Effect of slow releasing soil conditioner Zypmite on Productivity and Nutrient Uptake of Maize in Kosi Region of Bihar, India

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Abstract

Maize (*Zea mays* L.) is one of the important staple foods of not only India but the world. Area under maize cultivation and its production have been steadily increasing in recent past in Bihar. Currently farmers are opting for intensive cultivation which is causing very adverse effect on soil health. To improve productivity and manage soil health, the use of these nutrients is very essential. Major nutrients NPK are required for growth and development of the maize crop. But majorly, nutrient requirements vary depending on the growth stage of maize, as at different growth stages, different sets of nutrients are required. Zypmite is a Soil Conditioner, containing secondary nutrients sulphur, calcium, magnesium along with micro-nutrients zinc and boron. To study the effect of Zypmite Plus a slow releasing soil conditioner on nutrient uptake in maize, an experiment was conducted at Bhola Paswan Shastri Agricultural College, Purnea with 4 treatments {T_1 = Control (without RDF), T_2 = RDF (N:P:K:120:60:40), T_3 = RDF (N:P:K:120:60:40)+ Z_1 (125 kg ha^{-1}) & T_4 = RDF (N:P:K::120:60:40)+ Z2 (187.5 kg ha^{-1})} and five replications. Zypmite, when applied along with recommended dose of fertilizer, had an impact on maize crop in both the years of study. Doses of 125 kg per hectare of Zypmite plus and 187.5 kg per hectare of Zypmite plus along with recommended dose of fertilizer were performing better than recommended dose of fertilizer. Soil nutrient availability was also improved by using Zypmite plus for both macro nutrients and micronutrients. Total nitrogen, phosphorus and potassium uptake is the product of concentration of nutrient to the dry matter. Data pertaining to the total nitrogen, phosphorus and potassium uptake for the two years study (2019-21) shows that total N, P and K uptake was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). Uptake of nitrogen, phosphorus and potassium was significantly higher with the treatment RDF+Z_2 which remain at par with the treatment RDF+Z_1 for maize crops. The increase in the nitrogen, phosphorous and potassium uptake varied from 71-112%, 104-172% and 76-121% for maize crop.

Abbreviations

CAGR: Compound annual growth rate
FICCI: Federation of Indian chambers of commerce and industry
GOI: Government of India
ha: hectare
Kg: Kilogram
MT: Metric tonne
Mo SPI: Ministry of statistics and planning implementation
NP K: Nitrogen Phosphate & Potash
PPL: Paradeep phosphate limited
RDF: Recommended dose of fertilizer
RBD: Randomised block design
USA: United states of America
Z: Zypmite plus
Zn: Zinc

Introduction

Worldwide maize (*Zea mays* L.) is a very important cereal crop and stands at third in the world after wheat and rice, both in area sown and production obtained. In 2022, USA was the largest producer of maize contributing about 30% of global production followed by China (24%) and Brazil (9%). In 2022, India ranked 4^{th} in global maize acreage and 5^{th} in global production contributing to about 4.9% of acreage and 2.9% of production respectively (FICCI 2024). In India maize is most cultivated by farmers both in the Northern and Eastern plains. The state of Bihar acts as a main supplier of maize grain to other states for its utilization in feed and other industries. In the recent years Bihar has emerged as one of the promising states for maize production. The area, production and yield of Maize crop in Bihar from 2000-01 to 2020-21 reveals that in past years the yield and production of maize crops has shown a tremendous growth in Bihar (Mo SPI, 2021). As per the announcement made by the Bihar Agriculture Department on October 26, 2023, the state government has decided to increase the area of maize cultivation in all the 38 districts of the state. In context of part of Bihar's fourth agriculture roadmap (2023-2028), launched by President Draupadi Murmu, with emphasis on ethanol production, the Bihar government has set a target of planting 100 percent of hybrid maize seeds with the aim to achieve maximum production in the Rabi season from the target area of 1.50 lakh acres area in the state. Annually maize is grown in 10.04 million hectares area with 33.62 million tonnes of production and national productivity of 3349 kg/ha (GOI 2022). Maize is principally grown in two seasons: kharif (75% area) and rabi (20% area), with the average productivity of kharif maize being 2.94 MT/ha and rabi maize 5.36 MT/ha. Maize productivity in India has increased from 2.6 MT/Ha to 3.5 MT/Ha growing at a decadal CAGR of 3.3% (2012-13 to 2022-23 (FICCI, 2024).

Maize contributes nearly 9 % of the national food basket. In India, about 22% of maize is consumed directly as food while a major share of production is consumed for industrial usage mainly for animal feed and starch In addition to staple food for human consumption and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that include starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceuticals, cosmetics, film, textile, gum, package and paper industries etc. In India, maize is used as human food (23%), poultry feed (51 %), animal feed (12 %), industrial (starch) products (12%), beverages and seed (1 % each) which is towards matching to the global scenario. The maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, popcorn in *peri*-urban areas. Maize is a source of high fiber, antioxidants, other vitamins and minerals (Saritha *et al.*, 2020). It contains vitamin C, vitamin E, vitamin K, vitamin B1 (thiamine), vitamin B2 (niacin), vitamin B3 (riboflavin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine, and N-ferrulyl tryptamine. Potassium is a major nutrient present which has a good significance because an average human diet is deficient in it (Kumar & Jhariya, 2013). Maize is an essential source of various phytochemicals that play an important role in our health (Kopsell *et al.*, 2009). There is inverse correlation between the consumption of phytochemicals and the development of chronic diseases. The phytochemicals in whole grains have received less attention and sometimes been underestimated. The research has suggested that phytochemicals in grains due to their potent antioxidant activities demonstrate significant beneficial contribution in reducing the risk of many diseases (Liu, 2007; Madhujith & Shahidi, 2007; Shahidi, 2009).

In India hybrids of maize were developed and characterized by yield advantage of about 45 to 50 percent over traditional genotypes. Despite of this aspect, there is a lot of scope to improve the productivity of maize crop through agronomic manipulation to realize the full genetic yield potential. Nutrients like NPK play an important role for growth and development of plants. Motsara (2006) observed that there is a positive correlation between the applications of NPK balanced fertilization and crop yield. Among the various available fertilizer recommendation approaches, farmers are still opting general recommendations approach for applying fertilizers to the crops. The general recommendations are being used extensively in India and many other Asian countries for their simplicity and exclusion of costs involved in soil Testing, as reported by Yonika and Vinod (2022).

Generally, soil is deficient not only in NPK, but also it has inadequate secondary nutrients like sulphur, calcium and magnesium and micro nutrients like zinc, copper and iron in most of the Indian states. Maize crop is highly responsive to sulphur, calcium, magnesium, zinc and boron fertilizations. Sulphur has specific functions during plant growth, metabolism, and enzymatic reactions (Mengal and Kirkby 1987). Sulphur is required for the synthesis of sulphur-containing amino acids such as cysteine, cystine and methonine. Sulphur is also a constituent of S-glycosides (mustard oils), coenzymes-A, vitamin biotine, and thiamine (Tisdale *et al.*, 1985). Sulphur application up to 40 kg/ha enhanced the average grain yield of maize by 0.99 tonne/hectare (Sakal *et al.*, 2000). Just like any-other essential nutrient, sulphur also has certain specific functions to perform in the plant. Thus, sulphur deficiencies can only be corrected by the application of sulphur fertilizer (Tandon and Messick, 2007). Calcium is important for membrane stability, cell integrity, cell division and elongation (White and Broadley, 2003). Ca-deficiency symptoms are not often observed in field grown maize, but its application produced significant improvement on performance of crop. Like this magnesium also plays important role for improving productivity of maize crop. Mg is the fundamental component of chlorophyll pigments in the light-capturing complex of chloroplasts and, hence, is involved in photosynthetic CO_2 assimilation (Cakmak and Kirkby, 2008). Moreover, it participates in sucrose transport, energy metabolism, N utilization, pollen development and male fertility, stress tolerance, plant-microbe interactions, and other numerous biological processes (Li *et al.*, 2008; Tian *et al.*, 2021).

In addition to secondary nutrients, micro-nutrients are also crucial in improving productivity and crop quality. Among micronutrients, zinc and boron are the most important micro nutrients because of their widespread and increasing deficiency in soil. Zn plays a very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase and stabilization of ribosomal proteins (Tisdale *et al.*, 1985). Among cereal crops, maize shows the greater sensitivity to Zn deficiency for its physiological requirements. Zinc activates the plant enzymes by carbohydrate metabolism, maintaining the integrity of cellular membranes, protein synthesis and regulation of auxin synthesis (Marschner, 1995). Application of zinc fertilizers to maize crop not only boost its production, but also improves zinc contents in tissues (Cakmak, 2008). However, to overcome zinc shortage for human beings there is a prime need to feed them with zinc increased foods on sustainable basis. Similarly, B application improves growth, and enhances stress tolerance in plants and improves grain production (Hussain *et al.*, 2012). World-wide Boron deficiency is more extensive than any other plant micro nutrient deficiency (Gupta, 1979). The use of different sources of these nutrients leads to increase in cost of production and handling of a greater number of nutrient sources are a tedious job for the farmers. Zypmite is a new source for supply of these nutrients at a time. It is a soil conditioner, with micro-nutrient mixture containing Sulphur, Zinc, Boron, Calcium and Magnesium. Zypmite helps in improving the soil fertility, increasing the intake of NPK fertiliser and improving the quality and of yield of crops. Application of Zypmite also improves the physical properties of the soil. A field experiment was undertaken during two kharif seasons of 2019 and 2020 at research farm of Bhola Paswan Shastri Agricultural College, Purnea to evaluate the impact of Zypmite on performance of maize.

Materials and methods

Field Experimental Details are reported below:

Replications	**5**
Variety	Hybrid 7074 (Monsanto)
Seed rate	20 Kg per hectare
RDF (Recommended dose of fertilizer)	120-60-40 (NPK Kg per hectare) 1/3rd N, total P and K as basal dose 1/3rd N at Knee-High stage 1/3rd N at Tasseling stage
Zypmite plus	Basal application
Plot size	9 meter X 9 meter
Spacing	60 centimeter X 20 centimeter
Statistical design	RBD design
Month of sowing	July
Month of harvest	October
Weed management	Manual, No chemical application
Irrigation	As per the requirement

Field trial and treatments

The field experiment was conducted to study the effect of slow-releasing soil conditioner on maize, during 2019-21 at the Research Farm of Bhola Paswan Shastri Agricultural College, Purnea, under Bihar Agricultural University, Sabour, Bihar. The experiment was conducted in Randomised Block design, replicated five times with four treatments, namely treatment T_1 - Control (without fertilization); T_2 - RDF*; T_3- RDF*+ Zypmite plus (125 kg per hectare); T_4 - RDF* + Zypmite plus (187.5 kg per hectare). The plot size was 9m X 9 m. Full doses of phosphorous and potash were applied at the time of field preparation whereas, nitrogen was applied in the split dose with proper irrigation. Zypmite plus was applied as basal dose in the soil. Zypmite plus is a soil conditioner in which the base material is gypsum and dolomite (Calcium, Ca; Magnesium, Mg & Sulphur, S). Boron (B) and Zinc (Zn) are also present in the product. It is a slow releasing conditioner and application is basal along with the recommended dose of fertilizer (RDF). The cost of soil conditioner Zypmite plus was Rs. 385 per 25 Kg bag.

Soil analysis

After thorough field preparation initial soil sample collection was done for the analysis of initial soil parameter. Initial soil samples were collected from the whole field following the standard soil sampling procedure. The collected soil samples were analyzed for available nitrogen by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus was extracted using the method of 0.5 M $NaHCO_3$ extractable colorimetric method (Olsen *et.al.*, 1954) and available potassium was measured by shaking the required amount of soil sample with 1 N NH_4OAc (pH 7.0) solution (1:5 soil: solution ratio) for 5 minutes by (Jackson, 1973) method. The initial composite soil sample reading was with normal soil reaction, no salinity, low soil organic carbon, low available nitrogen, high available phosphorus and medium potassium for both years of experimentation.

Maize Traits

Plant height was recorded manually for maize crop at regular interval from five randomly selected representative plants from each plot of each replication separately as well as yield and yield attributing characters were recorded as per the standard method. The weight of maize cob and maize stover was taken after harvesting.

Statistical analysis

The collected data were statistically analyzed separately according to the analysis of variance (ANOVA). Mean comparisons had worked out at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

Maize Yield and Yield traits

Plant height is one of the growth parameters and has found a positive effect of balanced nutrient application. Data related to the plant height and weight of maize cob for the two years of study (2019 & 2020) has been shown in Table 1. It shows that the mean plant height and weight of maize cob was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). Although the treatment effect

Table 1 Pooled data of plant height and cob weight of maize crop at maturity from two-year study (2019 and 2020)

Treatments	Plant height (cm)			Cob weight of maize (g/cob)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1 = Control (without RDF)	144.2	142.1	143.2	135.00	139.00	137.00
T_2 = RDF (N:P:K:120:60:40)	187.3	185.3	186.3	178.00	185.00	181.50
T_3 = RDF (N:P:K:120:60:40)+ Z_1 (125 kg ha^{-1})	193.4	192.0	192.7	188.00	196.00	192.00
T_4 = RDF (N:P:K::120:60:40)+ Z2 (187.5 kg ha^{-1})	197.1	195.7	196.4	191.00	199.00	195.00
SEm±	7.6	7.7	5.4	7.31	7.83	5.36
LSD (P=0.05)	23.4	23.8	15.8	22.53	24.13	15.65

Note: RDF-Recommended dose of fertilizer; Z-Zypmite plus

Table 2 Grain and stover yield of maize in a two-year study

Treatments	Grain yield (t/ha)			Stover yield (t/ha)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1 = Control (without RDF)	3.04	3.14	3.09	5.07	4.99	5.03
T_2 = RDF (N:P:K:120:60:40)	4.65	4.72	4.69	7.03	7.02	7.03
T_3 = RDF (N:P:K:120:60:40)+ Z_1 (125 kg ha^{-1})	5.32	5.42	5.39	7.88	7.86	7.87
T_4 = RDF (N:P:K::120:60:40)+ Z_2 (187.5 kg ha^{-1})	5.55	5.61	5.53	8.15	8.07	8.09
SEm±	0.20	0.21	0.15	0.30	0.31	0.22
LSD (P=0.05)	0.62	0.65	0.43	0.93	0.95	0.63

Note: RDF-Recommended dose of fertilizer; Z-Zypmite plus

was at par with one other, represented no significant effect of use of Zypmite plus on the plant height of the maize crop. The maximum height was recorded with the treatment RDF+Z_2. The increase in the mean plant height varied from 28-34% for the maize crop compared to the treatment without fertilization (control).

Grain and stover yield of maize

Yield is the actual response of nutrient application in the soil. Data related to the yield of maize for the two years of study (2019 and 2020) has been shown in Table 2. It shows that yield was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) than in the control (without RDF). The yield was significantly higher with the treatment RDF+Z_2 which remains at par with the treatment RDF+Z_1 during both the years of experiment. Use of Zypmite plus has significantly improved yield at first dose of it along with RDF, over the RDF and control, however yield was at par with the treatment applied with second dose of Zypmite plus along with RDF compared to first dose of Zypmite plus alongwith RDF. The increase in the yield varied from 51-78% for maize grain and 39.7-61.2% for maize stover compared control.

Nitrogen uptake by maize grain and stover

Total nitrogen uptake is the product of concentration of nitrogen to the dry matter. Data related to the total nitrogen uptake for the two years study (2019-21) has been shown in the Table 3. It shows that total nitrogen uptake was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). The nitrogen uptake was significantly highest with the treatment RDF+Z_2 but was at par with the treatment RDF+Z_1. The increase in the nitrogen uptake varied from 89.2-132.8% for maize grain and 100-139% for maize stover compared to (control) *i.e.* without fertilization.

Table 3 Uptake of nitrogen by grain and stover of maize in a two-year study

Treatments	Grain yield (t/ha)			Stover yield (t/ha)		
	2019	2020	Pooled	2019	2020	Pooled
T_1 = Control (without RDF)	3.04	3.14	3.09	5.07	4.99	5.03
T_2 = RDF (N:P:K:120:60:40)	4.65	4.72	4.69	7.03	7.02	7.03
T_3 = RDF (N:P:K:120:60:40)+ Z_1 (125 kg ha^{-1})	5.32	5.42	5.39	7.88	7.86	7.87
T_4 = RDF (N:P:K::120:60:40)+ Z_2 (187.5 kg ha^{-1})	5.55	5.61	5.53	8.15	8.07	8.09
SEm±	0.20	0.21	0.15	0.30	0.31	0.22
LSD (P=0.05)	0.62	0.65	0.43	0.93	0.95	0.63

Note: RDF-Recommended dose of fertilizer; Z-Zypmite plus

Total phosphorus uptake is the product of concentration of phosphorus to the dry matter. Data related to the total phosphorus uptake for the two years study (2019-21) has been shown in the Table 4. It shows that total phosphorus uptake was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). The phosphorus uptake was significantly highest with the treatment RDF+Z_2 for both grain and stover of maize crops. Use of Zypmite plus has significantly improved phosphorus uptake at first dose of it along with RDF over the RDF and with second dose of Zypmite plus along with RDF. The increase in the phosphorus uptake varied from 118.2-186% for maize grain and 74.6-114.1% for stover of maize crop compared to T_1, control.

Uptake of potassium by maize grain and stover

Table 4 Uptake of phosphorus by grain and stover of maize in a two-year study

Treatments	Phosphorus uptake by grain (kg/ha)			Phosphorus uptake by stover (kg/ha)		
	2019	2020	Pooled	2019	2020	Pooled
T_1 = Control (without RDF)	5.32	5.53	5.42	5.37	5.34	5.36
T_2 = RDF (N:P:K:120:60:40)	11.70	11.96	11.83	9.30	9.42	9.36
T_3 = RDF (N:P:K:120:60:40)+ Z_1 (125 kg ha^{-1})	14.44	14.82	14.63	10.97	11.02	11.00
T_4 = RDF (N:P:K::120:60:40)+ Z_2 (187.5 kg ha^{-1})	15.33	15.61	15.47	11.50	11.47	11.48
SEm±	0.76	0.77	0.54	0.59	0.58	0.41
LSD (P=0.05)	2.34	2.38	1.58	1.80	1.80	1.21

Total potassium uptake is the product of concentration of potassium to the dry matter. Data related to the total potassium uptake for the two years study (2019-21) has been shown in the Table 5. It shows that total potassium uptake in case of maize grain was significantly higher in treatments T_3 (RDF+Z_1) and T_4 (RDF+Z_2) over the treatments T_2 (RDF) and treatments T_1 (control without RDF). Whereas, in case of maize stover the potassium uptake was recorded significantly highest with the treatment RDF+Z_2. Use of Zypmite plus has significantly improved potassium uptake at first and second dose of its along with RDF over the RDF and control. The increase in the potassium uptake varied from 92.6-135.7 % for maize grain and 60.3-93.3% for maize stover compared to control

Table 5 Uptake of potassium by grain and stover of maize in a two- year study

Treatments	Potassium uptake by Maize grain (kg/ha)			Potassium uptake by Maize stover (kg/ha)		
	2019	2020	Pooled	2019	2020	Pooled
T_1 = Control (without RDF)	11.92	12.28	12.10	58.05	57.19	57.62
T_2 = RDF (N:P:K:120:60:40)	23.11	23.50	23.31	92.43	92.39	92.41
T_3 = RDF (N:P:K:120:60:40)+ Z_1 (125 kg ha^{-1})	27.29	27.85	27.57	107.04	106.91	106.97
T_4 = RDF (N:P:K::120:60:40)+ Z_2 (187.5 kg ha^{-1})	28.83	29.08	28.95	111.91	110.88	111.40
SEm±	1.46	1.47	1.03	5.76	5.69	4.05
LSD (P=0.05)	4.49	4.53	3.02	17.74	17.53	11.82

Note: RDF-Recommended dose of fertilizer; Z-Zypmite plus

Soil available nitrogen at maize harvest

Data related to the soil available nitrogen for the two years study (2019-21) has been shown in the Table 6. It shows that soil available nitrogen was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). Although treatments effect was *at par* with one other represented no significant effect of use of Zypmite plus on the soil available nitrogen of maize crop. The average maximum soil available nitrogen was recorded for maize with the treatment RDF+Z_2 . The increase in the soil available nitrogen was varied from 9.21-11.51% for maize crop compared to without fertilization (control).

Table 6 Soil available nutrient status after maize harvesting

Treatments	Available nitrogen at harvest of maize (kg/ha)			Available phosphorus at harvest of Maize (kg/ha)			Available potassium at harvest of Maize (kg/ha)		
	2019	2020	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1 = Control (without RDF)	158.40	162.80	160.60	33.60	33.20	33.40	201.50	199.70	200.60
T_2 = RDF (N:P:K:120:60:40)	172.60	178.20	175.40	37.20	39.20	38.20	216.30	212.60	214.45
T_3 = RDF (N:P:K:120:60:40)+ Z_1 (125 kg ha^{-1})	174.70	182.60	178.65	38.50	40.40	39.45	219.40	215.90	217.65
T_4 = RDF (N:P:K::120:60:40)+ Z_2 (187.5 kg ha^{-1})	175.10	183.10	179.10	39.10	40.90	40.00	220.40	217.40	218.90
SEm±	6.96	7.44	5.10	1.52	1.64	1.12	8.75	8.85	6.23
LSD (P=0.05)	21.45	22.93	14.88	4.69	5.05	3.27	26.95	27.28	18.17

Soil available phosphorus after maize harvesting

Soil available phosphorus was increased over the initial soil available phosphorus except control treatment after harvesting of maize crops. Data related to the soil available phosphorus for the two years study (2019-21) has been shown in the Table 6. It shows that soil available phosphorus was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). Although treatments effect was at par with one other represented no significant effect of use of different doses of Zypmite plus on the soil available phosphorus in maize crop. The increase in the soil available phosphorus varied from 14.4-19.8% compared to control plot.

Soil available potassium after maize harvesting

After harvesting of maize crop, increase in the soil available potassium, over the initial soil available potassium was reported in all the treatments, except control. Data related to the soil available potassium for the two years study (2019-21) has been shown in the Table 6. It shows that soil available potassium was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). As treatments effect in case of soil available potassium was *at par* with one other represented no significant effect of different dose of Zypmite plus on the soil available potassium in Maize crops. The average maximum soil available potassium was recorded with the treatment T_4 *i.e.* RDF+Z_2. The increase in the soil available potassium varied from (6.90- 9.12%) for maize crop compared to (control) without fertilization.

Conclusions

A soil conditioner Zypmite plus had an impact on maize crops in both the years of study. Doses of 125 kg per hectare of Zypmite plus and 187.5 kg per hectare of Zypmite plus along-with recommended dose of fertilizer were performing better than recommended dose of fertilizer but the effect of using 125kg/ha of Zypmite had significant effect over the recommended dose of fertilizer. It shows that total uptake of all the three macro-nutrient was significantly higher in all the treatments (RDF, RDF+Z_1, RDF+Z_2) over the control (without RDF). The nutrient uptake was significantly highest with the treatment RDF+Z_2 but at par with the treatment RDF+Z_1 for both the years. Zypmite plus had improved soil quality as well as nutrient uptake and found suitable to use in both the years in maize crop. Soil nutrient availability was also improved on using Zypmite plus for majorly all the three primary nutrients.

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Conflict of interest

The authors declare no conflict of interest

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