Vol. 20, No. 2, pp. 166-175 (2020)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Effect of Different Tillage, Organic and Inorganic N-sources on Growth and Yield of Maize (*Zea mays* L.) under Maize-Rice Cropping Sequences in Terai-Agroecological Region of Humid Sub-Tropical Eastern India

SAMARESH SAHOO[1]*, PRABIR MUKHOPADHYAY[1], A.K. SINHA[1], PARTHENDU PODDAR[1], M.K DEBNATH[1], SOMNATH MONDAL[1], SOUVIK GHOSH[1], RAKESH S.[2] AND DEWALI ROY[3]

[1]*Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar-736165, West Bengal*
[2]*Research Associate (RA), National Agricultural Higher Education Project (NAHEP), ICAR-National Academy of Agricultural Research Management (NAARM), Rajendranagar, Hyderabad -500 030, Telangana*
[3]*Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi-110012,*

ABSTRACT

A field experiment was conducted to evaluate the tillage and integrated nutrient effect on growth, yield and yield attributes of maize (*Zea mays* L.) during rabi season, 2017-18 and 2018-19 at research farm of the Uttar Banga Krishi Viswavidyalaya, Pundibari (26°39'N, 89°38'E; 41 m msl), Cooch Behar, West Bengal, India. The experiment was laid out in split-plot design comprising three replications with three tillage, *viz.,* zero tillage (ZT), conventional tillage (CT), and Alternate tillage (AT) i.e., maize in ZT and rice in CT condition as main plot factor. Four nitrogen treatments including control i.e., NS_0= No nitrogen (0:50:100), NS_1=Full recommended dose of NPK fertilizer ($N_{160}P_{50}K_{100}$), NS_2= NS_1+ Crop residue @ 6 Mg/ ha, NS_3= 75% of fertilizer N along with FYM @ 25% N (N_{120} $P_{50}K_{100}$ +FYM @40 kg N /ha), NS_4= 75% of fertilizer N along with Vermicompost @ 25% fertilizer N. (N_{120} $P_{50}K_{100}$ + VM @ 40 kg N/ha) as subplot factor. The results revealed that maize grain yield, yield attributes (plant height, cob length, total no of grain in a cob and weight of 100 grains) and nutrient uptake increased significantly ($p<0.001$) in CT and AT practices over the zero tilled plots. In case of different N sources, NS_4 treatment had the significant effect in respect of yield, yield attributes and uptake over the control plot (NS_0). Results showed that grain yield 4.22% and 4.23% and total N uptake 6.16% and 3.23% increase was recorded in conventionally tilled plot and as well as alternate tilled plot respectively in 2 years pooled data. In case of total P and total K uptake followed the same trend in respect of different tillage practices. The major findings of this study revealed that nitrogen level of N_{120} $P_{50}K_{100}$ + VM @ 40 kg N/ ha along with conventionally and alternative tillage practices showed better performance of maize crop in terms of growth, yield, and yield attributes and nutrient uptake.

Key words: Tillage, Maize, Vermicompost, N, P, K uptake, Grain, Yield attributes

*Corresponding author,
Email: samareshubkv@yahoo.com

Introduction

Maize (*Zea mays* L.) is known as “Queen of cereals” in light of its high production potential and extensive adaptability. Maize is an essential cereal crop grown all over the world after rice and wheat, maize ranks third among cereals in India. The productivity of maize is largely dependent on its nutrient management and is known to be a heavy feeder of nutrients. Appropriate tillage operations are desired for improvement of the soil structure and better production of the crop and as a result yield increases. Proper tillage operations improve physical properties of soil while unsuitable, unnecessary and excessive tillage operations may not give the ideal outcomes and henceforth fundamentally diminishes the harvest yield (Iqbal *et al*., 2005). Continuous cultivation of fields with same tillage implement (cultivator) creates a plough/hard pan in the subsoil layers which adversely affects crop productivity in semi-arid regions (Wasaya *et al*., 2011, Shahzad *et al*., 2016). This rise in plough pan gradually prevents roots from penetrating into deep soil layers and also decreases the root proliferation (Whitmore *et al*., 2011), and yield of crops (Mao, 2009).

Many researchers reported that deep tillage (DT) or conventional tillage (CT) practices improve aeration (Zorita, 2000), soil porosity (Hao *et al*., 2001), conserve soil moisture and nutrients for plant and microbes (Patil *et al*., 2006). More grain yield (9%) and biomass (27%) in maize (Zorita, 2000) were achieved in DT or CT practices (Zorita, 2000). In contrast, minimum tillage (MT) plots have greater plant emergence, grain N and lower grain moisture (Wiatrak *et al*., 2006). Soon *et al*. (2005) obtained 12% increase in crop yield and 14% N uptake in MT plots.

Nitrogen fertilization plays a significant role in improving soil fertility and increasing crop productivity (Habtegebrial *et al*., 2007). Application of N had a strong and significant impact on different growth and yield traits (Sanjeev *et al*.,1997; Fedotkin and Kravtsov, 2001; Mahmood *et al*., 2001). Various N levels also had substantial effect on biomass production, grain yield, harvest index (Paolo and Rinaldi, 2008; Rafiq *et al*., 2010). N fertilization results in increased grain yield (43-68%) and biomass (25-42%) in maize (Ogola *et al*., 2002). The use of organic and inorganic nitrogen fertilizer with well managed agronomic practices can increase yields. Sole residue incorporation (Anatoliy and Thelen, 2007) or in combination with N fertilizer have positive effects on plant growth and production as well as on soil physiochemical properties. Synergistic effects of N with organic fertilizers (residue or FYM) accumulate more soil total N (Huang *et al*., 2007), but sole effects of FYM result in increased yield of maize (Anatoliy and Thelen, 2007), improved porosity (25%) and water holding capacity 16 times (Gangwar *et al*., 2006). The use of organic fertilizers such as vermicompost helps in maintaining soil fertility, and has evident environmental benefits as it enables on-farm recycling of organic waste. Vermi-compost increases growth, yield and tomato quality when used as a soil supplement (Gutierrez-Miceli *et al*., 2007) or as an alternative to mineral fertilizers in rice–legume intercropping (Jeyabal and Kuppuswamy, 2001). Maize plant height (218.9 cm), leaf area index (3.59) and dry matter (159 g/plant) owed their best expression in the treatment involving application of 100 per cent N, P_2O_5 and K_2O with FYM at 10 t/ha and was at par with 150 per cent N, P_2O_5 and K_2O compared to other treatment combinations (Verma *et al*., 2006).

Although several studies pointed out the benefits of tillage, organic and inorganic sources of N application on different cereals, but most of the work has been done on tillage and N as individual factors and little information is available on their interactive effects especially on maize. Therefore, the present study was designed with the objective to find out better tillage practice and N level for higher maize yield under terai-agroecological region of humid sub-tropical eastern India.

Materials and Methods

Soil and climate of experimental site

Field experiment was conducted at research farm of Uttar Banga Krishi Vishwavidyalaya, Pundibari, Cooch Behar, West Bengal, India for 2 consecutive year 2017-18 and 2018-19. The experimental site (26°19′ N, 89°23′ E; 41m above msl) represents the area under Terai agro-ecological situations. The climate of the region is sub-tropical and per humid in nature with moderate temperature in summer, cold in winter and monsoonal rainfall. The area receives a mean annual rainfall of 3261.2 mm, about 80% of which occurs between June to October. The mean maximum and minimum air temperature are recorded as 30.1°C and 19.7°C, respectively (average of 30 years: 1989-2019). Monthly rainfall distribution (bar), max. and min. temperature (line) all over the year in 2017-18 and 2018-19 data during study period showed a minor difference as compared to corresponding 30-years long-term average data presented in Fig. 1.

Soils at the site are broadly classified as *Typic Fluvaquent* of the order Entisols. Soils, in general, are classified with strong to moderately acidic in reaction, medium in organic carbon status, loamy sand to sandy loam in texture, high in total N and P, and medium to low in potash (Paul, 2009). Soils of the area are formed form alluvial sediments under the influence of high rainfall resulting into huge loss of base forming cations like Ca^{2+} and Mg^{2+} through percolating water. Soils of this area, in general, are characterized as coarse textured and acidic in reaction. According to soil fertility classification followed in West Bengal, soils are moderately to less fertile with medium to high in total N and total organic carbon, high in total P and medium to low in potassium (Sinha,2013). The dominant soil texture is sandy loam and it belongs to Aquic moisture regime according to USDA soil taxonomy (Biswas, 2016).

The weather conditions for maize growth period (December-April) under research are summarized in Fig. 1. The maximum rainfall was recorded in the month of April (213.60 mm) in 2017-18 and in 2018-19, the maximum rainfall was more or less similar with 30 years average data (137.00 mm and 147.26 mm, respectively). The air temperature during the season was normal. The maximum average temperature was recorded in the month of March (30.03, 29.45, 29.03°C, respectively). The minimum average temperature was observed in the month of January (9.81, 9.25, 9.02°C respectively).

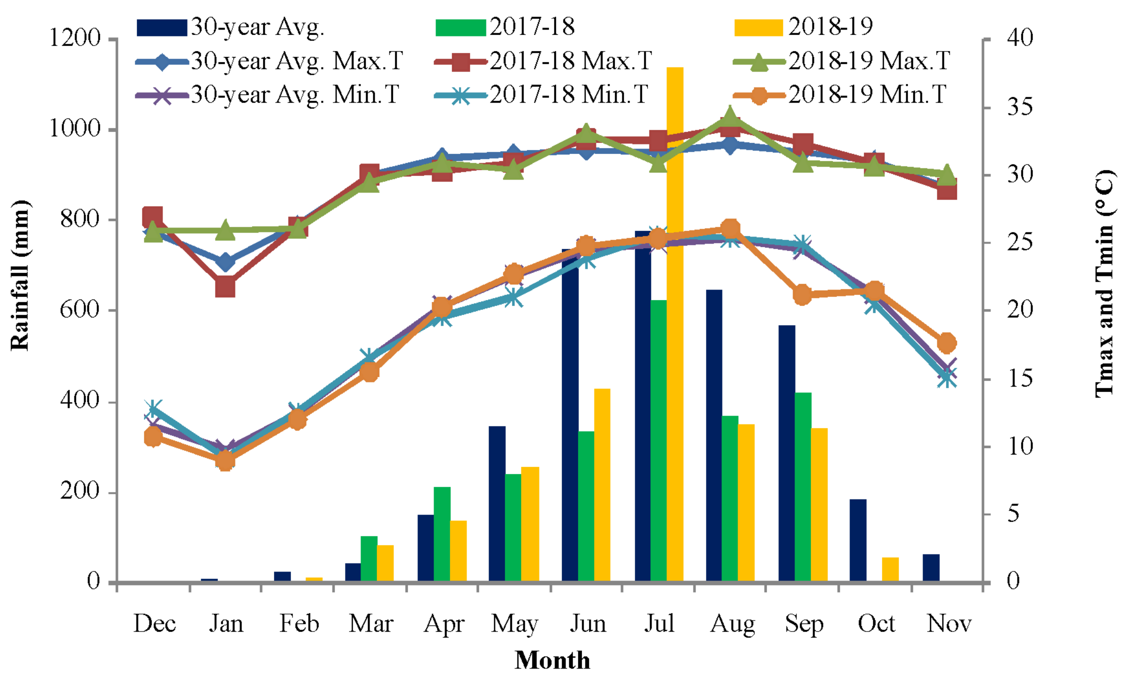

Fig. 1. Monthly rainfall, maximum and minimum temperature all over the year in 2017-18, 2018-19 and the 30-year average

Experiment details

The experiment was conducted to study the effects of three tillage methods and five nitrogen application rates including control (N_0) on some crop yield attributes. The experiment comprised of three treatment factors a) tillage- three methods - zero(ZT), conventional (CT) and alternative (AT) tillage and b) nitrogen application -five levels - Absolute N control (NS_0; $N_0P_{50}K_{100}$), Full dose of NPK fertilizer (NS_1; $N_{160}P_{50}K_{100}$), Full dose of NPK fertilizer along with crop residue application (NS_2; NS_1 + CR@ 6 Mg/ ha)., 75% of fertilizer N along with FYM @ 25% N. (NS_3; N_{120} $P_{50}K_{100}$ +FYM @40 kg N /ha.), 75% of fertilizer N along with Vermicompost @ 25% fertilizer N. (NS_4; N_{120} $P_{50}K_{100}$ + VM @ 40 kg N/ ha.) giving rise to altogether fifteen treatment combinations. Tillage was placed in the main plot and N levels were randomly placed in the sub plots in each replication with sub plot size of 8m×7m.The Plots under ZT and AT treatment, the seeds were sowing directly by no-till seed drill machine but in case of CT treatment, two times ploughed by cultivator followed by land levelling and finally the seeds were sown by seed drill. Standard agronomic package of practices were followed. Three irrigation in all the treatment plots. At 80% maturity plants were harvested manually from each treatment plots.

Grain and straw samples of maize were collected at harvest and analyzed for total N using a micro-Kjeldahl method (Bremner,1965), while in case of total P, digestion of oven dried plant sample with conc. H_2SO_4 and $HClO_4$ and P present in the digest was measured by vanado-molybdate yellow colour method as described in Jackson (1973) and K were determined using sulphuric-nitric-perchloric acid digest measured using flame photometer as described by Piper (1966). Nutrient removal was estimated by multiplying the N, P and K concentration (%) of grain and straw with their respective yield (kg/ha) and finally the nutrient uptake by grain and straw was sum up to obtain total nutrient uptake.

Statistical analysis

The experimental design was Split plot design with three replications. Analysis of variance for each parameter was performed using SPSS (Version-16.0) package. Treatment means for all variables were compared using ANOVA and significance of treatment means were assessed by either LSD or Duncan' s multiple range test (DMRT) at 5% probability level ($P \leq 0.05$).

Results and Discussion

Impact of tillage, organic and inorganic N sources on yield and yield attributes

Tillage practices had significant ($P \leq 0.05$) effect on yield attributes of maize crop showed in Table 1. Plant height was significantly higher in CT and AT over ZT plot and was statistically at par with each other. Length of cob was statistically higher in CT plot in 2 years average data. Weight of 100 grains (28.69 g) were statistically higher in CT than in ZT and AT. These results were in line with Albuquerque *et al*. (2001), who reported that plant height, number of grains per cob and grain weight were higher in CT as compared to ZT system. Khan *et al*. (2009) reported that maize crop grown on deep tillage produces heavier grain weight as compared to CT and ZT sown crops.

The increase in number of grains in a cob might be due to optimum dose of nitrogen, which plays an important role in tissue development, cell division, enhance plant growth and thereby increased number of grains per row. Similar results were in agreement with Shah *et al.* (2001) and Rasheed *et al.* (2002). Like as tillage, nitrogen also had significantly effect on yield and yield attributes. NS_2 ($N_{160}P_{50}K_{100}$+ crop residue @ 6 Mg/ ha) treatment only had the significant effect on more or less 70-80 % on yield attributes of maize crop. As noticed in case of tillage treatment, weight of 100 grain was statistically at par with each other under different N source treatments and it was higher than NS_0 (23.37 gm) and increased 100 grain weight by increasing amount of N level and it was in line with Gokmen *et al*. (2001) and Wajid *et al*. (2007) reported that 1000 grain weight increased with increasing N levels.

Among all the possible interaction effect, there was more or less similar trend followed.

Table 1. Main effect of different tillage and organic-inorganic N sources on yield of maize crop.

Treatment		Pooled data of 2017-18 and 2018-2019								
Main effect		Height of plant (cm)	Length of Cob (cm)	Total No of grain in a Cob	Weight of 100 grain (g)	Grain Yield (Mg/ha)	Harvest index	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total K uptake (kg/ha)
Tillage	ZT	206.22	14.87	491.72	28.04	7.91	41.42	150.64	49.04	212.18
	CT	209.99	15.47	511.16	28.69	8.26	42.40	160.53	50.04	224.65
	AT	210.36	15.07	484.09	28.70	8.25	41.44	155.34	48.93	221.59
SEM (±)		0.34	0.06	0.89	0.23	0.08	0.16	1.33	0.56	2.06
CD(P≤0.05)		1.11	0.19	2.89	0.74	0.25	0.52	4.35	1.82	6.72
N source	NS_0	176.72	11.18	260.89	23.37	3.28	38.33	48.97	26.27	101.94
	NS_1	216.72	16.49	548.36	29.96	8.89	42.32	177.44	47.47	245.31
	NS_2	218.03	16.40	569.12	29.98	9.57	43.04	195.68	53.21	275.73
	NS_3	216.93	15.58	547.50	29.45	8.94	42.25	168.88	62.11	230.18
	NS_4	215.90	16.03	552.41	29.62	10.01	42.82	186.55	57.62	244.21
SEM (±)		0.29	0.09	1.87	0.25	0.08	0.21	3.59	0.60	2.75
CD(P≤0.05)		0.83	0.26	5.32	0.72	0.23	0.61	10.20	1.69	7.82

ZT= Zero tillage, CT= conventional tillage, AT= Alternative tillage i.e., maize in zero tilled and rice in conventionally tilled condition, NS_0= No nitrogen (0:50:100), NS_1=Full recommended dose of NPK fertilizer ($N_{160}P_{50}K_{100}$), NS_2= NS_1+ Crop residue @ 6 Mg/ ha, NS_3= 75% of fertilizer N along with FYM @ 25% N ($N_{120}P_{50}K_{100}$) +FYM @40 kg N /ha), NS_4= 75% of fertilizer N along with Vermicompost @ 25% fertilizer N. ($N_{120}P_{50}K_{100}$) + VM @ 40 kg N/ ha).

Interaction effect of tillage regimes and nitrogen on grain yield, and harvest index of maize was shown in Table 2. From the consequence of the two years of experimentation and their information revealed that there was huge contrast in every boundary. There is no significant difference noticed in grain yield under conventional tillage (CT) (8.26 Mg/ha) and alternate tillage (AT) (8.25 Mg/ha) as the values were statistically at par with each other. Lowest grain yield was recorded in zero tillage (ZT) (7.91 Mg/ha) treatment and it was near about 1.3 Mg/ha decrease than any other tillage practices. There was no significant difference in harvest index (HI) of ZT (41.42) and AT (41.44), however, highest HI was observed in CT (42.40). Similar outcomes were also indicated by Ghumman *et al*. (2001), who reported that maize yield is less in minimum tillage as compared to CT. These results are additionally upheld by Marwat *et al*. (2007), who revealed that CT systems are more productive than zero and reduced tillage systems. Gomma *et al*. (2002) also found similar results. They conducted field experiments and studied maize grain yield under different tillage systems and highest grain yield was obtained by conventional tillage treatment.

Highest grain yield (10.01 Mg/ha) was recorded in $NS_{4,}$ and it was 67.23% higher than the absolute control treatment (NS_0) was observed in NS_0 (Table 1). There was no significant difference in grain yield of NS_1 and NS_3. However, treatment NS_2 was recorded second highest in grain yield (9.57 Mg/ha). Among different N sources treatment plots, NS_4 i.e., $N_{120} P_{50}K_{100}$ + VM @ 40 kg N/ha was the superior treatment along with CT and AT practices in respect of grain yield. Habtegebrial *et al*. (2007) also found similar results they reported that the various tillage practices have significant influence on grain yield of maize. However, grain yield increased continuously with the increasing nitrogen levels. The grain yield from 180 kg ha^{-1} N was at par with 120 kg ha^{-1} N treatment, which indicates that higher rate of nitrogen application is not a sound strategy to obtain maximum. Sharma *et al*. (2018) outlines 120 kg N ha^{-1} as an appropriate dose N fertilization for hybrids maize cultivation in inner Terai region of Nepal, which was close to our findings. Maize productivity invariably responded to organic and inorganic N-treatments probably due to the carry-over effects of inorganic N from the previous rice crop. The lower N level in the soil results in lower yield due to less unavailable N for the optimum plant growth (Lemcoff & Loomis, 1994). The maize grain yields under N and incorporated organic N were significantly higher than the sole organic treatments. The improved growth and yield of maize under the FYM combined with N plots were attributed to greater soil water content, higher nutrient availability, and more soil protection from erosion compared to control treatment (Chiroma *et al*., 2006). Conventional tillage also had good impact on harvest index and generally higher than AT as well as ZT. HI (43.04) was recorded in NS_3 treatment. There was no significant difference observed in HI of NS_1, NS_3 and NS_4. However, the lowest HI was recorded in NS_0 (38.33).

Impact of tillage, organic and inorganic N sources on nutrient uptake

Result of both years of experimentation and their pooled data revealed that there was a significant difference in each parameter. 2 years pooled data revealed that highest total N uptake was recorded highest in CT (160.53 kg/ha) and it was 3-6% higher than other tillage practices. There was no significant difference recorded in ZT (150.64 kg/ha) and AT (155.34 kg/ha) in respect of total N uptake. Tillage practice improved the availability of nutrients and water for efficient uptake that ultimately resulted in high grain yield. The results are also in line with the findings of Gul *et al*. (2009) and it may be due to availability of nutrients and more production of root hairs because of well tilth soil favourable for root proliferation and it may also have facilitated nutrient uptake.

Among the N sources, total N uptake was recorded highest in NS_2 (195.68 kg/ha) which was statistically at par with NS_4 (186.55 kg/ha) and NS_1 (177.44 kg/ha) treatments (Table 1). Lowest total N uptake was being with NS_0 (48.97 kg/ha).

Table 2. Interaction effect of different tillage and organic-inorganic N sources on yield of maize crop.

Treatment		Pooled data of 2017-18 and 2018-19								
Tillage	N sources	Height of plant (cm)	Length of Cob (cm)	Total No of grain in a Cob	Weight of 100 grain (g)	Grain Yield (Mg/ha)	Harvest index	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total K uptake (kg/ha)
ZT	NS_0	168.30	9.62	175.24	22.41	2.64	37.28	39.36	21.73	88.11
	NS_1	215.08	15.69	519.43	29.76	8.58	42.12	139.75	41.66	229.63
	NS_2	218.38	17.53	642.38	30.30	9.77	42.74	202.72	57.52	280.89
	NS_3	214.73	15.45	574.59	27.96	8.44	41.85	166.19	66.54	239.20
	NS_4	214.59	16.01	546.93	29.79	10.11	43.09	205.15	57.77	223.07
CT	NS_0	179.90	12.36	324.06	24.06	3.51	40.35	46.80	30.06	103.69
	NS_1	218.00	16.61	582.34	29.19	8.94	42.34	194.30	50.32	284.16
	NS_2	217.88	16.15	551.83	29.64	9.64	43.86	209.86	47.03	282.79
	NS_3	219.18	16.15	550.06	31.11	9.03	42.42	152.17	59.92	235.84
	NS_4	214.98	16.06	547.50	29.44	10.13	43.01	199.50	62.84	216.75
AT	NS_0	181.95	11.53	283.35	23.63	3.68	37.34	60.73	27.03	114.01
	NS_1	217.06	17.15	543.30	30.95	9.13	42.50	198.27	50.43	222.14
	NS_2	217.80	15.51	513.15	30.00	9.29	42.52	174.44	55.07	263.52
	NS_3	216.85	15.12	517.83	29.29	9.34	42.46	188.25	59.86	215.50
	NS_4	218.12	16.02	562.8	29.63	9.79	42.35	155.00	52.25	292.80
SEM (±)		0.50	0.16	3.24	0.44	0.14	0.37	6.21	1.03	4.77
CD($P \leq 0.05$)		1.43	0.44	9.22	1.26	0.41	1.06	17.66	2.93	13.55

ZT= Zero tillage, CT= conventional tillage, AT= Alternative tillage i.e. maize in zero tilled and rice in conventionally tilled condition, NS0= No nitrogen (0:50:100), NS1=Full recommended dose of NPK fertilizer (N160P50K100), NS2= NS1+ Crop residue @ 6 Mg/ ha, NS3= 75% of fertilizer N along with FYM @ 25% N (N120 P50K100 +FYM @40 kg N /ha), NS4= 75% of fertilizer N along with Vermicompost @ 25% fertilizer N. (N120 P50K100 + VM @ 40 kg N/ha).

In case of total P and total K uptake no similar trend was followed in mean effect as well as interaction effect. Tillage had no significant effect on total P and K uptake but nitrogen regimes had tremendous effect on uptake of P and K. Total P uptake was recoded highest (62.11 kg ha^{-1}) in FYM along with inorganic fertilizer treated plots (NS_3) followed by the vermicompost combined with 75% fertilizer nitrogen (NS_4) treated plot and lowest was recoded in absolute control plot (NS_0; 26.27 kg/ha). Total Potassium uptake by maize was highest (275.73 kg/ha) in inorganic fertilizer along with crop residue treated plot followed by vermicompost combined with 75% fertilizer treated plot. With regards to the N sources, crop residue addition plot and vermicompost treated plot was found best results in terms of total N and K uptake by the maize plant and FYM treated plot showed intermediate results. However, a combined use of organic and inorganic fertilizers gave a higher N and K values. The present work confirms that crop residue (6 Mg/ha) and vermicompost (5 Mg/ha) when used with NPK fertilizer ensured availability of more nutrients. Also, the need for NPK fertilizer can be reduced or combined with organic sources for better maize production. Plant N uptake of N can be better by application of a dose higher than the 120 kg/ ha used. An earlier study had reported maize grain yields from sole inorganic fertilizer and from complementary application of inorganic and organic fertilizers to be comparable and significantly higher than yields from sole organic fertilizer application (Makinde *et al*., 2001). Kasi *et al*. (2019) study shows that organic manure and inorganic sources treatment influenced the N, P, K content in grain and straw. This result was similar with our findings.

Conclusions

From this study, it was concluded conventionally tilled plot as well as alternate tillage practices along with NS_4 treatment that implies 75% of fertilizer N along with Vermicompost @ 25% fertilizer N (N_{120} $P_{50}K_{100}$ + VM @ 40 kg N/ha) promoted higher grain yield, stover yield, N uptake. In some cases, crop residue and FYM treated plot also had a good impact on yield attributes and N uptake by hybrid rabi maize rather than sole application of fully inorganic fertilizer. However, for obtaining higher maize yield and N uptake, use of vermicompost combined with 75% fertilizer N may be recommended.

Acknowledgement

The author is grateful for financial support by the fellowship given by the government of West Bengal. The authors would also like to acknowledge the help received from UBKV. I would like to acknowledge the logistic support received from the seniors, batchmates and juniors during the study period.

References

Albuquerque, J.A., Sangoi, L. and Ender, M. 2001. Modification in the Soil Physical Properties and Phosphorus on Growth and Yield of Maize. *Pakistan Journal of Biological Sciences* **1**: 19-20.

Anatoliy, G.K. and K.D. Thelen. 2007. Effect of winter wheat crop residue on no-till corn growth and development. *Agronomy Journal* **99**: 549-555.

Biswas. S. 2016. Phd thesis. Communications in soil science and plant analysis patterns of nitrogen mineralization under two water regimes in an acidic entisols as influenced by chemical composition of plant residues. U.B.K.V., Pundibari, Coochbehar, India.

Bremner, J.M. 1965. Total nitrogen. *Methods of Soil Analysis: Part 2 Chemical and Microbiological Properties* **9**: 1149-1178.

Chiroma, A.M., Folorunso, O.A. and Alhassan, A.B. 2006. The effects of land configuration and wood-shavings mulch on the properties of a sandy loam soil in northeast Nigeria. 1. Changes in chemical properties. *Tropicultura* **24**: 129-134.

Fedotkin, I.V. and Kravtsov, I.A. 2001. Production of grain maize under irrigated conditions. *Kukuruza-I-Sorgo*. **3**: 5-8.

Gangwar, K.S., Singh, K.K., Sharma, S.K. and Tomar, O.K. 2006. Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gangetic plains. *Soil and Tillage Research* **88**: 242-252.

Ghumman, B.S. and Sur, H.S. 2001. Tillage and Residue Management Effects on Soil Properties and Yields of Rainfed Maize and Wheat in a Subhumid Subtropical Climate. *Soil & Tillage Research* **58**: 1-10. http://dx.doi.org/10.1016/S0167-1987(00)00147-1

Gokmen, S., Sencar, O. and Sakin, M.A. 2001. Response of popcorn (*Zea mays* L.) to nitrogen rates and plant densities. *Turkish Journal of Agriculture And Forestry* **25**: 15-23.

Gomma, M.R., Gibbons, A.K. and Ei, D. 2002. Maize grain yield as influenced by nitrogen levels with and without organic manures under different tillage systems. *Annals Agricultural Science* **40**: 723-739.

Gul, B., Marwat, K.B., Hassan, G., Khan, A., Hashim, S. and Khan, I.A. 2009. Impact of tillage, plant population and mulches on biological yield of maize. *Pakistan Journal of Botany* **41**: 2243-2249.

Gutierrez-Miceli, F.A., Santiago-Borraz, J., Montes Molina, J.A., Nafate, C.C., Bud-Archila, M. and Oliva Llaven, M.A. 2007. Vermicompost as a soil supplement to improve growth, yield and fruit quality of tomato (Lycopersicum esculentum). *Bioresource Technology* **98**: 2781–2786 .

Habtegebrial, K., Singh, B.R. and Haile, M. 2007. Impact of tillage and nitrogen fertilization on yield, nitrogen use efficiency of tefEragrostis, Trotter and soil properties. *Soil and Tillage Research* **94**: 55-63.

Hao, X., Chang, C. and Lindwall, C.W. 2001. Tillage and crop sequence effects on organic carbon and total nitrogen content in an irrigated Alberta soil. *Soil and Tillage Research* **62**: 167-169.http://dx.doi.org/10.1016/S0167-1987(00)00147-1.

Iqbal, M., Ali, A. and Rizwanullah, M., 2005. Residual effect of tillage and farm manure on some soil physicalproperties and growth of wheat (Triticum aestivum L.). *International Journal of Agriculture and Biology (Pakistan)*.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd. New Delhi. 2nd Edition: 111-204.

Jeyabal, A. and Kuppuswamy, G. 2001. Recycling of organic wastes for the production of vermicompost and its response in rice–legume cropping system and soil fertility. *European Jojnal of Agronomy* **15**: 153–170 .

Kasi Viswanath, R., Sharma, R.K., and Mallikarjuna, G. 2019. Effect of organic and inorganic manures on n, p and k content in grain and straw at harvest of maize. *Journal of Pharmacognosy and Phytochemistry* **8**(4): 2475-2478.

Khan, A., Jan, M.T., Marwat, K.B., and Arif, M. 2009. Organic and inorganic nitrogen treatments effects on plant and yield attributes of maize in a different tillage system. *Pakistan Journal of Botany* **41**(1): 99-108.

Lemcoff, J.H. and Loomis, R.S. 1994. Nitrogen and density influences on silk emergence, endosperm development, and grain yield in maize (*Zea mays* L.). *Field Crops Research* **38**(2): 63-72.

Mahmood, M.T., Maqsood, M., Awan, T.H., Sarwar, R. 2001. Effect of different levels of nitrogen and intra–row plant spacing on yield and yield components of maize. *Pakistan Journal of Agriculture Science* **38**: 48–49.

Makinde, E.A., Agboola, A.A., and Oluwatoyinbo, F.I. 2001. The effects of organic and inorganic fertilizers on the growth and yield of maize in a maize – melon intercrop. *Moor Journal of Agricultural Research* **2**: 15-20.

Mao, Y. 2009. Effects of incorrect rotary tillage operation on soil fertilizer protecting and moisture keeping and yield of wheat. *Agriculture Development Equipment* **2**: 26-27.

Marwat, K.B., Arif, M. and Khan, M.A. 2007. Effect of Tillage and Zinc Application Methods on Weeds and Yield of Maize. *Pakistan Journal of Botany* **39**: 1583-1591.

Ogola, J.B.O., Wheeler, T.R. and Harris, P.M. 2002. Effects of nitrogen and irrigation on water use of maize crops. *Field Crops Research* **78**: 105-117.

Paolo, E.D. and Rinaldi, M. 2008. Yield response of corn to irrigation and nitrogen fertilization in a Mediterranean environment. *Field Crops Research* **105**: 202-210.

Patil, S.L. and Sheelavantar, M.N. 2006. Soil water conservation and yield of winter sorghum as influenced by tillage, organic materials and nitrogen fertilizer in semi-arid tropical India. *Soil and Tillage Research* **89**: 246-257.

Paul, S.C., Ray, S. and Ghosh, A.K. 2009. Suitability of Soil Test Phosphorus for Phosphorus Fertilization of Terai Soil of West Bengal. *Environment & Ecology* **27(3A)**: 1269-1273.

Piper, C.S. 1966. *Soil and Plant Analysis*. Hans. Pub., Bombay.

Rafiq, M.A., Ali, A., Malik, M.A. and Hussain, M. 2010. Effect of fertilizer levels and plant densities on yield and protein contents of autumn planted maize. *Pakistan Journal of Agricultural Science* **47**: 201-208.

Rasheed, M. 2002. Biological Response of Hybrid Maize to Plantation Methods and Nutrient Management. PhD Thesis, Department of Agronomy, University of Agriculture, Faisalabad.

Sanjeev, K., Bangarwa, A.S. and Kumar, S. 1997. Yield and yield components of winter maize (*Zea mays* L.) as influenced by plant density and nitrogen levels. *Agricultural Science Digest* **17**: 181-184.

Shah, S.H.A. 2001. Growth, Yield and Raditation Use Efficiency of Maize under Variable Irrigation Schedules. MSc. (Hons). Thesis, Department of Agronomy, University of Agriculture, Faisalabad.

Shahzad, M., Farooq, M., Jabran, K., Yasir, T.A. and Hussain, M. 2016. Influence of various tillage practices on soil physical properties and wheat performance in different wheat-based cropping systems. *International Journal of Agriculture & Biology* **18**: 821-829.

Sinha. A.K. 2013. Phd thesis. Short term effect of tillage and residue management on soil characteristics and crop yields under the rice-wheat cropping system. U.B.K.V., Pundibari, Cooch behar, India.

Soon, Y.K. and Arshad, M.A. 2005. Tillage and liming effects on crop and labile soil nitrogen in an acid soil. *Soil and Tillage Research* **80**: 23-33.

Verma, A., Nepalia, V. and Kanthaliya, P.C. 2006. Effect of integrated nutrient supply on growth, yield and nutrient uptake by maize (*Zea mays*) - wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **51(1)**: 3-6.

Wajid, A., Ghaffar, A., Maqsood, M., Hussain, K. and Nasim, W. 2007. Yield response of maize hybrids to varying nitrogen rates. *Pakistan Journal of Agricultural Sciences* **44**: 217-220.

Wasaya, A., Tahir, M., Manaf, A., Ahmed, M., Kaleem, S. and Ahmad, I. 2011. Improving maize productivity through tillage and nitrogen management. *African Journal Biotechnology* **10**: 19025-19034.

Whitmore, A.P., Whalley, W.R., Bird, N.R.A., Watts, C.W. and Gregory, A.S. 2011. Estimating soil strength in the rooting zone of wheat. *Plant and Soil* **339**: 363-375.

Wiatrak, P.J., Wright, D.L. and Marois, J.J. 2006. The impact of tillage and residual nitrogen on wheat. *Soil and Tillage Research* **91**: 150-156.

Zorita, M.D. 2000. Effect of deep-tillage and nitrogen fertilization interactions on dry land corn productivity. *Soil and Tillage Research* **54**: 11-19.

Received: August 1, 2020; Accepted: November 15, 2020