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RELATIVE EFFICACY OF DIFFERENT SOURCE OF ORGANIC MATERIALS COMBINED WITH INORGANIC SOURCE OF NITROGEN ON PHYSIOLOGICAL PARAMETERS AND YIELD OF MAIZE IN MAIZE-MUSTARD CROPPING SYSTEM UNDER SANDY LOAM SOILS OF TELANGANA, INDIA

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ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station, Polasa, Jagtial during *kharif*, 2018 and 2019 to study the effect of integrated nutrient management practices on physiological parameters (leaf area index, leaf area duration, leaf chlorophyll content) and yield of maize. The experiment was laid out in a randomized block design for maize during *kharif*, 2018 with nine treatments comprising of T_1-100% RDF, T_2-75% RDN + 25% N through FYM, T_3-75 % RDN + 25% N through vermicompost, T_4-75% RDN + 25% N through poultry manure, T_5-75% RDN+ 25% N through sheep manure, T_6-75% RDN + 25% N through neem cake, T_7-75% RDN + *Azotobacter* @ 5 kg $ha^{-1,}$ T_8-75% RDN + *Azospirillum* @ 5 kg ha^{-1}, T_9-75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1} replicated thrice. Significantly higher leaf area index, leaf area duration, leaf chlorophyll content and grain yield (kg ha^{-1}) were recorded. Among the different treatments, application of 75 % RDN + 25% N through vermicompost recorded, more grain yield (6349 and 6514 kg ha^{-1} in 2018 and 2019, respectively) over 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 5 kg ha^{-1}. While, it is comparable with 100% RDF, 75% RDN + 25% N through FYM and 75% RDN + 25% N through sheep manure.

Key words : Maize, Leaf area index, Leaf area duration, Chlorophyll content, Yield.

Introduction

Maize (*Zea mays* L.) is the world's third most important cereal crop after wheat and rice. It accounts to 8% and 25% of the world's total area and production, respectively under cereal crops. In India, maize occupies an area of 9.5 M. ha with an average production of 28.7 M.t with productivity of 3006 kg ha^{-1}, while in Telangana it is grown in an area of 0.56 M.ha with production of 2.99 M.t productivity of 5347 kg ha^{-1} (CMIE, 2020).

Nutrient management in maize is one of the significant yields influencing character. The organic sources besides supplying N, P and K also make unavailable source of elemental nitrogen, bound phosphorus, micronutrients and decomposed plant residues into available form to facilitate plant to absorb the nutrients. But, the combined use of chemical fertilizers along with various organic sources is capable of improving soil quality and crop productivity on long term basis. As cropping system serves as a component of integrated nutrient management (INM) for sustaining the productivity of the system through efficient nutrient cycling, balanced fertilization must be based on the concept of the system as a whole rather than a single crop. Intensified and multiple cropping systems require judicious application of chemical, organic and bio-fertilizers for yield sustainability and improved soil health.

Such integrated application is not only complementary but also has synergistic effects. Therefore, the nutrient needs of crop production systems can be met through integrated nutrient management and sustainable crop productivity, nutrient uptake and soil nutrient status in maize based cropping systems (Kemal and Abera, 2015).

Materials and Methods

A field experiment entitled "Effect of organic and inorganic sources of nitrogen on yield attributes and yield of maize under sandy loam soil conditions in Northren Telangana zone" was conducted during *kharif* 2018 and 2019 at Regional Agricultural Research Station, Polasa, Jagtial, Northern Telangana Zone of Telangana state. The soil of experimental site was sandy loam with pH of 7.7, Electrical conductivity 0.23 dSm^{-1}, low in organic carbon (0.30%), low in available nitrogen (180 kg ha^{-1}) and medium in phosphorus (53 kg ha^{-1}) and medium in potassium (315 kg ha^{-1}). The experiment was laid out in a randomized block design for maize during *kharif* 2018 and 2019 with nine treatments consisting of 100% RDF, 75% RDN + 25% N through FYM, 75% RDN + 25% N through vermicompost, 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through sheep manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azotobacter* @ 5 kg ha^{-1}, 75% RDN+ *Azospirillum* @ 5 kg ha^{-1} and 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum*@ 2.5 kg ha^{-1}. Crop was sown at spacing of 60 cm × 20 cm on 27th June during 2018 and 26th June during 2019. Organic manures were applied (on equal N basis) as per the treatment and incorporated into the soil 30 days before sowing. Crop was fertilized with uniform level of 60 kg P_2O_5 and 50 kg K_2O ha^{-1}. Half of the total N and full P and K fertilizers were applied at the time of sowing. Remaining N was applied at knee high stage by pocketing method and free living *Azotobacter* sp, *Azospirillum* sp were applied one day before sowing as per the treatments and incorporated into the soil. The required amount of N, P and K fertilizers was applied through urea, SSP and Muriate of potash, respectively. Other cultural operations and plant protection measures were followed as per the recommendations. Crop received 603 mm (31 rainy days) and 746 mm (44 rainy days) rainfall during the crop growth period in 2018 and 2019, respectively.

Leaf area index

Leaf area of maize from each plot was measured by using LI-3100 leaf area meter at 30, 60, 90 days after sowing and harvest and the following formula was used to obtain leaf area index (LAI) (Sestak *et al.,* 1971).

$$LAI = \frac{\text{Total leaf area (cm}^2\text{)}}{\text{Land area occupied by the plants (cm}^2\text{)}}$$

Leaf area duration (dm^2 days)

Leaf area duration (LAD) is an integral of leaf area index over the growth period (Watson, 1952). Leaf area duration at 30, 60, 90 DAS and at harvest was worked out by using the formula as stated by Power *et al.* (1967) and expressed in days.

$$LAD = \frac{(L_1+L_2)}{2} \times (t_2 - t_1)$$

Where,

LAD = Leaf area duration in days.

L_1, L_2 = LAI at stage 1 and 2

t_2-t_1 = Time interval in days between stages 1 and 2

Chlorophyll content (SPAD Value)

The SPAD-502 meter was used to record the readings on 10 green leaves from 5 plants in each treatment. The measurements were made on 30, 60, 90 days after sowing and harvest.

The instrument measures the transmission of red light at 650 nm at which chlorophyll absorbs light and transmission of infra-red light at 940 nm at which no absorption occurs. The chlorophyll concentration was measured from these SPAD values using the following relationships developed by Ling *et al.* (2011). The total chlorophyll per unit area (n moles cm^{-2}) was worked out from the equation

$$Y = 0.0419x^2 + 1.6475x + 1.5239. R^2 = 0.99$$

The chlorophyll concentration mg^{-1} fresh weight of leaf tissue was obtained from the relationship

$$Y = 0.0007 x^2 + 0.0230 x + 0.0544. R^2 = 0.9809$$

Results and Discussion

Leaf area index

Leaf area index computed at 60, 90 days after sowing and at harvest differed significantly with different fertilizer levels and their integration with 25% recommended dose of nitrogen through FYM or vermicompost or sheep manure or the substitution of 25% nitrogen with neem cake or the addition of *Azotobacter* and *Azospirillum* @ 5 kg ha^{-1} each and their combined application @2.5 kg ha^{-1} each except at 30DAS (Table 1 and Fig. 1). The leaf area index tends to increase up to 90 DAS, beyond which, it tends to decline towards harvest.

At 60 DAS, significantly higher leaf area index was recorded with application of 75% RDN + 25% N through vermicompost (4.08 and 4.10 during 2018 and 2019

Table 1 : Leaf area index of maize as influenced by integrated nutrient management treatments.

Treatments	2018				2019			
	30DAS	60DAS	90DAS	Harvest	30DAS	60DAS	90DAS	Harvest
T_1- 100% RDF	1.06	3.76	4.17	1.89	1.11	3.94	4.35	1.98
T_2-75% RDN + 25% N through FYM	1.05	3.67	4.12	1.87	1.09	3.80	4.27	1.85
T_3-75% RDN + 25% N through vermicompost	1.07	4.08	4.37	2.08	1.12	4.10	4.53	2.02
T_4-75% RDN + 25% N through poultry manure	0.92	3.52	3.80	1.78	1.00	3.55	3.95	1.72
T_5-75% RDN+ 25% N through sheep manure	1.01	3.60	3.90	1.85	1.03	3.63	4.24	1.80
T_6-75% RDN + 25% N through neem cake	0.91	3.47	3.79	1.74	0.98	3.49	3.92	1.68
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	0.87	3.10	3.41	1.61	0.89	3.26	3.55	1.62
T_8-75% RDN+ *Azospirillum* @ 5 kg ha^{-1}	0.88	3.31	3.54	1.66	0.95	3.37	3.58	1.63
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+ *Azospirillum* @ 2.5 kg ha^{-1}	0.89	3.36	3.61	1.68	0.95	3.41	3.89	1.64
SEm±	0.07	0.24	0.25	0.12	0.07	0.23	0.26	0.13
CD (*p*=0.05)	NS	0.51	0.53	0.25	NS	0.49	0.55	0.28

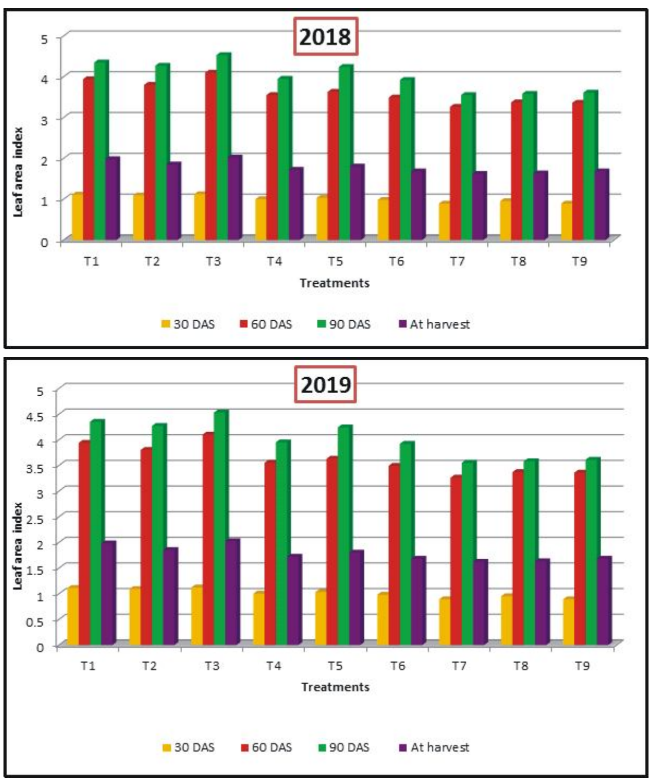

Fig. 1 : Leaf area index at different growth stages of maize as influenced by integrated nutrient management treatments.

respectively), which was on par with 100% RDF (3.76 and 3.94 during 2018 and 2019, respectively), 75% RDN + 25% N through FYM (3.67 and 3.80 during 2018 and 2019, respectively) and 75% RDN + 25% N through sheep manure (3.60 and 3.63 during 2018 and 2019 respectively) and significantly superior to 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}. Application of 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (3.10 and 3.26 during 2018 and 2019, respectively), recorded the lowest leaf area index.

At 90 DAS significantly higher leaf area index was recorded with application of 75% RDN + 25% N through vermicompost (4.37 and 4.53 during 2018 and 2019 respectively), which was on par with 100% RDF (4.17 and 4.35 during 2018 and 2019 respectively), 75% RDN + 25% N through FYM (4.12 and 4.27 during 2018 and 2019 respectively) and 75% RDN + 25% N through sheep manure (3.90 and 4.24) during 2018 and 2019 respectively. Application of 75% RDN + *Azotobacter* @ 5 kg ha^{-1} recorded the lower leaf area index of 3.41 and 3.55 during 2018 and 2019, respectively.

At harvest significantly higher leaf area index was recorded with application of 75% RDN + 25% N through vermicompost (2.08 and 2.02 during 2018 and 2019 respectively) which was on par with 100% RDF (1.89 and 1.98 during 2018 and 2019, respectively), 75% RDN + 25% N through FYM (1.87 and 1.85 during 2018 and 2019 respectively) and 75% RDN + 25% N through sheep manure (1.85 and 1.80) during 2018 and 2019 respectively. Application of 75% RDN + *Azotobacter* @ 5 kg ha^{-1} recorded the lower leaf area index of 1.61 and 1.62 during 2018 and 2019, respectively.

Leaf area index is principal important growth parameter in all crops, since the optimum leaf area is required for a maximum light interception, which results in higher photosynthesis (Boote *et al.*, 1996). The

Table 2 : Leaf area duration (dm^2 days) of maize as influenced by integrated nutrient management treatments.

Treatment	2018			2019		
	30-60 DAS	61-90 DAS	91DAS-Harvest	30-60 DAS	61-90 DAS	91DAS-Harvest
T_1- 100% RDF	72.2	115.0	31.3	75.7	120.1	32.8
T_2-75% RDN + 25% N through FYM	70.8	112.9	32.0	73.5	117.1	31.7
T_3-75% RDN + 25% N through vermicompost	77.3	122.5	33.4	78.2	125.1	36.0
T_4-75% RDN + 25% N through poultry manure	66.6	106.1	27.8	68.3	108.7	27.4
T_5-75% RDN+ 25% N through sheep manure	69.1	108.7	30.6	69.9	114.1	31.1
T_6-75% RDN + 25% N through neem cake	65.8	105.3	27.6	66.9	107.4	25.2
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	59.6	94.5	26.1	62.2	98.7	24.2
T_8-75% RDN+ *Azospirillum* @ 5 kg ha^{-1}	62.9	99.3	26.8	64.7	100.8	25.3
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}	63.7	101.0	27.2	65.5	105.9	26.8
SEm±	3.92	4.41	2.22	3.83	5.66	2.83
CD (p=0.05)	8.31	9.35	4.71	8.12	12.00	6.00

significant response to vermicompost or FYM or sheep manure application on leaf area index of maize might be due to addition of manures likely to increase the respiration rate, metabolism and growth of plants (Shabnam *et al.*, 2011; Atarzadeh *et al.*, 2013). Further, the beneficial effect of organic manures on leaf area index might be due to synthesis of certain phytohormones and vitamins and more interception of solar radiation and synthesis of more chlorophyll, more photosynthetic rate and accumulation of more assimilates which resulted in higher leaf area index in maize (Zeinab *et al.*, 2014).

Leaf area duration (LAD)

Data pertaining to the leaf area duration of maize at 30-60 DAS, 61-90 DAS and 91 days after sowing to harvest as influenced by different fertilizer levels and their integration with 25% RDN through vermicompost or FYM or poultry manure or sheep manure or neem cake or the addition of *Azotobacter* and *Azospirillum* @ 5 kg ha^{-1} each and their combined application @ 2.5 kg ha^{-1} each presented in Table 2 and Fig. 2. Leaf area duration increased with the age of crop up to 90 DAS and thereafter decreased towards maturity.

At 30-60 DAS the leaf area duration recorded significantly higher with application of 75% RDN + 25% N through vermicompost (77.3 and 78.2 dm^2 days during 2018 and 2019 respectively) over 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}. While, it was comparable with 100% RDF (72.2 and 75.7 d m^2 days during 2018 and 2019, respectively) and 75% RDN + 25% N through FYM (70.8 and 73.5 dm^2 days during 2018 and 2019 respectively) and 75% RDN + 25% N through sheep manure (69.1 and 69.9 dm^2 days during 2018 and 2019, respectively) over 75% RDN +

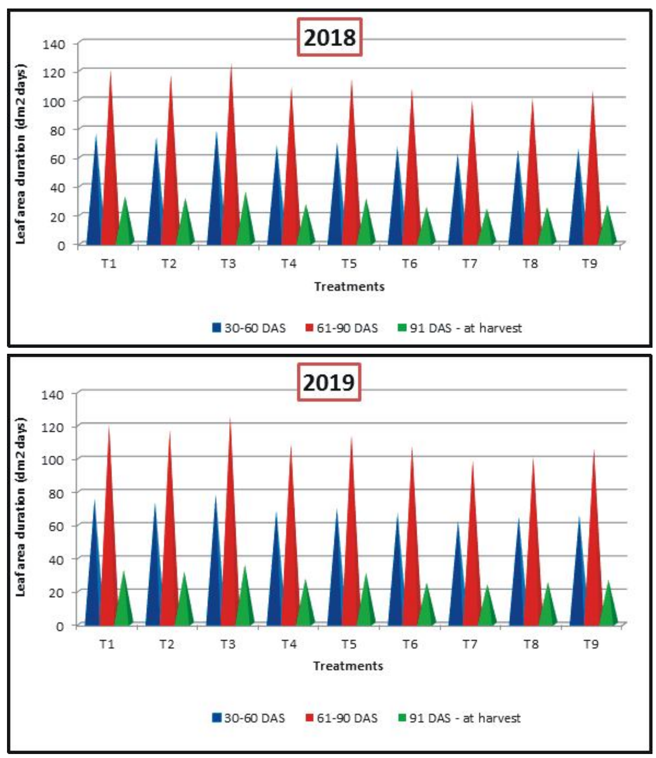

Fig. 2 : Leaf area duration at different growth stages of maize as influenced by integrated nutrient management treatments.

25% N through poultry manure, 75% RDN + 25% N through Sheep manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}. Significantly lower leaf area duration was recorded with 75% RDN + *Azotobacter @ 5* kg ha^{-1} (59.6 and 62.2 dm^2 days during 2018 and 2019, respectively).

At 61-90 DAS the leaf area duration recorded significantly higher with application of 75% RDN + 25% N through vermicompost (122.5 and 125.1dm^2 days during 2018 and 2019 respectively) over 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through sheep manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}. While, it was comparable with100% RDF (115.0 and 120.1 dm^2 days during 2018 and 2019 respectively) and 75% RDN + 25% N through FYM (112.9 and 117.1 dm^2 days during 2018 and 2019 respectively) during 2018 and 2019 respectively. Significantly, lower leaf area duration was recorded with 75% RDN + *Azotobacter @ 5* kg ha^{-1} (94.5 and 98.7 dm^2 days during 2018 and 2019, respectively).

At 91 DAS - at harvest, the leaf area duration recorded significantly higher with application of 75% RDN + 25% N through vermicompost (33.4 and 36.0 dm^2 days during 2018 and 2019 respectively) over 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through sheep manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter @ 5* kg ha^{-1}, 75% RDN + *Azotobacter @ 2.5* kg ha^{-1} + *Azospirillum @ 2.5* kg ha^{-1}. While, it was on par with 100% RDF (31.3 and 32.8d m^2 days during 2018 and 2019 respectively) and75% RDN + 25% N through FYM (32.0 and 31.7 dm^2 days during 2018 and 2019, respectively). Significantly lower leaf area duration was recorded with 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (26.1 and 24.2 dm^2 days during 2018 and 2019, respectively).

Photosynthetic productivity was not only related to LAI, but also related to LAD. It indicates the maintenance of assimilatory surface area over a period of time, which is prerequisite for prolonged photosynthetic activity and the ultimate productivity in crop plants. The duration of the leaf area reflects the photosynthesis time of maize and has great influence on the yield because the grain is primarily composed of starch. Kumar and Singh (2001) and Muqarrab *et al.* (2015) also reported increased LAD with increase in integrated nutrient management in maize crop.

Chlorophyll content

Leaf chlorophyll content is an important parameter frequently measured as an indication of chloroplast development, photosynthetic capacity, leaf nitrogen content or general plant health (Ling *et al*., 2011). In the present investigation, during both the years of study leaf chlorophyll content, no significant difference was observed with leaf chlorophyll content due to different treatments at 30, 90 DAS and harvest except 60 DAS, where the chlorophyll content exhibited significant differences due to application of nitrogenous fertilizer significantly with different fertilizer levels and their integration with 25% nitrogen through FYM or vermicompost or poultry manure or sheep manure or the substitution of 25% nitrogen with neem cake or the addition of *Azotobacter* and *Azospirillum* @ 5kg ha^{-1} each and their combined application of @ 2.5 kg ha^{-1} each with organic sources at 60 DAS (Tables 3 and 4).

At 60 DAS significantly higher chlorophyll content was recorded with application of 75% RDN + 25% N through vermicompost (189.1 and 198.7 n mole cm^{-2} during 2018 and 2019 respectively) which was comparable with 100% RDF (173.6 and 183.4 n mole cm^{-2}), 75% RDN + 25% N through FYM (173.3 and 181.9 n mole cm^{-2} during 2018 and 2019 respectively) and 75% RDN + 25% N through sheep manure (172.1 and 180.8 n mole cm^{-2} during 2018 and 2019 respectively) and significantly superior to 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azotobacter* @ 5 kg ha^{-1} (128.5 and 131.6 n mole cm^{-2} during 2018 and 2019 respectively), which in turn recorded the lowest chlorophyll content.

At 60 DAS significantly higher chlorophyll content was recorded with application of 75% RDN + 25% N through vermicompost (2.96 and 3.11 n mole mg^{-1} fresh weight during 2018 and 2019 respectively), which was comparable with 100% RDF (2.72 and 2.87 n mole mg^{-1} fresh weight during 2018 and 2019 respectively), 75% RDN + 25% N through FYM (2.71 and 2.85 n mole mg^{-1} fresh weight) and 75% RDN + 25% N through sheep manure (2.69 and 2.83 n mole mg^{-1} fresh weight during 2018 and 2019 respectively) and significantly superior to 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}. Application of 75% RDN +

Table 3 : Chlorophyll content (n mole cm^{-2}) of maize as influenced by integrated nutrient management treatments.

Treatments	2018				2019			
	30DAS	60DAS	90DAS	At harvest	30DAS	60DAS	90DAS	At harvest
T_1- 100% RDF	41.9 (144.6)	47.4 (173.6)	40.63 (138.9)	10.6 (23.8)	42.7 (148.5)	49.1 (183.4)	42.2 (145.6)	11.2 (25.2)
T_2-75% RDN + 25% N through FYM	41.1 (140.4)	47.3 (173.3)	39.53 (132.7)	10.2 (22.7)	42.5 (147.8)	48.7 (181.9)	43.9 (155)	10.2 (22.8)
T_3-75% RDN + 25% N through vermicompost	42.2 (146.2)	50.1 (189.1)	43.6 (153.5)	11.9 (27.3)	43.1 (150.7)	51.7 (198.7)	45.3 (162.2)	12 (27.4)
T_4-75% RDN + 25% N through poultry manure	41.2 (140.7)	44.9 (159.8)	38.0 (124.8)	9.4 (20.6)	41.8 (143.6)	46 (165.9)	43.5 (153.1)	9.8 (21.8)
T_5-75% RDN+ 25% N through sheep manure	41.8 (143.9)	47.1 (172.1)	38.3 (126.7)	10.1 (22.5)	42 (145.4)	48.6 (180.8)	44.1 (155.9)	10.1 (22.5)
T_6-75% RDN + 25% N through neem cake	40.3 (136)	44.3 (156.6)	37.7 (123.4)	9.1 (20)	41.7 (144.1)	44.6 (158.4)	42.2 (148.4)	9.3 (20.5)
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	37.9 (124.7)	38.7 (128.5)	33.9 (105.7)	8.7 (19)	39.1 (130.9)	39.3 (131.6)	41.7 (143.1)	8.8 (19.4)
T_8-75% RDN+ *Azospirillum* @ 5 kg ha^{-1}	39 (129.9)	40.3 (136.9)	34.9 (110.7)	8.8 (19.2)	40.8 (138.9)	42.7 (148.4)	41.7(143.3)	8.9(19.5)
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1}+ *Azospirillum* @ 2.5 kg ha^{-1}	39.9 (134.2)	41.6 (142.4)	35.1 (111.3)	9 (19.9)	41.4 (141.8)	43.1 (150.5)	41.8 (144.4)	9.2 (20.4)
SEm±	12.55	11.35	15.62	2.40	15.81	13.80	16.82	2.41
CD (p=0.05)	NS	24.06	NS	NS	NS	29.26	NS	NS

Figures outside the brackets are SPAD values. NS : Non-significant.

Azotobacter @ 5 kg ha^{-1} (2.0 and 2.05 n mole mg^{-1} fresh weight during 2018 and 2019 respectively), recorded the lowest chlorophyll content.

The substitution of 25% nitrogenous fertilizer either with vermicompost, FYM, sheep manure had equivocal effect on the chlorophyll content has with the entire level of nitrogen through the fertilizer. This response was consistent both during the 2018 and 2019. Obviously, the integration of these organic sources does not undermine the level of chlorophyll content in maize at the most crucial stage of flowering. On the contrary, substitution of 25% nitrogenous fertilizer with poultry manure and neem cake did not comply such a beneficial effect as there was a significant reduction in the chlorophyll content compared to the fertilizer treatment or the other source of organic manures substitution of 25% nitrogenous fertilizer.

Higher chlorophyll content might be due to application of nutrients synchronizing with crop demand enhanced growth, leaf turgidity as well as chlorophyll content and improved the efficiencies of fertilizers. The results are in accordance with the findings of Suryavanshi *et al.* (2008). Increased chlorophyll content with increasing nutrients, especially nitrogen, has been attributed to the direct involvement of nitrogen as a constituent for chlorophyll synthesis. Leaf chlorophyll concentration is often well correlated with plant metabolic activity. The significant impact of nutrients as chlorophyll formation has also been reported by Tajul *et al*. (2013).

Grain yield (kg ha^{-1})

The data on grain yield of maize in response to different integrated nitrogen management treatments is presented in Table 5.

During both the years of study, significantly higher grain yield of maize was recorded with application of 75% RDN + 25% RDN through vermicompost (6349 and 6514 kg ha^{-1}) which was on par with 100% RDF (6262 and 6342 kg ha^{-1}), 75% RDN + 25% RDN through FYM (6007 and 6211 kg ha^{-1}) and 75% RDN + 25% RDN through sheep manure (5424 and 5630 kg ha^{-1}) during 2018 and 2019, respectively over 75% RDN + 25% N through poultry manure, 75% RDN+25% N through neem cake,75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1} +*Azospirillum* @ 2.5kg ha^{-1}, 75% RDN + *Azospirillum* @ 5 kg ha^{-1},75% RDN+ *Azotobacter* @ 5 kg ha^{-1} (4545 and 4642 kg ha^{-1} during 2018 and 2019, respectively),which in turn recorded lower grain yield.

The pooled data over the two years indicate that

Table 4 : Chlorophyll content {n mole mg^{-1} fresh weight} of maize as influenced by integrated nutrient management treatments.

Treatments	2018				2019			
	30DAS	60DAS	90DAS	At harvest	30DAS	60DAS	90DAS	At harvest
T_1- 100% RDF	41.9 {2.25}	47.4 {2.72}	40.6 {2.17}	10.6 {0.38}	42.7 {2.32}	49.1 {2.87}	42.2 {2.27}	11.2 {0.4}
T_2-75% RDN + 25% N through FYM	41.1 {2.19}	47.3 {2.71}	39.5 {2.07}	10.2 {0.36}	42.5 {2.3}	48.7 {2.85}	43.9 {2.42}	10.2 {0.36}
T_3-75% RDN + 25% N through vermicompost	42.2 {2.28}	50.1 ({2.96}	43.6 {2.4}	11.9 {0.43}	43.1 {2.35}	51.7 {3.11}	45.3 {2.53}	12 {0.43}
T_4-75% RDN + 25% N through poultry manure	41.2 {2.19}	44.9 {2.5}	38.0 {1.94}	9.4 {0.33}	41.8 {2.24}	46 {2.59}	43.5 {2.39}	9.8 {0.35}
T_5-75% RDN+ 25% N through sheep manure	41.8 {2.24}	47.1 {2.69}	38.3 {1.97}	10.1 {0.36}	42 {2.27}	48.6 {2.83}	44.1 {2.43}	10.1 {0.36}
T_6-75% RDN + 25% N through neem cake	40.3 {2.12}	44.3 {2.44}	37.7 ({1.92}	9.1 {0.32}	41.7 {2.25}	44.6 {2.47}	42.2 {2.32}	9.3 {0.33}
T_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	37.9 {1.94}	38.7 {2}	33.9 {1.64}	8.7 {0.31}	39.1 {2.04}	39.3 {2.05}	41.7 {2.23}	8.8 {0.31}
T_8-75% RDN+ *Azospirillum* @ 5 kg ha^{-1}	39 {2.02}	40.3 {2.13}	34.91 {1.72}	8.8 {0.31}	40.8 {2.16}	42.7 {2.31}	41.7 {2.23}	8.9 {0.31}
T_9-75% RDN+ *Azotobacter* @ 2.5 kg ha^{-1} + *Azospirillum* @ 2.5 kg ha^{-1}	39.9 {2.09}	41.6 {2.22}	35.1 {1.73}	9 {0.32}	41.4 {2.21}	43.1 {2.35}	41.8 {2.25}	9.2 {0.33}
SEm±	0.20	0.18	0.25	0.04	0.25	0.22	0.27	0.04
CD (p=0.05)	NS	0.38	NS	NS	NS	0.47	NS	NS

Figures outside the brackets are SPAD values. NS : Non-significant.

the crop applied with 75% RDN + 25% N through vermicompost had significantly higher grain yield of maize (6431 kg ha^{-1}). However, it was on par with 100 % RDF 6302 kg ha^{-1}), 75% RDN + 25% N through FYM (6109 kg ha^{-1}) and75% RDN + 25% N through sheep manure 5527 kg ha^{-1}) and significantly superior to 75% RDN + 25% N through poultry manure, 75% RDN + 25% N through neem cake, 75% RDN + *Azospirillum* @ 5 kg ha^{-1}, 75% RDN + *Azospirillum* @ 5 kg ha^{-1} and 75% RDN + *Azotobacter* @ 2.5 kg ha^{-1}+*Azospirillum* @ 2.5 kg ha^{-1}.

Maize fertilized with the recommended level of 200:60:50 kg ha^{-1} NPK produced 6262 kg ha^{-1} grain yield in 2018 and 6342 kg ha^{-1} in 2019, respectively. This response was incident on sandy loam soil having a very low organic carbon content of 0.28% in the first year and 0.30% in the second year. The soil available nitrogen was also low. A plethora of literature confirmed that the present-day requirement of nitrogen is as high as 200-400 kg ha^{-1} in nitrogen starving soils (Wang *et al.*, 2020). In his review, Shaik Mohammad (2020) prompted that the excess and inappropriate application of fertilizers to improve crop production leads to an uncontrolled release of undesirable substances-nutrients and toxins in the soil, atmosphere, ground and surface waters. This is not safe for health. The soils have become sick and continuously degraded. The massive application of fertilizers and insufficient animal or green manures made the soils dusty and susceptible to erosion washing away the nutrients. Efforts to increase food grain production by the application of high doses of fertilizers with imbalanced nutrient proportions to the new high yielding varieties disrupted the equilibrium of native nutrient fertility. Rehm (2018) pointed that the green revolution varieties have a weakness. They cannot absorb as much nitrogen as the traditional varieties.

The results in the present investigation showed that the substitution of 25% recommended level of nitrogenous fertilizer with Farm Yard Manure, vermicompost, sheep manure or poultry manure are the best options to realize similar yield as with the entire recommended level of nitrogen. This trend was consistent in both the years. But the pooled analysis of variance did not maintain this consistency with the integration of sheep or poultry manure. The effect of other sources of organic complements was not effective. The substitution of 25% nitrogenous fertilizer with neem cake or the addition of *Azotobacter* and *Azospirillum* @ 5 kg ha^{-1} each and their combined application @ 2.5 kg ha^{-1} each significantly reduced the yield of maize both in 2018 and 2019. The response

Table 5 : Grain yield of maize as influenced by different nutrient sources, levels and their integration treatments.

Treatment	Grain yield(kg ha^{-1})		
	2018	2019	Pooled
N_1- 100 % RDF	6262	6342	6302
N_2-75 % RDN + 25% N through FYM	6007	6211	6109
N_3-75 % RDN + 25% N through Vermicompost	6349	6514	6431
N_4-75 % RDN + 25% N through Poultry manure	5369	5557	5463
N_5-75 % RDN+ 25% N through Sheep manure	5424	5630	5527
N_6-75 % RDN + 25% N through Neem cake	5151	5326	5239
N_7-75% RDN + *Azotobacter* @ 5 kg ha^{-1}	4545	4642	4594
N_8-75% RDN+ *Azospirillum*@ 5 kg ha^{-1}	4816	4981	4898
N_9-75% RDN+*Azotobacter*@ 2.5 kg ha^{-1} +*Azospirillum* @ 2.5 kg ha^{-1}	4973	5067	5020
Mean	5433	5586	368
SEm ±	440	436	780
CD @ 5%	934	924	8

of bacterial cultures *Azotobacter* and *Azospirillum* were highly inconsistent ranging from a positive to no response in previous investigations made by Kannan *et al.* (2019).

Adequate supply of NPK in the early stages of a plant is considered very important in promoting rapid vegetative growth and in increasing sink in terms of flowering and seed setting, including their development. Thus, overall improved growth coupled with increased net photosynthesis on one hand and greater mobilization of photosynthates towards reproductive structure on the other hand, might have improved the grain yield.

Conclusion

The results showed considerable variation in the growth of maize owing to the substitution of 25% nitrogenous fertilizer with different organic manures. The physiological parameters - leaf area index, leaf area duration, leaf chlorophyll content did not alter significantly by the substitution of 25% nitrogenous fertilizer through vermicompost, FYM or sheep manure compared to the response due to the sole application of inorganic fertilizer. The part substitution of inorganic nitrogen significantly hindered these parameters.

The existing practice of nurturing maize with inorganic supplement of 200:60:50 kg ha^{-1} NPK produced 6262 kg ha^{-1} grain yield in 2018 and 6342 kg ha^{-1} in 2019. The results showed that it is possible to substitute 25% level of nitrogenous fertilizer with vermicompost, FYM or sheep manure with equivalent production levels. The grain yield was 6349 kg ha^{-1} in 2018 and 6514 kg ha^{-1} in 2019 owing to the substitution of 25% nitrogenous fertilizer with vermicompost. Maize produced 6007 and 6211 kg ha^{-1} grain yield by the substitution of 25% nitrogenous fertilizer with FYM, while the production level realized was 5424 and 5630 kg ha^{-1} with sheep manure. The yield reduced significantly with the part substitution of inorganic fertilizer with other sources of organic nutrients.

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