of Diameter of Head (cm) during the year 2018-19 and 2019-20, where Treatment T_9 (FYM 20 t+75% N+P, K+ Azotobacter+ PSB) was found to be the significantly superior over other treatments and recorded significantly the highest Diameter of Head (cm) i.e., [16.45 cm (2018-19), 17.60 cm (2019-20) and 17.03 cm (Pooled)] where-as treatment T_{10} (Biochar 30 t+50% N+P, K) recorded significantly the lowest Diameter of Head (cm) i.e., [12.61 cm (2018-19), 13.49 cm (2019-20) and 13.05 cm (Pooled)] during both the years. The pooled analysis data also shows the same trend. The gain in head diameter may be attributed to the coordinated use of organic manure, inorganic fertilizers, and biofertilizers, which increased NPK availability and soil fertility and productivity (Das *et al.*, 2006) [8]. Biofertilizers might have enhanced the head diameter due to the availability of sufficient nitrogen through direct addition, the solubility of the nutrient in soil, and increasing nitrogen levels. These variables support nutrient intake and effective use for enhanced metabolism and glucose synthesis, vegetative growth, and partitioning and translocation. Sood and Vidyasagar (2007) [35] in cabbage, Vimla and Natarajan (2000) [38] in pea, Nagar and Meena (2004) [26] in cluster bean and Kachari and Korla (2009) [11] in cauliflower have also reported similar findings.

Table 5; Fig 5 displays the collected data in terms of Weight of trimmed head (g) during the year 2018-19 and 2019-20, where Treatment T_9 (FYM 20 t+75% N+P, K+ Azotobacter+ PSB) was found to be the significantly superior over other treatments and recorded significantly the highest Weight of trimmed head (g) i.e., [1054.38 g (2018-19), 1159.82 g (2019-20) and 1107.10 g (Pooled)] where-as treatment T_{10} (Biochar 30 t+50% N+P, K) recorded significantly the lowest Weight of trimmed head (g) i.e., [777.85 g (2018-19), 842.58 g (2019-20) and 816.74 g (Pooled)] during both the years. The pooled analysis data also shows the same trend. FYM improves plant growth, nutritional availability, and biological activity. Biofertilizers may have helped sustain nutrient availability due to Azotobacter's nitrogen fixation and PSB's phosphate solubilization, as well as the synthesis of growth-stimulating hormones. Its impact on cabbage head yield may be linked to secondary and micronutrient availability. Biofertilizers may have boosted nutrient absorption, nutrient accumulation, growth and yield, and cabbage output. These results are in conformity with the findings of Maurya *et al.* (2008) [21] in broccoli, Chatterjee *et al.* (2012) [4] in cabbage and Chaudhary *et al.* (2015) [5] in cabbage.

The observations regarding the Total weight of plant without roots (g) during the year 2018-19 and 2019-20 are shown in Table 5; Fig 5. Treatment T_9 (FYM 20 t+75% N+P, K+ Azotobacter+ PSB), was found to be the most effective and recorded significantly the highest Total weight of plant

without roots (g), measuring [1093.38 g (2018-19), 1308.38 g (2019-20) and 1200.88 g (Pooled)], while treatment T_{10}, (Biochar 30 t+50% N+P, K), recorded significantly the lowest the Total weight of plant without roots (g) i.e., [824.28 g (2018-19), 855.63 g (2019-20) and 833.43 g (Pooled)] during both the years. Organic manures improve the soil's physical state, which increases the availability of nutrients to plants and distributes nutrients throughout the plant's growth period. Azotobacter thrived in the friendly environment FYM provided. PSB converts insoluble phosphate into soluble forms by secreting organic acids. Photosynthesis relies on nitrogen- and phosphorus-based protein and chlorophyll. This enhanced glucose accumulation improved growth, yield, and plant weight without roots. Similar conclusion was also drawn by Meena and Gautam (2005) [23], Kanzaria *et al.* (2010) [13], Priyadarshani *et al.* (2012) [32], Kumar *et al.* (2014) [16] and Patil *et al.* (2014) [30].

The observations regarding the Head yield per plot (Kg) during the year 2018-19 and 2019-20 are shown in Table 5; Fig 4. Treatment T_9 (FYM 20 t+75% N+P, K+ Azotobacter+ PSB), was found to be the most effective and recorded significantly the highest Head yield per plot (Kg), measuring [6.33 kg (2018-19), 16.96 kg (2019-20) and 6.64 Kg (Pooled)], while treatment T_{10}, (Biochar 30 t+50% N+P, K), recorded significantly the lowest the Head yield per plot (Kg) i.e., [4.67 kg (2018-19), 5.13 kg (2019-20) and 4.90 kg (Pooled)] during both the years. Organic manures emit macro and micronutrients during microbial breakdown. They offer energy to soil microorganisms, which moves organic nutrients. Organic manure improves soil physical characteristics, nutrient availability during growth, and nutrient and water efficiency. Increased cation exchange capacity of plant roots, which boosts their ability to absorb nutrients, and nitrogen's positive impacts on growth metrics and yield quality may also be significant causes. Better root and shoot development from higher nitrogen led to increased phosphate and potash uptake and dry matter production. Nagar and Meena (2004) [26] in cluster bean, Kadlag *et al.* (2007) [12] in tomato, Mahfouz and Sharaf-Eldin (2007) [19] in fennel and Kachari and Korla (2009) [11] in cauliflower have also reported similar findings.

The observations regarding the Head yield per hectare (t/ha) during the year 2018-19 and 2019-20 are shown in Table 5; Fig 4. Treatment T_9 (FYM 20 t+75% N+P, K+ Azotobacter+ PSB), was found to be the most effective and recorded significantly the highest Head yield per hectare (t/ha), measuring [39.05 t/ha (2018-19), 42.96 t/ha (2019-20) and 41 t/ha (Pooled)], while treatment T_{10}, (Biochar 30 t+50% N+P, K), recorded significantly the lowest the Head yield per hectare (t/ha) i.e., [28.81 t/ha (2018-19), 31.69 t/ha (2019-20) and 30.25 t/ha (Pooled)] during both the years. FYM improved plant growth, nutritional availability, and biological activity. Biofertilizers may have helped maintain a consistent supply of nutrients due to Azotobacter's nitrogen fixation and PSB's phosphate solubilization, as well as growth-stimulating hormones. Increased secondary and micronutrient availability may also boost cabbage head output. Biofertilizers may boost nutrient absorption, accumulation, growth, yield, and cabbage production per head by encouraging root development and changing root form. These results are in conformity with the findings of Maurya *et al.* (2008) [21] in broccoli, Chatterjee *et al.* (2012) [4] in cabbage and Chaudhary *et al.* (2015) [5] in cabbage.

Table 2: Effect of FYM, Biochar and biofertilizers on Plant Height (cm) of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

Treatment Symbol	Plant Height (cm)								
	20 DAT			40 DAT			At Harvest		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	19.09	19.05	19.07	25.17	25.04	25.11	31.79	32.74	32.27
T_2	20.25	20.25	20.25	26.69	27.23	26.96	32.61	33.56	33.09
T_3	21.07	21.03	21.05	28.37	28.45	28.41	33.46	34.57	34.02
T_4	20.85	20.87	20.86	27.44	27.28	27.36	33.31	34.42	33.86
T_5	21.46	21.43	21.45	28.72	28.32	28.52	33.75	35.62	34.69
T_6	20.69	20.65	20.67	27.03	27.33	27.18	32.91	34.02	33.47
T_7	21.91	22.04	21.98	30.00	30.30	30.15	34.26	36.13	35.20
T_8	21.90	21.91	21.90	29.35	29.55	29.45	34.12	35.99	35.06
T_9	22.33	22.71	22.52	30.65	30.45	30.55	34.46	36.33	35.40
T_{10}	16.69	16.76	16.73	21.12	21.30	21.21	28.91	29.76	29.34
T_{11}	18.64	18.72	18.68	24.62	24.95	24.79	30.79	31.60	31.20
T_{12}	18.22	18.18	18.20	23.81	23.57	23.69	30.41	31.20	30.81
T_{13}	19.27	19.32	19.30	26.17	25.94	26.06	31.82	32.77	32.30
T_{14}	17.12	17.19	17.16	22.70	22.89	22.80	29.82	30.61	30.22
T_{15}	18.95	18.93	18.94	24.99	24.78	24.89	31.59	32.40	32.00
T_{16}	18.86	18.90	18.88	24.78	25.01	24.90	31.36	32.17	31.77
T_{17}	19.66	19.71	19.68	26.52	26.84	26.68	32.01	32.96	32.49
F-test	**	**	**	**	**	**	**	**	**
S.E. (m)(±)	0.29	0.34	0.22	0.68	0.71	0.49	0.21	0.21	0.21
C.D. @5%	0.84	0.99	0.63	1.97	2.03	1.38	0.61	0.61	0.64
C.D. @1%	1.14	1.33	0.84	2.65	2.74	1.84	0.82	0.82	0.88
Treatment*Year	NS			NS			**		

Table 3: Effect of FYM, Biochar and biofertilizers on Number of leaves per plant of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

Treatment Symbol	Number of leaves per plant								
	20 DAT			40 DAT			At Harvest		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	7.74	7.68	7.71	13.36	13.30	13.33	19.21	20.91	20.06
T_2	8.19	8.24	8.22	14.02	14.07	14.05	20.23	22.33	21.28
T_3	8.61	8.56	8.59	14.59	14.54	14.57	20.81	23.62	22.22
T_4	8.49	8.54	8.52	14.38	14.43	14.41	20.62	23.43	22.03
T_5	8.74	8.69	8.72	14.75	14.70	14.73	20.97	23.97	22.47
T_6	8.35	8.42	8.39	14.24	14.31	14.28	20.38	23.19	21.79
T_7	9.11	9.06	9.09	15.12	15.07	15.10	21.41	24.41	22.91
T_8	8.90	8.85	8.88	14.98	14.93	14.96	21.29	24.29	22.79
T_9	9.24	9.29	9.26	15.25	15.30	15.28	21.58	24.58	23.08
T_{10}	6.65	6.70	6.68	11.87	11.92	11.90	17.31	18.41	17.86
T_{11}	7.25	7.20	7.23	12.68	12.63	12.66	18.39	19.79	19.09
T_{12}	7.09	7.04	7.07	12.46	12.41	12.44	18.11	19.51	18.81
T_{13}	7.86	7.80	7.83	13.49	13.43	13.46	19.52	21.62	20.57
T_{14}	6.82	6.77	6.80	12.07	12.02	12.05	17.65	18.75	18.20
T_{15}	7.62	7.56	7.59	13.21	13.15	13.18	18.93	20.63	19.78
T_{16}	7.49	7.44	7.47	13.09	13.04	13.07	18.62	20.32	19.47
T_{17}	7.99	7.93	7.96	13.62	13.56	13.59	19.83	21.93	20.88
F-test	**	**	**	**	**	**	**	**	**
S.E. (m)(±)	0.11	0.10	0.07	0.16	0.18	0.12	0.21	0.19	0.35
C.D. @5%	0.32	0.29	0.20	0.47	0.52	0.34	0.59	0.54	1.06
C.D. @1%	0.43	0.38	0.27	0.63	0.71	0.45	0.79	0.73	1.47
Treatment*Year	NS			NS			**		

Table 4: Effect of FYM, Biochar and biofertilizers on Plant spread (cm) of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

Treatment Symbol	Plant spread (cm)								
	20 DAT			40 DAT			At Harvest		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	30.47	30.30	30.39	44.44	42.46	43.45	48.08	45.76	46.92
T_2	31.67	31.88	31.78	45.23	43.19	44.21	49.54	47.23	48.39
T_3	32.42	32.70	32.56	45.67	43.59	44.63	50.01	47.70	48.86
T_4	32.15	32.43	32.29	45.55	43.51	44.53	49.86	47.17	48.52
T_5	32.64	32.84	32.74	45.89	43.29	44.59	50.14	47.83	48.99
T_6	31.92	32.20	32.06	45.40	43.36	44.38	49.72	47.41	48.57
T_7	32.54	33.19	32.87	46.31	43.76	45.04	50.59	48.27	49.43
T_8	32.89	32.94	32.92	46.01	43.37	44.69	50.42	48.11	49.27
T_9	33.47	33.77	33.62	46.48	43.77	45.13	50.67	48.36	49.52
T_{10}	28.04	27.93	27.99	42.74	41.37	42.06	46.51	44.20	45.36
T_{11}	29.38	29.24	29.31	43.77	41.93	42.85	47.32	44.98	46.15
T_{12}	29.01	28.87	28.94	43.41	41.57	42.49	47.09	44.77	45.93
T_{13}	30.80	31.01	30.91	44.58	42.60	43.59	48.98	46.65	47.82
T_{14}	28.42	28.28	28.35	42.98	41.53	42.26	46.69	44.38	45.53
T_{15}	30.18	30.01	30.10	44.28	42.30	43.29	47.93	45.59	46.76
T_{16}	29.93	29.76	29.85	44.16	42.32	43.24	47.74	45.40	46.57
T_{17}	31.11	31.32	31.22	44.79	42.75	43.77	49.14	46.81	47.98
F-test	**	**	**	**	**	**	**	**	**
S.E. (m)(±)	0.23	0.19	0.15	0.18	0.14	0.18	0.18	0.17	0.12
C.D. @5%	0.67	0.56	0.42	0.52	0.41	0.56	0.51	0.49	0.34
C.D. @1%	0.90	0.75	0.56	0.7	0.55	0.78	0.69	0.66	0.46
Treatment*Year	NS			**			NS		

Table 5: Effect of FYM, Biochar and biofertilizers on Yield attributes of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

Treatment Symbol	Diameter of Head (cm)			Weight of trimmed head (g)			Total weight of plant without roots (g)			Head yield per plot (Kg)			Head yield per hectare (t/ha)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	14.46	15.47	14.97	877.08	964.78	920.93	936.71	1105.53	1021.12	5.26	5.79	5.53	32.48	35.73	34.11
T_2	14.93	15.97	15.45	950.54	1045.59	998.07	992.43	1187.43	1089.93	5.70	6.27	5.99	35.21	38.73	36.97
T_3	15.61	16.70	16.16	994.14	1093.56	1043.85	1035.37	1225.37	1130.37	5.96	6.56	6.26	36.82	40.50	38.66
T_4	15.49	16.57	16.03	973.51	1070.86	1022.19	1015.40	1210.40	1112.90	5.84	6.43	6.13	36.06	39.66	37.86
T_5	15.60	16.69	16.14	1007.07	1107.78	1057.42	1047.41	1237.41	1142.41	6.04	6.65	6.34	37.30	41.03	39.16
T_6	15.35	16.42	15.89	957.21	1052.93	1005.07	999.10	1194.03	1096.57	5.74	6.32	6.03	35.45	39.00	37.22
T_7	16.38	17.53	16.95	1042.11	1146.32	1094.22	1081.11	1277.78	1179.45	6.25	6.88	6.57	38.60	42.46	40.53
T_8	15.98	17.10	16.54	1028.65	1131.52	1080.08	1067.65	1257.22	1162.43	6.17	6.79	6.48	38.10	41.91	40.00
T_9	16.45	17.60	17.03	1054.38	1159.82	1107.10	1093.38	1308.38	1200.88	6.33	6.96	6.64	39.05	42.96	41.00
T_{10}	12.61	13.49	13.05	777.85	842.58	816.74	824.28	855.63	833.43	4.67	5.13	4.90	28.81	31.69	30.25
T_{11}	13.42	14.36	13.89	835.28	918.80	877.04	879.73	1053.73	966.73	5.01	5.51	5.26	30.94	34.03	32.48
T_{12}	13.43	14.37	13.90	834.43	917.87	876.15	879.97	1054.66	967.31	5.01	5.51	5.26	30.90	34.00	32.45
T_{13}	14.58	15.60	15.09	892.26	981.49	936.87	957.56	1120.08	1038.82	5.35	5.89	5.62	33.05	36.35	34.70
T_{14}	12.83	13.73	13.28	798.32	878.15	838.24	844.75	996.97	920.86	4.79	5.27	5.03	29.57	32.52	31.05
T_{15}	14.26	15.26	14.76	868.23	955.05	911.64	919.75	1098.45	1009.10	5.21	5.73	5.47	32.16	35.37	33.76
T_{16}	14.08	15.07	14.57	914.11	1005.52	959.81	912.04	1080.22	996.13	5.48	6.03	5.76	33.86	37.24	35.55
T_{17}	14.54	15.55	15.05	916.11	1007.72	961.91	958.78	1153.33	1056.05	5.50	6.05	5.77	33.93	37.32	35.63
F-test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
S.E. (m)(±)	0.19	0.2	0.14	10.97	12.07	8.15	11.3	16.07	21.51	0.07	0.07	0.04	0.41	0.45	0.3
C.D. @ 5%	0.55	0.59	0.39	31.6	34.76	23.03	32.56	46.29	64.49	0.19	0.21	0.13	1.17	1.29	0.85
C.D. @ 1%	0.74	0.79	0.52	42.49	46.74	30.61	43.78	62.23	88.86	0.25	0.28	0.18	1.57	1.73	1.13
Treatment*Year	NS			NS			**			NS			NS		

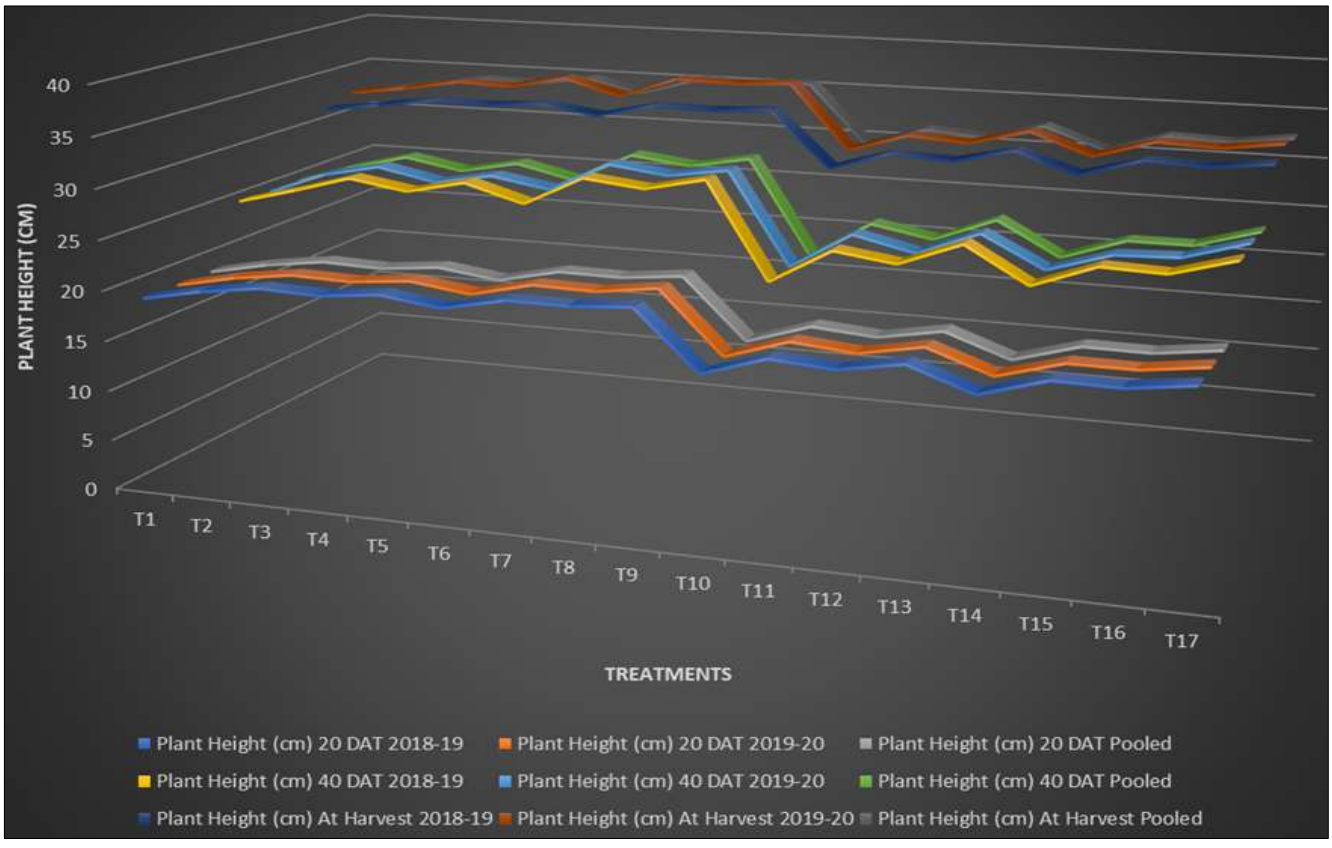

Fig 1: Effect of FYM, Biochar and biofertilizers on Plant Height (cm) of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

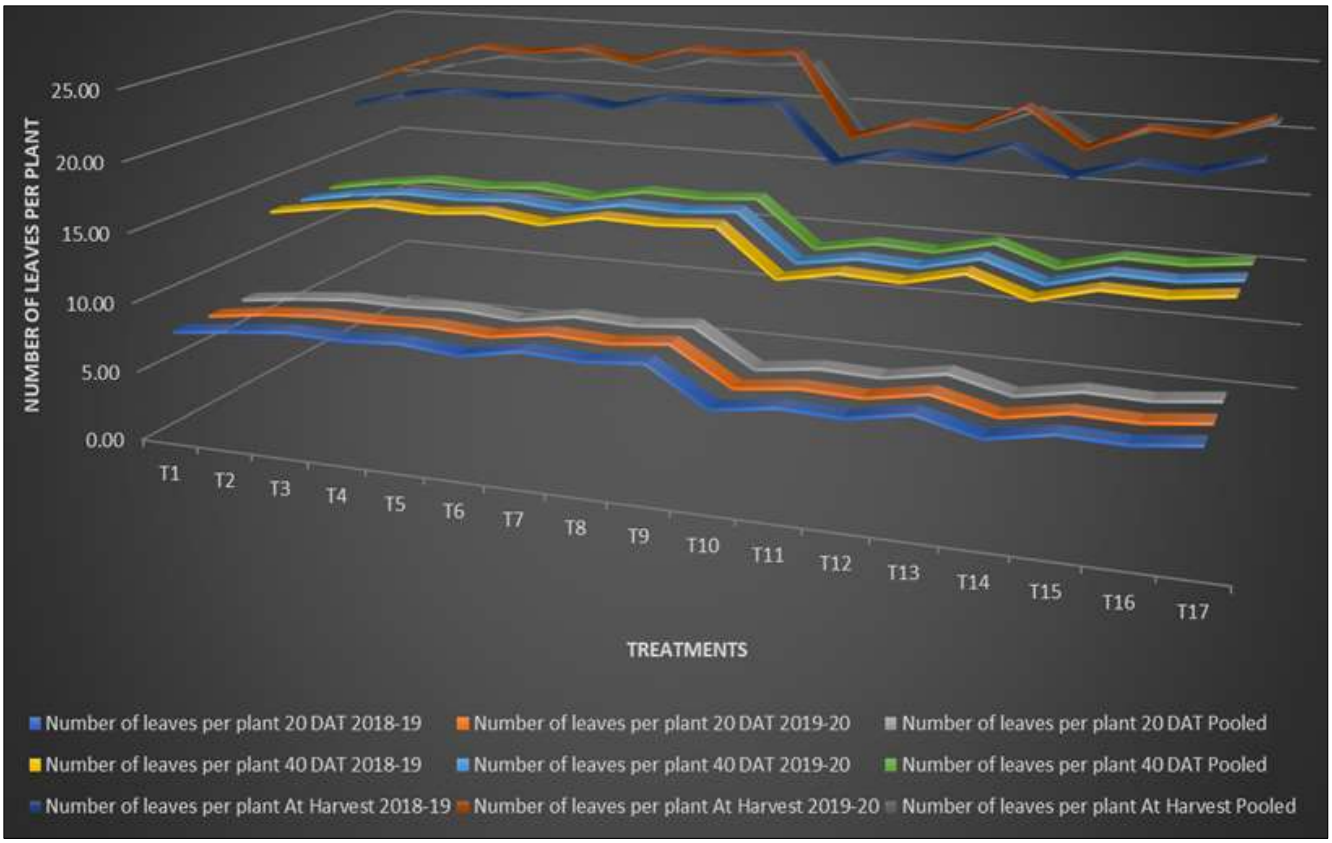

Fig 2: Effect of FYM, Biochar and biofertilizers on Number of leaves per plant of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

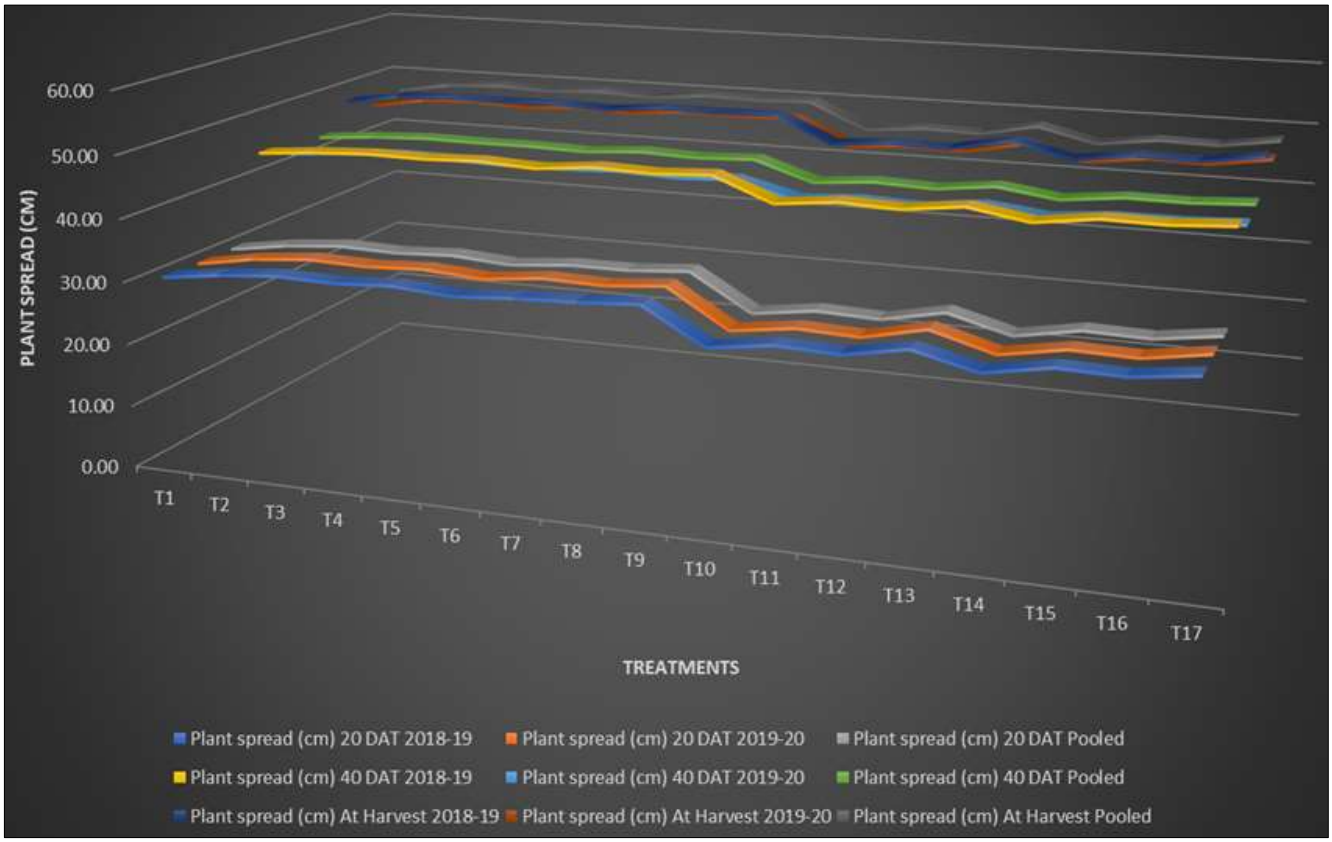

Fig 3: Effect of FYM, Biochar and biofertilizers on Plant Spread (cm) of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

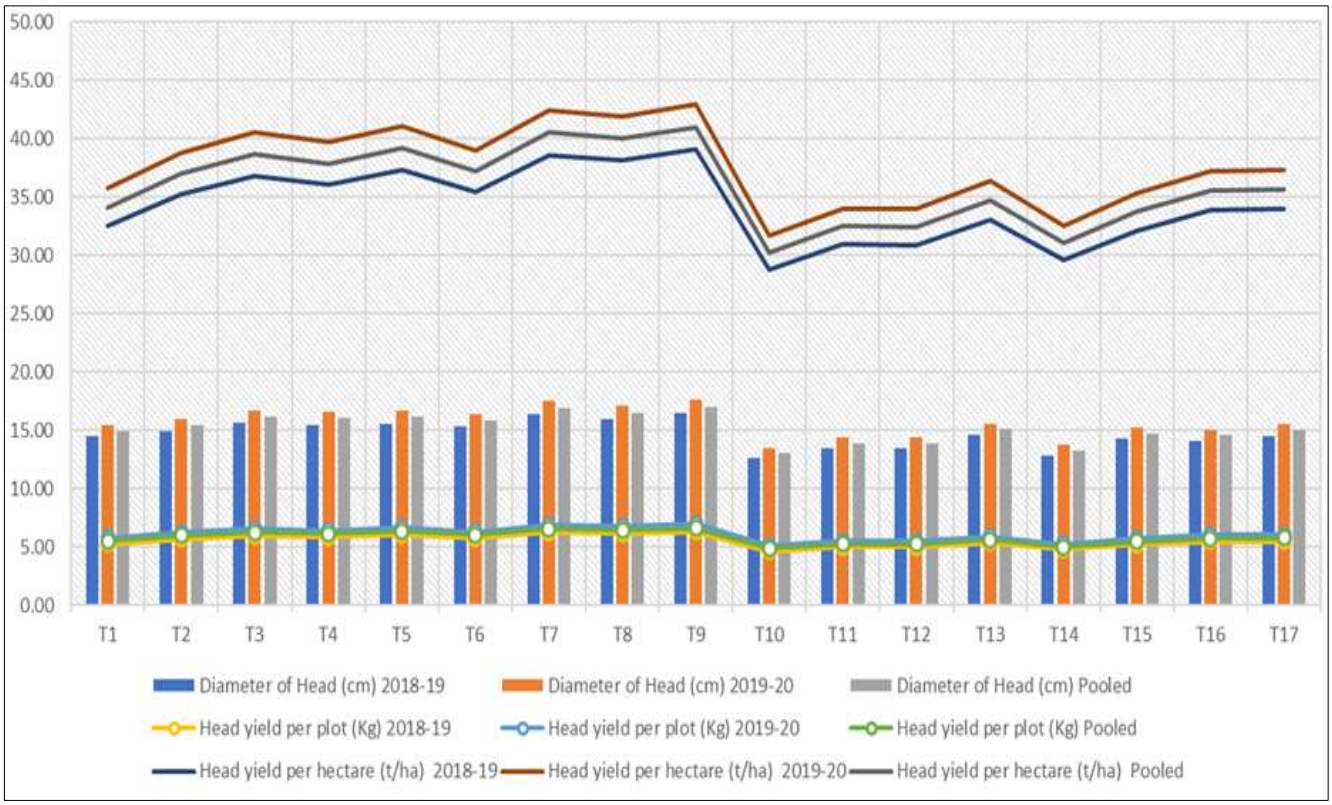

Fig 4: Effect of FYM, Biochar and biofertilizers on Diameter of Head (cm), Head yield per plot (Kg) & Head yield per hectare (t/ha) of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

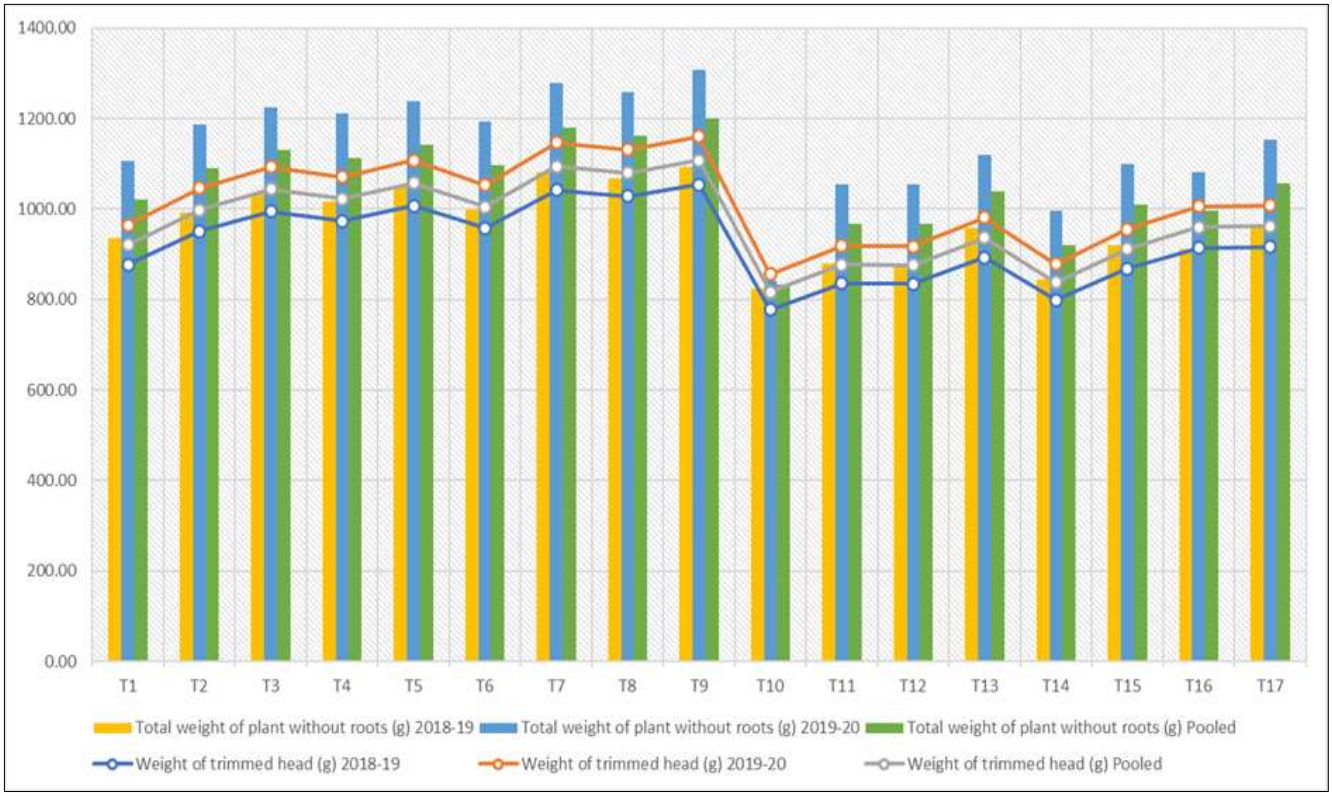

Fig 5: Effect of FYM, Biochar and biofertilizers on Weight of trimmed head (g) & Total weight of plant without roots (g) of Kharif Cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India

4. Conclusion

From the results of the current experiment, it can be inferred that Treatment T_9 i.e., (FYM 20 t+75% N+P, K+ Azotobacter+ PSB), had the best effects. It was deemed to have the best growth characteristics, including plant height (cm), number of leaves per plant, and plant spread (cm) & yield characteristics, including head diameter (cm), weight of the trimmed head (g), total weight of the plant without roots (g), head yield per plot (kg), and head yield per hectare.

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6. References

1. Baral BR, Adhikari P. Effect of Azotobacter on growth and yield of maize. SAARC Journal of Agriculture. 2013;11(2):141-147.
2. Beecher CW. Cancer preventive properties of varieties of *Brassica oleracea*: A review. The American journal of clinical nutrition. 1994;59(5):1166S-1170S.
3. Bhatta S, Pande KR, Khanal BR, Marahatta S. Soil physical properties and yield of Cabbage (*Brassica oleracea* var. *capitata*) as affected by application of biochar and organic manures in Nawalparasi, Nepal; c2017.
4. Chatterjee R, Jana JC, Paul PK. Enhancement of head yield and quality of cabbage (*Brassica oleracea*) by combining different sources of nutrients. Indian Journal of Agricultural Sciences. 2012;82(4):323-7.
5. Chaudhary MM, Bhanvadia AS, Parmar PN. Effect of integrated nutrient management on growth, yield attributes and yield of cabbage (*Brassica oleracea* var. *capitata* L.) Under Middle Gujarat Conditions Trends in Biosci. 2015;8(8):2164-2168.
6. Chiang MS, Chong C, Landry BS, Crete R. Cabbage: *Brassica oleracea* subsp. *capitata* L. In Genetic improvement of vegetable crops. Pergamon; c1993. p. 113-155.
7. Choudhary S, Soni AK, Jat NK. Effect of organic and inorganic sources of nutrients on growth, yield and quality of sprouting broccoli cv. CBH-1. Indian Journal of Horticulture. 2012;69(4):550-554.
8. Das A, Prasad M, Gautam RC, Shivay YS. Productivity of cotton (*Gossypium hirsutum*) as influenced by organic and inorganic sources of nitrogen. Indian J Agric. Sci. 2006;76:354-357
9. Ding C, Chang Z, Wang Y, You S, Wang S, Ding Y. Proteomic analysis reveals that developing leaves are more sensitive to nitrogen fertilizer than mature leaves. Journal of Plant Growth Regulation. 2018;37(2):426-437.
10. FAOSTAT, FAO statistics, food and agriculture organisation of the United Nations, Rome; c2019. http://faostat.fao.org/. (Accessed on 05 June 2021).
11. Kachari M, Korla BN. Effect of biofertilizers on growth and yield of cauliflower cv. PSB K-1. Indian Journal of Horticulture. 2009;66(4):496-501.
12. Kadlag AD, Jadhav AB, Bharti R. Yield and quality of tomato fruit as influenced by bio-fertilizers. Asian Journal of Soil Science. 2007;2(2):95-99.
13. Kanzaria KK, Sutaria GS, Akbari KN, Vora VD, Padmani DR. Effect of integrated nutrient management on productivity of pearl millet and soil fertility of sandy loam soils under rain fed conditions. Asian Journal of Soil Science. 2010;5(1):154-156.
14. Katyal SL, Chadha KL. Vegetable growing in India. Second Edition, Oxford and IBM Publication, New Delhi; c1985.
15. Kumar A, Sharma N, Sharma CL, Singh G. Studies on nutrient management in apple cv. Oregon Spur-II under the cold desert region of Himachal Pradesh in India. Indian Journal of Agricultural Research. 2017, 51(2).
16. Kumar P, Kumar R, Singh SK, Kumar A. Effect of fertility on growth yield and yield attributes of pearl millet (*Pennisetum glaucum* L.) under rainfed condition. Agriways. 2014;2(2):89-93.
17. Kumar S, Girwani G, Reddy S, Bhagwan A. Studies on nutrient management in custard apple banalagar. Acta horticulturae. 2011;890:381-385.
18. Lazare S, Lyu Y, Yermiyahu U, Heler Y, Ben-Gal A, Holland D, *et al*., Optimizing nitrogen application for growth and productivity of pomegranates. Agronomy. 2020;10(3):366.
19. Mahfouz SA, Sharaf-Eldin MA. The effect of minerals vs. biofertilizer on growth, yield and essential oil content of fennel. International Agrophysics. 2007;21:361-366.
20. Masclaux-Daubresse C, Daniel-Vedele F, Dechorgnat J, Chardon F, Gaufichon L, Suzuki A. Nitrogen uptake, assimilation and remobilization in plants: challenges for sustainable and productive agriculture. Annals of botany. 2010;105(7):1141-1157.
21. Maurya AK, Singh MP, Srivastava BK, Singh YV, Singh DK, Singh S, *et al*., Effect of organic manures and inorganic fertilizers on growth characters, yield and economics of sprouting broccoli cv. Fiesta. Indian J Hortic. 2008;651):116-118.
22. Mazumdar SP, Kundu DK, Ghosh D, Saha AR, Majumdar B, Ghorai AK. Effect of long-term application of inorganic fertilizers and organic manure on yield, potassium uptake and distribution of potassium fractions in the new Gangetic alluvial soil under jute-rice-wheat cropping system. International Journal of Agriculture and Food Science Technology. 2014;5(4):297-306.
23. Meena R, Gautam RC. Effect of integrated nutrient management on productivity, nutrient uptake and moisture-use functions of pearlmillet (*Pennisetum glaucum*). Indian Journal of Agronomy. 2005;50(4):305-307.
24. Mishra R, Bisen RK, Agrawal HP, Verma SK. To study the effects of organic, inorganic and Biofertlizer on yield attributes of cabbage (*Brassica oleracea* var. capitata). Journal of Pharmacognosy and Phytochemistry. 2021;10(4):133-134.
25. Mostafa MR. Effects on growth, yield, and fruit quality in tomato (*Lycopersicon esculentum* Mill.) using a mixture of potassium humate and farmyard manure as an alternative to mineral-N fertiliser. The Journal of Horticultural Science and Biotechnology. 2011;86(3):249-254.
26. Nagar KC, Meena NL. Effect of phosphorus solubilizing bacteria on yield components, yield and quality of clusterbean. Legume Research. 2004;27(1):27-31.
27. Narayan S, Ibrahim A, Khan FA, Hussain K, Malik A, Mir SA, *et al*. Organic Nutrient Management for Improved Plant Growth and Head Yield of Chinese Cabbage (Brassica rapa L. var pekinensis). International Journal of Current Microbiology and Applied Sciences. 2018;7:3049-59.
28. National Horticulture Board. State wise Area and Production estimates of Horticultural crops. Ministry of Agriculture. Government of India; c2020.
29. Ojetayo AE, Olaniyi JO, Akanbi WB, Olabiyi TI. Effect

of fertilizer types on nutritional quality of two cabbage varieties before and after storage. Journal of Applied Biosciences. 2011;48(5):3322-3330.
30. Patil AS, Patel HK, Chauhan NP. Yield, quality and monetary returns of summer pearl millet (*Pennisetum glaucum* L.) as influenced by integrated nitrogen management and sowing methods. Crop Research. 2014;47(1, 2 & 3):24-28.
31. Poonia MK, Dhaka BL. Effect of phosphorus solublizing bacteria (PSB) on growth and yield in tomato. Journal of Horticultural Sciences. 2012;7(1):104-107.
32. Priyadarshini A, Khambalkar Tomar PS, Verma SK. Long-term effects of integrated nutrient management on productivity and soil fertility in pearl millet (*Pennisetum glaucum*) – mustard (*Brassica juncea*) cropping sequence. Indian Journal of Agronomy. 2012;57(3):222-228.
33. Rai N, Yadav GD. Advances on vegetable production. Kalyani Publications; c2005. p. 52.
34. Singh J, Upadhyay AK, Bahadur A, Singh B, Singh KP, Rai M. Antioxidant phytochemicals in cabbage (*Brassica oleracea* L. var. *capitata*). Scientia Horticulturae. 2006;108(3):233-237
35. Sood R, Vidyasagar. Integrated nitrogen management through biofertiliser in cabbage (*Brassica oleracea* var. capitata). Indian Journal of Agriculture Science. 2007;77(9):589-590.
36. Umami N, Abdiyansah A, Agus A. November. Effects of different doses of NPK fertilization on growth and productivity of Cichorium intybus. In IOP Conference Series: Earth and Environmental Science. IOP Publishing. 2019;387(1):012097.
37. Umar I, Wali VK, Kher R, Jamwal M. Effect of Fym, Urea and Azotobacter on Growth, Yield and Quality of Strawberry Cv. Chandler. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 2009, 37(1).
38. Vimala B, Natarajan S. Effect of nitrogen, phosphorus and biofertilizers on pod characters, yield and quality in pea (*Pisum sativum* L. spp. hortense). South Indian Horticulture. 2000;48:60-63.
39. Wang T, Liu MQ, Li HX. Inoculation of phosphate-solubilizing bacteria *Bacillus thuringiensis* B1 increases available phosphorus and growth of peanut in acidic soil. Acta Agriculturae Scandinavica, Section B–Soil & Plant Science. 2014;64(3):252-259.
40. Zaidi A, Khan M, Ahemad M, Oves M. Plant growth promotion by phosphate solubilizing bacteria. Acta microbiologica et immunologica Hungarica. 2009;56(3):263-284.
41. Zargar J, Kumar M, Kumar S, Chopra S, Kumar S, Bhushan A, *et al*., Integrated nutrient management studies in cabbage (*Brassica oleracea*) under subtropical plains of Jammu. The Indian Journal of Agricultural Sciences. 2022;92(1):59-62.