Plant Archives Vol. 18 No. 2, 2018 pp. 1795-1800 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

STUDIES ON THE EFFECT OF INTEGRATED NUTRIENT MANAGEMENT IN YIELD OF MAIZE (*ZEA MAYS* L.)

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Abstract

Maize (*Zea mays* L.) is one of the most important cereal crop in the world agriculture as food, feed and industrial raw material which ranked *third important cereal crop next to rice and wheat in the World*. In India, it is grown in more than 8.69 million hectares, having a production of 21.81 million tonnes and average productivity of 2509 kg ha^{-1} (Agri. Stat. 2016). However, the average crop yield of 2.50 t ha^{-1} is still very low as compared to the other Asian countries like Bangladesh (6.8 t ha^{-1}), China (5.7 t ha^{-1}), Indonesia (4.6 t ha^{-1}) and Pakistan (3.8 t ha^{-1}). Over reliance on use of chemical fertilizers has been associated with declines in soil physical and chemical properties and crop yield and significant land problems, such as soil degradation due to over exploitation of land and soil pollution caused by high application rates of fertilizers and pesticide application. Efficacy of organic sources to meet the nutrient requirement of crop is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long- term basis in maize cultivation. The field experiment was carried out during March to June, 2014 and was conducted in randomized block design with three replications. All the treatments were found to significantly influence the growth and yield components of maize. Among the integrated nutrient management practices evaluated, 100 per cent RDF + vermicompost @ 5 tonnes ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} resulted in the enhanced values of various growth and yield attributes *viz.,* plant height, leaf area index, dry matter production, cob length, cob diameter, number of grains cob^{-1} and yield of maize. Application of 75 per cent RDF alone resulted in the lowest values of the growth and yield components of maize. It may be inferred that application of vermicompost @ 5 tonnes ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} along with 100 per cent recommended N, P and K holds promise as an eco-friendly and economically viable integrated nutrient management practice for increasing the yield of maize.

Key words : Integrated nutrient management, yield, maize, cereal crop.

Introduction

Maize has been an important cereal crop because of the increasing market price and its high production potential in both irrigated as well as rainfed conditions compared to any other cereal crop and adaptability to wide range of environments. Since, the crop has very high genetic yield potential, it is called as the "Queen of cereals". Maize occupies an important place in Indian economy as like rice, wheat and millets. Maize crop has better yield response to chemical or inorganic fertilizers. Maize is considered as most exhaustive crop after sugar cane and requires both micro and macro nutrients to obtain high growth and yield potentials. Hence heavy doses of the chemical fertilizers are applied to maize. Over reliance on use of chemical fertilizers has been associated with declines in soil physical and chemical properties and crop yield. The average maize yield of 2.50 t ha^{-1} is still very low as compared to the other countries in the World. Majorly poor management of fertilizer has key role to play in obtaining low yield productivity, so in order to higher crop productivity management of nutrients through judicious application of fertilizers, organic sources, bio-fertilizers and micro-nutrients are required.

Chemical fertilizers cannot be avoided completely since they are the potential sources of high amount of nutrients in easily available forms. Continuous use of chemical fertilizers in intensive cropping system is leading to imbalance of nutrients in soil, which has an adverse effect on soil health and also on crop yields. Most of the crops respond quickly to chemical fertilizers and give higher yield and maize is more responsive. Excessive and continuous use of chemical fertilizers coupled with

pesticides and fungicides have damaged the soil health which causes deleterious effects on crop cultivation and productivity (Karthika and Vanangamudi, 2013). But continuous application of chemical fertilizers alone in intensive cropping system is leading to imbalance of nutrients in soil which has an adverse effect on soil health and also on crop yields. But, use of organics alone does not result in spectacular increase in crop yields, due to their low nutrient status.

In fact, organic manures not only supply macronutrients but also meet the requirements of micronutrients besides improving soil health. Therefore, suitable combination of chemical fertilizer and organic manure culture need to be developed for particular cropping system and soil (Heitkamp *et al*., 2011). Sustainable yield could be achieved only by applying appropriate combination of organic manures and chemical fertilizers (Verma and Bhagat, 1990; Obi and Ebo, 1995). Integrated nutrient management (INM) is a judicious use of organic and maintaining soil productivity. However, the use of appropriate and conjunctive use of application of suitable nutrients through organic and inorganic solely or in combination can provide the solutions to the problems such as increase in the price of inorganic fertilizers and deterioration effect of soil fertility and productivity. Hence, judicious application of these combinations can sustain the soil fertility and productivity. Vermicompost are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium and micro nutrients, microbial and enzyme activities and growth regulators. Enriched Farmyard manure (EFYM) is also considered as an important source of macro and micronutrients to increase crop yield. Due to higher prices of inorganic fertilizers, farmers in India could easily manage to prepare EFYM in their farms and to apply them in fields. Organic Manure contains all the plant nutrients needed for the crop growth. The biofertilizer *azospirillum* is an important free living organism that can fix atmospheric nitrogen into the soil ranging from 20 to 30 kg ha^{-1} (Reddy and Reddy, 2003).

Materials and Methods

Field investigation was conducted at Annamalai University Experimental Farm, Annamalai Nagar to study the effect of integrated nutrient management in growth attributes of maize. The field experiment was carried out during March to June, 2014 and was conducted in randomized block design with three replications. The treatments comprised of 100 per cent recommended dose of fertilizer (RDF) (T_1), 75 per cent RDF (T_2), 100 per cent RDF + enriched FYM @ 750 kg ha^{-1} (T_3), 75 per cent RDF + enriched FYM @ 750 kg ha^{-1} (T_4), 100 per cent RDF + vermicompost @ 5 tonnes ha^{-1} (T_5), 75 per cent RDF + vermicompost @ 5 tonnes ha^{-1} (T_6), 100 per cent RDF + enriched FYM @ 750 kg ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_7), 75 per cent RDF + enriched FYM @ 750 kg ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_8), 100 per cent RDF + vermicompost @ 5 tonnes ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_9), 75 per cent RDF + vermicompost @ 5 tonnes ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_{10}).

Results and Discussion

The data on maize plant height, LAI an DMP recorded are given in table 1. Application of 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_9) significantly registered the highest plant height 223.67 and 258.25 cm, respectively at 60 DAS and harvesting stage respectively. The application of 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_9) significantly registered the highest LAI values of 3.37 and 7.84 respectively at 30 and 60 DAS. The dry matter production (DMP) of maize was influenced by varied integrated nutrient management practices. In general, the values of DMP showed linear response to advancement in age of the crop. Application of 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_9) significantly recorded the highest DMP of 3787, 7246 and 10733 kg ha^{-1} respectively at 30 DAS, 60 DAS and harvesting stages. The other treatments *viz.,* T_7, T_{10}, T_8, T_5, T_3, T_6, T_4 and T_1 stood next in order of ranking at all the stages of crop growth. The 75 per cent RDF (T_2) recorded the lowest plant height of 71.12, 171.69 and 193.24 cm at respective stages of crop growth and lowest LAI values of 2.14 and 5.86 respectively at 30 DAS and 60 DAS. The lowest dry matter production (2801, 4760 and 6283 kg ha^{-1}on 30 DAS, 60 DAS and harvesting stages respectively) was recorded with 75 per cent recommended dose of fertilizer (RDF) (T_2).

The data on maize plant yield attributes *viz.,* cob length, cob diameter, number of grains cob^{-1} and grain yield are given in table 2. Application of 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_9) significantly registered the highest cob length and cob diameter of 19.35 cm and 7.26 cm, respectively. Likewise, in number of grains cob^{-1} and grain yield also the treatment application of 100 per

Table 1 : Effect of INM on growth attributes of hybrid maize.

Treatments	Plant height (cm)		LAI	DMP (Kg ha^{-1})	
	60 DAS	Harvest	60 DAS	60 DAS	Harvest
T_1 - Recommended dose of fertilizers (RDF)	178.62	199.66	6.16	5128	7293
T_2 - 75 per cent RDF	171.69	193.24	5.86	4759	6283
T_3 - 100 per cent RDF + EFYM @ 750 kg ha^{-1}	195.37	223.18	6.97	5936	8602
T_4 - 75 per cent RDF + EFYM @ 750 kg ha^{-1}	184.99	209.27	6.44	5420	7849
T_5 - 100 per cent RDF + vermicompost @ 5 t ha^{-1}	202.10	231.12	7.19	6211	9042
T_6 - 75 per cent RDF + vermicompost @ 5 t ha^{-1}	190.87	217.15	6.81	5691	8391
T_7 - 100 per cent RDF + EFYM @ 750 kg ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	216.87	250.26	7.60	6926	10027
T_8 - 75 per cent RDF + EFYM @ 750 kg ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	206.62	237.18	7.34	6399	9264
T_9 - 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	223.67	258.25	7.84	7246	10732
T_{10} - 75 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	212.44	245.15	7.57	6684	9868
S.Ed	2.40	3.23	0.08	111	160
CD (p=0.05)	5.34	7.19	0.19	246	356

cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} (T_9) significantly recorded highest number of grains cob^{-1} (338.74) and grain yield (6041 kg ha^{-1}). The other treatments *viz.,* T_7, T_{10}, T_8, T_5, T_3, T_6, T_4 and T_1 stood next in order of ranking at all the stages of crop growth. The least yield components and yield was recorded with 75 per cent recommended dose of fertilizer (RDF) (T_2).

Discussion

It has been reported that application of organic source of nitrogen (vermicompost followed by *Azospirillum*) positively influenced the plant height, LAI, dry-matter due to prolonged release of nutrients from vermicompost, which increase the efficiency of nutrients and provide favourable conditions for plant growth. Application of chemical fertilizers with organic manure increased the plant height significantly owing to the stronger role of nutrients in cell division, cell expansion and enlargement which ultimately affect the vegetative growth of plant and ultimately higher dry-matter production. Nitrogen is the key element which affects the chlorophyll content in leaf of the plants. The increase translocation of N by biological supply results in more chlorophyll content. Potassium plays significant role in nutrient transportation in plants. The increase in chlorophyll content might be owing to synergistic effect of potassium over the other nutrients.

The other reasons for maximum height, dry-matter and LAI of maize with of 100% RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} might be due to fertilizer source that fulfilled the nutrient requirements at early growth stages, while vermicompost + soil application of *azospirillum* facilitated crop at later stages by providing continuous and uniform supply of nutrients coupled with high photosynthetic rates and excellent vegetative growth resulting in accumulation of dry matter into the plants.

The consistent increments observed with the values of plant height and LAI might have positively reflected on dry matter production. Increments in values of growth attributes of maize through the practice of INM were also reported by Sunitha and Maheswara Reddey (2012) and also distinct improvement in soil physical properties *viz*., texture, structure and porosity and making a suitable environment for root's growing. Higher growth characters predominantly registered in N application and higher growth was due to quicker availability of nutrients from the vermicompost when compared to FYM due to their narrow C: N ratio (Shilpashree *et al*., 2012). Application of 75 per cent of recommended dose of fertilizers (T_2) resulted in the least values of growth parameters, attributable to the absence of beneficial effect of biofertilizer, lesser levels of NPK and vermicompost, which contains nutrients in forms that are readily taken

Table 2 : Effect of INM on yield attributes and yield of hybrid maize.

Treatments	Cob length (cm)	Cob diameter (cm)	Number of grains cob^{-1}	Grain yield (kg ha^{-1})
T_1 - Recommended dose of fertilizers (RDF)	15.46	4.16	261.25	3637
T_2 - 75 per cent RDF	14.61	3.48	247.07	3066
T_3 - 100 per cent RDF + EFYM @ 750 kg ha^{-1}	17.19	5.50	289.35	4484
T_4 - 75 per cent RDF + EFYM @ 750 kg ha^{-1}	16.28	4.80	271.96	3979
T_5 - 100 per cent RDF + vermicompost @ 5 t ha^{-1}	17.91	5.99	300.31	4768
T_6 - 75 per cent RDF + vermicompost @ 5 t ha^{-1}	17.06	5.32	281.75	4301
T_7 - 100 per cent RDF + EFYM @ 750 kg ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	18.90	6.84	327.47	5592
T_8 - 75 per cent RDF + EFYM @ 750 kg ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	18.10	6.22	308.37	4970
T_9 - 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	19.35	7.26	338.74	6041
T_{10} - 75 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1}	18.69	6.59	318.85	5373
S.Ed	0.10	0.12	4.22	108
CD (p=0.05)	0.23	0.27	9.39	240

up by the plants such as nitrates, exchangeable phosphorus and soluble potassium, calcium and magnesium. The results are conformity with the findings of Aspasia *et al.* (2010).

The yield potential of maize is determined by the resultant values of yield components which are greatly influenced by the growth parameters. This is well reflected in the present investigation also. Almost all yield attributing characters *viz.,* cob length, cob diameter, number of grain cob^{-1} and grain yield were remarkably influenced by the practice of integrated nutrient management. The variation in grain yield across the treatment may be traced to their favourable effects on the growth attributes, which further got translated to yield attributes and finally on grain yield. The integrated nutrient treatments might have resulted in sufficient amount of released nutrients by mineralization at a constant level and increased the nutrient uptake because of the better soil environment created owing to cumulative effect of organic sources combined with inorganic source of nutrients, which improved the plant growth and consequently enhanced the yield attributes and yield. Nanjappa *et al*. (2001) reported that combined application of 50 or 75% recommended dose of fertilizer with 12 t/ ha FYM or 2.7 t/ ha vermicompost caused higher productivity of maize compared with the application of either only inorganic fertilizer or organic sources.

Vermicompost when applied to the soil it changes the form and has best characters *viz.,* porosity, ventilation, capacity to maintain humidity in it overfilled with humic material and absorbable elements resulting in beneficial changes in yield and yield components (Omid Alizadeh and Ardalan Alizadeh, 2011). *Azospirillum* grows in the rhizosphere of the plants and thereby penetrate through the root system and grow intracellular fixing up atmospheric nitrogen and secretion of growth promoting substances, combined together might have increased the growth and yield parameters and ultimately increased yield of maize. The microbial inoculants bring about improvement in the nutrient availability by fixation of atmospheric nitrogen in the rhizosphere and make them readily available to plant. Significant improvement of yield attributes and yield due to the application of 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* 2 kg ha^{-1} resulted in increased yield parameters *viz.,* cob length, cob diameters, number of seed cob^{-1} and grain yield of maize. The constant and optimum release of nutrients from vermicompost supplemented with NPK fertilizers and *azospirillum* might have satisfied the nutrition demand of maize at different stages of crop growth. In addition the presence of growth influencing substances, such as plant growth hormones and humic acids in vermicompost might be the possible factor for increased uptake of nutrients and their effective utilization for photosynthates production and subsequent translocation to sink (Radhakrishnan, 2009). The considerable improvement in grain yield owing to application of organic sources of nutrients had the positive

effects on yield attributes and cumulative effects of yield attributes mainly responsible for higher productivity with the application of organic sources. These results are in conformity with the findings of Meena *et al*. (2013).

Eventhough the enriched FYM contained higher quantum of both macro and micro nutrients, its integrated application with NPK + *azospirillum* did not exert effect on yield parameters of maize. This might be due to the fact that the absence of plant hormone and growth regulators compared to vermicompost. The superiority of vermicompost over enriched FYM and its favourable effect on maize was earlier reported by Tolessa and Sharanappa (2003). The higher yield observed with the application of vermicompost in comparison to FYM may be explained on the basis of higher nutrient content, faster decomposition and released nutrients in vermicompost besides enhancing the microbial population and higher root biomass (Kannan *et al*., 2005).

The application of 100 per cent recommended dose of fertilizers (RDF) alone (T_1) resulted in the lesser values of yield parameters *viz.,* cob length (15.46 cm), cob diameter (4.16 cm), number of grains cob^{-1} (261.25) and grain yield (3637 kg ha^{-1}) attributable to the absence of beneficial effect of biofertilizer and vermicompost, which contains nutrients in forms that are readily taken up by the plants such as nitrates, exchangeable phosphorus and soluble potassium, calcium and magnesium. The results are conformity with the findings of Aspasia *et al.* (2010). Application of 75 per cent of recommended dose of fertilizers (T_2) resulted in lowest yield, attributable to the absence of beneficial effect of biofertilizer, lesser levels of NPK and vermicompost.

Conclusion

On the basis of the results of these field experiment, it may be concluded that, application of 100 per cent RDF + vermicompost @ 5 t ha^{-1} + soil application of *azospirillum* @ 2 kg ha^{-1} as an eco-friendly and economically viable integrated nutrient management practices for enhancing the productivity of hybrid maize.

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