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Effect of integrated Nutrient Management on Leaf and Soil Nutrient Status of Papaya (*Carica papaya* L.) cv. Pusa Delicious under Varanasi Region of Uttar Pradesh

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ABSTRACT: Papaya (*Carica papaya* L.) is one of the most important and delicious fruit, but it is a heavy feeder of nutrients and requires judicious supplies of nutrients at frequent intervals for better growth and fruiting. Growers applied heavy dose of fertilizers without knowing the soil status, that leads to deterioration in the soil physical and chemical composition and also causes environmental pollution. Hence, it is imperative to shift from conventional nutrient management systems to integrated nutrient management systems for sustainable production as well as for maintaining the soil health. The present study underlying the principal of INM is to maintain and improve soil fertility for sustaining the crop use of all possible sources of nutrient and their scientific management for optimum growth, yield, and quality of different crops in specific agro-ecological conditions. The INM helps restoring and sustain soil fertility along with crop productivity. Further, it also helps checking the emerging deficiency of nutrients other than N, P, K and favorably affects the physical, chemical, and biological environment of the soil.

Keywords: Nutrients, fertilizers, soil physical, pollution, INM, agro-ecological.

INTRODUCTION

Papaya (*Carica papaya* L.) also known as paw paw is an evergreen herbaceous plant that is dioecious in nature. It is a commercial fruit crop which belongs to the family *Caricaceae*. Papaya is a highly remunerative fruit crop and provides more income/ha than other crops. It is a quick growing, typically single stemmed, and large perennial herb. Papaya is a cross between two species of the genus *Carica*. It is an important fruit in tropical and sub-tropical regions of the world (Hofmeyr, 1938) and was introduced in India in the 16th century. It is grown in tropical and sub-tropical regions of the countries like Australia, Hawaii, Taiwan, California in U.S.A., Gold Coast in various parts of Central and South Africa, Pakistan, Bangladesh, and India. It is the fourth most important fruit in India and commercially cultivated in Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka, Bihar, Gujarat, West Bengal, Tamil Nadu, Andhra Pradesh, Rajasthan, and Assam.

Papaya fruit has occupied a place of pride in the human diet because of its great nutritional as well as medicinal values, and is a good source of carbohydrate, protein, fiber, minerals, vitamin A, and C, carotene, iron, calcium, phosphorus, and potassium. 100 g of fresh weight contains 0.04 mg of vitamin B2, 40 g Vit. C, 0.2 mg of nicotinic acid and 250 mg of riboflavin. It is an abundant source of the carotene precursor of vitamin A, which prevents blindness. Among the fruits, papaya is second most important in Vitamin-A (2020IU) after Mango (4800IU). The immature fruit produces milky latex, which contains the protrolytic enzyme called papain. Papain is used in meat-tendering, the manufacture of chewing gum, dental paste, and cosmetics, pharmaceutical, tanning, and silk industries (Chadha, 1992). It is used in the medical field for the treatments of piles, dyspepsis of the spleen, liver, neurotic disorders, skin blemishes, and also digestive ailments like ring worm and round worm infection and to reduce blood clotting.

Papaya bears flowers and fruit throughout the year, and hence it requires fertile soil with good drainage condition (Ram, 1996). A rich, well drained sandy loam soil is the best for papaya cultivation. Soils with high pH (8) and low pH (5) should be avoided. Papaya prefers slightly acidic soil, and clayey soil is unsuitable for this crop. It requires a warm and humid climate and can be cultivated upto an elevation of about 1000 metres.

The nutritional requirement of papaya is quite typical in view of its continuous vegetative growth, flowering, and fruiting habits. Owing to continuous fruiting habits nutrient requirement of papaya is high, and use of large quantities of chemical fertilizers alone is not only feasible but also costly to the poor farmers. It pollutes soil and ground water. However, biofertilizers offer an alternative to chemical inputs, which have the ability of mobilizing the important elements from non-useable to useable form and are known to increase yield.

For sustainable soil productivity, it is very essential to strike a balance in soil biological activity, as any disturbance will affect the nutrient transformation in the soil. Soil organic matter builds up the nutrient content, and balanced microbial activity contributes to a wide range of transformations for the sustainable functioning of soil. At present, intensification of production systems without maintaining the biological properties of soil has deteriorated soil health. Integrated Nutrient Management (INM) is one of the most effective alternative, which involves use the of inorganic fertilizers, organic manures, and bio fertilizers for the maintenance of long term soil fertility and productivity along with sustainable crop production. The basic concept underlying the principle of INM is maintenance and improvement of soil fertility for sustaining crop productivity on a long term basis, which may be achieved through combined use of all possible sources of nutrient and their scientific agro-ecological situation. The recent concept of integrated nutrient supply involving organic, inorganic, and bio-fertilizer has been developed to meet the growing need for nutrient supply system. The basic goal is to improve soil fertility and nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all the possible sources of plant nutrients in an integrated manner.

MATERIAL AND METHODS

A field investigation was carried out at Agricultural Research farm (25º18' North latitude and 83º03' E), Banaras Hindu University, Varanasi assigning fifteen different combination of organic manure and bio fertilizer along with recommended dose of fertilizer i.e. (T_1) control, (T_2) FYM + NPK (100%) 250:250:500 g plant^{-1} recommended dose, (T_3) FYM + NPK (75%) + *Azotobacter*, (T_4) FYM + NPK (75%) + *Azospirillum*, (T_5) FYM + NPK (75%) + *Azotobacter* + PSB, (T_6) FYM + NPK (75%) + *Azospirillum* + PSB, (T_7) FYM + NPK (50%) + *Azotobacter*, (T_8) FYM + NPK (50%) + *Azospirillum*, (T_9) FYM + NPK (50%) + *Azotobacter* + PSB, (T_{10}) FYM + NPK (50%) + *Azospirillum* + PSB, (T_{11}) FYM + NPK (100%) + *Azotobacter*, (T_{12}) FYM + NPK (100%) + *Azospirillum*, (T_{13}) FYM + NPK (100%) + *Azotobacter* + PSB, (T_{14}) FYM + NPK (100%) + *Azospirillum* + PSB and (T_{15}) FYM (20 Kg).The treatments were replicated three time in a Randomized Block Design. Pusa delicious variety of papaya was used as a test crop.

The observations on crop Nitrogen (%), phosphorous (%) and potassium (%) content of papaya leaves and Nitrogen (kg ha^{-1}), phosphorous (kg ha^{-1}), potassium (kg ha^{-1}) and pH content of soil were determined after harvest. The recorded data were subjected to statistical analysis as prescribed by Gomez ad Gomez (1984). The interpretation of the treatment effects was made on the basis of Fisher's critical difference at p=0.05 level.

RESULT AND DISCUSSION

The different integrated nutrient management treatments significantly influenced the nitrogen content of papaya leaf. During the course of the investigation, the highest 'N' content (1.71%) papaya leaf was recorded with the application of (T_{13}) FYM + NPK (100%) + *Azotobacter* + PSB than rest of the treatments. Whereas the minimum N content of the leaf was recorded in treatment (T_1) control i.e. 1.32%. The Phosphorous content of papaya leaf was significantly altered by different integrated nutrient treatments. The highest 'P_2O_5' content (0.52%) in leaf was recorded with application of (T_{14}) FYM + NPK (100%) + *Azospirillium* + PSB than the rest of the treatments. Whereas the minimum P_2O_5 content of leaf was recorded in the treatment (T_1) control i.e. 0.29 %. The different integrated nutrient management treatments significantly influenced the potassium content of the papaya leaf. During course of investigation, the highest 'K_2O' content (4.37%) papaya leaf was recorded with the application of (T_{13}) FYM + NPK (100%) + *Azotobacter* + PSB than the rest of the treatments. Whereas, the minimum potassium content of the leaf was recorded in the treatment (T_1) control i.e. 2.26%. The increase in available nitrogen due to application of organic manure might be attributed to the greater multiplication of soil microbes. These organics, during mineralization convert organically bound N to inorganic form resulting in higher available nitrogen to the soil. It also enhanced phosphorus activities that mobilizes sparingly the available nutrient sources and ectozymes, resulting in improved phosphorous uptake. The mechanism involved in solubilizing phosphorus was due to acid production and enzyme activities, *viz*., dehydrogenase, phosphate, and urenase activities. Thus, the transport of solubilized phosphorus through hyphae to roots led to an efficient increase in phosphorus. Increased microbial activities have resulted in greater uptake of potassium in plant due to the solubilization action of certain organic acids produced during the decomposition of organic manure and its greater capacity to hold K in available form in soil (Kuttimani *et al*., 2013). This might have resulted in a higher level of nutrient status in the leaves of papaya, in the present study compare to the control treatment. These results are in agreement with those reported by Anjaneyulu (2007); Khade and Rodrigues (2009) in papaya.

The data on soil studies after the harvesting of papaya was analyzed in form of pH, available nitrogen, phosphorous, and potassium (kg ha^{-1}). Among the integrated nutrient management treatments, application of(T_{14}) FYM + NPK (100%) + *Azospirillium* + PSB recorded significantly higher pH, available nitrogen, higher available phosphorous and available potassium of soil having values of 7.8, 176.80 kg ha^{-1}, 23.80 kg ha^{-1} and 172.80 kg ha^{-1} respectively. Whereas, the minimum soil pH, available nitrogen, available phosphorous, and available potassium of soil after harvesting of papaya was observed with application of (T_1) control.

The increase in available nitrogen due to the application of organic manures along with chemical fertilizers might be attributed to the greater multiplication of soil microbes by the application of nitrogen through nitrogenous fertilizers along with organic manures. These organic manures during mineralization convert organically bound N to inorganic, resulting in available higher amount nitrogen of soil (Selvamani *et al.*, 2011).

The higher availability of phosphorus in the organic manures treated plot as compared to control plots might be due to the release of organic acids during the microbial decomposition of organic matter, which might have helped in the solubility of native phosphorus. In addition, the organic anions compete with phosphate ions for the binding sites on the soil particles. The complex organic anions chelate $A1^{3+}$, Fe^{3+} and Ca^{2+} and thus decrease the phosphate precipitating power of these cations and thereby increase the phosphorus availability (Patel, 2008).

The higher K_2O content might be the organic and inorganic acids produced due to during decomposition of organic manures helping the release which mine rally bound insoluble potassium and also might had reduced the potassium fixation. The buildup of available potassium in soil was due to the beneficial effect of organic manures in releasing potassium due to the interaction of organic matter with clay and the direct addition of potassium to the available pool of soil (Shivakumar *et al.*, 2010).

Table 1: Leaf and soil nutrient status of papaya (*Carica papaya* L.) cv. Pusa Delicious influenced by integrated nutrient management.

Treatments	Leaf Nitrogen %	Leaf Phosphorous %	Leaf Potassium %	Soil pH	Soil Nitrogen kg ha^{-1}	Soil Phosphorous kg ha^{-1}	Soil Potassium kg ha^{-1}
T_1 - Control (Without Nutrient)	1.32	0.29	2.26	7.3	173.08	16.77	164.23
T_2- FYM + NPK (100%)	1.55	0.42	3.53	7.6	175.43	22.40	169.23
T_3- FYM + NPK (75%) + *Azotobacter*	1.55	0.42	3.20	7.5	174.16	19.62	169.30
T_4- FYM + NPK (75%) + *Azospirillum*	1.53	0.46	3.07	7.5	174.04	19.72	169.10
T_5- FYM + NPK (75%) + *Azotobacter* + PSB	1.59	0.44	3.54	7.6	174.54	20.62	168.72
T_6- FYM + NPK (75%) + *Azospirillum* + PSB	1.58	0.48	3.25	7.5	174.81	20.82	169.60
T_7- FYM + NPK (50%) + *Azotobacter*	1.41	0.36	2.72	7.5	173.17	18.06	166.50
T_8- FYM + NPK (50%) + *Azospirillum*	1.42	0.40	2.62	7.4	173.06	18.17	166.72
T_9- FYM + NPK (50%) + *Azotobacter*+ PSB	1.51	0.38	2.88	7.5	173.44	18.57	167.17
T_{10}- FYM + NPK (50%) + *Azospirillum* + PSB	1.45	0.42	2.78	7.5	173.87	18.73	167.52
T_{11}- FYM + NPK (100%) + *Azotobacter*	1.66	0.46	3.87	7.6	175.74	22.52	171.82
T_{12}- FYM + NPK (100%) + *Azospirillum*	1.65	0.51	3.68	7.5	175.46	22.72	171.87
T_{13}- FYM + NPK (100%) + *Azotobacter* + PSB	1.71	0.48	4.37	7.6	176.57	23.42	172.38
T_{14}- FYM + NPK (100%) + *Azospirillum* + PSB	1.68	0.52	4.04	7.8	176.80	23.80	172.80
T_{15}- FYM (20 kg)	1.38	0.31	2.61	7.4	173.09	17.22	164.80
SE.m. ±	0.002	0.002	0.017	0.020	0.016	0.050	0.087
LSD (p=0.05)	0.007	0.007	0.050	0.058	0.046	0.144	0.251

CONCLUSIONS

In case of leaf nutrient content, significantly higher nutrient content were noted under the application of (T_{13}) FYM + NPK (100%) + *Azotobacter* + PSB except or phosphorous content which was higher under (T_{14}) FYM + NPK (100%) + *Azospirillum* + PSB during both years. Available nutrient status of soil, significantly higher values of available nutrients were reported under (T_{14}) FYM + NPK (100%) + *Azospirillum* + PSB during the period of research. Overall, the appraisal study shows that the use of integrated nutrient management increases soil fertility, and improves soil health. If these treatments are continued for a few years, then minimise the use of inorganic fertilizers so farmers get more benefits.

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Conflict of Interest. None.

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