

Original Research Article

PERFORMANCE OF GLUCONATE AND LACTATE BASED FORMULATIONS ON PLANT GROWTH AND YIELD ATTRIBUTES IN MAIZE (*Zea mays* L.)

Abstract

Aim/Objectives: To check the efficacy of gluconates and lactate based formulations on plant growth and yield characteristics of maize

Study Design: Randomized Block Design

Place and Duration of Study: School of Agricultural Sciences, Malla Reddy University, Hyderabad, rabi 2021

Methodology: The experiment was laid-out in Randomized Block Design (RBD), with Maize hybrid (DHM-117) spacing adopted (60 x 20 cm) with 4 replications. The treatments viz; T₁: Control (No fertilizer), T₂:100 % RDF, T₃: 75 % RDF + 25 % Sahasra Organic Formulations (SOF), T₄:50 % RDF + 50 % SOF, T₅: 25 % RDF + 75 % SOF, T₆: 100 % SOF. The RDF (N:72-80; P:24; K:20 kg/acre).

Results: The yield attributes were recorded intermittently and maximum grain yield (7,649.8 kg ha⁻¹) and Stover yield (8,859.87 kg ha⁻¹) were recorded with T₂ (100% RDF), followed by T₃ (75 % RDF + 25 % Sahasra Organic Formulations). Similarly gross returns (₹ 123606.5 ha⁻¹), net returns (₹ 87116.49 ha⁻¹) and B: C (3.4) ratio was also recorded highest in T₂ followed by T₃ (75 % RDF + 25 % SOF), while the lowest were recorded with T₁ (control).

Conclusion: Adoption of gluconate and lactate based formulations enhanced soil fertility, soil organic carbon and yield in Maize crop. The study concludes that the integrated approach *i.e.*, T₃ (75 % RDF + 25 % SOF) has realized highest net returns (₹ 82466.8 ha⁻¹) and B:C ratio (3.4) in comparison to 100 % RDF treatment thus reducing the cost of fertilizers and benefiting the net returns to the farmers.

Key words: Gluconates, Lactates, Innovative Technologies, Soil Fertility, Net Returns.

1 Introduction

Maize is grown almost all over the world in different agro-climatic conditions and in different seasons. It is the third most important food crop next to rice and wheat. It is also known as

the miracle crop or queen of cereals due to its high productivity potential among the cereal crops of Gramineae family. In India, maize is not only grown for food and fodder but also for several industrial usage and acquired dominant role in the farming sector and macro-economy of the Asian region (Mauria *et al.*, 1998). Furthermore, one of the most critical elements influencing maize crop development and yield productivity is fertilizer management (Ghosh *et al.*, 2020). The current NPK fertilizer consumption ratio is 10: 2.9 : 1 as against optimal ratio of 4 : 2 : 1 (Walia and Kler, 2010). Maize area and production have steadily increased in India during the past two decades and it is cultivated in an area of 9.2 M ha with an average production of 28.7 Mt and productivity of 3115 kg ha⁻¹. This non-judicious nutrient application by farmers causes multi-nutrient deficiencies. In this context, smart use of integrated nutrient management and use of organic formulations is one of the greatest options for ensuring long-term crop productivity, while maintaining soil fertility in maize and other cereal-based cropping systems. This ultimately improves crop yield (Garima and Pant, 2018). Cultivation of rabi maize is a common practice in Peninsular India (Telangana, Andhra Pradesh, Karnataka and Tamil Nadu) as well as in North Eastern plains, where the winter remains frost free and temperature does not fall below 12°C.

1.1 Gluconic acid based formulations:

Among various organic acids, gluconic acid seems to be the major mechanism of phosphate solubilization by gram negative bacteria (Goldstein *et al.*, 1993; Kim *et al.*, 1997). Gluconic acid is produced by the oxidative metabolism of glucose dehydrogenase enzyme through microbial fermentation with different types of *Aspergillus niger* strains.

1.2 Lactic acid based formulations:

Different strains of Lactobacilli are used for Lactic acid production. Lactic acid bacteria have also been used for the treatment of animal manures, farm yard manure and sewage for odor abatement and as an inoculant to accelerate the composting of organic wastes (Okada, 1998).

1.3 Amino acids based formulations:

The chelating ability of amino acids has been used in fertilizers for agriculture to facilitate the delivery of minerals to plants in order to correct mineral deficiencies, such as iron chlorosis and other nutrient deficiencies. These fertilizers are also used to prevent deficiencies from occurring and improving the overall health of the plants (Ashmead, H. DeWayne, 1986). Amino acids can be extracted from marine algae like sea weeds (*Ascophyllum nodosum*), plant like soybean, maize gluten, protein cake from vegetable oil industries and animal proteins.

1.4 Protein lacto gluconate Nutrients:

Several organic carbon (OC) rich formulations tailored with amino acids, gluconic and lactic acids blended with elemental Nitrogen (N), phosphorous (P), potassium (K) , sulfur (S), calcium (Ca), magnesium (Mg), boron (B), copper (Cu), iron (Fe), molybdenum (Mo), manganese (Mn) etc., were produced from research & development based biotech industries. These formulations were proved through bio-efficacy studies by several national and international agriculture universities and research laboratories on various crop systems and environmental conditions.

The experiment will be conducted to study the efficacy of integrated usage of the recommended dose of fertilizers and Lacto gluconate based organic formulations on Maize. The study will focus on growth and development in terms of soil physico chemical characteristics, microbial characteristics, plant growth parameters, yield attributes and post harvest parameters.

2. Material and Methods:

2.1 Preamble

The experiment will be conducted to study the efficacy of integrated usage of the recommended dose of fertilizers and Lactate, Gluconate based organic formulations on Maize. The study will focus on growth and development in terms of plant growth and yield attributes.

2.2 Location

The experimental site Malla Reddy University is situated in Southern Telangana Agro Climatic Zone at longitude - 78° 46' 22.69" E (78.772971), latitude - 17° 21' 9.86" N (17.352743) with an altitude of 547 meters above Mean Sea Level.

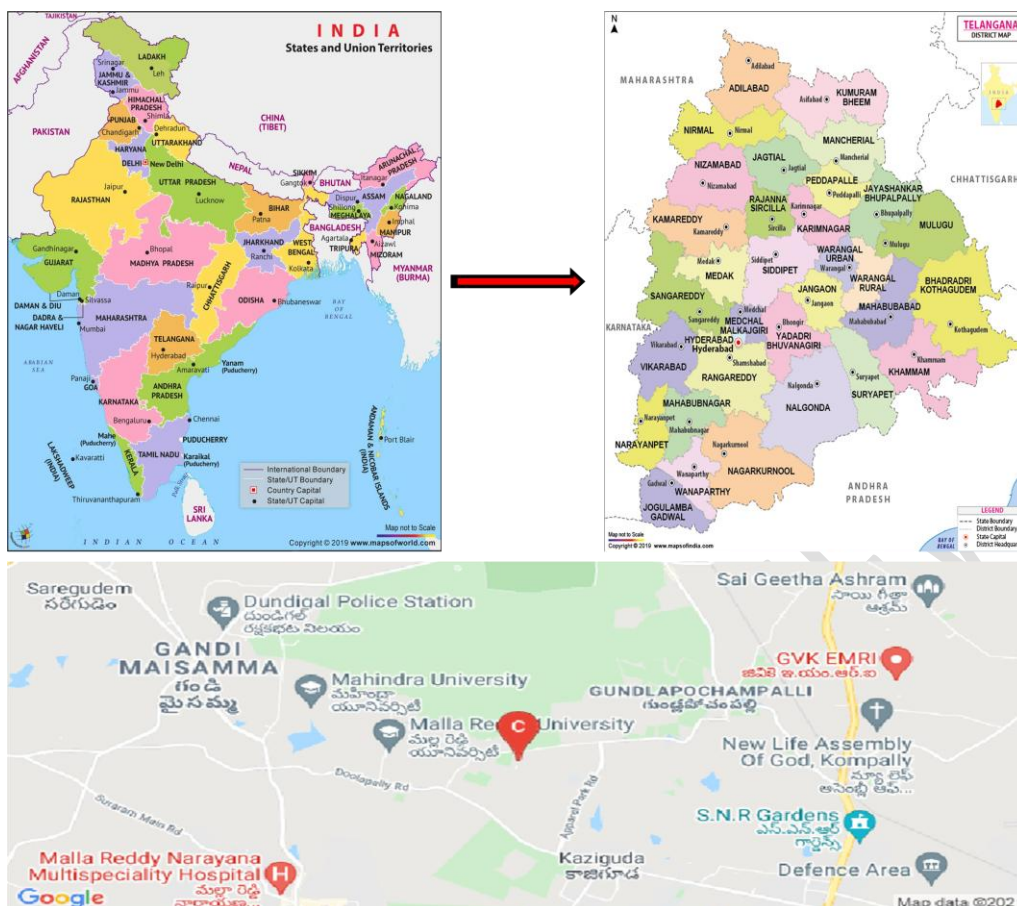


Fig. 1. Location map of field experiment

2.3 Crop and Variety

Maize variety, DHM-117 a short duration high yielding genotype suitable for *kharif* and *rabi* seasons was used for the field experiment.

2.4 Experimental details:

Table 1. Experimental details of Maize crop

S.No.	Particulars	Details
1.	Year of Experiment	2021-22
2.	Crop	Maize
3.	No. of Treatments	6
4.	No. of Replications	4
5.	Spacing	60×20 cm
6.	Experimental Design	Randomized Block Design
7.	Season	<i>kharif</i> -2021

8.	Variety	DHM-117
9.	Location	Malla Reddy University, Telangana

Treatment Details:

T₁: Control (No fertilizer)

T₂: 100 % RDF

T₃: 75 % RDF + 25 % Sahasra Organic Formulations

T₄: 50 % RDF + 50 % Sahasra Organic Formulations

T₅: 25 % RDF + 75 % Sahasra Organic Formulations

T₆: 100 % Sahasra Organic Formulations

Recommended Dose of Fertilizer (kg/acre) N: 72-80; P: 24; K: 20

2.5 Sahasra Organic Products:

Sahasra organic products i.e., Organic manure, Sage, Nutri and Poshak were formulated and supplied by Sahasra crop science, Hyderabad for testing the efficacy of the products for improving the soil health and yield.

Table 2. Details of Sahasra Organic Formulations

S.No.	Crop	Product	Dosage	Time of Application	Spraying Intervals
		Organic Manure	50 kg/acre	Basal Dose (Before sowing)	Single Dose
1.	Maize	Sage	3 ml/lit	20, 40, 60 DAS	Three Sprays
		Poshak	3 ml/lit	30 & 40 DAS	Two Sprays
		Nutri	2 ml/lit	20 & 40 DAS	Two Sprays

*Coragen 10 DAS (for fall army worm)

Spraying Schedule:

20, 40 & 60 Days After Sowing

Note:

Organic Manure (50 kg/acre as Basal Application); **Sage** (3 ml/lit at 20-40-60 DAS); **Nutri** (2 ml/lit at 20 & 40 DAS); **Poshak** (3 ml/lit at 30 & 40 DAS); If micronutrient deficiency observed on leaves additional spray can be given.

Crop raised as per recommended package of practices of the University. All the recommended agronomic practices uniformly followed for all treatments viz; hoeing, interculture operations, weedicides application and irrigations. For data recording five sample plants and cobs were identified randomly collected and stacked separately for sun drying and

various observations for treatment evaluation were recorded as per experimental design. The data were statistically analyzed by standard tools for interpretation of the results. Data recorded from the experimental identified plants in each sub-plot were randomly selected and taken average weight of all the cobs weight per plant⁻¹, no.of cobs per plant, cob length (cm), cob girth (cm), No. of kernels cob⁻¹, grain (kg ha⁻¹) and stover yield (kg ha⁻¹).

2.6 Grain yield It was noted by weighing the grains shelled from the cobs obtained from the central four rows of each sub-plot and converted it into kg ha⁻¹.

2.7 Biological yield recorded by weighing the sun dried plants along with ears obtained from central four rows of each sub-plot. The biological yield thus obtained in each sub-plot was converted into kg ha⁻¹.

2.8 Harvest Index (%)

$$HI (\%) = \text{Grain yield} / \text{Biological yield} \times 100 \text{ (Reddy, 2004)}$$

2.9 Statistical analysis

The data obtained from the field experiment was subjected to statistical analysis. Wherever the treatments difference were significant, Critical differences were worked out at 0.05 per cent probability level and the values were furnished. The treatment differences that were not significant at five per cent were denoted as “NS”. Brief interpretation of the results was given at the end of each parameter.

3. Results and Discussion

3.1 Plant Height (cm)

Table 3. Plant height of maize crop under different stages of crop growth

Plant height (cm)	6th Leaf	Silk stage	Dough stage	Maturity
T ₁	34.1	130.8	82.4	142.6
T ₂	45.8	171.1	108.4	178.1
T ₃	42.6	172.2	107.4	185.6
T ₄	40.3	160.1	100.2	165.4
T ₅	38.1	143.9	91.0	158.1
T ₆	37.7	138.9	88.3	149.8
C.D.	1.755	6.850	5.286	17.476
SE(m)	0.577	2.252	1.738	5.475
SE(d)	0.816	3.185	2.458	7.743
C.V.	2.904	2.947	2.171	5.675

The increased plant height among all the treatments on 6th leaf stage was observed in T₂ (100 % RDF) 45.8 cm, T₃ (75 % RDF + 25 % Sahasra Organic Formulations) 172.2 cm on silking stage, T₂ (100 % RDF) 108.4 cm on dough stage and in T₃ (75 % RDF + 25 % Sahasra Organic Formulations) 185.6 cm at maturity stage.

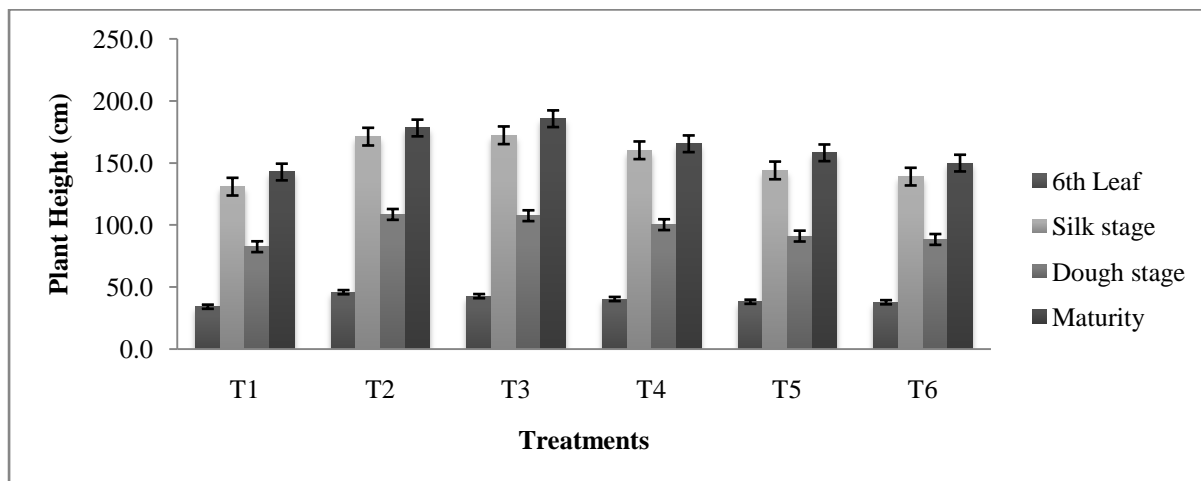


Fig. 2. Plant height of maize crop under different stages of crop growth

Table 4. Yield attributes of maize (*Zea mays* L.) as influenced by different doses of fertilizers and Sahasra Organic formulations.

Treatments	No. of Cobs/plant	Cob length (cm)	Cob girth (cm)	Cob weight (g)	No. of Kernels/Cob	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Test weight (g)	Harvest Index (%)
T ₁	9.6	16.5	11.7	128.3	457.4	4,808.2	7,835.60	29.1	38.03
T ₂	11.9	19.8	14.5	175.9	550.7	7,649.8	8,859.87	31.5	46.34
T ₃	11.8	20.7	14.3	180.6	554.6	7,241.3	8,850.63	31.8	45.00
T ₄	10.4	18.8	13.9	167.6	526.3	7,019.9	8,394.90	30.4	45.54
T ₅	10.2	18.0	13.2	157.3	509.1	6,763.6	8,252.73	30.4	45.04
T ₆	10.4	16.9	12.1	142.2	494.2	6,179.1	8,049.30	30.2	43.43
SE.m±	0.388	0.305	0.186	2.457	7.546	136.68	31.179	0.395	1.172
CD (P=0.05)	1.238	0.975	0.593	7.842	24.085	415.75	99.515	1.260	3.741

T₁: Control (No fertilizer), T₂: 100 % RDF, T₃: 75 % RDF + 25 % Sahasra Organic Formulations, T₄: 50 % RDF + 50 % Sahasra Organic Formulations, T₅: 25 % RDF + 75 % Sahasra Organic Formulations, T₆: 100 % Sahasra Organic Formulations. Recommended Dose of Fertilizer (kg/acre) N: 72-80; P: 24 K: 20

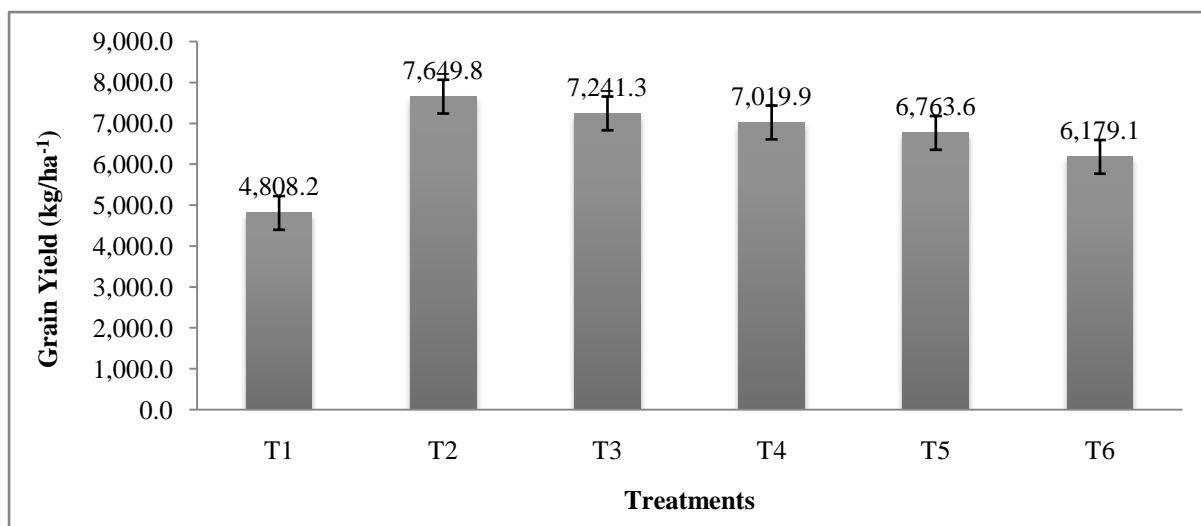


Fig. 3. Grain yield of maize as influenced by different doses of fertilizers and Sahasra Organic Formulations

Table 5. Economics of maize (*Zea mays* L.) as influenced by different doses of fertilizers and Sahasra organic formulations

Treatment	Gross returns	Net returns	B:C
T ₁	79958.975	51308.98	2.8
T ₂	123606.491	87116.49	3.4
T ₃	117469.759	82466.76	3.4
T ₄	113693.399	79477.40	3.3
T ₅	109706.733	76627.73	3.3
T ₆	100736.175	68811.18	3.2

- Grain cost Rs 15 /kg ; Stover cost = Rs 1/kg

3.4 Number of cobs per plant

The cob-bearing capacity is one of the most important crop yield components. More or less cobs, it is the genetic character of any cultivar but some improvement can be expected owing to agronomic manipulations. The number of cobs per plant was not affected significantly by different treatment combinations. Highest number of cobs per plant was observed with with recommended dose of fertilizer treatment. (T₂).

3.5 Cob length (cm)

The highest cob length (20.7 cm) recorded with T₃ (75 % RDF + 25 % SOF) followed by T₂ (100 % RDF) *i.e* 19.8 cm, while the least cob length has been recorded in T₁ control (16.5 cm) treatment. Increase in cob length might be due to adequate and uniform availability of nutrients during the crop growth which resulted in enhancement of the yield attributes Pathak *et al.* (2005) also observed the similar results.

3.6 Cob girth (cm)

Maximum cob girth (14.5 cm) recorded with T₂ (100 % RDF) followed by T₃ (75 % RDF + 25 % SOF) *i.e* 14.3 cm, while the least cob girth (11.7 cm) was recorded with T₁ (control)

3.7 Cob weight (g)

The highest cob weight (180.6 g) was recorded with T₃ (75 % RDF + 25 % SOF) followed by T₂ (100 % RDF) (175.9), while the lowest cob weight (128.3 g) noted with T₁ (control).

3.8 Number of kernels cob⁻¹

Higher number of kernels per cob (554.6) were recorded with T₃ (75 % RDF + 25 % SOF) followed by T₂ (100 % RDF) (550.7), while the lowest number of kernels per cob (457.4) were recorded with T₁ (control)

3.9 Grain yield (kg ha⁻¹)

Significantly higher grain yield (7649.8 kg ha⁻¹) was recorded with T₂ (100% RDF) which was statistically on par with T₃ (75 % RDF + 25 % SOF) (*i.e* 7241.3 kg ha⁻¹), followed by T₄ which recorded 7,019.9 kg ha⁻¹ grain yield closely followed by T₅ and T₆ (6,763.6 and 6,179.1 kg ha⁻¹ respectively), while significantly lower grain yield (4808.2 kg ha⁻¹) was recorded with T₁ (control). The maximum grain yield might be attributed due to combined effect of fertilizer along with organic formulations which escalated the availability of nutrients and transport of major nutrients like N, P and K which also resulted in increased plant height, no.of leaves and leaf area which in turn lead to increased production and translocation of photosynthates and yield attributes like cob length (cm), cob girth (cm), number of rows cob⁻¹ , cob weight (g), grain weight (g). The results are in similar trend with the results of increase of stover yield due to biofertilization of microbes as reported by

Abdelhamid *et al.* (2011), Baral and Adhikari (2013) and Meena *et al.* (2013). Sonawane *et al.* (2009) also reported better grain and dry fodder yield with combined application of nutrient due to improvement in yield parameter of maize crop. Application of organic manures because of combination with inorganic fertilizers not only enhanced the nutrient supply for higher grain yield, but also alters the soil physical and chemical properties which favour better crop growth and yield (Prasad *et al.*, 2011).

3.10 Stover yield (kg ha⁻¹)

Significantly higher stover yield (8859.8 kg ha⁻¹) was recorded with T₂ (100% RDF) which was statistically on par with T₃ (75 % RDF + 25 % SOF) which is (8850.6 kg ha⁻¹), followed by T₄, T₅, T₆ respectively (*i.e.* 8394.9, 8252.7, 8049.3 kg ha⁻¹), while the lowest stover yield (7835.6 kg ha⁻¹) was recorded with T₁ (control). The increase in stover yield might be due to combined effect of fertilizer along with organic formulations which enhanced the availability of nutrients like N, P and K, which resulted in increased in plant biometric observations such as plant height, number of leaves and leaf area which in turn lead to higher production and translocation of photosynthates and more dry matter production plant⁻¹. The results are in similar trend were the increase of stover yield due to biofertilization of microbes as reported by Abdelhamid *et al.* (2011) through biofertilization, by seed inoculation in maize by Baral and Adhikari (2013) and Meena *et al.* (2013). Manjhi *et al.* (2014) reported the maximum grain and stover yield under integrated treatment. Karki *et al.* (2005) also recorded similar result in respect of grain and stover yield of maize.

3.11 Test weight (g)

The highest test weight (31.8 g) was observed with T₃ (75 % RDF + 25 % SOF) which was on par with T₂ (100% RDF) (*i.e.* 31.5 g) followed by T₄, T₅, T₆ respectively (*i.e.* 30.4, 30.4, 30.2 g), while the lowest test weight (29.1 g) was recorded with T₁ (control). Due to the application of organic formulations plants received maximum nutrients throughout their growth period and nourished sufficiently, which resulted in maximum 100 kernel weight. Similar findings of more grain weight with imposing integrated treatment in Maize crops reported by Cheema *et al.* (2010)

3.12 Harvest index (%)

Significantly more harvest index (46.34) noted with T₂ (100% RDF) followed by T₃ (75 % RDF + 25 % SOF which is (45.54), while the lowest harvest index (38.03) observed with T₁ (control).

4. Conclusion:

From this study, it can be concluded that, application of integrated application of (75 % RDF + 25 % Sahasra Organic Formulations) was found to be on par with 100% recommended dose of fertilizer (T₂) recorded the highest grain yield (7649.8 kg ha⁻¹) and stover yield (8859.8 kg ha⁻¹), gross returns (₹ 123606.5 ha⁻¹), net returns (₹ 87116.49 ha⁻¹) with B:C ratio 3.4. and economical with highest net returns (₹ 82466.8 ha⁻¹) and B:C ratio (3.4) in both the treatments. This clearly indicates the advantage of application of Sahasra organic nutrients (75 % RDF + 25 % Sahasra Organic Formulations) recording the same yield thus reducing the total fertilizer cost by 25% with similar yield. In addition to this, application of Sahasra organic nutrients enhances the soil health in respect of total nitrogen, phosphorus and potassium content. Significant differences were also recorded in total microbial activity resulting in efficient uptake of nutrients.

So this study clearly indicates that application of recommended dosages of chemical fertilizers in combination with Sahasra organic nutrients gives higher yields and improves the soil health and reduces the cost of cultivation by benefiting the net returns to the farmers.

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