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Effect of Conventional, Non-conventional Organic Sources and Industrial By-Products on Growth and Yield of Maize (*Zea mays)*

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A B S T R A C T

A field experiment was conducted to study the response of conventional, non-conventional organic sources and industrial by-products in yield maximization of maize at the farmer's field in Karapadi village, Sathyamangalam taluk, Erode district located in Western Zone of Tamil Nadu during April to June 2018. The present study was made to evaluate the extent of contribution RDF as control, 100 % RDF + Municipal solid waste compost @ 5 t ha^{-1} and 75 % RDF with Municipal solid waste compost @ 10 t ha^{-1}, 100 % RDF with bio-compost @ 2.5 t ha^{-1} and 75 % RDF with bio-compost @ 5 t ha^{-1}, 100 % RDF with Bagasse Ash @ 5 t ha^{-1} and 75% RDF with Bagasse Ash @ 10 t ha^{-1}, 100 % RDF with Rice Husk Ash @ 5 t ha^{-1} and 75 % RDF with Rice Husk Ash @ 10 t ha^{-1} on growth, yield of maize. The experiment was conducted in a Randomized Block Design (RBD).75% RDF + MSWC @ 10 t ha^{-1} significantly produced taller plants, Leaf length, Leaf breadth, Leaf area per plant and higher LAI, while on contrary, the 75 % RDF + Bagasse Ash @ 10 t ha^{-1} did not favor the growth parameters conspicuously. 75% RDF + MSWC @ 10 t ha^{-1}treatments significantly enhanced the Yield parameters like Cob length, Cob girth, Number of grains per cob, Grain weight per cob, 100 grain weight, Number of kernel rows per cob, Number of kernels per row when compared to the control. Among the treatment, The application of 75% RDF + MSWC @ 10 t ha^{-1}edged over the other treatments and resulted highest grain yield (10.09 t ha^{-1}) and Stover yield (11.55 t ha^{-1}).

Introduction

Maize (*Zea mays*) is a cereal crop grown all around the world. It serves as the third important cereal next to Rice and Wheat. Even though the maize consumption by human as food is minimum when compared to other cereals, it gains the importance as poultry feed. In India, it has its scope due to its ability to grow throughout the year and its adaptability to the sub continental climatic conditions and also because of our country's cattle and poultry populations, as it acts as a good feed source. The reuse of wastes for agricultural purpose to improve soil properties and increase crop yield is a good solution for effective waste management. Nowadays, with increasing demand to conserve natural resources and energy, recycling of wastes assumes major importance (Padmavathiamma *et al.,* 2008). The organic waste of plant and animal origin provides a good source of nutrients to improve soil productivity. The extensive tillage operations without the addition of organic matter (OM) the soil health is degrading. The organic matter content in soil can be increased by the addition of organic wastes such as Municipal solid waste, bagasse ash, Pressmud, Rice husk ash etc. The quality of soil and improvement of soil health can be restored by incorporation of recycling organic wastes in the soil (Zhang *et al.,* 2014). Considering the importance of the above aspects, field study was carried outto study the direct effect of conventional and non- conventional organic sources and industrial by-products on the growth and yield of maize

Materials and Methods

The field experiment was conducted during April to June 2018 at the farmer's field in Karapadi village, Sathyamangalam taluk, Erode district located in Western Zone of Tamil Nadu at an altitude of 577.6 meters above mean sea level. The experiment was conducted with nine treatment such as RDF as control, 100 % RDF + Municipal solid waste compost @ 5 t ha^{-1} and 75 % RDF with Municipal solid waste compost @ 10 t ha^{-1}, 100 % RDF with bio-compost @ 2.5 t ha^{-1} and 75 % RDF with bio-compost @ 5 t ha^{-1}, 100 % RDF with Bagasse Ash @ 5 t ha^{-1} and 75% RDF with Bagasse Ash @ 10 t ha^{-1}, 100 % RDF with Rice Husk Ash @ 5 t ha^{-1} and 75 % RDF with Rice Husk Ash @ 10 t ha^{-1}in a Randomized Block Design (RBD) and replicated thrice.

Sowing and application of organics

The Maize variety KAVERI 25K55 was sown in the treatment plots. The RDF 150:75:75 N: P_2 O_5: K_2O kg ha^{-1} and organics such as Municipal solid waste, bagasse ash, Pressmud (bio-compost), Rice husk ash were applied to the respective plots.

Biometric observation

In each treatment, five samples were taken and the mean of those samples were used for recording growth parameters. The plant heights of selected five plants were measured from the base of the plant to fully opened top leaf. Leaf length was measured from the junction of the leaf blade and leaf sheath at the time of harvest from the randomly selected plants and the mean of observation were expressed in cm. Leaf width from randomly selected five plants was measured from the widest part of the leaf of each leaf at the time of harvest and the mean of observation were expressed in cm. Leaf area was measured by following formula Leaf area = Length x Breadth x Factor. The length of the fully opened leaf lamina was measured from the base to the tip. Leaf breadth was taken at the widest point of the leaf lamina. The product of the leaf length and breadth was multiplied by the factor 0.75 (Saxena and Singh, 1968) and the sum of all the leaves was expressed as leaf area in dm^2 plant^{-1}.

Leaf area index (LAI)

Leaf area index is defined as leaf area (assimilatory source) per unit land area. It was calculated by dividing the leaf area per plant by land area occupied by single plant (Sestak *et al.,* 1971).

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area (cm}^2\text{)}}$$

Yield parameters

The cobs from plants at the time of harvest were used to record the yield components. Length of the cob from randomly tagged five plants was measured from the base to the tip of the cob and the average was expressed in centimetre. Cob girth selected from the tagged five plants was selected and their circumferences are measured at the centre of the cobs using thread.

This was taken as girth of the cob and average of those was expressed in centimetre. Grain number cob^{-1} was obtained by manual counting of number of grains after separation of grains from cob in a randomly selected five plants and average was recorded as number of grains cob^{-1}. Number of kernel rows per cob was counted in randomly selected each five plants and the average of those samples was taken as number of kernel rows per cob. Number of kernels per row was counted in each cob of five selected plants. The grains from the randomly tagged five plants were removed separately, air dried, cleaned and weighed. The average grain weight per cob was taken as weight of grain in gram per cob. The weight of hundred grains were recorded from the samples drawn from randomly selected five plants and then pooled and hundred seeds were taken out of it and weighed and expressed in gram per hundred seeds.

Grain yield and Stover yield

Grains were separated by threshing the produce obtained from each plot and sun dried, winnowed and weighed at physiological maturity. The grain yield obtained in each treatment was expressed in t ha^{-1}. Stover obtained from each plot was dried under the sun for ten days and weight was recorded and expressed in t ha^{-1}.

Statistical analysis

The data obtained from the field experiment and the analytical data obtained from chemical analysis of soil and plant samples were subjected to statistical scrutiny. The statistical analysis was done by using AGRES and AGDATA packages through computer**.**

Results and Discussion

Growth attributes

Plant growth is the net result of several metabolic activity take place in different part of the plant during its growth and development. In maize, the growth parameters like plant height, no. of leaf plant^{-1}, leaf length and leaf width directly contribute to the economic yield of grain and stover.

There exists a significant variation between the control and other treatments of the maize crop. Among the Conventional, Non-conventional Organic Sources and Industrial By-Products MSWC found to be increase the plant height, when compared to other treatment. 75% RDF + MSWC @ 10 t ha^{-1} registered its superiority by registering significantly taller plants (219.6 cms) when compared to all other organic source treatments. However the treatment 75% RDF + Bagasse ash @ 10 t ha^{-1} (201 cm) registered the lowest plant height. Among the organic sources, MSWC produced the tallest plant which might be due to higher mineralization and availability of nutrients in the root zone of the soil. The lower height of maize plant was observed in Bagasse ash which might be due to their unsynchronized and slower decomposition.

The leaf length, Leaf breadth, Leaf area per plant was influenced by conventional, non-conventional organic sources and industrial by products treatments. It was highest in 75% RDF + MSWC @ 10 t ha^{-1} and recorded leaf length of 121 cm, Leaf breath of 9.2cm, leaf area per plant 50.22cm^2which was comparable with 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}. The treatment receiving 75% RDF + Bagasse ash @ 10 t ha^{-1} registered the lowest values leaf length (104.8 cm), Leaf breadth (8.1cm) and leaf area $plant^{-1}$of 38.35 cm^2

The data on the effect of conventional, non-conventional organic sources and industrial by products significantly influenced the leaf area index. The highest leaf area index was recorded in the treatment receiving 75% RDF + MSWC @ 10 t ha^{-1}(3.35). This was followed by the treatments 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1} (3.27). The treatment receiving 75% RDF + bagasse ash @ 10 t ha^{-1} registered lowest value of 2.55. The increase in growth attributes might be due to sufficient amount of available P and micronutrients supplied by the conventional, non-conventional organic sources and industrial by products (Njoku and Mhah 2012).

Yield parameters

Significant difference in cob length was observed due to conventional, nonconventional and industrial by products. The highest cob length of 27.01cm was recorded in treatment 75% RDF + MSWC @ 10 t ha^{-1}. This was followed by the treatments 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}26.8cm. The treatment T_7 (23.1cm) receiving (75% RDF + Bagasse ash @ 10 t ha^{-1}) registered the lowest cob length.

Cob girth was non-significant due to conventional, nonconventional and industrial by products. The highest cob girth of 19.1 cm was recorded in treatment T_3 receiving 75% RDF + MSWC @ 10 t ha^{-1}.

There was significant difference in number of grains per cob due to application of conventional, nonconventional organic sources and industrial by products.

Application of municipal solid waste compost, bio-compost, bagasse ash, and rice husk ash recorded significantly highest number of grains per cob (464) in the treatment T_3 (75% RDF + MSWC @ 10 t ha^{-1}). This was followed by the treatment 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}(450). The lowest value of 405 (T_7) was recorded in the treatment receiving 75% RDF + Bagasse ash @ 10 t ha^{-1}.

Grain weight cob^{-1} differed significantly with respect to application of conventional, nonconventional organic sources and industrial by products.

The treatment T_3 (75% RDF + MSWC @ 10 t ha^{-1}) recorded the highest grain weight of 186.6 g per cob. This was followed by the treatment 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}(180.72g), T_5 (169.94g), and T_4 (186.69g) were on par with each other. The treatment T_8 (165.29), T_9 (161.7g), T_6 (159.3g) and T_1 (156.62g) were comparable with each other. The lowest value was registered in the treatment T_7 (153.9g).

100 grain weight was non-significant due to application of MSWC, BC, BA, and RHA. The highest value of 38.9 g was registered in the treatment T_3 (75% RDF + MSWC @ 10 t ha^{-1}). This was followed by the treatments 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1} and T_4 (38.8g), T_5 (38.7g), T_6 (38.6g), T_8 (38.5g), T_9 (38.4g) and T_1 (38.2g) stand next in order. The lowest value of 38 g was recorded in the treatment T_7.

Table.1 Effect of conventional, non-conventional organic sources and industrial by-products on plant height, leaf length, leaf width, leaf area per plant and leaf area index

Treatments	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area per plant (cm^2)	Leaf area index
T_1 - Control 100 % RDF	204	106	8.2	39.44	2.63
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	216	119	9.1	48.98	3.27
T_3 - 75 % RDF + Municipal Solid Waste Compost @10 t ha^{-1}	219	121	9.2	50.22	3.35
T_4 - 100 % RDF + Bio-compost @ 2.5 t ha^{-1}	212	115	8.7	45.66	3.17
T_5 - 75% RDF + Bio-compost @ 5 t ha^{-1}	213	117	9	47.53	3.04
T_6 - 100 % RDF + Bagasse Ash @ 5 t ha^{-1}	207	107	8.3	40.18	2.90
T_7 - 75 % RDF + Bagasse Ash @ 10 t ha^{-1}	201	104	8.1	38.25	2.55
T_8 - 100 % RDF + Rice Husk Ash @ 5 t ha^{-1}	211	112	8.5	43.50	2.79
T_9 - 75 % RDF + Rice Husk Ash @ 10 t ha^{-1}	210	110	8.4	41.79	2.68
Mean	205	112	8.6	43.94	2.93
S.Ed	8.0	4.0	0.35	3.58	0.23
CD (p = 0.05)	18.0	9.0	0.7	7.59	0.50

Table.2 Effect of conventional, non-conventional organic sources and industrial by-products on cob length, cob girth and No. of grains cob^{-1}.

Treatments	Cob length (cm)	Cob girth (cm)	No. of grains cob^{-1}
T_1 - Control 100 % RDF	23.40	17.6	410
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	26.80	18.9	450
T_3 - 75 % RDF + Municipal Solid Waste Compost @10 t ha^{-1}	27.01	19.1	464
T_4 - 100 % RDF + Bio-compost @ 2.5 t ha^{-1}	26.00	18.5	430
T_5 - 75% RDF + Bio-compost @ 5 t ha^{-1}	26.60	18.8	438
T_6 - 100 % RDF + Bagasse Ash @ 5 t ha^{-1}	23.60	17.8	415
T_7 - 75 % RDF + Bagasse Ash @ 10 t ha^{-1}	23.10	17.4	405
T_8 - 100 % RDF + Rice Husk Ash @ 5 t ha^{-1}	23.80	18.4	428
T_9 - 75 % RDF + Rice Husk Ash @ 10 t ha^{-1}	25.70	18.0	420
Mean	25.11	18.2	430
S.Ed	1.01	0.74	17.65
CD (p = 0.05)	2.15	NS	37.0

Table.3 Effect of conventional, non-conventional organic sources and industrial by-products on 100 grain weight, Grain weight cob^{-1}, No of kernel rows cob^{-1} and No of kernels row^{-1}.

Treatments	Grain weight cob^{-1} (g)	100 grain weight (g)	No of kernel rows cob^{-1}	No of kernels row^{-1}
T_1 - Control 100 % RDF	156.6	38.20	13.8	27.1
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}	180.72	38.80	14.8	30.0
T_3 - 75 % RDF + Municipal Solid Waste Compost @10 t ha^{-1}	186.60	38.90	15	31.0
T_4 - 100 % RDF + Bio-compost @ 2.5 t ha^{-1}	166.41	38.80	14.5	28.4
T_5 - 75% RDF + Bio-compost @ 5 t ha^{-1}	169.94	38.70	14.6	29.0
T_6 - 100 % RDF + Bagasse Ash @ 5 t ha^{-1}	159.30	38.60	14.1	27.4
T_7 - 75 % RDF + Bagasse Ash @ 10 t ha^{-1}	153.90	38.00	13.5	26.8
T_8 - 100 % RDF + Rice Husk Ash @ 5 t ha^{-1}	165.20	38.50	14.5	28.3
T_9 - 75 % RDF + Rice Husk Ash @ 10 t ha^{-1}	161.70	38.40	14.3	28.1
Mean	168.27	38.50	14.3	28.4
S.Ed	6.96	1.56	0.58	0.97
CD (p = 0.05)	14.75	NS	NS	2.1

Table.4 Effect of conventional, non-conventional organic sources and industrial by-products on grain yield and stover yield.

Treatments	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)
T_1 - Control 100 % RDF	8.90	9.67
T_2 - 100 % RDF + Municipal Solid Waste Compost @ 5 $t\ ha^{-1}$	9.75	11.26
T_3 - 75 % RDF + Municipal Solid Waste Compost @10 $t\ ha^{-1}$	10.09	11.55
T_4 - 100 % RDF + Bio-compost @ 2.5 $t\ ha^{-1}$	9.50	10.66
T_5 - 75% RDF + Bio-compost @ 5 $t\ ha^{-1}$	9.71	11.18
T_6 - 100 % RDF + Bagasse Ash @ 5 $t\ ha^{-1}$	9.23	9.83
T_7 - 75 % RDF + Bagasse Ash @ 10 $t\ ha^{-1}$	8.70	9.41
T_8 - 100 % RDF + Rice Husk Ash @ 5 $t\ ha^{-1}$	9.40	10.54
T_9 - 75 % RDF + Rice Husk Ash @ 10 $t\ ha^{-1}$	9.10	10.34
Mean	9.37	10.49
S.Ed	0.38	0.43
CD ($p = 0.05$)	0.81	0.91

Number of kernel rows per cob was non-significant with respect to the application of conventional, nonconventional organic sources and industrial by products. The maximum number of kernel rows per cob (15) was recorded in treatment T_3 (75% RDF + MSWC @ 10 t ha^{-1}). This was followed by the treatment 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}(14.8), T_5 (14.6), T_4 and T_8 (14.5), T_9 (14.3), T_6 (14.1), T_1 (13.8) stand next in order. The lowest value of T_7 (13.5) was recorded in the treatment receiving 75% RDF + Bagasse ash @ 10 t ha^{-1}.

Number of kernels per row differed significantly with respect to application of conventional, nonconventional organic sources and industrial by products. Higher number of kernels per row (31) was registered in the treatment T_3 receiving75% RDF + MSWC @ 10 t ha^{-1}. This was followed by the treatment 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}(30), and T_5 (29) which were on par with each other. The treatment T_4 (28.4), T_8 (28.3), T_9 (28.1) stand next in order. The treatment T_6 (27.4) and T_1 (27.1) were comparable with each other. The treatment T_7 (75% RDF + Bagasse ash @ 10 t ha^{-1}) recorded the lowest yield of 26.8. The yield parameters increased combined use of chemical fertilizer and MSWC might be due to improvement in the availability of plant nutrients and balanced supply of nutrients through MSWC and inorganic fertilizers that might have induced the cell division, expansion of cell wall, photosynthetic efficiency increased nutrient absorption by increased root activity, this resulting in better growth and development of crop. This was in accordance with the findings of Albert Ribas Agusti *et al.*, (2016).

Grain yield

The treatments were significant due to the application of conventional, nonconventional organic sources and industrial by products. The highest grain yield of 10.09 t ha^{-1} was recorded in the treatment T_3 (75% RDF + MSWC @ 10 t ha^{-1}). This was followed by the treatment 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}(9.75 t ha^{-1}), T_5 (9.7 t ha^{-1}), T_4 (9.5 t ha^{-1}) and T_8 (9.4 t ha^{-1}) which were comparable with each other. The lowest grain yield of 8.7 t ha^{-1}was registered in treatment T_7 receiving 75% RDF + Bagasse ash @ 10 t ha^{-1}. The easy availability of nutrients leading to balanced C: N ratio enhancing the vegetative growth resulting in high photosynthetic activity was help to increase the grain yield. (Onwudiwe *et al.*, 2013).

Stover yield

Significant difference was observed among the conventional, nonconventional organic sources and industrial by products. Among treatments the highest Stover yield of 11.55 t ha^{-1} was recorded in the treatment T_3 (75% RDF + MSWC @ 10 t ha^{-1}). This was followed by the treatments 100 % RDF + Municipal Solid Waste Compost @ 5 t ha^{-1}(11.26 t ha^{-1}), T_5 (11.18 t ha^{-1}) and T4(10.66 t ha^{-1}) were on par with each other. The treatment T_7 (75% RDF + Bagasse ash @ 10 t ha^{-1}) recorded lowest Stover yield of 9.41 t ha^{-1}. This may be due to the higher amount of K in the added organic sources and the role of potassium on production of enzyme activity and enhanced translocation, assimilation and photosynthesis which resulted to increase the stover yield.

From the above, it could be concluded that MSWC along with 75 per cent of RDF was found to be the suitable for Maize crop shall be advocated to INM Maize as it resulted in higher production. The post era of green revolution has led to environmental pollution due to excessive use of agrochemicals and fertilizers and thus threatened the fragile ecosystem. INM is the key to a sound development which avoids over use of harmful chemicals and use of natural resources such as organic matter, minerals and microbes to the environment clean, ecological balance and to provide stability to the production without polluting the soil, water and air.

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