Effect of Integrated Nitrogen Management on Growth and Yield of Maize and Soil Properties (*Zea mays* L.)

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Abstract

A field experiment was conducted during *kharif* 2019 on *Alfisols* (*Kandicpaleustalfs*) of farmers field at Byrasandra situated in the Eastern dry zone (Zone 5) of Karnataka to study the effect of integrated nitrogen management on growth, yield and soil properties of maize (*Zea mays* L.). The experiment was laid out in RCBD, comprising ten treatments replicated thrice. The results revealed that significantly higher plant height (207.13 cm) and number of leaves (15.53) cob length (19.53 cm), number of rows cob-1 (17.93), number of kernels row-1 (32.87) and test weight (31.53 gm) at harvest were recorded in the treatment which received 75 per cent of RDN + 50 per cent RD FYM + 25 per cent RDN equivalent vermicompost. Similarly, significantly higher kernel yield (79.62 q ha^{-1}) and stover yield (89.07 q ha^{-1}) of maize were recorded in treatment which received 75 per cent of RDN + 50 per cent FYM + 25 per cent RDN equivalent vermicompost was compared to inorganic fertilized treatment (T^2) and absolute control (T_1). Further, the soil test values of available N, P_2O_5, K2O (255.82, 51.19 and 169.87 kg ha^{-1}, respectively) after the harvest of maize were significantly higher in the plot treated with 100 per cent RDN through (inorganic 75 per cent of RDN + organic 25 per cent RDN equivalent vermicompost or USWC sources with only 50 per cent RD FYM compared to the application of a recommended dose of fertilizer (RDF) through inorganic source and absolute control (T_1). The integrated use of nitrogen along with organic manures could be the main reason for improving growth, yield and soil properties of maize crop grown in Alfisols

Keywords : INM, Maize, Vermicompost, Urban solid waste compost (USWC)

Maize (*Zea mays* L.) is multipurpose crop with wider adaptability under various agro-climatic conditions. In Karnataka, maize occupies an area of 1.34 m ha with a production of 3.91 Mt and an average productivity of 3920 kg ha^{-1} (Anonymous, 2015). Maize is being grown in India primarily as a food grain crop to meet the food demand of humans and animals. Thus, the production of quality maize is imperative to maintain the health of humans and animals. Maize's productivity is largely dependent on nutrient management during its production, as maize is a heavy feeder of nutrients. In general, the soil fertility determines in large the production potential of maize.

Intensive land use in association with continuous use of high doses of chemical fertilizers significantly influences soil health and crop growth. In view of the declining productivity levels and increased environmental risks, increasingly greater emphasis is now being given to the integrated nutrient supply system, which may play an important role in sustaining soil conditions (Sunitha *et al.*, 2020) and crop productivity. The addition of organic manures not only supplies all the essential nutrients to the growing plants in various proportion but also affects the availability of native nutrients from soil and chemical fertilizers due to release of organic acids and other microbial products during the decomposition (Chethan *et al.,* 2020). Prior to and early in the green revolution, the cultivators were solely dependent on organic manures for crop production. With the introduction of high yielding varieties / hybrids of the crop species coupled with the decline in the availability of organic manure it has become a practice to use only inorganic fertilizers. In recent years it is being advocated to use the nutrients from both sources for sustain soil health and crop productivity. Supplementing crop nutrient demand through organic sources of nutrient not only conserve the loss of nutrients but also improves the physical, chemical and biological properties of soil besides reducing the usage of commercial fertilizers, thus reducing the risk of environmental pollution by using aheavy dose of chemical fertilizers.

There are several factors like climate, nutrient availability and management practices that affect Maize's productivity. Maize is a heavy feeder of nutrients and remove large amount of nutrients from soil. Among the various plant nutrients, N is one of the major elements absorbed by plants in large quantities. Nitrogen is an integral constituent of photosynthetically active pigment, chlorophyll by virtue of which plants are able to utilize solar energy and enzyme nucleotides leading to increased growth and development, accumulation of higher dry matter and increase of higher crop growth of Maize (Gahlout *et al.,* 2010).

The information leading to efficient and economical use of integrated nitrogen management is of paramount importance. Keeping these in view, the present investigation entitled 'Effect of integrated nitrogen management on growth and yield of maize and soil properties (*Zea mays* L.)' was carried out.

Material and Methods

A field experiment was carried out to assess the effect of integrated nitrogen management on the growth and yield of maize and soil properties (*Zea mays* L.) in farmer's field at Byrasandrain Eastern Dry Zone (Zone 5) of Karnataka. The soil of the experimental site was sandy loam in texture and acidic in reaction (pH 5.81). Electrical conductivity was 0.091 dSm^{-1} with an organic carbon content of 5.20 g kg^{-1}. Available nitrogen was low (254.34 kg N ha^{-1}), phosphorus was medium (31.66 kg P_2O_5 ha^{-1}) and potassium was medium (191.30 kg K_2O ha^{-1}). The required organic manures *viz*., urban solid waste compost (USWC) was collected from Karnataka Compost Development Corporation Ltd. (KCDC), Bengaluru. Vermicompost and Farm yard manure (FYM) were procured from ZARS, UAS, GKVK, Bengaluru. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and ten treatments. Treatments consists of T_1: Absolute control, T_2: RDF (100 % NPK), T_3: RDF (100 % NPK + FYM @ 10 t ha^{-1}), T_4: 75 % RDN + 50 % RD FYM + 25 % RDN equivalent USWC, T_5: 50 % RDN + 25 % RD FYM + 50 % RDN equivalent USWC,T_6: 75 % RDN + 50 % RD FYM + 25 % RDN equivalent vermicompost, T_7: 50 % RDN + 25 % RD FYM + 50 % RDN equivalent vermicompost, T_8: 100 % RDN equivalent USWC, T_9: 100 % RDN equivalent vermicompost and T_{10}: 100 % RDN equivalent FYM. Recommended P & K was common for T_2-T_{10} treatments. RDF: Recommended dose of fertilizers (RDF) for maize is 150:75:40 kg of $N:P_2O_5:K_2O$ ha^{-1} and RD FYM is 10 t ha^{-1}. Maize hybrid MAH-14-5 was grown as a test crop with spacing of 60 x 30 cm.

Growth parameters like plant height, number of leaves and yield parameters like cob length, number of rows per cob, number of kernels per row and one hundred seeds were recorded from randomly selected five plants in each treatment. The above ground biomass harvested at physiological maturity of crop was separated into kernel and stover. They were dried under shade and then the weight was recorded. The kernel and stover yields were expressed in q ha^{-1}.

Soil samples were collected from each plot after laying out the plan at 0-15 cm depth before and after the experiment and were anlysed for soil chemical properties. The initial physico- chemical properties are furnished in Table 1.

Characterization of USWC, Vermicompost and FYM

The samples collected were analyzed for pH, EC (Jackson, 1973), organic carbon (dry combustion method, Jackson, 1973), total nitrogen (micro kjeldahl digestion and distillation method, Piper, 1966), phosphorus (vanadomolybdic yellow colour spectrophotometry method, Piper, 1966), potassium (flame photometry method, Piper, 1966) and total micronutrients (Cu, Zn, Fe and Mn) (atomic absorption

TABLE 1
Initial physico-chemical properties of soil at the experimental site

Soil properties	Value
Mechanical composition	
Sand (%)	67.27
Silt (%)	19.28
Clay (%)	13.25
Textural class	Sandy loam
Chemical properties	
pH (1:2.5 soil water extract)	5.81
EC (1:2.5 soil water extract) (dS m^{-1})	0.091
Organic Carbon (g kg^{-1})	5.20
Available N (kg ha^{-1})	254.34
Available P_2O_5 (kg ha^{-1})	31.66
Available K_2O (kg ha^{-1})	191.30
Exch. Ca [c. mol (P^+) kg^{-1}]	3.25
Exch. Mg [c.mol (P^+) kg^{-1}]	1.55
Available S (mg kg^{-1})	16.82
Available Cu (mg kg^{-1})	0.86
Available Zn (mg kg^{-1})	1.21
Available Fe (mg kg^{-1})	12.94
Available Mn (mg kg^{-1})	30.59

spectrophotometry method, Lindsay and Norvell (1978).

RESULTS AND DISCUSSION

Effect of Integrated Nitrogen Management on Plant Height and Number of Leaves

The perusal of data presented in Table 3 revealed that there was a significant increase in plant height of maize at different days of intervals with the application of in organic fertilizer and different organics as N sources. At 30 DAS, treatment that received recommended N P and K + FYM (T_3) recorded significantly higher plant height (33.47 cm). This treatment was found on par with T_2 (32.87 cm), T_6 (31.60 cm) and T_4 (30.43cm), respectively. Significantly lower plant height was recorded in T_1 (21.10 cm). Similarly, at 60 DAS, 90 DAS and at harvest, treatment T_6 had significantly higher plant

TABLE 2
Nutrient composition of different composts used in the study

Parameter	Organics		
	USWC	Vermicompost	FYM
Colour	Black	Black	Brown
pH	8.29	6.84	7.05
EC (dS m^{-1})	0.54	2.60	2.29
OC (%)	24.61	14.67	12.85
N (%)	1.52	1.04	0.56
P (%)	0.72	0.86	0.24
K (%)	1.26	1.35	0.52
Ca (%)	2.57	7.12	2.46
Mg (%)	0.68	1.96	0.87
S (%)	0.51	0.48	0.08
Cu (mg kg^{-1})	56.42	4.65	3.22
Zn (mg kg^{-1})	281.63	19.87	17.15
Fe (mg kg^{-1})	4614.13	196.08	141.95
Mn (mg kg^{-1})	364.60	87.90	62.51

height (191.80, 204.93 and 207.13 cm, respectively) compared to other treatments. However it was on par with T_4, T_3, T_7, T_5 and T_2. Significantly lower plant height was observed at all the growth stages in absolute control. Reduced plant height in absolute control was mainly due to the inadequate supply of required plant nutrients. Whereas, a significant increase in the plant height was observed in response to the integrated application of organics along with inorganic source of nutrients might be due to the continuous supply of nutrients throughout the growth period (Chari, 2011).

Data pertaining to the number of maize leaves at 30 DAS, 60 DAS, 90 DAS and at harvest as influenced by the application of integrated source of inorganic N fertilizer and different organic sources of nutrients are presented in Table 3. At 30 DAS, treatment that received recommended NPK+ FYM (T_3) had a significantly higher number of leaves (8.20) compared to other treatments except T_2 (7.80) and T_6 (7.60). Similarly, at 60 DAS, 90 DAS and at harvest, treatment T_6 produced a significantly higher number of leaves (15.20, 15.33 and 15.53, respectively)

TABLE 3

Effect of integrated nitrogen management on growth parameters of maize crop

Treatments	Plant height (cm)				No of leaves			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	24.10	146.80	148.93	151.47	4.20	7.33	8.67	8.27
T_2	32.87	178.67	188.67	191.20	7.80	13.00	12.77	12.53
T_3	33.47	186.13	196.33	198.16	8.20	14.20	14.33	13.87
T_4	30.43	188.20	202.73	203.47	7.13	14.87	14.87	14.05
T_5	28.73	180.20	192.60	192.80	6.20	13.13	13.53	14.13
T_6	31.60	191.80	204.93	207.13	7.60	15.20	15.33	15.53
T_7	29.15	181.33	193.80	193.16	6.40	13.60	13.71	13.20
T_8	26.73	170.13	182.80	183.60	5.40	11.20	11.33	10.13
T_9	27.20	171.60	185.13	186.53	5.73	11.80	11.73	10.80
T_{10}	26.20	168.80	179.53	181.87	5.00	10.60	10.93	9.53
S.Em±	1.28	5.72	5.49	5.73	0.28	0.52	0.53	0.62
CD at 5 %	3.80	17.02	16.33	17.05	0.84	1.54	1.59	1.84

compared to other treatments except for T_4 and T_3. Significantly lower plant height was observed at all the growth stages in the absolute control treatment (T_1).

A significant increase in the growth parameters of maize was mainly due to response of maize crop to the integrated application of organics along with inorganic sources of nutrients. The combined application of both sources of the nutrient might have resulted in better availability of nutrients throughout the crop growth period. Inorganic fertilizer nutrients might have taken care of the nutrient requirement of the plants in early growth stages. On the other hand, the mineralized nutrients from the organic manures could supply the nutrients in the later growth stages of the crop. Hence, there was a continuous supply of nutrients throughout crop growth period. The results are in line with those reported by Singandupe *et al.* (2008). Whereas, in 100 per cent organic manure treatments, mineralization occurs slowly because of a wider C:N ratio of organic manures and the supply of nutrients in the earlier stages of crop growth may be delayed. Thus, the crop might have deficient supply of nutrients, which might have affected crop growth. The higher values observed for growth parameters with the substitution of recommended N with vermicompost might be due to its higher nutrients status and presence of vitamins and plant growth hormones. Similar, results were earlier recorded by Arancon *et al.* (2008). They have observed an improvement in the germination, growth, and yield of plants with the application of vermicompost due to faster release of nutrients than traditional composts and the production of plant growth hormones. Similarly, Norman *et al.* (2005) reported that the potential of vermicompost to improve plant growth might be due to changes in the physico-chemical properties of soils, overall increases in microbial activity, or the effects of plant growth regulators produced by the micro-organisms.

Effect of Integrated Nitrogen Management on Yield Parameters and Yield of Maize Crop

The perusal of data presented in Table 4 revealed that significantly higher cob length (19.53 cm) was observed in the treatment T_6 and was found on par with (T_4, T_3, T_7, T_5 and T_2) (19.07, 18.87, 18.67, 18.13 and 17.53

cm, respectively). Significantly lower cob length was recorded in T_1 (13.27 cm). Significantly higher number of rows cob^{-1} and number of kernels row^{-1} (17.93 and 32.87, respectively) recorded in treatment T_6 and it wason par with T_4, T_3, T_7 and T_5 treatments. Significantly lower number of rows cob^{-1} and higher number of kernels row^{-1} were noticed in control T_1 (11.73 and 22.87, respectively). Significantly higher test weight (31.53 g) was recorded in T_6 treatment compared to other treatments except T_4 (31.43 g), T_3 (30.94 g), T_7 (30.66 g), T_5 (30.33 g), T_2(29.28 g) and T_9 (28.80 g). Significantly lower test weight was recorded in absolute control (24.11g).

Kernel yield of 79.62 q ha^{-1} (Table 4) recorded with the application of 75 per cent RDN + 50 per cent RD FYM + 25 per cent RDN equivalent vermicompost (T_6) was significantly higher compared to T_1, T_8 and T_{10} treatments. However, it was on par with treatments T_4 (78.83 q ha^{-1}), T_3 (77.59 q ha^{-1}), T_7 (75.89 q ha^{-1}), T_5 (75.12 q ha^{-1}), T_2 (73.63 q ha^{-1}) and T_9 (71.04 q ha^{-1}). Similarly, treatment (T_6) produced significantly higher stover yield (89.07 q ha^{-1}) compared to rest of the treatments except T_4 (87.23 q ha^{-1}), T_3 (86.92 q ha^{-1}), T_7 (84.92 q ha^{-1}) and T_5 (84.37 q ha^{-1}). A significantly lower stover yield was recorded in T_1 (46.43 q ha^{-1}).

The higher kernel and stover yield of maize obtained in T_6 treatment which was on par with rest of the treatments except T_1, T_8 and $T_{10}$was due to improved growth and yield attributing parameters. The lower kernel yield and growth recorded with the application of 100 per cent RDN by vermicompost or USWC or FYM might be due to the lower availability of nutrients as the entire quantity of applied organic may not undergo mineralization. The data in Table 4 also indicated that the yield level obtained with 25 per cent and 50 per cent substitution of recommended N through vermicompost and USWC with a lower level of recommended FYM was higher compared to the application of 100 per cent N through inorganic sources, still it was on par with yield level recorded with the application of 100 per cent RDF + 100 per cent recommended FYM. The higher yield obtained with substituting RDN (inorganic) through organics might be due to enhanced supply of available nutrients besides improvement in soil physical, chemical and biological properties. The variations among the organic manures substituted treatments might be attributed to the differential mineralization rate due to varied C: N ratio. These results conform to those reported by. Chadwick ***et al.*** (2000). Hankare *et al.* (2005) reported significantly higher grain and

TABLE 4

Effect of integrated nitrogen management on yield parameters and yield of maize

Treatments	Cob length (cm)	No of rows cob^{-1}	No kernels row^{-1}	Test weight	Kernel yield (q ha^{-1})	Stover yield (q ha^{-1})
T_1	13.27	11.73	22.87	24.11	42.39	46.43
T_2	17.53	14.80	27.33	29.28	73.63	79.32
T_3	18.87	17.13	31.40	30.94	77.59	86.92
T_4	19.07	17.67	32.47	31.43	78.83	87.23
T_5	18.13	16.07	29.27	30.30	75.12	84.37
T_6	19.53	17.93	32.87	31.53	79.62	89.07
T_7	18.67	16.33	29.87	30.66	75.89	84.92
T_8	17.07	14.00	26.20	28.13	70.30	77.66
T_9	17.26	14.60	26.73	28.80	71.04	78.49
T_{10}	16.73	13.87	25.93	27.86	68.97	75.73
S.Em. ±	0.76	0.64	1.22	1.16	2.94	3.24
C.D. @ 5 %	2.26	1.91	3.64	3.26	8.73	9.65

fodder yield of maize in maize-wheat cropping system under 120 kg N ha^{-1} (1/4th vermicompost + 3/4th urea) than the remaining treatments except the application of 120 kg N ha^{-1} (1/4th compost + 3/4thurea), which was at par with the former treatment.

Effect of Integrated Nitrogen Management on Soil Available Macronutrients.

Soil available N was significantly higher in treatment T_6 (255.87 kg ha^{-1}) compared to control, T_8 and T_{10} treatment it was on par with T_4 (251.57 kg ha^{-1}), T_3 (244.20 kg ha^{-1}), T_7 (241.43 kg ha^{-1}), T_5 (238.66 kg ha^{-1}), T_2 (232.43 kg ha^{-1}) and T_9 (231.10 kg ha^{-1}) (Table 5). Similarly, among the treatments, significantly higher soil available P_2O_5 and K_2O (51.19 and 169.87 kg ha^{-1}, respectively) was observed in T_7 and it was at par with T_6 for available P_2O_5 and T_5 for available K_2O. Significantly lower soil available P_2O_5 and K_2O was recorded in T_1 (23.51 and 136.79kg ha^{-1}, respectively).

A significant increase in soil available N in the treatment T_6 could be attributed to the addition of vermicompost, which released N as a result of rapid mineralization compared to urban solid waste compost. The increase in available nitrogen could be due to the buildup of organic matter, which caused greater soil microbial proliferation leading to conversion of organically bound N to inorganic forms.

TABLE 5

Effect of integrated nitrogen management on soilavailable macronutrientsafter harvest of maize crop

Treatments	Avail. N	Avail. P_2O_5	Avail. K_2O
T_1	197.86	23.51	136.79
T_2	232.43	30.91	141.82
T_3	244.20	33.70	147.04
T_4	251.57	41.15	153.29
T_5	238.66	42.12	159.30
T_6	255.87	47.83	161.15
T_7	241.43	51.19	169.87
T_8	228.80	38.12	148.21
T_9	231.10	40.42	151.57
T_{10}	225.60	35.87	145.29
S.Em. ±	8.85	1.49	5.43
C.D. @ 5%	26.30	4.43	16.19

In case of available phosphorous status in the soil, after harvest of maize due to the vermicompost application might have enhanced the phosphatase activity, which has helped in the release of phosphorous (Suthar, 2008 and Vinotha *et al*., 2000).

The significant increase of potassium in vermicompost treated soil was mainly due to higher potassium content in vermicompost and faster mineralization rate. Kaviraj and Sharma (2003) reported that the enhanced microflora present in the gut of earthworms in the case of vermicomposting has played an important role in the potassium mineralization process and increased K_2O over the raw material.

Under integrated nitrogen management approach, application of optimum dose of inorganics and organics *i,e.,* 75 per cent RDN + 50 per cent RD FYM + 25 per cent RDN equivalent vermicompost and USWC showed a beneficial effect on growth parameters *viz*., plant height, number of leaves of maize and increasing yield and yield compared to chemical fertilizers alone. The harvest soil recorded higher available N, P_2O_5 and K_2O in the soil amended with organics and inorganic nitrogen sources. Further, with the application of vermicompost or urban solid waste compost to substitute 25 per cent RDN it is possible to reduce recommended FYM dose.

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