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Effect of inorganic and biofertilizers on yield and yield attributes of papaya

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Abstract
The experiment was carried out to find out the Effect of inorganic and biofertilizers on growth of gynodioecious papaya. The treatment combinations involving ten levels of T^{-1} Recommended dose of NPK (RDF) i.e. 250: 250:250 g/plant/year, T^{-2} 100% RDF + PSB (50g/plant), T^{-3} 100% RDF + *Azospirillum* (50g/plant), T^{-4} 100% RDF + *Azotobactor* (50g/plant), T^{-5} 75% RDF + PSB (50g/plant) + *Azospirillum* (50g/plant), T^{-6} 75% RDF + PSB (50g/plant) + *Azotobactor* (50g/plant), T^{-7} 75% RDF + PSB (50g/plant) + *Azospirillum* (50g/plant) + *Azotobactor* (50g/plant), T^{-8} 50% RDF + PSB (50g/plant) + *Azotobactor* (50g/plant), T^{-9} 50% RDF + PSB (50g/plant) + *Azospirillum* (50g/plant) + *Azotobactor* (50g/plant), T^{-10} Farmer's Practices were given in Red Lady variety. Maximum Number of fruits per plant, Fruit weight (kg), Fruit yield (kg/plant), Fruit yield (t/ha), Fruit length (cm), Fruit width (cm), Thickness of pulp (cm), Length of fruit cavity (cm), Width of cavity (cm), Cavity index (%). were observed by the maximum at 180, 270 and 360 DAT were observed under the treatment T_7- 75% RDF + PSB (50g/plant) + *Azospirillumn* (50g/plant) +*Azotobactor* (50g/plant) at all the growth stages.

Keywords: Biofertilizers, inorganic, fruit, papaya

Introduction
Papaya (*Carica papaya* L) is a fruit found ample in tropical and sub-tropical regions. In India it is commonly known as Papita, pawpawa or True Melon. Papaya's country of origin is South American country Mexico. From there it reached other parts of the world. Now this crop is cultivated in Australia, Hawaii, Brazil, Malaysia, Burma, Philippines, Sri Lanka, India, South Africa, Thailand, Tropical America and all other tropical and sub-tropical countries. According to the data made available by NHB 2017, due to ideal climatic conditions in Andhra Pradesh the production of Papaya is excellent. However, in India Papaya is produced successfully all over the country round the year. According to the data available for the agricultural cycle year 2016-17 in India, around 136.1 thousand hectares of area is cultivated with Papaya which is around 2.10% of total fruit area production. On an average nearly 6500 MT per year of Papaya is yielded which is 6.57% of total fruit production in India. In Madhya Pradesh Papaya is cultivated on estimated area of 10.45 hectares. Productivity of Papaya in Madhya Pradesh is around 44.9 MT per hectare. If proper management is done nearly 70 to 80 tonnes per hectare of Papaya can be produced. The fruits of excellent quality are produced under mild subtropical climates where as a dry warm sunny climate tends to add the sweetness to the fruit. Cultivation of Papaya is easy and gives easy returns. The plant of Papaya has adaptability in diverse soil. Fruit of Papaya is attractive, delicious and has multifarious uses. Papaya is a very wholesome fruit. It is one of the best sources of vitamin A. Usually it is assumed that a fruit has yellow pigment due to Carotene in it but Papaya has yellow pigment because of caricaxanthin. Papaya fruit also have ß-Cryptoxanthin (8.1µg/g) representing 62% of carotenoid content causing yellow/orange fleshed cultivars which are common. Papaya fruit also has red fleshed cultivars which are due to Lycopene. Organic manures and bio-inoculants are substitute of inorganic fertilizers. When these organic manures and bio-inoculants are used in the field where Papaya plant is grown the faster development of plant is clearly visible. The use of organic fertilizers and bio-inoculants increases crop productivity and also improves soil properties. The organic matter in the soil is increased. Water holding property of the soil is improved and nutrients in the soil increases thus increasing the nutritional value of Papaya fruit. The importance of organic manure and bio-fertilizers in Indian agriculture has been known since ancient times as it augments part of N, P, K and also fairly a good amount of micronutrients apart from increasing availability of applied and native soil nutrients. The practice also improves the soil quality, texture, structure, porosity, infiltration rate, aeration,

flora and fauna and better root growth which have beneficial effects on crops by improving their yield, quality and post-harvest traits.

Materials and Methods

A field experiment on different inorganic, biofertilizers techniques on growth Papaya (*Carica papaya* L.) was carried out during 2016 and 2017 at Mahatma Gandhi Chitrakoot Gramodaya Vishwa Vidyalaya, Chitrakoot, District Satna (M.P.). The research work was conducted in the Randomized Block Design with three replications. Each replication was comprised of 10 treatment combinations. In T^{-1} Recommended dose of NPK (RDF) i.e. 250: 250:250 g/plant/year, T^{-2} 100% RDF + PSB (50g/plant), T^{-3} 100% RDF + *Azospirillum* (50g/plant), T^{-4} 100% RDF + *Azotobactor* (50g/plant), T^{-5} 75% RDF + PSB (50g/plant) + *Azospirillum* (50g/plant), T^{-6} 75% RDF + PSB (50g/plant) + *Azotobactor* (50g/plant), T^{-7} 75% RDF + PSB (50g/plant) + *Azospirillum* (50g/plant) + *Azotobactor* (50g/plant), T^{-8} 50% RDF + PSB (50g/plant) + *Azotobactor* (50g/plant), T^{-9} 50% RDF + PSB (50g/plant) +*Azospirillum* (50g/plant) + *Azotobactor* (50g/plant), T^{-10} Farmer's Practices. The Chitrakoot is situated in semi-arid and sub-tropical zone of Kymore Plateau & Satpuda Hills of Madhya Pradesh, North of 24° 31' latitude and East of 81° 15' longitude with an altitude of 306 m from mean sea level. The soil of the investigation field was clay loam with good drainage and uniform texture with medium NPK status. Observations were recorded according to standard procedure on Number of fruits per plant, Fruit weight (kg), Fruit yield (kg/plant), Fruit yield (t/ha), Fruit length (cm), Fruit width (cm), Thickness of pulp (cm), Length of fruit cavity (cm), Width of cavity (cm), Cavity index (%).

Results and discussion

Yield attributes and Yield (Table No. 1-2)

The yield and yield perimeter like number of fruits per plant, fruit weight (kg) and fruit yield per plant (kg) as well as per hectare yield (t/ha) are considered to be an important factor to judge the yield and yield perimeter in papaya crop.

Number of fruits per plant, fruit weight (kg), fruit yield per plant (kg) and per hectare (t/ha) were maximum with treatment T7 - 75% RDF + PSB (50g/plant) + *Azospirillumn* (50g/plant) + *Azotobactor* (50g/plant), which was closely followed by the treatments T2- 100% RDF + PSB (50g/plant), T3- 100% RDF + *Azospirillum (50g/plant) and T4 - 100% RDF + Azotobactor* (50g/plant), while the minimum number of fruits per plant was found under T10- Farmer's Practices. Fruit yield increased with application of biofertilizers application in combination with inorganic fertilizers as against the straight fertilizer application. Increase in fruit attributes could be due to the enhanced in morphological traits such as plant height, girth, number of leaves, leaf area, faster rate of leaf production and also higher nutrient uptake by the plant. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates. Relatively higher carbohydrates could have helped the growth rate and in turn increased yield. Higher fruit yield (t/ha) in papaya was realized due to increase in fruit number and fruit weight per plant. Higher yield response owing to use of organics ascribed to increased biological, chemical and physical properties of soil cussed in better availability of plant nutrients, which turn led to good crop growth and yield (Shivakumar, 2010) [7].

Maximum fruit length and fruit width by pooled basis was observed under the treatment T7 - 75% RDF + PSB (50g/plant) + *Azospirillumn* (50g/plant) + *Azotobactor* (50g/plant), followed by the treatments T2- 100% RDF + PSB (50g/plant), while the minimum fruit length and fruit width was found under T10- Farmer's Practices.

In second things the steady and regular availability of essential plant nutrients by the addition of bio fertilizers along with chemical fertilizers which supplements all the essential nutrients, increased the availability of more quantity of major nutrients and growth enhancing substances from the beginning of the initial vegetative stage up to completion of cropping period (Yadav *et al*., 2011b) [6]. These results are in corroborated with the findings observed by Ganeshamurthy *et al*. (2004) [3], Shivaputra *et al*. (2004) [9], Singh *et al*. (2010) [8] and Suresh *et al*. (2010) [10] in papaya and Ray *et al*. (1999) [6], Chezhiyan *et al*. (1999), Jeyabaskaran *et al*. (2001), Soorianathasundarum *et al*. (2001) [12].

Maximum thickness of pulp by pooled basis was observed under the treatment T7 - 75% RDF + PSB (50g/plant) + *Azospirillumn* (50g/plant) + *Azotobactor* (50g/plant), while the minimum thickness of pulp was found under T10- Farmer's Practices. The increase in fruit growth might be due to optimum supply of plant nutrients and growth hormones in good quantity during the entire crop period causing vigorous vegetative development of the plants and finally more photosynthesis and thereby higher yield. Similar findings have been found by Shrivastava (2008) [11]. Increase in yield parameters might be due to dual role of *Azotobacter* in nitrogen fixation and production of phytohormones and increased uptake of nutrients such as nitrogen (Govindan and Purushothaman, 1984) [4]. The application of bio-fertilizers with major nutrients helped for enhancing the available primary nutrients as well as other essential elements. The higher nutrient content and metabolic levels enhanced the growth parameters, finally leading to higher yield. The results are also in close corroborated with the findings of Ravishanker *et al*. (2010) [5] and Chaudhri *et al*. (2001) [2] in papaya.

Maximum length of fruit cavity, width of cavity and fruit cavity index (%) of fruit were obtained from papaya plant treated with T7 - 75% RDF + PSB (50g/plant) + *Azospirillumn* (50g/plant) + *Azotobactor* (50g/plant) and while the minimum was found under T10- Farmer's Practices. The mobility of photosynthates from source to sink i.e., higher translocation was possible perhaps due to better sink capacity as showed by the higher number of fruits per plant and weight of fruit. Similarly, increase in fruit number, fruit weight and fruit volume with use of organic manures in combination to inorganic fertilizers as against the straight fertilizer use were reported in various crops by Ushakumari *et al*. (1997) [13] and Athani *et al*. (1999) [1], Similar findings were also observed by Shivaputra *et al*. (2004) [9], Shivakumar (2010) [7]

Table 1: Effect of inorganic and bio-fertilizers on yield attributes and yield of Papaya

Treatments	Number of fruits per plant	Fruit weight (kg)	Fruit yield (kg/plant)	Fruit yield (t/ha)	Fruit length (cm)
T_1	24.43	0.93	22.58	62.55	24.18
T_2	26.53	1.04	27.69	76.87	26.71
T_3	26.03	1.02	26.60	73.86	25.87
T_4	24.91	1.01	25.08	69.63	25.06
T_5	24.16	0.87	21.08	58.51	24.08
T_6	23.30	0.85	19.75	54.83	23.30
T_7	28.58	1.06	30.26	84.00	27.10
T_8	23.09	0.84	20.85	54.71	22.46
T_9	23.24	0.83	20.08	53.55	21.72
T_{10}	22.07	0.83	18.21	50.56	21.12
S.Em.±	0.0400	0.0020	0.0812	0.2346	0.0420
CD at 5%	0.1147	0.0057	0.2328	0.6728	0.1205

Table 2: Effect of inorganic and bio-fertilizers on yield attributes and yield of Papaya

Treatments	Fruit width (cm)	Thickness of pulp (cm)	Length of fruit cavity (cm)	Width of cavity (cm)	Cavity index (%)
T_1	14.19	1.71	10.67	7.71	24.49
T_2	16.05	2.23	12.68	9.29	27.04
T_3	14.56	1.93	11.76	8.64	27.03
T_4	14.17	1.88	11.38	8.20	26.95
T_5	13.70	1.70	10.44	7.39	24.39
T_6	13.48	1.65	9.65	6.75	24.31
T_7	16.37	2.38	12.99	9.49	27.30
T_8	13.34	1.56	9.62	6.69	24.20
T_9	12.34	1.48	9.28	6.47	24.13
T_{10}	11.83	1.39	9.26	6.38	23.41
S.Em.±	0.0237	0.0065	0.0284	0.0237	0.0317
CD at 5%	0.0681	0.0187	0.0814	0.0681	0.0910

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