



## Studies on organic acid based biotech nutrients to enhance Soil organic carbon (SOC) and grain yield in Maize (*Zea Mays*) crop

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### Abstract

Maize (*Zea mays*) is one of the staple foods in many third world nations. Its production has increased over years as people change their consumption trends. Maize has evolved from a purely substance to a successful commercial crops. Maize is sold mainly for food in schools, relief by World Food programme (WFP). Maize Production has improved with the adoption of innovative technologies in farmer fields. These technologies include Organic acid based biotech formulations, Integrated nutrient management, improved seeds like hybrid and Longe varieties, timely planting, proper spacing and timely harvesting. Organic farming enhances soil carbon and its benefits (Hepperly, 2007). Adoption of Organic farming practices and usage of Lacto-gluconate based organic manures, vegetable protein and sea-weed based amino-acids, gluconic acid and lactic acid formulations enhanced the soil fertility, soil organic carbon (SOC) and increase in grain yield in Maize crop. As all these products are made from natural ingredients with microbial actions through fermentation, the formulations are ideal substitutes of inorganic nutrients in organic farming.

### 1. Introduction:

The nutrient bounded lacto-gluconate based products, not only ensures the supply of particular nutrient to the soil and crop, but they also enhances microbial activity by supplying carbon rich organic acids particularly glucose, an ideal food source for soil microorganisms and increases biological activity and soil organic carbon(SOC). The protein hydrolysate based products from vegetable protein and sea weed are rich source of soluble proteins and amino acids; hence act as growth promoters and ideal microbial activity enhancers and grain yield.

### 1.1 Soil Organic Carbon:

Soils contain carbon (C) (Milne, Eleanor 2008) in both organic and inorganic forms. In most soils (with the exception of calcareous soils) the majority of C is held as soil organic carbon (SOC) (Batjes, N.H., 1996). The term soil organic matter (SOM) is used to describe the organic constituents in the soil (tissues from dead plants and animals, products produced as these decompose and the soil microbial biomass). The term 'soil organic carbon' refers to the C occurring in the soil in SOM. The constituents of SOM can be divided into non-humic substances, which are discrete identifiable compounds such as sugars, amino acids and lipids, and humic substances, which are complex largely unidentifiable organic compounds. As organic compounds, both humic and non-humic substances contain carbon, oxygen (O) and hydrogen (H) and can also contain nitrogen (N), phosphorus (P) and sulfur (S).

### 1.2 Management of SOC:

Soil organic carbon is important for the function of ecosystems and agro-ecosystems having a major influence on the physical structure of the soil, the soil's ability to store water (water holding capacity), and the soil's ability to form complexes with metal ions and supply nutrients. Loss of SOC can, therefore, lead to a reduction in soil fertility, land degradation and even desertification. After conversion to cropland, appropriate management can maintain or increase SOC thereby improving the productivity and sustainability of the soil. The content of SOC in a soil is determined by losses of organic carbon (through decomposition, erosion of particles and losses through dissolved organic matter (Nelson, D.W., and L.E. Sommers. 1982) and inputs of organic C (e.g. crop residues, manures and other

organic wastes). Management of soils (Smith.P 2004) to increase SOC content therefore involves measures that reduce losses and/or measures that increase inputs.

## 2.0 Organic formulations through Biotechnology route:

### 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., 1998). Gluconic acid is produced by the oxidative metabolism of glucose dehydrogenase enzyme through microbial fermentation with different types of *Aspergillus niger* strains.

### 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).

### 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 (*Ascophylum nodosum*), plant like soybean, maize gluten, protein cake from vegetable oil industries and animal proteins.

### 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.

## 3.0 MATERIALS AND METHODS

**Apparatus:** Analytical balance, Kjeldhal flask – 500 ml, distillation assembly, conical flasks (250ml,500 ml), Measuring cylinders(50ml, 250 ml) Absorption spectrophotometer, Hydrometer, Burette, pipette, heating mantels

### Soil Analysis:

Soil analysis was conducted on two soil samples for fertility. The analysis also involved pH, Organic matter (OM), total nitrogen (N), available phosphorus (Av. P), exchangeable bases of calcium (Ca), magnesium (Mg) and potassium (K) and texture (percentage sand, clay and silt).

Standard laboratory analytical methods for soil fertility analysis were used. pH was done in water at a ratio of 1:2.5 (soil: water); OM was determined using the wet Walkley and Black carbon determining method (Walkley, A. and I.A. Black. 1934) and then using a conversion factor to compute for (OM); Kjeldhal method was employed to analyze for N; Ammonium acetate extraction method was used for the exchangeable bases and thereafter the cation determined using atomic absorption spectrophotometer; Hydrometer method used to determine soil texture. The soil is ideal for maize and beans production in the plots but requires improvement of organic matter for soil fertility and addressing the nutrient deficits highlighted. The fertility and productivity will depend on the increase of soil organic carbon, nutrient management and effective farming practices.

**Experiment Field Soil analysis data:**

Sample	pH	Total N	OM	Av.P	K	Ca	Mg	Texture (%)			Textural class
								sandy	clay	Silt	
		%		mgkg-1	cmoles/kg						
Sample 1	6.41	0.067	1.3	9.58	0.62	4.4	1	61	16	23	Sandy loamy
Sample 2	5.9	0.05	1.0	8.0	0.51	3.9	0.8	63	18	19	Sandy loamy

**Field Experiment:**

To evaluate Soil Organic carbon and grain yield in different treatments of only Organic, integrated (Inorganic Fertilizers + Organic inputs) and only inorganic farming practices in Maize (*Zea mays*).

Crop: Maize (*Zea Mays*)

Variety: Longe-5

Seed rate: 10-12 kg seed/Acre

Spacing: 75 cms x 30 cms (Bet. R –R: 75 cms; P –P: 30 cms)

Maturity: 100 -115 days

No. of treatments: 6 (T0, T1, T2, T3, T4, T5,)

No. of replications: 3 (R1, R2, R3)

Experiment Design: Randomized block design (RBD) (Addelman, Sidney, 1969)

Total Area: 1 Acre, Each Block: 224 sq.mts

Field Experiment Plot details with block-wise Treatment number and Replication number:

T0-R1	T1-R1	T2-R1	T3-R1	T4-R1	T5-R1
T3-R1	T4-R2	T5-R2	T1-R2	T2-R2	T0-R2

T5-R3	T0-R3	T2-R3	T3-R3	T1-R3	T4-R3
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**Treatments:**

T0: Control (No fertilizer)

T1: 100% Inorganic fertilizers

T2: 100% Organic inputs

T3: 75% Inorganic fertilizers + 25% Organic fertilizers

T4: 50% Inorganic fertilizers + 50 % Organic fertilizers

T5: 25% Inorganic fertilizers + 75% Organic fertilizers

**Inorganic fertilizers:**

DAP (Di-ammonium phosphate), Urea, MOP (Muriate of potash)

**Organic inputs (Organic acids – gluconic acid, lactic acid, amino acids):**

Organic N: source Aminoacids from vegetable protein

Organic P: Phosphorous, proteinhydrolysates/Aminoacids

Organic K: Potassium Gluconate and potassium lactate/potassium blend of proteinhydrolysates, gluconic acid and lactic acid.

Organic Micronutrients: micronutrients Ca, Mg, B, Cu, Fe, Mo, Mn blend of gluconic and lactic acids.

Organic Zn : Zinc blend with amino acids, gluconic and lactic acids.

**Table 1: Total organic carbon (TOC) in each Organic input.**

Organic Inputs	%Total Organic Carbon(TOC)(mg kg <sup>-1</sup> )
Compost	3.364
Organic P	3.230
Organic N	3.054
Organic K	3.970
Organic Micronutrient	2.931
Organic Zn	4.420

**Table 2: Treatments of Inorganic and Organic inputs (T0 –T5)**

Treatments	Dosage of fertilizer/Acre	Application stage
<b>T0</b> <b>No fertilizer</b>	Control – no fertilizer	nil
<b>T1</b> <b>100% Inorganic</b>	DAP: 50 kg; UREA: 100 kg; MOP: 50 kg	Basal Dosage 2 splits 25 & 45 DAS 45 DAS
<b>T2</b> <b>100% Organic</b>	Compost 100 kg Organic P 50 kg Organic N 50 kg Organic k 50 kg Organic P @ 3 ml per liter of water Organic N @ 3ml per liter Organic Zn @ 3ml per liter of water Organic Micronutrient @ 3ml per liter of water Organic k @ 3ml per liter of water	Last Basal Basal/At sowing 25 DAS 45 DAS 20 DAS between 21 – 30 DAS between 31 - 35 DAS between 40 – 50 DAS between 50 – 60 DAS
<b>T3</b> <b>75% Inorganic</b> + <b>25% Organic</b>	Compost 25 kg DAP: 37.5 kg + Organic P:12.5kg Urea:75kg + Organic N:12.5 kg MOP:37.5 kg + Organic k: 12.5 kg Organic P @ 0.75 ml per liter of water Organic N @ 0.75 ml per liter Organic Zn @ 0.75 ml per liter of water Organic Micronutrient @ 0.75 ml per liter of water Organic k @ 0.75 ml per liter of water	Last Basal Basal/At sowing 25 DAS 45 DAS 20 DAS between 21 – 30 DAS between 31 - 35 DAS between 40 – 50 DAS between 50 – 60 DAS

<p style="text-align: center;"><b>T4</b> <b>50% Inorganic</b>  + <b>50 % Organic</b></p>	<p>Compost :50 kg DAP: 25 kg + Organic P:25kg ,Urea:50kg + Organic N:25 kg MOP:.50 kg + Organic k: 25 kg Organic P @ 1.5 ml per liter of water Organic N @1.5 ml per liter Organic Zn @ 1.5 ml per liter of water Organic Micronutrient @1.5 ml per liter of water Organic k @1.5 ml per liter of water</p>	<p>Last Basal Basal/At sowing 25 DAS 45 DAS 20 DAS between 21 – 30 DAS between 31 – 35 DAS between 40 – 50 DAS between 50 – 60 DAS</p>
<p style="text-align: center;"><b>T5</b> <b>25% Inorganic</b>  + <b>75% Organic</b></p>	<p>Compost 75 kg DAP: 12.5 kg + Organic P:37.5kg ,Urea:25kg + Organic N:37.5 kg MOP:.12.5 kg + Organic k:37.5 kg Organic P @ 1.5 ml per liter of water Organic N @2.25 ml per liter Organic Zn @ 2.25 ml per liter of water Organic Micronutrient @2.25 ml per liter of water Organic k @2.25 ml per liter of water</p>	<p>Last Basal Basal/At sowing 25 DAS 45 DAS 20 DAS between 21 – 30 DAS between 31 – 35 DAS between 40 – 50 DAS between 50 – 60 DAS</p>

**Table 3:Block-wise grain yield per each treatment (T0-T5)**

TREATMENTS	Plot references	Yield/Block 224 sq.mts(Kgs)	Grain yield/Treatment	Yield/ Acre (Tonnes)

<b>T0 -No fertilizer</b>	<b>T0-R1</b>	<b>22.14</b>	<b>66.43</b>	<b>1.20</b>
	<b>T0-R2</b>	<b>22.37</b>		
	<b>T0-R3</b>	<b>21.92</b>		
<b>T1- 100% Inorganic</b>	<b>T1-R1</b>	<b>43.40</b>	<b>129.55</b>	<b>2.34</b>
	<b>T1-R2</b>	<b>41.52</b>		
	<b>T1-R3</b>	<b>44.63</b>		
<b>T2-100% Organic</b>	<b>T2-R1</b>	<b>48.54</b>	<b>145.05</b>	<b>2.62</b>
	<b>T2-R2</b>	<b>49.20</b>		
	<b>T2-R3</b>	<b>47.31</b>		
<b>T3-75% Inorganic+25% Organic</b>	<b>T3-R1</b>	<b>55.38</b>	<b>173.07</b>	<b>3.09</b>
	<b>T3-R2</b>	<b>58.94</b>		
	<b>T3-R3</b>	<b>58.75</b>		
<b>T4-50% Inorganic+50 % Organic</b>	<b>T4-R1</b>	<b>68.62</b>	<b>203.18</b>	<b>3.67</b>
	<b>T4-R2</b>	<b>67.13</b>		
	<b>T4-R3</b>	<b>68.43</b>		
<b>T5-25% Inorganic+75% Organic</b>	<b>T5-R1</b>	<b>59.74</b>	<b>181.03</b>	<b>3.27</b>
	<b>T5-R2</b>	<b>60.35</b>		
	<b>T5-R3</b>	<b>60.94</b>		

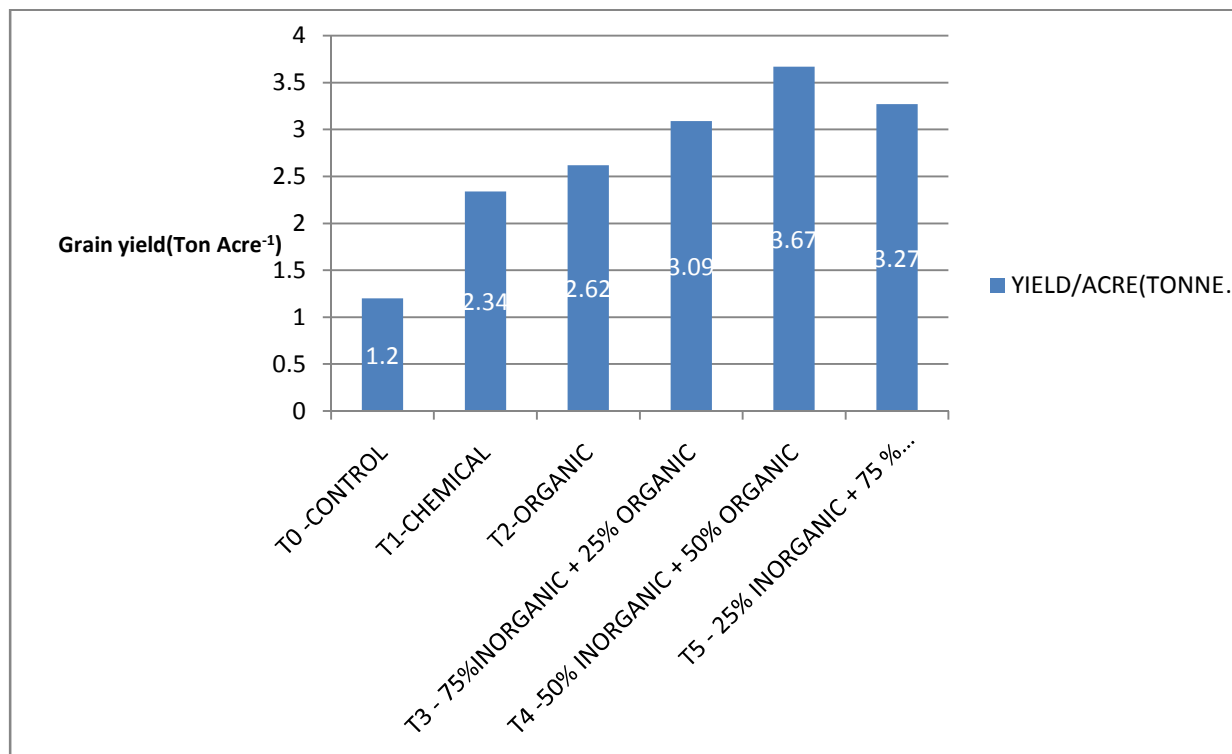
#### 4.0 RESULTS:

Table -4: Grain yield in tonnes acre<sup>-1</sup> for each treatment.

<b>TREATMENTS</b>	<b>Grain yield/Treatment</b>	<b>Yield/ Acre (Tonnes)</b>
<b>T0 -No fertilizer</b>	<b>66.43</b>	<b>1.20</b>
<b>T1- 100% Inorganic</b>	<b>129.55</b>	<b>2.34</b>
<b>T2-100% Organic</b>	<b>145.05</b>	<b>2.62</b>

<b>T3-75% Inorganic+25% Organic</b>	<b>173.07</b>	<b>3.09</b>
<b>T4-50% Inorganic+50 % Organic</b>	<b>203.18</b>	<b>3.67</b>
<b>T5-25% Inorganic+75% Organic</b>	<b>181.03</b>	<b>3.27</b>

**Diagram-2: Grain yield in tonnes per acre for each treatment.**



**Table -5: %Soil organic carbon (%SOC) in different soil levels.**

<b>TREATMENTS</b>	<b>0-15 Cms</b>	<b>15-30Cms</b>	<b>30-45 Cms</b>	<b>Avg% SOC</b>
<b>T0 -No fertilizer</b>	<b>1.32</b>	<b>1.14</b>	<b>0.98</b>	<b>1.14</b>
<b>T1- 100% Inorganic</b>	<b>1.35</b>	<b>1.24</b>	<b>1.38</b>	<b>1.32</b>
<b>T2-100% Organic</b>	<b>2.23</b>	<b>2.36</b>	<b>2.20</b>	<b>2.26</b>

<b>T3-75% Inorganic+25% Organic</b>	<b>1.47</b>	<b>1.29</b>	<b>1.42</b>	<b>1.39</b>
<b>T4-50% Inorganic+50 % Organic</b>	<b>1.75</b>	<b>1.66</b>	<b>1.72</b>	<b>1.71</b>
<b>T5-25% Inorganic+75% Organic</b>	<b>1.96</b>	<b>1.82</b>	<b>1.87</b>	<b>1.88</b>

**Table - 6: Average Percentage of soil organic carbon (%SOC) in each treatment plot as follows:**

<b>TREATMENTS</b>	<b>% SOC</b>
<b>T0 -No fertilizer</b>	<b>1.14</b>
<b>T1- 100% Inorganic</b>	<b>1.32</b>
<b>T2-100% Organic</b>	<b>2.26</b>
<b>T3-75% Inorganic+25% Organic</b>	<b>1.39</b>
<b>T4-50% Inorganic+50 % Organic</b>	<b>1.71</b>
<b>T5-25% Inorganic+75% Organic</b>	<b>1.88</b>

### 5.0 Results:

Among different treatments and practices the maximum **grain yield** was recorded in **T4-50% Inorganic fertilizers + 50% Organic fertilizers (3.67 t/acre)** followed by T5-25% Inorganic fertilizers + 75% Organic fertilizers(3.27 t/acre), T3-75% Inorganic fertilizers + 25% Organic fertilizers(3.09 t/acre), T2-100% Organic inputs (2.62 t/acre), T1-100% Inorganic fertilizers(2.34 t/acre), T0-Control (No fertilizer) (1.20 t/acre).

The maximum percentage of increased **soil organic carbon (%SOC)** was recorded in **T2: 100% Organic inputs (2.26)** followed by T5: 25%

Inorganic fertilizers + 75% Organic fertilizers(1.88), T4: 50% Inorganic fertilizers + 50 % Organic fertilizers (1.71), T3: 75% Inorganic fertilizers + 25% Organic fertilizers(1.39), T1: 100% Inorganic fertilizers (1.32), T0: Control (No fertilizer) (1.14) .

### 6.0 Discussions:

The results revealed that the T2-100% Organic(2.26)is having the maximum percentage of Soil Organic carbon (%SOC) when compared to T1-100% inorganic(1.32).The percentage of SOC was increased along with the quantitative increase of organic fertilizers (25%>50%>75%) and quantitative decrease in inorganic fertilizers(75%<50%< 25%)

respectively in T3,T4,T5 integrated treatments. Organic fertilizers are rich in carbon content that enhanced the soil organic matter thus increased the percentage of SOC. The grain yield is higher in Integrated treatments T3-75% Inorganic fertilizers + 25% Organic fertilizers(3.09 t/acre),T4-50% Inorganic fertilizers + 50% Organic fertilizers (3.67 t/acre), T5-25% Inorganic fertilizers + 75% Organic fertilizers(3.27 t/acre), than solo inorganic fertilizer T1-100% Inorganic fertilizers(2.34 t/acre), Hence the increased levels of organic fertilizer 25%, 50% and 75% in integrated (T3-T5) treatments were given higher grain yield of maize crop than T0- control and T1-100% inorganic treatment.

### 7.0 Conclusion:

The above comparative field studies in Maize (*Zea mays*) showed that the organic acids (Amino acid, gluconic and lactic acid) based products increased the percentage of soil organic carbon (SOC) in maize. The treatment T2-100% organic practice is the maximum increase of SOC (2.26). The SOC percent was increased in plots where the ratio of organic fertilizers increased gradually. The SOC was decreased where the ratio of inorganic fertilizers increased. Hence, it is clear that Organic acid based nutrients played the vital role in increasing the percentage of SOC. The highest grain yield is in T4-50% Inorganic fertilizers + 50% Organic fertilizers (3.67 t/acre) in compared to T1: 100% Inorganic fertilizers (1.69). This is due to the chelating nature of amino acids and organic acids in Protein-lactogluconate formulations in organic fertilizers increased the bioavailability of the available nutrients in the inorganic fertilizers to the crop. Hence Grain yield was increased along with the increased ratio of organic fertilizers.

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