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Effect of manures, soil recipes and PGPR on soil and plant quality parameters in bell pepper

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Abstract
The present investigation was aimed to understand the effect of Manures, Soil Recipes and PGPR and was carried out in research farm, Department of Soil Science and Water Management, DR YSPUHF Nauni-Solan. The experiment was carried out for two consecutive years 2016 and 2017 in mid hills conditions of Himachal Pradesh. Research trial comprised of 7 treatments with T_1 is 100% RDN (Recommended dose of nutrients) and from T_2 to T_7 there was 90, 80, 70, 60, 50, 40 % RDN with PGPR and Soil recipes i.e. Panchagavya, Jeevamrut and Amritpani. The results revealed that among soil physicochemical properties of soil, pH value ranged from 6.77 to 7.56 and EC values ranged from 0.58 dSm^{-1} to 0.79 dSm^{-1}. The maximum (1.19) value of fruit shape index was observed in treatment T_2 and minimum (0.91) in treatment T_7. The maximum TSS value was recorded under treatment T_6 (5.20 ºBrix) and lowest was recorded in treatment T_3 (4.02ºBrix). The maximum (4.12 mm) pericarp thickness was recorded in treatment T_5 and minimum (3.11 mm) pericarp thickness was recorded in treatment T_2. The longest (29 days) harvest duration was observed under treatment T_4 and the shortest (25.67 days) harvest duration was revealed in T_2. This leads to conclusion that there was no significant effect of manure, Soil recipes like Panchagavya, Jeevamrut and Amritpani and PGPR on soil pH, EC and on plant growth parameters like fruit shape index, Total soluble solids, pericarp thickness, harvest duration and days taken to flowering and first harvest.

Keywords: Soil recipes, PGPR, pH, EC, total soluble solids, harvest duration

Introduction
Capsicum annuum is an annual herb from Genus *Capsicum* and belongs to family Solanaceae. It is an important vegetable crop that is extensively growing in India. Unripe capsicum fruits are green in colour and turns, orange and yellow when ripe (Udoh *et al*. 2005) [17]. After commencement of green revolution, the crop productivity has elevated manifold to meet the need of ever growing population the world over and it has met needs of food but also has ill effects such as ecological degradation, high rate of pollution of air, water and soil which results in deterioration of overall health of living beings (Gupta and Gopal, 2001) [8]. Bell pepper is an enormous value crop and is exposed to unsystematic use of fertilizer and pesticides for high yield. Massive use of chemical fertilizer, pesticides and fungicides causes health hazards and environmental pollution apart from imparting resistance to pathogens and insects also the usage of synthetic fertilizers indiscriminately in an unbalanced manner has been shown to result in several problems like loss of fertility, soil health and multiple nutrient deficiencies and loss of microbial activities etc which ultimately resulting in reduced crop productivity and quality. Hence a natural balance needs to be maintained at all cost for existence of life and property. One of the approaches which are the alternative to conventional production system is organic approach (Subbarao *et al*. 2007) [14] also it is considered as an alternative for maintaining the sustainability in agriculture (Ramesh *et al*. 2005) [11]. The organic agriculture is a management system in which there is usage of off-farm inputs which further enhances health of agroecosystem (FAO, 1999) [7]. With the use of organic management practices, there is significant improvement in quality of soil which further includes bulk density, infiltration rate, water holding capacity, organic carbon and available NPK (Babalad *et al*. 2009) [2]. For crops, organic manures provide balanced source of nutrients and it has direct effect on plant growth (Laharia *et al*. 2013) [10].

Along with this, organic manures enrich the soil with organic matter and mineral matter (Ravusaheb *et al.* 2010) [12], and addition of this also stimulate the activity of soil micro-organisms (Darshana *et al*. 2012) [5]. Organic farming also helps in rejuvenating the degraded soil and ensures sustainability of crop production. There should be proper combination of various nutrient resources and their optimum utilization along with maintenance of soil productivity and ecology. The beneficial effect of combined application of chemical fertilizers with organic manures viz., Farm yard manure, vermicompost, bio fertilizers, Panchagavya and many more of such are universally known. Application of organic manures in general improves availability of micro nutrients like Zn, Fe, Mn and Cu. Therefore the present studies were carried out to study and to understand the effect of manures, various soil recipes and PGPR on fruit parameters and soil parameters under capsicum.

Materials and Methods

Site description

The study was carried out in mid hills of Himachal Pradesh and the experimental site lies in research farm of Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh. It is situated at 30º 52′ North latitude and 77º 11′ East longitude at an elevation of 1260 m above mean sea level having average slope of 7-8%.

Climate and weather conditions

The Experimental site lies in transition zone between subtropical and temperate climate. The area accompanied with a wide range of temperature i.e. 1°C (minimum) during winters to 37°C (maximum) during summers. Maximum rainfall in this area is received during mid-June to mid-September i.e. monsoon season.

Field Studies and Experimental Details

The field experiment was laid out in Randomized Block Design with seven treatments and three replications during 2017. Vermicompost and poultry manure, PGPR were sources of nutrients and Soil recipes like Panchagavya, Jeevamrut and Amritpani were also applied in according to treatments plots of size 2.40 m× 2.25 m. On nutrient basis, the recommended doses of nutrients were applied by using vermicompost and poultry manure in 50:50 ratio.

The treatments details are given as follow:

T_1:100 per cent RDN*

T_2:90 per cent+ PGPR + Soil recipes (Panchagavya, Jeevamrut and Amritpani each @ 5%)

T_3:80 per cent+ PGPR + Soil recipes (Panchagavya, Jeevamrut and Amritpani each @ 5%)

T_4:70 per cent + PGPR + Soil recipes (Panchagavya, Jeevamrut and Amritpani each @ 5%)

T_5:60 per cent + PGPR + Soil recipes (Panchagavya, Jeevamrut and Amritpani each @ 5%)

T_6:50 per cent + PGPR + Soil recipes (Panchagavya, Jeevamrut and Amritpani each @ 5%)

T_7:40 per cent+ PGPR + Soil recipes (Panchagavya, Jeevamrut and Amritpani each @ 5%)

RDN*= Recommended Doses of Nutrients

Plant growth parameters estimation

The data were recorded on five randomly selected plants for all the characters. During the course of random selection of plants, the border plants were excluded. Plant parameters like days taken to flowering, fruit shape index, TSS (°Brix), Pericarp thickness, number of days to first harvesting and harvest duration were determined. For estimating days taken to flowering, days were counted from the date of transplanting to the opening of the first flower on per plant basis and mean was worked out. For estimating fruit shape index, Polar and equatorial diameter of five randomly picked fruit was measured with digital vernier calliper after cutting the fruit from stem end to blossom end. Ratio of polar diameter to equatorial diameter was worked out to calculate fruit shape index. The TSS content in fruits was determined by Erma hand refractometer (0-32% range). The refractometer was calibrated with distilled water before use and then a few drops of juice were placed on the prism and the readings were recorded. The readings thus obtained were corrected for temperature variation to 20°C as per international temperature correlation table and expressed as degree Brix (A.O.A.C, 1980) [1]. In order to find pericarp thickness of fruit, five randomly picked fruit from each plot was worked out after cutting the fruits transversely. Measurement was taken with digital vernier caliper in millimeters. For calculating number of days from transplanting to first harvesting, mean number of days were worked out. Similarly for harvest duration, total numbers of days from first harvesting to final harvesting were counted and average value was expressed as harvest duration.

Physico-chemical parameters analysis

For estimating Soil Physico-chemical parameters, samples were collected from 0-15 cm soil depth and after harvesting of crop, soil samples from each plot were collected to find out the effect of different organic amendments on pH and EC, which is further determined in soil: water suspension (1:2) according to Jackson (1973) [9].

Results and Discussions

Effect of Manures, Soil recipes and PGPR on Plant growth parameters

The data shown in Table 1 concluded that the effect of manures, soil recipes and PGPR on days taken to flowering was found to be non- significant during both years of study and the maximum days taken to flowering (52.17) was observed in treatment T_7 and minimum (47.5) was observed in treatment T_3. These findings are similar with results of Thumar *et al*. (2013) [16] who found that days taken to 50% flowering did not vary significantly with the application of different organic inputs in African marigold (*Tagetus erecta* L.) cv. Pusa Narangi. Similarly, fruit shape index did not vary significantly by the application of different manures, soil recipes and PGPR however, the value of fruit shape index ranges from 0.91 to 1.19. The maximum (1.19) value of fruit shape index was observed in treatment T_2 and minimum (0.91) in treatment T_7. These results are in accordance with the findings of who investigated that by addition of different organic fertilizers in citrus cultivar, there was no significant effect on fruit shape index (Zhang *et al*. 2018) [18]. Also, in case of total soluble solids, an appraisal of data presented in Table 1 revealed that none of the tried treatment registered showed significant effects on Total Soluble Solids (TSS) of fruit during both the years of study. The value of TSS ranges from 4.02 ºBrix to 5.20 ºBrix. The maximum TSS value was recorded under treatment T_6 (5.20 ºBrix) and lowest was recorded in treatment T_3 (4.02 ºBrix). Similar findings were also observed by Del Amor (2007) [6], who found that total soluble solids did not vary significantly with the application

of different cultivation methods (organic, integrated and conventional farming) in bell pepper. In a similar way, a scrutiny of data presented in Table 1 showed that organic amendments had no significant effects on pericarp thickness and the value of pericarp thickness ranges from 3.11 mm to 4.12 mm. The maximum (4.12 mm) pericarp thickness was recorded in treatment T_5 and minimum (3.11 mm) pericarp thickness was recorded in treatment T_2. These results are similar with the observations of Del Amor (2007) [6], who found that pericarp thickness did not vary significantly with the application of different cultivation methods (organic, integrated and conventional farming) in capsicum. The data pertaining to number of days to first harvesting presented in Table 1 revealed that the application of different organic amendments had no significant effects on number of days to first harvest. These findings are in line with the observations of Thakur *et al*. (2013) [15] who found that days to first harvest did not vary significantly with the application of organic manures and biofertilizers in tomato. Also, the pattern of data presented in Table 1 showed that all the tried treatments showed non-significant effect on harvest duration and the harvesting duration ranges from 25.67 days to 29 days. The longest (29 days) harvest duration was observed under treatment T_4 and the shortest (25.67 days) harvest duration was revealed in T_2.

Table 1: Effect of Manures, Soil recipes and PGPR on plant quality parameters in Bell Pepper

	Days taken to flowering		Fruit Shape Index		TSS		Pericarp Thickness		No. of days to first harvesting		Harvest Duration	
T1	48.83		1.11		4.57		3.19		60.67		27.33	
T2	48.5		1.19		4.72		3.11		58.67		25.67	
T3	47.5		1.14		4.02		3.37		59.5		27.83	
T4	49.5		1.11		4.88		4.05		61.33		29.00	
T5	49		1.08		5.05		4.12		60.33		28.83	
T6	49		1.04		5.2		4.03		60.33		28.33	
T7	52.17		0.91		5.1		3.55		61.83		28.83	
Mean	49.21		1.08		4.79		3.63		60.38		27.98	
Source	**SE(m)±**	**CD**	**SE(m)±**	**CD**	**SE(m)±**	**CD**	**SE(m)±**	**CD**	**SE(m)±**	**CD**	**SE(m)±**	**CD**
T	0.88	NS	0.05	NS	0.24	NS	0.23	NS	0.64	NS	0.57	NS
Y	1.65	NS	0.09	NS	0.45	NS	0.43	NS	1.19	NS	1.07	NS
T×Y	2.33	NS	0.13	NS	0.64	NS	0.61	NS	1.68	NS	1.51	NS

Effect of Manures, Soil recipes and PGPR on Physico-chemical parameters of soil

Soil pH and Electrical conductivity (EC)

The data on soil pH and EC presented in Table 2 clearly revealed that none of the tried treatment has significant effect on pH and EC. The pH and EC values ranged from 6.77 to 7.56 & 0.58 dS m^{-1} to 0.79 dS m^{-1} respectively. These findings are similar with the findings of Badhulkar *et al*. (2000) [3], Selvi *et al.* (2004) [13] and Bajpai *et al.* (2006) [4] who reported that in some Physico-chemical properties of soil, only experimentation of long term may bring changes.

Table 2: Effect of Manures, Soil recipes and PGPR on soil parameters in Bell Pepper

	pH		EC	
T1	6.77		0.71	
T2	7.00		0.68	
T3	7.56		0.61	
T4	6.79		0.68	
T5	7.10		0.63	
T6	7.10		0.58	
T7	6.99		0.79	
Mean	7.04		0.67	
Source	SE(m)±	CD	SE(m)±	CD
T	0.19	NS	0.04	NS
Y	0.35	NS	0.08	NS
T×Y	0.50	NS	0.12	NS

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