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Agronomic Approaches for Enhancing the Growth and Yield of Irrigated Maize (*Zea mays* L.)

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A B S T R A C T

A field experiment was conducted at Farmer's Field, Chinnapalambakkam, Kaniyambadi, Vellore (Tamil Nadu) during 2020 to study the agronomic approaches for enhancing the growth and yield of irrigated maize (*Zea mays* L.). The experiments were laid out in randomized block design (RBD) with three replications comprising of 9 treatments. The combined application of organic, inorganic and biofertilizer influenced the plant growth characters, yield attributes and yield of maize. Among the different treatments tried, application of 100 per cent RDN (50% N through Fertilizer + 50% N through Vermicompost) + Biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + Micronutrient mixture @ 25 Kg ha^{-1} (T_9), recorded the maximum values of growth characters viz., plant height, leaf area index, dry matter production and yield attributes viz., cob length, cob diameter and number of grains cob^{-1}, grain yield, stover yield and harvest index.

***Key words*:** Maize, *Azospirillum*, Nitrogen, Vermicompost, Micronutrient mixture

Maize is an emerging multipurpose crop with wider adaptability and photo-insensitivity under the different ecological conditions. It has the potential to address key issues such as food and nutritional security. Maize increases the farmers income within short period of 110-115 days. In the world, it is cultivated over an area of 193.7 million hectares with production and productivity of 1,147.7 million tonnes and 5.75 t ha^{-1} respectively. In India, it occupies an area of 9.18 million hectares and production of 27.23 million tonnes with a productivity of 2.97 t ha^{-1}. In Tamil Nadu, it is grown over an area of 0.38 million hectares with production and productivity of 2.51 million tonnes and 6.6 t ha^{-1} [1].

Fertilizer management is crucial for maize cultivation [2]. Maize being a C_4 plant has higher yield potential which also depends on nutrient supplying capacity of the soil. Judicious nutrient management through application of organic manure and inorganic fertilizers essential for obtaining higher productivity [3]. Earlier, the soil health was good by applying of organic manures, but yield response is low. At present due to economic development, farmers use mineral fertilizer because its more profitable, cost – efficient and fast response [4]. Among major nutrient, Nitrogen is the most important element required for plant growth and development. N produces an affluent growth of abundant green leaves. Therefore, N element is low in plants, it results stunted growth and decrease the flowering. Among several major nutrients are needed for good growth, N has an essential role proven by many trials [5-6].

The only way out to this gloomy scenario is to develop sustainable and nutrient balanced technology packages and cropping system, which would increase the food production sustainably without harming the precious environment. Vermicompost is an eco-friendly organic waste product used in agriculture for its nutrients and it improves the soil health. It has large biological components hence, it is used as both organic manure and soil amendments and rich in nutrient concentration especially nitrogen [7]. *Azospirillum* can be considered an economically viable and environmentally sustainable strategy for maize cultivation. It forms associative symbiotic relationship with the roots of graminaceous plants and the organism is microaerophilic, some are aerobic motile and gram negative [8]. *Azospirillum* promote plant growth by tolerance of abiotic stress [9].

Micronutrients are the key elements used by the plants in very small amount. Boron (B) is one of the essential micronutrients for the plant growth and processes involved such as cell wall synthesis, respiration, nitrogen metabolism, Indole Acetic Acid (IAA) metabolism and sugar transport. Worldwide, boron deficiency has been recognized as the second important nutrient after zinc [10]. Copper (Cu) is essential role in the plant micronutrients for protein components, plant metabolism, electron transport chain for photosynthesis, nitrogen utilization. It improves the fertility, yield and good cob development. Manganese is an important plant mineral micronutrient, plays a vital role in many physiological process, photosynthesis, hormone activation and amino acid synthesis. Hence, the

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present experiment was conducted to study the synergistic effect of the integrated nutrient management system on the growth and yield of maize.

MATERIALS AND METHODS

Field experiment was conducted to study the agronomic approaches for enhancing the growth and yield of irrigated maize (*Zea mays* L.) at farmer's field of Chinnapalambakkam village, Kaniyambadi, Vellore District, Tamil Nadu, India during June to September 2020. The experimental field was located at 12°47' North latitude and 79°6' East longitude with an altitude of +254 m above mean sea level. The total rainfall received during cropping period is of 285.8 mm. The mean and maximum temperature during cropping period is 31.22°C and 28.07°C respectively. The relative humidity ranges from 68 to 81 per cent. The soil of the experiment site is sandy clay loam (Soil pH 7.4; EC 0.23 dSm^{-1}). The available soil nitrogen, phosphorus, potassium was 180, 21.5, 230 and kg ha^{-1} respectively. The experiment was laid out in randomized block design replicated thrice with nine treatments viz., T_1 - Control, T_2 - 100 per cent recommended dose of nitrogen through fertilizer, T_3 - 100 per cent RDN (50% N through Fertilizer + 50% N through Vermicompost), T_4 - 100 per cent RDN through fertilizer + Biofertilizer (*Azospirillum*) @ 10 packets ha^{-1}, T_5 - 100 per cent RDN (50% N through Fertilizer + 50% N through Vermicompost) + Biofertilizer (*Azospirillum*) @10 packets ha^{-1}, T_6 - 100 per cent RDN through fertilizer + Micronutrient mixture @ 25 Kg ha^{-1}, T_7 - 100 per cent RDN (50% N through Fertilizer + 50% N through Vermicompost) + Micronutrient mixture @ 25 Kg ha^{-1}, T_8 - 100 per cent RDN through fertilizer + Biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + Micronutrient mixture @ 25 Kg ha^{-1} and T_9 - 100 per cent RDN (50% N through Fertilizer + 50% N through Vermicompost) + Biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + Micronutrient mixture @ 25 Kg ha^{-1}. The entire dose of phosphorus and potassium were applied basally. A half dose of nitrogen was applied basally, and the remaining half dose of nitrogen were applied as two splits on 25 and 45 days after sowing. The hybrid chosen for study Shivani KSMH 1980. The biometric observations on plant height, leaf area index and dry matter production were taken at critical stages of the crop growth. Yield attributes, grain and straw yield were recorded at harvest. All the recorded data were analyzed statistically as suggested by Gomez and Gomez [11].

RESULTS AND DISCUSSION

Growth attributes

The growth characters were markedly influenced by the application of nitrogen, vermicompost, *Azospirillum* and micronutrient mixture (Table 1). Application of 100 per cent RDN (50% N through fertilizer + 50% N through vermicompost) + biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + micronutrient mixture @ 25 kg ha^{-1} (T_9) recorded the maximum values of plant height (228.55 cm), leaf area index (7.96), dry matter production (11779 kg ha^{-1}), crop growth rate (7.15). This was on par with the application of 100 per cent RDN (50% N through Fertilizer + 50% N through Vermicompost) + Micronutrient mixture @ 25 Kg ha^{-1} (T_7). This was followed by application of 100 per cent RDN through fertilizer + Biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + Micronutrient mixture @ 25 Kg ha^{-1} (T_8). The least values for growth attributes were recorded under the control (T_1).

Table 1 Effect nitrogen, vermicompost, *Azospirillum* and micronutrient mixture on growth attributes of hybrid maize

Treatment	Plant height at harvest	LAI at flowering	DMP at harvest (kg ha^{-1})	CGR at 60 DAS – harvest (g $m^{-2}day^{-1}$)
T_1	138.99	5.58	6650	4.06
T_2	158.11	5.97	8584	5.42
T_3	178.60	6.48	9510	5.91
T_4	164.85	6.13	8977	5.65
T_5	186.04	6.75	9895	6.11
T_6	200.73	7.11	10421	6.37
T_7	220.59	7.71	11363	6.90
T_8	208.23	7.39	10847	6.62
T_9	228.55	7.96	11779	7.15
SEm±	3.24	0.09	148.37	0.08
CD (P=0.05)	9.80	0.30	448.08	0.25

Nitrogen being an essential constituent of plant tissue favours rapid cell division and its enlargement. The higher plant height favored under integrated nutrient management. The reason for maximum crop growth is due to synergistic effect of integration of inorganic fertilizer, organic manure, bio fertilizer and micronutrient that resulted in increased availability and absorption of nutrients through production of growth promoting substances and solubilization of nutrient by combined use of vermicompost and bio fertilizer (*Azospirillium*). It is in conformity with findings of several research workers [12-14]. Nitrogen is an essential constituent of proteins, enzymes and chlorophyll and has been observed to influence the leaf growth and its expansion, resulting in increased leaf area index [15]. In addition to that the influence of organic fertilization through vermicompost on LAI could be attributed by increment of metabolic process in plants which seems to have promoted meristematic activities causing apical growth [16-17]. Dry matter accumulation is considered to be the reliable index of crop growth and was significantly influenced by the nutrient management practices. Dry matter production significantly increased with the application of 100 per cent recommended dose of nitrogen (RDN) (50% N through fertilizer + 50% N through vermicompost) + biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + micronutrient mixture @ 25 kg ha^{-1}. The increase

in periodic dry matter accumulation with application of integrated fertilizer management may be attributed to increase in plant height and leaf area index resulting thereby in better light interception by crop which accumulated more photosynthates and thus produced more dry matter [18]. The higher CGR obtained during the study under the above treatment is the reflection of accumulation of dry matter at the respective periods [19].

Yield attributes and yield

The yield attributes viz., cob length, cob diameter and number of grains cob^{-1} were significantly influenced by the application of nitrogen, vermicompost, *Azospirillum* and micronutrient mixture (Table 2). Among the different treatments, T_9 [100 per cent RDN (50% N through fertilizer + 50% N through vermicompost) + biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + micronutrient mixture @ 25 kg ha^{-1}] recorded the maximum cob length (26.12 cm), cob diameter (7.32 cm), number of grains cob^{-1}(390), grain yield (5989 kg ha^{-1}), straw yield (9212 kg ha^{-1}), harvest index (39.39). It was on par with the application of 100% RDN (50% N through Fertilizer + 50% N through Vermicompost) + Micronutrient mixture @ 25 Kg ha^{-1} (T_7). This was followed by application of 100 per cent RDN through fertilizer + Biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + Micronutrient mixture @ 25 Kg ha^{-1} (T_8). The least values for yield attributes were recorded under the control (T_1).

Table 2 Effect nitrogen, vermicompost, *Azospirillum* and micronutrient mixture on yield attributes and yield of hybrid maize

Treatment	Cob length (cm)	Cob diameter (cm)	Number of grains cob^{-1}	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
T_1	13.93	3.36	201	2104	5094	29.23
T_2	15.93	3.98	234	3204	6240	33.92
T_3	19.01	4.86	275	4229	7237	36.88
T_4	17.24	4.23	240	3336	6434	34.14
T_5	20.19	5.12	287	4341	7396	36.98
T_6	22.03	5.77	320	4658	7802	37.38
T_7	25.01	6.85	368	5780	8991	39.13
T_8	23.19	6.20	336	4792	8003	37.45
T_9	26.12	7.32	390	5989	9212	39.39
SEm±	0.54	0.18	9.70	69.69	120.42	0.10
CD (P=0.05)	1.66	0.56	29.31	210.47	363.69	0.31

The length of cob, girth of cob and number of grains cob^{-1} are primarily attributed due to better growth of plants in terms of plant height and dry matter accumulation due to integrated application of nitrogen, biofertilizer and micronutrient mixture. The conjunctive application has been reported to increase in the plant greenery level causing increase in the production of photosynthesis materials, duration of flowering and flowers fertility and therefore increase in number of grains cob^{-1} [20].

Higher grain yield owing to application of nitrogen, vermicompost, biofertilizer and micronutrient mixture might be attributed to steady release of nutrients to soil for longer duration resulting in better utilization of solar energy and intern led to enhance the values of yield attributing characters, which resulted in higher grain yield of maize [21-22]. Lower grain yield was recorded under control (T_1), where nutrients are not supplied, maize has to be obviously depending upon initial soil nutrients, which is not sufficient to produce even reasonable yields.

CONCLUSION

Integrated nutrient management practices ensure the soil health and protect the environment in sustainable way. Application of 100 per cent recommended dose of nitrogen (50% N through fertilizer + 50% N through vermicompost) + biofertilizer (*Azospirillum*) @ 10 packets ha^{-1} + micronutrient mixture @ 25 kg ha^{-1} (T_9) remarkably increased the growth characters, yield attributes and yield of hybrid maize. Therefore, this practice is found to be agronomically sound and economically viable practice, thereby ensuring long term sustainability of soil health and can be recommended for realizing better yield and returns.

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