Effect of Zeolite and Rice husks Ash on Soil Salinity of Sandy Loam Soil Irrigated with Saline Water and Yield of Tomato (*Lycopersicon esculentum* Mill)*

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ABSTRACT

A field experiment was conducted in Al-Zubair district, Al-Raha region, south of Basrah province, Iraq during agricultural season 2018, in order to determine the effect of irrigation with saline water (16 dS m^{-1}) and three types of amendments zeolite, rice husk ash (RHA), and mixture of zeolite and rice husk ash on soil salinity and yield of the tomato plant (*lycopersicon esculentum* Mill), jasmine cultivar. The amendments were added to the soil surface layer at three levels for each amendment (0, 5, and 10 ton ha^{-1}). Soil samples and yield were taken at the end of the growing season included electrical conductivity of the soil and total yield of tomato. The results showed that addition of mineral and organic amendments led to a decrease electrical conductivity for sandy soil irrigated with saline water, which increased total yield of tomato. Zeolite and zeolite mixed with rice husk ash had reduced salinity of the soil, which in turn affected the total yield of tomato plants. The results showed that the level of 10 and 5 tons ha^{-1} of zeolite gave highest average to reduce soil salinity 2.12 and 4.65 dS m^{-1}, respectively, with a percentage of a reduction 80.47 and 57.18%, respectively, for control treatment. Results of study also showed that the zeolite at rate of 10 tons ha^{-1} gave the highest yield of tomato 60.76 ton ha^{-1} compared to control treatment, which gave an average for tomato yield 24.55 ton ha^{-1}.

Keywords: Zeolite, Rice Husk Ash, Soil Salinity, Tomato.

تأثير الزيولايت ورماد قشور الرز في خفض ملوحة الترب الرملية المزيجية المروية بالمياه المالحة وانتاجية محصول الطماطة (Lycopersicon esculentum Mill)

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المستخلص

نفذت تجربة حقلية في قضاء الزبير منطقة الراحة في جنوب محافظة البصرة/العراق خلال الموسم الزراعي 2018 بهدف معرفة تأثير الري بالمياه المالحة (16 ديسي سيمنزم$^{-1}$) وثلاث أنواع من المصلحات (الزيولايت ورماد قشور الرز والزيولايت المخلوط مع رماد قشور الرز) على ملوحة التربة وانتاجية نبات الطماطة (lycoperscion esculentum Mill) صنف الياسمين. تم تهيئة تربة الحقل من حراثة وتنعيم وسمدت بالسماد الحيواني وبعد ذلك فتحت المروز ثم اضافة المصلحات خلطا الى التربة مع الطبقة السطحية وبثلاث مستويات لكل مصلح (0 و5 و10 طن هكتار$^{-1}$) كما صممت منظومة الري بالتنقيط ونقلت شتلات الطماطة بتاريخ 2018/10/1 الى الحقل

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بعد وصولها الى عمر 4–5 أوراق حقيقية وبواقع شتلتين على جانبي كل منقط وبذلك احتوت كل وحدة تجريبية على 40 نبات وتمت عمليات الزراعة واضافة الاسمدة اللازمة ومتابعة عمليات الخدمة وبوشر بالري بنوعية المياه حتى نهاية التجربة. أخذت عينات التربة والحاصل في نهاية موسم النمو وتضمنت الايصالية الكهربائية للتربة والحاصل الكلي للنبات في نهاية الموسم. وأظهرت النتائج أن اضافة المصلحات المعدنية والعضوية ادت الى خفض قيم الايصالية الكهربائية للتربة الرملية المروية بالمياه المالحة مما زاد الحاصل الكلي للنبات. تفوق مصلح الزيولايت ومصلح الزيولايت المخلوط مع رماد قشور الرز على مصلح رماد قشور الرز في خفض ملوحة التربة والذي انعكس بدوره على الحاصل الكلي لنباتات الطماطة. كما أظهرت النتائج أن المستوى 10 و5 طن هكتار$^{-1}$ من مصلح الزيولايت أعطى أعلى معدل لانخفاض ملوحة التربة بلغ 2.12 و4.65 ديسي سيمنزم$^{-1}$ على التتابع، وبنسبة خفض بلغت 80.47 و 57.18% على التتابع، عن معاملة المقارنة بدون اضافة وكذلك اظهرت نتائج الدراسة ان مصلح الزيولايت عند المستوى 10 طن هكتار$^{-1}$ اعطى أعلى حاصل كلي للنبات بلغ 60.76 ميكا غرام هكتار$^{-1}$ مقارنتا مع معاملة المقارنة بدون اضافة والتي اعطت حاصل كلي بلغ 24.55 ميكا غرام هكتار$^{-1}$.

INTRODUCTION

Salinity has many and varied effects on soil and plants. Increasing of soil salinity effects on physical and chemical properties of soil and productivity of crops (Salman, 2000). This relationship between salinity and reducing growth is not the same but differs with different ions. Some ions have more toxicity than other ions, and the interaction between ions leads to low effects than the ionic concentrations affect alone (Al-Shahwani,2006). Al-Amiri, (2010) found in a study conducted on nine wells in the western desert region, south of Basra province, water used for irrigation of tomatoes, whose values of electrical conductivity ranged between 8.7 to 12.04 dS m^{-1}, caused a decrease in yield of tomato plants from 45.28 to 44.36 ton ha^{-1}, respectively. The use of natural amendments and organic fertilizers improves physical, chemical, and fertility properties of soil, thus creating a good environment for plant growth in terms of increasing the moisture content and providing nutrients for plant. One of the enhancers that have received great interest in improving the physical and chemical properties of soils is zeolite (Yamada et al., 2002). Zeolite minerals possess some unique properties that may let them a desirable enhancer to improve soil properties, soil porosity, water retention and distribution of particle sizes, which allowing nutrients to release for plants (Ok *et al*, 2003). Noori *et al.*, (2006) showed that using zeolite in saline soils improved the quality of the soil and increasing the average of agricultural production for the soil through reducing the values of electrical conductivity for soil by reserving the ions causing salinity away from the root zone in addition to increasing the soil content, the reason for the structural of the zeolite. Muntohar, (2002) observed that adding rice husk ash to soil reduces the values of electrical conductivity due to an increase in the firing temperature which leads to an increase in the specific surface area and the number of pores for the ash, thus leads to an increase in the retention of dissolved ions that cause salinity. Salman, (2018) showed that the terminology used in the study had a significant effect on increasing the value of electrical conductivity for the study soils, increasing the yield of wheat and other growth components, and the availability of nutrients in the soil. Due to the deterioration of the quality of water and its scarcity and the continued irrigation of it has caused the salinization of the soil in recent years, the study aimed to use of natural amendments as plant residues in order to treat soil salinity and increase the productivity of tomato in Al-Zubair farms, southern Iraq.

MATERIALS AND METHODS

A field experiment was conducted in field of Al-Raha region, Al-Zubair district, south of Basrah province, during the season 2018, to study the effect of adding amendments (zeolite, rice husk ash a mixture of zeolite and rice husk ash) on reducing soil salinity and yield of tomato plant (*lycoperscion esculentum* Mill). The field soil was analyzed before planting according to methods mentioned in (Richards, 1954; Black *et al.*, 1965; Page *et al.*, 1982) as shown in Table 1. Raw Rice Husk (Amber cultivar) (*Oriza Sativa* L.) was collected from agricultural fields in Al-Shamiya District, Qadisiyah province. The impurities, as well as the soil, were removed after cleaning and washing with distilled water. The samples were air-dried, and they were burned in the Muffle Furnace at a temperature of 1000 °C for 3 hours to obtain Rice Husk ASH (RHA).While the zeolite amendment was prepared by the General Company for Agricultural Supplies belonging to the Ministry of Agriculture in the form of particles. The field soil was prepared by plowing, furrows were then opened, field soil was fertilized with one level of organic manures (6 tons ha^{-1}), zeolite and rice husk ash mixed with the soil at three levels 0, 5, and 10 tons ha^{-1}, zeolite, rice husk ash, and zeolite mixture with rice husk ash. Drip irrigation system was designed with main lines of 5.08 cm, sub-lines of 2.5 cm, and dripper's holders with diameter of (1.3 cm), drippers with diameter of (0.2 mm), and the distance between the dripper and another was 40 cm. Seeds of tomato crop (Jasmine cultivar) were planted in cork trays inside a plastic house, and when the growth reached 4-5 leaves, they were transferred to the field on 10/1/2018 with two seedlings on either side of each dripper, so each experimental unit contained 40 plants. Mineral fertilizers were added at levels of (320 kg N ha^{-1}) as urea fertilizer (46% N) in two doses, the first before planting mixed with the soil and the second 30 days after planting date. Phosphate fertilizer, it was added at a level of (90 kg P ha^{-1}) as concentrated

Table1.Chemical and Physical properties of the initial soil used in the experiment.

Properties	Value	Unit
pH	7.78	-
EC	5.24	dS m^{-1}
CEC	3.41	Cmol kg^{-1}
O.M.	0.61	gm kg^{-1}
$CaCO_3$	183	
Ca^{++}	12.75	mmol L^{-1}
Mg^{++}	10.91	
Na^{+}	23.31	
K^{+}	0.48	
Cl^{-}	19.62	
SO_4^{--}	10.22	
CO_3	0	
HCO_3	3.18	
Clay	18.06	gm kg^{-1}
Silt	9.77	
Sand	72.17	
Texture	Sandy loam	

super phosphate (20.21%P) in one dose at planting, and Potassium fertilizer at a level of (120 kg K.ha^{-1}) as Potassium sulfate fertilizer(43%K), one dose according to the recommendations of Ministry of Agriculture/Public Authority for Agricultural Services.

Crop service operations continued, including maintenance of drippers, controlling diseases and insects, and protecting plants from the cold by covering them with plastic, in addition to cleaning, and other operations until the end of the growing season with irrigation of plants with treated well water in addition to the control treatment with water from wells at electrical conductivity (16 dS m^{-1}) (Table 2).

Table 2.Chemical and Physical properties of the water irrigation used in the experiment.

Properties	Value	Unit
pH	7.36	-
EC	16	dS m^{-1}
Ca^{++}	337.94	mg L^{-1}
Mg^{++}	267.42	
Na^{+}	1465.27	
K^{+}	224.67	
Cl^{-}	3259.84	
SO_4^{--}	490.93	
CO_3	0	
HCO_3	793.00	
TS	13100	mg L^{-1}
TSS	1800	
TDS	11318	
SAR	13.58	(mmol L^{-1})$^{1/2}$

Two factors were used in the experiment: type of amendment (zeolite, rice husk ash, and mixture of zeolites with rice husk ash) and three levels of amendments (0, 5, and 10 tons ha^{-1}). Soil samples were collected at the end of the agricultural season and electrical conductivity (EC) was measured according to the method mentioned in Page *et al.*(1982). At end of the season, yield of tomato fruits (ton ha^{-1}) was calculated, where the yield of the experimental unit was calculated from total cumulative for yield of the harvest until end of the season (20 harvests), yield was then calculated basis on yield of experimental unit according to following equation:

$$\text{Yield of tomato (ton ha}^{-1}\text{)} = \frac{\text{yield of the experimental unit} \times \text{hectare area } (m^2)}{\text{area of the experimental unit } (m^2)}$$

RESULTS AND DISCUSSION

Electrical conductivity of Soil

Figure (1) shows the effect of type of amendments on electrical conductivity values in sandy loam soil irrigated with water (16 dS m^{-1}), where zeolite and mixture of zeolite with RHA had excelled on RHS treatment, the average values of the decrease in the value of electrical conductivity were 5.88, 7.60, and 10.74 dS m^{-1}, with a percentage of reducing 45.25 and 29.23%, respectively.

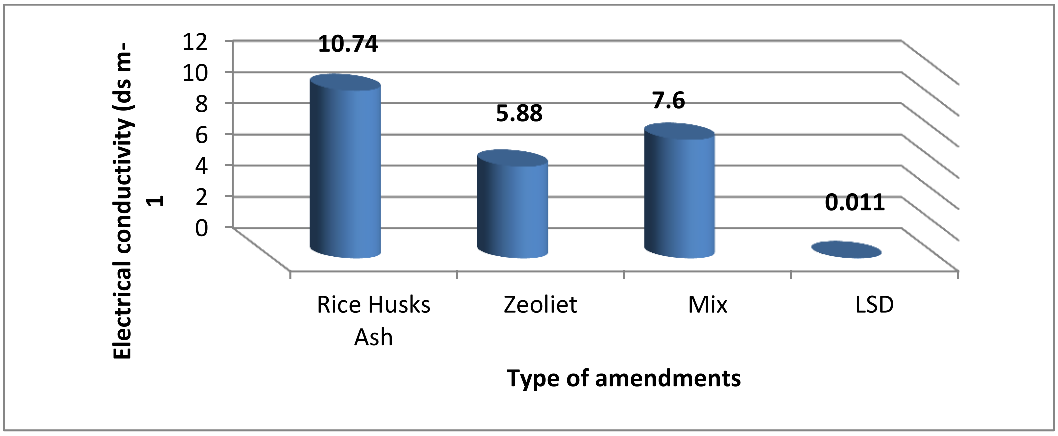

Figure 1. Effect Type of amendments on electrical conductivity of sandy loam soil irrigated with saline water (16 dS m^{-1}).

The reason may be due to the role of amendments in an improving of physical and chemical properties of soil, including increasing moisture content of water in soil, which reduces the effect of salts in the soil and improves the porosity of the soil, which increase leaching of salts, especially sodium and chloride ions from the soil profile, causing a decrease in soil salinity (Ramesh and Reddy, 2011; Spokas *et al.*,2012; Al-Mathy,2018). Zeolite mineral leads to an increase in the moisture content of soil due to the high absorption of water by its crystals, thus reducing the salt concentration in the soil solution, which increases with the increase in the rate of zeolite added to the soil (Ajirloo *et al*, 2013). Among to properties of zeolites are hold water molecules and cations, and reducing the concentration of salts in the soil solution, thus greatly reduce the values of electrical conductivity. Where the zeolite tends to adsorb potassium and calcium ions more than sodium, which reduces the sites of sodium adsorption, thus leaches from the soil, so its concentration in the soil solution decreases. Therefore, zeolite can be very useful in reducing high soil salinity (Ghorbani and Agha,2009; Cabanilla *et al.*, 2016). These results agree with Al-Khuder et al, (2017) who found a decrease in ele *t* ctrical conductivity of two soils (medium and high salinity) treated with zeolites at the end of the growing season. Figure 1 shows an increase in soil electrical conductivity values when using RHA amendment compared to other treatments. The reason may be due to RHA trapped ions, which are quickly released into the soil solution upon hydrolysis of the ash, which contributes to an increase in soil salinity. These results agree with Salman, (2018), Al Amary and Mahdi,(2015).

Figure 2 shows effect of adding amendments levels on the values of electrical conductivity for soil, where all the treatments, had excelled control treatment, where values of electrical conductivity for treatments of amendments levels 6.97 and 6.39 dS m^{-1} for the level of 5 and 10 tons ha^{-1}, respectively, while value of the electrical conductivity for control treatment was (10.86 dS m^{-1}) highest percentage of reduction was at level of 10 tons.ha^{-1} which reached to 41.16% compared to control treatment, followed by the treatment of level 5 tons ha^{-1} with a percentage of reduction reached to 35.81% with control treatment, where it is noticed that reducing values of electrical conductivity with increasing of amendments level to the sandy soil irrigated with saline water, which shows the role of the amendments in reducing electrical conductivity when raising the level of the amendments (0 to 5 and 10 tons ha^{-1}).

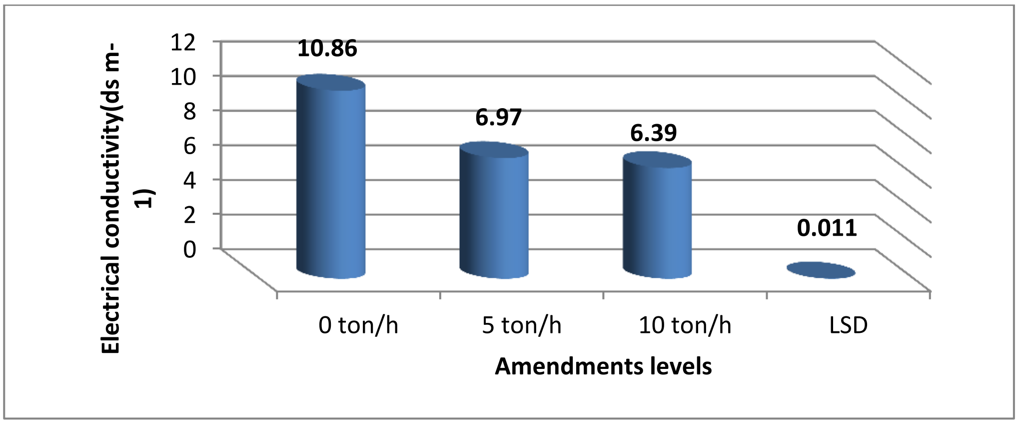

Figure 2. Effect of amendments levels on electrical conductivity of sandy loam soil irrigated with saline water (16 dS m^{-1}).

This is due to the role of zeolite and RHA in reducing soil salinity, where zeolite is an effective amendment in reducing salts from the soil due to its effective role in an increasing porosity of soil and movement of water downward, transporting salts with it, which leads to a reduction of salts in soil. These results agree with (Abdel-Hassan, 2018).

Figure 3 shows that there was a significant effect of interaction between type of amendments and their levels on values of electrical conductivity of soil. There was a significant decrease in values of electrical conductivity for zeolite treatment and mixture of zeolite with RHA treatment compared to RHA treatment alone. It varied depending on level of amendment added where variance between the amendment increases with the increase in the level of addition, and highest significant variance appeared at level of 10 tons.ha^{-1}, where interaction treatment of level of zeolite amendment at the level of 10 tons ha^{-1} and treatment of zeolite amendment at level of 5 tons ha^{-1}had excelled over rest of treatments, where value of electrical conductivity was 2.12 and 4 65 dS m^{-1}, respectively, while treatment of RHA at the level of 10 tons ha^{-1} gave highest value (11.23 dSm^{-1}). These results agree with (Al-Khuder,2017;Al-Mathy, 2018).

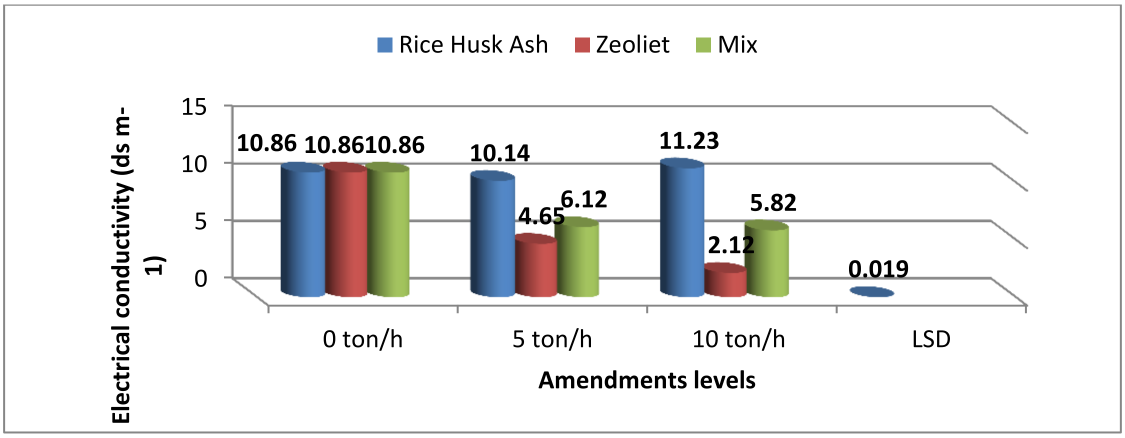

Figure 3. Effect Levels and Type of amendments on electrical conductivity of sandy soil irrigated with saline water (16 dS m^{-1}).

Yield of Tomato Plant

Figure 4 showed that the type of amendment had a significant effect on yield of tomato (ton ha^{-1}), where the treatments of amendments differed among themselves in affecting the amount of yield of tomato plant, where treatment of zeolite had excelled on the rest of the amendments and gave a yield 44.48 ton ha^{-1}. It was followed by the zeolite amendment mixed with RHA, which gave a yield 42.48 ton ha^{-1}. The increases in yield can be attributed to the amount of nutrients, such as nitrogen, phosphorous, and potassium supplied by amendment and increasing their availability in soil, which increased the absorption processes of these elements from soil, which leads to the activation of the photosynthesis process as a result of increase in the synthesis of nutrients in leaves and their transfer to the fruits (Okon *et al*, 2005; AL-Busaidi *et al*, 2008).

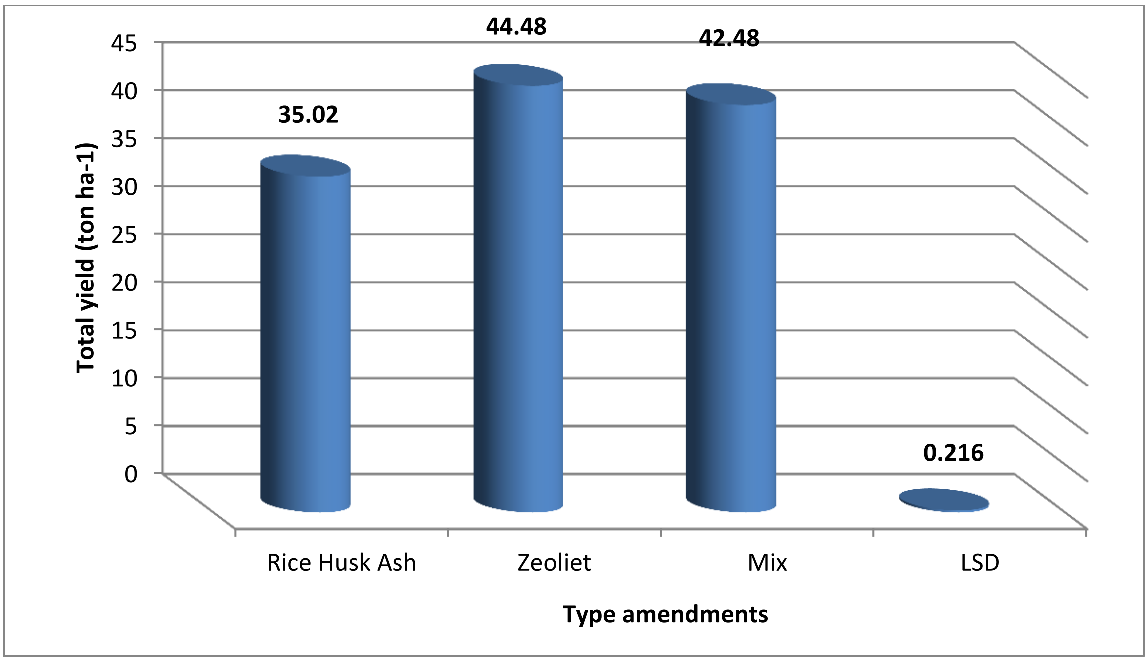

Figure 4. Effect of type amendments on tomato yield (ton ha^{-1})

Figure 5 shows that there was a significant effect of interaction of type of amendment and level of amendment on tomato yield, where zeolite amendment at the level of 10 tons.ha^{-1} had excelled on the rest of amendments by giving highest yield of tomato which reached to 60.76 ton ha^{-1} followed by treatment of zeolite amendment mixed with RHA at level of 10 tons.ha^{-1}, zeolite amendment at level of 5 tons.ha^{-1} and zeolite amendment mixed with RHA at the level of 5 tons.ha^{-1} which reached to 57.45, 48.15 and 45.44 ton ha^{-1}, respectively. These results agree with (Al-Khuder et al,2017; Abdel-Hassan, 2018; Al-Mathy, 2018).

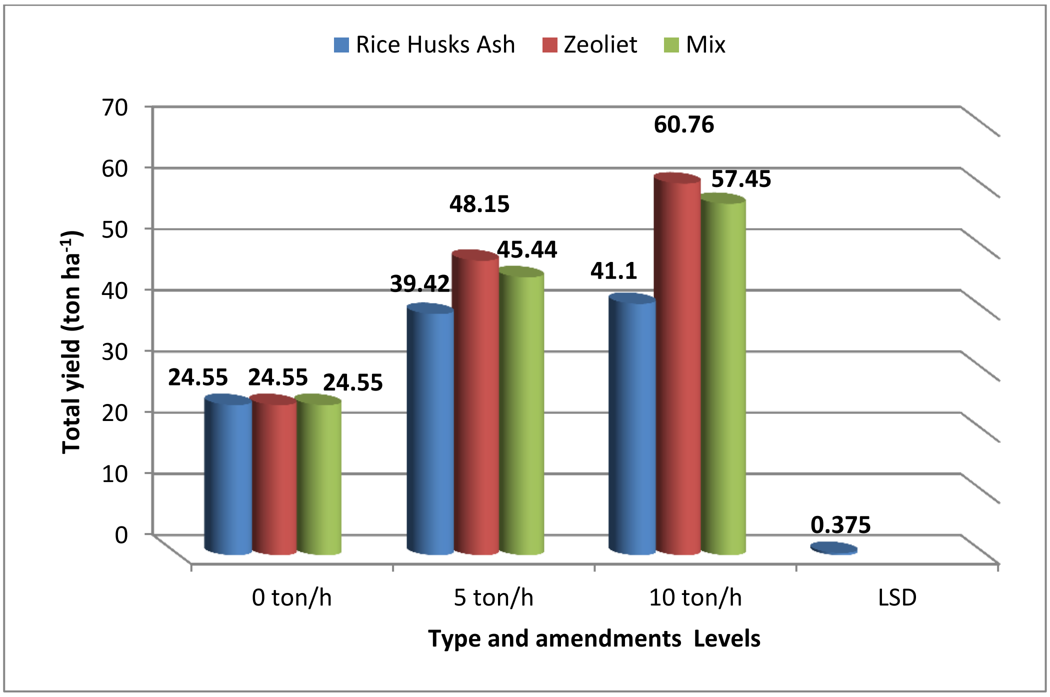

Figure 5. Effect of type and amendments levels on tomato yield (ton ha^{-1})

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