

**Growth, flowering and post-harvest life of
chrysanthemum (*Dendranthema grandiflora* Tzvelev.)
cv. Thai Chen Queen in response to organic
and biodynamic manures**

Thesis

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By

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*Pantnagar
September, 2021*


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CERTIFICATE-I

This is to certify that the thesis entitled “**Growth, flowering and post-harvest life of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Thai Chen Queen in response to organic and biodynamic manures**” submitted in partial fulfilment of the requirement for the degree of **Doctor of Philosophy** with major in **Horticulture (Floriculture and Landscaping)** and minor in **Plant physiology**, of the College of Post Graduate Studies, G.B. Pant University of Agriculture and Technology, Pantnagar, is a record of bonafide research carried out by **Mr. Syed Khudus, Id. No. 50917**, under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation have been duly acknowledged.

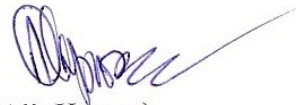
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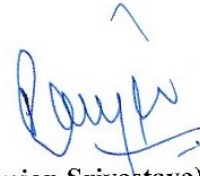
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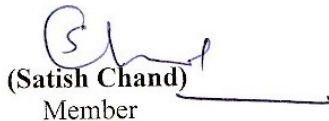
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Introduction



Floriculture is a burgeoning commercial sector in India, with revenue produced from both export and domestic consumption. As a result, floriculture has become one of the most important commercial trades in agriculture. Commercial floriculture has emerged as a hi-tech activity under controlled climatic conditions inside the greenhouse. The relaxation in industrial and business-related policies made the way stronger for developing export-oriented production of cut flowers. In 2018-19, India exported 19726.57 MT of floriculture products to the world for worth ₹ 571.38 crores/81.94 million USD \$ (**Anonymous, 2018**). Floriculture commodities mainly consist of cut flowers, cut foliage, pot plants, seeds, bulbs, root cuttings, tubers, dried flowers or leaves. Moreover, various value-added products like rose water, gulkand, perfumes, essential oils, insect repellents, cosmetics, etc. are also obtained from floriculture. Rose, chrysanthemum, carnation, gerbera, gladiolus, gypsophilas, orchids, archilea, anthurium, tulip and lilies are among the most common cut flower crops in the international flower trade.

Among all flower crops, chrysanthemum (*Dendranthema grandiflora* Tzvelev.) is one of the most popular flowering plants belonging to Asteraceae family. Chrysanthemum ranks second in the cut flower trade after rose at the dutch auctions, which is a good indicator of its global business. In India, chrysanthemum occupies a place of pride, both as a commercial flower crop and a popular exhibition flower. It is very popular as cut flower, loose flower, as well as pot plant (**Kumar et al., 2017**). Chrysanthemum is native of Northern Hemisphere predominantly in Europe and Asia. Confucius, a great Chinese philosopher, who has mentioned the chrysanthemum in his writings in 500 BC, marked the chrysanthemum as one of the most significant ancient cultivated flowers. Popularization and large-scale cultivation of chrysanthemum was started in China. In Japan, being the national flower, its cultivation became prevalent and its cultural practices were standardized and evolved a lot of species from there. From Japan, it reached England in 1789 via France and Holland, did good improvement

work, and produced many exhibition varieties. Chrysanthemum is famous by different names in various languages in India. It is called "*Chandramallika*" in Bengali, "*Shevanti*" in Marathi and Gujarati. In Hindi, it is known as *guldaudi* meaning flower of Daud, which suggests that chrysanthemum was grown in the Mughal period of the country (**Kher, 2014**).

Nutrients are the primary entity present in the soil, which are exploited by the human in crop production. The nutrients transfer from the ground into the crop; hence their quantity declines after harvest. Its concentration is still recovering in the soil either through natural decomposition or artificial chemical fertilizer application. Although, chemical fertilizers are beneficial for plants as they ameliorate growth, development, vigour and productivity of the plants, but their continuous use in excess has led to various problems.

Moreover, a large portion of applied chemical fertilizer gets converted into an immobilized form in the soil and becomes inaccessible for the plants. The toxic compound of the chemical fertilizers gets fixed in various parts of crops, which, upon consumption, accumulates in the human body and leads to numerous health-related issues and diseases. The harmful effects of chemical fertilizers start from their manufacturing process because it generates numerous toxic by-products such as NH_4 , CO_2 , CH_4 , etc. during their manufacturing, which leads to air pollution and the disposal of their untreated wastes from industries into water bodies causes water pollution. Moreover, a hazardous outcome of chemical fertilizer accumulation is eutrophication in water bodies, leading to the depravation of water and death of aquatic flora and fauna. In addition, intensive application of chemical fertilizers into the soil for a longer period degrades soil quality and health, ultimately converting fertile land into barren land and declining its productivity, hence cause soil pollution. Therefore, it is time to understand that intensive application of chemical fertilizers is the main reason for depleting the environment and ecosystem. Thus, its excessive use without any remedial strategy will exhaust all land and lapse food security on the earth. Therefore, alternative methods or technologies are required to reduce dependency on chemical fertilizers and sustainably accomplish food demands. One of the revolutionary approaches is applying organic

inputs such as manure, biofertilizers, biopesticides, slow-release fertilizer, nano fertilizers, etc. It improves plant growth, productivity, nutrient content, soil health and enhances the use efficiency of the chemical fertilizers. Implementation of organic farming will generate the healthiest natural environment for present as well as future generations. Organic manures directly help to increase the productivity of soil in the long run and produce chemical residue-free healthy crops (**Chakraborty and Sarkar, 2019**). Hence, there is an urgent need for the development of organic modules and promoting organic cultivation technologies of cut flowers (**Selvaraj et al., 2007**). Many other technologies are emerging in the manner of slow or continuous release fertilizers, prilled or granulated fertilisers, nitrification inhibitors and similar substances. There are a lot of valuable strategies we can implement to confront these serious problems and help save the ecosystem.

The use of organic liquid preparations has been an age-old practice in India. *Kunapajala*, an on-farm product, prepared by fermenting animal flesh and herbal products was used to be an established technique in ancient India. As an alternative, the number of organic farmers devised organic boosters based on local experiences and gave specific names such as *Amritpani*, *Panchagavya*, *Bijamrita*, *Jiwamrita*, etc. Similarly, in other organic farming systems, few adequate preparations such as BD 500, BD-501, Cow Pat Pit, BD-liquid manures and in Homa Organic Farming, Agnihotra ash enriched water and Biosol are practical tools that were used by several organizations. It is interesting to note that in all these preparations, the essential ingredients are cow-based products. To give the generic name, subsequently, these are named as "Bio-enhancers". Review of available literature with bio-enhancers indicates that there is immense scope for their promotion in agriculture. Bio-enhancers are organic preparations obtained by active fermentation of animal and plant residues over a specific duration. These are rich sources of microbial consortia, macro and micronutrients and plant growth-promoting substances, including immunity enhancers. It is interesting to know that we can prepare these at the farm with some basic infrastructure facilities and hands-on training. These are utilized to treat seeds/seedlings

and enhance the decomposition of organic materials, thereby enriching the soil and inducing better plant vigour (**Pathak and Ram, 2013**).

Organisms (bacteria and moulds) improve soil health by solubilizing the complex organic substrates into simple forms and make them available to the plants, resulting in increased productivity. It is pertinent to mention that "cow" plays a vital role in most organic farming systems prevalent in India and elsewhere (**Pathak, 2010**). Different organic methods use five cow products (dung, urine, milk, ghee and curd). It is said that the organisms partially assimilate food that enters in cow's intestine to develop their dynamic forces. Most of these are excreted along with dung. It is unfortunate that with the advent of fertilizers, slowly Indian farmers have forgotten cow products in agriculture and thus face the current crisis. Now, it is high time that the farming community and scientific fraternity must accept the importance of cow for assuring sustainability in farming and try to bring cow's glory again with our culture and agriculture. For sustainability in agriculture, one should adopt liquid organic manures to no small extent (**Kannaiyan, 2000; Kanwar et al., 2006**). Nowadays, liquid organic manures are becoming popular to combat the adverse effect of chemical fertilizers. They can supply essential nutrients to crop plants and provide several growth promoters and bio-control agents to prevent disease and pest infestation. Among different biodynamic manures, liquid organic manures such as *Panchagavya*, *Jeevamrutha*, *Beejamrutha* and *Kunapajala* are traditional manures that can be prepared easily with minor farm inputs and household materials. So, the required cost for these liquid organic manures is significantly less as compared with the chemical fertilizers. According to the Hindu mythology, *Panchagavya* has a significant influence on plant development. According to the Ayurveda, it is used as a medicine and it has been used as an organic fertiliser and pesticide (**Dhama et al., 2005**). It is a special bio-enhancer prepared from five products obtained from cow, *i.e.*, dung, urine, milk, curd and ghee. When these are mixed in a correct proportion, incubated for the recommended period, the ready fermented solution has miraculous effects on crops. This preparation is rich in nutrients, auxins, gibberellins and microbial fauna and acts as a tonic to enrich the soil, induce plant vigour with quality production. In the

beginning, pioneer work has been done by a medical doctor (**Natarajan, 2003**), which was subsequently studied by TNAU, Coimbatore and other institutes where they have reported the positive influence of such preparations on growth and development of various crops. As Panchagavya contains macro as well as micro-nutrients along with various bioagents such as *Azospirillum*, *Azotobacter*, *Phosphobacteria* and *Pseudomonas* (**Yadav and Lourduraj, 2005**), growth-promoting enzymes along with essential plant nutrients (**Swaminathan, 2005 and Sreenivas et al., 2011**), it is now gaining attention as an efficient organic growth promoter. The composition of Panchagavya investigated by **Patnaik et al. (2012)**, revealed the presence of aerobic heterotrophic bacteria, lactic acid bacteria, yeast, fungi and anaerobic bacteria.

Another bioagent is Jivamrita, which is also pronounced as *jivamruta*, *Jeevamrutha*, etc., in India. *Jeevamrutha* is one of the four pillars of Zero Budget Natural Farming (ZBNF). *Jeevamrutha* is highly cost-effective for farmers (**Anonymous, 2016**). The meaning of *Jivamrita* is the 'Nectar of life'. Jivamrita is popularized by Shri Subhash Palekar and considered a panacea for small farmers' prosperity. It is essential to provide a friendly environment for microorganisms. These microorganisms make nutrients, viz., nitrogen, phosphorus and potassium available to the plants through several mechanisms such as potassium, phosphate, zinc solubilization, iron chelation, IAA production, etc. which improve the growth of the plants.

The application of Jivamrita to soil improves the soil considerably. It also encourages microbial activity in the ground. Credit for the development of recipes for Jivamrita and its extensive use goes to **Palekar (2006)**, a strong natural farming promoter. Jivamrita can be used at 15 to 30 days interval through irrigation water coupled with mulching (green/dry monocot + dicot) and proper soil aeration. *Jivamritha* should be used within 3-7 days of its preparation. *Panchagavya* and *Jivamritha* have good potential as manure to improve physical, chemical and biological properties of soil. In the commercial cultivation of chrysanthemum, the conventional farming system leads to the deterioration of crops and soil. These problems can be nullified through organic farming as chemical fertilizers are continuously increasing the soil health, growth and productivity-related problems, which ultimately deteriorate

human health and the environment. Keeping these aspects in mind, the present investigation was designed to address the problems as mentioned earlier and promote the growth of chrysanthemum with the application of two liquid organic bio-enhancers *i.e.*, *Panchagavya* and *Jivamrita* with the following objectives:

Objectives

- To study the effect of organic manures and biodynamic amendments on vegetative growth and flowering in chrysanthemum cv. Thai Chen Queen
- To evaluate the influence of organic manures and biodynamic amendments application on postharvest life and economics (cost of cultivation) of chrysanthemum cv. Thai Chen Queen
- To determine the influence of organic manures and biodynamic amendments on soil nutrient status (N, P and K), microbial count (fungi, bacteria and actinomyces) and metagenomic analysis of best treatment.



*Review
of
Literature*



The scripts of the Vedas (divine writings of Indian wisdom) and Vrikshayurveda (*Vriksha* means plant, and Ayurveda means health system) describe Panchagavya. The texts in Vrikshayurveda are systematizations of farming methods at the field level, placing them in a theoretical sense and describing such plant growth stimulants. Panchagavya is one of the liquid bio-stimulants derived from cow products, typically used in agriculture and horticulture for different crops. Panchagavya is a Sanskrit word that refers to a mixture of five cow-based products: cow dung, urine, milk, curd and ghee. When properly mixed and applied, these have miraculous effects. Panchagavya can be applied in a variety of ways, including foliar spray, soil application, irrigation water, seeds or seedling treatment, and so on. It improves crop growth, pest and disease resistance, and fruit and vegetable quality (**Natarajan, 2002**).

Panchagavya has got the reference in Vedas' scripts and Vrikshayurveda. The texts on Vrikshayurveda are systematizations of the farmers' practices at the field level, placed in a theoretical framework, and defined certain plant growth stimulants. Among them, Panchagavya is an important one that enhanced crop plants' biological efficiency and the quality of fruits and vegetables (**Natarajan, 2002**).

Jivamrita is also referred in India as *Jiwamrita*, *Jivamruta*, *Jeevamrutha*, etc. The 'Nectar of life' is the meaning of Jivamrita. Popularized by Shri Subhash Palekar, Jivamrita is considered a panacea for the prosperity of small farmers. It is important to provide microorganisms with a pleasant environment that helps make the necessary nutrients for plant growth available, such as nitrogen, phosphorus and potassium. For beneficial microbes, it also provides a suitable environment. The application of Jivamrita to the soil significantly improves the soil. In addition, it promotes microbial activity in the soil. Credit goes to Sh. Palekar, a strong natural farming promoter, for the development of recipes for Jivamrita and its extensive use. It should be used through irrigation water coupled with mulching green/dry (monocot + dicot) and proper soil aeration at 15 to 30 days interval. Jivamrita is a rich bio-formulation of beneficial

microbes containing consortia. Within 3-7 days of preparation, this formulation is used **(Palekar, 2006)**.

The traditional agriculture practiced by our forefathers was purely organic. The use of animal excrement on cultivated soils was usual as far back can trace agricultural records. The use of mineral salts as fertilizer material to promote plant growth was established only during the last 100 years In the previous few years, based on the famous "Mineral Nutrition Theory" proposed by German chemist Justus Von Liebig in 1840, in which he demonstrated potassium's essentiality in 1845 while Lawes, Gilbert, and Pugh of Rothamsted Experiment Station, England, established nitrogen's essentiality. Similarly, albeit bones were one of the first fertilizing materials and animal excrement, guano excreta, fish wastes, wood ash, etc were other fertilizing materials. Basic slag is a phosphorus source used in England in 1884. The above-mentioned materials are the nutshell traces of the origin, development and use of N, P and K as fertilizer elements in the past **(Ramnathan, 2006)**.

Chaudhary (2010) used various biofertilizers (*Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria and *Arbuscular Mycorrhiza* fungi) to demonstrate their suitability for use in a variety of flower crops, including rose, tuberose, carnation, marigold, aster and jasmine. These biofertilizers have been discovered to aid in plant nutrient uptake, the release of growth hormones and antibiotics, and the improvement of plant quality. Biofertilizers can increase plant growth by identifying the best strains of microorganisms, verifying their compatibility and combining their efficiency before using them in the crop production system as a potential source for sustainable horticultural systems, particularly in floriculture.

Hayat et al. (2010) reported that soil bacteria convert atmospheric N₂ into ammonia, which is beneficial to soil and plant health. They are important for nutrient cycling in the soil. In the soil, there are many different microbial genera, many of which are essential for nutrient cycling and disease protection. Plant growth-promoting rhizobacteria (PGPRs) benefit plant growth and development in many ways, both directly and indirectly. The development of secondary metabolites, *i.e.*, plant growth metabolites, changes in root morphology result in greater root surface area for the

uptake of nutrients, antagonism to soil-borne root pathogens, phosphate solubilization, and di-nitrogen fixation. The root surface area for nutrient uptake and PGPR production may help to improve nutrient cycling in the event of stress caused by unsuitable weather or soil conditions. Biological legume inoculums have generated a lot of curiosity around the world. Other PGPR inoculants (*Azospirillum*, *Azotobacter*, *Bacillus*, *Pseudomonas*, etc.) are also available for different crops and can be used alone or in combination with *Rhizobium sp.* These technologies have shown to be effective in regulated environments (laboratories and greenhouses), but natural variations make it difficult to predict how PGPR will perform in the field. PGPR must be artificially propagated to improve its viability and biological activity in field applications. It is also recommended that PGPR should be reinoculated every year/season because they cannot survive forever in the soil.

Chadha et al. (2011) studied the efficacy and effectiveness of Panchagavya in supplementing and protecting crop nutritional needs from disease. The nutritional and microbial study of Panchagavya revealed the existence of various macro- and micronutrients as well as a large population of important microbes such as *Azotobacter sp.*, *Actinomycetes sp.* and phosphate solubilizers. In comparison to control, Panchagavya was found to be quite effective in enhancing the productivity of knol-khol (31.8 per cent), onion (6.3 per cent) and pea seed yield (33.1 per cent). As a seed treatment for peas, Panchagavya was found to be very effective. It was also noticed that Panchagavya suppressed the growth of different plant pathogens by producing anti-bacterial and anti-fungal compounds, hormones and siderophores. Panchagavya was found most effective in controlling cauliflower stalk rot (88.9 per cent).

Vedic literature (Vrikshayurveda) has clearly outlined systematised agricultural practises that have insisted on the use of Panchagavya (a mixture of five cow products in a particular proportion) and Kunapajala (a decomposed fish or animal product in liquid form) to improve the biological efficiency of crops and the production of fruits and vegetables. Seedlings of chili, tomato and cowpea were treated with Panchagavya, Kunapajala, and a combination of both along with control. Panchagavya and Kunapajala were prepared according to Vrikshayurveda and used as soil drenching on seedlings at a rate of 3 and 1%, respectively. In all three treatments, the experimental seedlings of each

crop had higher rates of linear growth of both shoots and roots than the control. In comparison to control, for all of the vegetables growth parameters and yield, a combination of Panchagavya and Kunapajala produced the best results. The application of two organics resulted in consistently higher leaf chlorophyll content, which was reflected in the crops' increased fruit yield. Application of Panchagavya in all three vegetables significantly induced the production of defense-related enzymes such as polyphenol oxidase that could have enhanced the induced systemic resistance in the plant body, which would have reduced the disease incidence (**Sarkar *et al.*, 2014**).

The greatest challenge of India in the coming years will be to ensure that its rising population has access to healthy food. Organic farming, which improves agroecosystem health, has gained wide acceptance as a viable alternative to traditional food products and confirms healthy food for human consumption. As a result, natural products like Panchagavya are needed to grow chemical residue-free food crops, and Panchagavya can thus play an important role in organic farming (**Singh *et al.*, 2018**).

In agriculture, PGPR is being used widely, and it provides an alternative way to supplement and replace chemical inputs. PGPR is said to increase the highest growth, root and shoot growth, total plant biomass, early flowering, grain yield, fodder and fruits. Panchagavya is a low-cost organic liquid manure with regulatory substances like IAA (Indoleacetic acid), GA, cytokinins, essential plant nutrients and effective microorganisms that promote plant development. In addition, Jeevamrut has a high microbial load, which multiplies and improves the soil. Increased soil microbial activity ensures that nutrients are available and are absorbed by crops. Amritpani and the use of biofertilizers improve nutrient absorption in many crops (**Brar *et al.*, 2019**).

By default, in India, the large percentage of the cropped area is organic as resource-poor farmers cannot buy high-cost inputs such as chemical fertilisers, pesticides, etc. Therefore, organic production systems are always challenged by organic techniques to boost soil fertility, crop productivity and pest control. An age-old tradition in India has been the use of organic fluid preparations. The use of Panchagavya and Kunapajala to improve the biological productivity of crop plants and the production of fruits and vegetables was clearly illustrated in Vedic literature

(Vrikshayurveda), which insisted on using them to improve the biological productivity of crop plants and the production of fruits and vegetables. The Panchagavya and Kunapajala liquid organic manures have a strong capacity as manure to enhance the physical, chemical and biological properties of the soil. This leads to improved soil fertility and production of crops and offers health-free food grains and is used as an alternative to chemical fertilisers and pesticides. Thus, in organic farming and sustainable agriculture, Panchagavya and Kunapajala play a significant role (**Chandra et al., 2019**).

Ram and Pathak (2019) reported the use of bio-enhancers to overcome the indiscriminate use of agrochemicals over 5-6 decades which adversely affected soil fertility, crop productivity, product quality and the environment in particular. In most Indian soils, the organic carbon content of the soil has been reduced to $>0.5\%$. In these circumstances, the maintenance of soil fertility and crop production in agriculture are major challenges. Many macro-and micro-nutrients in one or the other areas of the country are also becoming deficient. Fertigation in most states is becoming common. Beyond the reach of ordinary farmers, most of the soluble fertilizers are imported into the country, which are very expensive. It was reported that "bio-enhancers" may be an inexpensive and alternative tool to resolve many problems, including an affordable and effective fertigation alternative. An age-old tradition in India has been the use of organic fluid preparations. Organic farmers, as an alternative, developed plant growth boosters based on local experiences and names such as *Amritpani*, *Panchagavya*, *Bijamrita*, *Jeevamrita*, etc. Similarly, there are few adequate preparations in biodynamic farming, such as BD-500, BD-501, Cow Pat pit, biodynamic liquid manures/bio-pesticides and Homa Organic Farming: water enriched with Agnihotra ash, and Biosol. Such suitable preparations are used by many farmers and organisations in India. It is important to note that cow-based products are the basic ingredients for these preparations. In organic crop production, studies conducted on bio-enhancers have shown an enormous variety of different crops.

A plant biostimulant is any substance or microorganism that is applied to plants to increase nutrient production, abiotic stress tolerance, or crop quality characteristics, regardless of nutrient content. Biostimulants are materials other than fertilisers that

encourage plant growth when applied in low concentrations. They offer a potentially novel approach to regulate/modify physiological processes in plants to stimulate development, alleviate stress-induced limitations and increase yield. Increased interest in sustainable agriculture favours research on more environmentally friendly, more readily available organic-based products. Global demand for residue-free pesticide products has evoked keen interest in crop production due to the adverse effects of conventional fertilizers on the environment. It uses eco-friendly materials that, besides protecting nature, are readily biodegradable and have no harmful toxic residues. Therefore, among farmers and research communities, the use of fermented organic nutrients such as Panchagavya, *Jeevamrit*, *Beejamrit*, Vermiwash, etc., is becoming common to increase crop productivity and achieve sustainable soil fertility, along with reducing the cost of cultivation (**Sharma *et al.*, 2019**).

A substance containing live microorganisms is referred to as a biofertilizer. The microbes employ various mechanisms to increase nutrient uptake, such as nitrogen fixation, solubilization of potassium and phosphorus, phytohormone excretion, production of substances that suppress phytopathogens, defence of plants from biotic and abiotic stresses and detoxification of pollutants below ground. Biofertilizers are considered promising and non-toxic alternative to synthetic agrochemicals, which involve reducing mycotoxin pollution by fungal control as well as excessive use of chemical fertilizers and pesticides. To eliminate the negative effect of chemical-based farming methods, various experiments are conducted using biofertilizers is an important discovery in sustainable agriculture (**Maçik *et al.*, 2020**).

The greatest challenges of the 21st century are environmental sustainability and food security. However, the green revolution has achieved high food production goals at the expense of environmental degradation, including water pollution, soil degradation, global warming and biodiversity loss. The two main challenges of the Indian farming system are feeding the increasing population and preserving the quality of the environment. A key component of India's food production seems to have been orthodox farming practices for centuries. These activities can reduce the various adverse effects of climate change in spatial and sequential terms. Three aspects of the cultivation of traditional Indian agricultural systems, methods of biological pest

control, and sustainable practices of crop protection are locally available. Double cropping, mixed cropping, crop rotation, agroforestry, local varieties and host pathogenic resource interactions are apparently traditional agricultural practices. By enhancing food quality, these activities play an important role in the sustainable development of agriculture (**Patel *et al.*, 2020**).

The overuse of chemical fertilizers has resulted into a major ecosystem deterioration in many areas of modern agriculture. Soil health is the crucial part of fertile soils which have been seriously damaged by modern farming practices. Excessive and unjustified synthetic fertilizers and pesticides have caused significant soil contamination that negatively impact the biodiversity of soils. The ground microbiota has been exposed to a high concentration of toxic, persistent and structural and functional chemical fertilizers and pesticides. Such chemical exposures to soils in agriculture are more relevant to their critical properties such as nutrient contents, dominant soil species, microbial structural and functional ecosystems, soil-enzyme activities and much more. These effects often range from brief, temporary and permanent to irreversible changes. However, in order to sustain overall soil quality and fertility, organismic improvements and biocontrol agents are better, thereby contributing to sustainable farming practices. In contrast to the chemical inputs, organic modifications are cost-effective and environmentally friendly solutions for a sustainable solution (**Sachchidanand *et al.*, 2020**).

Organic and biodynamic amendments have a potential scope in floriculture. However, the information on organic and biodynamic amendments in flower crop production is very scanty. A few workers have reviewed the available information on using these manures in other crops. It will be useful to review these works in chrysanthemum and related ornamental flower crops and supplement the view to strengthen the concept developed from the present study. Thus, after screening a broad spectrum of literature available on this line, some of the most relevant ones are being presented for vegetative, floral, post-harvest life, and soil nutrient status of chrysanthemum under the following heads:

2.1 Effect of Organic and Biodynamic Manures on Vegetative, Floral, Post-harvest attributes and Economics (cost of cultivation)

Beulah (2001) reported that in annual moringa, Panchagavya spray accelerated the days to first flowering and 50% flowering (93 days). Annual moringa quality parameters such as crude fibre, protein ($5.81 \text{ g } 100\text{g}^{-1}$), ascorbic acid ($209.47 \text{ mg } 100\text{g}^{-1}$), carotene content ($5.47 \text{ mg } 100\text{g}^{-1}$), and shelf life (5.48 days) were all higher when organic manure was applied with Panchagavya as a spray.

Bhalla et al. (2006a) conducted an experiment to see how biostimulants influenced flowering in gladiolus cv. Red Beauty. They found that application of 6% Manchurian mushroom tea + 6% Panchagavya produced the longest flowering period (14.70 days), the most florets per spike (13.53), and the largest florets (10.67 cm). whereas, maximum vase life (8.20 days) was observed with treatments 4% Manchurian mushroom tea. In addition, the maximum weight of corm (29.63 g), number of cormels per plant (11.3) and weight of cormels per plant (19.10 g) were recorded when plants were treated with 2 % Manchurian mushroom tea + 6% Panchagavya.

Bhalla et al. (2006b) investigated effect of bio-stimulants (Manchurian mushroom tea and Panchagavya) on standard carnation. Application of 3 percent Manchurian mushroom tea treatment resulted in full flower size and 'a' grade flower based on stem length. Moreover, they have recorded longest vase life in the treatment consisting of 3% per cent Manchurian mushroom tea + 3% per cent Panchagavya.

Dharma (2006) used spray of Panchagavya and Manchurian mushroom tea on carnation cv. Sunrise and found increase in plant height, leaf N, Ca, Zn and Mn content when 3% Panchagavya + 3% Manchurian mushroom tea was used, whereas, spray of only 3% Manchurian mushroom tea produced maximum stem length. Moreover, It was also observed that spraying with 3% Manchurian mushroom tea produced maximum flower size (8.26 cm) and 'a' grade flowers of maximum flower stem length (64.87 cm).

Rajesh et al. (2006) studied the effect of biofertilizers such as *Azospirillum*, VAM and PSB, as well as decomposed coir along with typical basal dose of *Trichoderma viridae*, FYM in the gladiolus cv. Red Beauty. The maximum plant height (102.8 cm) was achieved when plants were treated with 4% Manchurian mushroom tea

+ 6% Panchagavya, as was the maximum flowering period (14.70 days) with 6% Panchagavya, the largest number of florets per spike (13.53) with 4% Panchagavya, the largest florets (10.67 cm) with 6% Panchagavya, and the maximum vase life (8.70 days) with 6% Panchagavya.

Singh et al. (2006) carried out an investigation to evaluate the efficiency of various combinations of manures and biofertilizers on rose. Treatment consisting of FYM 4 kg/m² + NPK 25, 20 and 15 g/m² increased stem diameter (3.30 cm) and No. of leaves/plant (164.37) whereas, treatment combination of poultry manure 4 kg/m² + NPK 25, 20 and 15 g/m² + *Azotobacter* increased fresh weight of leaves (0.268 gm) and second order lateral shoots/plant (23.66). Moreover, combination consisting of poultry manure 4 kg/m² + NPK 25, 20 and 15 g/m² + VAM registered maximum flower production in all the three seasons *i.e.*, winter, summer and rainy (205.3, 340.0, 116.0 flowers/m², respectively).

Waheeduzzama et al. (2006) studied the effect of integrated nutrient management methods on improving the flower yield of *Anthurium andraeanum* cv. 'Meringue' by using six types of organic substrates and inorganic fertilisers. The treatment combination of Panchagavya 4% + 50% RDF affected the spathe length (7.5 cm), spathe width (7.0 cm), spadix length (4.5 cm) and spike length (32.10 cm) in a positive way. The results showed that using Panchagavya 4% foliar spray + 50% RDF increased flower size. Moreover, the treatment combination of vermicompost 100 g/plant + 50% RDF had the highest inflorescence longevity (88.30 days), number of days for exhibiting gloss loss, spathe blueing, and spadix necrosis (17.50, 18.50 and 21.6 days, respectively). In the treatment combination of vermicompost 100 g/plant + 50% RDF, the results showed that 4 per cent Panchagavya foliar spray + 50 percent RDF improved vase life of anthurium flowers.

Singh (2007) studied the effect of Panchagavya and Manchurian mushroom tea on tuberose cv. Pearl Double and found that 4 per cent spray of Panchagavya exhibited maximum vase life of spikes (17 days). The bulb characters *viz.*, average number of bulblets of size more than 1 cm (7.26) and average number of bulbs/m² (652.0) were significantly increased by Panchagavya 4% spray.

Singh et al. (2007) investigated the effect of organics (Panchagavya and Manchurian mushroom tea) with different concentrations (2 and 4%) and their combinations in tuberose (*Polianthes tuberosa* Linn.) cv. Pearl Double. Bulbs of the required size (1.5–2.0 cm) were planted at a 25 x 25 cm² spacing. Panchagavya (4%) spray had the earliest spike emergence (85.13 days) and number of days to first floret opening (25.13). The highest spike length (98.16 cm), lowest floret diameter (4.21 cm), number of florets/spike (65.25) and spike yield/m² (38.25) were all observed in the same treatment. In postharvest studies, Panchagavya (4%) spray had the highest total number of florets (50.75), number of opened florets (45.00), lowest floret diameter (4.15 cm), water uptake (135.50 mL) and vase life (17.00 days).

Selvaraj et al. (2007) conducted an experiment to observe the effect of Panchagavya spray 3% on plants and they observed that plants invariably produce bigger leaves and develop denser canopy in horticultural crops. The photosynthetic system is able to produce more metabolites and photosynthates, allowing for increased biological activity. Side shoots grew from the trunk, which are strong and capable of carrying a large number of fruits to maturity. Branching was abundant and thick. It was also found that the roots spread and penetrate into deeper layers. These roots aid in nutrient and water absorption. Panchagavya is used to increase the number of shoots, leaves and plant height in roses when pruned and budded.

Saraswati and Vadivel (2009) conducted an experiment with marigold (*Tagetes erecta*) cv. Local Orange in Coimbatore, Tamil Nadu. Treatments with the application of farmyard manure and recommended dose of fertilizer were included. The highest flower yield was recorded in the recommended dose of fertilizer followed by combined spraying of Panchagavya 3% + salicylic acid (100 ppm) + nitrobenzene (150 ppm). The next best results were recorded in nitrobenzene (150 ppm), nitrobenzene (150 ppm) + Panchagavya (3%), and Panchagavya (3%) alone.

Sangeetha and Thevanathan (2010) investigated potential of Panchagavya as a biofertilizer by growing the pulses *Vigna radiata*, *Vigna mungo*, *Arachis hypogea*, *Cyamopsis tetragonoloba*, *Lablab purpureus*, *Cicer arietinum*, and the cereal *Oryza sativa* var. Ponni in soil amended with dried traditional and seaweed-based

Panchagavya. Higher rates of linear growth of both shoots and roots than control were recorded by experimental seedlings. These seedlings produced 264 to 390 per cent more lateral roots than the control, and maximum lateral root development was observed at low concentrations in seedlings grown in soil modified with seaweed-based Panchagavya. The number of leaves produced, leaf area and the number of root nodules formed by rhizobia in the pulses were similarly observed. In plants grown in seaweed-based Panchagavya, a gradual decrease in the chlorophyll a/b ratio and a better efficiency of nitrogen use in these plants.

Sharma *et al.* (2010) reported the effect of biostimulant foliar sprays on growth and flowering of carnation cv. Sunrise. In each treatment combination, biostimulants such as 2, 4 and 6% solutions of Panchagavya and Manchurian mushroom tea were combined with two controls. Maximum plant height (71.00 cm), stem length (64.77 cm), number of flowers (6.60), flower size (4.99 cm), vase life (15.30 days) and 'a' grade flower based on stem strength (100%) and length were recorded in plants grown in 6% Panchagavya + 6% Manchurian mushroom tea. With 4% Panchagavya + 6% Manchurian mushroom tea, flowering was noticed in the shortest time (173.47 days). While with 6% Panchagavya + 6% Manchurian mushroom tea, the flowering period was found to be 23.57 days. For a 6% Manchurian mushroom tea, no calyx splitting was observed and Panchagavya (4%) had the lowest disease incidence.

Kumar *et al.* (2010) investigated the effects of NAA (Naphthaleneacetic acid) at 100 and 200 ppm, GA₃ (Gibberellic acid) at 100 and 200 ppm, BAP (Benzylaminopurine) @ 25 and 50 ppm, and Panchagavya (5 and 10%) on flowering and corm development in gladiolus cv. Candyman. Before planting, uniform sized (4 – 4.5 cm) corms were soaked in different concentrations of bio-regulators for 24 hours. Panchagavya @ 5% had the highest florets/spike (10.55), spike diameter (0.80 cm), rachis length (41.90 cm), corm weight (105.78 cm), cormels/plant (20.85) and propagation coefficient (525.25%). When corms were treated with Panchagavya @ 10%, maximum spike length (92.61 cm), length of first internode (5.44 cm) and corm diameter (7.79 cm) were all significantly increased. Early first floret showing colour (84.52 days), full opening of first florets (88.74 days), and full opening of last floret

(95.34 days) were observed after corm soaking with GA₃ (200 ppm). However, BAP (25 ppm) increased the weight of the cormels/plant (20.84 g).

Mahawer et al. (2010) reported that plants of tuberose cv. Phule Rajani were sprayed with 3% Panchagavya + 4% Manchurian mushroom tea; exhibited maximum flowering duration (140.50 days), length of spike (52.83 cm), weight of spike (79.18 g), number of florets per spike (50.17), florets remain open at a time (13.99), keeping quality of cut spikes in plain water (12.95 days), number of spikes per plant (2.55) and yield of spikes per square meter (22.95), followed by 4% Panchagavya + 2% Manchurian mushroom tea as compared to RDF-NPK @ 200 :150 : 00 kg/ha.

Kumar et al. (2011) investigated the effects of mixing chemical fertilizers, biofertilizers and biostimulants on gladiolus (*Gladiolus grandiflorus* L.) cv. Sancerre. The treatment T₁₇ i.e., CBD + Vermicompost 5 t/ha + Panchagavya 3% + Manchurian tea 3% had the longest spike length (88.2 cm), rachis length (62.4 cm) and number of florets per spike (14.4). common basal dose + Vermicompost 5 t/ha + Panchagavya 3% (T₁₆) had the longest flowering time (11.4 days) and the largest floret size of the treatments (10.5 cm).

Boraiah (2013) assessed the effect of FYM and coir pith compost, as well as Panchagavya (3 to 6%) spray on capsicum, which resulted in a higher net returns and B:C ratio. Similarly, spraying capsicum with Jeevamrutha, cow urine, and Panchagavya (3 – 6%) resulted in higher net returns and B:C ratios during *kharif* 2008 and summer 2009.

Naik et al. (2013) evaluated the stimulatory effect of Panchagavya on the *Cymbidium* cv. 'Sleeping Nymph'. The pseudobulb length and girth increased by 31.66 and 41.3 per cent, respectively, when 1:30 Panchagavya was added to the media. The media application of Panchagavya at 1:30, which resulted in a 130 per cent increase over control, had the greatest increase in spikes per plant (3), florets per spike (11.65), spike length (48.35 cm), and rachis length (24 cm). When the foliar application of Panchagavya was done at 1:30, the *Cymbidium* hybrids grew faster and came into blooms. *Cymbidium* hybrids developed and flowered best when Panchagavya was applied at 1:30 in the media or as a foliar application.

Verma et al. (2013) evaluated the combined effect of amended media and vermiwash on flowering of landscape gerbera grown under greenhouse condition. Cocopeat, perlite and vermiculite (CPV) and soil amended with vermicompost, Pusa Hydrogel (PHG) and horn bio manure (HBM) had significant positive effects on flowering of gerbera. Minimum days taken for appearance of first flower bud (49.67), minimum days taken for first flower harvest (71.67), maximum flower head diameter (10.11 cm), maximum days taken to flower senescence in plants (20.33), maximum fresh and dry weight of plants were recorded on cocopeat, perlite and vermiculite (CPV) + Pusa Hydrogel (PHG) + vermicompost with 20% vermiwash spray. Compared to all other treatments, chlorophyll content and relative water content were significantly higher with vermicompost 20%, Pusa Hydrogel (PHG) 0.25% and horn bio manure (HBM) 1.0% with 20% vermiwash spray. The beneficial effects of amended media were associated with change in physical and chemical properties and hormone like effect of vermiwash which increased the growth of plants. Therefore, it can be concluded that, plant performance was best in the media containing cocopeat, perlite and vermiculite (CPV) + Pusa Hydrogel (PHG) + vermicompost with 20% vermiwash concentration.

Bohra and Kumar (2014) studied the effect of organic and bio-inoculants on growth attributes of chrysanthemum cv. Little Darling. Among different treatments, the combination consisting of VAM (20 g/plant) + vermicompost (300 g/m²) increased the plant height (30.17 cm), number of primary and secondary branches (3.78 and 19.78, respectively), plant spread (28.53 cm) and number of leaves per plant (184.33). In addition to this increased flowering parameters like bud initiation in minimum days (55.78), days to first flowering (73.33), maximum flowering duration (28.33 days), flower longevity (16.33 days), number of flowers per plant (70.56), flower stalk length (7.80 cm) and weight of flower (1.67 g) also observed in same treatment.

Singh et al. (2015) investigated the effect of organic and biodynamic manures on growth of marigold (*Tagetes patula* L.). The results of experiment revealed that treatment combination consisting of sand + soil + vermicompost (1:1:2) + biodynamic amendment (5%) significantly gave maximum plant height (27.75 cm), plant spread (23.18 cm), number of branches per plant (25.45), stem diameter (1.55 cm), number of

leaves per plant (140.71), leaf length (9.31 cm) and leaf width (4.90 cm) compared to other treatments. Moreover, treatment with sand, soil and vermicompost (1:1:2), as well as a biodynamic amendment of 5% Panchagavya had significant effect on days to first flower bud initiation (24.22), flower bud diameter (1.94 cm), bud length (3.49 cm), number of flowers per plant (16.27) and flower diameter (7.98 cm) which are found to be superior over control.

Gayathri et al. (2015) studied the influence of Panchagavya on the growth of plants such as tomato, French bean and okra. Panchagavya was prepared and used to soak the seeds at first. The germination percentage was then assessed. The germination percentage of seeds treated with Panchagavya solution was found to be higher than that of control seeds. Plants treated with different concentrations of Panchagavya solution had their morphological characteristics such as the number of leaves, shoot length, and root length measured (5, 6, 7 and 8%). As the concentration increased, the values also got enhanced in all of the plants that were tested.

Harshavardhan et al. (2016) conducted an experiment with treatments consisting of 75% recommended dose of nitrogen, phosphorus and 100% potassium along with vermicompost, *Azospirillum brasilense*, *Bacillus megaterium*, VAM fungi, Panchagavya 3%, Jeevamrutha 10% and *Trichoderma* in carnation. They found highest plant height (92.60 cm), number of branches per plant (6.00), number of leaves per plant (171.30), individual leaf area (6.20 cm²), leaf area per plant (1062.06 cm²) and flower yield per m² for two years (739.59 flowers/m²). Even application of 50% recommended dose of fertilizers along with biofertilizers, organic manures and biostimulants were better than the inorganic source of nutrients alone. These results suggest that combined application of inorganic fertilizers, biofertilizers and biodynamic manures were superior over their individual application for better plant growth.

Kumbar and Devakumar (2016) studied the effect of different concentrations of Jeevamrutha and Panchagavya on French bean. They found that application of higher levels of Jeevamrutha (2000 l ha⁻¹) and Panchagavya (6%) recorded significantly higher plant height (27.26 and 26.74 cm), No. of branches (6.64 and 6.13), leaf area (1181.26 and 1136.6 cm²), pods per plant (15.36 and 14.69) and green pod

yield (134.3 and 124.4 q ha⁻¹) followed by Jeevamrutha at 1500 litres per ha and 1000 l ha⁻¹ application (115.0 and 106.7 q ha⁻¹) and Panchagavya at 3 per cent (116.0 q ha⁻¹). Significantly lower growth and green pod yield (101.4 q ha⁻¹) was found in treatment without Panchagavya and Jeevamrutha application.

Trivedi et al. (2016) carried out an investigation to find out the response of different bio-enhancers, *i.e.*, *Panchagavya*, *Jivamrita* and vermiwash on flowering of rose (*Rosa hybrida*) cv. Grand Gala. There were three levels of each treatment used. Panchagavya at 0, 3 and 6% and Jivamrita at 0, 20 and 30% were drenched while vermiwash was sprayed on the plants at 0, 1:5 and 1:10 times dilution. Results revealed that treatment combination of 6% Panchagavya + 1:5 times dilution of vermiwash + 30% Jivamrita was found to be the most superior than other treatments and resulted in earliest bud initiation (52.83 days), maximum number of flowers/plant (4.50), maximum flower bud length (4.83 cm), maximum number of petals/flower (30.71), larger flower diameter (8.97 cm), duration of flowering (25.40 days), flower stem length (109.75 cm), flower stem thickness (8.25 mm) and flower yield (9.33/m²). Similarly, treatment combination of 6% Panchagavya + 1:5 times dilution of Vermiwash + 30% Jivamrita also demonstrated elevated attributes of post-harvest attributes, *viz.*, initial flower diameter at harvesting stage (5.68 cm), final flower diameter in vase (8.43 cm), initial flower weight at harvesting stage (26.05 gm), final flower weight in vase (25.56 gm).

Boraiah et al. (2017) conducted an experiment to study the effect of different sources and levels of organic manures and Panchagavya spray on capsicum growth and yield. Significantly higher growth, yield and yield attributes were recorded with various organic manure sources and levels. Among the sources, application of FYM with 3% Panchagavya spray recorded a higher yield of 692.14 q ha⁻¹, fruits (89.28 No.), branches (43.58 No.) and plant height (44.83 cm). Whereas, composted coir pith with 6% Panchagavya spray recorded a higher yield of 529.60 q ha⁻¹, fruits (57.55 No.), branches (25.31 No.) and plant height (32.96 cm).

Gopal et al. (2017) reported that 4% Panchagavya increased the gross returns (₹. 89,642.00 ha⁻¹), net returns (₹. 67042.00 ha⁻¹) and B:C ratio (2.96:1) in blackgram as compared to control and other doses of Panchagavya.

Patel et al. (2017) conducted an experiment to study the effect of organic manures and biofertilizers on yield of rose (*Rosa hybrida* L.) cv. Gladiator and they reported that the treatment consisting of castor cake @ 0.8 kg + *Azotobacter* @ 1 mL + phosphate solubilizing microorganisms @ 1 mL + potash solubilizing bacteria @ 1 mL / plant resulted in maximum gross returns (₹. 8.64 lakh ha⁻¹) and net return (₹. 5.39 lakh ha⁻¹) but the highest B:C ratio (2.70:1) was obtained under the treatment consisting farmyard manure @ 4 kg + *Azotobacter* @ 1 mL + PSM @ 1 mL + KSB @ 1 mL / plant.

Sendhilnathan et al. (2017) investigated the effect of bio-regulators and organics on Gundumalli (*Jasminum sambac* Ait.) growth and yield. Foliar applications included organic manures such as farmyard manure, vermicompost and bioregulators such as naphthaleneacetic acid, gibberellic acid and Panchagavya. Plant growth characters such as plant height (124.52 cm), number of primary shoots (10.71), number of secondary shoots (10.41), number of leaves (260), leaf area (27.56 cm²), number of active shoots (55.47) and chlorophyll content (2.64 CCI) were significantly increased when vermicompost @ 2.5 t ha⁻¹ was combined with a foliar spray of Panchagavya @ 3%. The initiation of flowering (50.97 days), length of a flower bud (3.66 cm), diameter of a flower bud (3.58 cm), bud length without corolla (1.89 cm), and corolla tube length (1.63 cm) and flower yield characteristics such as hundred bud weight (26.39 g), flower yield per plant (677.74 g), flower yield per plot (4066.44 g) and flower yield per hectare were increased significantly. The treatment combination of vermicompost @ 2.5 t ha⁻¹ and foliar spray of Panchagavya 3 per cent was found to be the best treatment for Gundumalli production in open field conditions.

Sau et al. (2017) investigated application of three fertilizer sources on mango tree growth, yield and fruit quality to find out how healthy each tree and soil is in the orchard. The Panchagavya treatment led to a substantial increase in canopy spread, yield and fruit weight, while treatment using chemical fertilizers and control plants yielded the lowest results. The biofertilizer (*Azotobacter chorococcum* + *Azospirillum brasilense* + AM (*Glomus musseae*) and Panchagavya @ 3% showed maximum fruit weight (237.12 g), yield (42.14 kg plant⁻¹), and fruit biochemical qualities like TSS

(19.70 °Brix) and total sugars (13.41%) with a shelf life of 10 days. The same treatment exhibited maximum content for soil bacterial population and usable N, P and K in soil and leaf, while control plants exhibited minimal results. To maintain soil health, biofertilizer and liquid organic manure (*Azotobacter chorococcum* + *Azospirillum brasilense* + AM (*Glomus musseae*) + Panchagavya 3% may be a good alternative for the mango growers

Vetrivel et al. (2017) carried out an investigation for the effect of bio-stimulants on growth and yield of chrysanthemum var. Amalfi during the period from August 2013 to April 2014. The treatments comprised of Panchagavya (2 and 4%), seaweed extract (2 and 4%) and their combinations along with control. Among the treatments applied, maximum plant height (98.43 and 144.23 cm), number of leaves (34.64 and 39.78) at bud appearance and peak flowering stage, respectively. internodal length (4.45 cm), leaf area per plant at bud appearance (1205.06 cm²) and peak flowering stage (1516.78 cm²), number of flowers per spray (9.20), stalk girth (3.18 cm), flower diameter (6.33 cm), A grade stems (72.49) and vase life (14.22 days) were recorded in Panchagavya @ 2% + seaweed extract @ 4%. Thus, it can be concluded from the findings that application of Panchagavya @ 2% + seaweed extract @ 4% can be recommended for the commercial cultivation of chrysanthemum var. Amalfi.

Boraiah et al. (2018) studied the effect of interaction between different liquid formulations (Panchagavya, Jeevamrutha and cow urine) and reported that 10% spray of Jeevamrutha in capsicum has higher shelf life (19.06 days) while lower shelf life (15.67 days) was observed without Jeevamrutha. Similarly, 6% Panchagavya spray influenced shelf life significantly. Higher shelf life of 18.58 days while lower shelf life of 16.21 days was recorded without Panchagavya spray. Shelf life of capsicum did not vary significantly due to the interaction effect of Jeevamrutha and cow urine, Jeevamrutha and Panchagavya and cow urine and Panchagavya.

Vishwajith and Devakumar (2018) reported that the use of 5% Panchagavya result in substantial differences in okra growth and yield. At all stages of crop development, except at 30 DAS, the application of Panchagavya resulted in substantial differences in growth parameters At 60, 90 days after planting and harvest, foliar sprays

of 5% Panchagavya substantially increased plant height (42.60, 77.83 and 86.66 cm), leaf area (2044, 3231, and 1889 cm² plant⁻¹), and total dry matter accumulation (25.49, 51.48 and 61.29 g plant⁻¹), respectively.

Reshma et al. (2019) conducted an experiment to study the effects of various levels of Jeevamrutha and Panchagavya on cowpea growth and yield attributes. Application of Jeevamrutha at 1000 l ha⁻¹ and Panchagavya at 7.5% significantly influenced plant height, number of branches, number of leaves, leaf area, and leaf area index. The interaction of Jeevamrutha and Panchagavya increased cowpea grain yield, with benefits including more pods per plant, longer pods, higher pod weight, and more seeds per pod. The interaction between Jeevamrutha and Panchagavya, as well as the complete and effective number of nodules, as well as the fresh and dry weight of nodules, caused significant changes in nodule characteristics. In order to increase cowpea grain yield, both Jeevamrutha and Panchagavya were useful.

2.2 Effect of Organic and Biodynamic Manures on Soil Nutrient Status (N, P and K), Microbial Count (Fungi, Bacteria, Actinomyces) and N-fixers, P-solubilizers

Beulah (2001) reported that different organic manures and bioenhancers (poultry manure + neem cake + Panchagavya) treatments have sufficient amounts of secondary and micronutrients (Ca, S and Fe), as well as macronutrients (N, P and K) in annual moringa leaves and pods. In both the main and ratoon crops of annual moringa, higher nutrient uptake and nutrient use efficiency were observed. Similarly, under organic manure applied with Panchagavya spray, quality parameters such as crude fibres, protein, ascorbic acid, carotene content and shelf life were all higher.

Yadav and Lourduraj (2007) studied the effect on soil microbial mass and soil enzyme activity of organic manures (farmyard manure, composted poultry manure, composted coir pith and green leaf manure) application and foliar spray of 3 per cent Panchagavya on rice. The findings showed that Panchagavya spray had no significant impact on soil characteristics. 50 per cent N application through composted poultry manure + 50 per cent N application through green leaf manure reported higher bacteria (36.50 CFU 10⁶ g⁻¹), fungi (52.17 CFU 10³ g⁻¹) and actinomycetes population (31.17 CFU 10⁴ g⁻¹) as well as higher dehydrogenase (25.25 micro g TPF g⁻¹ soil 24 h⁻¹),

urease ($46.26 \text{ micro g NH}_3 \text{ g}^{-1} \text{ soil } 24 \text{ h}^{-1}$) and phosphatase ($26.31 \text{ micro g nitrophenol g}^{-1} \text{ soil h}^{-1}$) enzyme activity, which was significantly superior to recommended NPK fertilizers applied.

Ali et al. (2011) studied the effects of Panchagavya and sanjivini on green gram (*Vigna radiata*), chili (*Capsicum frutescens*) and mustard (*Brassica campestris*). It was found that organic carbon content increased from 0.71 to 1.1 percent, available phosphorus increased by more than three times, and potassium increased by more than two times after a year of organic farming. The pH and EC values were close to neutral (pH from 6.8 to 7.0 and EC from 0.2 to 0.3 m mhos).

Kumawat et al. (2010) observed that growth and yield increased significantly in groundnut as Panchagavya solution was increased from 0 to 3.0 lit/m^2 . Panchagavya solution at 3.0 lit/m^2 increased pod, haulm and biological yield by 85%. It increased SLW (Specific leaf weight), CGR (Crop growth rate), RGR (Relative growth rate) and NAR (Net assimilation rate). At 35 and 55 days after application, the leaves of the plants were examined for growth and yield in comparison to a water-sprayed control. The foliar datura + Panchagavya solution application increased CGR, RGR, and NAR at 45–70 DAS and 70 DAS–harvest compared to other foliar applications sources. Application of 3 lit/m^2 of Panchagavya to the soil increased the availability of all major and minor nutrients like P, Fe, Cu, Zn and Mn compared to other Panchagavya levels. Soil organic carbon increased due to Panchagavya providing available OC (with 1.5 percent OC)

Gore and Sreenivasa (2011) reported that Jeevamrutha contains a large amount of microbial load that multiplies and acts as a soil tonic. It is used to boost microbial activity in the soil, ensuring nutrient availability and absorption by crops. Jeevamrutha supports a lot of biological activity in the soil and lets crops get more nutrients. Jeevamrutha is a low-cost improvised preparation that enriches the soil with indigenous microorganisms, making mineralization possible.

Kumawat et al. (2012) tested the effect of plant leaf extracts on biochemical properties, yield, and yield attributes in the soil of groundnut (*Arachis hypogaea* L.) under irrigated conditions. As Panchagavya levels increased from 0 to 3.0 lit/m^2 ,

groundnut dry matter, chlorophyll content, nitrate reductase activity, yield and yield attributes all increased significantly. Application of Panchgavya @ 3.0 lit/m² increased pod, haulm, and biological yield by 85, 93, and 90%, respectively, over the control. At 35 and 55 days after sowing, neem (*Azadirachta indica*), datura (*Datura metel*), and tumba (*Citrullus colocynthis*) leaf extracts combined with Panchgavya in a 1: 1 ratio increased chlorophyll, plant dry matter, yield attributes and pod yields compared to a water sprayed control. Among the biochemical properties, pH was decreased by the application of Panchagavya. This might be due to organic acids produced during Panchgavya fermentation by *Lactobacillus*, *Saccharomyces*, *Streptomyces*, *Rhodopseudomonas* and *Aspergillus* may have lowered the pH of both the formulation and the soil rhizosphere.

Devakumar et al. (2014) reported that a Jeevamrutha formulation with a pH of 4.92 contains nutrients such as nitrogen, phosphorus, and potassium (1.96, 0.28 and 0.17 percent, respectively), as well as micronutrients such as magnesium (46 ppm) and copper (51 ppm). They also revealed that the microbial load is typically lower on the day of Jeevamrutha preparation, and that it reaches its peak on the tenth day of preparation and then gradually diminishes as the day progresses. The highest colony forming unit of bacteria (855×10^5), fungi (29×10^5) actinomycetes (8×10^5), N-fixers (69×10^4), and P-solubilizers (80×10^3) can be found on the tenth day of Jeevamrutha preparation.

Lavanya et al. (2016) revealed that maximum population of general bacteria, fungi, actinomycetes, N-fixers, *Pseudomonas* and PSB were observed to be 40×10^5 , 32×10^3 , 15×10^4 , 21×10^5 , 3×10^5 and 25×10^5 CFU g⁻¹, respectively in the soil treated with Jeevamrutha at 400 l acre⁻¹ and 7.5 per cent Panchagavya in field bean when compared to without Jeevamrutha and Panchagavya treated soil (5×10^5 , 3×10^4 , 8×10^3 , 10×10^5 , 1×10^5 and 10×10^5 CFU g⁻¹ general bacteria, fungi, actinomycetes, N-fixers, *Pseudomonas* and PSB, respectively).

Boraiah et al. (2017) studied the effect of organic liquid formulations on beneficial microorganisms and yield of capsicum. Among different organic liquid formulations, application of Jeevamrutha recorded significantly higher fruit yield

(32.26, 39.55, 51.63, 121.20, 100.28, 86.40, 50.05 q ha⁻¹ at 60, 70, 80, 90, 100, 110 and 120 DAT, respectively), N-fixers (23.86, 24.49 at 60 DAT and 16.79, 17.37 X 10³ at harvest during *kharif* and summer, respectively) and P-solubilizer (27.90, 31.50 at 60 DAT and 26.68, 30.43 X 10³ at harvest during *kharif* and summer respectively). Significantly higher fruit yield (30.76, 38.0, 48.52, 117.73, 97.15, 84.33, 48.44 q ha⁻¹ at 60, 70, 80, 90, 100, 110 and 120 DAT, respectively), N-fixers (23.18, 25.03 x 10³ at 60 DAT and 16.48, 18.27 x 10³ at harvest during *kharif* and summer seasons, respectively) and P-solubilizer (28.91, 31.18 x 10³ at 60 DAT and 27.26, 30.34 x 10³ at harvest during *kharif* and summer seasons, respectively) were recorded with the application of cow urine. Application of Panchagavya 6 per cent spray recorded significantly higher fruit yield (30.25, 37.49, 48.91, 118.91, 96.15, 86.29, 47.81 q ha⁻¹ at 60, 70, 80, 90, 100, 110 and 120 DAT, respectively), N-fixers (23.68, 25.59 x 10³ at 60 DAT and 17.77, 17.18 x 10³ at harvest during *kharif* and summer seasons, respectively) and P-solubilizer (28.43, 33.04 x 10³ at 60 DAT and 27.46, 34.53 x 10³ at harvest during *kharif* and summer seasons, respectively).

Devakumar et al. (2018) studied the influence of organic liquid manures, Panchagavya and Jeevamrutha on soil microbial population and yield of field bean (*Dolichos lablab* L.) and the soil samples from rhizosphere were analysed at initial and final stages of crop growth for different groups of micro-organisms by Serial Plate Count method. Among different treatments tested, treatment combination of Jeevamrutha 10% and Panchagavya 7.5% recorded maximum population of general bacteria, fungi and actinomycetes (Initial: 40.33 x 10⁵, 20.33 x 10⁴, 15.33 x 10³ CFU/g and final: 50.33 x 10⁵, 32.33 x 10⁴, 20.33 x 10³ CFU/g), respectively as compared to control. At 7.5 percent application of Panchagavya, there was a significant difference in field bean yield with different levels of Jeevamrutha and Panchagavya. When compared to the control treatment, higher levels of Panchagavya and Jeevamrutha (7.5 percent and 1000 liter/ha) application resulted in a higher yield of 1472.4 kg per ha. The findings showed that liquid manures, such as Jeevamrutha and Panchagavya, resulted in the multiplication of various beneficial microbial populations as well as the yield of field bean crop.

Chakraborty and Sarkar (2019) reported that Panchagavya had highest content of N (2366 ppm) followed by Sasyamrutha (742 ppm) and Jeevamrutha (658 ppm). Highest content of P was reported in Jeevamrutha (195 ppm) followed by Panchagavya (187 ppm) and Sasyamrutha (96 ppm). Potassium content was highest in Panchagavya (1354 ppm) followed by Jeevamrutha (821 ppm) and Sasyamrutha (323 ppm). Highest content of Ca was found in Sasyamrutha (194 mg/L) followed by Jeevamrutha (189 mg/L) and Panchagavya (152 mg/L). Panchagavya had highest content of Mg (48 mg/L) followed by Sasyamrutha (34 mg/L) and Jeevamrutha (19 mg/L). Sulphur content was highest in Jeevamrutha (564 mg/L) followed by Sasyamrutha (503 mg/L) and Panchagavya (485 mg/L). Highest Fe content was found in Jeevamrutha (42.44 mg/L) followed by Sasyamrutha (14.47 mg/L) and Panchagavya (9.17 mg/L), Jeevamrutha had highest content of Mn (0.394 mg/L), followed by Panchagavya (0.287 mg/L) and Sasyamrutha (0.238 mg/L). Higher amount of Zn was contained in Jeevamrutha (1.56 mg/L) followed by Panchagavya (0.268 mg/L) and Sasyamrutha (0.249 mg/L). Copper content was highest in Jeevamrutha (2.44 mg/L) followed by Sasyamrutha (2.36 mg/L) and Panchagavya (2.18 mg/L).

Ravanachandar and Lakshmanan (2019) investigated the effect of organic and biofertilizers on soil microbial population in black pepper (*Piper nigrum* L.). Presence of microbial population was studied in the treatments of organic manures and biofertilizers viz., FYM, *Azospirillum*, *Phosphobacteria* and VAM. It was found that combined application of organic manures and biofertilizers result in higher population of bacteria, fungi and actinomycetes at initial (18.9×10^3 , 7.5×10^4 and 6.0×10^7 CFU g^{-1} soil), flowering (26.44×10^3 , 10.56×10^4 and 8.85×10^7 CFU g^{-1} soil) and harvesting stage (23.56×10^3 , 8.85×10^4 and 8.21×10^7 CFU g^{-1} soil, respectively).

Groundnut (*Arachis hypogaea* L.) growth and yield was studied using soil-applied Panchgavya and foliar-applied plant leaf extracts. Groundnut growth and yield increased significantly as Panchgavya solution was increased from 0 to 3.0 lit/m². Panchgavya solution at 3.0 lit/m² increased pod, haulm and biological yield by 85%. It increased SLW (specific leaf weight), CGR (Crop growth rate), RGR (Relative growth rate), and NAR (Net assimilation rate). At 35 and 55 days after application, the leaves of the plants were examined for growth and yield in comparison to a water-sprayed

control. The foliar datura + Panchgavya solution application increased CGR, RGR, and NAR at 45–70 DAS and 70 DAS–harvest compared to other foliar applications sources. Application of 3 lit/m² of Panchgavya to the soil increased the availability of all major and minor nutrients P, Fe, Cu, Zn, and Mn compared to other Panchgavya levels. Soil organic carbon increased due to Panchgavya providing available OC (with 1.5 percent OC) (Kumawat *et al.*, 2010)

2.2.1 Metagenomics

In terms of microbial diversity and community size, soil is one of the most dynamic systems for microbiologists to study. Prokaryotes are the most abundant organisms in soil and make up the majority of the soil biomass, which is composed primarily of organic matter. It is estimated that these soil microbial communities contain an unlimited number of new genes encoding novel and beneficial products. Nevertheless, one of the most difficult challenges in soil metagenomics is to comprehend the heterogeneity, temporal and spatial dynamics of complex soil microbial community structure within a complex soil system (Delmont *et al.*, 2015).

The great majority of microorganisms on the entire globe are incapable of being cultured. When it comes to environmental samples, approximately 1-2 % of the microorganisms can be cultured in a laboratory, while the remaining 98-99 % cannot be cultured using standard cultivation practises and are thus referred to as unculturable microorganisms (Soni *et al.*, 2016)

For unculturable microbes, culture independent methods are used to investigate their diversity, population structure, and ecological roles in detail, thereby overcoming the limitations of culture dependent approaches. The ground-breaking work of Carl Woese, who discovered that the 16S rRNA genes can be used as evolutionary chronometers, paved the way for a new perspective on microbial ecology known as metagenomics (Prakash *et al.*, 2013). The sequencing of the 16S rRNA gene signalled the beginning of a new era in microbiology, as it enabled the identification of previously unculturable microorganisms through metagenomics, rather than by culturing them.

Scientists in the Netherlands used metagenomics to investigate different bacterial communities across different farmLands. They discovered that the most significant differences in bacterial communities were not related to land-use type, but rather to soil-related parameters. In terms of explaining differences in bacterial communities across fields, phosphate was found to be the most significant factor. *Firmicutes* were the most dominant group in almost all fields except for pine forest soils and deciduous forest soils (DFS). *Alphaproteobacteria* were found to be the most abundant in PFS, whereas *Firmicutes* and *Gammaproteobacteria* were found to be the most abundant in deciduous forest soils. Interestingly, the abundance of *Bacillii* and *Clostridium* OTUs was found to be correlated with pH and phosphate, which may explain their widespread distribution across many Dutch soils. There were significant correlations found between numerous bacterial groups and specific soil factors, suggesting that they could be used as indicators of soil health (Kuramae *et al.*, 2012)



*Materials
and
Methods*



The present investigation on “Growth, flowering and post-harvest life of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Thai Chen Queen in response to organic and biodynamic manures” was carried out at Experimental Farm, Model Floriculture Center, G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The details are given below:

3.1 Geographical Location, Climatic Conditions and Soil Properties of Experimental Site

G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), is geographically situated at 29⁰N latitude, 79.3⁰E longitude and at altitude of 243.84 meters above mean sea level in *Tarai* belt of Shivalik range of the Himalayas. The region is characterized by humid subtropical climate with maximum temperature of 43⁰C in summer and minimum 0⁰C in winter months. This region receives heavy rainfall up to 1400 mm annually. The soils of experimental field of Model Floriculture Centre, Pantnagar comes under order of mollisols with sandy loam textured having proper drainage and optimum water holding capacity.

The weekly average of different weather data parameters that prevailed during the course of investigation were collected from University Meteorological observatory, Norman E. Borloug Crop Research Centre, Pantnagar are reported and depicted in Figures 3.1 and 3.2 and data are given in Appendix I a and I b respectively.

3.2 Soil status

A basic study of the soil of the experimental field was conducted before starting the experiment. Sampling is done at several locations in a *zig-zag* pattern which ensured homogeneity in the sample as chrysanthemum is shallow rooted crop, samples were collected up to 15 cm depth of soil. Using spade ‘V’ shaped cut to a depth of 15 cm in the sampling spot was done using khurpi thick slices of soil up to 2.5 cm from top to bottom of exposed face of the ‘V’ shaped cut was taken and placed in a clean container. Quartering was done by dividing the thoroughly mixed sample into four equal parts. The two opposite quarters were discarded and the remaining two quarters

were remixed and the process repeated until the desired sample size is obtained. Samples were collected and air dried and then soil samples were sieved through 2 mm sieve. The soil which is sieved is analysed for physico-chemical properties. The results of the soil analysis are given below in Table 3.1.

Table 3.1: Methods used for determination of different physico-chemical properties of soil sample and nutrient status of initial soil sample

S. No.	Soil properties	Status of initial soil	Methodology followed
1.	pH	7.24	Digital pH meter (Jackson, 1967)
2.	Electrical conductivity	0.35 dSm ⁻¹	EC Meter (Bower and Wilcox, 1965).
3.	Organic carbon (%)	0.52	Rapid titration method (Walkley and Black, 1934)
4.	Nitrogen (N)	193.80 kg/ha	Alkaline permanganate method (Subbiah and Asija, 1956)
5.	Phosphorus (P)	13.19 kg/ha	Olsen method (Olsen et al., 1954)
6.	Potassium (K)	147.32 kg/ha	Flame photometer (Hanway and Heidel, 1952)

3.3 Experimental Details

Crop	:	Chrysanthemum
Cultivar	:	Thai Chen Queen
No. of treatments	:	16
Replications	:	3
Net bed size	:	1.2 m x 1.2 m
Spacing	:	40 cm x 40 cm
No. of plants per treatment	:	9
Length of plot	:	30 m
Width of plot	:	6.5 m
Total experimental area	:	195 m ²
Design	:	Randomized block design (RBD)

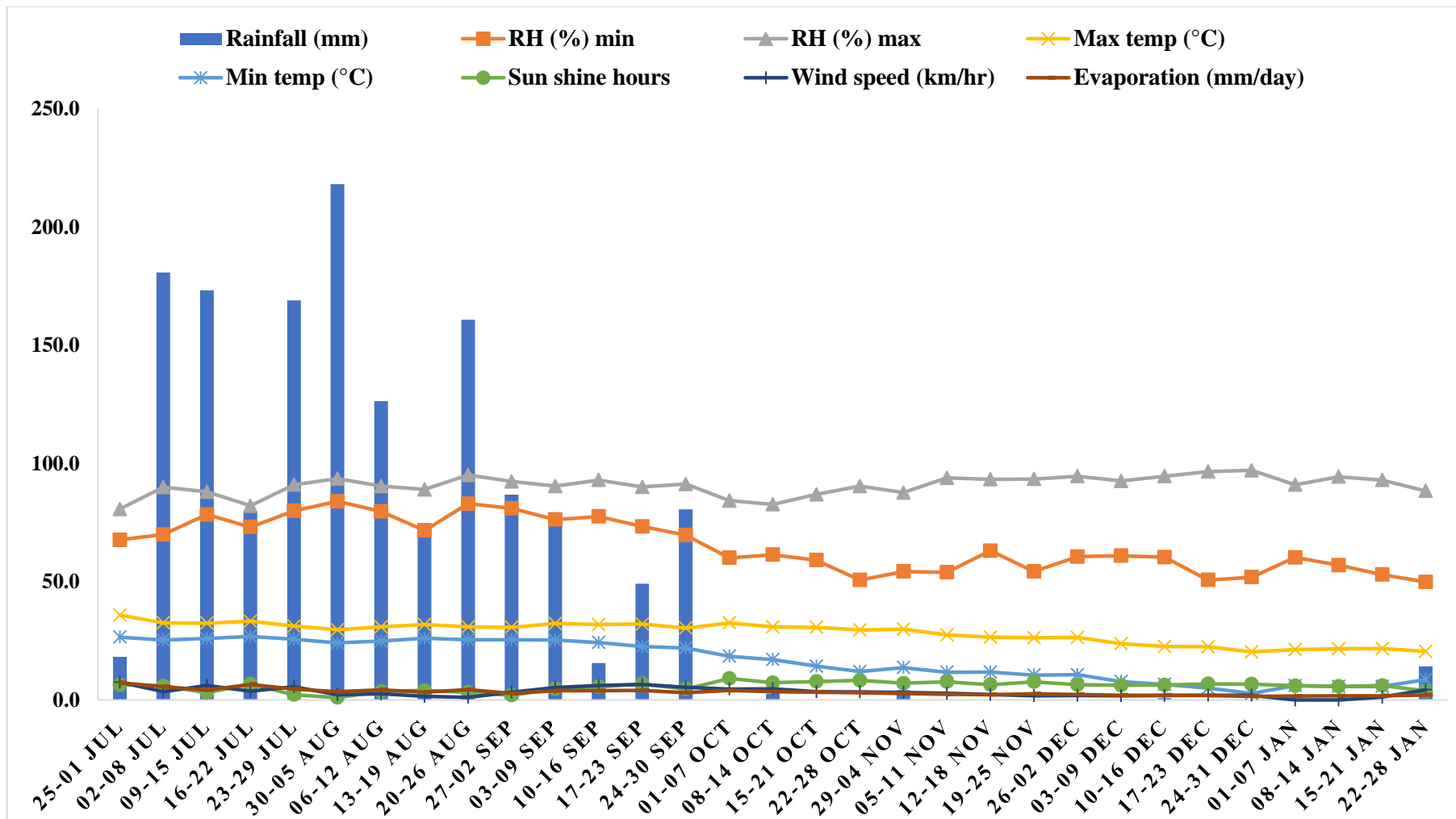


Fig. 3.1: Meteorological data during the crop growth period (weekly) 2018-19

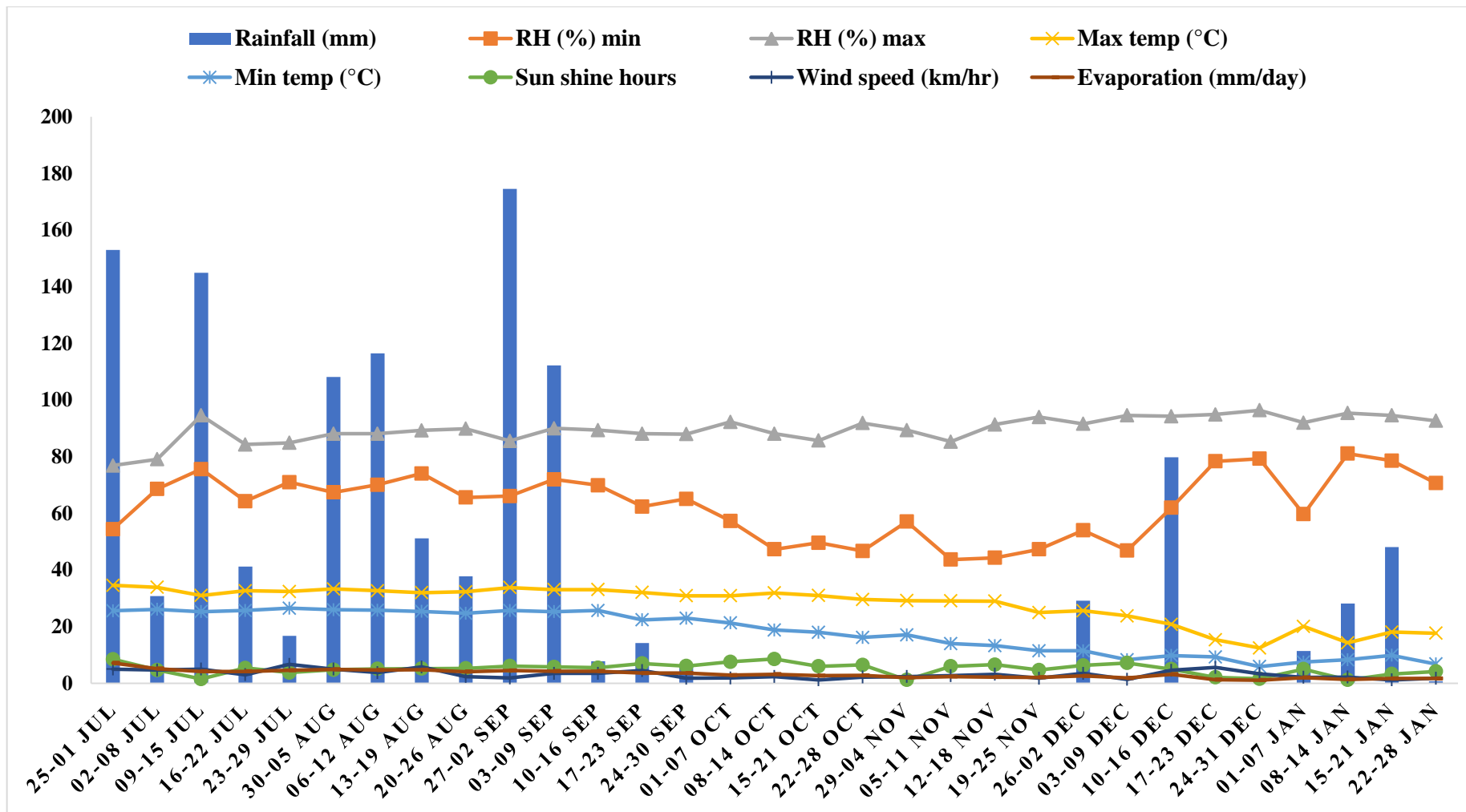


Fig. 3.2: Meteorological data during the crop growth period (weekly) 2019-20



Plate 1a: Layout of experimental field



Plate 1b: Fully grown crop in the field

3.4 Layout of Experimental Field

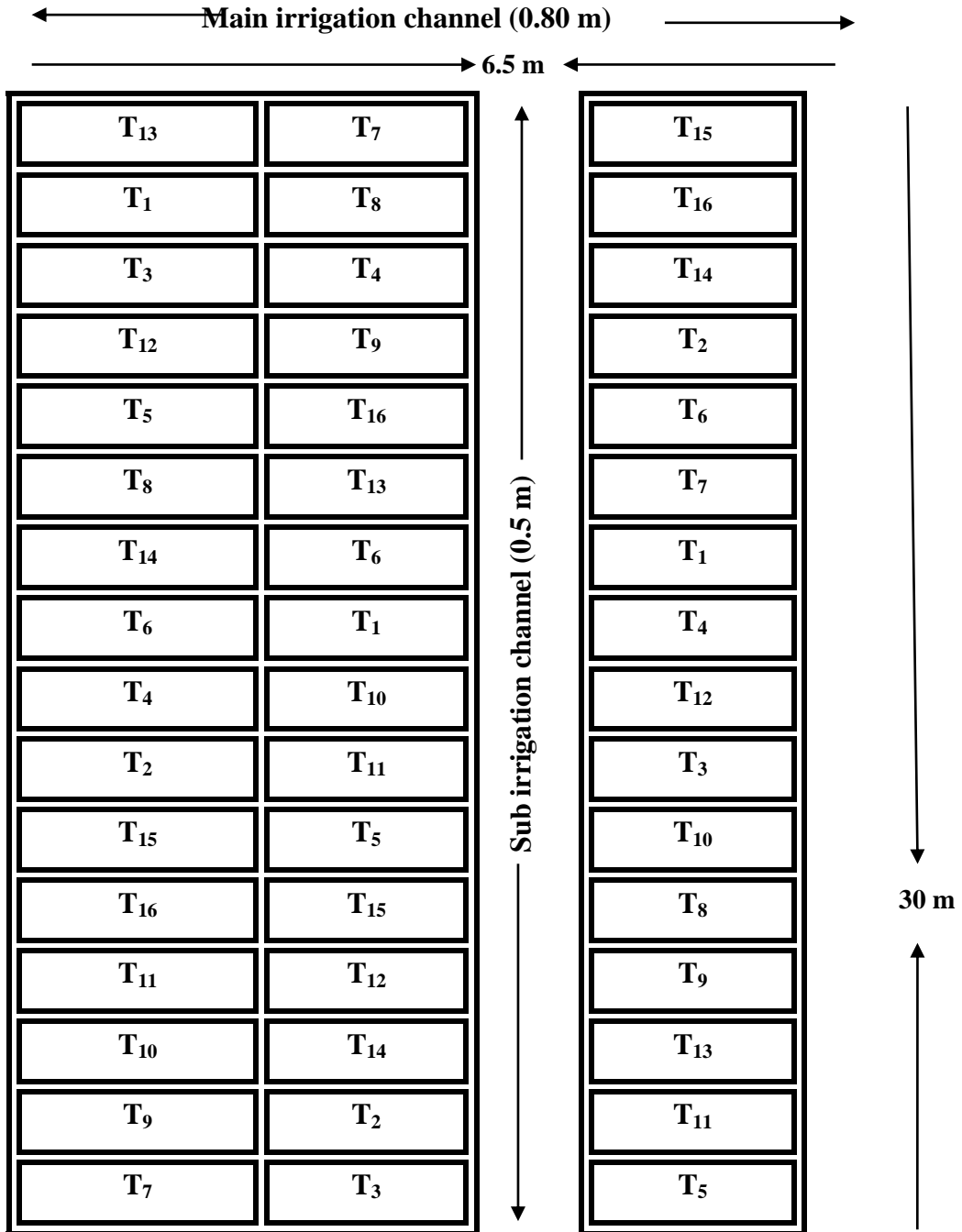
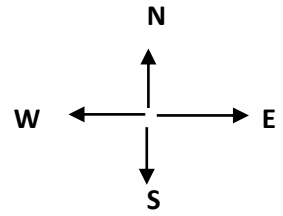


Table 3.2: Treatments details

S. No.	Treatments	Treatment combinations
1.	T ₁	Control
2.	T ₂	1% Panchagavya + CBD*
3.	T ₃	2% Panchagavya + CBD*
4.	T ₄	3% Panchagavya + CBD*
5.	T ₅	4% Panchagavya + CBD*
6.	T ₆	5% Panchagavya + CBD*
7.	T ₇	6% Panchagavya + CBD*
8.	T ₈	7% Panchagavya + CBD*
9.	T ₉	8% Panchagavya + CBD*
10.	T ₁₀	9% Panchagavya + CBD*
11.	T ₁₁	10% Panchagavya+ CBD*
12.	T ₁₂	10% Jeevamruth + CBD*
13.	T ₁₃	20% Jeevamruth + CBD*
14.	T ₁₄	30%Jeevamruth +CBD*
15.	T ₁₅	40% Jeevamruth + CBD*
16.	T ₁₆	50% Jeevamruth + CBD*

CBD*: Common basal dose

CBD: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB as well as potash bacteria (Phosphorus solubilizing bacteria).

Four packets of biofertilizers (200 g each), along with 10 liters of jaggery water were mixed with 150 kg of farmyard manure and decomposed for about 15 days. This biofertilizer compost was incorporated into each bed @ 3 kg/bed.



Plate 2: Different steps in preparation and application of common basal dose of biofertilizers in field

3.5 Design

The experiment was plotted according to randomized block design (**Gomez and Gomez, 1984**) with sixteen treatments and three replications per treatment.

3.6 Experimental material

The experiment was carried out on chrysanthemum cultivar Thai Chen Queen. Chrysanthemum was propagated through terminal cuttings by taking about 5-6 cm long cuttings from the terminal portion of healthy mother plants maintained at mother block of chrysanthemum at Model Floriculture Centre, Pantnagar. From these cuttings, lower leaves were removed, and after making bundles, treated with Bavistin @ 0.3% for 30 minutes to prevent the cuttings from the damping-off disease. It was followed by dipping in IBA solution @ 2500 ppm by quick dip method to initiate better rooting and planted in a mixture of FYM, soil and cocopeat in portrays for raising of rooted cuttings.

3.6.1 Preparation of Panchagavya

Panchgavya means a blend of five items in Sanskrit, viz., ghee, milk, curd, cow dung and cow urine obtained from cows. All these products are individually referred to as *Gavya* and generally collectively referred to as Panchgavya. For the preparation of 20 liters of Panchgavya, following ingredients are used:

S. No.	Ingredients	Quantity
1.	Fresh cow dung	5 kg
2.	Cow urine	3 liters
3.	Cow milk	2 liters
4.	Cow curd	2 liters
5.	Cow ghee	500 g
6.	Sugarcane juice	3 liters
7.	Tender coconut juice	2 liters
8.	Ripened banana	12 Nos.



Plate 3: Different steps in preparation of Panchgavya

Cow ghee was thoroughly mixed in a plastic drum in fresh cow's dung and held for three days. Twice a day, this mixture was thoroughly stirred. Cow urine, milk and curd obtained from cow were properly mixed on the 4th day. Sugarcane juice, tender coconut water and meshed ripened banana fruits were then thoroughly mixed together. To alleviate aerobic microbial activities, this solution was kept for 18 days with stirring twice a day for about 20 minutes. Panchagavya stock solution will now be available for use on the 19th day. The solution was stored under the shade and covered with a muslin cloth.

Physico-chemical and biological properties of Panchgavya

Chemical composition

S. No.	Particulars	Values
1.	pH	6.4
2.	EC (dSm ²)	10.22
3.	Total N (ppm)	229.0
4.	Total P (ppm)	209.0
5.	Total K (ppm)	232.0
6.	Sodium (ppm)	90.0
7.	Calcium (ppm)	25.0
8.	IAA (ppm)	8.5
9.	GA (ppm)	3.5

Microbial load

Microorganism population

S. No.	Microorganisms	Microbial Count
1.	Fungi	38,800/mL
2.	Bacteria	18,80,000/mL
3.	Lactobacillus	22,60,000/mL
4.	Total anaerobes	10,000/mL
5.	Acid formers	360/mL
6.	Methanogen	250/mL

3.6.2 Preparation of Jeevamruth

Jeevamruth is a combination of cow urine, cow dung, jaggery, pulse flour and organic soil from the rhizosphere. Jeevamruth is a rich bio-formulation containing group of beneficial microbes.

The following ingredients are used for the preparation of Jeevamruth to be applied in one acre of area:

S. No.	Ingredients	Quantity
1	Cow dung	10 kg
2	Cow urine	5-10 liters
3	Sugarcane juice	4 liters
4	Organic soil	1 kg
5	Pulse flour	2 kg
6	Water	200 liters



Plate 4: Ingredients used in preparation of Jeevamruth

In a plastic drum, the appropriate quantities of fresh cow dung and cow urine were thoroughly mixed into 200 liters of water. It is then blended with 4 litres of sugarcane juice, 2 kg of pulse flour and 1 kg of virgin soil. The soil under a tree or undisturbed area (soil free of chemicals) is considered organic soil. This solution was stirred well enough and kept under shade for 7 days for fermentation. To avoid any undesirable contamination, the drum of Jeevamruth solution was covered with a muslin cloth. The Jeevamruth solution is ready for use after 7 days of fermentation and was applied according to treatments.

Microbial load in different bio-enhancers

Microorganisms	Population (CFU mL ⁻¹)	
	Panchgavya	Jivamrita
Bacteria	26.1 x 10 ⁵	15.4 x 10 ⁵
Fungi	18.0 x 10 ³	10.5 x 10 ³
Actinomycetes	4.2 x 10 ³	6.8 x 10 ³
P solublizers	5.7 x 10 ²	2.7 x 10 ²
Free living N ₂ fixers	2.7 x 10 ²	3.1 x 10 ²

Nutrient status of different bio-enhancers

Parameter	Panchgavya	Jivamrita
pH	6.82	8.2
Soluble salts (EC)	1.82 dsm ⁻¹	5.5 dsm ⁻¹
Total nitrogen	0.1 per cent	0.4 per cent
Total phosphorus	175.4 ppm	155.3 ppm
Total potassium	194.1 ppm	252.0 ppm
Total zinc	1.27 ppm	2.96 ppm
Total copper	0.83 ppm	0.52 ppm
Total iron	29.71 ppm	15.35 ppm
Total manganese	1.81 ppm	3.32 ppm

Both Panchagavya and Jivamrita formulations were applied thrice as soil drenching, *i.e.*, after planting, followed by disbudding and before flowering.

3.6.3 Experimental site preparation

Removing weeds and other crop residues from the soil is the first major step in field preparation. The land was deeply ploughed with harrow and rotavator to bring it to a fine tilth and levelled. With the help of rope, the layout was prepared and the entire area of experiment, was divided into three parts for replication and each part was divided into 16 plots. With a spacing of 40 cm x 40 cm, net plot of 1.2 m x 1.2 m scale was laid out. As per the plan to adopt a randomized block design, the experimental field was laid out.

3.7 Cultural Operations

3.7.1 Irrigation and weeding

The irrigation and weeding were done regularly as and when required. Excess irrigation should be avoided as chrysanthemum is sensitive to waterlogging.

3.7.2 Pinching and disbudding

First pinching was done at 3 weeks after planting of rooted cuttings. Disbudding was done to remove excess buds for cut flower purpose.

3.7.3 Staking

Staking was done at the opening stage of the bud to prevent plant lodging as the chrysanthemum cv. Thai Chen Queen has several buds and flowers of big size. Staking was done with the help of bamboo sticks and strings.

3.8 Observations Recorded

The observations recorded regarding the growth and flowering of the plants are listed below:

3.8.1 Vegetative growth parameters

3.8.1.1 Plant height (cm)

Plant height was recorded by measuring from the base of plant stem at ground level to the main growing tip of the plant. This was recorded at 30, 60 and 90 days after planting with the help of meter scale. The average height was then worked out.

3.8.1.2 Plant spread (cm)

The plant spread (cm) was recorded in N-S and E-W directions at bud initiation stage and average values were calculated.

3.8.1.3 No. of branches per plant

At the onset of the first flower bud after planting, the number of branches were counted on the five tagged plants and the average values were calculated.

3.8.1.4 Length of branches (cm)

A meter scale was used to measure the length of the branches from the tagged plants from the end that is connected to the main stem to the other, *i.e.*, the tip of the main branch and the unit used to express the length of the branches is centimeters, and the mean value was recorded.

3.8.1.5 Estimation of chlorophyll (mg g⁻¹ FW)

The chlorophyll content in the leaves was measured by using DMSO method (**Hiscox and Israelstam, 1979**). In this method, 50 mg of fine chopped fresh leaf was taken and filled with 10 mL of dimethyl sulphoxide (DMSO) poured into test tubes. The filled tubes were covered with aluminium foil and kept in an oven for 4 h at 65⁰C. The tubes were subsequently shaken to allow the pigment to distribute uniformly and the absorbance was read at 645, 663 and 470 nm wavelengths in a spectrophotometer using pure DMSO as a blank reading. For the estimation of the content of chlorophyll a, chlorophyll b, and total chlorophyll, the following formulae were used.

$$\text{Chlorophyll a (mg g}^{-1}\text{ FW)} = \frac{(12.7 \times A_{663}) - (2.69 \times A_{645}) \times V}{(1000 \times W)}$$

$$\text{Chlorophyll b (mg g}^{-1}\text{ FW)} = \frac{(22.9 \times A_{645}) - (4.68 \times A_{663}) \times V}{(1000 \times W)}$$

$$\text{Total chlorophyll (mg g}^{-1}\text{ FW)} = \frac{(20.2 \times A_{645}) - (8.02 \times A_{663}) \times V}{(1000 \times W)}$$

Where, A = absorbance at given wavelength; V = final volume of solvent in mL; W = weight of plant sample in gm.

3.8.2 Flowering and yield parameters

3.8.2.1 Days to first bud initiation

The observation was recorded by counting the number of days from the date of planting to appearance of first flower bud for each treatment.

3.8.2.2 Bud diameter (cm)

Bud diameter was measured when buds are full turgid in size and before florets are opened and mean data was collected and tabulated from five tagged plants from each replicated plot.

3.8.2.3 No. of buds/plant

From five tagged plants in the plot, number of buds/plants were counted and the mean value is calculated.

3.8.2.4 No. of cut flowers /plant

From the net plot, the total number of cut flowers per plant (tagged plants) were recorded and the average number of flowers per plant were then determined.

3.8.2.5 Flower diameter (cm)

The flower diameter from one point to another extreme point of maximum size of width of flower for two directions was measured at the peak flowering stage with the help of Vernier caliper. The average value was worked out.

3.8.2.6 Days to flowering

Days taken to flowering were counted from the date of planting in the field to the days taken to fully opening of first flower in each treatment.

3.8.2.7 No. of cut flowers/ha ('000 Nos.)

After recording the number of cut flowers from the randomly selected five tagged plants, all the flowers were harvested and weighed. For the five plants, the total yield was determined and the average yield per plant was calculated. In the remaining plants in the net plot, flowers were harvested separately and counted, to which five plants yield were added and cut flowers per hectare were calculated.

3.8.2.8 Average flower weight (g)

Using weighing balance, the weight of flowers randomly selected from each plot's tagged plants was recorded and the mean value was calculated.

3.8.2.9 Duration of flowering (days)

The flowering period in days was measured from the date the flowers were opened to the period till the flowers were seen in attractive forms in all treatments.

3.8.2.10 Length of flower stalk (cm)

From each plot, five flowers were selected at random from tagged plants and the length from the neck of the flower to the nearest branching point was measured by scale. The average was calculated and expressed in cm.

3.8.2.11 Stem diameter (mm)

By using Vernier calipers, stem diameter was recorded. The diameter was recorded from the top of the 9-10th plant node. Five plants were selected for each replication, and data tabulated.

3.8.2.12 Days taken from colour showing stage to harvesting stage

The number of days for five tagged plants in the plot were calculated from the colour indicating stage to the harvest stage and the average is calculated.

3.8.3 Post Harvest Attributes

3.8.3.1 Initial flower weight (g) after harvesting from field

Initial fresh flower weight was recorded in all treatments after harvesting from the tagged plants and expressed in gram.

3.8.3.2 Final flower weight (g) after keeping in vase life solution

At the completion of the vase life experiment, the final flower weight was recorded in all treatments and expressed in gram.

3.8.3.3 Initial flower diameter (cm) in vase solution

After harvesting of flowers from the field, they were placed in vase solution and the diameter of flower was recorded with the help of Vernier caliper and average was worked out.

3.8.3.4 Final flower diameter (cm) after keeping in vase solution

After the complete opening of the bloom in the vase, the open flower diameter was recorded and an average value was measured.

3.8.3.5 Percent increase in flower diameter (cm)

This is the difference in the vase solution of the flowers between the initial and final flower diameter.

3.8.3.6 Water uptake by flowers (mL)

Flower stems were kept in 250 mL conical flask test holding 200 mL of vase solution. The amount of solution taken up by stem was measured daily and expressed as volume taken up in mL /day. This was measured as the difference in the amount of water in the conical flask from initial to final quantity till the end of their vase-life.

3.8.3.7 Vase life (days)

Five fully opened and well-developed flowers were selected and then cut with sharp knife and were immediately put in 250 mL volumetric flasks containing distilled water. The days were calculated from the date of putting the flowers in the flask till the day when the flowers totally withered.

3.8.4 Physico-chemical parameters of soil

3.8.4.1 Soil pH

A soil-water suspension was prepared in the ratio of 1:2.5 (10 g soil with 25 mL of distilled water) and pH was measured with the help of pH meter (**Jackson, 1967**).

3.8.4.2 Electrical conductivity

The suspension of soil water prepared for pH determination was used to estimate soil electrical conductivity. Soil suspension was allowed to settle until it became clear of a supernatant. Using an EC meter, electrical conductivity was measured and expressed as dSm^{-1} (**Bower and Wilcox, 1965**).

3.8.4.3 Organic carbon (%)

Soil organic carbon content was determined by rapid titration method (**Walkley and Black, 1934**). In this method one gram of soil was oxidized with a mixture of 1N

potassium dichromate and concentrated sulphuric acid utilizing the heat of dilution of sulphuric acid. 200 mL of distilled water and 10 mL of orthophosphoric acid were added to the conical flask. Unconsumed potassium dichromate was back-titrated with 0.5 N ferrous ammonium sulphate in presence of diphenylamine indicator.

$$\text{Organic carbon (\%)} = \frac{10(B-S)}{B \times 0.003} \times \frac{100}{\text{wt of sample (gm)}}$$

Where, B and S stand for the titre value (mL) of blank and sample, respectively

3.8.4.4 Available nitrogen (kg/ha)

Available nitrogen was determined by alkaline potassium permanganate method (**Subbiah and Asija, 1956**). Almost 20 g of soil was treated with 100 mL of 0.32 % alkaline KMnO_4 solution. The organic matter present in the soil was oxidized by nascent oxygen liberated by KMnO_4 in presence of sodium hydroxide (NaOH). Ammonia thus released was absorbed in known volume of standard acid (2 % boric acid). Titrate the distillate with standard alkali using methyl red against 0.02 N H_2SO_4 taken in burette until the pink colour appeared. Run a blank sample without soil with each set of five samples.

$$\text{Available N (kg/ha)} = \frac{(S-B) \times 0.00028}{20 \times 10^{-6}} \times 10^{-6} \times 2.24$$

$$\text{Available N (kg/ha)} = (S-B) \times 31.36$$

Where, S and B stand for the volume of H_2SO_4 of sample and blank, respectively.

3.8.4.5 Available phosphorus (kg/ha)

Available Phosphorus was extracted from soil with 0.5 M NaHCO_3 (pH 8.5) as described by **Olsen *et al.* (1954)** and determined by ammonium molybdate blue colour method using Spectrophotometer at 882 nm.

$$\text{Available P (kg/ha)} = \frac{R \times \text{volume of extract}}{\text{volume of aliquot}} \times \frac{2.24 \times 10^6}{\text{wt. of soil}} \times 10^6$$

Where R= quantity of P in μg read on X- axis against a sample reading.

3.8.4.6 Available potassium (kg/ha)

Available potassium was determined with neutral normal ammonium acetate solution (pH 7.0) by shaking for 30 minutes. Potassium content in the extract was determined flame-photometrically as given by **Hanway and Heidel, 1952**.

$$\text{Available K (kg/ha)} = \frac{\text{R x volume of extract x 2.24}}{\text{wt. of soil sample}}$$

Where R = ppm of K in the extract obtained from the standard curve.

3.8.4.7 Microbial count

Soil samples were collected after harvesting of crop from each plot. The samples were analysed for bacterial, fungal and actinomycetes count through serial dilutions method (**Wollum, 1982**). Dilutions ($1-10^8$) of soil samples were prepared by mixing 1 gm of soil with 10 mL of water blanks followed by the transfer of 1 mL suspension into subsequent 9 mL blank. Afterwards, 1 mL properly mixed soil suspension was poured in sterile petri plate and then 20 mL of molten nutrient agar, potato dextrose agar and actinomycetes agar (HiMedia) were poured in separate petri plate to support the growth of bacteria, fungi and actinomycetes, respectively. Afterwards, petri plates were incubated at $28 \pm 2^\circ\text{C}$ and regularly observed for appearance of microbial colonies. Number of appeared microbial colonies were counted through colony counter and CFU/gm was calculated.

3.8.4.8 P-solubilizer and N-fixers in rhizosphere soil

Soil samples were collected from the soil rhizosphere for counting of P-solubilizer and N-fixers load present in the soil. One gram of soil was serially diluted up to 10^{-6} by using sterilized distilled water and P-solubilizer and N-fixers cell count per gram of rhizosphere soil was enumerated for by pouring 1mL of cell suspension in Pikovaskaya's media and Jensen agar media, respectively (**Allen, 1959**). Afterwards, petri plates were incubated at $28 \pm 2^\circ\text{C}$ and regularly observed for appearance of microbial colonies.

3.8.4.9 Metagenomic analysis of soil sample through NGS (Next generation sequencing)

Soil samples of best treatment and control were analysed through metagenomic sequencing. In brief, V₃-V₄ of 16S rRNA gene was amplified from DNA of soil sample and were sequenced through next generation sequencing. All sequencing and bioinformatic analysis were done through outsourcing in following steps:

- a. **DNA extraction:** As per the instructions provided by the kit manufacturer, total soil DNA was extracted from 0.25 g soil sample using QIAGEN kit.
- b. **DNA QC:** Extracted DNA from the samples was subjected to Nano Drop and GEL Check before being taken for PCR amplification. The Nano Drop readings of 260/280 at an ~ value of around 1.8 to 2 is used for further PCR amplification.
- c. **PCR Amplification or library preparation:** Extracted DNA was used to amplify 16S rRNA hyper variable region *i.e.*, V3-V4 from soil sample using primers V13F: - 5' AGAGTTTGATGMTGGCTCAG3' V13R: - 5' TTACCGCGGCMGCSGGCAC3. The PCR involved an initial denaturation at 95°C for 5 minutes followed by Denaturation @ 95°C for 15 sec, Annealing @ 60°C for 15 sec, Elongation @ 72°C for 2 mins and final extension at 72°C for 10 mins and held at 4°C. The amplicons from each sample were purified with Ampure beads to remove unused primers and an additional 8 cycles of PCR was performed using Illumina barcoded adapters to prepare the sequencing libraries. Libraries were purified using Ampure beads and quantitated using Qubit dsDNA High Sensitivity assay kit. Sequencing was performed using Illumina Miseq with 2x300PE v3 sequencing kit
- d. **Bioinformatic analysis:** The quality check of raw reads was carried out by FastQC (v0.11.7), and further processed using TrimGalore (v0.5.0) to trimming the adapter to avoid further contamination. The trimmed reads are further taken for processing which includes merging of paired end reads. Paired end data were given as input to QIIME and Operational taxonomy unit (OTU) were assigned to similar sequences. For this UCLUST algorithm was used at sequence similarity threshold of 97% against green genes as the reference database for picking up OTUs. Species richness and diversity were estimated by the abundance-based coverage estimator (Ace), Chao 1 estimator (Chao1), JackKnife richness estimator (JackKnife), non-

parametric Shannon diversity index (Np-Shannon), Shannon diversity index (Shannon), using Mothur v.1.21.1. PICRUST's software was used to predict the function profile of metagenome present in the soil samples. OTU table was used to assign the functional pathways related to the OTU present in the soil samples.

3.8.5 Economics

3.8.5.1 Cost of cultivation

Individual components of cost of cultivation were taken into consideration in calculating the economics. The cost of components includes the preparation of land, planting material, manures, materials required for the preparation of Jeevamrutha and Panchagavya, and labour charges prevailed during the experimental period. The cost of the inputs that was prevailing at the time of their use was considered to work out the cost of cultivation which is given in rupees per hectare

3.8.5.2 Gross returns (₹)

Gross returns were calculated based on the prevailing market price for the produce and given in the Table 4.24.3 and 4.24.4

3.8.5.3 Net returns (₹)

The net returns per m² were calculated on the basis of gross income and cost of cultivation per m² as follows and values are given in Table 4.24.3 and 4.24.4

Net returns = Gross returns – Cost of cultivation

3.8.5.4 Benefit cost ratio

The benefit cost ratio was worked out by using the following formula

$$\text{Benefit cost ratio} = \frac{\text{Gross income (₹./ha)}}{\text{Cost of cultivation (₹./ha)}}$$

3.8.6 Statistical analysis

The data were statistical analysed by using randomized block design. The critical difference (CD) at 5 per cent level of significance was calculated. The results presented in the form of graphs and Tables are given at appropriate places for result interpretation.

3.8.6.1 Analysis of Variance

The Table for analysis of variance (ANOVA) was set as explained by **Gomez and Gomez (1984)**.

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	Fc value
Replication (r)	(r-1)	Sr	$Sr / r - 1 = Mr$	Mr / Me
Treatment (t)	(t-1)	St	$St / t - 1 = Mt$	Mt / Me
Error (e)	(r-1) (t-1)	Se	$Se / (r-1) (t-1) = Me$	

Where,

r = Number of replications

t = Number of treatments

Sr = Sum of square due to replications

St = Sum of square due to treatments

Se = Sum of square due to error

Mr = Mean sum of square due to replication

Mt = Mean sum of square due to treatments/varieties

Me = Mean sum of square due to error

The calculated f value was compared with the tabulated F value. If F-test was found significant, then standard error and critical difference were calculated as under:

$$SE_{m\pm} = \sqrt{Me/r}$$

$$SE_{d\pm} = \sqrt{2Me/r}$$

$$C.D (5\%) = SE_{d\pm} \times t_{0.05 \text{ error degree of freedom}}$$

Where,

$SE_{m\pm}$ = standard error mean

$SE_{d\pm}$ = standard error of difference

C.D (5%) = Critical difference at 5% level of Significance.



*Results
and
Discussion*



The present study entitled "Growth, flowering and post-harvest life of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Thai Chen Queen in response to organic and biodynamic manures" was conducted at Model Floriculture Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) during 2018-19 and 2019-20. To obtain the experiment's comprehensive findings, the detailed observations were recorded and subjected to statistical analysis and significance of results was verified. The findings are presented in tabular forms and graphically depicted under respective headings. The results obtained during the present investigation are enumerated and justified with scientific reasons and findings of other workers. The experimental results obtained during two years of investigations are presented in this chapter under following heads:

4.1 Effect of Bio-dynamic Manures on Vegetative Growth

Vegetative attributes of chrysanthemum plants such as plant height (cm), plant spread (cm), number of branches per plant, internodal length (cm) and length of branches (cm) and chlorophyll content of leaves were measured in both the years 2018-19 and 2019-20. The results on above mentioned traits are discussed below:

4.1.1 Plant height

Data pertaining to the effect of organic and biodynamic manures on plant height are presented in Table 4.1. and Fig. 4.1. Perusal of data revealed that all the treatments of experiment increased the plant height significantly over control during both the years of study.

During both the years of investigation maximum plant height (*i.e.*, 36.2 and 35.2 cm) at 30 days of planting, was observed in the treatment T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) with plant height of 34.6 and 33.6 cm. However, lower plant height (23.8 and 21.5 cm) was observed with T₁ (Control) in both years. Pooled data from both years indicate that maximum plant height (35.6 cm) was observed in the treatment T₇ (6% Panchagavya + CBD*).

At 60 day after planting, significant differences in plant height were observed in all treatments over control. Among different levels of Panchagavya and Jivamrita application during both the years of investigation, maximum plant height (46.8 and 45.6 cm) at 60 days after planting was observed in the treatment T₇ (6% Panchagavya + CBD*). Similarly, treatment T₁₆ (50% Jivamrita + CBD*) also exhibited at par plant height of (45.7, 44.8 cm), while control plants demonstrated significantly lower plant height (32.6, 31.4 cm) in both years. After pooling data from both years, it was concluded that application of 6% Panchagavya + CBD* and 50% Jivamrita + CBD* after 60 days of planting had a significant effect on plant height (46.2 cm).

The combination of organic and biodynamic manures had a significant effect on plant height at 90 days after planting. During both the years of the study, T₇ (6% Panchagavya + CBD*) demonstrated the highest plant height (*i.e.* 52.6, 50.8 cm), followed by T₁₆ (50% Jivamrita + CBD*), and T₄ (3% Panchagavya + CBD*) treatment, while T₁ (Control) exhibited the shortest plant height (37.6, 33.7 cm), which was much lower when compared to all other treatments. The combined data for plant height at 90 days after planting indicated that the treatment T₇ (51.7 cm) was the highest, followed by T₁₆ (48.9 cm), and the control had the lowest plant height (35.6 cm).

The data in the Table show that applying 6% Panchagavya + CBD* significantly increased plant height at 30, 60 and 90 days after planting in both years, which is statistically significant to other treatment combinations. The minimum plant height was recorded for T₁ (Control). Increase in plant height at different stages might be possible due to application of Panchagavya which contains macronutrients like N, P and K, essential micronutrients, many vitamins, essential amino acids and growth promoting hormones like IAA, GA, which may provide nutrition to rhizosphere microorganisms and thus help to increase their population, which improved plant growth by increasing the availability of nutrients like N, P and K, Zn, Cu, etc. (Natarajan, 2002). Increased plant height could also be attributed to improved nutrient uptake, photosynthesis and better source-sink relationships, in addition to excellent physiological and biochemical activities due to the presence of *Azotobacter*, PSB and VAM. Dharma (2006) reported a similar increase in plant height in carnation with 3% Panchagavya, Rajesh *et al.*, (2006) in gladiolus with 4% Manchurian Mushroom Tea + 6% Panchagavya, and Boraiah *et al.*, (2017) in capsicum with 6% Panchagavya application.

Table 4.1: Effect of organic and biodynamic manures on plant height at 30, 60 and 90 days after planting in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Plant height (cm)								
		30 days			60 days			90 days		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	23.8	21.5	22.7	32.6	31.4	32.1	37.6	33.7	35.6
T ₂	1% Panchagavya + CBD*	28.6	27.2	27.9	35.6	34.5	35.1	39.1	38.4	38.7
T ₃	2% Panchagavya + CBD*	28.2	26.8	27.4	35.2	34.2	34.7	39.7	39.2	39.5
T ₄	3% Panchagavya + CBD*	33.9	32.2	33.1	44.3	43.6	44.2	48.1	47.3	47.7
T ₅	4% Panchagavya + CBD*	25.6	24.3	25.1	36.8	35.1	36.3	41.3	40.8	41.1
T ₆	5% Panchagavya + CBD*	24.4	22.4	23.4	34.6	33.6	34.1	38.6	37.6	38.1
T ₇	6% Panchagavya + CBD*	36.2	35.2	35.6	46.8	45.6	46.2	52.6	50.8	51.7
T ₈	7% Panchagavya + CBD*	23.4	21.8	22.6	35.3	34.6	35.2	37.7	39.4	38.6
T ₉	8% Panchagavya + CBD*	32.4	31.4	31.9	43.7	42.4	43.1	47.6	46.2	46.9
T ₁₀	9% Panchagavya + CBD*	24.9	22.1	23.5	34.1	33.2	33.6	42.6	41.9	42.3
T ₁₁	10% Panchagavya + CBD*	25.6	24.7	25.2	37.8	35.7	36.7	40.4	41.4	40.9
T ₁₂	10% Jivamrita + CBD*	28.3	26.5	27.4	36.6	35.2	35.9	42.3	41.6	42.2
T ₁₃	20% Jivamrita + CBD*	31.3	30.2	30.6	42.4	41.2	41.8	45.3	44.2	44.7
T ₁₄	30% Jivamrita + CBD*	30.9	29.5	30.2	41.3	40.6	41.1	44.3	43.6	44.1
T ₁₅	40% Jivamrita + CBD*	26.3	25.2	25.8	35.5	33.9	34.7	40.7	38.2	39.5
T ₁₆	50% Jivamrita + CBD*	34.6	33.6	34.1	45.7	44.8	45.3	49.2	48.6	48.9
	SEm±	0.39	0.33	0.34	0.52	0.49	0.69	0.71	0.62	0.61
	C.D. at 5%	1.13	0.96	0.98	1.51	1.41	1.99	2.05	1.80	1.78

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria.

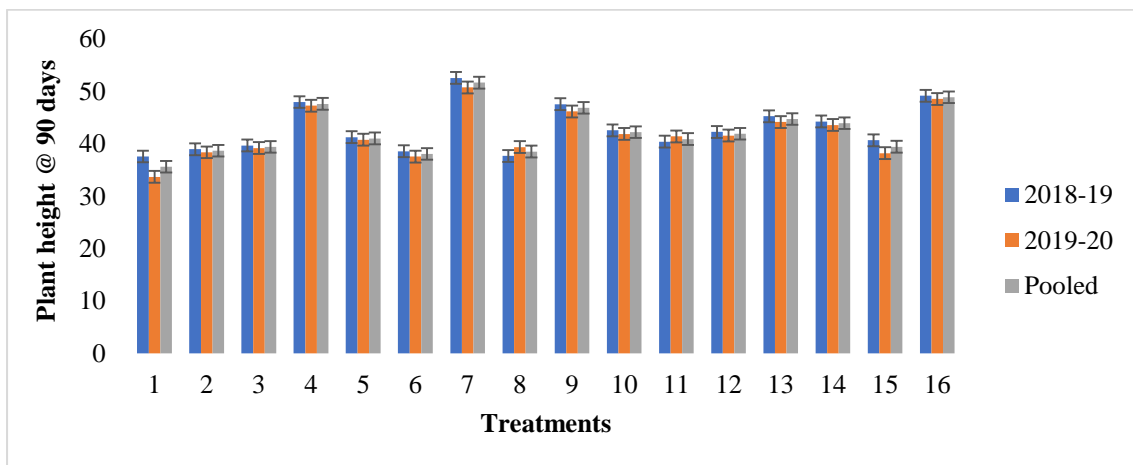
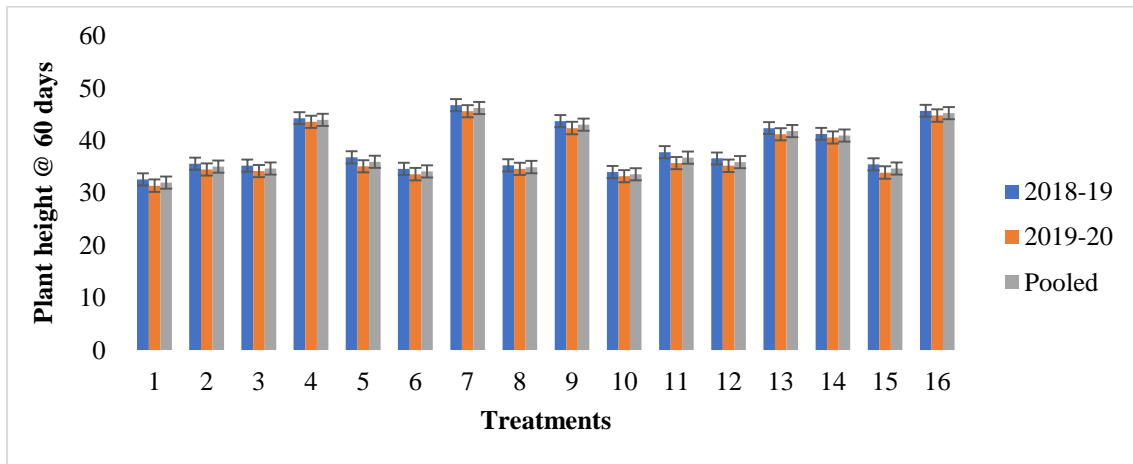
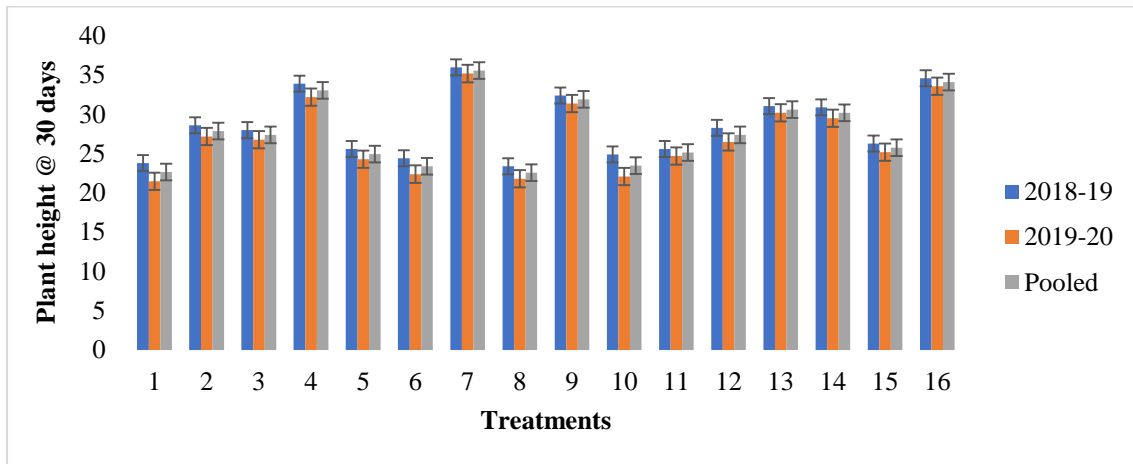


Fig. 4.1: Influence of organic and biodynamic manures on plant height at 30, 60 and 90 days after planting in chrysanthemum cv. Thai Chen Queen

4.1.2 Plant spread (cm)

Effect of Panchagavya and Jivamrita concentrations on plant spread during the year 2018-19 and 2019-20, respectively are presented in the Table 4.2 and Figure 4.2.

The data in Table 4.2 show that the plant spread differed significantly upon implication of various organic and bio-dynamic manure treatments. During the year 2018-19, maximum plant spread (38.1 cm) was observed in the treatment T₇ (6% Panchagavya + CBD*) which was followed by T₁₆ (50% Jivamrita + CBD*), T₄ (3% Panchagavya + CBD*) and T₉ (8% Panchagavya + CBD*) treatments with a reading of 35.60, 34.10 and 30.5 cm spread, respectively.

In the year 2019-20, effect of 6% Panchagavya on plant spread was found significant over control. Maximum plant spread (35.80 cm) was recorded in the treatment T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*). Minimum plant spread (17.50 cm) was found in T₁ (Control). Plant spread of T₇ treatment was found significantly higher with and all other treatments.

Pooled data of both the years showed that plants treated with 6% Panchagavya + CBD* *i.e.*, T₇ produced maximum plant spread (37.2 cm) which was found to be closest with T₁₆ (50% Jivamrita + CBD*), T₄ (3% Panchagavya + CBD*) treatments with a recording of 35.20 and 33.70 cm plant spread, respectively. Minimum plant spread of the pooled data was recorded in the control T₁ (18.0 cm). In general, higher plant spread (38.1 cm) was observed during the year 2018-19 in comparison to the year 2019-20 (35.80 cm). Increase in plant spread might be due to plants treated with Panchagavya produce larger leaves and develop a denser canopy, resulting in an increase in plant spread. The photosynthetic system is turned on to boost biological efficiency and allow for the production of more metabolites and photosynthates. The trunk of the stem produces side shoots that are strong and capable of carrying the maximum number of fruits to maturity. Jivamrita, on the other hand, provides a favourable environment for microorganisms. Through mechanisms such as potassium, phosphate and zinc solubilization, iron chelation, and IAA production, these microorganisms make nutrients such as nitrogen, phosphorus and potassium available to plants. Above results are in conformity with the findings of **Kumbar and Devakumar (2016)** in French bean, **Sau *et al.*, (2017)** in mango, and **Sendhilnathan *et al.*, (2017)** in jasmine who reported similar increase in plant spread.

Table 4.2: Effect of organic and biodynamic manures on plant spread of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Plant spread (cm)		
		2018-19	2019-20	Pooled
T ₁	Control	18.6	17.5	18.0
T ₂	1% Panchagavya + CBD*	26.2	24.2	25.2
T ₃	2% Panchagavya + CBD*	25.9	24.6	25.3
T ₄	3% Panchagavya + CBD*	34.1	33.4	33.7
T ₅	4% Panchagavya + CBD*	29.0	28.6	28.8
T ₆	5% Panchagavya + CBD*	22.7	23.9	23.3
T ₇	6% Panchagavya + CBD*	38.1	35.8	37.2
T ₈	7% Panchagavya + CBD*	20.5	21.2	20.9
T ₉	8% Panchagavya + CBD*	30.5	29.8	30.2
T ₁₀	9% Panchagavya + CBD*	21.1	20.9	21.0
T ₁₁	10% Panchagavya + CBD*	21.1	20.6	20.8
T ₁₂	10% Jivamrita + CBD*	23.6	22.8	23.2
T ₁₃	20% Jivamrita + CBD*	27.4	26.8	27.1
T ₁₄	30% Jivamrita + CBD*	28.2	27.4	27.8
T ₁₅	40% Jivamrita + CBD*	21.8	22.3	22.1
T ₁₆	50% Jivamrita + CBD*	35.6	34.8	35.2
SEM±		0.44	0.44	0.39
C.D. at 5%		1.28	1.28	1.14

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria.

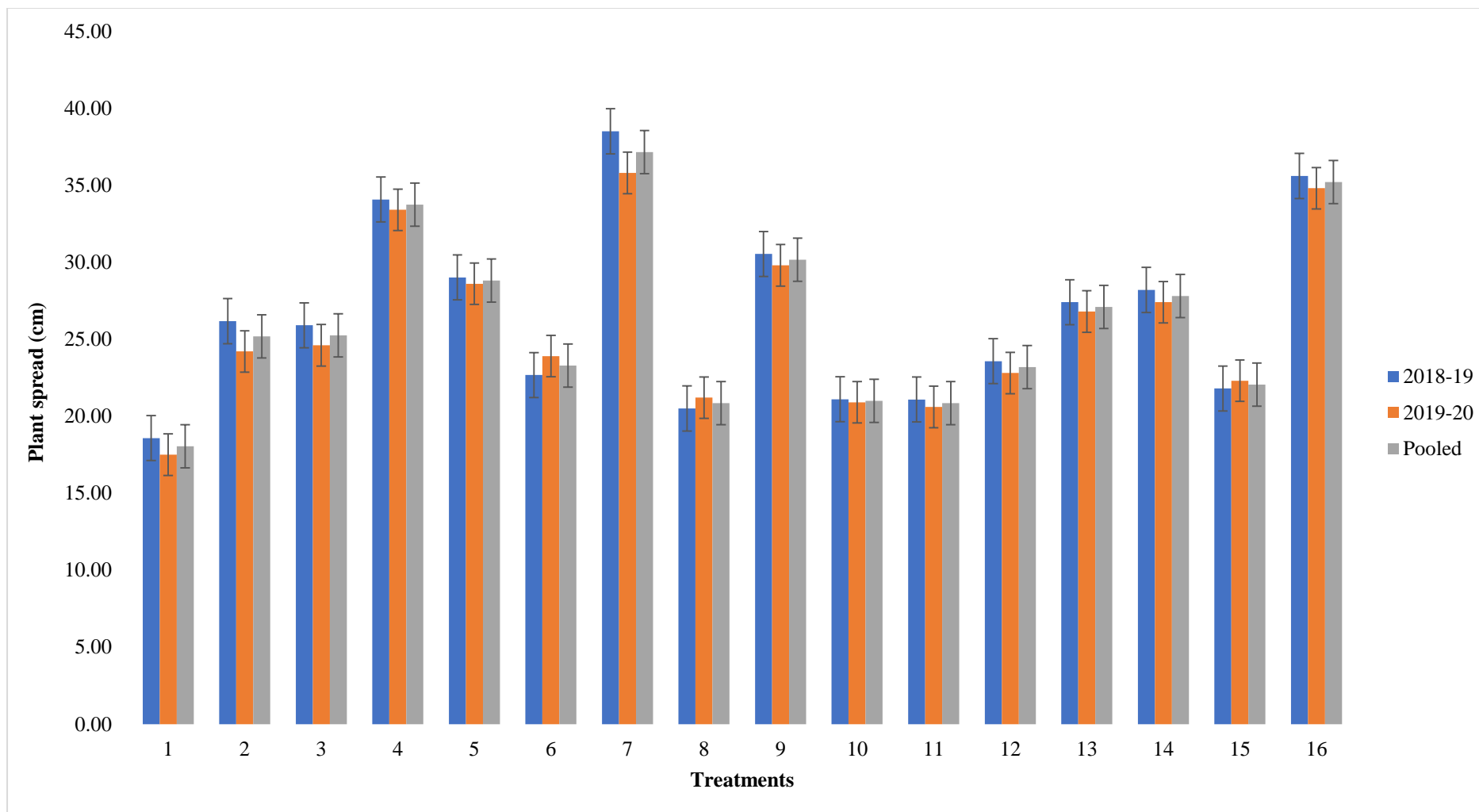


Fig. 4.2: Influence of organic and biodynamic manures on plant spread of chrysanthemum cv. Thai Chen Queen

4.1.3 No. of branches per plant

The data regarding number of branches per plant are given in Table 4.3 and Fig 4.3. indicate that they increased significantly with different combinations of biodynamic manures.

In 2018-19, maximum number of branches per plant (6.7) were observed with the application 6% Panchagavya + CBD* *i.e.*, T₇, which was found statistically at par with the T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) producing 6.4 and 6.0 branches, respectively. However, minimum number of branches per plant (2.7) were found in control (T₁).

During the year 2019-20, maximum number of branches per plant (7.2) were observed with the application of 6% Panchagavya + CBD* *i.e.*, T₇ which was closest to T₁₆ (50% Jivamrita + CBD*), T₄ (3% Panchagavya + CBD*), T₁₃ (20% Jivamrita + CBD*) and T₁₄ (30% Jivamrita + CBD*) with reading of 6.5, 6.5, 6.1 and 5.9 number of branches, respectively. In contrast, minimum branches (3.2) were recorded in the control T₁ plants.

Pooled data revealed that treatment T₇ (6% Panchagavya + CBD*) produced more number of branches (6.9) followed by T₁₆ (50% Jivamrita + CBD*), T₄ (3% Panchagavya + CBD*) with reading of 6.5 and 6.2, respectively, whereas minimum no. of branches were found in the control T₁ (2.9). More no. of branches per plant are related to the application of biodynamic manures with the biofertilizers like *Azotobacter*, *Azospirillum*, PSB (phosphorus solubilizing bacteria) and potash bacteria and also due to application Panchagavya which is rich source of nutrients, auxins, gibberellins and microbial fauna and acts as a tonic to enrich the soil, induce plant vigour with quality production. Moreover, Jivamrita provides microorganisms with a pleasant environment that helps make the necessary nutrients for plant growth available, such as nitrogen, phosphorus and potassium (Palekar, 2006), These findings are in line with the work of Kumbar and Devakumar (2016) in French bean, Sendhilnathan *et al.* (2017) in jasmine and Boraiah *et al.* (2017) in capsicum.

Table 4.3: Effect of organic and biodynamic manures on No. of branches per plant of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	No. of branches per plant		
		2018-19	2019-20	Pooled
T ₁	Control	2.7	3.2	2.9
T ₂	1% Panchagavya + CBD*	3.7	3.9	3.8
T ₃	2% Panchagavya + CBD*	3.3	3.6	3.5
T ₄	3% Panchagavya + CBD*	6.0	6.5	6.2
T ₅	4% Panchagavya + CBD*	3.4	3.8	3.6
T ₆	5% Panchagavya + CBD*	3.3	3.7	3.5
T ₇	6% Panchagavya + CBD*	6.7	7.2	6.9
T ₈	7% Panchagavya + CBD*	4.2	4.9	4.6
T ₉	8% Panchagavya + CBD*	4.8	5.7	5.3
T ₁₀	9% Panchagavya + CBD*	3.2	3.7	3.5
T ₁₁	10% Panchagavya + CBD*	3.9	4.3	4.1
T ₁₂	10% Jivamrita + CBD*	4.3	4.8	4.6
T ₁₃	20% Jivamrita + CBD*	5.6	6.1	5.9
T ₁₄	30% Jivamrita + CBD*	5.3	5.9	5.6
T ₁₅	40% Jivamrita + CBD*	3.2	4.1	3.7
T ₁₆	50% Jivamrita + CBD*	6.4	6.5	6.5
S.E.m±		0.44	0.06	0.06
C.D. at 5%		1.28	0.19	0.17

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria.

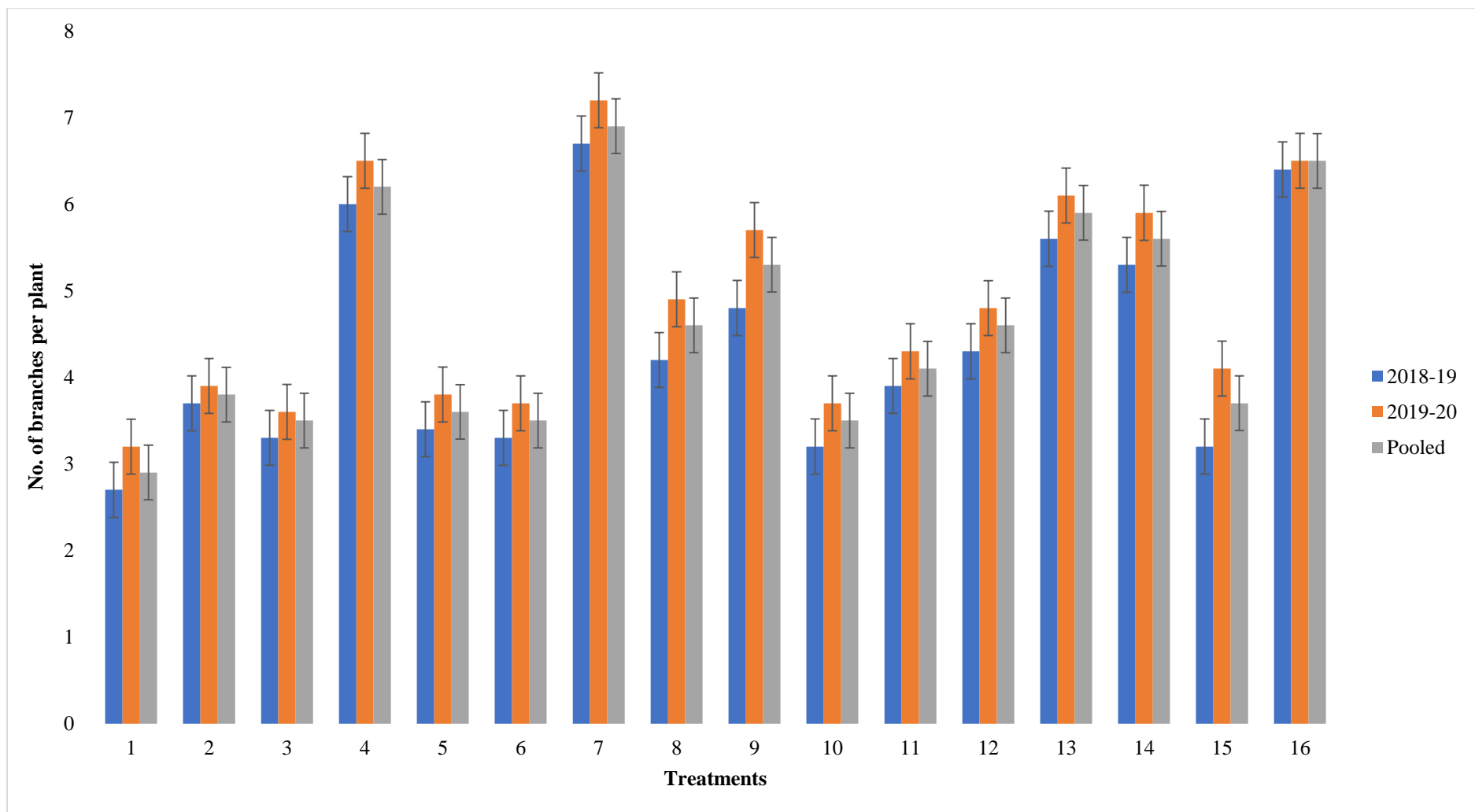


Fig. 4.3: Influence of organic and biodynamic manures on No. of branches in chrysanthemum cv. Thai Chen Queen

4.1.4 Length of branches (cm)

Data shown in Table 4.4 and Fig. 4.4 reveal that the effect of organic and biodynamic manures on length of branches (cm) was significant in both the years 2018-19 and 2019-20.

During the year 2018-19, the maximum length of branch (15.8 cm) was recorded in the treatment T₇ (6% Panchagavya + CBD*) which was subsequently followed by T₁₆ (50% Jivamrita + CBD*), T₄ (3% Panchagavya + CBD*) and T₉ (8% Panchagavya + CBD*) with length of branches 15.2, 14.8 and 14.4 cm and minimum length of branch (9.6 cm) was found in the treatment T₁ (Control).

In the year 2019-20, the same treatment T₇ (6% Panchagavya + CBD*) exhibited maximum length of branch (15.3 cm) which was at par with the previous year data and also it was found statistically significant with other treatments. After T₇, highest effect on branch length was demonstrated by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*). While, minimum length was recorded for the T₁ (Control) *i.e.*, 8.5 cm.

Pooled data of the two years reveal that maximum length of branch (15.6 cm) was observed in the plants treated with 6% Panchagavya + CBD* *i.e.*, (T₇) which was statistically at par with T₁₆ (50% Jivamrita + CBD*) with a length of 15.1 cm while minimum length of branch (9.1 cm) was observed in the T₁ (Control) plants. Increase in length of branches is due to presence of growth regulatory substances in Panchagavya, such as IAA (Indoleacetic acid), GA and cytokinins. Jivamrita also has a high microbial load, which multiplies and improves soil quality. Increased microbial activity in the soil ensures that nutrients are available to crops (**Brar *et al.*, 2019**). This finding is consistent with **Bohra and Kumar (2014)** who reported that application of VAM (20 g/plant) + vermicompost (300 g/m²) increased number of primary and secondary branches in chrysanthemum cv. Little Darling, **Kumbar and Devakumar (2016)** observed that application of higher levels of Jeevamrutha (2000 l ha⁻¹) and Panchagavya (6%) recorded highest length of branches in French bean. **Harshavardhan *et al.* (2016)** discovered that combined application of inorganic fertilizers, biofertilizers and biodynamic manures increased length of branches in carnation and **Reshma *et al.*, (2019)** found that application of Jeevamrutha at 1000 l ha⁻¹ and Panchagavya at 7.5% significantly increased length of branches in cowpea.

Table 4.4: Effect of organic and biodynamic manures on length of branches per plant in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Length of branches (cm)		
		2018-19	2019-20	Pooled
T ₁	Control	9.6	8.5	9.1
T ₂	1% Panchagavya + CBD*	12.2	11.8	12.1
T ₃	2% Panchagavya + CBD*	12.7	12.5	12.6
T ₄	3% Panchagavya + CBD*	14.8	14.2	14.5
T ₅	4% Panchagavya + CBD*	13.0	12.9	13.1
T ₆	5% Panchagavya + CBD*	10.9	10.2	10.6
T ₇	6% Panchagavya + CBD*	15.8	15.3	15.6
T ₈	7% Panchagavya + CBD*	11.8	11.3	11.5
T ₉	8% Panchagavya + CBD*	14.4	13.8	14.1
T ₁₀	9% Panchagavya + CBD*	12.9	12.7	12.8
T ₁₁	10% Panchagavya + CBD*	11.2	10.8	11.1
T ₁₂	10% Jivamrita + CBD*	13.2	13.1	13.2
T ₁₃	20% Jivamrita + CBD*	14.4	13.5	14.1
T ₁₄	30% Jivamrita + CBD*	13.8	13.2	13.5
T ₁₅	40% Jivamrita + CBD*	12.5	12.1	12.3
T ₁₆	50% Jivamrita + CBD*	15.2	14.8	15.1
SEm±		0.44	0.22	0.18
C.D. at 5%		1.28	0.65	0.53

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

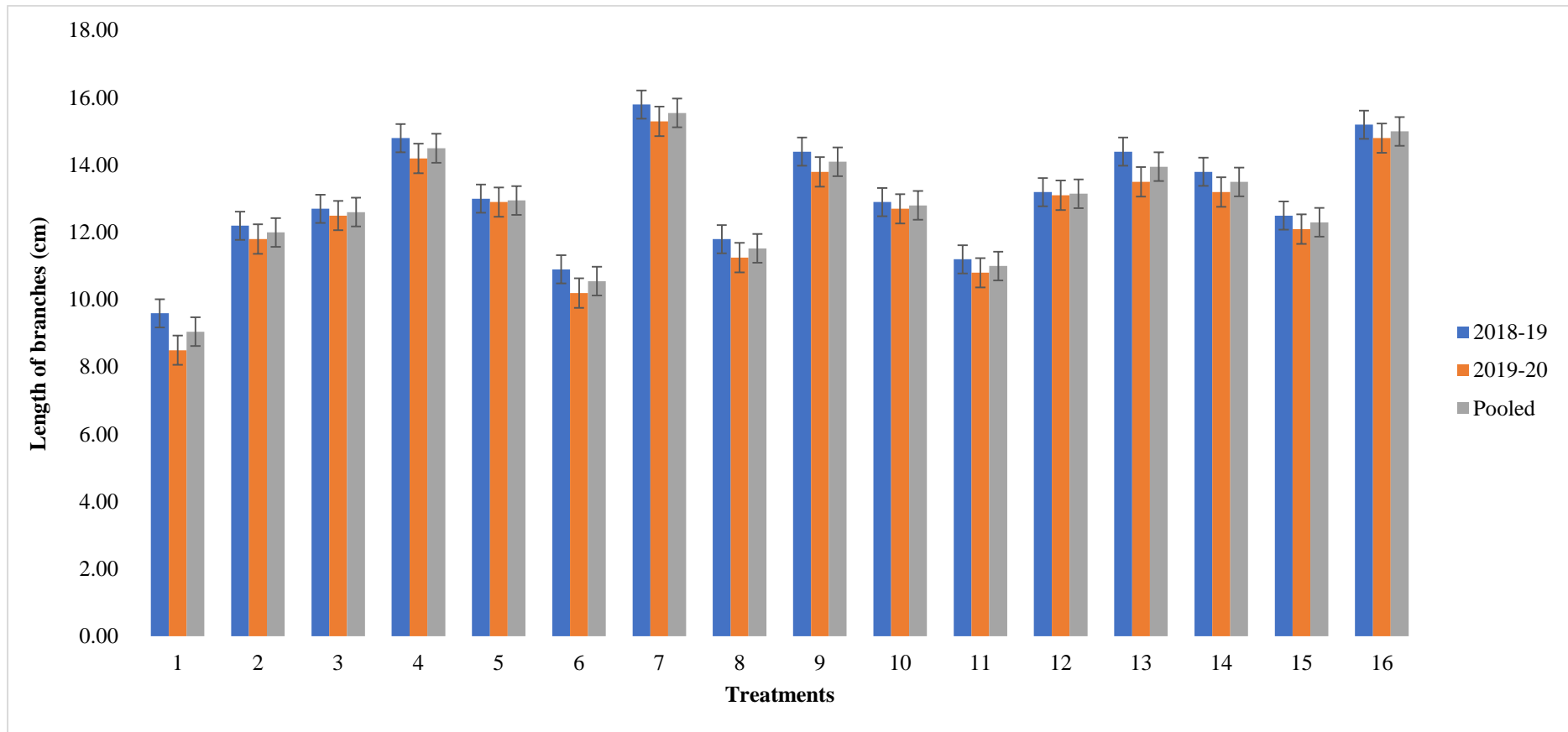


Fig. 4.4: Influence of organic and biodynamic manures on length of branches in chrysanthemum cv. Thai Chen Queen

4.1.5 Chlorophyll content (mg g⁻¹ FW leaf)

Effects of organic and biodynamic manures on chlorophyll 'a', chlorophyll 'b' and total chlorophyll content of leaves during the year 2018-19 and 2019-20, respectively have been analysed and results are presented in Table 4.5.1 to 4.5.4 and Fig. 4.5.

4.1.5.1 Chlorophyll 'a' content (mg g⁻¹ FW leaf)

Response of organic and biodynamic manures on chlorophyll 'a' content of leaves was measured during both the years of investigation at 30, 60 and 90 days after planting and results are presented in Table 4.5.1 and Fig. 4.5.

During both the years (2018-19, 2019-20) of investigation, maximum chlorophyll 'a' (1.64, 1.63 mg g⁻¹, respectively) content at 30 days after planting was recorded in the treatment T₇ *i.e.*, 6% Panchagavya + CBD* followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading of 1.56, 1.57 and 1.55, 1.56 mg g⁻¹, respectively. Moreover, treatments T₁₀, T₁₁ and T₁₂ also exhibited same amount of chlorophyll 'a' content *i.e.*, 1.44 and 1.43 mg g⁻¹ in both the years, respectively. Whereas, minimum chlorophyll 'a' (1.43 mg g⁻¹) was recorded in the treatment T₃ (2% Panchagavya + CBD*) but in the year 2019-20, it was recorded in the T₁, T₁₀, T₁₁ and T₁₂ (1.43 mg/g each). Pooled data of chlorophyll 'a' after 30 days after planting revealed that the treatment T₇ (6% Panchagavya + CBD*) exhibited maximum chlorophyll 'a' content *i.e.*, 1.64 mg g⁻¹ and minimum (1.44 mg g⁻¹) was recorded in the treatment T₁₀, T₁₂ and T₄.

At 60 days after planting, highest content of chlorophyll 'a' was recorded in the treatment T₇ *i.e.*, 6% Panchagavya + CBD*, with a reading of 1.33 and 1.34 mg g⁻¹ followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading 1.29, 1.28 and 1.26, 1.25 mg g⁻¹ in 2018-19 and 2019-20, respectively. Minimum chlorophyll 'a' during 2018-19 was recorded in the treatment 2% Panchagavya + CBD* (T₃). Whereas during 2019-20, minimum chlorophyll a was recorded for T₅ and T₁₅. Pooled data of chlorophyll 'a' after 60 days after planting revealed that the treatment T₇ *i.e.*, 6% Panchagavya + CBD* demonstrated maximum

content of chlorophyll 'a' *i.e.*, 1.34 mg g⁻¹ and minimum 1.07 mg g⁻¹ was recorded in the T₅ and T₁₅ treatments.

At 90 days after planting, highest chlorophyll 'a' content was recorded in treatment T₇ (6% Panchagavya + CBD*), with a reading of 0.95 and 0.93 mg g⁻¹ in both the years, respectively. Treatments T₁₆ has same amount of chlorophyll 'a' content of leaves *i.e.*, 0.94 mg g⁻¹ in 2018-19 and 0.91 mg g⁻¹ in 2019-20. While, minimum chlorophyll 'a' content (0.78 mg g⁻¹) was recorded in the treatment T₃ (2% Panchagavya + CBD*). Pooled data of chlorophyll 'a' after 90 days after planting revealed that the treatment T₇ *i.e.*, 6% Panchagavya + CBD* exhibited maximum chlorophyll 'a' content *i.e.*, 0.94 mg g⁻¹ and minimum 0.78 mg g⁻¹ was recorded in the treatment 2% Panchagavya + CBD* (T₃).

4.1.5.2 Chlorophyll 'b' content (mg g⁻¹ FW leaf)

Response of organic and biodynamic manures on chlorophyll 'b' content of leaves during both the years of investigation have been analysed at 30, 60 and 90 days after planting and results are presented in Table 4.5.2 and Fig. 4.5.

Throughout the two years of investigation, maximum chlorophyll 'b' content of leaves (0.40 and 0.41 mg g⁻¹) at 30 days after planting was recorded in the treatment T₇ *i.e.*, (6% Panchagavya + CBD*) followed by 50% Jivamrita + CBD* (T₁₆) and 3% Panchagavya + CBD* (T₄). Minimum chlorophyll 'b' (0.24 mg g⁻¹) was recorded in the treatment T₃ (2% Panchagavya + CBD*). Pooled data of chlorophyll 'b' after 30 days after planting revealed that the treatment T₇ *i.e.*, 6% Panchagavya + CBD* has maximum content of chlorophyll 'b' content *i.e.*, 0.41 mg g⁻¹ and minimum chlorophyll b (0.24 mg g⁻¹) was recorded in the T₃ (2% Panchagavya + CBD*).

During both the years of investigation, the highest chlorophyll 'b' content (0.273 and 0.28 mg g⁻¹) at 60 days after planting was recorded in the treatment T₇ *i.e.*, (6% Panchagavya + CBD*), followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading of 0.25, 0.26, and 0.24, 0.25 mg g⁻¹, respectively. Chlorophyll 'b' content was lowest (0.13 mg g⁻¹) in the treatment T₁₅ (40% Jivamrita + CBD*). Pooled data on chlorophyll 'a' content 60 days after

planting revealed that the treatment T₇, *i.e.*, 6% Panchagavya + CBD*, exhibited the highest chlorophyll 'b' content, 0.28 mg g⁻¹, and the lowest, 0.13 mg g⁻¹, was observed for the treatment T₁₅.

After 90 days after planting, the maximum content of chlorophyll 'b' (0.19 and 0.20 mg g⁻¹) was reported in treatment T₇ *i.e.*, 6% Panchagavya + CBD* in both years of research followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*). Treatments T₅, T₆, T₁₀ and T₁₁ demonstrated same amount of chlorophyll 'b' content of leaves in the year 2018-19. Minimum amount of chlorophyll 'b' content of leaves (0.13 mg g⁻¹) is recorded in T₂ (1% Panchagavya + CBD*). Pooled data of chlorophyll 'b' after 90 days after planting revealed that the treatment T₇ *i.e.*, 6% Panchagavya + CBD* has maximum chlorophyll 'b' content *i.e.*, 0.20 mg g⁻¹. Minimum amount of chlorophyll 'b' (0.11 mg g⁻¹) was recorded in T₁₅.

4.1.5.3 Total chlorophyll content (mg g⁻¹ FW leaf)

The effect of organic and biodynamic manures on total chlorophyll content of leaves was studied over two years. at 30, 60 and 90 days after planting and results are presented in Table 4.5.3 and Fig. 4.5.

During both the years of investigation, the highest total chlorophyll content (1.92 and 1.95 mg g⁻¹) at 30 days after planting was observed in the treatment T₇ (6% Panchagavya + CBD*). Moreover, nearly equivalent total chlorophyll content was also demonstrated by the T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) treatments with 1.81, 1.88 and 1.79 mg g⁻¹ in 2018-19 and 2019-20, respectively. Minimum total chlorophyll (1.55 mg g⁻¹) was recorded in the treatment T₈ (7% Panchagavya + CBD*). But in the year 2019-20, it was decreased as 1.52 mg g⁻¹ in the T₁₁ (10% Panchagavya + CBD*). Pooled data on total chlorophyll content at 30 days after planting revealed that the treatment T₇ (6% Panchagavya + CBD*) contains the highest amount of total chlorophyll, 1.94 mg g⁻¹. A minimum of 1.54 mg g⁻¹ was recorded in the T₈ (7% Panchagavya + CBD*).

In two years of research, the maximum total chlorophyll content (1.74 mg g⁻¹) at 60 days after planting was recorded in the treatment T₇ *i.e.*, (6% Panchagavya + CBD*), followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*)

with a reading of 1.65, and 1.60, 1.58 mg g⁻¹, respectively. Whereas, lowest total chlorophyll content (1.31 and 1.30 mg g⁻¹) was recorded in the treatment T₅ (4% Panchagavya + CBD*). Pooled data on total chlorophyll content at 60 days after planting revealed that the treatment T₇, *i.e.*, 6% Panchagavya + CBD*, showed the highest total chlorophyll content, 1.74 mg g⁻¹, and the lowest, 1.31 mg g⁻¹, in the treatment T₅ and T₅ (4% Panchagavya + CBD*).

Throughout the two years of investigation, total chlorophyll content, at 90 days after planting was recorded highest in treatment T₇ *i.e.*, 6% Panchagavya + CBD*, with a reading of 1.14 and 1.16 mg g⁻¹. During the year 2019-20, treatment T₁₆ (50% Jivamrita + CBD*) was the closest to the T₇ (6% Panchagavya + CBD*) with reading of 1.14 mg g⁻¹ of total chlorophyll. Pooled data reveal that highest total chlorophyll (1.15 mg g⁻¹) was recorded in T₇ (6% Panchagavya + CBD*) which was at par with T₁₆ (50% Jivamrita + CBD*) with reading 1.13 mg g⁻¹ of total chlorophyll. Whereas, minimum total chlorophyll content 0.93 mg g⁻¹ each was recorded in the 7% Panchagavya + CBD* (T₈) and 10% Jivamrita + CBD* (T₁₂).

Increase in chlorophyll with the interaction of bio-enhancers in this study might be ascribed to supply of essential nutrients to the plants by different bio-enhancers. The fermented solution of Panchagavya and Jivamrita contains various nutrients rich in N, P, K, S and micronutrients in plant available form. Hence, availability of these nutrients to the plants helps in the formation of chlorophyll in the leaves. Increased chlorophyll 'a', 'b' and total chlorophyll content in green leaves with spray of organic manures. The above findings are in conformity with the findings of **Sangeetha and Thevanathan (2010)** who observed that application of seaweed-based Panchagavya in pulse crops and rice increased levels of chlorophyll b content and a better efficiency of nitrogen use in these plants. **Verma *et al.* (2013)** found that application of vermicompost 20% increased chlorophyll content and relative water content in landscape gerbera grown under greenhouse condition. **Sendhilnathan *et al.* (2017)** found that application of vermicompost @ 2.5 t ha⁻¹ and foliar spray of Panchagavya 3% was found to increase chlorophyll content in Gundumalli (*Jasminum sambac* Ait.). **Vetrivel *et al.* (2017)** observed that Panchagavya @ 2% + seaweed extract @ 4% increased no. of leaves in chrysanthemum var. Amalfi.

Table 4.5.1: Effect of organic and biodynamic manures on chlorophyll 'a' content (mg g⁻¹ FW leaf) in leaves of chrysanthemum

Treatments	Combinations	Chlorophyll 'a' (mg g ⁻¹ FW leaf)								
		30 days			60 days			90 days		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	1.44	1.43	1.44	1.13	1.12	1.13	0.81	0.82	0.82
T ₂	1% Panchagavya + CBD*	1.45	1.44	1.44	1.18	1.18	1.18	0.91	0.88	0.89
T ₃	2% Panchagavya + CBD*	1.43	1.44	1.44	1.07	1.09	1.08	0.78	0.78	0.78
T ₄	3% Panchagavya + CBD*	1.55	1.56	1.56	1.26	1.25	1.26	0.93	0.90	0.92
T ₅	4% Panchagavya + CBD*	1.47	1.46	1.47	1.04	1.07	1.06	0.81	0.80	0.80
T ₆	5% Panchagavya + CBD*	1.44	1.45	1.45	1.14	1.14	1.14	0.88	0.86	0.87
T ₇	6% Panchagavya + CBD*	1.64	1.63	1.64	1.33	1.34	1.34	0.95	0.93	0.94
T ₈	7% Panchagavya + CBD*	1.36	1.35	1.36	1.13	1.14	1.14	0.81	0.78	0.80
T ₉	8% Panchagavya + CBD*	1.54	1.54	1.54	1.25	1.25	1.25	0.92	0.89	0.91
T ₁₀	9% Panchagavya + CBD*	1.44	1.43	1.43	1.19	1.87	1.53	0.81	0.80	0.81
T ₁₁	10% Panchagavya + CBD*	1.44	1.43	1.43	1.16	1.52	1.34	0.89	0.86	0.87
T ₁₂	10% Jivamrita + CBD*	1.44	1.43	1.43	1.08	1.08	1.08	0.81	0.80	0.80
T ₁₃	20% Jivamrita + CBD*	1.51	1.51	1.51	1.22	1.23	1.23	0.92	0.91	0.91
T ₁₄	30% Jivamrita + CBD*	1.49	1.50	1.49	1.21	1.21	1.21	0.92	0.91	0.91
T ₁₅	40% Jivamrita + CBD*	1.45	1.46	1.45	1.06	1.07	1.07	0.82	0.81	0.82
T ₁₆	50% Jivamrita + CBD*	1.56	1.57	1.57	1.29	1.28	1.28	0.94	0.91	0.93
SEm±		0.021	0.024	0.019	0.01	0.017	0.015	0.011	0.011	0.013
C.D. at 5%		0.061	0.069	0.054	0.029	0.049	0.043	0.032	0.032	0.036

Table 4.5.2: Effect of organic and biodynamic manures on chlorophyll 'b' content (mg g⁻¹ FW leaf) in leaves of chrysanthemum

Treatments	Combinations	Chlorophyll 'b' (mg g ⁻¹ FW leaf)								
		30 days			60 days			90 days		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	0.28	0.27	0.27	0.20	0.19	0.19	0.14	0.14	0.14
T ₂	1% Panchagavya + CBD*	0.31	0.30	0.31	0.17	0.17	0.17	0.13	0.13	0.13
T ₃	2% Panchagavya + CBD*	0.24	0.24	0.24	0.19	0.18	0.18	0.14	0.13	0.13
T ₄	3% Panchagavya + CBD*	0.35	0.33	0.34	0.24	0.24	0.24	0.16	0.16	0.16
T ₅	4% Panchagavya + CBD*	0.27	0.27	0.27	0.19	0.18	0.19	0.14	0.13	0.14
T ₆	5% Panchagavya + CBD*	0.28	0.27	0.28	0.17	0.17	0.17	0.14	0.14	0.14
T ₇	6% Panchagavya + CBD*	0.40	0.41	0.41	0.27	0.28	0.28	0.19	0.20	0.20
T ₈	7% Panchagavya + CBD*	0.27	0.27	0.27	0.18	0.18	0.18	0.14	0.13	0.14
T ₉	8% Panchagavya + CBD*	0.33	0.32	0.33	0.23	0.24	0.24	0.15	0.15	0.15
T ₁₀	9% Panchagavya + CBD*	0.27	0.26	0.27	0.17	0.17	0.17	0.14	0.13	0.14
T ₁₁	10% Panchagavya + CBD*	0.28	0.27	0.28	0.18	0.19	0.18	0.14	0.14	0.14
T ₁₂	10% Jivamrita + CBD*	0.26	0.26	0.26	0.20	0.19	0.19	0.13	0.13	0.13
T ₁₃	20% Jivamrita + CBD*	0.32	0.31	0.31	0.22	0.22	0.22	0.15	0.14	0.14
T ₁₄	30% Jivamrita + CBD*	0.31	0.29	0.30	0.21	0.20	0.20	0.14	0.14	0.14
T ₁₅	40% Jivamrita + CBD*	0.27	0.26	0.27	0.13	0.13	0.13	0.11	0.11	0.11
T ₁₆	50% Jivamrita + CBD*	0.36	0.36	0.36	0.25	0.26	0.26	0.19	0.19	0.19
SEm±		0.004	0.005	0.004	0.004	0.003	0.002	0.003	0.002	0.002
C.D. at 5%		0.012	0.014	0.011	0.011	0.008	0.007	0.008	0.007	0.006

Table 4.5.3: Effect of organic and biodynamic manures on total chlorophyll content (mg g⁻¹ FW leaf) in leaves of chrysanthemum

Treatments	Combinations	Total chlorophyll (mg g ⁻¹ FW leaf)								
		30 days			60 days			90 days		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	1.63	1.60	1.62	1.41	1.38	1.39	0.95	0.94	0.95
T ₂	1% Panchagavya + CBD*	1.62	1.56	1.59	1.49	1.46	1.48	1.04	1.02	1.03
T ₃	2% Panchagavya + CBD*	1.62	1.58	1.59	1.32	1.31	1.31	0.95	0.93	0.94
T ₄	3% Panchagavya + CBD*	1.79	1.79	1.79	1.60	1.58	1.59	1.10	1.08	1.09
T ₅	4% Panchagavya + CBD*	1.66	1.62	1.64	1.31	1.30	1.31	0.94	0.96	0.95
T ₆	5% Panchagavya + CBD*	1.61	1.54	1.58	1.42	1.42	1.42	1.02	1.03	1.03
T ₇	6% Panchagavya + CBD*	1.92	1.95	1.94	1.74	1.74	1.74	1.14	1.16	1.15
T ₈	7% Panchagavya + CBD*	1.55	1.53	1.54	1.40	1.39	1.40	0.95	0.92	0.93
T ₉	8% Panchagavya + CBD*	1.76	1.75	1.76	1.58	1.56	1.57	1.08	1.04	1.06
T ₁₀	9% Panchagavya + CBD*	1.61	1.60	1.60	1.45	1.44	1.45	0.96	0.95	0.95
T ₁₁	10% Panchagavya + CBD*	1.61	1.52	1.57	1.44	1.43	1.44	1.03	1.02	1.02
T ₁₂	10% Jivamrita + CBD*	1.64	1.62	1.63	1.35	1.32	1.34	0.94	0.92	0.93
T ₁₃	20% Jivamrita + CBD*	1.73	1.72	1.73	1.54	1.52	1.53	1.07	1.06	1.06
T ₁₄	30% Jivamrita + CBD*	1.70	1.67	1.69	1.52	1.50	1.51	1.06	1.02	1.04
T ₁₅	40% Jivamrita + CBD*	1.59	1.57	1.58	1.33	1.33	1.33	0.96	0.95	0.96
T ₁₆	50% Jivamrita + CBD*	1.81	1.88	1.85	1.65	1.65	1.65	1.12	1.14	1.13
SEm±		0.028	0.027	0.026	0.021	0.027	0.023	0.01	0.015	0.015
C.D. at 5%		0.081	0.079	0.076	0.062	0.077	0.066	0.04	0.044	0.042

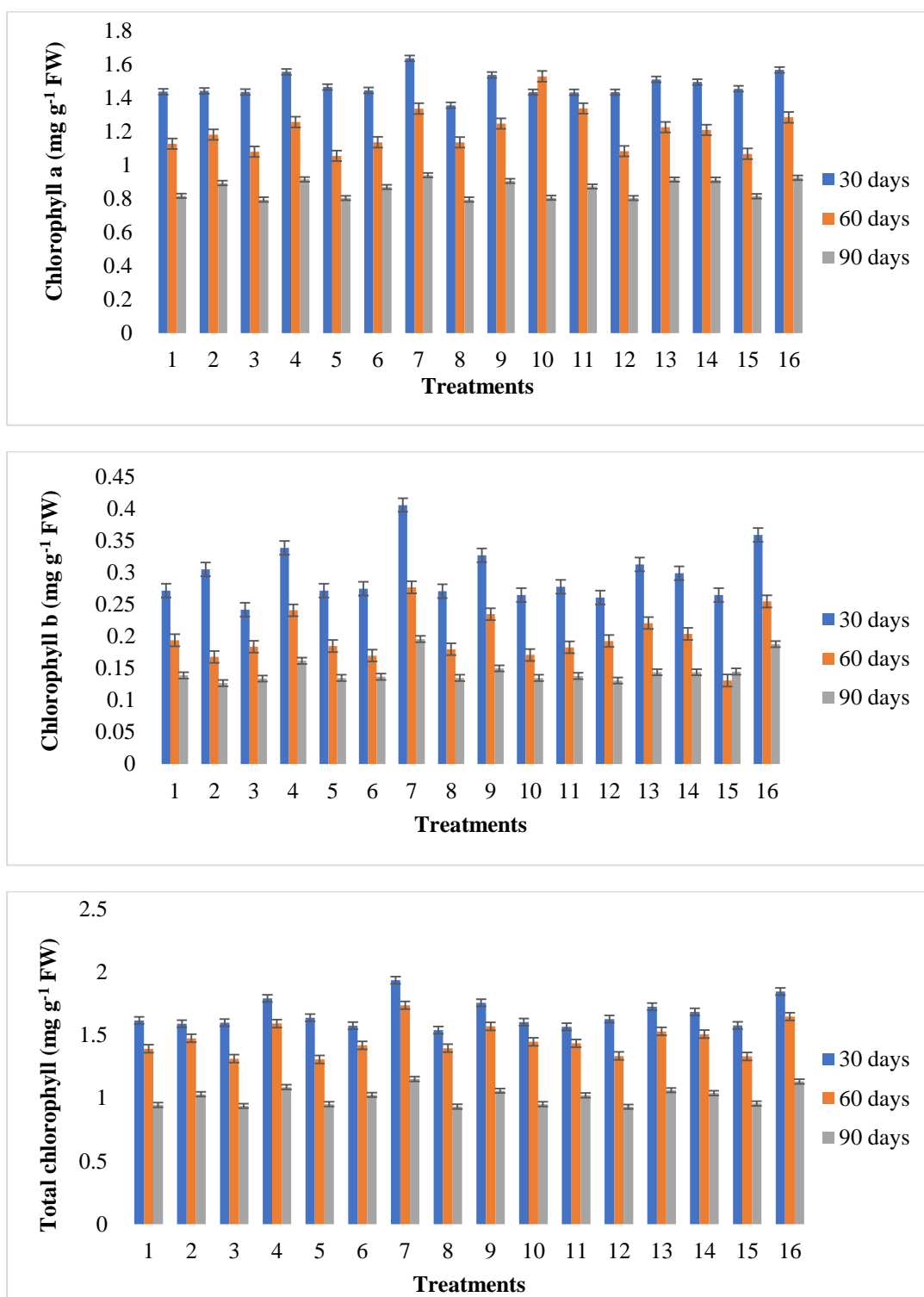


Fig. 4.5: Influence of organic and biodynamic manures on chlorophyll a, b and total chlorophyll content in leaves of chrysanthemum cv. Thai Chen Queen

4.2 Flowering and Yield Parameters

4.2.1 Days to first bud initiation

The data on number of days taken to flower bud appearance after planting are presented in Table 4.6. and Figure 4.6. Days taken for appearance of the first bud is an important character signifying early or late flowering habit.

During the year 2018-19, minimum number of days (45) to flower bud appearance were recorded in T₇ (6% Panchagavya + CBD*) which was statistically at par with T₁₆ (50% Jivamrita + CBD*) (46 days). The maximum number of days taken to flower bud appearance (59 days) were recorded in T₁, T₃ and T₁₁. The results reflect that the differences were significant among the treatments with respect to days taken to first bud appearance.

In the year 2019-20, there was significant difference in bud initiation between the control and biodynamic manures. Minimum days required for first bud initiation (44) were recorded again in the same treatment *i.e.*, 6% Panchagavya + CBD* (T₇) which was statistically at par with T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with 45 and 46 days, respectively. Maximum no. of days required for bud initiation was seen in Control (T₁) with 62 days.

Pooled analysis of two years data revealed that minimum no. of days for bud initiation is 45 days which was recorded in the 6% Panchagavya + CBD* (T₇) which was statistically at par with T₁₆ (50% Jivamrita + CBD*) with 46 days. Maximum no. of days required for bud initiation were seen in Control (T₁) with 61 days for first bud initiation.

Early bud initiation may be assisted by the use of biodynamic manures, which aid in the accumulation of C:N ratios and the synthesis of more gibberilins in plant systems, both of which may aid in bud initiation. The current findings find support from **Beulah (2001)** who found that Panchgavya application accelerated the time to first flowering in *Moringa oleifera*. According to **Bohra and Kumar (2014)**, the application of VAM (20 g/plant) and vermicompost (300 g/m²) aided bud initiation in chrysanthemum cv. Little Darling. The biodynamic amendment of 5% Panchagavya had a significant effect on days to first flower bud initiation in marigold, according to **Singh et al. (2015)**. **Trivedi et al. (2016)** observed that application of combination of 6 % Panchagavya + 1:5 times dilution of Vermiwash + 30% Jivamrita resulted in earliest bud initiation in rose cv. Grand Gala.

Table 4.6: Effect of organic and biodynamic manures on days to first bud initiation in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Days to first bud initiation		
		2018-19	2019-20	Pooled
T ₁	Control	59	62	61
T ₂	1% Panchagavya + CBD*	53	57	55
T ₃	2% Panchagavya + CBD*	59	56	57
T ₄	3% Panchagavya + CBD*	48	46	47
T ₅	4% Panchagavya + CBD*	57	59	58
T ₆	5% Panchagavya + CBD*	58	56	57
T ₇	6% Panchagavya + CBD*	45	44	45
T ₈	7% Panchagavya + CBD*	56	57	56
T ₉	8% Panchagavya + CBD*	49	50	50
T ₁₀	9% Panchagavya + CBD*	52	51	52
T ₁₁	10% Panchagavya + CBD*	59	59	59
T ₁₂	10% Jivamrita + CBD*	53	51	52
T ₁₃	20% Jivamrita + CBD*	49	53	51
T ₁₄	30% Jivamrita + CBD*	53	56	54
T ₁₅	40% Jivamrita + CBD*	55	49	52
T ₁₆	50% Jivamrita + CBD*	46	45	46
SEm±		0.81	0.93	0.89
C.D. at 5%		2.35	2.72	2.61

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria.

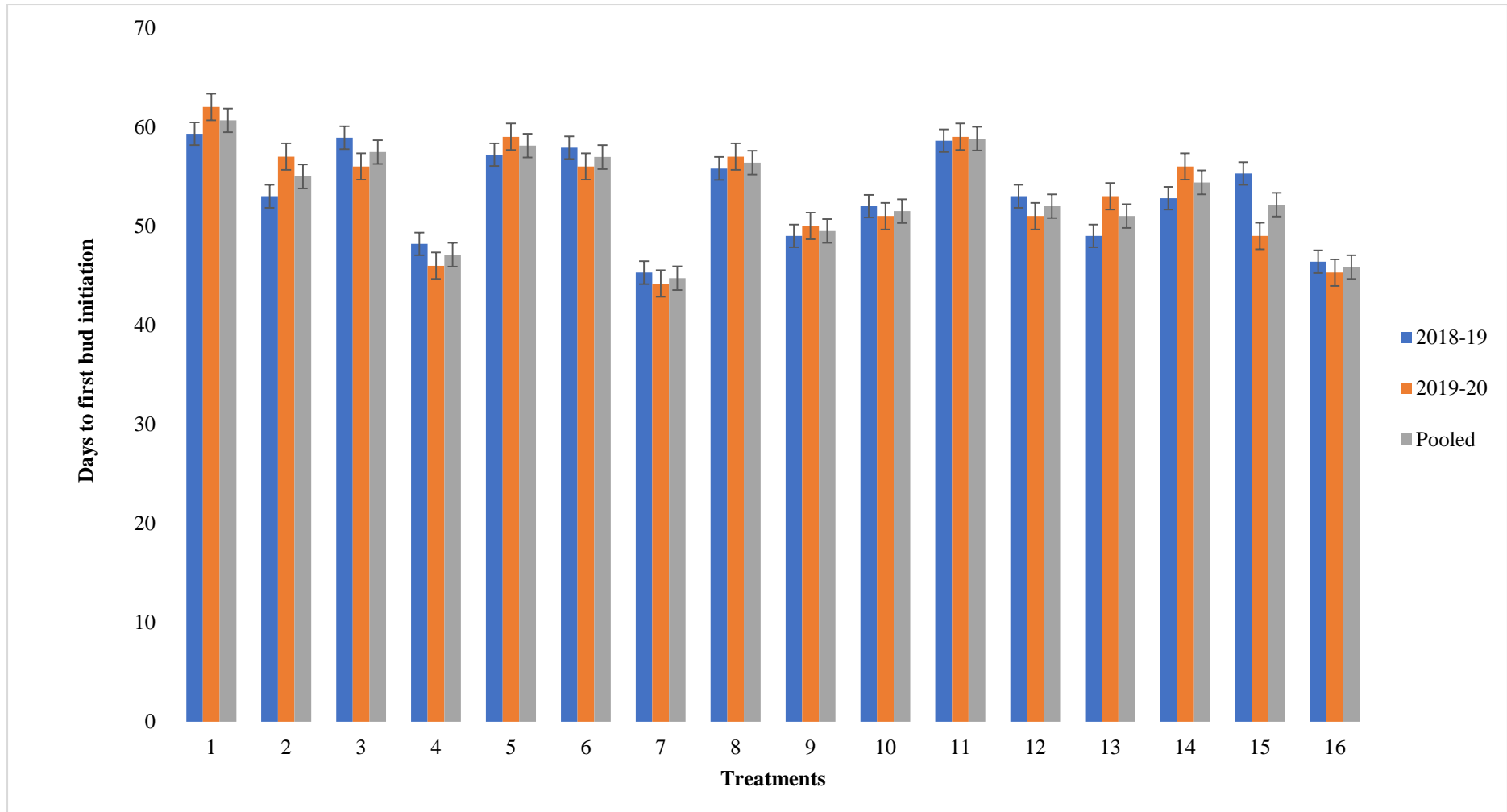


Fig. 4.6: Influence of organic and biodynamic manures on days to first bud initiation in chrysanthemum cv. Thai Chen Queen

4.2.2 Bud diameter (cm)

Data pertaining to the effect of organic and biodynamic manures treatments and their effect on bud diameter (cm) during 2018-2019 and 2019-20, are presented in Table 4.7 and Figure 4.7.

The analysis of the data revealed that the diameter of the buds varies significantly upon treatment of organic and biodynamic manures. During the 2018-19 crop season, the use of various organic and biodynamic manures resulted in a considerable increase in bud diameter compared to the control. The treatment T₇ (6% Panchagavya + CBD*) exhibited the largest bud diameter (2.55 cm), followed by T₁₆ (50% Jivamrita + CBD*) which had the bud diameter of 1.73 cm. T₁ (Control) demonstrated the smallest bud diameter (0.83 cm).

During the second year (2019-20), again treatment T₇ (6% Panchagavya + CBD*), exhibited the maximum bud diameter (2.53 cm) followed by T₁₆ (50% Jivamrita and CBD*) (1.72 cm) which was much better than the other treatments. In contrast, treatment T₁ (Control) showed the smallest bud diameter of 0.81 cm.

Pooled data of two years reveal that maximum bud diameter (2.54 cm) was recorded in the application of T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) *i.e.*, (1.72 cm) and minimum bud diameter was recorded in the T₁ (Control) *i.e.*, 0.82 cm.

Increased flower bud diameter could be due to a combined application of Panchagavya and common basal dose of biofertilizers, which increased nutrient availability and absorption, as well as the release of growth promoting hormones like IAA and GA, which promote growth through increased cell division and enlargement, resulting in larger flower buds. These findings are in agreement with **Singh *et al.*, (2015)**, who discovered that a biodynamic amendment of 5% Panchagavya had a significant effect on marigold bud length. According to **Trivedi *et al.* (2016)**, a combination of 6% Panchagavya + 1:5 times Vermiwash dilution + 30 percent Jivamrita resulted in the maximum flower bud length in rose cv. Grand Gala.

Table 4.7: Effect of organic and biodynamic manures on bud diameter of chrysanthemum

Treatments	Combinations	Bud diameter (cm)		
		2018-19	2019-20	Pooled
T ₁	Control	0.83	0.81	0.82
T ₂	1% Panchagavya + CBD*	1.56	1.55	1.56
T ₃	2% Panchagavya + CBD*	1.46	1.44	1.45
T ₄	3% Panchagavya + CBD*	1.67	1.67	1.68
T ₅	4% Panchagavya + CBD*	1.12	1.13	1.13
T ₆	5% Panchagavya + CBD*	1.61	1.58	1.59
T ₇	6% Panchagavya + CBD*	2.55	2.53	2.54
T ₈	7% Panchagavya + CBD*	1.41	1.38	1.39
T ₉	8% Panchagavya + CBD*	1.24	1.22	1.23
T ₁₀	9% Panchagavya + CBD*	1.38	1.37	1.38
T ₁₁	10% Panchagavya + CBD*	1.41	1.39	1.40
T ₁₂	10% Jivamrita + CBD*	1.16	1.16	1.16
T ₁₃	20% Jivamrita + CBD*	1.47	1.46	1.47
T ₁₄	30% Jivamrita + CBD*	1.62	1.60	1.61
T ₁₅	40% Jivamrita + CBD*	1.41	1.39	1.40
T ₁₆	50% Jivamrita + CBD*	1.73	1.72	1.72
SEm±		0.02	0.02	0.02
C.D. at 5%		0.06	0.06	0.05

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria). as well as potash bacteria

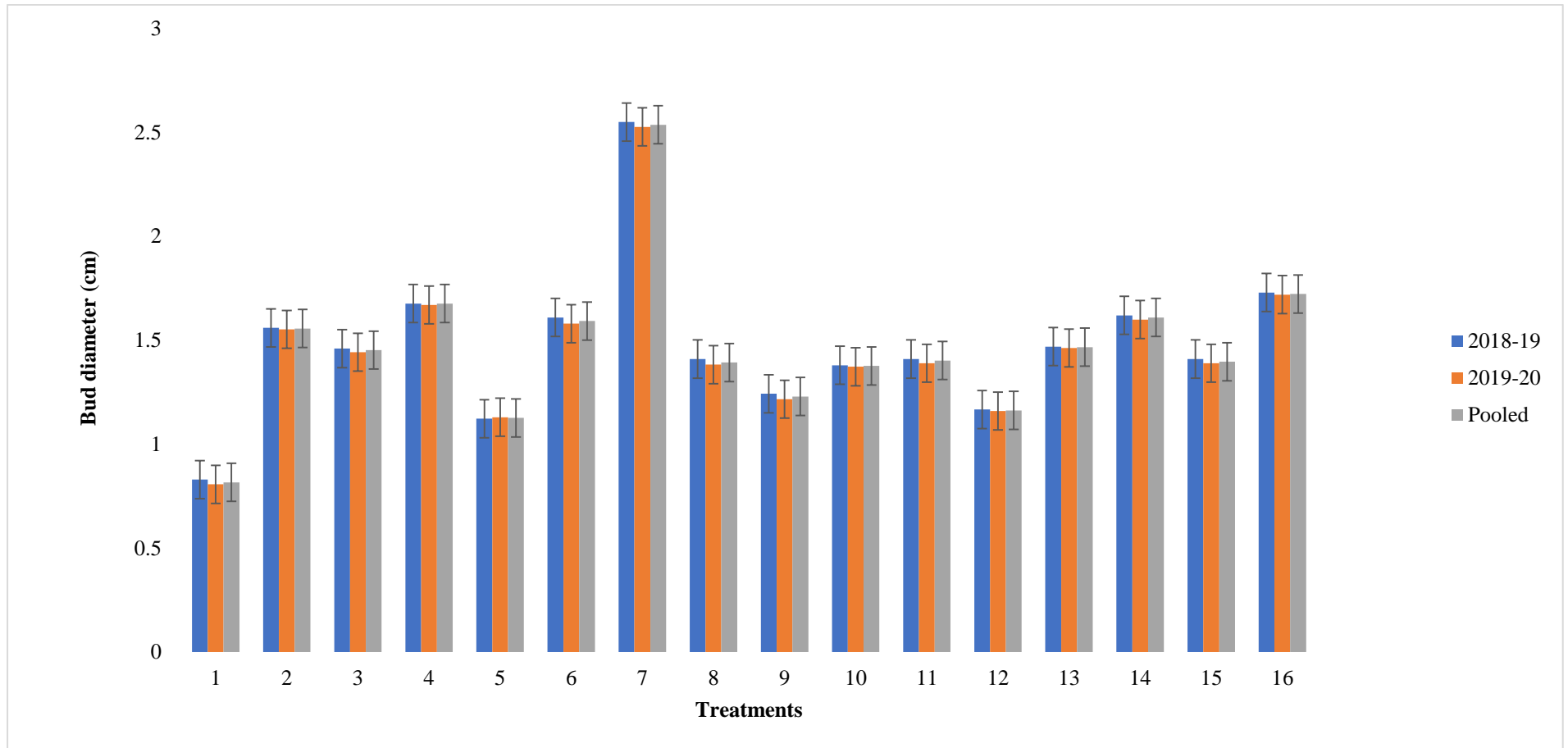


Fig 4.7: Influence of organic and biodynamic manures on bud diameter in chrysanthemum cv. Thai Chen Queen

4.2.3 No. of buds per plant

A data pertaining to the no. of buds per plant in chrysanthemum during the year 2018-19 and 2019-20, respectively are given in the Table 4.8 and illustrated in the figure 4.8.

The data on number of buds per plant as influenced by different levels of organic and biodynamic manures. During the year 2018-19, maximum number of buds per plant (42) were recorded in 6% Panchagavya + CBD* (T₇) and T₁₆ (50% Jivamrita + CBD*) (41) treatments, which was at par in the year 2018-19. The minimum number of buds per plant (29) were observed in T₁ (Control).

The influence of biodynamic manures on number of buds per plant was also found significant in 2019-20. The maximum number of buds per plant (38) was found in 6% Panchagavya + CBD* (T₇) which was subsequently followed by T₁₆ (50% Jivamrita + CBD*) with 36 buds per plant. The minimum number of buds per plant (24) was recorded in T₁₃.

Pooled analysis of data for both the years concluded that treatment with 6% Panchagavya + CBD* application recorded maximum no. of buds per plant (40) which was statistically at par with the treatment T₁₆ (50% Jivamrita + CBD*) with 39 buds per plant. Minimum no. of buds (27) per plant were recorded in the T₁ (Control) and T₁₃ (20% Jivamrita + CBD*).

Increase in no. of buds per plant might be due to application of liquid manures like Panchagavya and Jivamrita. Among this Panchagavya, nutritional and microbial analysis revealed that it contains a wide variety of macro- and micronutrients, as well as a large population of important microbes, such as *Azotobacter* sp., *Actinomycetes* sp., and phosphate solubilizers. Among these roles of *Azotobacter* in atmospheric nitrogen fixation, improved root proliferation by VAM, and nutrient uptake by PSB and potash bacteria, increased food accumulation in the plants, which may have resulted in better plant growth and a higher number of buds per plant **Chadha et al (2011)**. The findings with regard to the number of buds per plant are also in agreement with the findings of **Bhalla et al., (2006a)**, who reported that a combination of 6% Manchurian mushroom tea and 6% Panchgavya resulted in more florets per spike in gladiolus cv. Red Beauty and **Mahawer et al., (2010)** discovered that applying 3% Panchgavya + 4% Manchurian mushroom tea increased the number of florets per spike in tuberose cv. Phule Rajani.

Table 4.8: Effect of organic and biodynamic manures on no. of buds per plant of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	No. of buds per plant		
		2018-19	2019-20	Pooled
T ₁	Control	29	25	27
T ₂	1% Panchagavya + CBD*	33	25	29
T ₃	2% Panchagavya + CBD*	31	27	29
T ₄	3% Panchagavya + CBD*	40	35	38
T ₅	4% Panchagavya + CBD*	38	34	36
T ₆	5% Panchagavya + CBD*	37	33	35
T ₇	6% Panchagavya + CBD*	42	38	40
T ₈	7% Panchagavya + CBD*	34	29	31
T ₉	8% Panchagavya + CBD*	39	34	37
T ₁₀	9% Panchagavya + CBD*	33	29	31
T ₁₁	10% Panchagavya + CBD*	35	31	33
T ₁₂	10% Jivamrita + CBD*	32	26	29
T ₁₃	20% Jivamrita + CBD*	30	24	27
T ₁₄	30% Jivamrita + CBD*	34	31	33
T ₁₅	40% Jivamrita + CBD*	35	28	32
T ₁₆	50% Jivamrita + CBD*	41	36	39
SEm±		0.56	0.49	0.45
C.D. at 5%		1.64	1.4	1.31

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria). as well as potash bacteria

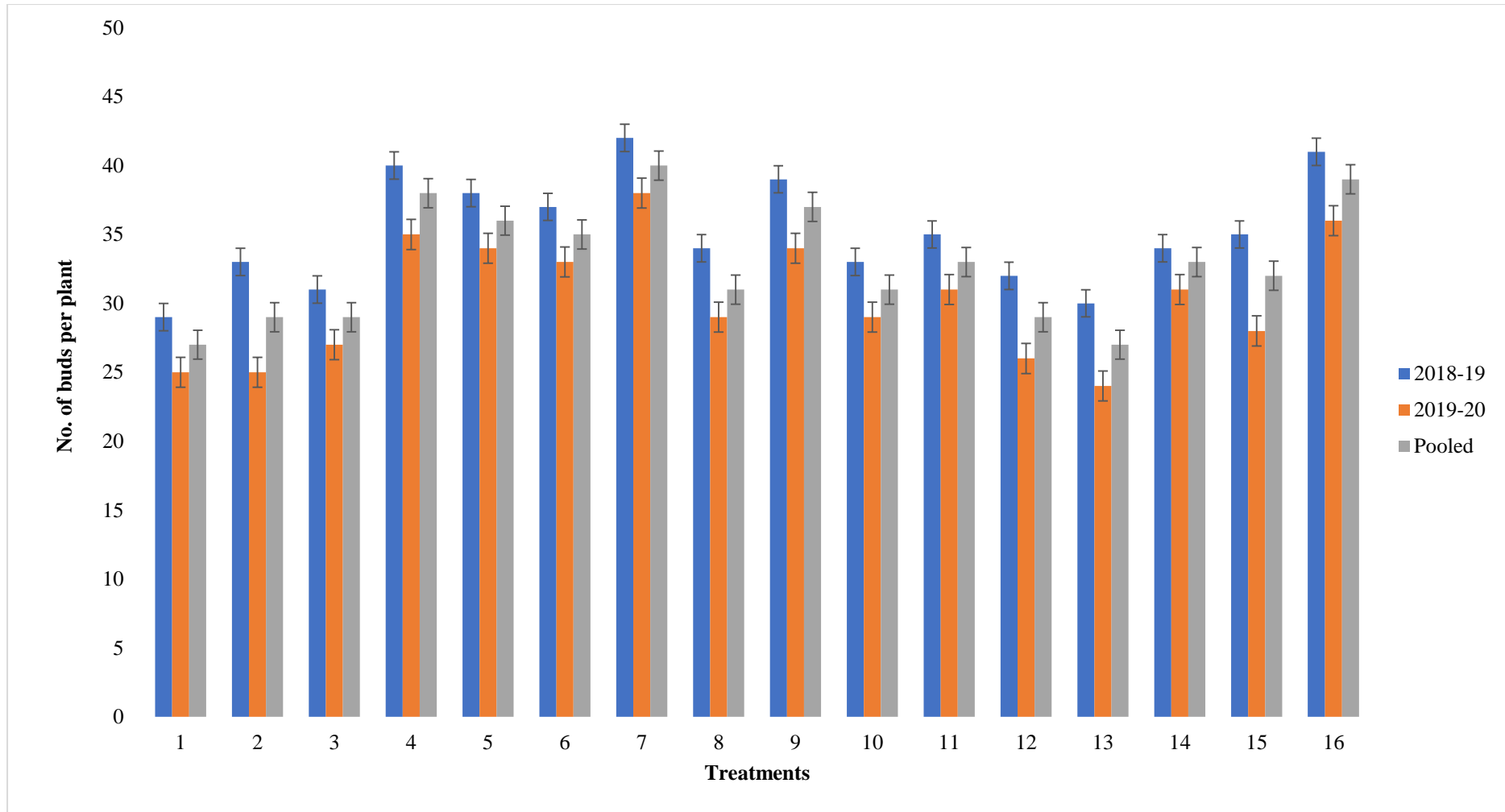


Fig 4.8: Influence of organic and biodynamic manures on No. of buds per plant in chrysanthemum cv. Thai Chen Queen

4.2.4 No. of cut flowers / plant

Response of organic and biodynamic manures treatment combinations and their response on no. of cut flowers/plant during 2018-19 and 2019-20, are presented in Table 4.9 and Fig. 4. 9.

The data pertaining to number of cut flowers per plant have been presented in Table 4.9. It is apparent from the data that number of cut flowers per plant were significantly influenced by the different levels of biodynamic manures. The maximum number of cut flowers per plant (7.46) were recorded with 6% Panchagavya + CBD* (T₇), followed by T₁₆ (50% Jivamrita + CBD*). while the minimum number of cut flowers per plant (4.13) were recorded in T₁ (Control).

The perusal of data further reveals that the effect of different levels of biodynamic manures was significant with respect to number of cut flowers per plant over control during 2019-20 year of investigation. The maximum number of cut flowers per plant (7.52) were recorded with the application of T₇ (6% Panchagavya + CBD*) whereas, the minimum number of cut flowers per plant (4.10) were observed in T₁ (Control).

Pooled data revealed that Application of T₇ (6% Panchagavya + CBD*) produced maximum number (7.49) of cut flower / plant which was closest to T₁₆ (50% Jivamrita + CBD*) producing 6.90 cut flower/plant. Minimum no. of cut flowers/plant (4.12) were recorded in the T₁ (Control).

The use of biodynamic manures such as Panchagavya and Jivamrita, which contain almost all major nutrients, micronutrients and growth hormones such as IAA and GA, may have resulted in an increase in the number of cut flowers per plant. The use of liquid manures in combination with biofertilizers improved the soil's ability to absorb nutrients. The presence of auxins in Panchagavya regulated flower initiation and development, and soil microbe activity ensures that nutrients are available and absorbed (Brar *et al.*, 2019). These results are consistent with findings of Singh *et al.*, (2006) in rose and Mahawer *et al.*, (2010) in tuberose cv. Phule Rajani Bohra, and Kumar (2014) in chrysanthemum cv. Little Darling, Singh *et al.*, (2015) in marigold, while Trivedi *et al.*, (2016) found that application of 6% Panchagavya + 1:5 times dilution of Vermiwash + 30 percent Jivamrita increased the number of flowers in rose cv. Grand Gala.

Table 4.9: Effect of organic and biodynamic manures on No. of cut flowers/plant in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	No. of cut flowers/plant		
		2018-19	2019-20	Pooled
T ₁	Control	4.13	4.10	4.12
T ₂	1% Panchagavya + CBD*	5.12	5.23	5.17
T ₃	2% Panchagavya + CBD*	5.64	5.31	5.47
T ₄	3% Panchagavya + CBD*	6.40	6.48	6.44
T ₅	4% Panchagavya + CBD*	5.70	5.54	5.62
T ₆	5% Panchagavya + CBD*	4.90	4.82	4.86
T ₇	6% Panchagavya + CBD*	7.46	7.52	7.49
T ₈	7% Panchagavya + CBD*	4.80	4.96	4.88
T ₉	8% Panchagavya + CBD*	6.11	6.25	6.18
T ₁₀	9% Panchagavya + CBD*	5.56	5.93	5.75
T ₁₁	10% Panchagavya + CBD*	4.72	4.28	4.50
T ₁₂	10% Jivamrita + CBD*	5.36	5.16	5.26
T ₁₃	20% Jivamrita + CBD*	4.76	4.89	4.82
T ₁₄	30% Jivamrita + CBD*	5.29	5.64	5.46
T ₁₅	40% Jivamrita + CBD*	5.62	5.23	5.43
T ₁₆	50% Jivamrita + CBD*	6.98	6.82	6.90
S.Em±		0.07	0.08	0.09
C.D. at 5%		0.21	0.25	0.28

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria



Plate 5a: Flowers in control plot (T₁)



Plate 5b: Flowers in plots treated with 6% Panchagavya + CBD* (T₇)

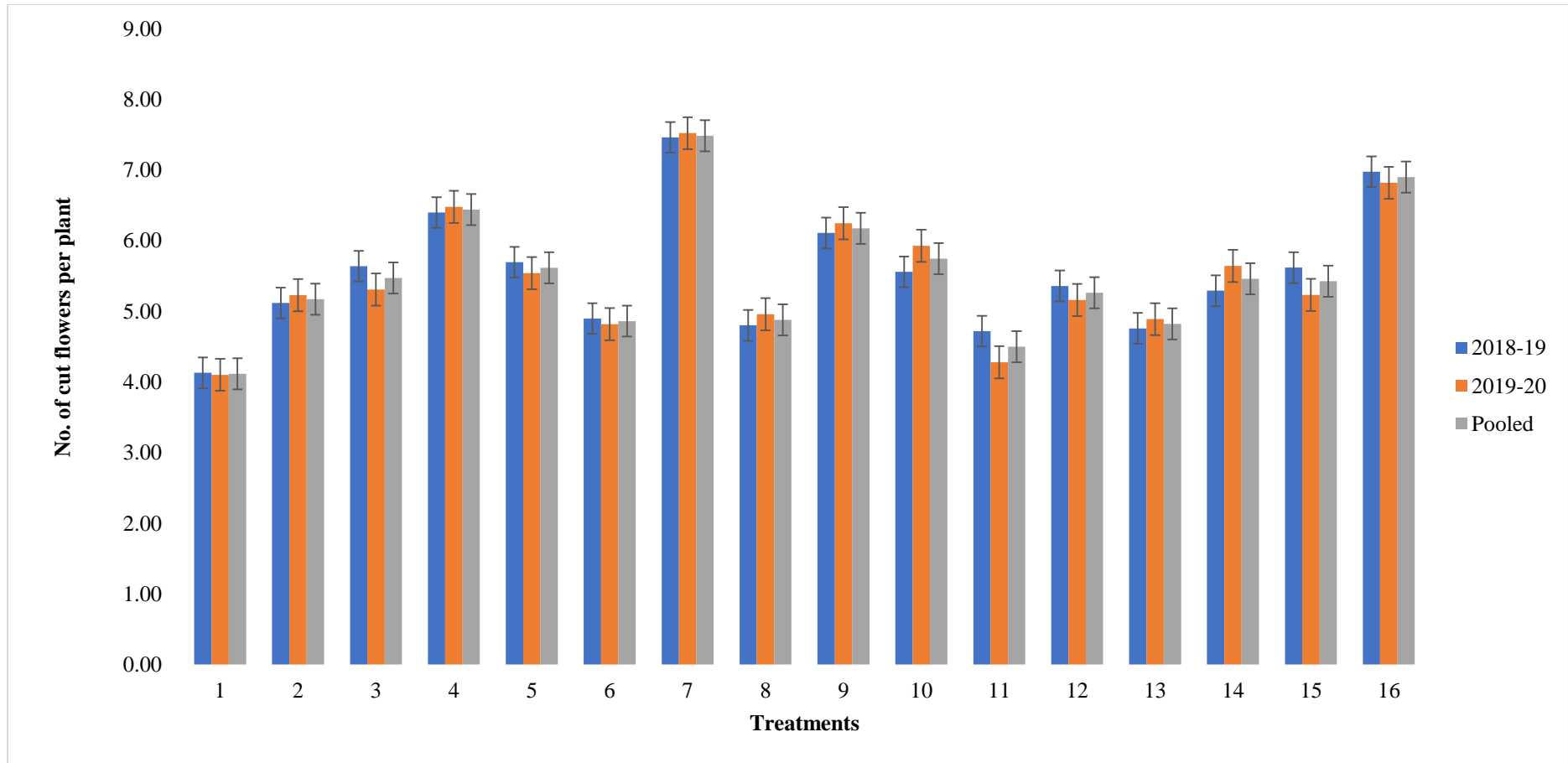


Fig 4.9: Influence of organic and biodynamic manures on No. of cut flowers/plant in chrysanthemum cv. Thai Chen Queen

4.2.5 Flower diameter

Data pertaining to the flower diameter of chrysanthemum as influenced by various organic and biodynamic manure treatments have been presented in Table 4.10 and Figure 4.10. Perusal of data reveal that flower diameter varied significantly due to different treatments.

During the year 2018-19, the application of different organic and biodynamic treatments significantly increased the flower diameter over control (7.23 cm). Among these treatments, maximum flower size (12.27 cm) was observed in treatment T₇ (6% Panchagavya + CBD*) followed by of T₁₆ (50% Jivamrita + CBD*) with flower diameter of 11.85 cm.

In the year 2019-20, the performance of 6% Panchagavya + CBD* was found superior in terms of flower diameter (11.80 cm) *i.e.*, in the treatment T₇ followed by of 50% Jivamrita + CBD* *i.e.*, T₁₆ (10.50 cm). Minimum flower diameter (6.40 cm) was found in the T₁ (Control), which was at par with treatment T₂ comprising of 1% Panchagavya + CBD* *i.e.*, 6.80 cm only.

Pooled data of both the years showed that maximum flower diameter (12.04 cm) was recorded in the plants receiving 6% Panchagavya + CBD* *i.e.*, T₇ and minimum flower diameter (6.82 cm) was noted in the T₁ (Control).

It is possible that the increased flower diameter in chrysanthemum is due to the combined application of biodynamic manures and biofertilizers. The beneficial influence of biofertilizers on flower diameter of chrysanthemum is evident from the fact that these microbes have assisted in the uptake and absorption of nutrients which is present in rhizosphere of soil. These findings are consistent with the findings of **Dharma (2006)**, who discovered that the application of Panchagavya and Manchurian mushroom tea resulted in the largest flower size in the carnation cv. Sunrise. **Waheeduzzama et al. (2006)** reported that application of Panchgavya 4% foliar spray combined with 50% RDF increased flower size in *Anthurium andraeanum* cv. 'Meringue'. **Singh et al. (2015)** found that the application of 5% Panchagavya increased the diameter of marigold flowers, and **Trivedi et al. (2016)** discovered that the application of 6 % Panchagavya + 1:5 times dilution of Vermiwash + 30% Jivamrita resulted in larger flower diameter in rose cv. Grand Gala.

Table 4.10: Effect of organic and biodynamic manures on flower diameter of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Flower diameter (cm)		
		2018-19	2019-20	Pooled
T ₁	Control	7.23	6.40	6.82
T ₂	1% Panchagavya + CBD*	7.62	6.80	7.21
T ₃	2% Panchagavya + CBD*	10.71	11.70	11.21
T ₄	3% Panchagavya + CBD*	11.31	10.40	10.86
T ₅	4% Panchagavya + CBD*	9.71	8.90	9.31
T ₆	5% Panchagavya + CBD*	9.10	8.60	8.85
T ₇	6% Panchagavya + CBD*	12.27	11.80	12.04
T ₈	7% Panchagavya + CBD*	9.80	9.20	9.50
T ₉	8% Panchagavya + CBD*	11.24	10.70	10.97
T ₁₀	9% Panchagavya + CBD*	9.08	8.90	8.99
T ₁₁	10% Panchagavya + CBD*	10.02	9.80	9.91
T ₁₂	10% Jivamrita + CBD*	9.62	8.50	9.06
T ₁₃	20% Jivamrita + CBD*	9.72	8.70	9.21
T ₁₄	30% Jivamrita + CBD*	9.43	8.20	8.82
T ₁₅	40% Jivamrita + CBD*	10.13	9.40	9.77
T ₁₆	50% Jivamrita + CBD*	11.85	10.50	11.18
SEm±		0.12	0.17	0.11
C.D. at 5%		0.36	0.49	0.33

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria



Plate 6a: Flower diameter in control T₁



Plate 6b: Flower diameter in 6% Panchagavya + CBD* (T₇)

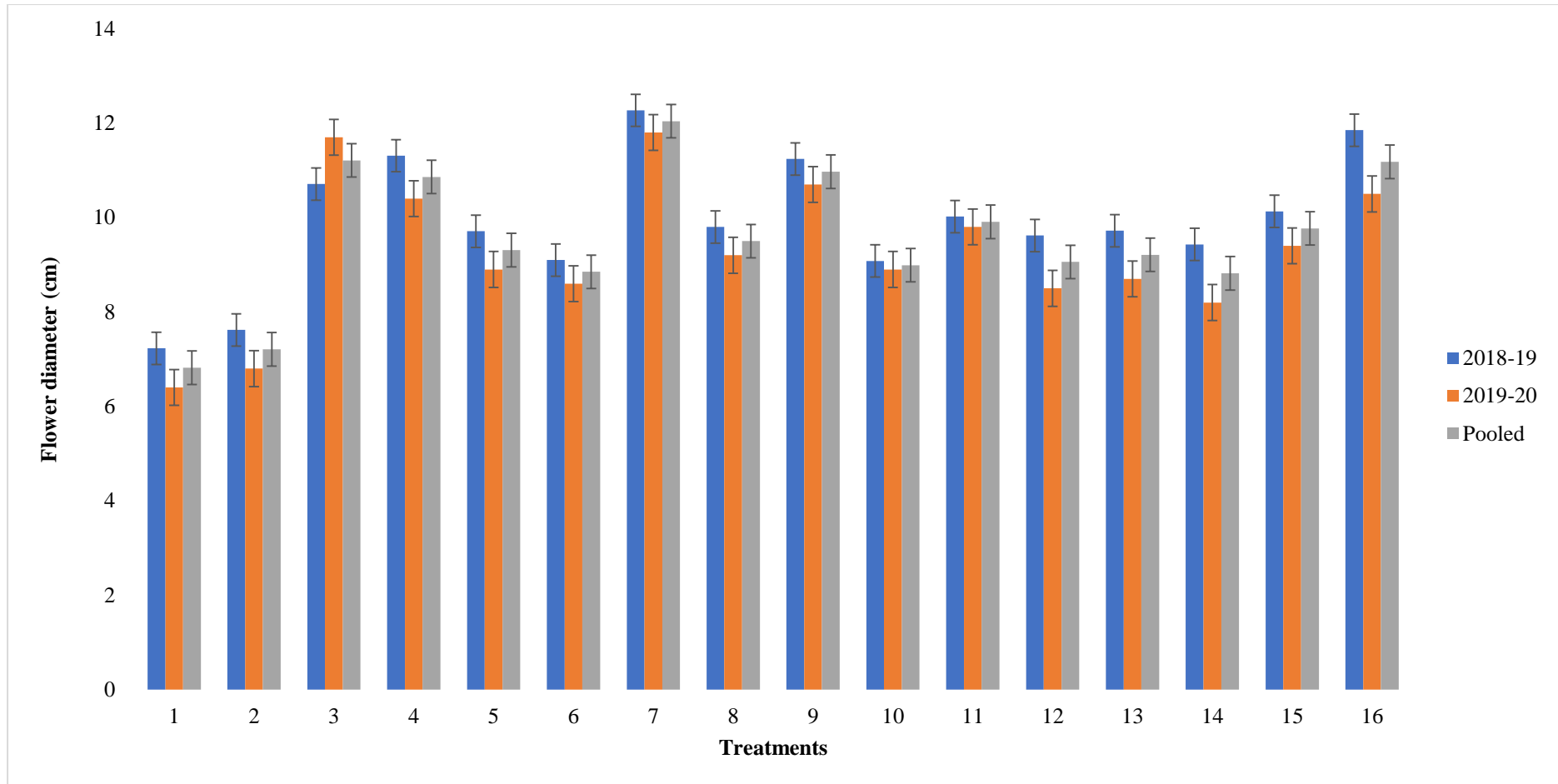


Fig. 4.10: Influence of organic and biodynamic manures on flower diameter in chrysanthemum cv. Thai Chen Queen

4.2.6 Days to flowering

During both the years of the study, days required for flowering in chrysanthemum varied significantly due to different organic and biodynamic treatments. Table 4.11 and Fig. 4.11 summarise the above experimental results.

The data in Table 4.11 demonstrate that varying quantities of biodynamic manures had a substantial impact on the days to flowering. The minimum number of days taken to flowering (52.30 days) were observed with treatment T₇ (6 percent Panchagavya + CBD*) in 2018-19, whereas the maximum number of days taken to first flowering (73.60) were found in T₁ (Control).

During 2019-20, application of 6% Panchagavya + CBD* (T₇) recorded minimum no. of days (51 days) for flowering which was statistically at par with T₁₆ (50% Jivamrita + CBD*) with minimum of 53 days to flowering. Maximum no. of days (72 days) taken for flowering were recorded in T₁ (Control).

Pooled data of two years revealed that application of 6% Panchagavya + CBD* (T₇) required minimum no. of days (51.7) for flowering which was statistically at par with the T₁₆ (50% Jivamrita + CBD*) with 53.6 days to flowering. Further, maximum no. of days (72.8) to flowering were observed in the T₁ (Control).

Days to flowering are directly proportional to the number of days it takes for the first bud to appear, indicating that the combined application of bio-enhancers results in increased accumulation of C:N ratio and synthesis of more gibberellins in the plant system, both of which aid in the advancement of flowering time (**Ram and Pathak, 2019; Sharma et al., 2019**), which resulted in the chrysanthemum flowering at an earlier stage than expected. Moreover, the above findings are consistent with those of **Verma et al. (2013)**, who discovered that media containing cocopeat, perlite and vermiculite (CPV) + Pusa Hydrogel (PHG) + vermicompost with a 20% vermiwash concentration resulted in early flowering in gerbera. According to **Bohra and Kumar (2014)**, using VAM (20 g/plant) and vermicompost (300 g/m²) resulted in the shortest number of days to flowering.

Table 4.11: Effect of organic and biodynamic manures on days to flowering in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Days to flowering		
		2018-19	2019-20	Pooled
T ₁	Control	73.6	72.0	72.8
T ₂	1% Panchagavya + CBD*	67.1	66.0	66.6
T ₃	2% Panchagavya + CBD*	71.0	68.0	69.5
T ₄	3% Panchagavya + CBD*	56.7	55.0	55.9
T ₅	4% Panchagavya + CBD*	68.3	64.0	66.2
T ₆	5% Panchagavya + CBD*	70.2	67.0	68.6
T ₇	6% Panchagavya + CBD*	52.3	51.0	51.7
T ₈	7% Panchagavya + CBD*	64.7	62.0	63.4
T ₉	8% Panchagavya + CBD*	58.3	59.0	58.7
T ₁₀	9% Panchagavya + CBD*	63.5	61.0	62.3
T ₁₁	10% Panchagavya + CBD*	72.4	71.0	71.7
T ₁₂	10% Jivamrita + CBD*	66.1	65.0	65.6
T ₁₃	20% Jivamrita + CBD*	61.2	60.0	60.6
T ₁₄	30% Jivamrita + CBD*	60.4	63.0	61.7
T ₁₅	40% Jivamrita + CBD*	71.4	70.0	70.7
T ₁₆	50% Jivamrita + CBD*	54.2	53.0	53.6
SEm±		1.17	0.92	0.93
C.D. at 5%		3.40	2.68	2.70

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

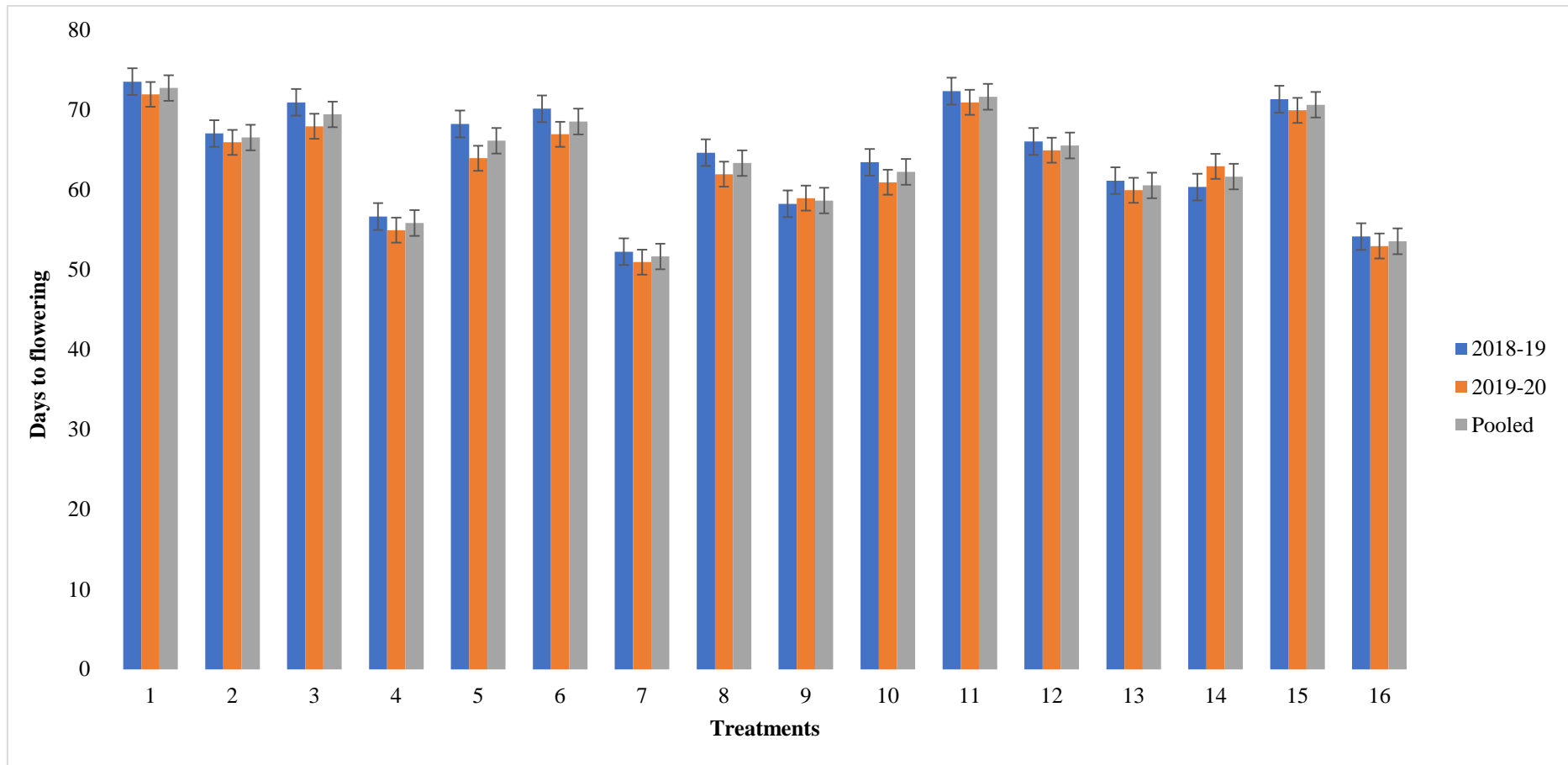


Fig. 4.11: Influence of organic and biodynamic manures on days to flowering in chrysanthemum cv. Thai Chen Queen

4.2.7 No. of cut flowers/ha ('000 Nos.)

The data with respect to no. of cut flowers/ha during 2018-19 and 2019-20, have been presented in Table 4.12 and Fig. 4.12.

The perusal of data tabulated in Table 4.12 indicates that effect of different concentrations of biodynamic manures on number of cut flowers/ha was significant during 2018-19. The maximum number of cut flowers/ha ('000 Nos.) (298.52) were recorded in treatment T₇ (6% Panchagavya + CBD*) and subsequently by T₁₆ (50% Jivamrita + CBD*) with 279.81 cut flowers/ha ('000 Nos.). Whereas, minimum No. of cut flowers/ha ('000 Nos.) (165.2) were observed in treatment T₁ (Control).

During the year 2019-20, influence of different levels of biodynamic manures on the number of cut flowers/ha have been presented in Table 4.12. It is inferred from the data that the number of cut flowers/ha were significantly influenced by different levels of Panchgavya and Jivamrita. The maximum number of cut flowers/ha ('000 Nos.) (300.9) were recorded with T₇ (6% Panchagavya + CBD*) while minimum in T₁ (Control).

Pooled data of the two years reveal that maximum number of cut flowers/ha ('000 Nos.) (299.5) were observed in the plants treated with 6% Panchagavya + CBD* i.e., T₇ while minimum flower yield/plant was observed in the control with 164.7 thousand cut flowers/ha. The use of biodynamic manures in combination with biofertilizers such as Azotobacter, Azospirillum, PSB and potash bacteria in conjunction with vermicompost have been attributed for easier and better translocation of nutrients, as well as transportation of growth-promoting substances such as auxins and gibberilins to the plant parts. Furthermore, effective root colonisation by VAM fungi has been attributed to better nutrient absorption and wilting resistance in plants (Brar et al., 2019). The presence of a greater number of leaves may have resulted in higher photosynthetic activities and greater carbohydrate accumulation, which in turn resulted in better plant growth and, as a result, an increase in the number of cut flowers produced. These findings are congruent with the findings of Kumar et al. (2010) who noticed that application of Panchagavya @ 5% had the highest florets/spike in gladiolus cv. Candyman and Singh et al., (2015), reported that biodynamic amendment of 5% Panchagavya increased flower yield in marigold. Trivedi et al. (2016) discovered that foliar application of 6 % Panchgavya + 1:5 times dilution of Vermiwash + 30% Jivamrita increased flower yield in rose cv. Grand Gala.

Table 4.12: Effect of organic and biodynamic manures on No. of cut flowers/ha in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	No. of cut flowers/ha ('000 Nos.)		
		2018-19	2019-20	Pooled
T ₁	Control	165.2	164.1	164.7
T ₂	1% Panchagavya + CBD*	204.8	209.3	206.9
T ₃	2% Panchagavya + CBD*	225.6	212.4	218.9
T ₄	3% Panchagavya + CBD*	256.3	259.2	257.6
T ₅	4% Panchagavya + CBD*	227.9	221.6	224.7
T ₆	5% Panchagavya + CBD*	196.6	192.8	194.5
T ₇	6% Panchagavya + CBD*	298.5	300.9	299.5
T ₈	7% Panchagavya + CBD*	192.1	198.4	195.2
T ₉	8% Panchagavya + CBD*	244.4	249.9	247.1
T ₁₀	9% Panchagavya + CBD*	222.5	237.2	229.9
T ₁₁	10% Panchagavya + CBD*	188.9	171.2	180.2
T ₁₂	10% Jivamrita + CBD*	214.5	206.4	210.5
T ₁₃	20% Jivamrita + CBD*	190.5	195.6	192.9
T ₁₄	30% Jivamrita + CBD*	211.7	225.7	218.5
T ₁₅	40% Jivamrita + CBD*	224.8	209.3	217.1
T ₁₆	50% Jivamrita + CBD*	279.8	272.3	276.1
SEm±		2.71	3.22	3.29
C.D. at 5%		7.86	9.36	9.56

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

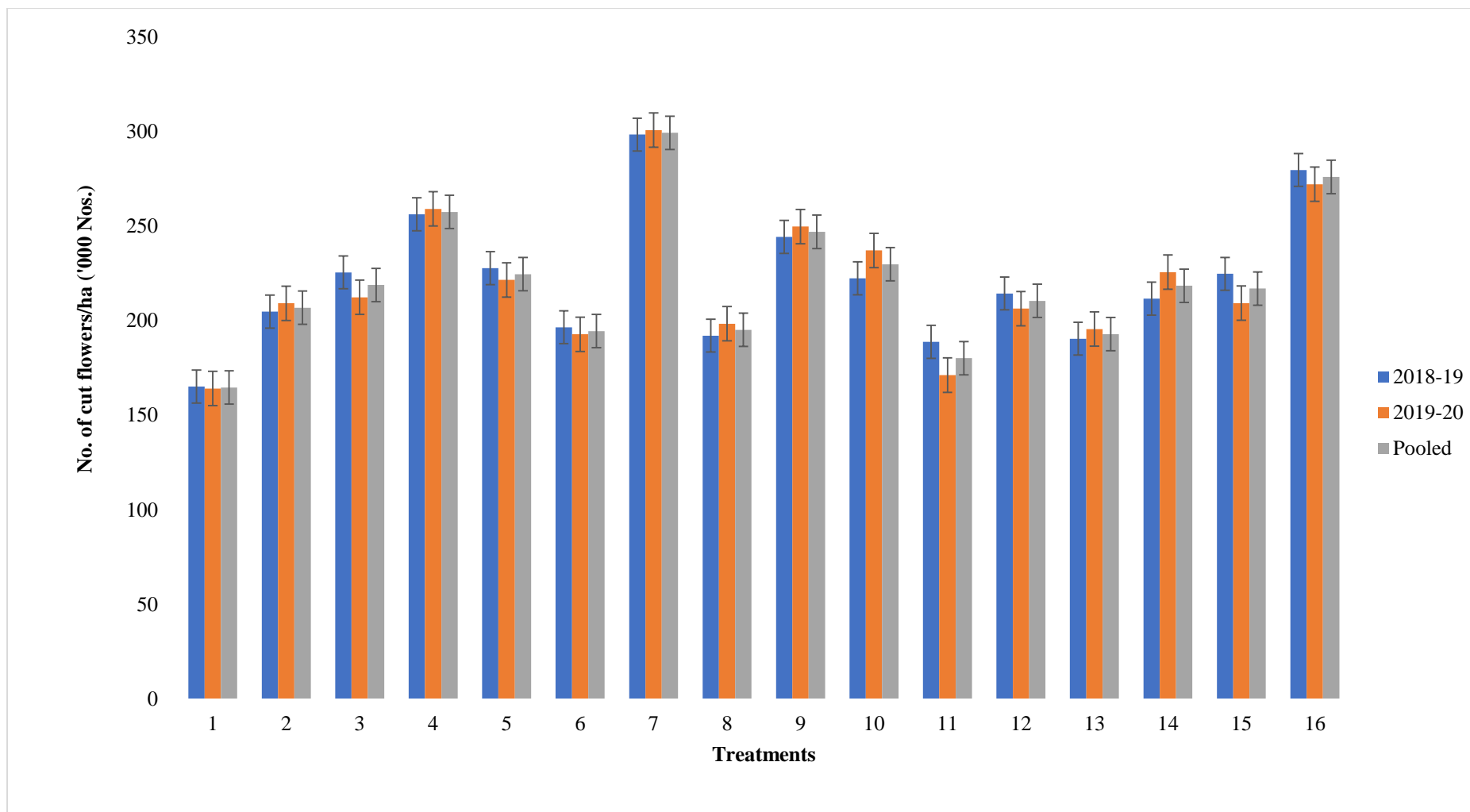


Fig. 4.12: Influence of organic and biodynamic manures on No. of cut flowers/ha in chrysanthemum cv. Thai Chen Queen

4.2.8 Average flower weight (gm)

The data with respect to average flower weight are conferred in Table 4.13 and Fig. 4.13. It is clear from the data that the levels of biodynamic manures had significant effect on average flower weight. During the year 2018-19, maximum weight of flower (14.6 g) was recorded with T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) with the value of 12.9 g. The minimum weight of flower (7.2 g) was found in T₁ (Control).

During the year 2019-20, maximum flower weight (14.2 g) was acquired with the application of T₇ (6% Panchagavya + CBD*), which was found to be nearly closer to the flower weight (11.5 g) of treatment T₁₆ (50% Jivamrita + CBD*). Minimum flower weight (6.0 g) was recorded in the treatment T₁ (Control).

Pooled data presented in the Table reveal that flowers with more weight (14.4 g) were obtained in treatment T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) with a weight of 12.2 gm, while the minimum flower weight (6.6 g) was recorded with the control. In general, flowers in the preceding year (2018-19) marginally were heavier (14.69 g) than the flowers (14.2 g) in succeeding year *i.e.*, 2019-20.

The use of biodynamic manures in combination with biofertilizers increases flower weight. These liquid manures contain all of the important nutrients, and the use of potash bacteria inoculation has a significant impact on flower weight. These bacteria release insoluble potash from the soil, secrete enzymes that lower soil pH, and then mobilise insoluble potash into soluble form, making it available to plants (Macik *et al.*, 2020). Potassium is an important nutrient for flower development, and higher potassium levels have been linked to higher flower weight. This finding is consistent with Mahawer *et al.* (2010) who reported that spraying with 3% Panchgavya + 4% Manchurian mushroom tea resulted in the highest spike weight in tuberose cv. Phule Rajani. Reshma *et al.* (2019) discovered that combining Jeevamrutha at 1000 l ha⁻¹ with Panchagavya at 7.5% increased cowpea pod weight significantly.

Table 4.13: Effect of organic and biodynamic manures on average flower weight of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Average flower weight (gm)		
		2018-19	2019-20	Pooled
T ₁	Control	7.2	6.0	6.6
T ₂	1% Panchagavya + CBD*	10.8	10.5	10.7
T ₃	2% Panchagavya + CBD*	11.2	10.8	11.0
T ₄	3% Panchagavya + CBD*	12.2	11.4	11.8
T ₅	4% Panchagavya + CBD*	7.4	7.1	7.2
T ₆	5% Panchagavya + CBD*	10.0	9.3	9.6
T ₇	6% Panchagavya + CBD*	14.6	14.2	14.4
T ₈	7% Panchagavya + CBD*	8.2	7.8	8.0
T ₉	8% Panchagavya + CBD*	11.2	10.9	11.1
T ₁₀	9% Panchagavya + CBD*	10.4	9.8	10.1
T ₁₁	10% Panchagavya + CBD*	8.9	8.4	8.6
T ₁₂	10% Jivamrita + CBD*	7.6	7.2	7.4
T ₁₃	20% Jivamrita + CBD*	9.2	8.9	9.0
T ₁₄	30% Jivamrita + CBD*	8.5	8.6	8.5
T ₁₅	40% Jivamrita + CBD*	9.5	9.2	9.4
T ₁₆	50% Jivamrita + CBD*	12.9	11.5	12.2
SEm±		0.16	0.11	0.10
C.D. at 5%		0.48	0.31	0.31

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria



Plate 7a: Flower weight in control



Plate 7b: Flower weight in 6% Panchagavya + CBD* (T₇)

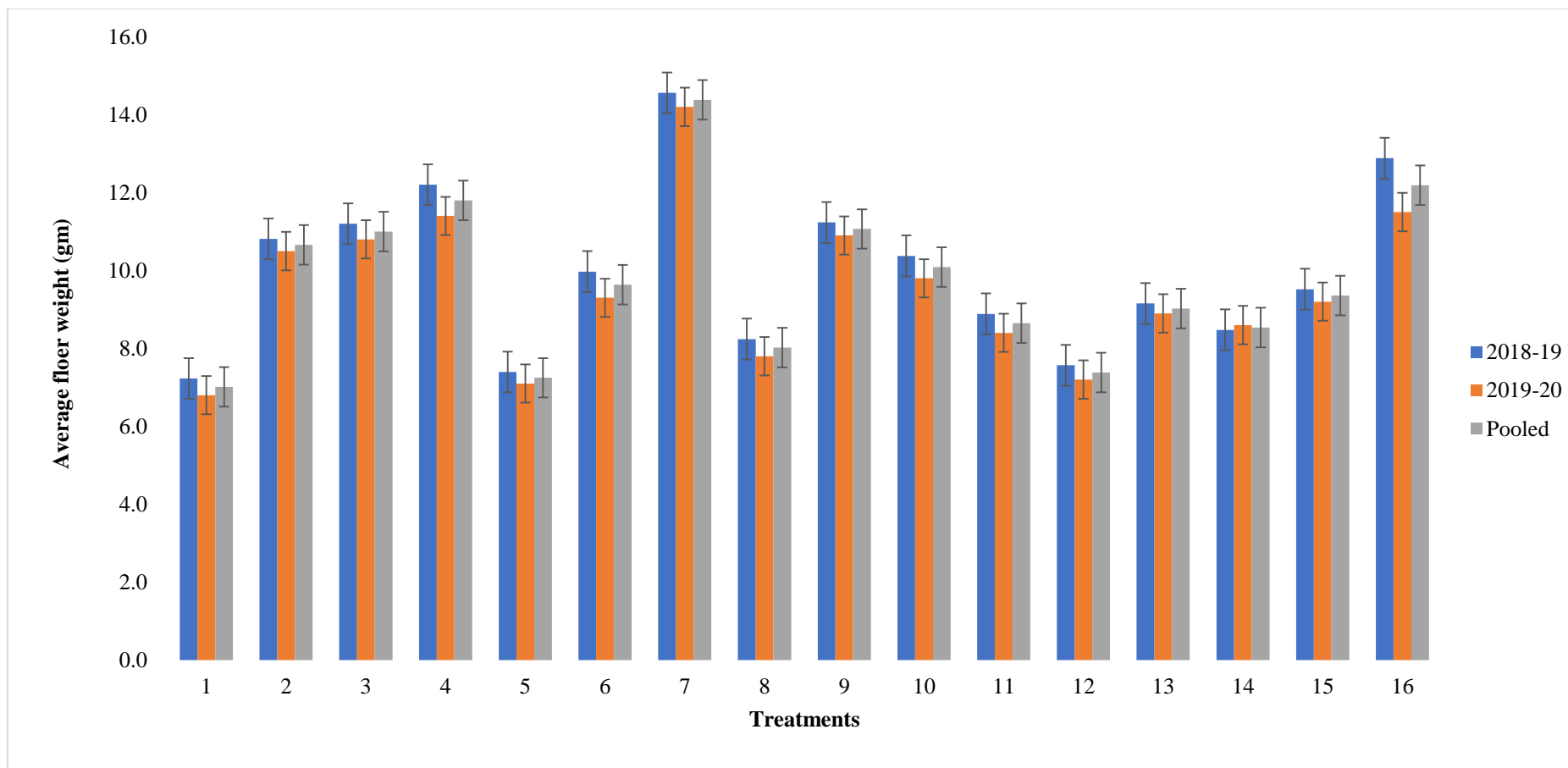


Fig. 4.13: Influence of organic and biodynamic manures on average flower weight of chrysanthemum cv. Thai Chen Queen

4.2.9 Duration of flowering (days)

Influence of different organic and biodynamic manure combinations and their effect on the duration of flowering (days) are presented in Table 4.14 and depicted in Fig. 4.14.

It is evident from the Table 4.14 that in the year 2018-19, among different treatment combinations, T₇ (6% Panchagavya + CBD*) treated plants recorded the longest flowering duration (35 days), which was followed by T₁₆ (50% Jivamrita + CBD*) with duration of flowering of 32 days. Shortest duration of flowering (19 days) was recorded in the T₁ (Control).

During 2019-20 also, treatment T₇ (6% Panchagavya + CBD*) had longest flowering duration (36 days) followed by combinations of Panchagavya and Jivamrita and it is statistically at par with the treatment T₁₆ (50% Jivamrita + CBD*) with duration of flowering 33 days. Minimum duration of flowering (16 days) was recorded in the T₁ (Control).

Pooled data of two seasons concluded that treatment T₇ (6% Panchagavya + CBD*) exhibited longest flowering duration of 36 days whereas the shortest flowering duration (18 days) was found with T₁ (Control) during both the years. The increase in duration of flowering due to application of bio-enhancers may be because of continuous synthesis of florigen and more accumulation of photosynthetes in plant system which in turn help in increasing duration of flowering. The present findings are in accordance with result of **Bhalla *et al.* (2006a)** who reported that application of 6 % Manchurian mushroom tea + 6% Panchagavya produced the longest flowering period in gladiolus cv. Red Beauty. **Mahawer *et al.* (2010)** found that spraying with 3% Panchagavya + 4% Manchurian mushroom tea exhibited maximum flowering duration in tuberose cv. Phule Rajani. **Kumar *et al.* (2011)** observed that application of CBD + Vermicompost 5 t/ha + Panchagavya 3 % (T₁₆) had the longest flowering time in gladiolus cv. Sancerre. **Trivedi *et al.* (2016)** found that application of combination of 6% Panchagavya + 1:5 times dilution of Vermiwash + 30% Jivamrita was found to increase duration of flowering in rose cv. Grand Gala.

Table 4.14: Effect of organic and biodynamic manures on duration of flowering in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Duration of flowering (days)		
		2018-19	2019-20	Pooled
T ₁	Control	19	16	18
T ₂	1% Panchagavya + CBD*	21	24	23
T ₃	2% Panchagavya + CBD*	24	23	24
T ₄	3% Panchagavya + CBD*	31	32	32
T ₅	4% Panchagavya + CBD*	26	25	26
T ₆	5% Panchagavya + CBD*	23	21	22
T ₇	6% Panchagavya + CBD*	35	36	36
T ₈	7% Panchagavya + CBD*	28	24	26
T ₉	8% Panchagavya + CBD*	29	26	28
T ₁₀	9% Panchagavya + CBD*	22	21	22
T ₁₁	10% Panchagavya + CBD*	25	24	25
T ₁₂	10% Jivamrita + CBD*	20	22	21
T ₁₃	20% Jivamrita + CBD*	25	24	25
T ₁₄	30% Jivamrita + CBD*	25	23	24
T ₁₅	40% Jivamrita + CBD*	27	28	28
T ₁₆	50% Jivamrita + CBD*	32	33	33
SEm±		0.39	0.44	0.37
C.D. at 5%		1.14	1.30	1.09

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

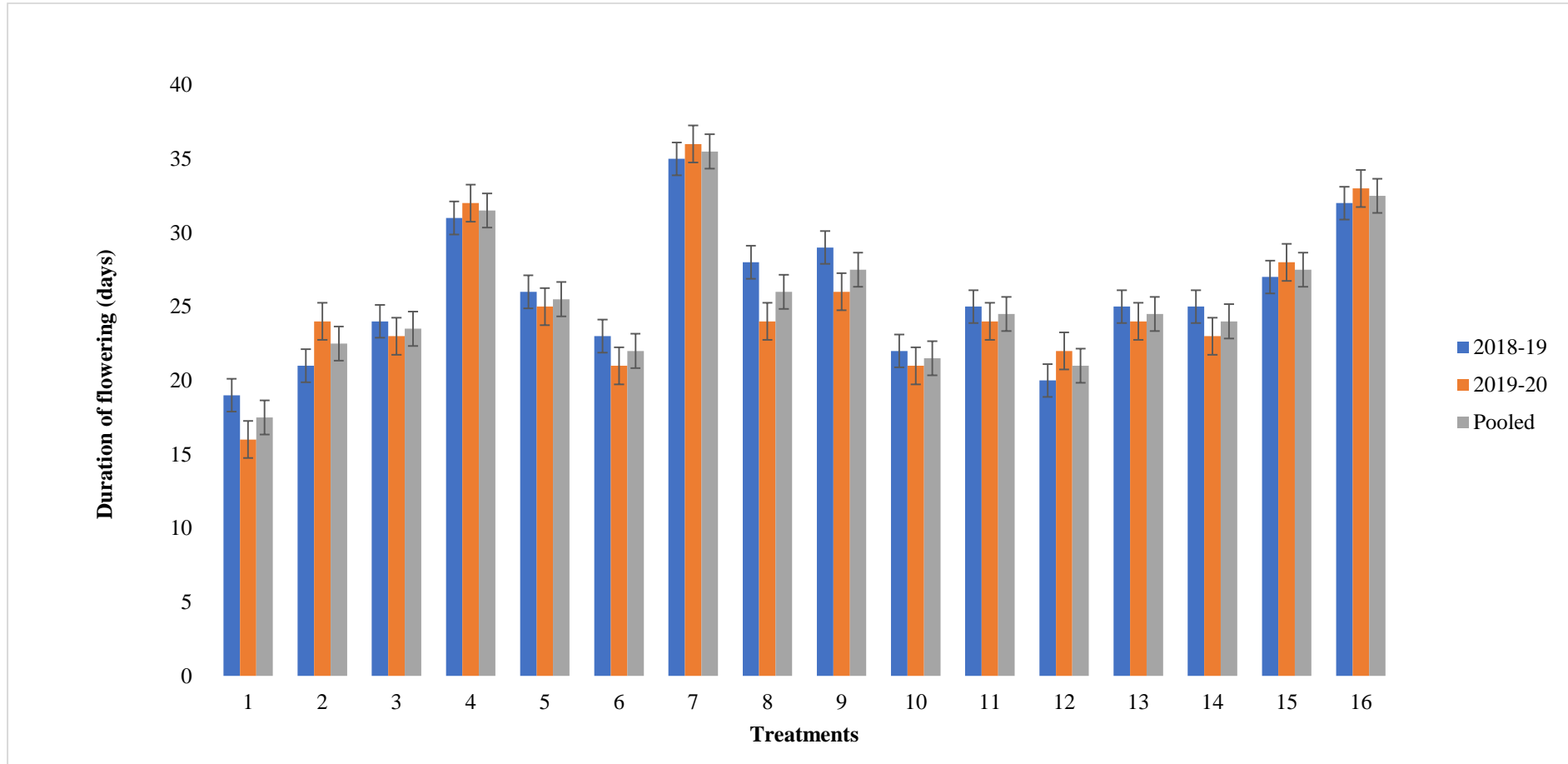


Fig. 4.14: Influence of organic and biodynamic manures on duration of flowering in chrysanthemum cv. Thai Chen Queen

4.2.10 Length of flower stalk (cm)

During both the years of research, effects of organic and biodynamic manures on flower stalk length (cm) have been presented in Table 4.15 and Fig. 4.15.

It is clear from Table 4.15 that length of flower stalk was significantly affected by various treatments. During 2018-19, the highest length of flower stalk (24.20 cm) was observed in treatment T₇ (6% Panchagavya + CBD*) which was at par with T₁₆ (50% Jivamrita + CBD*) with 23.30 cm length. However, lowest length of flower stalk (14.53 cm) was recorded in the T₁ (Control).

Similar results were obtained during 2019-20 when the plants were applied with different levels of biodynamic manures. The longest flower stalk (25.60 cm) was measured with treatment T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) with 22.60 cm length of flower stalk. The smallest flower stalk (13.60) was recorded T₁ (Control).

Pooled data of both the years showed that longest flower stalk (24.90 cm) was obtained when the plants were supplied with 6% Panchagavya + CBD* (T₇). In contrast, minimum flower stalk (14.07 cm) was recorded in the T₁ (Control). The improved absorption of immobile elements such as N, P, Zn, Fe, Mg, and Cl, as well as the presence of auxins and gibberellins in Panchgavya and Jivamrita, which increase cell division and cell enlargement, may be responsible for the increase in stem length of plants. These findings are in conformity with the result of **Bhalla et al. (2006a)** who reported that 6% Manchurian mushroom tea + 6% Panchagavya produced largest florets in gladiolus cv. Red Beauty. **Dharma (2006)** found that 3% Manchurian mushroom tea produced maximum flower stem length in carnation cv. Sunrise. **Waheeduzzama et al. (2006)** found that application of Panchagavya 4% + 50 % RDF increased spike length in *Anthurium andraeanum* cv. 'Meringue'. **Kumar et al. (2011)** observed that CBD + Vermicompost 5 t/ha + Panchagavya 3 % + Manchurian tea 3 % had the longest spike length in gladiolus cv. Sancerre. **Bohra and Kumar (2014)** found that application of VAM (20 g/plant) and vermicompost (300 g/m²) increased flower stalk length in chrysanthemum cv. Little Darling. **Trivedi et al. (2016)** found that application of 6% Panchagavya + 1:5 times dilution of Vermiwash + 30% Jivamrita increased flower stem length in rose cv. Grand Gala.

Table 4.15: Effect of organic and biodynamic manures on length of flower stalk of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Length of flower stalk (cm)		
		2018-19	2019-20	Pooled
T ₁	Control	14.53	13.60	14.07
T ₂	1% Panchagavya + CBD*	15.17	14.80	14.98
T ₃	2% Panchagavya + CBD*	15.13	14.60	14.87
T ₄	3% Panchagavya + CBD*	22.43	21.40	21.92
T ₅	4% Panchagavya + CBD*	19.50	18.50	19.00
T ₆	5% Panchagavya + CBD*	17.97	17.20	17.58
T ₇	6% Panchagavya + CBD*	24.20	25.60	24.90
T ₈	7% Panchagavya + CBD*	19.33	18.70	19.02
T ₉	8% Panchagavya + CBD*	22.03	20.60	21.32
T ₁₀	9% Panchagavya + CBD*	18.77	17.80	18.28
T ₁₁	10% Panchagavya + CBD*	21.37	21.20	21.28
T ₁₂	10% Jivamrita + CBD*	18.50	18.20	18.35
T ₁₃	20% Jivamrita + CBD*	21.73	21.40	21.57
T ₁₄	30% Jivamrita + CBD*	19.33	18.60	18.97
T ₁₅	40% Jivamrita + CBD*	19.60	19.20	19.40
T ₁₆	50% Jivamrita + CBD*	23.30	22.60	22.95
SEm±		0.31	0.34	0.26
C.D. at 5%		0.91	0.99	0.77

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

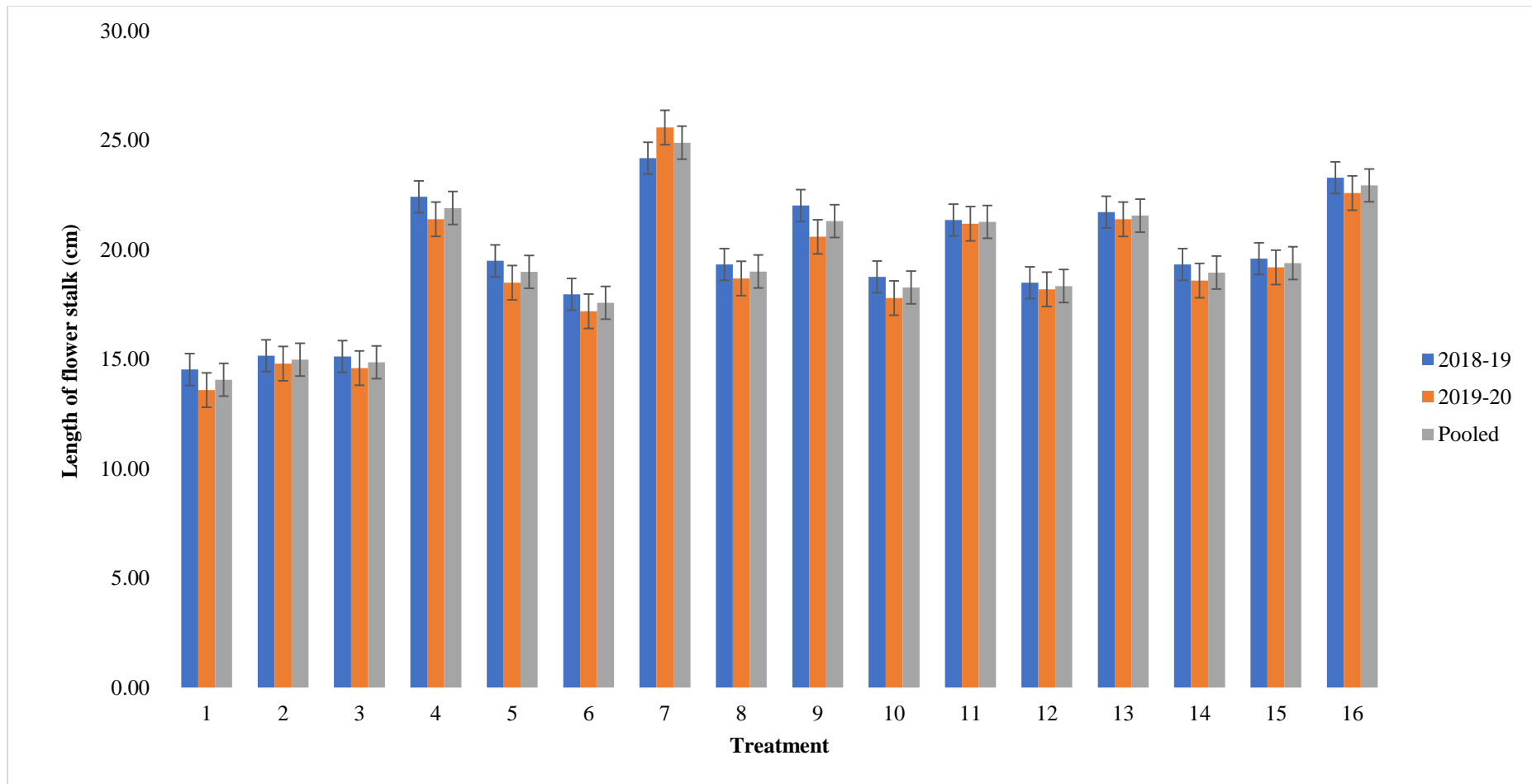


Fig. 4.15: Influence of organic and biodynamic manures on length of flower stalk of chrysanthemum cv. Thai Chen Queen

4.2.11 Stem diameter (mm)

Data pertaining to application of different concentrations of biodynamic manures on stem diameter (mm) during 2018-19 and 2019-20 have been presented in Table 4.16 and Fig. 4.16.

The perusal of data tabulated in Table 4.16 reveal that during 2018-19, stem diameter was maximum (36 mm) in plants of treatment T₇ (6% Panchagavya + CBD*) which was subsequently followed by T₄ (3% Panchagavya + CBD*) with a stem diameter of 34 mm while the shortest stem diameter (21 mm) was obtained in the T₁ (Control) plants.

During the year 2019-20 also, treatment T₇ (6% Panchagavya + CBD*) recorded highest stem diameter (35.40 mm) in comparison with other treatments which was found closest by T₄ (3% Panchagavya + CBD*) with a stem diameter of 33.4 mm. While, minimum stem diameter (19 mm) was recorded in control plants.

Pooled data of chrysanthemum stem diameter treated with different concentrations of Panchgavya and Jivamrita revealed that 6% Panchagavya + CBD* treated plants recorded highest stem diameter (35.70 mm) followed by 3% Panchagavya + CBD* (T₄) and 50% Jivamrita + CBD* (T₁₆) and with stem diameter of 33.70 and 32.20 mm, respectively, while the minimum stem diameter was recorded in the control plants *i.e.*, 20 mm. When bio-enhancers were used, the amount of nutrients taken in and assimilated increased, resulting in an increase in cell division and cell enlargement, which could have resulted in a greater thickness of the stem diameter. This may be due to fermented fertilizers enhance better nutrient uptake, photosynthesis and source and sink relationship besides, excellent physiological and biochemical activities (**Waheeduzzama *et al.*, 2006**). The present findings are in corroboration with the findings of **Singh *et al.* (2007)** in tuberose cv. Pearl Double and **Mahawer *et al.* (2010)** in tuberose cv. Phule Rajani. **Trivedi *et al.* (2016)** found that application of 6% Panchgavya + 1:5 times dilution of Vermiwash + 30% Jivamrita increased stem thickness in the rose cv. Grand Gala.

Table 4.16: Effect of organic and biodynamic manures on stem diameter of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Stem diameter (mm)		
		2018-19	2019-20	Pooled
T ₁	Control	21.00	19.00	20.00
T ₂	1% Panchagavya + CBD*	28.00	27.00	27.50
T ₃	2% Panchagavya + CBD*	26.00	27.00	26.50
T ₄	3% Panchagavya + CBD*	34.00	33.40	33.70
T ₅	4% Panchagavya + CBD*	27.50	26.40	26.95
T ₆	5% Panchagavya + CBD*	25.80	26.30	26.05
T ₇	6% Panchagavya + CBD*	36.00	35.40	35.70
T ₈	7% Panchagavya + CBD*	29.40	28.60	29.00
T ₉	8% Panchagavya + CBD*	31.80	31.00	31.40
T ₁₀	9% Panchagavya + CBD*	30.60	29.40	30.00
T ₁₁	10% Panchagavya + CBD*	25.20	24.20	24.70
T ₁₂	10% Jivamrita + CBD*	28.10	26.70	27.40
T ₁₃	20% Jivamrita + CBD*	26.70	25.30	26.00
T ₁₄	30% Jivamrita + CBD*	24.90	23.60	24.25
T ₁₅	40% Jivamrita + CBD*	26.70	25.80	26.25
T ₁₆	50% Jivamrita + CBD*	32.00	32.40	32.20
SEm±		0.37	0.45	0.43
C.D. at 5%		1.09	1.32	1.27

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

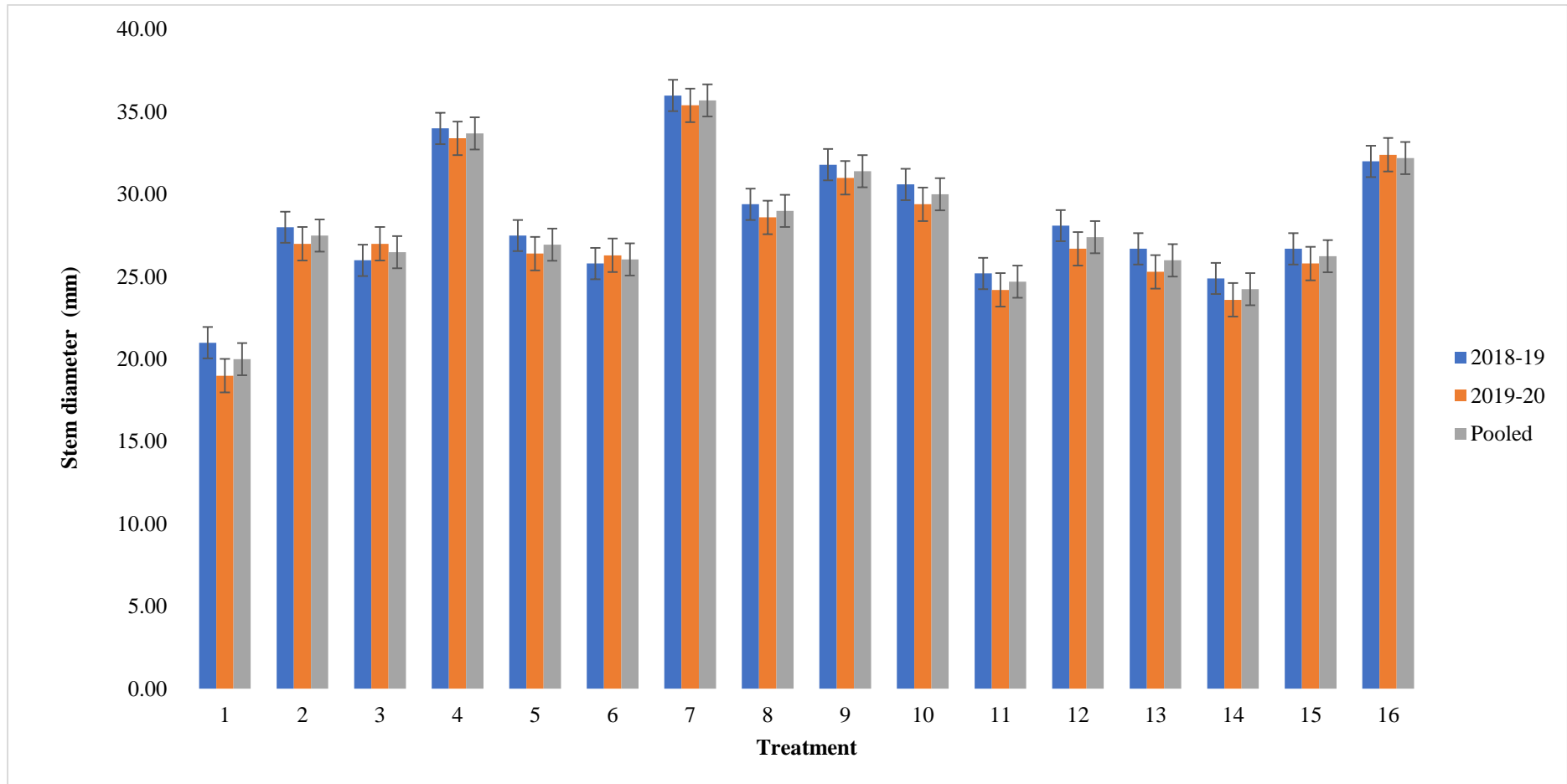


Fig. 4.16: Influence of organic and biodynamic manures on stem diameter of chrysanthemum cv. Thai Chen Queen

4.2.12 Days taken from colour showing stage to harvesting stage

The impact of organic and biodynamic manures on days taken from colour showing stage to harvesting has been reported throughout the course of two years of investigation and represented in Table 4.17 and Fig. 4.17.

The analysis of data from Table 4.17 reveal that the number of days between colour showing stage to harvesting stage were significantly influenced by biodynamic manures. During 2018-19, the shortest time interval between colour showing stage and harvesting stage (26 days each) was observed with 6% Panchagavya + CBD* (T₇) and 50% Jivamrita + CBD* (T₁₆), whereas the longest time interval between colour showing stage and harvesting stage (38 days) was observed in T₁ (Control) plants.

Likewise in 2019-20, plants treated with 6% Panchagavya + CBD* required significantly less time (25 days) to reach the harvesting stage from the bud showing colour stage followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) treatments, which took 27 days each to reach from colour showing stage to harvesting stage. In control plants, the maximum duration of 37 days between colour showing stage and harvesting stage was recorded.

Pooled data from the Table revealed that the minimum number of days (25.5 days) required from colour showing stage to harvesting stage were found in T₇ (6% Panchagavya + CBD*) and the maximum number of days (37.5 days) in T₁ (Control) plants. In general, the duration required to reach the harvesting stage from the bud colour showing stage was advanced by one day (25 days) in 2019-20 as compared to 2018-19 (26 days).

Because of the use of bioenhancers, the time it takes to transition from colour to harvesting is shorter. This could be due to continuous synthesis of florigen and increased accumulation of photosynthetes in the plant system, which aids in flower harvesting in less time. The current findings find support from those of **Beulah (2001)** in annual moringa and **Kumar *et al.* (2010)** in gladiolus cv. Candyman. **Verma *et al.* (2013)** found that combining cocopeat, perlite, and vermiculite (CPV) + Pusa Hydrogel (PHG) + vermicompost with a 20% vermiwash spray reduces the time it takes to harvest the first flower in gerbera.

Table 4.17: Effect of organic and biodynamic manures on days taken from colour showing stage to harvesting stage in chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Days taken from colour showing stage to harvesting stage		
		2018-19	2019-20	Pooled
T ₁	Control	38	37	37.5
T ₂	1% Panchagavya + CBD*	32	35	33.5
T ₃	2% Panchagavya + CBD*	33	31	32
T ₄	3% Panchagavya + CBD*	28	27	27.5
T ₅	4% Panchagavya + CBD*	32	30	31
T ₆	5% Panchagavya + CBD*	31	32	31.5
T ₇	6% Panchagavya + CBD*	26	25	25.5
T ₈	7% Panchagavya + CBD*	31	37	34
T ₉	8% Panchagavya + CBD*	30	29	29.5
T ₁₀	9% Panchagavya + CBD*	34	32	33
T ₁₁	10% Panchagavya + CBD*	30	33	31.5
T ₁₂	10% Jivamrita + CBD*	29	36	32.5
T ₁₃	20% Jivamrita + CBD*	36	32	34
T ₁₄	30% Jivamrita + CBD*	35	34	34.5
T ₁₅	40% Jivamrita + CBD*	27	36	31.5
T ₁₆	50% Jivamrita + CBD*	26	27	26.5
SEm±		0.47	0.41	0.44
C.D. at 5%		1.39	1.19	1.28

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

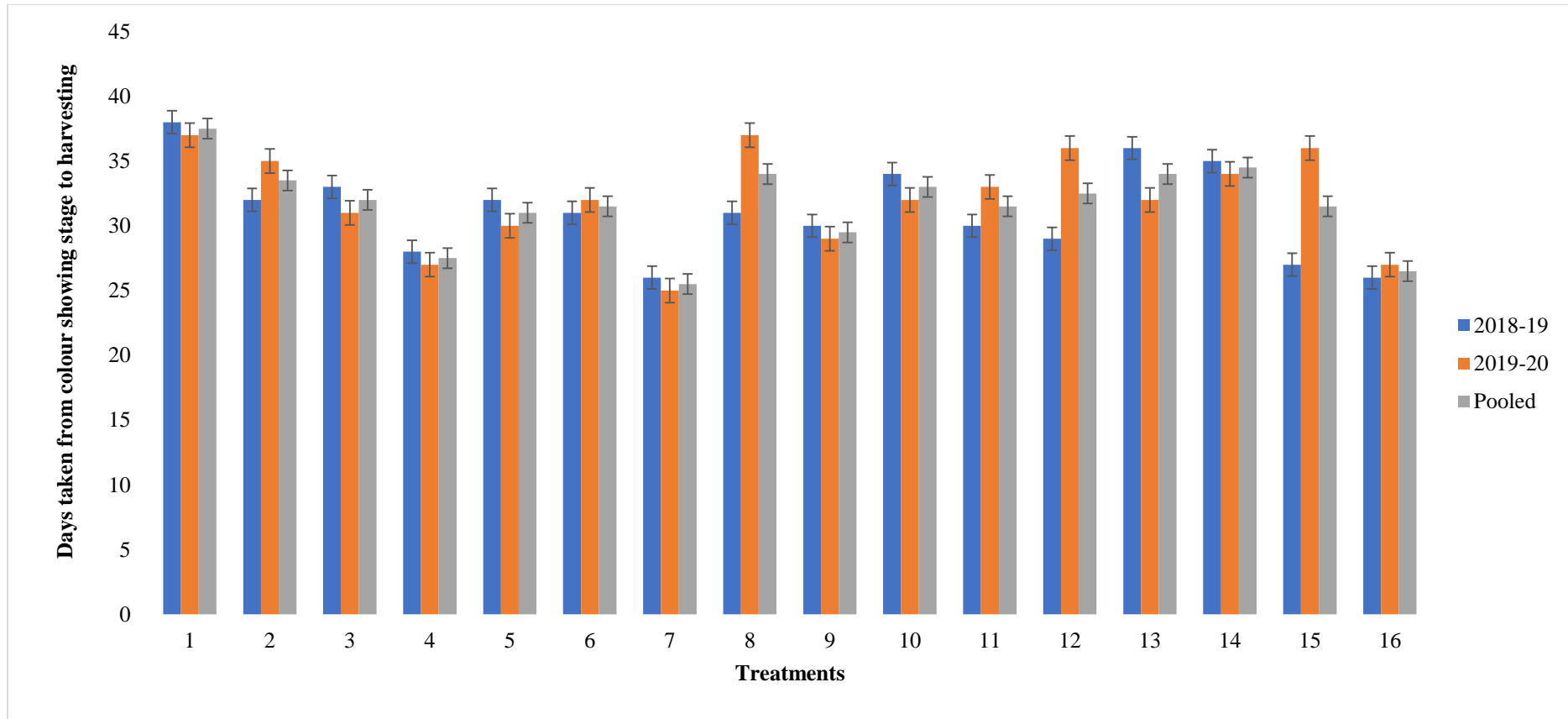


Fig. 4.17: Influence of organic and biodynamic manures on days taken from colour showing stage to harvesting stage in chrysanthemum cv. Thai Chen Queen

4.3 Post Harvest Attributes

4.3.1 Initial flower weight (g) of cut flower after harvesting from field

The data presented in Table 4.18 and graphically depicted in Fig. 4.18 indicate initial flower weight (g) after harvesting from field during both the years of investigation

Response of different biodynamic manure treatments on initial flower weight (g) after harvesting stage was significant during 2018-19. The maximum initial flower weight (28.2 g) at harvesting stage was recorded in treatment T₇ (6% Panchagavya + CBD*) which was followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with initial flower weight of 27.1 and 26.7 g. Minimum flower weight (8.6 g) was observed in Control treatment (T₁).

During 2019-20, perusal of data tabulated in Table 4.18 indicated that organic manures has significant effect on initial flower weight (g) after harvesting from field. Treatment T₇ with the application 6% Panchagavya + CBD* demonstrated maximum initial flower weight (32.1 g) than other treatment combinations which was found closest by T₁₆ (50% Jivamrita + CBD*) with initial flower weight of 28.9 g. Minimum flower weight (12.1 g) was recorded in the control (T₁).

Pooled data from the Table 4.18 reveal that the maximum flower weight (30.1 g) was recorded at harvesting stage in treatment T₇ (6% Panchagavya + CBD*) and the minimum flower weight (10.4 g) was observed in T₁ (Control).

The increase in weight of flower bud at harvesting stage may be due to the role of microorganisms present in the Panchgavya and Jivamrita which might have resulted in better absorption of nutrients and water uptake. These results are in close conformity with the findings of **Waheeduzzama et al. (2006)** in *Anthurium*, **Bhalla et al. (2006a)** in gladiolus, **Singh et al. (2007)** in tuberose.

Trivedi et al., 2016 reported that application of 6% Panchagavya + 1:5 times dilution of vermiwash + 30% Jivamrita has increased flower weight at harvesting stage of rose cv. Grand Gala.

4.3.2 Final flower weight (g) of cut flower after keeping in vase solution

Influence of applied biodynamic manures on final flower weight (g) after keeping in vase solution during both the years of investigation have been presented in Table. 4.18 and Fig. 4.18.

It is clear from Table 4.18 that final weight of flower after keeping in vase solution was significantly affected by different treatment combinations. The flower weight of cut chrysanthemum flowers differed significantly due to different levels of Panchagavya and Jivamrita. The treatment T₇ (6% Panchagavya + CBD*) recorded significantly highest flower weight (15.4 g) after keeping in vase solution followed by T₄ and T₁₆ with final weight of 14.1 g and the lowest flower weight (4.5 g) was recorded with T₁ control. All other treatments recorded the intermediate results values.

During the year 2019-20, there were significant differences in flower weight of cut chrysanthemum flowers in the vase life period. Maximum flower weight (18.4 g) after keeping in vase solution was recorded in the plants treated with the 6% Panchagavya + CBD* (T₇) in the field which was found closest by 50% Jivamrita + CBD* (T₁₆) with 14.8 gm weight of flower. Lowest flower weight was recorded with T₁ control (7.1 g).

Pooled data from the Table 4.18 revealed that the maximum final flower weight (16.9 g) was recorded in vase solution in treatment T₇ (6% Panchagavya + CBD*) and the minimum flower weight (5.7 g) was observed in T₁ (Control). In general, flower weight was recorded maximum in the year 2019-20 (18.4 g) than in 2018-19 (15.4 g) in the same treatment consisting of 6% Panchagavya + CBD* (T₇).

Flower weight in the vase solution decreased compared to weight of harvesting stage because the food which is accumulated in stem tissues is absorbed by the flower tissues which caused decrease in flower weight. These results are in close conformity with the findings of **Singh *et al.* (2007)** in tuberose and **Waheeduzzama *et al.* (2006)** in *Anthurium*. **Trivedi *et al.*, 2016** reported that application of 6% Panchagavya + 1:5 times dilution of vermiwash + 30% Jivamrita increased final flower weight at harvesting stage of rose cv. Grand Gala.

4.3.3 Initial flower diameter (cm) in vase solution

Response of biodynamic manures on initial flower diameter (cm) in vase solution during 2018-19 and 2019-20, have been presented in Table. 4.18 and Fig. 4.18.

During 2018-19, the effect of various levels of organic and biodynamic manures on the initial flower diameter (cm) in vase solution was significant. At harvesting stage, the maximum flower diameter (11.2 cm) was observed in treatment T₇ (6% Panchagavya + CBD*), which was closest to T₁₆ (50% Jivamrita + CBD*) and T₉ (8% Panchagavya + CBD*) with initial flower diameters of 10.6 cm and 9.9 cm, respectively. Smallest flower diameter (5.2 cm) was observed in treatment T₁ (Control).

In the year 2019-20, varying the amount of Panchgavya and Jivamrita had a significant effect on the initial flower diameter (cm) after harvesting from the field. Treatment T₇ (6% Panchagavya + CBD*) had larger initial flower diameter (10.7 cm) than other treatment combinations and smallest flower diameter (5.7 cm) was observed in T₁ (Control).

Pooled data from the Table 4.18 revealed that the maximum flower diameter (10.9 cm) was recorded at harvesting stage in treatment T₇ (6% Panchagavya + CBD*) and the minimum flower diameter (5.4 cm) was observed in T₁ (Control). In general, flower diameter was observed higher during the year 2018-19 (11.2 cm) than in 2019-20 (10.7 cm) in the treatment consisting of 6% Panchagavya + CBD* (T₇).

Initial flower diameter is less because flower is harvested when outer florets are fully expanded and centre florets are yet to open. Biodynamic manures like Panchagavya and Jivamrita has macro and micronutrients and a group of beneficial microorganisms which help in obtaining good quality of cut flowers for vase. These results are in close conformity with the findings of **Singh *et al.* (2007)** in tuberose, **Sharma *et al.* (2010)** in carnation cv. Sunrise and **Mahawer *et al.* (2010)** in tuberose. **Trivedi *et al.*, 2016** reported that application of 6% Panchgavya + 1:5 times dilution of vermiwash + 30% Jivamrita has highest initial flower diameter before keeping in vase solution.

4.3.4 Final flower diameter (cm) after keeping in vase solution

Data pertaining to final flower diameter (cm) after keeping in vase solution have been presented in Table. 4.18 and Fig. 4.18.

It is clear from Table 4.18 that final flower diameter after keeping in vase solution was significantly affected by different treatment combinations. The flower diameter of cut chrysanthemum flowers increased after keeping in water. The treatment T₇ (6% Panchagavya + CBD*) from which flowers were harvested and kept in vase solution recorded significantly highest flower diameter (13.3 cm) which was closest to T₁₆ (50% Jivamrita + CBD*) with 12.6 cm and T₄ (3% Panchagavya + CBD*) with 11.4 cm and the lowest flower diameter was recorded with T₁ control (6.1 cm). All other treatments recorded the intermediate results values.

During the year 2019-20, there were significant differences in final flower diameter of cut chrysanthemum in the vase life period. Maximum flower diameter (12.9 cm) after keeping in vase solution was recorded in the T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) with 12.6 cm flower diameter. Lowest flower diameter was (6.70 cm) recorded with T₁ control.

Pooled data from the Table 4.18 reveal that the maximum flower diameter (13.1 cm) was recorded in treatment T₇ *i.e.*, 6% Panchagavya + CBD* (T₇) in vase solution and the minimum flower diameter (6.4 cm) was observed in Control (T₁).

Increase in diameter of flower could be possible because of better source sink relationship, excellent physiological and biochemical activities. The results are in line with the findings of **Singh *et al.* (2007)** who reported that application of 2% Panchagavya and 4% Manchurian mushroom tea in vase solution has highest number of opened florets in tuberose. **Trivedi *et al.*, 2016** found that application of 6 % Panchagavya + 1:5 times dilution of vermiwash + 30% Jivamrita has increased flower diameter in vase solution of rose cv. Grand Gala.

Table 4.18: Effect of organic and biodynamic manures on flower weight and diameter of cut flower after harvesting from field and after keeping in vase solution of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Initial flower weight (g) of flower after harvesting from field			Final flower weight (g) after keeping in vase solution			Initial flower diameter (cm) after harvesting from field			Final flower diameter (cm) after keeping in vase solution		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	8.6	12.1	10.4	4.5	7.1	5.7	5.2	5.7	5.4	6.1	6.7	6.4
T ₂	1% Panchagavya + CBD*	11.1	13.0	12.1	5.8	5.9	5.9	9.6	9.1	9.3	10.8	10.3	10.5
T ₃	2% Panchagavya + CBD*	17.8	16.4	17.1	9.2	8.1	8.6	8.9	8.4	8.6	10.3	9.2	9.7
T ₄	3% Panchagavya + CBD*	26.7	21.4	24.1	14.1	11.7	12.9	9.9	9.3	9.6	11.4	10.6	11.0
T ₅	4% Panchagavya + CBD*	21.9	18.1	20.1	11.1	9.9	10.5	7.5	8.2	7.8	8.6	9.1	8.8
T ₆	5% Panchagavya + CBD*	17.1	14.8	15.9	8.1	7.2	7.6	5.9	7.1	6.5	7.5	8.9	8.2
T ₇	6% Panchagavya + CBD*	28.2	32.1	30.1	15.4	18.4	16.9	11.2	10.7	10.9	13.3	12.9	13.1
T ₈	7% Panchagavya + CBD*	13.8	14.7	14.3	6.4	7.8	7.1	7.6	7.1	7.3	9.2	8.6	8.9
T ₉	8% Panchagavya + CBD*	19.1	17.1	18.1	9.5	8.7	9.1	9.9	9.6	9.7	11.2	10.5	10.8
T ₁₀	9% Panchagavya + CBD*	17.6	15.6	16.6	8.4	8.6	8.5	7.3	7.2	7.2	8.9	8.5	8.7
T ₁₁	10% Panchagavya + CBD*	12.9	14.8	13.8	6.7	7.4	7.1	8.3	7.5	7.9	9.5	8.7	9.1
T ₁₂	10% Jivamrita + CBD*	17.2	13.9	15.5	8.8	7.6	8.2	6.4	6.8	6.6	7.9	8.2	8.1
T ₁₃	20% Jivamrita + CBD*	21.5	18.1	19.8	12.4	9.2	10.8	5.9	8.2	7.1	7.5	10.2	8.8
T ₁₄	30% Jivamrita + CBD*	15.2	18.3	16.7	7.7	9.1	8.4	6.8	6.4	6.6	8.5	7.8	8.1
T ₁₅	40% Jivamrita + CBD*	16.4	18.4	17.4	8.9	9.8	9.3	7.7	7.2	7.5	9.5	9.1	9.3
T ₁₆	50% Jivamrita + CBD*	27.1	28.9	28.1	14.1	14.8	14.5	10.6	10.1	10.3	12.6	12.1	12.3
SEm±		0.24	0.27	0.30	0.16	0.16	0.11	0.10	0.14	0.14	0.12	0.14	0.14
C.D. at 5%		0.70	0.78	0.88	0.48	0.4	0.33	0.31	0.41	0.42	0.36	0.411	0.41

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB (Phosphorus solubilizing bacteria) as well as potash bacteria

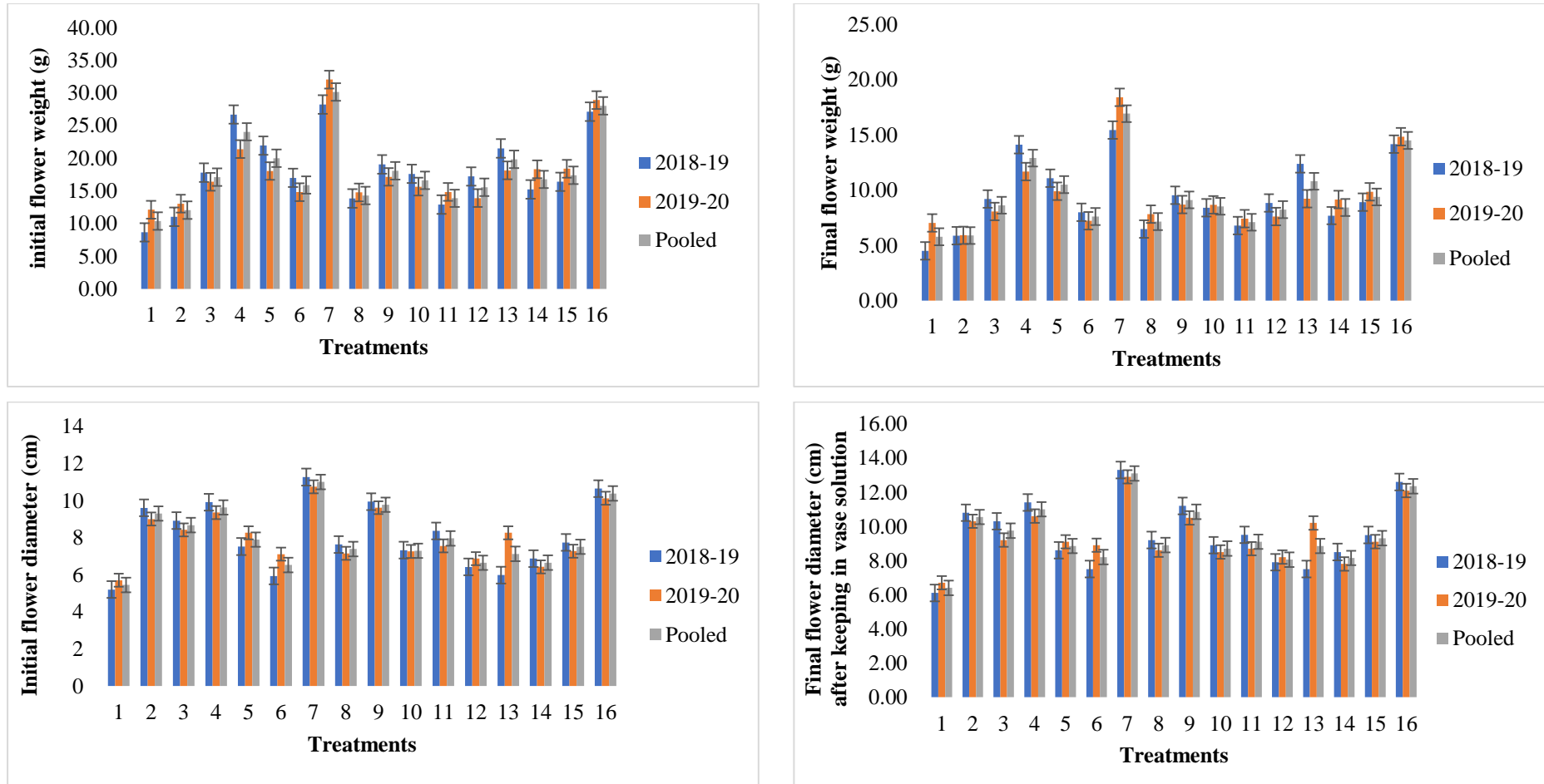


Fig. 4.18: Influence of organic and biodynamic manures on flower weight and diameter of cut flower after harvesting from field and after keeping in vase solution

4.3.5 Increase in flower diameter

Increase in flower diameter is the difference between initial flower diameter and final flower diameter in the vase solution and it was recorded in the both years *i.e.*, 2018-19 and 2019-20, and has been presented in Table. 4.19 and Fig. 4.19.

During 2018-19, after harvesting of flowers from field, they were kept in the plain distilled water. After the flowers fully opened in vase solution, the difference between the diameter was recorded. From the Table it is revealed that flowers from the treatment T₇ (6% Panchagavya + CBD*) exhibited maximum increase of flower diameter *i.e.*, 2.0 cm and was found to be at par with the treatment T₁₆ (50% Jivamrita + CBD*) *i.e.*, (1.96 cm).

In the year 2019-20 also, the same treatment combination T₇ *i.e.*, 6% Panchagavya + CBD* from which flowers were harvested and kept in vase solution showed maximum increase in flower diameter (2.2 cm) followed by T₁₆ (50% Jivamrita + CBD*) with 2.0 cm increase in flower diameter. Minimum increase in flower diameter (1 cm) was found in the T₁ (Control).

Pooled data of both the years showed that maximum increase in flower diameter (2.1 cm) was recorded from the flowers which were harvested from the treatment 6% Panchagavya + CBD* *i.e.*, T₇ and minimum flower diameter (1.0 cm) was noted in the T₁ (Control) plants.

Increased flower diameter in vase solution could be due to stomatal closure, which reduced carbohydrate loss through respiration and transpiration, as well as absorption of nutrients stored in the healthy stem tissues of cut flowers This finding is consistent with **Bhalla *et al.* (2006b)** in carnation, **Waheeduzzama *et al.* (2006)** in *Anthurium andraeanum* cv. 'Meringue'. **Singh (2007)** found that a 4% spray of Panchagavya increased the size of bulblets in tuberose cv. Pearl Double. **Trivedi *et al.*, 2016** reported that application of 6% Panchagavya + 1:5 times dilution of vermiwash + 30% Jivamrita increased flower diameter in vase solution of rose cv. Grand Gala.

4.3.6 Water uptake by flowers (mL)

Response of organic and biodynamic manures on quality of flowers and their effect on volume of water absorbed by cut flower stems from vase solution for the year 2018-19 and 2019-20, were presented in the Table 4.19 and Fig. 4.19.

Data presented in the Table 4.19 on volume of water absorbed by cut flower stems indicated that during 2018-19, treatment combination of T₇ (6% Panchagavya + CBD*) was significant with other treatments of Panchgavya and Jivamrita. The maximum volume of water absorbed by cut flower stem (65 mL) was measured in T₇ (6% Panchagavya + CBD*) which was closest to T₄ (3% Panchagavya + CBD*) and T₁₆ (50% Jivamrita + CBD*) with a volume of 62 and 58 mL of water uptake, respectively. Minimum volume of water absorbed by cut flower stem (26 mL) was recorded in T₁ (Control).

During the year 2019-20, different levels of biodynamic manures were found to be significantly effective on the volume of water absorbed by cut flower stems. Maximum volume of water absorbed by cut flower stem (63 mL) was measured in T₇ (6% Panchagavya + CBD*) which was nearest to T₄ (3% Panchagavya + CBD*) and T₁₆ (50% Jivamrita + CBD*) with a volume of 61 and 59 mL of water uptake, respectively. The minimum volume of water absorbed by cut flower stems (24 mL) was measured in T₁ (Control).

Pooled data of both the years showed that treatment combination of T₇ (6% Panchagavya + CBD*) absorbed maximum volume of water from the vase solution *i.e.*, 64 mL followed by T₄ (61.5 mL) and T₁₆ (58.5 mL). Minimum volume of water absorbed by cut flower stems (25.0 mL) was measured in T₁ (Control).

Water uptake by flowers was maximum in T₇ (6% Panchagavya + CBD*). This might be due to the improved water uptake by healthy tissues of flower stem and lower levels of peroxidise. These results are in the confirmation with the findings of **Singh *et al.*, 2007** who found that 4% Panchagavya spray resulted in maximum uptake of water in tuberose cv. Pearl Double and **Mahawer *et al.*, 2010** in tuberose cv. Phule Rajani. **Trivedi *et al.*, 2016** noticed that application of 6% Panchagavya + 1:5 times dilution of vermiwash + 30% Jivamrita in rose cv. Grand Gala absorbed maximum water from the vase solution.

4.3.7 Vase life (days)

During both the years of investigation, the effects of organic and biodynamic manures on vase life have been presented in Table 4.19 and Fig. 4.19.

During the year 2018-19, the maximum vase life (23.4 days) was recorded in T₇ (6% Panchagavya + CBD*) which was found to be closest with T₄ (3% Panchagavya + CBD*), T₉ (8% Panchagavya + CBD*), T₁₆ (50% Jivamrita + CBD*) and T₁₁ (10% Panchagavya+ CBD*) recording vase life of 22.8, 21.9, 21.6 and 20.6 days, respectively. Minimum vase life (14.4 days) was observed in treatment (T₁) Control.

During 2019-20, cut flowers of treatment T₇ (6% Panchagavya + CBD*) recorded significantly high vase life than other treatments. Among different levels of Panchagavya and Jivamrita treatments, application of T₇ (6% Panchagavya + CBD*) recorded maximum vase life of 22.6 days which was closest to T₄ (3% Panchagavya + CBD*) with vase life of 21.7 days. The minimum vase life (13.3 days) was recorded in Control.

Pooled data reveals that flowers from the treatment T₇ (6% Panchagavya + CBD*) plants produced significantly more vase life (23.0 days) than the rest of the treatments. Minimum vase life was recorded in cut flower harvested from Control plants. In general, slightly longer vase life (23.4 days) was observed during the year 2018-19 than during 2019-20 (22.6 days).

Vase life in distilled water was recorded maximum in the T₇ (6% Panchagavya + CBD*). This long vase life may be attributed to the presence of nutrient elements like N, P, K, Ca, Mg, Cu, Fe, Na and Mn present in Panchagavya (**Dharma, 2006**). This finding is in accordance with the observations of **Bhalla et al. (2006a)** who found that 4% Manchurian mushroom tea recorded maximum vase life in gladiolus cv. Red Beauty. **Waheeduzzama et al. (2006)** reported that 4% Panchagavya foliar spray + 50% RDF improved vase life of anthurium cv. 'Meringue'. **Bhalla et al. (2006b)** reported that 3% Manchurian mushroom tea + 3% Panchagavya recorded longest vase life in standard carnation. **Singh et al. (2007)** observed that 4% Panchagavya spray has longest vase life in tuberose cv. Pearl Double. **Boraiah et al. (2018)** found that 6% Panchagavya spray influenced shelf life in capsicum.

Table 4.19: Effect of organic and biodynamic manures on increase in flower diameter, water uptake by flowers and vase life of chrysanthemum cv. Thai Chen Queen

Treatments	Combinations	Increase in flower diameter (cm)			Water uptake by flowers (mL)			Vase life (days)		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	0.9	1.0	1.0	26	24	25.0	14.4	13.3	13.8
T ₂	1% Panchagavya + CBD*	1.2	1.3	1.3	39	42	40.5	18.1	19.4	18.7
T ₃	2% Panchagavya + CBD*	1.4	0.8	1.1	53	51	52.0	19.1	20.4	19.7
T ₄	3% Panchagavya + CBD*	1.5	1.3	1.4	62	61	61.5	22.8	21.7	22.1
T ₅	4% Panchagavya + CBD*	1.1	0.8	1.0	46	49	47.5	15.0	18.0	16.5
T ₆	5% Panchagavya + CBD*	1.6	1.8	1.7	52	55	53.5	16.1	17.2	16.6
T ₇	6% Panchagavya + CBD*	2.0	2.2	2.1	65	63	64.0	23.4	22.6	23.0
T ₈	7% Panchagavya + CBD*	1.6	1.5	1.5	47	48	47.5	18.4	21.5	20.1
T ₉	8% Panchagavya + CBD*	1.3	0.9	1.1	52	50	51.0	21.9	20.6	21.2
T ₁₀	9% Panchagavya + CBD*	1.6	1.2	1.4	49	51	50.0	16.8	15.6	16.2
T ₁₁	10% Panchagavya + CBD*	1.1	1.2	1.1	46	41	43.5	20.6	15.4	18.0
T ₁₂	10% Jivamrita + CBD*	1.5	1.3	1.4	29	32	30.5	14.9	16.3	15.6
T ₁₃	20% Jivamrita + CBD*	1.5	1.9	1.7	37	35	36.0	18.6	17.6	18.1
T ₁₄	30% Jivamrita + CBD*	1.6	1.4	1.5	42	40	41.0	15.7	16.3	16.1
T ₁₅	40% Jivamrita + CBD*	1.8	1.8	1.8	44	39	41.5	16.2	18.4	17.3
T ₁₆	50% Jivamrita + CBD*	1.96	2.0	2.0	58	59	58.5	21.6	19.2	20.4
SEm±		0.02	0.02	0.02	0.73	0.82	0.65	0.01	0.01	0.01
C.D. at 5%		0.07	0.07	0.07	2.13	2.39	1.90	0.04	0.03	0.03

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB as well as potash bacteria

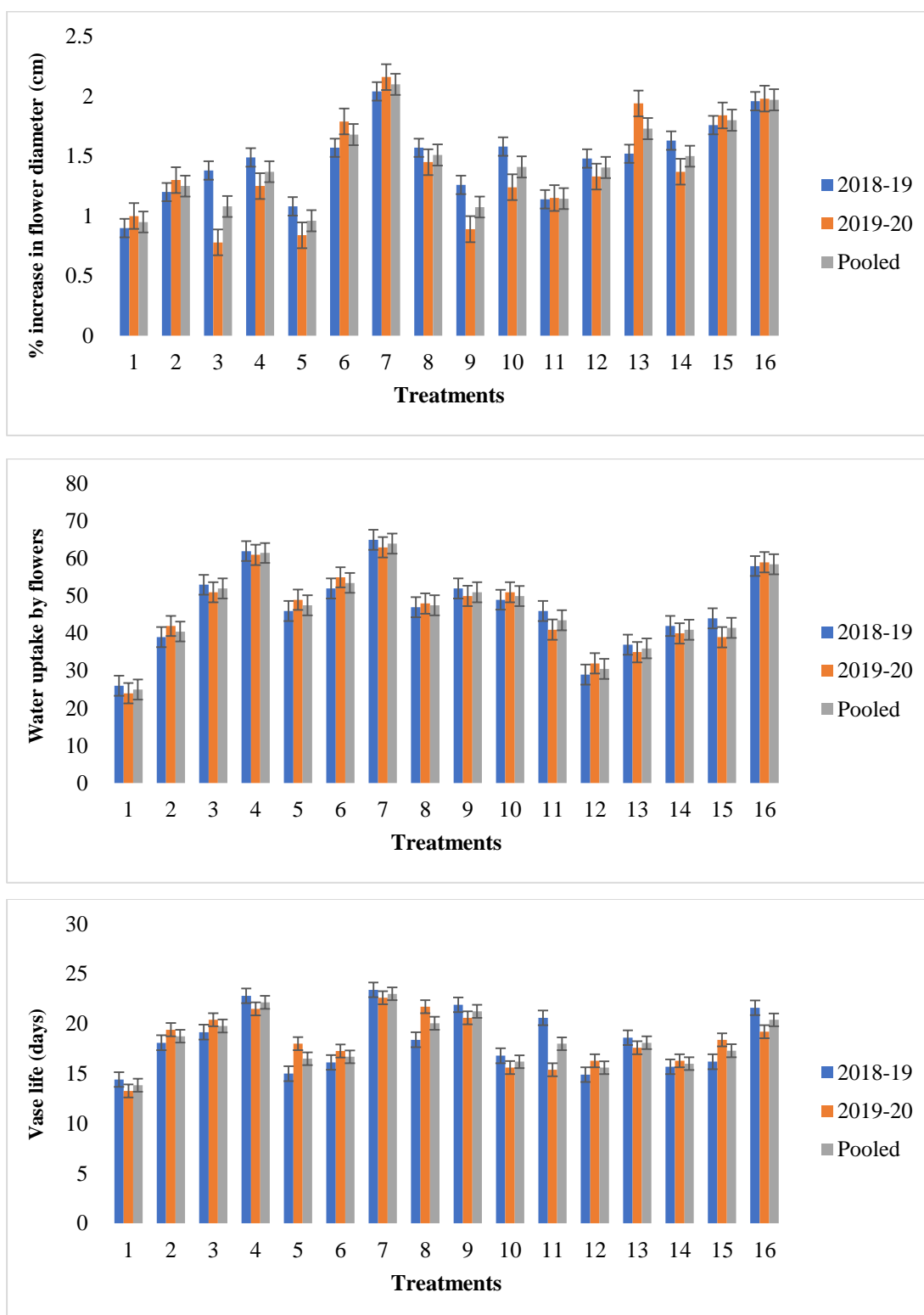


Fig. 4.19: Influence of organic and biodynamic manures on increase in flower diameter, water uptake by flowers and vase life of chrysanthemum cv. Thai Chen Queen

4.4 Soil Nutrient Parameters

4.4.1 Physico-chemical properties of soil

Physico-chemical properties of soil after harvesting of chrysanthemum flowers as influenced by different sources and levels of biodynamic manures application and their effects are presented in Table 4.20 and depicted in Fig 4.20.

During both the years of research, soil pH value was significantly influenced by different sources and levels of Panchagavya and Jivamrita application. For estimation of soil pH, soil was taken from 0-15 cm depth which varied from 6.70 to 8.0 pH in the season 2018-19 and from 6.50 to 8.36 pH in the season 2019-20. The highest pH (8.0) was observed in T₁₂ (10% Jivamrita + CBD*), followed by T₁₃ (20% Jivamrita + CBD*), (T₁) Control, T₈ (7% Panchagavya + CBD*) and lowest value (6.70) in T₇ (6% Panchagavya + CBD*). However, plants in the treatment T₇ *i.e.*, 6% Panchagavya + CBD* has the near neutral to slight acidic soil pH range in both the seasons (6.70 and 6.50) in the year 2018-19 and 2019-20, respectively. which was ideal for chrysanthemum growth. Pooled data of both the years indicated that soil pH value was significantly influenced due to different organic treatments of Panchagavya and Jivamrita. Highest soil pH (8.08) was recorded in T₁₄ (30% Jivamrita + CBD*) and lowest (6.60) was recorded in T₇ (6% Panchagavya + CBD*).

A glance of the data (Table 4.20) revealed that EC of the soil was significantly influenced by different treatments in both the years. The EC of the soil in the year 2018-19 ranged from 0.40 to 0.82 and 0.38 to 0.78 dSm⁻¹ in 2019-20. During both the years the highest EC (0.82 and 0.78 dSm⁻¹) was observed highest in treatment T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading of 0.67 and 0.65, 0.63 and 0.61 dSm⁻¹, respectively. The lowest EC (0.40 and 0.38 dSm⁻¹) was observed in the Control (T₁).

From the data presented in Table 4.20 and depicted in Fig 4.20 showed that the soil organic carbon content was significantly influenced by the different treatments during both the years of investigation. Soil organic carbon content in the year 2018-19 ranged in between 0.51 to 1.63 % and in the year 2019-20, ranged in between 0.53 to 1.62 %. All the treatments showed significant increase in soil organic carbon content over control.

Table 4.20: Effect of organic and biodynamic manures on physico-chemical properties of soil of chrysanthemum

Treatments	Combinations	pH			EC (dSm ⁻¹)			Organic carbon (%)		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	pooled
T ₁	Control	7.68	7.66	7.70	0.40	0.38	0.39	0.51	0.53	0.52
T ₂	1% Panchagavya + CBD*	7.58	7.57	7.60	0.43	0.42	0.43	0.77	0.76	0.76
T ₃	2% Panchagavya + CBD*	7.32	7.63	7.50	0.50	0.47	0.49	1.24	1.23	1.23
T ₄	3% Panchagavya + CBD*	6.80	6.90	6.90	0.63	0.61	0.62	1.55	1.54	1.54
T ₅	4% Panchagavya + CBD*	7.42	7.42	7.40	0.52	0.50	0.51	1.42	1.41	1.41
T ₆	5% Panchagavya + CBD*	7.54	7.51	7.50	0.44	0.43	0.43	1.15	1.14	1.14
T ₇	6% Panchagavya + CBD*	6.70	6.50	6.60	0.82	0.78	0.80	1.63	1.62	1.62
T ₈	7% Panchagavya + CBD*	7.65	7.63	7.60	0.47	0.46	0.47	1.28	1.26	1.27
T ₉	8% Panchagavya + CBD*	7.61	7.62	7.60	0.56	0.52	0.54	1.32	1.30	1.31
T ₁₀	9% Panchagavya + CBD*	7.24	7.58	7.40	0.53	0.50	0.52	1.51	1.50	1.50
T ₁₁	10% Panchagavya + CBD*	7.36	7.53	7.40	0.55	0.54	0.54	0.95	0.94	0.94
T ₁₂	10% Jivamrita + CBD*	8.00	7.91	7.96	0.45	0.44	0.44	1.14	1.15	1.14
T ₁₃	20% Jivamrita + CBD*	7.90	8.20	8.05	0.47	0.47	0.42	1.27	1.26	1.26
T ₁₄	30% Jivamrita + CBD*	7.80	8.36	8.08	0.54	0.52	0.53	1.35	1.35	1.35
T ₁₅	40% Jivamrita + CBD*	7.64	7.63	7.64	0.48	0.47	0.48	1.44	1.41	1.42
T ₁₆	50% Jivamrita + CBD*	7.92	7.87	7.90	0.67	0.65	0.66	1.57	1.55	1.56
SEm±		0.10	0.12	0.11	0.01	0.01	0.01	0.02	0.02	0.02
C.D. at 5%		0.28	0.26	0.31	0.02	0.02	0.03	0.06	0.05	0.06

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB as well as potash bacteria

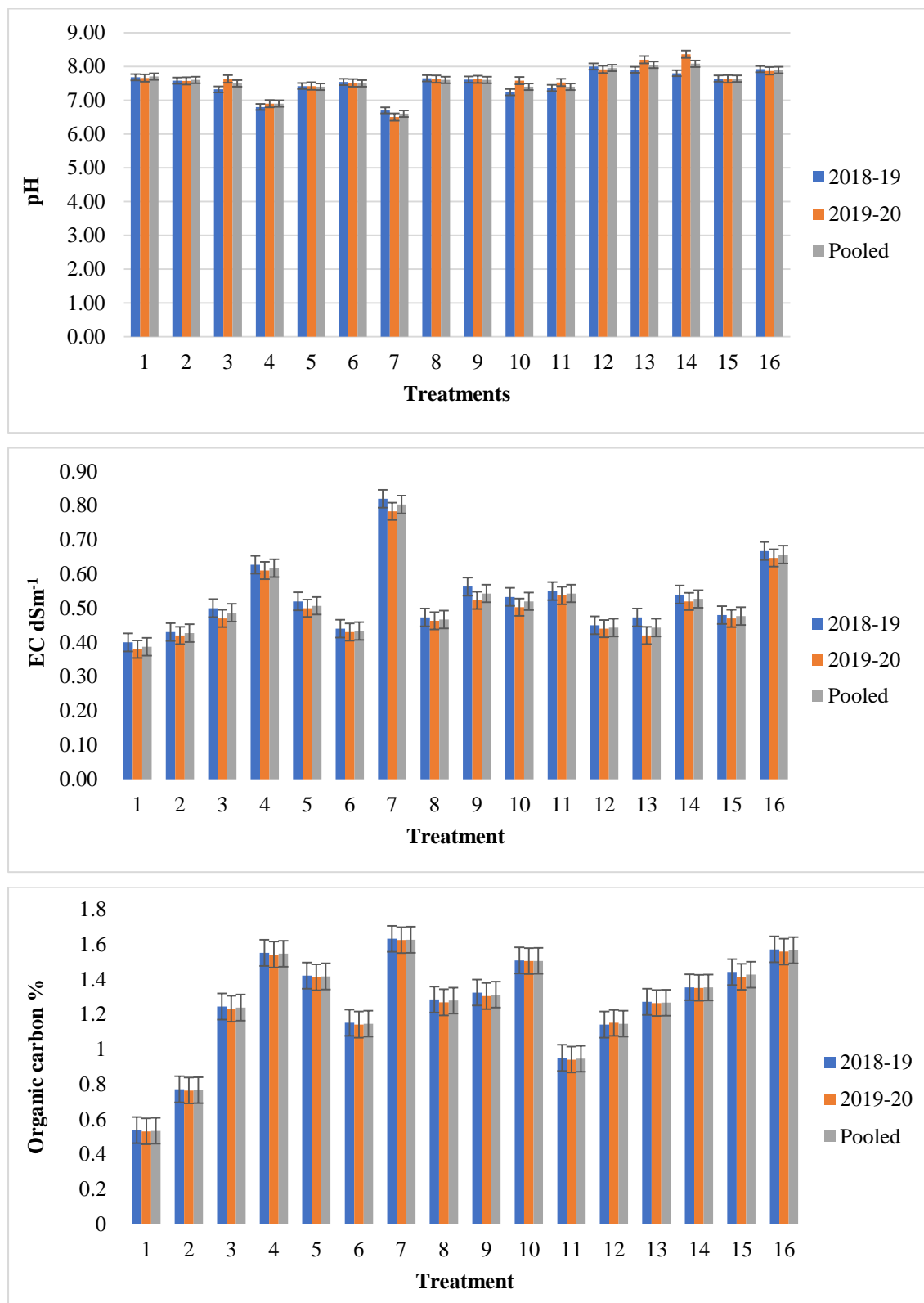


Fig. 4.20: Influence of organic and biodynamic manures on physico-chemical properties of soil in chrysanthemum cultivated plots

However, in pooled data the highest soil organic carbon content was found in T₇ (6% Panchagavya + CBD*) *i.e.*, 1.62 %, followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading of 1.56 and 1.54 %, respectively. whereas, the lowest value (0.52 %) was observed in control plot.

Decrease of soil pH might be because of acidic nature of Panchagavya and moreover fermentation of Panchgavya solution produced certain organic acids that contributed to the reduction in pH solution. During the fermentation of Panchgavya bacteria like *Lactobacillus*, *Saccharomyces*, *Streptomyces*, *Rhodopseudomonas*, and *Aspergillus* could have lowered the pH of both the formulations and the soil rhizosphere (Kumawat *et al.*, 2012). The decrease in soil EC following Panchgavya application may be due to its inherent capacity to supply soluble salts of Ca⁺⁺, Mg⁺⁺, and SO₄, which formed soluble salts (Na₂SO₄) with Na in the soil exchange complex. These soluble salts can be absorbed by crop plants or leached from the rhizosphere by irrigation water (Singh, 1996). The observed increase in SOC (Soil organic carbon) might be due to supply of available organic carbon through Panchgavya (with 1.5% OC) (Kumawat *et al.*, 2010). It was also reported that soil OC is negatively correlated with high soil pH (Pal and Shurpali, 2006) and hence, application of Panchgavya might have increased soil OC by reducing the soil pH. The present findings are in confirmation with the findings of Ali *et al.* (2011) who found that application of Panchagavya and Sanjivini on green gram, chili and mustard increased organic carbon content and the pH and EC values of soil were also close to neutral.

4.4.2 Available soil nitrogen (kg ha⁻¹)

The data on available nitrogen presented in Table 4.21 and depicted in Fig 4.21 show that the available soil nitrogen was significantly influenced by biodynamic manures in chrysanthemum cultivated plots during both the years (2018-19 and 2019-20) of investigation.

The initial available nitrogen of the soil collected from the field was 193.80 kg ha⁻¹ before planting (Table 3.1). Data enumerated in Table 4.21 reveal that all the treatments, except the control showed increased quantity of available nitrogen when assessed after flowering of the plants of chrysanthemum during both the years of study. Available soil N in the chrysanthemum field during the year 2018-19 varied from 198.0

to 288.3 kg ha⁻¹ and 190.50 to 284.30 kg ha⁻¹ during 2019-20. All the treatments showed significantly increase in available soil nitrogen as compared to control.

During the year 2018-19, the highest available soil nitrogen in soil (288.3 kg ha⁻¹) was observed in T₇ (6% Panchagavya + CBD*), which was at par with T₁₆ (50% Jivamrita + CBD*) with a reading of 283.3 kg ha⁻¹. In the different levels of Panchagavya application, nitrogen varied from 215.7 to 288.3 kg ha⁻¹ whereas in the different concentrations of Jivamrita, nitrogen varied from 203.0 to 283.3 kg ha⁻¹. On contrary, the lowest value 198.0 kg ha⁻¹ was observed in control plot (T₁).

In the year 2019-20, same trend was followed with highest available soil nitrogen in soil (284.3 kg ha⁻¹) observed in T₇ (6% Panchagavya + CBD*), which was at par with T₁₆ (50% Jivamrita + CBD*) with a reading of 280.20 kg ha⁻¹. The lowest value 190.50 kg ha⁻¹ of nitrogen was observed in control plot (T₁). It can be observed that concentration of nitrogen was decreased in the year 2019-20 compared to 2018-19 due to uptake by plants.

Pooled data revealed that highest available soil nitrogen in soil (286.30 kg ha⁻¹) was observed in T₇ (6% Panchagavya + CBD*), while the minimum (194.3 kg ha⁻¹) was observed in the control. The plot in which Panchagavya was applied, nitrogen concentration varied from 212.9 to 286.30 kg ha⁻¹ whereas, in the different concentrations of Jivamrita, nitrogen concentration varied from 201.40 to 281.8 kg ha⁻¹

4.4.3 Available soil phosphorous (kg ha⁻¹)

The data on available soil phosphorous presented in Table 4.21 and depicted in Fig 4.21 show that the available soil phosphorous was significantly influenced by the organic and biodynamic manures in chrysanthemum cultivated plots during both the years of study.

The initial available phosphorous of the soil collected from the field was 13.19 kg ha⁻¹ before planting (Table 3.1). The data elaborated in Table 4.21 show that different treatments of Panchagavya and Jivamrita had significant influence on available P content in soil during both the years of study. Available soil phosphorous in the chrysanthemum field during the year 2018-19 varied from 13.5 to 24.8 kg ha⁻¹ and 12.5 to 25.4 kg ha⁻¹ during 2019-20. All the treatments showed significant increase in available soil phosphorous as compared to control.

It is clear from the Table 4.21 that during 2018-19, highest amount of available P in the soil (24.8 kg ha^{-1}) was noted with the application of T₇ (6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading of 24.1 and 23.3 kg ha^{-1} . In the different levels of Panchagavya application, available phosphorous varied from 16.5 to 24.8 kg ha^{-1} whereas, in the different concentrations of Jivamrita application, available soil phosphorous varied from 15.4 to 24.1 kg ha^{-1} . while minimum P (13.5 kg ha^{-1}) was observed in control plots.

Similarly, during the year 2019-20 also, same treatment *i.e.*, T₇ had highest available soil phosphorous in soil (25.4 kg ha^{-1}) which was closest with T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading of 23.4 and 22.3 kg ha^{-1} and the lowest value of P *i.e.* 12.56 kg ha^{-1} was observed in control plot (T₁).

Pooled data revealed that highest available soil phosphorous in soil (25.1 kg ha^{-1}) was observed in 6% Panchagavya + CBD* (T₇), while the minimum (13.1 kg ha^{-1}) was observed in the control. The plot in which Panchagavya was applied, phosphorous concentration varied from 16.2 to 25.1 kg ha^{-1} whereas, in the different concentrations of Jivamrita, phosphorous concentration varied from 15.5 to 23.7 kg ha^{-1} .

4.4.4 Available soil potassium (kg ha^{-1})

The available soil potassium data was statistically analysed and furnished in Table 4.21 and depicted in fig. 4.21. Available soil potassium was significantly influenced by the different treatments during both the years of 2018-19 and 2019-20.

The initial available potassium of the soil collected from the field was 147.3 kg ha^{-1} before planting (Table 3.1). The data elaborated in Table 4.21 show that different treatments of Panchagavya and Jivamrita had significant influence on available P content in soil during both the years of study. Available soil potassium in the chrysanthemum field during the year 2018-19 varied from 155.4 to 214.6 kg ha^{-1} and 148.6 to 213.6 kg ha^{-1} during 2019-20, respectively. All the treatments showed significant increase in available soil potassium as compared to control.

It is clear from the Table 4.21 that during 2018-19, highest amount of available potassium in the soil (214.6 kg ha^{-1}) was noted with the application of T₇

(6% Panchagavya + CBD*) followed by T₁₆ (50% Jivamrita + CBD*) and T₄ (3% Panchagavya + CBD*) with a reading of 212.5 and 204.7 kg ha⁻¹. In the different levels of Panchagavya application, available soil potassium varied from 166.6 to 214.6 kg ha⁻¹ whereas, in the different concentrations of Jivamrita application, available potassium varied from 163.3 to 212.5 kg ha⁻¹. while minimum K (155.4 kg ha⁻¹) was observed in control plots.

During the year 2019-20 same treatment i.e., T₇ has highest available soil potassium in soil (213.6 kg ha⁻¹) which was at par with T₁₆ (50% Jivamrita + CBD*) with a reading of 210.9 and the lowest value (148.6 kg ha⁻¹) was observed in control plot (T₁).

Pooled data revealed that highest available soil potassium in soil (214.1 kg ha⁻¹) was observed in T₇ (6% Panchagavya + CBD*), while the minimum (152.2 kg ha⁻¹) was observed in the control. The soil in which Panchagavya was applied, potassium concentration varied from 165.5 to 214.1 kg ha⁻¹ whereas, in the different concentrations of Jivamrita potassium concentration varied from 161.8 to 211.7 kg ha⁻¹.

Panchagavya is a low-cost organic liquid manure with regulatory substances like IAA (Indoleacetic acid), GA, cytokinins, essential plant nutrients and effective microorganisms that promote plant development. In addition, Jivamrita has a high microbial load, which multiplies and improves the soil. Increased soil microbial activity ensures that nutrients are available and are absorbed by crops (**Brar et al., 2019**). Strains of biofertilizers contain microbes that employ various mechanisms to increase nutrient uptake, such as nitrogen fixation, solubilization of potassium and phosphorus (**Mącik et al., 2020**). The present findings are in confirmation with the findings of **Beulah (2001)** who reported that different organic manures and bioenhancers (poultry manure + neem cake + Panchagavya) treatments have sufficient amounts of secondary and micronutrients (Ca, S and Fe), as well as macronutrients (N, P and K) in annual moringa leaves and pods. **Kumawat et al., 2010** also found that soil application of Panchgavya @ 3 lit/m² increased the availability of P, Fe, Cu, Zn and Mn among all the Panchgavya levels applied. **Chakraborty and Sarkar (2019)** found that in quality analysis, Panchagavya has the highest content of nitrogen and potassium and Jivamrita has highest content of phosphorous.

Table 4.21: Effect of organic and biodynamic manures on N, P and K in soil after harvesting of crop

Treatments	Combinations	Available nitrogen (kg ha ⁻¹)			Phosphorous (kg ha ⁻¹)			Potassium (kg ha ⁻¹)		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	198.0	190.5	194.3	13.5	12.6	13.1	155.4	148.6	152.2
T ₂	1% Panchagavya + CBD*	235.7	230.4	233.0	17.3	15.6	16.4	175.6	172.5	174.6
T ₃	2% Panchagavya + CBD*	238.3	234.6	236.4	17.6	15.8	16.7	177.8	175.4	176.3
T ₄	3% Panchagavya + CBD*	277.0	271.3	274.1	23.3	22.3	22.8	204.7	201.3	203.1
T ₅	4% Panchagavya + CBD*	228.3	223.8	226.0	16.9	15.6	16.2	171.1	169.8	170.6
T ₆	5% Panchagavya + CBD*	249.7	242.6	246.1	18.8	17.3	18.1	185.6	182.6	184.1
T ₇	6% Panchagavya + CBD*	288.3	284.3	286.3	24.8	25.4	25.1	214.6	213.6	214.1
T ₈	7% Panchagavya + CBD*	261.0	255.6	258.3	20.7	19.8	20.2	195.7	192.4	194.1
T ₉	8% Panchagavya + CBD*	273.7	270.5	272.1	22.6	21.6	22.1	201.3	198.7	200.3
T ₁₀	9% Panchagavya + CBD*	243.0	238.6	240.8	18.4	17.9	18.1	181.1	178.6	179.9
T ₁₁	10% Panchagavya + CBD*	215.7	210.2	212.9	16.5	15.9	16.2	166.6	164.5	165.5
T ₁₂	10% Jivamrita + CBD*	203.0	199.8	201.4	15.4	14.7	15.5	209.2	205.6	207.4
T ₁₃	20% Jivamrita + CBD*	266.0	262.4	264.2	20.7	19.9	20.3	198.5	195.2	196.8
T ₁₄	30% Jivamrita + CBD*	254.7	250.6	252.6	19.9	19.1	19.5	190.1	188.6	189.3
T ₁₅	40% Jivamrita + CBD*	208.0	205.9	206.9	15.7	15.6	15.7	163.3	160.4	161.8
T ₁₆	50% Jivamrita + CBD*	283.3	280.2	281.8	24.1	23.4	23.7	212.5	210.9	211.7
SEm±		3.6	3.4	3.3	0.9	0.7	0.8	2.7	1.5	2.6
C.D. at 5%		10.4	9.9	9.6	0.3	0.2	0.2	7.8	4.5	7.5

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB as well as potash bacteria

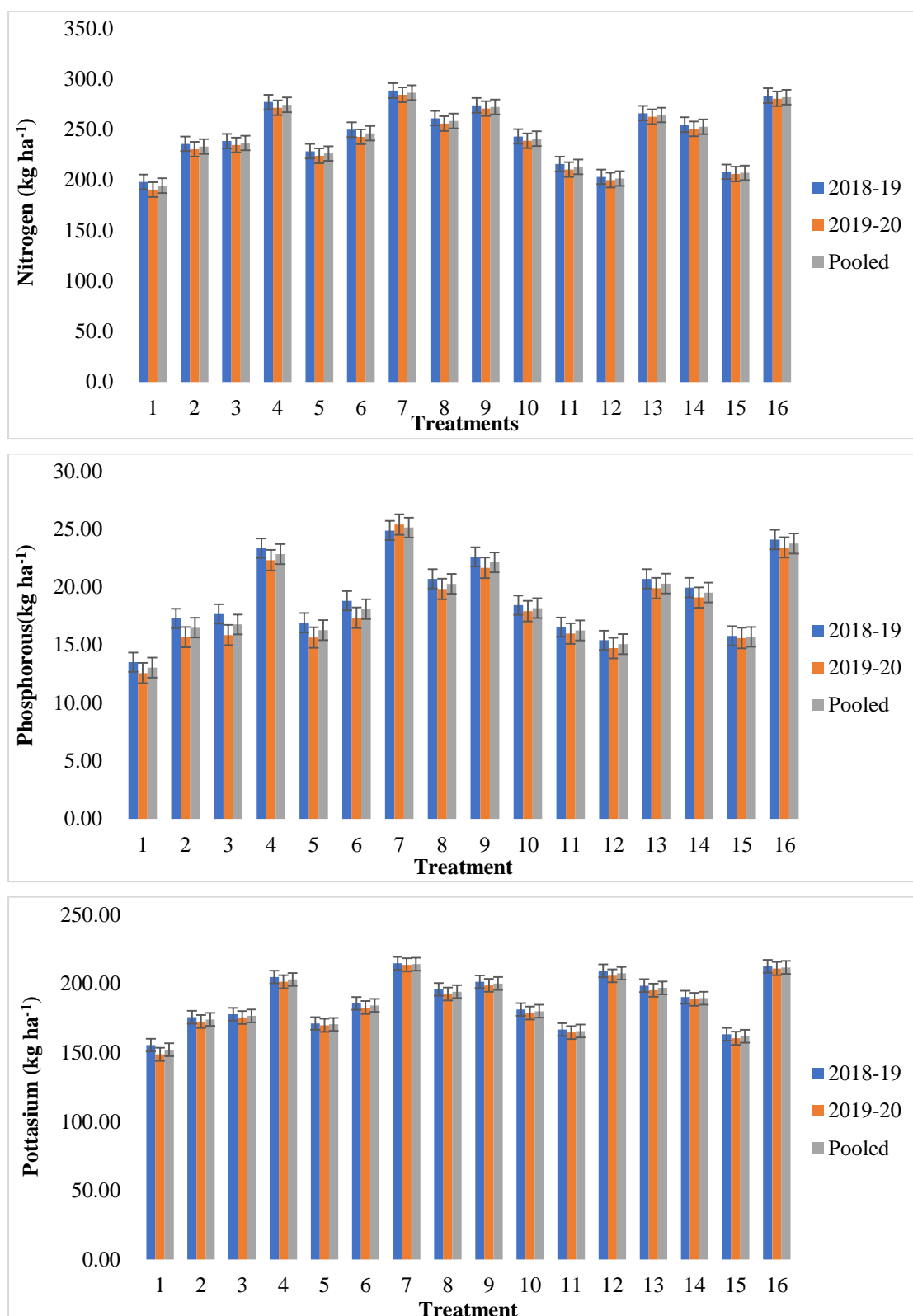


Fig. 4.21: Influence of organic and biodynamic manures on N, P and K in soil after harvesting of crop

4.4.5 Soil Microbial Population

4.4.5.1 Bacterial, fungal and actinomycetes population (10^5 CFU g^{-1})

The data pertaining to the effect of different levels of organic and biodynamic manures on soil microbial population of chrysanthemum are presented in Table 4.22 and depicted in fig. 4.22.

Perusal of data in Table 4.22 clearly reflect that soil microbial population were significantly influenced by the various treatments. During the year 2018-19 and 2019-20, treatment combination of T₇ (6% Panchagavya + CBD) resulted in maximum bacterial colonies ($290, 288 \times 10^5$ CFU g^{-1}) followed with T₁₆ (50% Jivamrita + CBD*) ($237, 236 \times 10^5$ CFU g^{-1}), T₄ (3% Panchagavya + CBD*) ($220, 218 \times 10^5$ CFU g^{-1}), T₉ (8% Panchagavya + CBD*) ($202, 200 \times 10^5$ CFU g^{-1}) and T₅ (4% Panchagavya + CBD*) ($195, 194 \times 10^5$ CFU g^{-1}), respectively. While, minimum bacterial colonies were observed in Control (T₁) ($94, 91 \times 10^5$ CFU g^{-1}). Pooled data revealed that bacterial colonies varied from 93 to 289×10^5 CFU g^{-1} of which highest bacterial colonies were recorded in T₇ (6% Panchagavya + CBD*) with a reading of 289×10^5 CFU g^{-1} . Minimum bacterial colonies were observed in T₁ (Control) (93×10^5 CFU g^{-1}).

In pooled data, the highest fungi count in soil was observed in 6% Panchagavya + CBD* (T₇) *i.e.*, 141×10^5 CFU g^{-1} and lowest value was observed in the control plot *i.e.*, 36×10^5 CFU g^{-1} . The count of fungi observed in soil ranged from 37 to 142×10^5 CFU g^{-1} soil after 2018-19 and from 35 to 140×10^5 CFU g^{-1} soil after 2019-20.

The effect of various concentrations of Panchagavya and Jivamrita on the Actinomycetes population in the rhizosphere of chrysanthemum is summarised in Table 4.22 and illustrated in Fig. 4.22. During the years 2018-19 and 2019-20, T₇ (6% Panchagavya + CBD*) treatment combination resulted in the highest number of Actinomycetes colonies ($147, 146 \times 10^5$ CFU g^{-1}) which was followed by T₁₆ (50% Jivamrita + CBD*) ($119, 118 \times 10^5$ CFU g^{-1}), T₄ (3% Panchagavya + CBD*) ($92, 91 \times 10^5$ CFU g^{-1}), T₉ (8% Panchagavya + CBD*) ($88, 86 \times 10^5$ CFU g^{-1}), and T₅ (4% Panchagavya + CBD*) ($82, 80 \times 10^5$ CFU g^{-1}). In T₁ (Control), minimum actinomycetes colonies were observed ($39, 37 \times 10^5$ CFU g^{-1}). The pooled data revealed that actinomycetes colonies ranged from 38 to 146×10^5 CFU g^{-1} , with the highest reading being 146×10^5 CFU g^{-1} in the T₇ (6% Panchagavya + CBD*). In T₁ (Control), minimum actinomycetes colonies were observed (38×10^5 CFU g^{-1}).

Table 4.22: Effect of organic and biodynamic manures on soil microbial population (Bacterial, fungal and actinomycetes population) of soil

Treatments	Combinations	Bacterial population (10^5 CFU g^{-1})			Fungal population (10^5 CFU g^{-1})			Actinomycetes population (10^5 CFU g^{-1})		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	94	91	93	37	35	36	39	37	38
T ₂	1% Panchagavya + CBD*	176	172	174	54	52	53	45	44	44
T ₃	2% Panchagavya + CBD*	123	121	122	79	75	77	74	72	73
T ₄	3% Panchagavya + CBD*	220	218	219	87	86	86	92	91	91
T ₅	4% Panchagavya + CBD*	195	194	194	63	60	61	82	80	81
T ₆	5% Panchagavya + CBD*	141	138	140	38	36	37	44	42	43
T ₇	6% Panchagavya + CBD*	290	288	289	142	140	141	147	146	146
T ₈	7% Panchagavya + CBD*	102	101	101	40	38	39	40	39	40
T ₉	8% Panchagavya + CBD*	202	200	201	82	79	80	88	86	87
T ₁₀	9% Panchagavya + CBD*	103	101	102	45	44	44	38	37	38
T ₁₁	10% Panchagavya + CBD*	144	141	143	55	54	54	52	51	51
T ₁₂	10% Jivamrita + CBD*	161	162	162	76	75	76	58	55	57
T ₁₃	20% Jivamrita + CBD*	154	153	153	43	41	42	45	44	44
T ₁₄	30% Jivamrita + CBD*	133	131	132	73	72	72	65	64	64
T ₁₅	40% Jivamrita + CBD*	144	140	142	75	74	74	81	80	81
T ₁₆	50% Jivamrita + CBD*	237	236	237	121	120	121	119	118	119

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB as well as potash bacteria

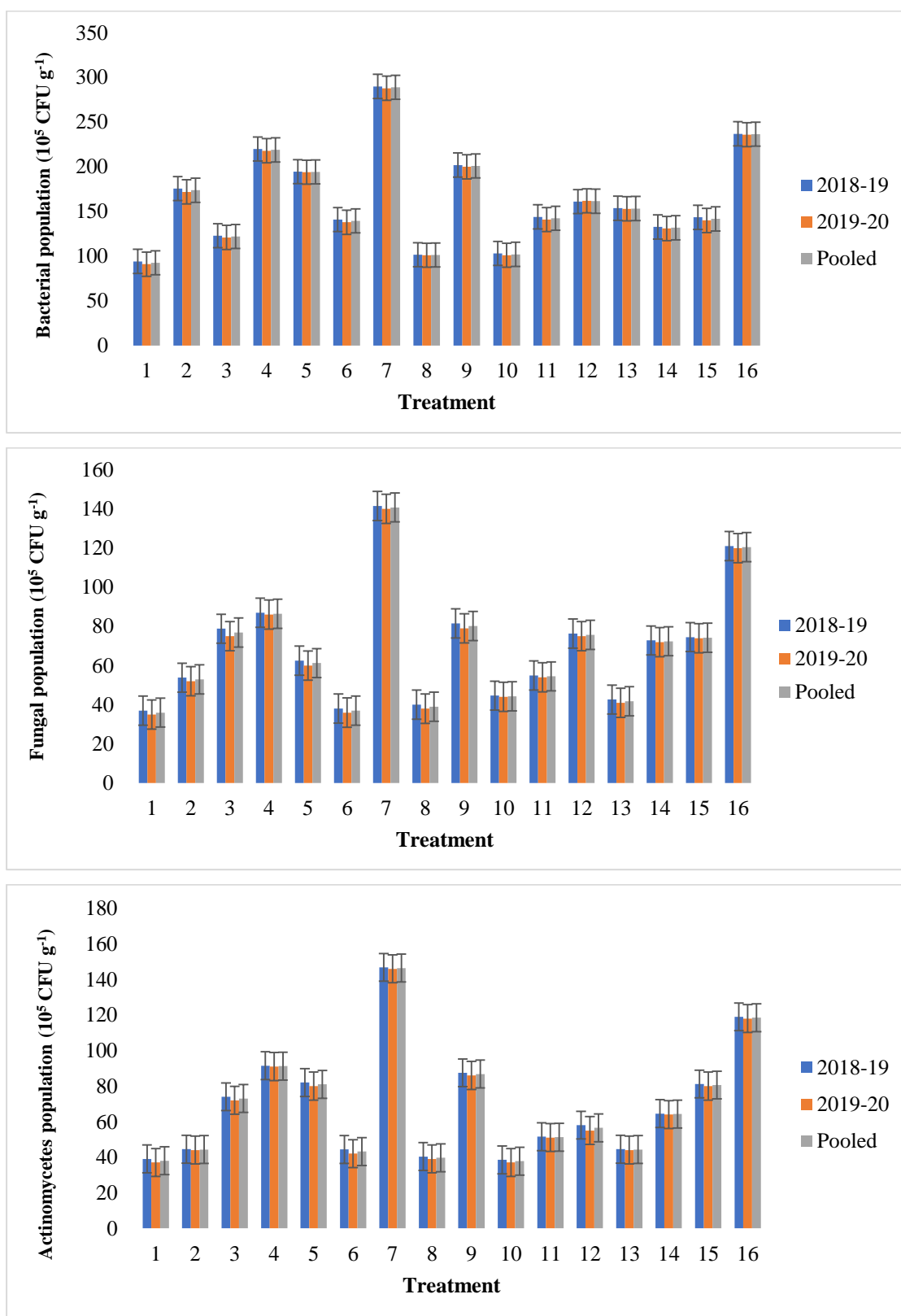


Fig. 4.22: Influence of organic and biodynamic manures on biological parameters (Bacterial, fungal and actinomycetes population) of soil

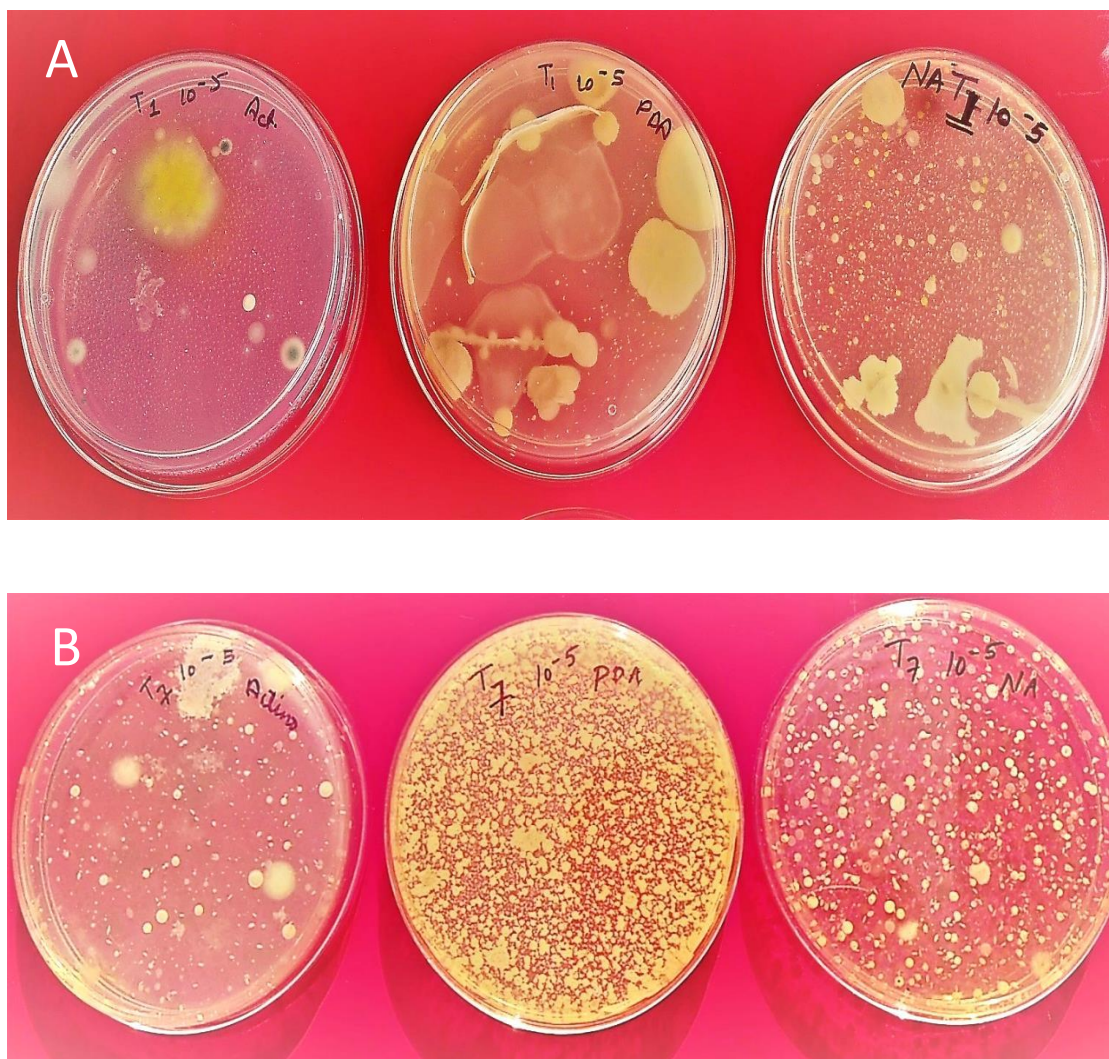


Plate 8: Effect of biodynamic manures on microbial population (Actinomycetes, fungal and bacterial)

- A. T₁ (Control) has less growth of microbial population (Actinomycetes, fungal and bacterial)
- B. T₇ (6% Panchagavya + CBD*) has excellent growth of microbial population (Actinomycetes, fungal and bacterial)

4.4.5.2 N-fixers and P-solubilizers in soil

The effect of various concentrations of Panchagavya and Jivamrita on the N-fixers in the rhizosphere of chrysanthemum is summarised in Table 4.23 and illustrated in fig. 4.23. During the years 2018-19 and 2019-20, T₇ (6% Panchagavya + CBD) treatment combination resulted in the highest number of N-fixers (74, 71 x 10⁴ CFU g⁻¹) followed by T₁₆ (50% Jivamrita + CBD*) (70, 69 x 10⁴ CFU g⁻¹), T₄ (3% Panchagavya + CBD) (68, 65 x 10⁴ CFU g⁻¹), T₉ (8% Panchagavya + CBD*) (64, 61 x 10⁴ CFU g⁻¹), and T₈ (7% Panchagavya + CBD*) (63, 60 x 10⁴ CFU g⁻¹). In Control (T₁), minimum N-fixers were observed (31, 30 x 10⁴ CFU g⁻¹). The pooled data revealed that N-fixers ranged from 30.50 to 72.50 x 10⁴ CFU g⁻¹, with the highest reading being 72.50 x 10⁴ CFU g⁻¹ in the 6% Panchagavya + CBD* (T₇). In T₁ (Control), minimum N-fixers were observed (30.50 x 10⁴ CFU g⁻¹).

Perusal of data in Table 4.23 and Fig. 4.23 clearly reflect that P-solubilizers were significantly influenced by the various treatments. During the year 2018-19 and 2019-20, treatment combination of T₇ (6% Panchagavya + CBD) resulted in maximum P-solubilizers (163, 160 x 10³ CFU g⁻¹) followed by T₁₆ (50% Jivamrita + CBD*) (158, 154 x 10³ CFU g⁻¹), T₄ (3% Panchagavya + CBD) (154, 152 x 10³ CFU g⁻¹), T₁₅ (40% Jivamrita + CBD*) (136, 137 x 10³ CFU g⁻¹) and T₁₄ (30% Jivamrita + CBD*) (132, 130 x 10³ CFU g⁻¹), respectively. Minimum P-solubilizers were observed in T₁ (Control) (42, 41 x 10³ CFU g⁻¹). Pooled data revealed that P-solubilizers varied from 41.50 to 161.50 x 10³ CFU g⁻¹ of which highest P-solubilizers were recorded in T₇ (6% Panchagavya + CBD*) with a reading of 161.50 x 10³ CFU g⁻¹. Minimum P-solubilizers (41.50 x 10³ CFU g⁻¹) were observed in T₁ (Control).

It is well known that adding organic matter to the soil boosts soil microbial populations and biological activities (**Brady and Weil 1999**), which is in accordance with the present investigation where organically treated plots showed an increase in fungal, bacterial and actinomycetes population as well as N-fixers and P-solubilizers compared to the control. Among all bio-enhancer treatments, T₇ (6% Panchagavya + CBD*) had the highest fungal, bacterial, and actinomycetes, as well as N-fixers and P-solubilizers. This could be due to Panchagavya which has high microbial load, which multiplies in the soil and acts as a tonic to boost microbial activity. The current findings can be supported with those of **Devakumar et al., (2014)**, who found that

Table 4.23: Effect of organic and biodynamic manures on N-fixers and P-solubilizers in soil of chrysanthemum plot

Treatments	Combinations	N-fixers (10^4 CFU g^{-1})			P-solubilizers (10^3 CFU g^{-1})		
		2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T ₁	Control	31	30	30.5	42	41	41.5
T ₂	1% Panchagavya + CBD*	45	41	43.0	110	108	109.0
T ₃	2% Panchagavya + CBD*	46	45	45.5	113	111	112.0
T ₄	3% Panchagavya + CBD*	68	65	66.5	154	152	153.0
T ₅	4% Panchagavya + CBD*	48	45	46.5	98	97	97.5
T ₆	5% Panchagavya + CBD*	44	43	43.5	107	105	106.0
T ₇	6% Panchagavya + CBD*	74	71	72.5	163	160	161.5
T ₈	7% Panchagavya + CBD*	63	60	61.5	121	118	119.5
T ₉	8% Panchagavya + CBD*	64	61	62.5	126	125	125.5
T ₁₀	9% Panchagavya + CBD*	61	59	60.0	116	114	115.0
T ₁₁	10% Panchagavya + CBD*	56	54	55.0	124	122	123.0
T ₁₂	10% Jivamrita + CBD*	55	52	53.5	109	108	108.5
T ₁₃	20% Jivamrita + CBD*	60	58	59.0	127	125	126.0
T ₁₄	30% Jivamrita + CBD*	53	50	51.5	132	130	131.0
T ₁₅	40% Jivamrita + CBD*	58	56	57.0	136	137	136.5
T ₁₆	50% Jivamrita + CBD*	70	69	69.5	158	154	156.0

CBD*: Consists of vermicompost @ 5 kg/bed and bio-fertilizers comprising of *Azotobacter*, *Azospirillum*, PSB as well as potash bacteria

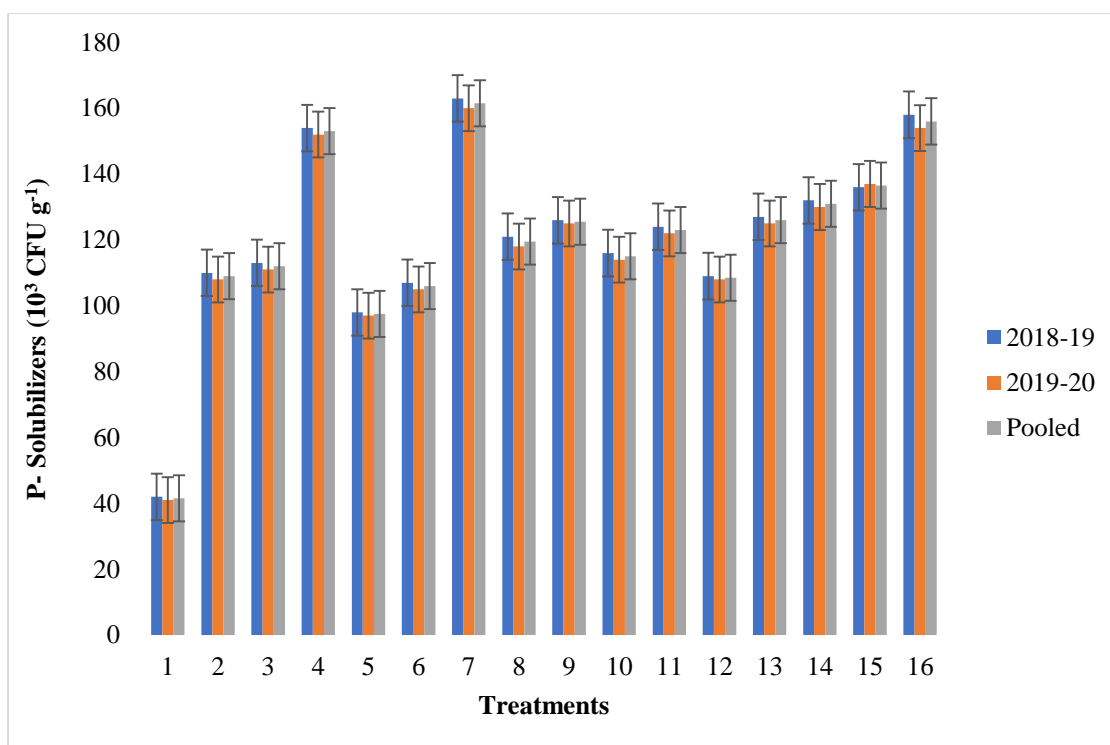
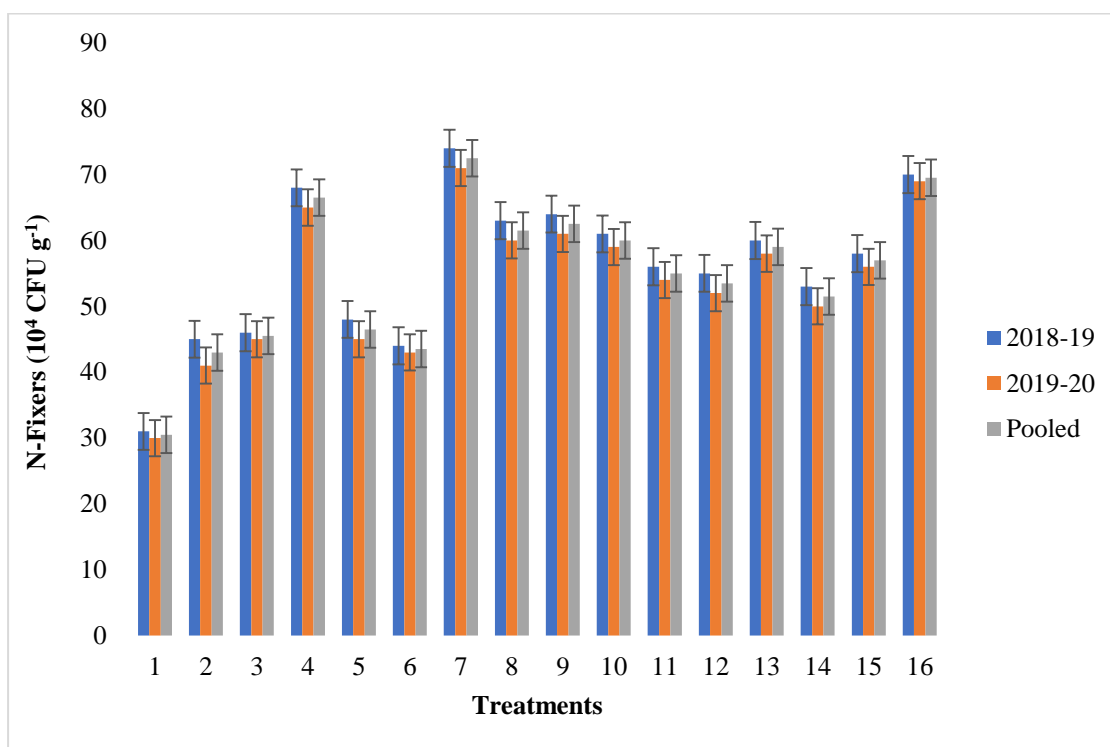


Fig. 4.23: Influence of organic and biodynamic manures on N-Fixers and P-Solubilizers in soil of chrysanthemum plot

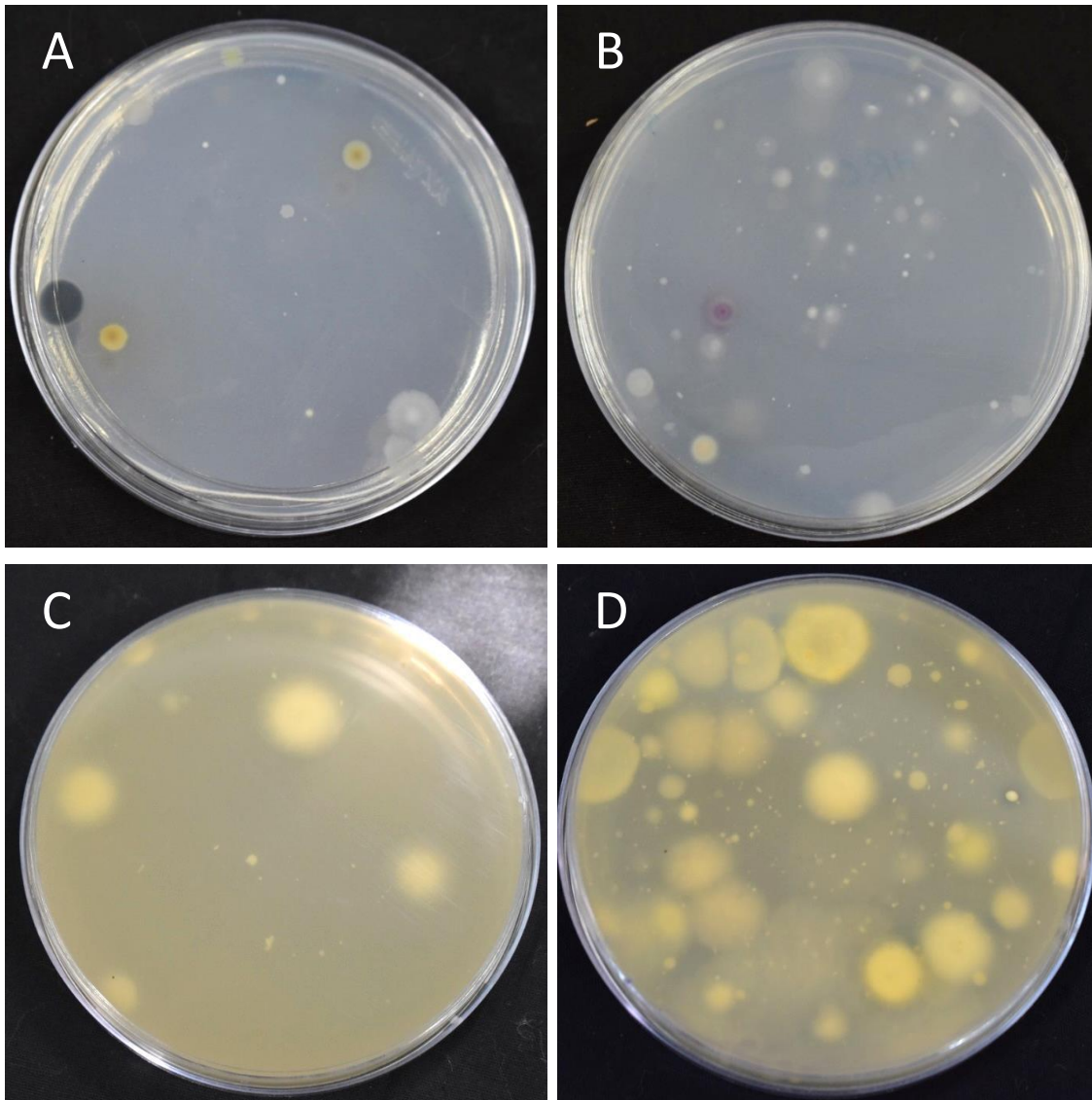


Plate 9: Effect of biodynamic manures N-fixers and P-solubilizers

- A. T₁ (Control) showed minimum growth for N-fixers
- B. T₇ (6% Panchagavya + CBD*) showed excellent growth of N-fixers
- C. T₁ (Control) showed minimum growth for P-Solubilizers
- D. T₇ (6% Panchagavya + CBD*) showed excellent growth of P-solubilizers

using a handful of soil for Jeevamrutha preparation provides an initial inoculum of bacteria, fungi, actinomycetes, N-fixers, and P-solubilizers. As a result, organic liquid manure contains a greater number of beneficial microorganisms. According to **Lavanya et al. (2016)**, soil treated with Jeevamrutha at 400 l acre⁻¹ and 7.5% Panchagavya in field bean revealed the highest population of general bacteria, fungi, actinomycetes, N-fixers, *Pseudomonas*, and PSB. **Boraiah et al., (2017)** found that using Panchagavya 6% spray resulted in significantly higher N-fixers and P-solubilizers in capsicum. **Devakumar et al. (2018)** discovered that using Jeevamrutha @ 10% and Panchagavya 7.5% resulted in the highest population of general bacteria, fungi, and actinomycetes in field bean. **Ravanachandar and Lakshmanan (2019)** found that combining organic manures and biofertilizers increase the population of bacteria, fungi and actinomycetes in black pepper.

4.4.6 Metagenomics through NGS (Next generation sequencing)

In the present study, best performing treatment *i.e.*, 6% Panchagavya + CBD* which is assigned as T₁ and control assigned as T₂ for metagenomic analysis of soil. Here 6% Panchagavya + CBD* had a significant effect on soil microbial diversity and their metabolic activity, which can be supported with higher soil biological activity as described in previous sections.

4.4.6.1 Shared operational taxonomic unit (OTU)

After NGS sequencing and filtering, a total of 1,20,980 OTUs were recovered from the two treatments *i.e.*, T₁ and T₂. The number of OTUs present in group T₁ (6% Panchagavya + CBD*) and T₂ (Control) are 68,940 and 52,040, respectively. Subsequently all OTUs were assigned their taxonomy through QIIME. To extract the unique and the overlapped genera distribution among both the samples, a Venn diagram was plotted based on OTUs distribution (Fig. 4.24.1). The results demonstrated that among both the samples, T₁ (6% Panchagavya + CBD*) represented higher unique type of genera in comparison of T₂ (Control) *i.e.*, 74 and 20, respectively. Moreover, 262 genera were shared by both the samples. Earlier studies have demonstrated that Panchagavya and Jivamrita possess the several plant growth promoting microorganisms and they also favoured the growth of other type of microorganisms (**Palekar 2006, Brar et al., 2019**) This might be the reason to elevated proliferation of the microbial genera in T₁ sample in comparison to the T₂ samples which do not contain any bio-dynamic amendments.

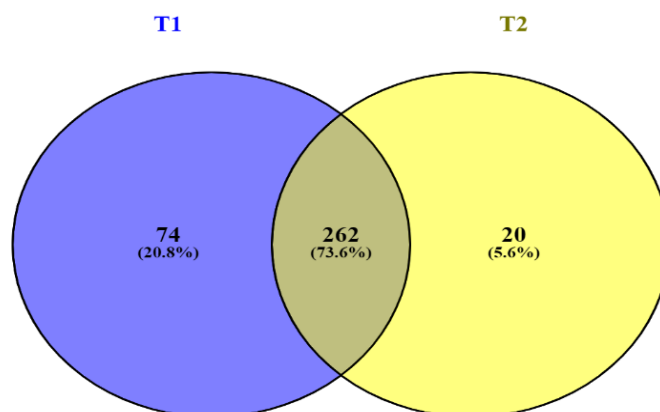


Fig. 4.24.1: Venn diagram depicting the total number of genera observed in the soil metagenomes. A total of 120980 OTU were recovered by both T₁ and T₂, along with 68,940 exclusive OTU in T₁ and 52,040 in T₂.

4.4.6.2 Taxonomic distribution and effect on soil diversity

The taxonomic distribution was done from phylum up to species level. At phylum level 28.68 and 28.53% of OTUs were assigned with Firmicutes in T₁ and T₂, respectively, whereas 22.30 and 19.53% were assigned to phylum Actinobacteria in T₁ and T₂, respectively. However, 7.60 and 6.84% of OTUs were assigned with Proteobacteria in T₁ and T₂ (**Fig 4.24.2**). At class level, the abundance of Actinobacteria in T₁ was 22.91% as compared to T₂ (20.44%). At order level, 20.50 and 19.29% of OTUs were assigned with Actinomycetales for T₁ and T₂, respectively. At family level, 10.41 and 13.13% of OTUs were assigned with Bacillaceae for T₁ and T₂, respectively. At Genus level, 10.14 and 12.24% of OTUs were assigned with *Bacillus* for T₁ and T₂, respectively. However, 7.65 and 4.96% of OTUs were assigned with *Clostridium* for T₁ and T₂, respectively

Under current study T₁, possessed both PSB and lactic acid bacteria, which might be the reason for more proliferation of firmicutes in T₁ soil. In comparison to T₂, T₁ sample possessed higher abundance of phylum firmicutes subsequently genera *Bacillus*. Firmicutes consist by many aerobic bacteria such as *Bacillus*, *Lactobacillus* which generally proliferate in low pH and improve phosphate concentration in soil. Moreover, 2nd most abundant phylum was actinobacteria which possess the bacteria responsible for the decomposition of organic matter of dead sample in the soil and also some actinobacteria perform nitrogen fixation for plant. In addition, Proteobacteria which

consist bacteria responsible for nitrogen fixation were abundantly present in T₁ soil sample. Above results clearly demonstrated that T₁ harbour the growth of diversified microbial microbes which are capable to mobilize nutrients in soil milieu and hence improve the soil health and support the plant growth and productivity.

Taxonomic distribution is high in population density of major taxa and diversity indices is being more diverse in the 6% Panchagavya + CBD* (T₁). It may result in increased organic material pools and nutrient availability and further improve the physical environment of soil and thus the yield of crops. This finding is in accordance with the observations of **Kuramae *et al.*, 2012.**

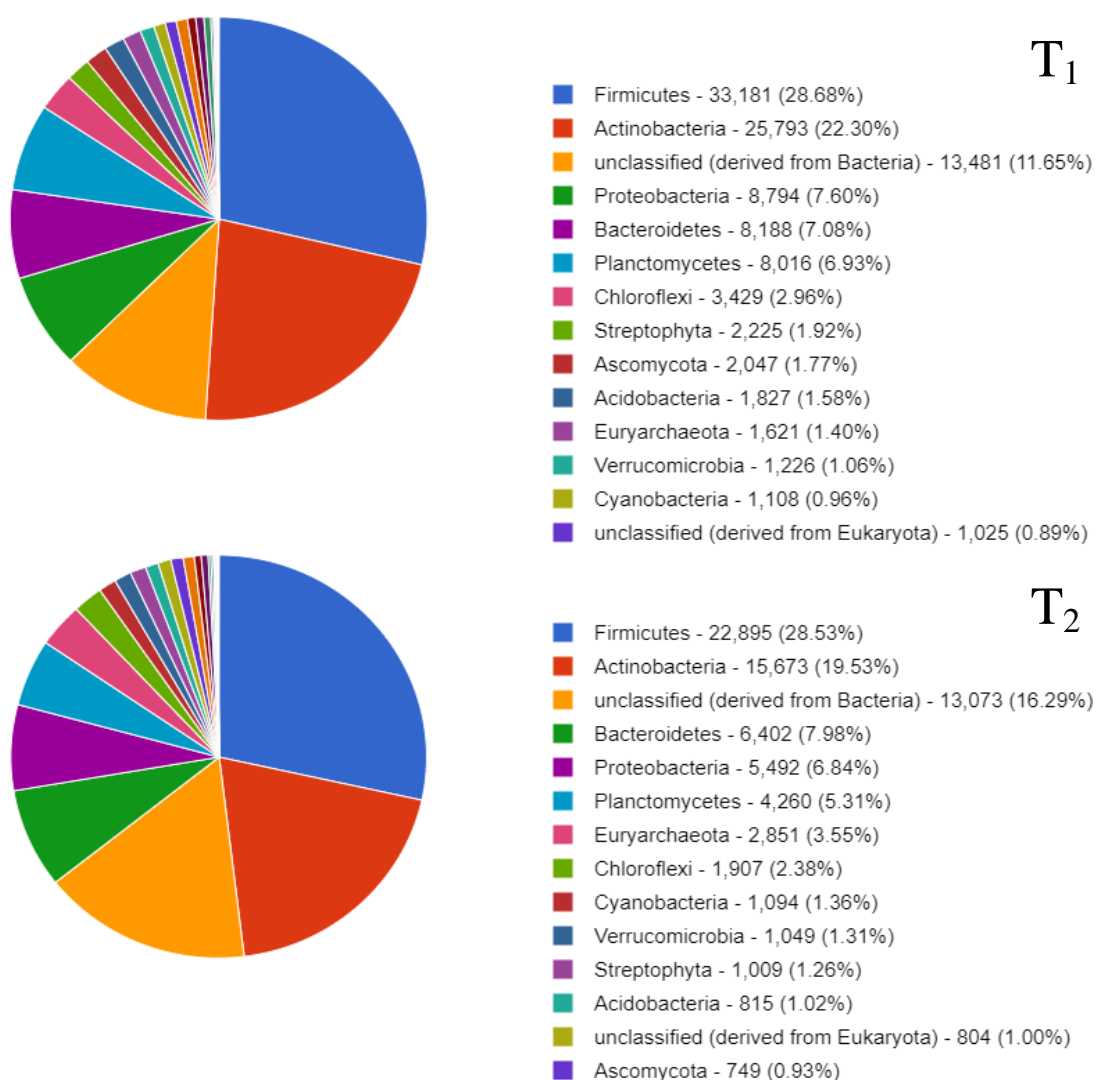


Fig. 4.24.2: Taxonomic distribution of the obtained soil metagenomes sequences at phylum level

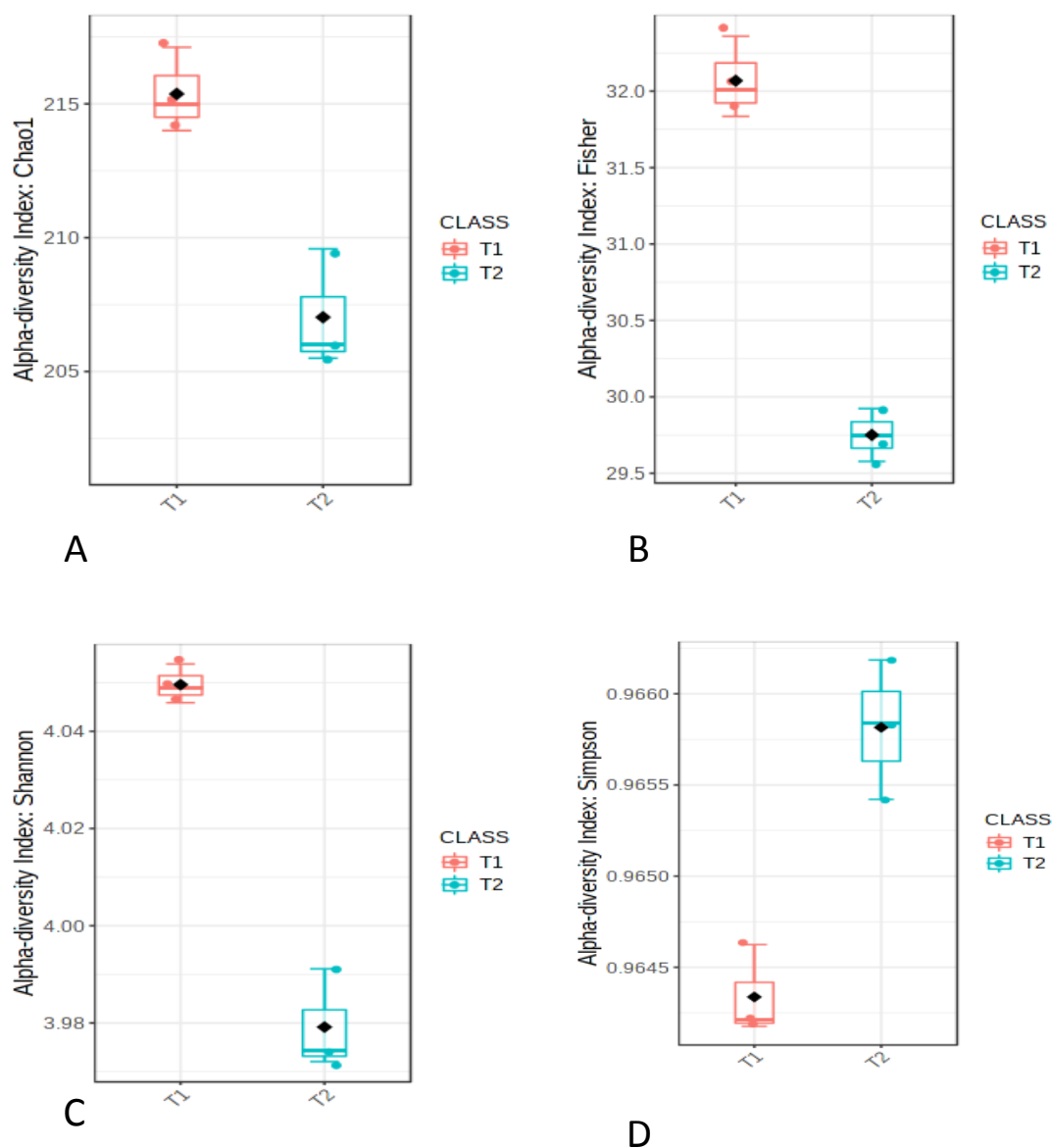


Fig. 4.24.3: Boxplot of Alpha-diversity indices. Alpha diversity indexes are composite indexes reflecting abundance and consistency. (A) Chao1 and (B) Fischer index (C) Shannon and (D) Simpson index reflect the diversity of species in samples. The greater the Chao1 or Fischer index, the higher the expected species richness of the microbiota; the smaller the Simpson index, the higher the diversity of the microbiota, and the greater the Shannon index, the higher the diversity of the microbiota. Boxes represent the interquartile range (IQR), and the horizontal line inside the box defines the median.

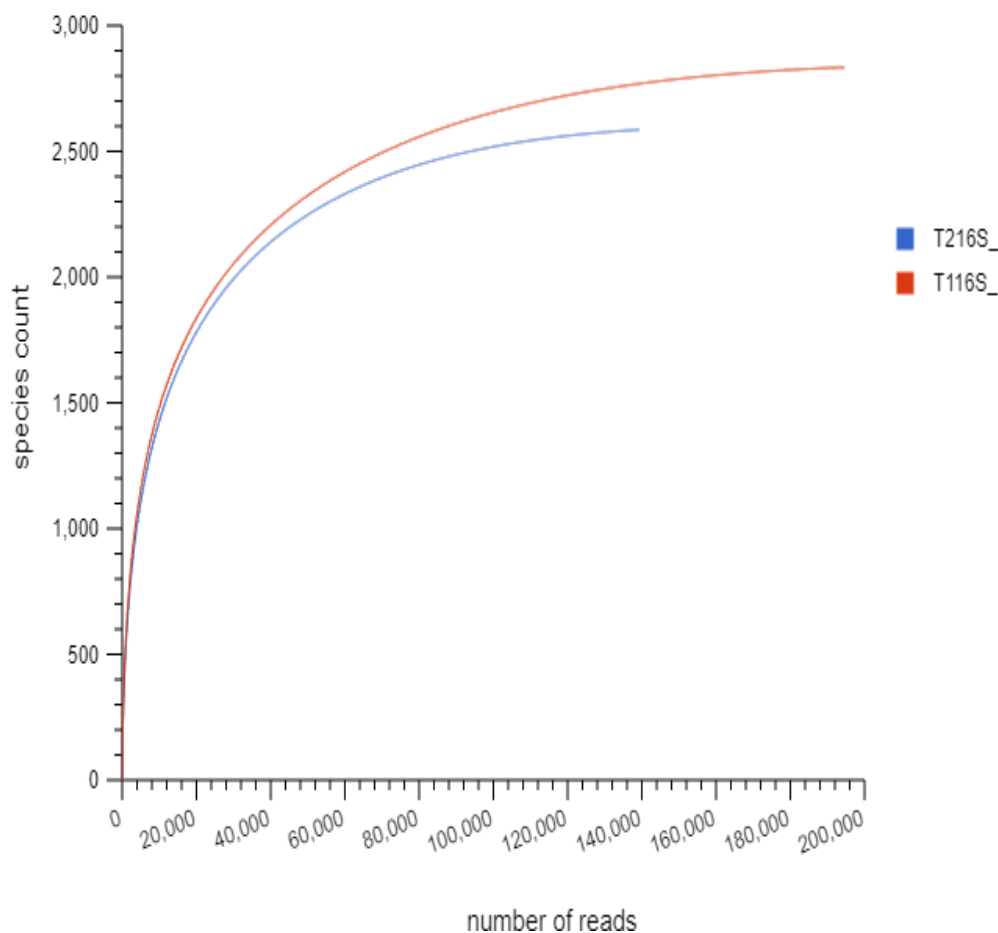


Fig. 4.24.4: Rarefaction curve of T₁ an T₂ sample.

4.4.6.3 Soil diversity indices

Diversity indices are the major measures of sample diversity. The Alpha diversity indices for samples T₁ and T₂ include the species richness and evenness in the samples. The results of the diversity analysis in the samples showed that T₁ had higher Chao, Shannon and Simpson indices, indicating higher microbial diversity, than T₂. Also, the Fisher index shows a very small difference in the evenness of the species in both samples. Moreover, the rarefaction curve clearly supports the above results by showing that T₁ sample has more reads and species count than T₂ sample. They reported higher soil diversity when amended with organic manure compared to control.

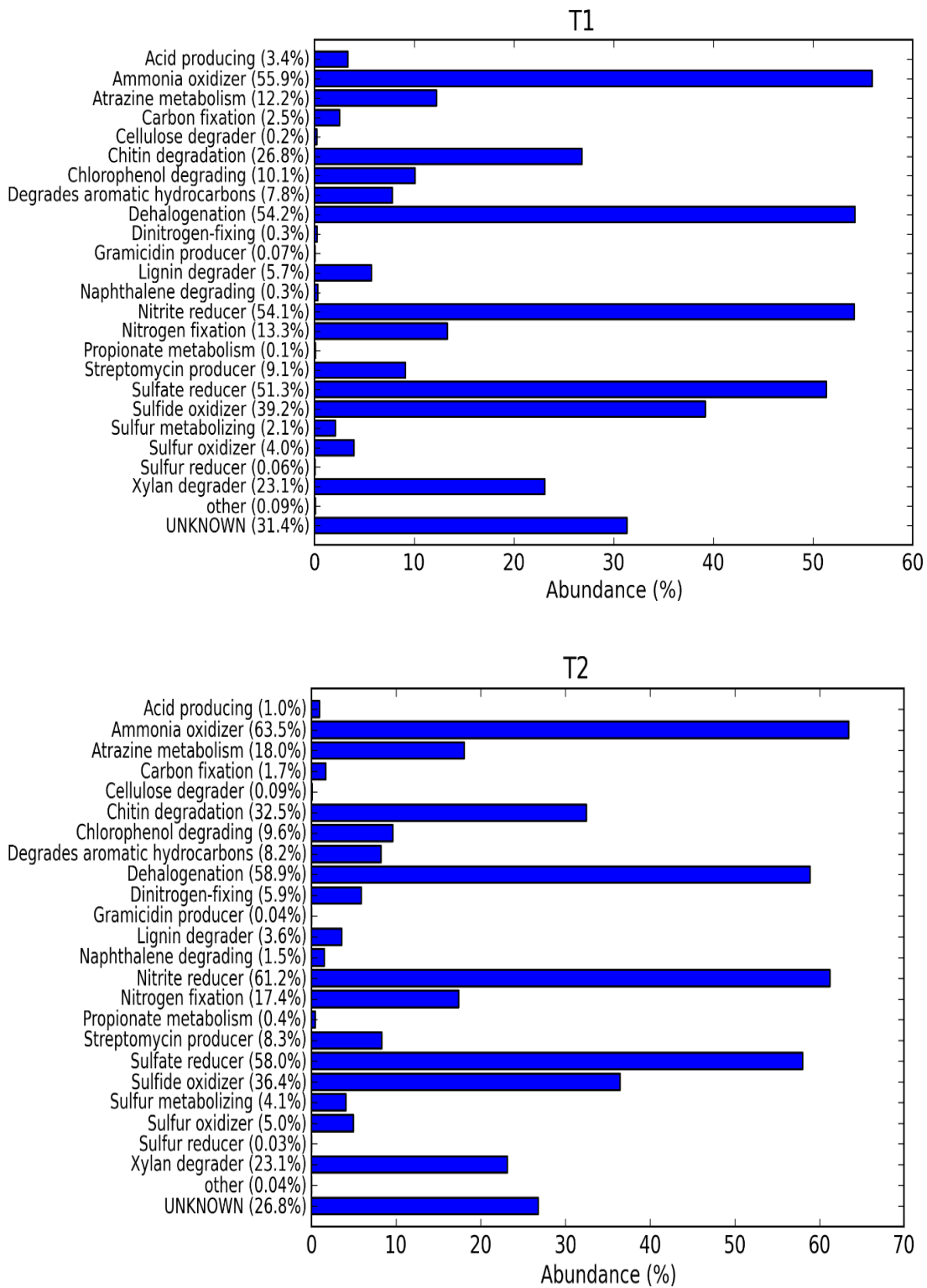


Fig. 4.24.5: Functional gene profile of soil metagenome predicted by Picrust analysis

4.4.6.4 Functional profile of soil metagenome

Soil of T₁ sample exhibited 3.4% of acid producing gene expression whereas soil of T₂ sample displayed only 1% of acid producing gene, which might be due to the lactic acid bacteria and PSB bacterial amendment in the soil, responsible for lowering the pH and harbouring the growth of acidophilic or acid tolerant microbes. Moreover, higher carbon fixation gene was also expressed in T₁ soil sample *i.e.*, 2.5%, which could be a concrete reason for the high organic carbon in the soil.

4.5 Cost of cultivation (₹)

In the present investigations, economic analysis of different treatments reveals that application of T₇ (6% Panchagavya + CBD*) gave maximum return over control and other treatments. This increase in monetary returns may be attributed to higher yield and improved quality of flowers which fetch more price in the market.

From the Table 4.24.2 clearly reflect that cost of cultivation is highest in T₁₁ 10% Panchagavya + CBD* and minimum cost of cultivation is in control (T₁).

The data obtained for the gross returns are depicted in Table 4. 24.3 and 4.24.4. During 2018-19, the maximum gross returns/ha were obtained in T₇ (₹. 17,96,880) followed by T₁₆ (₹. 16,56,720), T₄ (₹. 15,45,780) and T₁₀ (₹. 14,82,462). The minimum gross returns (₹. 9,88,080) were obtained in control. In the year 2019-20, maximum gross returns were obtained in T₇ (₹. 18,05,502) and minimum gross returns (₹. 9,84,720) were obtained in control.

In 2018-19, net returns of chrysanthemum given in Table 4.24.3 and 4.24.4 clearly indicated that maximum net returns were obtained in T₇ (₹. 12,55,915) which was followed by the net returns of T₁₆ (₹. 11,15,695) and minimum net returns were obtained in control. In the year 2019-20, maximum net returns were obtained in T₇ (₹. 12,64,537) which was followed by T₁₆ with net returns of (₹. 10,92,535) and minimum net returns were obtained in control.

The data regarding B:C ratio as influenced by different fertilizers doses are furnished in Table 4.24.3 and 4.24.4. During the year 2018-19, highest B:C ratio was

found in T₇ (3.32) which was nearly similar with the T₁₆ and T₄ with B:C ratio of 3.06:1 and 2.86:1, respectively. Lowest B:C ratio was obtained in T₁₁ (2.0:1). In 2019-20, the maximum B:C ratio was obtained in T₇ (3.34:1) which were followed by T₁₆(3.02:1) and T₄(2.88:1). However, the treatment at T₁ and T₁₃ has same B:C ratio *i.e.*, 2.17:1. The minimum B:C ratio (1.90) were obtained in T₁₁ that is 10% Panchagavya + CBD*.

The yield and quality of a crop are the factors that determine its economic value. The full expression of genetic potential, yield and quality of plants can be maintained for a long period of time if the growing conditions include the proper microclimate and nutrition. The acceptance of any package by farmers is heavily influenced by the comparative economics of a practise, as well as the feasibility of its implementation and the impact on yield and quality as an outcome. The above results are in conformity with the results of **Boraiah (2013)** who reported that 6 % spray of Panchagavya resulted in higher net returns and B:C ratio in capsicum **Gopal et al. (2017)** reported that 4% Panchagavya increased the gross returns, net returns and B:C ratio in blackgram.

Table 4.24.1: Cost of cultivation (₹/ha)

A. Cost of labour				
Sl. No.	Cost components	Quantity/No.	Cost/unit (₹)	Total cost (₹)
1. Land preparation				
	a. Ploughing	3 days	₹. 800 per day	₹. 2,400
	b. Levelling and bed preparation	60 man-days	₹. 200 per man-day	₹. 12,000
2.	Planting	40 man-days	₹. 200 per man-day	₹. 8,000
3. Intercultural operations				
	a. Pinching and disbudding and desuckering	50 man-days	₹. 200 per man-day	₹. 10,000
	b. Fertilizer application	30 man-days	₹. 200 per man-day	₹. 6,000
	c. Weeding	60 man-days	₹. 200 per man-day	₹. 12,000
	d. Irrigation	40 man-days	₹. 200 per man-day	₹. 8,000
	e. Staking	60 man-days	₹. 200 per man-day	₹. 12,000
	f. Plant protection spray	40 man-days	₹. 200 per man-day	₹. 8,000
4.	Harvesting	60 man-days	₹. 200 per man-day	₹. 12,000
Total labour charges				₹. 90,400
B. Material cost				
Sl. No.	Cost components	Quantity/No	Cost/unit (₹)	Total cost (₹)
1.	Chrysanthemum cuttings	62,500	₹. 5 per cutting	₹. 3,12,500
2.	Organic fertilizers			
	a. Panchagavya	50 litres	₹. 30/litre	₹. 1500
	b. Jivamrita	100 litres	₹. 4/litre	₹. 400
	c. Vermicompost	12305 kg	₹. 5/kg	₹. 61,525
	d. FYM	37500 kg	₹. 120/quintal	₹. 45000
	e. Biofertilizers (Azotobacter, Azospirillum, PSB, Potash bacteria)	15 kg	₹. 50/kg	₹. 750
	f. VAM	1250 kg	₹. 20/kg	₹. 25,000
3.	Plant protection chemicals (Neem oil)	15 litres	₹. 350/litre	₹. 5250
	Total cost			₹. 451925 + 90,400 = ₹. 542325

Table 4.24.2: Total cost of cultivation in each treatment

Treatments	Combinations	Cost of organic manures	Cost of labour	Material cost	Total cost of treatment ₹ ha ⁻¹
T ₁	Control	-	90,400	362,750	4,53,150
T ₂	1% Panchagavya + CBD*	90	90,400	450025	5,40,515
T ₃	2% Panchagavya + CBD*	180	90,400	450025	5,40,605
T ₄	3% Panchagavya + CBD*	270	90,400	450025	5,40,695
T ₅	4% Panchagavya + CBD*	360	90,400	450025	5,40,785
T ₆	5% Panchagavya + CBD*	450	90,400	450025	5,40,875
T ₇	6% Panchagavya + CBD*	540	90,400	450025	5,40,965
T ₈	7% Panchagavya + CBD*	630	90,400	450025	5,41,055
T ₉	8% Panchagavya + CBD*	720	90,400	450025	5,41,145
T ₁₀	9% Panchagavya + CBD*	810	90,400	450025	5,41,235
T ₁₁	10% Panchagavya + CBD*	900	90,400	450025	5,41,325
T ₁₂	10% Jivamrita + CBD*	120	90,400	450025	5,40,545
T ₁₃	20% Jivamrita + CBD*	240	90,400	450025	5,40,665
T ₁₄	30% Jivamrita + CBD*	360	90,400	450025	5,40,785
T ₁₅	40% Jivamrita + CBD*	480	90,400	450025	5,40,905
T ₁₆	50% Jivamrita + CBD*	600	90,400	450025	5,41,025

Table 4.24.3: Effect of organic and biodynamic manures on gross returns, net returns and B:C ratio of chrysanthemum during the year 2018-19

Treatments	Combinations	Total cost of treatment ₹ ha ⁻¹	No. of cut flowers/ha ('000 Nos.) in 2018-19	Sale rate (Rs / stem)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	Benefit cost ratio
T ₁	Control	4,53,150	164.68	6/ stem	9,88,080	5,34,930	2.18
T ₂	1% Panchagavya + CBD*	5,40,515	206.92	6/ stem	12,41,520	7,01,005	2.30
T ₃	2% Panchagavya + CBD*	5,40,605	218.92	6/ stem	13,13,520	7,72,915	2.43
T ₄	3% Panchagavya + CBD*	5,40,695	257.63	6/ stem	15,45,780	10,05,085	2.86
T ₅	4% Panchagavya + CBD*	5,40,785	224.68	6/ stem	13,48,080	8,07,295	2.49
T ₆	5% Panchagavya + CBD*	5,40,875	194.517	6/ stem	11,67,102	6,26,227	2.16
T ₇	6% Panchagavya + CBD*	5,40,965	299.48	6/ stem	17,96,880	12,55,915	3.32
T ₈	7% Panchagavya + CBD*	5,41,055	195.21	6/ stem	11,71,260	6,30,205	2.16
T ₉	8% Panchagavya + CBD*	5,41,145	247.077	6/ stem	14,82,462	9,41,317	2.74
T ₁₀	9% Panchagavya + CBD*	5,41,235	229.88	6/ stem	13,79,280	8,38,045	2.55
T ₁₁	10% Panchagavya + CBD*	5,41,325	180.213	6/ stem	10,81,278	5,39,953	2.00
T ₁₂	10% Jivamrita + CBD*	5,40,545	210.52	6/ stem	12,63,120	7,22,575	2.34
T ₁₃	20% Jivamrita + CBD*	5,40,665	192.92	6/ stem	11,57,520	6,16,855	2.14
T ₁₄	30% Jivamrita + CBD*	5,40,785	218.52	6/ stem	13,11,120	7,70,335	2.42
T ₁₅	40% Jivamrita + CBD*	5,40,905	217.07	6/ stem	13,02,420	7,61,515	2.41
T ₁₆	50% Jivamrita + CBD*	5,41,025	276.12	6/ stem	16,56,720	11,15,695	3.06

Table 4.24.4: Effect of organic and biodynamic manures on gross returns, net returns and B:C ratio of chrysanthemum during the year 2019-20

Treatments	Combinations	Total cost of treatment ₹ ha ⁻¹	No. of cut flowers/ha ('000 Nos.) in 2018-19	Sale rate (₹/ stem)	Gross returns (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	Benefit cost ratio
T ₁	Control	4,53,150	164.12	6/ stem	984720	5,31,570	2.17
T ₂	1% Panchagavya + CBD*	5,40,515	209.26	6/ stem	1255560	7,15,045	2.32
T ₃	2% Panchagavya + CBD*	5,40,605	212.433	6/ stem	1274598	7,33,993	2.36
T ₄	3% Panchagavya + CBD*	5,40,695	259.2	6/ stem	1555200	10,14,505	2.88
T ₅	4% Panchagavya + CBD*	5,40,785	221.62	6/ stem	1329720	7,88,935	2.46
T ₆	5% Panchagavya + CBD*	5,40,875	192.827	6/ stem	1156962	6,16,087	2.14
T ₇	6% Panchagavya + CBD*	5,40,965	300.917	6/ stem	1805502	12,64,537	3.34
T ₈	7% Panchagavya + CBD*	5,41,055	198.41	6/ stem	1190460	6,49,405	2.20
T ₉	8% Panchagavya + CBD*	5,41,145	249.88	6/ stem	1499280	9,58,135	2.77
T ₁₀	9% Panchagavya + CBD*	5,41,235	237.203	6/ stem	1423218	8,81,983	2.63
T ₁₁	10% Panchagavya + CBD*	5,41,325	171.24	6/ stem	1027440	4,86,115	1.90
T ₁₂	10% Jivamrita + CBD*	5,40,545	206.41	6/ stem	1238460	6,97,915	2.29
T ₁₃	20% Jivamrita + CBD*	5,40,665	195.6	6/ stem	1173600	6,32,935	2.17
T ₁₄	30% Jivamrita + CBD*	5,40,785	225.72	6/ stem	1354320	8,13,535	2.50
T ₁₅	40% Jivamrita + CBD*	5,40,905	209.32	6/ stem	1255920	7,15,015	2.32
T ₁₆	50% Jivamrita + CBD*	5,41,025	272.26	6/ stem	1633560	10,92,535	3.02



*Summary
and
Conclusions*



The present investigation on “**Growth, flowering and post-harvest life of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Thai Chen Queen in response to organic and biodynamic manures**” was carried out at Model Floriculture Center, G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) during the year 2018-19 and 2019-20. The experiment was laid out in RBD with 16 treatments, replicated thrice.

Objectives:

- To study the effect of organic manures and biodynamic amendments on vegetative growth and flowering in chrysanthemum cv. Thai Chen Queen
- To evaluate the influence of organic manures and biodynamic amendments application on postharvest life and economics (cost of cultivation) of chrysanthemum cv. Thai Chen Queen
- To determine the influence of organic manures and biodynamic amendments on soil nutrient status (N, P and K), microbial count (fungi, bacteria and actinomyces) and metagenomic analysis of best treatment.

The salient findings of the investigation are summarized below:

1. Maximum plant height of 36, 46.8 and 52.6 cm in the year 2018-19 and 35.2, 45.6 and 50.8 during 2019-20 at 30, 60 and 90 days after planting was observed in T₇ and minimum (23.8, 32.6 and 37.6 cm) in the year 2018-19 and 2019-20 (21.5, 31.4 and 33.7 cm) was measured in control in both years, respectively.
2. During 2018-19 and 2019-20, the maximum average plant spread (38.1 and 35.8 cm) was observed in T₇ and minimum (18.6 and 17.5 cm) was recorded in control, respectively.
3. The highest No. of branches in the year 2018-19 and 2019-20 were recorded in the treatment T₇ *i.e.*, 6.7 and 7.2 and minimum (2.7 and 3.2) recorded in the control T₁ during both the years, respectively.

4. The maximum branch length (15.8 and 15.3 cm) was recorded in T₇ in both years, and the minimum branch length (9.6 and 8.5 cm) was recorded in the control T₁ during both years, respectively.
5. Chlorophyll content of leaf was observed highest in treatment T₇ *i.e.*, 6 % Panchagavya + CBD*. The values of content recorded for chlorophyll a during 2018-19 and 2019-20 is (1.64, 1.63 mg at 30 days 1.33, 1.34 mg at 60 days and 0.95, 0.93 mg at 90 days). The values of content recorded for chlorophyll b during 2018-19 and 2019-20 is (0.40, 0.41 mg at 30 days 0.27, 0.28 at 60 days and 0.19, 0.20 at 90 days). Total chlorophyll content during 2018-19 and 2019-20 was (1.92, 1.95 at 30 days 1.74, 1.74 at 60 days and 1.14 and 1.16 at 90 days).
6. Days to first bud initiation (45 and 44 days) were recorded first in the treatment (T₇) 6% Panchagavya + CBD* and maximum no. of days for first bud initiation were recorded in the control T₁ during both the years.
7. Bud diameter of chrysanthemum was maximum in the treatment (T₇) 6% Panchagavya + CBD* *i.e.*, 2.55 and 2.53 cm during the year 2018-19 and 2019-20. Minimum bud diameter (0.83 and 0.81) was recorded in the control T₁ in both the years.
8. Application of 6% Panchagavya + CBD* produced maximum no. of buds (42, 38) during the year 2018-19 and 2019-20, respectively. During both the years, less no. of buds was observed in the control T₁.
9. Highest no. of cut flowers per plant 7.46 during 2018-19 and 7.52 during 2019-20 were counted in the treatment T₇ (6% Panchagavya + CBD*) and minimum no. of cut flowers were obtained in the control T₁ during both the years.
10. Larger flower diameter was recorded in the treatment T₇ (6% Panchagavya + CBD*) with value of 12.27 and 11.80 cm, respectively for both years
11. Earliest flowering (52.3 and 51.0 days) was seen in the treatment T₇ (6% Panchagavya + CBD*) during both years, respectively.

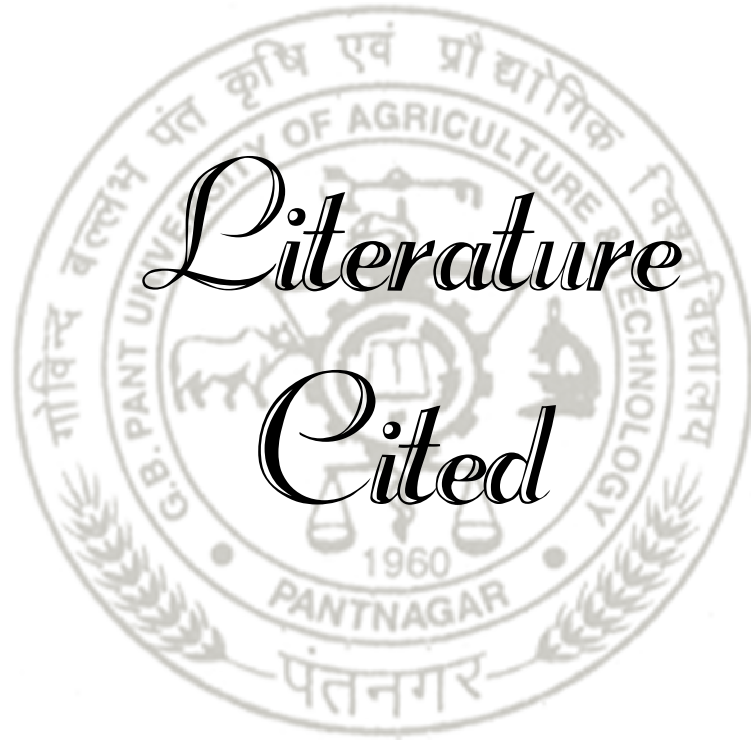
12. No. of cut flowers/ha ('000 Nos.) were highest in plants treated with 6% Panchagavya + CBD* *i.e.*, T₇ with the value of 298.5 and 300.9 ('000 Nos.) during both the years, respectively.
13. Average flower weight was recorded maximum (14.6 and 14.2 gm) in the plants treated with 6% Panchagavya + CBD* *i.e.*, T₇ and minimum flower weight was recorded in the control plants during both the years.
14. Chrysanthemum bloomed for a longer period with the combined application of 6% Panchagavya + CBD* for year 2018-19 and 2019-20 with a duration of 35 and 36 days, respectively.
15. Longer flower stalk length was observed in the treatment 6% Panchagavya + CBD* *i.e.*, T₇ with the values of 24.20 and 25.60 cm, respectively for both years.
16. Stem diameter was also obtained greater (36 and 35.4 mm) in the treatment (T₇) 6% Panchagavya + CBD* for both years, respectively.
17. Days taken from colour showing stage to harvesting of flowers (26 and 25 days) during the year 2018-19 and 2019-20 were minimum in the treatment (T₇) 6% Panchagavya + CBD* for both years, respectively.
18. In post- harvest studies, maximum initial weight of flower at harvesting stage (28.2 and 32.1 g) was recorded in the treatment (T₇) 6% Panchagavya + CBD* for both years, respectively.
19. Maximum final weight of flower in vase (18.4 g and 18.3 g) was found in treatment (T₇) 6% Panchagavya + CBD* in the year 2018-19 and 2019-20, respectively.
20. Under the post-harvest attributes, maximum initial diameter of flower at harvesting stage (11.2 and 10.7 cm) for both years was recorded with the application of 6% Panchagavya + CBD* for both years, respectively.
21. Final diameter of flower in vase (13.3 and 12.9 cm) was superior in the treatment (T₇) 6% Panchagavya + CBD* for both years, respectively.

22. Percentage increase in flower diameter (2.0 and 2.2 cm) was found with the application of 6% Panchagavya + CBD* during both year of investigation.
23. The maximum amount of water (65 and 63 mL) absorbed by flower stem in the vase was measured in the treatment (T₇) 6% Panchagavya + CBD* for both years, respectively.
24. Like other traits, superior vase life was observed in treatment (T₇) 6% Panchagavya + CBD*. The values of vase life were recorded as 23.4 days (2018-19) and 22.6 days (2019-20).
25. Different organic and biodynamic manures treatments influenced the soil pH and electrical conductivity significantly over control. However, pH was recorded minimum (6.7) in treatment (T₇) 6% Panchagavya + CBD* in the year 2018-19 and it decreased to 6.5 in the year 2019-20. electrical conductivity recorded with a range of 0.80 and 0.78 (mS/m) in 2018-19 and 2019-20, respectively.
26. Highest soil organic carbon content (1.63 and 1.62%) was recorded in the with the application of 6% Panchagavya + CBD* for both years, respectively.
27. Maximum available soil nitrogen (kg ha⁻¹) (288.3 and 284.3 kg ha⁻¹), phosphorous (24.8 and 25.4 kg ha⁻¹) and potassium (214.6 and 213.6 kg ha⁻¹) was recorded with the application of 6% Panchagavya + CBD* for both years, respectively.
28. The greater bacterial population of the rhizosphere of the plot (290 x 10⁵, 288 x 10⁵ CFU g⁻¹) was found in the treatment 6% Panchagavya + CBD* for both years, respectively.
29. The soil contained maximum population of fungi in the plots treated with 6% Panchagavya + CBD* (142 x 10⁵, 140 x 10⁵ CFU g⁻¹) that was significant with other treatments.
30. Higher population of actinomycetes (147, 146 x 10⁵ CFU g⁻¹) were seen during both years, respectively in the treatment 6% Panchagavya + CBD*.

31. Maximum N-fixers ($74, 71 \times 10^4$ CFU g^{-1}) and P solubilizers ($163, 160 \times 10^3$ CFU g^{-1}) were recorded with the application 6% Panchagavya + CBD* for both years, respectively.
32. Soil metagenomic analysis revealed that soil applied with the 6% Panchagavya + CBD* has significant effect on soil microbial diversity and their metabolic activity. Taxonomic distribution is high in population density of major taxa and diversity indices is being more diverse in the 6% Panchagavya + CBD*.
33. Cost of cultivation was maximum in T₁₁ *i.e.*, 10 % Panchagavya + CBD* (₹. 5,41,325) and minimum is in control T₁ (₹. 4,53,150).
34. Gross returns were maximum in T₇ (₹. 17,96,880) during the year 2018-19 and (₹. 18,05,502) in the year 2019-20 with the same treatment.
35. Net returns of the treatments were maximum (₹. 12,55,915 and ₹. 12,64,537) in treatment with the application of 6% Panchagavya + CBD for both years, respectively.
36. B:C ratio from all the treatments was recorded highest (3.32:1 and 3.34:1) in the treatment applied with 6% Panchagavya + CBD* during the year 2018-19 and 2019-20, respectively.

Conclusion

Based on the results, it can be concluded that a combination of organic and biodynamic manures (6% Panchagavya + CBD) has been shown to be a sustainable tool for enhancing growth, flowering, post-harvest life and soil microbial health in chrysanthemum cv. Thai Chen Queen. This treatment combination is suitable for organic chrysanthemum cultivation for high-quality cut flowers in a profitable and sustainable manner.



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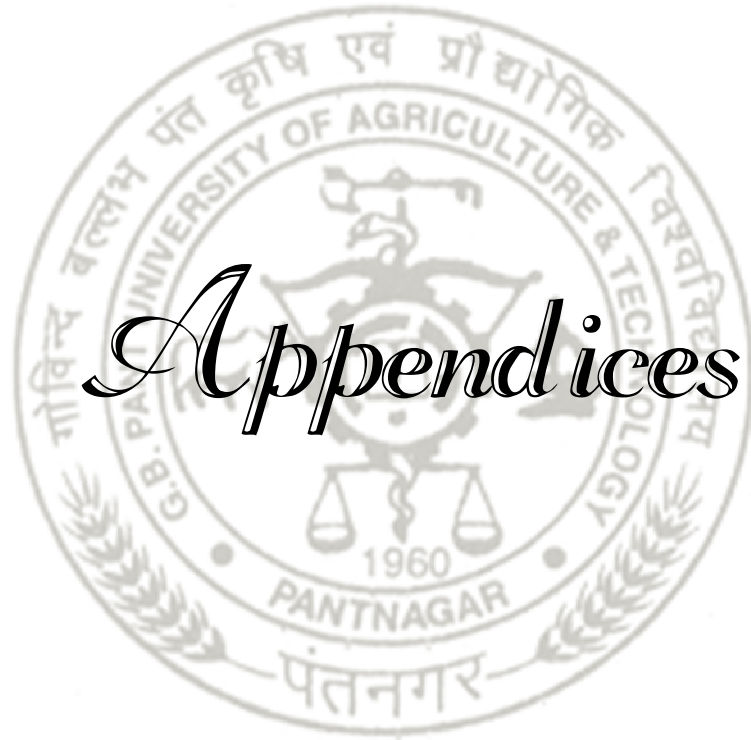
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Appendices



APPENDIX

Appendix I (a)

Standard Meteorological week's average weather data of season 2018-19

Month	Date	Year	Metro week No.	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	No. of rainy days	Sun shine Hrs.	Wind Velocity (Km/hr)	Evap. (mm)
				Max.	Min.	7-12 am	14-12 pm					
Jun-Jul	25-01	2018	26	35.9	26.6	80.7	67.7	18.2	1	6.4	7.5	7.3
Jul	02-08	2018	27	32.6	25.4	90.0	70.0	180.8	3	6	3.5	5.6
Jul	09-15	2018	28	32.5	26.0	88.0	78.4	173.2	3	3.1	6.1	4.2
Jul	16-22	2018	29	33.3	26.9	82.1	73.1	79.6	2	6.7	3.7	6.6
Jul	23-29	2018	30	31.2	25.7	91.0	80.0	169.0	4	2.2	5.6	4.6
Jul-Aug	30-05	2018	31	29.7	24.1	93.6	84.0	218.1	6	1	2.2	3.5
Aug	06-12	2018	32	30.9	24.9	90.4	79.7	126.4	3	3.6	2.6	4.3
Aug	13-19	2018	33	31.9	26.1	89.0	71.7	73.4	1	4	1.5	3.3
Aug	20-26	2018	34	30.9	25.5	95.1	83.0	160.8	5	3.2	1.1	4.4
Aug-Sep	27-02	2018	35	30.7	25.5	92.4	81.0	86.8	3	2	3.3	2.7
Sep	03-09	2018	36	32.3	25.3	90.4	76.3	76.6	2	4.7	5.3	3.9
Sep	10-16	2018	37	31.9	24.3	93.0	77.6	15.6	2	5.6	6.1	3.9
Sep	17-23	2018	38	32.1	22.6	90.1	73.4	49.2	1	6.8	6.6	4
Sep	24-30	2018	39	30.4	22.0	91.3	69.7	80.6	1	4.6	5.4	3.1
Oct	01-07	2018	40	32.6	18.5	84.3	60.1	0.0	0	9.1	4.6	4
Oct	08-14	2018	41	30.9	17.1	82.7	61.4	2.6	0	7.3	4.7	3.5
Oct	15-21	2018	42	30.7	14.3	86.9	59.1	0.0	0	7.8	3.5	3.3
Oct	22-28	2018	43	29.6	12.0	90.4	50.7	0.0	0	8.3	3.4	3.1
Oct-Nov	29-04	2018	44	29.9	13.7	87.7	54.3	4.2	1	7.1	3.2	2.7
Nov	05-11	2018	45	27.5	11.7	93.9	54.0	0.0	0	7.7	2.8	2.4
Nov	12-18	2018	46	26.5	11.8	93.3	63.1	0.0	0	6.5	2.3	2.2
Nov	19-25	2018	47	26.3	10.5	93.4	54.3	0.0	0	7.7	1.8	2.6
Nov-Dec	26-02	2018	48	26.4	10.7	94.6	60.6	0.0	0	6.4	1.9	2.3
Dec	03-09	2018	49	23.8	7.8	92.6	61.0	0.0	0	6.2	1.8	2
Dec	10-16	2018	50	22.6	6.6	94.6	60.4	0.8	0	6.3	1.9	2
Dec	17-23	2018	51	22.5	5.0	96.6	50.7	0.0	0	6.8	2	1.9
Jan	01-07	2019	1	21.3	6.1	91	60	0	0	6	NR	1.6
Jan	08-14	2019	2	21.6	5.7	94	57	0	0	5.7	NR	1.7
Jan	15-21	2019	3	21.7	5.7	93	53	0	0	6.1	1.2	1.8
Jan	22-28	2019	4	20.5	8.6	88	50	14.2	1	3.8	4.3	2.1

Appendix I (b)

Standard Meteorological week's average weather data of season 2019-20

Month	Date	Year	Metereo week No.	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	No. of rainy days	Sun shine Hrs.	Wind Velocity (Km/hr)	Evap. (mm)
				Max.	Min.	7-12 am	14-12 pm					
Jun-Jul	25-01	2019	26	34.6	25.6	76.9	54.4	153	1	8.5	5	7.2
Jul	02-08	2019	27	33.9	26.1	79.1	68.6	30.8	3	4.7	4.7	5.2
Jul	09-15	2019	28	31.0	25.3	94.6	75.6	144.9	5	1.5	5	4.2
Jul	16-22	2019	29	32.7	25.7	84.3	64.3	41.2	1	5.4	3	4.2
Jul	23-29	2019	30	32.4	26.5	84.9	71.0	16.8	3	3.8	6.7	4.6
Jul-Aug	30-05	2019	31	33.3	26.0	88.1	67.4	108.2	4	4.8	5	4.9
Aug	06-12	2019	32	32.7	25.8	88.1	70.1	116.5	3	5.1	3.8	4.7
Aug	13-19	2019	33	32.0	25.4	89.3	74.1	51.2	4	5.2	5.8	4.8
Aug	20-26	2019	34	32.3	24.7	89.9	65.6	37.8	1	5.3	2.4	4.1
Aug-Sep	27-02	2019	35	33.8	25.7	85.6	66.1	174.6	2	6.1	1.9	4.5
Sep	03-09	2019	36	33.1	25.3	90.0	72.0	112.2	2	5.8	3.5	4.3
Sep	10-16	2019	37	33.1	25.7	89.4	69.9	7.8	1	5.5	3.5	4.3
Sep	17-23	2019	38	32.1	22.4	88.1	62.4	14.2	2	7	4.5	3.6
Sep	24-30	2019	39	30.9	23.0	88.0	65.1	6.2	1	6.1	1.8	3.6
Oct	01-07	2019	40	30.9	21.3	92.3	57.3	0	0	7.6	1.9	2.9
Oct	08-14	2019	41	31.9	18.8	88.1	47.3	0	0	8.6	2.4	3.2
Oct	15-21	2019	42	31.0	18.0	85.7	49.6	0	0	6	1.2	2.7
Oct	22-28	2019	43	29.6	16.2	91.9	46.7	0	0	6.5	2.2	2.8
Oct-Nov	29-04	2019	44	29.2	17.1	89.4	57.1	0	0	1.2	2.4	2
Nov	05-11	2019	45	29.1	14.0	85.3	43.7	0	0	6	2.7	2.4
Nov	12-18	2019	46	29.0	13.3	91.4	44.3	0	0	6.6	3.2	2.2
Nov	19-25	2019	47	25.0	11.5	94.0	47.3	0	0	4.7	1.8	2.1
Nov-Dec	26-02	2019	48	25.6	11.5	91.6	54.0	29.2	1	6.3	3.5	2.6
Dec	03-09	2019	49	23.8	8.3	94.6	46.9	0	0	7.2	1.4	1.9
Dec	10-16	2019	50	20.8	9.8	94.3	62.0	79.8	2	5	4.6	3.2
Dec	17-23	2019	51	15.4	9.3	94.9	78.4	0	0	2.1	5.6	1.3
Jan	01-07	2020	1	20.1	7.5	92	60	11.4	2	5	2.1	2
Jan	08-14	2020	2	14.3	8.3	95	81	28.2	1	1.2	2.2	1.4
Jan	15-21	2020	3	18.1	9.9	95	79	48.1	2	3.3	1.2	1.7
Jan	22-28	2020	4	17.7	6.8	93	71	0.7	0	4.2	1.8	1.7

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List of papers presented in conference/seminar during degree programme :

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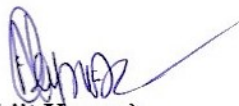
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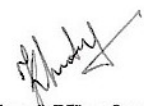

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ABSTRACT

The present investigation was carried out at Model Floriculture Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during 2018-19 and 2019-20 to assess the impact of organic and biodynamic manures on growth, flowering and post-harvest life of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cv. Thai Chen Queen. Therefore, current investigation was setup with an experiment laid out in RBD with sixteen treatments replicated thrice. Different combinations of biodynamic manures (Panchagavya and Jivamrita) were used in this experiment ranging from 1-10% concentrations levels of Panchagavya and 10-50% concentrations levels of Jivamrita along with common basal dose of biofertilizers which includes *Azotobacter*, *Azospirillum*, Phosphorous solubilizing bacteria and Potash bacteria along with vermicompost and farmyard manure. Multiple observations were recorded on vegetative growth, flowering and yield parameters, post-harvest attributes of cut flowers and soil nutrient and microbiological attributes. Results demonstrated that during both the years, the treatment T₇ (6% Panchagavya + common basal dose) was found most superior than other treatments and resulted in higher plant height (35.6, 46.2 and 51.7 cm) at 30, 60 and 90 days after planting, plant spread (37.2 cm), higher number of branches (6.9), longest length of branches (15.6 cm) and maximum chlorophyll content (a, b and total). This treatment also exhibited with improved flowering traits like days to first bud initiation (45 days), bud diameter (2.54 cm), No. of buds/plant (40), No. of cut flowers/plant (7.49), flower diameter (12.04 cm), days to flowering (51.7 days), No. of cut flowers/ha ('000 Nos.) (299.5), flower weight (14.4 g), duration of flowering (36 days), length of flower stalk (24.90), stem diameter (35.70 mm), days taken from colour showing stage to harvesting stage (25.5 days). The significant differences were obtained in post-harvest attributes in the treatment T₇ (6% Panchagavya + common basal dose) which includes initial weight after harvesting from field (30.1 g), final flower weight (16.9 g) after keeping in vase solution, initial flower diameter in vase solution (10.9 cm), final flower diameter (13.1 cm) in vase solution, increase in flower diameter (2.1 cm), water uptake by flowers (64.0 mL) and vase life (23 days) of cut flowers. Effect of biodynamic manures on soil physico-chemical properties, nutrient status N, P and K (286.3, 25.1 and 214.1 kg h⁻¹) and microbiological attributes like bacterial (289 x 10⁵), fungal (140 x 10⁵) and actinomycetes (146 x 10⁵) populations along with N-fixers (72.5 x 10⁴) and P-solubilizers (161.5 x 10³) were also enriched with the treatment of T₇ (6% Panchagavya + common basal dose). Soil metagenomic analysis revealed that beds applied with the 6% Panchagavya + common basal dose has favoured the acid producing and nutrient mobilizing microbial diversity, which ultimately supported the plant growth, physiology and productivity of chrysanthemum. Moreover, among all the treatments, gross returns, net returns and B:C ratio (3.32:1 and 3.34:1) were also recorded as highest in the same treatment applied with 6% Panchagavya + common basal dose during both the years 2018-19 and 2019-20, respectively. Hence, after some field trial testing this treatment could be used by the farmers to grow chrysanthemum commercially in a sustainable, economic, ecofriendly manner.



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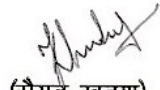

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पृष्ठ संख्या	: 158	सलाहकार	: डाण अजीत कुमार

सारांश

वर्तमान जॉच आदर्श पुष्पविज्ञान केन्द्र गोविन्द बल्लभ पन्त कृषि एवं प्रौद्योगिक विश्वविद्यालय, पन्तनगर में 2018-19 और 2019-20 के दौरान जैविक और बायोडायनामिक खाद का प्रभाव गुलदाऊदी (डेंड्रान्थेमा ग्रैडिपलोरा)सी.वी. थाईचीन क्वीन के विकास, फूल और कटाई के बाद के जीवन का अध्ययन करने के लिए किया गया था। इसलिए वर्तमान प्रयोग को आर.बी.डी मे तीन रैप्लिकेशन के साथ बार दोहराया गया, तथा सोलह उपचारों के साथ किया गया था। इस प्रयोग में बायोडायनामिक खाद के विभिन्न सयोजनो जैसे पंचगव्य और जीवामृत का उपयोग पंचगव्य के 1-10 प्रतिशत सांद्रता स्तर और जीवामृत के 10-50 प्रतिशत सांद्रता स्तर के साथ जैव उर्वरकों की सामान्य बेसल खुराक के साथ किया गया है। जिसमें एजोटोवेक्टर एजोस्परिलम फॉस्फोरस धुलनशील बैक्टीरिया एवं पौटाश बैक्टीरिया शामिल किया गया था। वर्मी कम्पोस्ट और फार्मयार्ड खाद के साथ बैक्टीरिया का उपयोग किया गया। वानस्पतिक वृद्धि, पुष्पन और उपज के मापदंडों एवं कटे हुये फूलों की कटाई के बाद की विशेषता और मिट्टी के पोषक तत्व एवं सूक्ष्मजीव विज्ञानी विशेषताओं पर अवलोकन दर्ज किये गये थे। जॉच के दोनो वर्षों के परिणामों से पता चला है कि उपचार टी7 (6 प्रतिशत पंचगव्य एवं सी.बी.डी.*) अन्य उपचारों की तुलना में सबसे बेहतर पाया गया और इसके परिणाम स्वरूप उच्च पौधों की ऊचाई (35.6, 46.2 और 51.7 cm) रॉपण के 30वे, 60वे, 90वे दिन पौधों का फैलाव (37.2 cm), शाखाओं की अधिक संख्या (6.9) एवं शाखाओं की लम्बाई (15.6 cm) क्लोरोफिल सामग्री (ए, बी एवं कुल) पाई गयी। इसी उपचार में फूल आने के पहले के दिन (45 दिन) से लेकर कली का व्यास (2.54), कलियों की संख्या प्रति पौधा (40), कट पुष्प प्रति पौधा (7.49), पुष्प व्यास (12.04), खिलने के दिन (51.7), कट पुष्पों की संख्या प्रति हैक्टयर (299.5) (*000 Nos.), पुष्प भार (14.4), पुष्प खिलने का अन्तर (दिनों में) (36) पुष्प तने की लम्बाई (24.90 cm) तने का व्यास (35.70 mm), पुष्प का रंग दिखने से लेकर पुष्प के कटान (25.5 days) में सुधार प्रदर्शित हुआ। उपचार टी 7 (6 प्रतिशत पंचगव्य एवं सी.बी.डी.*)मे कटाई के बाद की विशेषताओं मे महत्वपूर्ण अन्तर प्राप्त पाए गये थे। जिसमें खेत से कटाई के बाद प्रारम्भिक पुष्प भार (30.1 gm) एवं वास समाधान में रखने के बाद अन्तिम पुष्प भार (16.9 gm), फूलदान समाधान में प्रारम्भिक पुष्प व्यास (10.9 cm) एवं अन्तिम पुष्प व्यास (13.1 cm) शामिल हैं। फूलदान के धोल में पुष्प के व्यास में प्रतिशत वृद्धि (2.1 cm), पुष्पों द्वारा पानी लेने की क्षमता (64.0 mL) अधिक पायी गयी। मिट्टी पर बायोडायनामिक खाद का प्रभाव द्वारा मिट्टी के भौतिक-रसायनिक गुण, पौषक तत्व की स्थिति (286.3, 25.1, 214.1 एन.पी.के. किग्रा/हैक्टयर) और सुक्ष्म जीवविज्ञानी गुण जैसे बैक्टीरिया (289 x 10⁵), कवक (140 x 10⁵) और एक्टिनोमाइसेट्स (146 x 10⁵) आबादी के साथ-साथ एन-फिक्सर (72.5 x 10⁴) एवं पी-सॉल्युबिलाइजर्स (161.5 x 10³) इसी उपचार में उच्चतम मात्रा में पाए गये थे। मृदा मेटाजिनोमिक विश्लेषण से पता चला है कि 6 प्रतिशत पंचगव्य एवं सी.बी.डी. के साथ लगाए गए बेड में एसिड उत्पादन और पोषक तत्व जुटाने वाली सुक्ष्मजैविक विविधताको बढ़ावा दिया। जिससे अंततः पौधो कि वृद्धि, पादप शरीर कार्यिकी, गुलदाऊदी कि उत्पादन को बढ़ाया। इसके अलावा, सभी उपचारों में से, सकल रिटर्न, शुद्धता रिटर्न, और बी : सी अनुपात (3.32:1 और 3.34:1) भी इसी उपचार 6 प्रतिशत पंचगव्य एवं सी.बी.डी के साथ दोनों वर्षों (2018-2019 और 2019-20) में उच्चतम दर्ज किया गया था। इसलिए कुछ क्षेत्र परिक्षण के बाद, इसी उपचार कर किसानो द्वारा एक स्थाई, मितव्ययी, पर्यावरण अनुकूल से गुलदाऊदी को व्यावसिक रूप से उगाने में किया जा सकता है।


(अजीत कुमार)
सलाहकार


(सैयद खुदुश)
लेखक