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Influence of Agro-industrial Wastes and *Azospirillum* on Nutrients Status and Grain Yield under Corn Plant Growth in Arid Regions

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Agro-industrial wastes such as spent grain and compost, amended with *Azospirillum brasilense* inoculation seeds before sowing were studied as to their effect on soil properties, plant growth parameters, seeds yield and nutrients composition of corn (*Zea mays* Var. 352.) under greenhouse conditions for four months. *Azospirillum,* one of the plant growth promoting bacteria (PGPB), has been recently used as a biofertilizer in soil to increase soil nitrogen fixation, phosphate availability and reducing soil salinity. Spent grain a by-product from beer industries, has a negative value for environmental quality due to its accumulation as an industrial waste. It has been recently applied as an environment-friendly organic waste increasing total organic carbon (TOC) in soil to improve its nutrient status. In this study, treatments of 1% (T1) and 2% (T2) of spent grain, 1% (C1) and 2% (C2) of compost and mix of both sources (C1T1), *Azospirillum* inoculation for soil (A1), *Azospirillum* with C1 (A1C1), *Azospirillum* with T1 (A1T1) were used and compared to the control. Treatments were mixed with calcareous soil; analysis showed varying nutrients composition with compost and spent grain 33% and 75%, of OM respectively, while spent grain had the highest nitrogen. The spent grain applied at 25.5gkg^{-1} increased total nitrogen, phosphorus and potassium of corn. *Azospirillum* inoculation with organic wastes increased growth and seed yield significantly (P>0.05).The highest rate of spent grain with *Azospirillum* most effectively increased total organic carbon, macronutrients, growth parameters, and reduced soil Na^+ concentration, being more effective than compost in improving properties of calcareous soil, and much non-expensive compared with compost or any chemical fertilizers.

Keywords: Agro-industrial fertilizer, plant growth, macronutrient, seed yield and *Azospirillum*

INTRODUCTION

The Egypt's agricultural production has been constrained by, among other factors, aridity, soil productivity and inappropriate fertilization practices. The aridity is mainly due to low precipitation, high temperature and low soil water holding capacity. The soil productivity is affected by several factors such as calcareous condition, aridity, soil organic matter and soil texture. The fertilization practice should consider the enhancement of nutrient availability and environmental dimension. Human intervention, through control operation or application of viable land use system, can enhance and promote the soil productivity. For exemple, alleviation of soil constrains can be enhanced using such an organic source that improve soil physical, chemical, and biological properties.

A soil is considered calcareous from the chemical point of view when it is in equilibrium with excess of calcium carbonate ($CaCO_3$) at the partial pressure of the atmospheric carbon dioxide (CO_2). In $CaCO_3$ rich soils, the dominant weather able mineral is calcium carbonate. In these calcareous systems, the important rate, limiting step in the dissolution kinetics is the transfer of atmospheric CO_2 to solution (Avnimelech, 1980 and Amrhein et al., 1985). Calcareous soils are characterized by the presence of calcium carbonate in the parent material and may have a calcic horizon, a layer of secondary accumulation of carbonates (usually calcium or magnesium carbonates), in excess of 15% calcium carbonate equivalent and at least 5% more carbonate than an underlying layer (FAO, 2016). Calcareous soils have $CaCO_3$ in the soil that may occur in various forms (powdery, nodules, crusts etc…). Calcareous soils are common in semi-arid and arid regions and they are expanded on 30% of the world's arable soils (Guerinot, 2001). The total Calcisol (calcareous) area may well amount to some one billion ha, nearly all of it in the arid and semi-arid tropics and subtropics of both hemispheres (FAO, 2016). The availability of water and plant nutrients (i.e. N and P, among others nutrients) is a mandatory mean for management of a calcareous soil. It is well known that high levels of $CaCO_3$ lead to low bioavailability of mineral nutrients (Cartmill et al., 2008), in particular phosphorous (P) (Shen et al., 2004; Mhindu et al., 2013).

The soil organic matter is considered as a pH buffering. Application of solid cattle manure moves soil pH towards neutrality in acidic (Benke et al., 2009) and alkaline soils thus improving nutrient availability especially for P and micronutrient. Organic source should be regarded not only as a store of nutrients, but also as a beneficial soil conditioner.Aboukila, et al., (2018); Šimek and Cooper (2002) reported that decrease of pH might be due to the presence of phenolic and fatty acids resulted from organic source composition that reduces soil pH sharply.

Organic matter content was proportionate to the amount of manure applied and the practice of fertilization. Melero- Sanchez et al., (2008); Rashad et al., (2016)reported that organically fertilized soils show significant increases in total organic carbon, macronutrients, microbial biomass carbon and enzymatic activities compared with those found under inorganically fertilized plots. Other investigators have also reported that combined organic/inorganic fertilization both enhanced C storage in soils, reduced emissions from N fertilizer and enhance of plant growth (Pan et al., 2009; Rashad et al., 2016).

In addition, plant growth-promoting bacteria (PGPB) have been recently applied as a biofertilizer in soil to increase nitrogen fixation and phosphate availability and reduce soil salinity. One of the PGPB is the *Azospirillumbrasilense (Azospirillum*). They are free-living bacteria capable of affecting growth and seed yield of numerous plant species and many of agronomic and ecological significance. *Azospirillum* produces growth regulators, such as gibberellin, auxins and cytokinins as well as amino acids (Thuler et al., 2003).

Azospirillum improving plant growth promotion capacity lies in its ability to produce various phytohormones that improve plant and root growth to absorb water and minerals that eventually yield larger, and in many cases more productive plants by increasing seed yield and fresh weight for plants (Tiquia 2005; Dobbelaere et al., 2001).

The work was a comparative study of friendly organic wastes (Agro-industrial) and *Azospirillum* inoculation on the macro-nutrients, growth parameters and yield of corn (Zeamayz L. Var. 352) cultivated in the calcareous soil in Egypt. In this work, *Azospirillum* was used as a potential agent to solve environmental problems caused through the accumulation of agricultural and industrial wastes. It could be inoculated into spent grain and compost as a substrate. The main goals are to determine the effectiveness of using *Azospirillum*, spent grain and compost with either calcareous soils for enhancing soil nitrogen fixation, increasing concentrations of soil necessary elements (N, P, K) and macro-nutrients (Ca^+, Mg^{2+} and K^+), decreasing P fixation in calcareous soils, increasing growth and seed yield of plant in reclaimed soils and determining the optimum application rates of amendments to increase soil fertility and to enhance crop growth in the studied soil.

MATERIALS AND METHOD

Soiland Study Area

The soil samples were collected from the experimental farm of the City of Scientific Research and Technological Applications (SRTA-City), Alexandria, Egypt. (Plate.1) (Approximately latitude is 30◦ 53' 33.17''N and, 29◦ 22' 46.43'' E).

Table 1.Characterization of calcareous soil before treatment addition

Soil parameter	Calcareous Soil
pH (1:2.5 w: w)	8.34
EC(dS/m, 1:1 w:w)	1.74
Total N (gkg^{-1})	0. 30
Available P ($mgkg^{-1}$)	4.20
Available K^+ ($mgkg^{-1}$)	320.2
Total $CaCO_3$ (%)	30.6
CEC ($Cmol^+/kg$)	11.81
Organic Matter ($g\ kg^{-1}$)	9.8
Organic C ($g\ kg^{-1}$)	5.6
Total DOC (%)	0.012
ESP (%)	12.86
Sand (%)	64.1
Silt (%)	15.2
Clay (%)	20.7
Texture	Sandy Clay Loam
Soluble ions (mg/kg, 1:1w:w)	
Ca^{2+}	162.4
Mg^{2+}	61.32
Na^+	52.90
K^+	71.76
CO_3^{2-}	0.00
HCO_3^-	381.2
SO_4^-	274
Micronutrients ($mgkg^{-1}$)	
Fe^{2+}	4.10
Zn^{2+}	1.43
Mn^{2+}	3.49
Cu^{2+}	0.61
B^+	0.30
Cl^-	192

This area was located in the north-west coast of Egypt, the calcareous soil contains many problems, and this is due to the climate and parent material of this soil is limestone. The climate is arid and hot summers and semi- cool and wet winters. The average precipitation very low is 130mm, and the average temperature is 25.6 (FAO, 2016). The soil samples were collected at the depth of 0–25 cm, air dried and sieved through a 2-mm sieve prior to analysis. The sub samples of the air-dried soil used for the physical and chemical parameters of the calcareous soil are shown in (Table 1).

Green house additives (Agro-industrial wastes and *Azospirillum*)

Three types of amendments (*Azospirillum*, compost and spent grain) were used. The *Azospirillum* bacteria it was from faculty of Agriculture, Ain Shams, Cairo Governorate, Egypt. The compost consisted of plant and animal wastes from the national factory for the production of compost, Alexandria, Governorate, Egypt. The spent grain, a by-product from beer industry, was obtained from Al Ahram Beverages Company, Abu Hammad, Al Sharkia Governorate, Egypt. The characteristics of the Agro-industrial wastes were determined according to the standard procedures described (Table 2)

Experimental preparation

Amendment materials were applied to calcareous soil with *Azospirillum* inoculation at two different rates of Agro-industrial wastes (Compost and Spent grain) (Table 3).These organic amendments to calcareous soil increase soil content 1% and 2% of organic matter. The base rate of compost (C1) and spent grain (T1) was the amount of compost or spent grain important to increase soil organic matter by 1%.

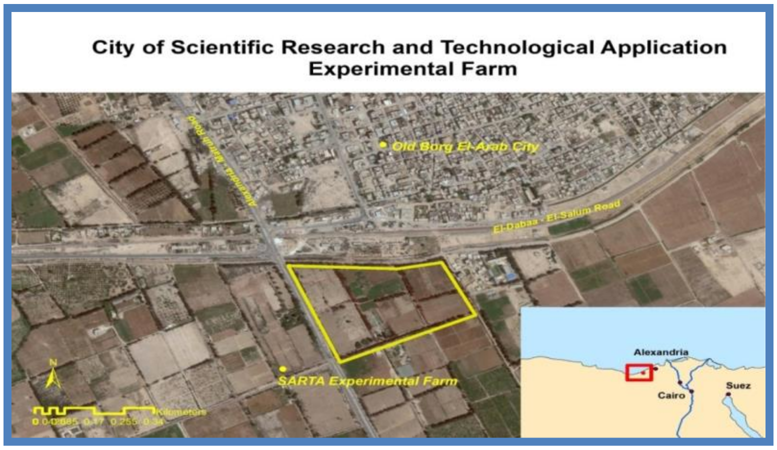

Plate1. The experimental farm of SRTA-City, New Borg El-Arab City, Alexandria, Egypt, Location30^0 53$^/$ 33.17$^{''}$ N, 29^0 22$^/$ 46.43$^{''}$E (Source: Google earth, 2018).

Table 2. Agro-industrial wastes characteristics (oven dry weight).

Parameter	Compost	Spent grain
pH (1:5 w:w)	7.2	4.16
EC (dS/m, 1:5 w:w)	5.81	1.45
Organic Matter (g kg^{-1})	332	750
Total N (gkg^{-1})	21.0	31.2
Total P (gkg^{-1})	10.3	18.6
Total K (gkg^{-1})	5.70	17.4
C: N ratio	9.16	13.9
Organic carbon (%)	19.25	43.5
Fe^{2+} (mgkg^{-1})	960	1130
Zn^{2+} (mgkg^{-1})	220	368
Mn^{2+} (mgkg^{-1})	100	210
Cu^{+} (mgkg^{-1})	61	98

Table 3.Agroindustrial wastes application rates (oven dry weight).

Treatments		**Application Rates**
		Green house Exp. (gkg^{-1})
Control (-)	Negative Control	Without amendment
Control (+)	Positive Control	NPK*
T1	Spent grain (1%)	12.8
T2	Spent grain (2%)	25.5
C1	Compost (1%)	23.5
C2	Compost (2%)	47.0
C1T1	Compost + Spent grain	C1+T1
A1	*Azospirillum*	Inoculation (seeds and soil)
A1T1	*Azospirillum* + Spent grain	A1+T1
A1C1	*Azospirillum* + Compost	A1+C1

NPK* means 100% recommended dose of NPK fertilizers

Agro-industrial wastes (Compost and spent grain) were also added at two times the base rate (C2 and T2).

Additional treatments included a mixed of *Azospirillum* inoculation (A1) with compost (A1C1) and spent grain (A1T1), control positive (100% of NPK fertilizer) and a control negative (without amendment). All treatments were mixed with 25 kg soil in a greenhouse experiment.

Experimental period

The green house experiment was carried out during the summer of 2017 at the experimental farm of the SRTA-City. The organic amendment was mixed with soil for 4 months; all pots were watered with tab water according to Romanenko's equation till germination completed after that irrigation was used according to the needs of the plant. The experiment was performed using calcareous soil under growing corn (ZeamayzL.).

Soil analyses

Soil samples from all treatments mentioned were air dried ground then sieved through a 2-mm sieve. They were analyzed for several physical and chemical properties. The particles-size distribution was determined by a hydrometer as described by Jackson (1973). The electrical conductivity (EC) was determined in 1:1 soil-water extract (Jackson, 1973). The soil pH was measured in soil suspension1:2.5. Soluble ions were measured in the 1:1 soil water extract. Soluble calcium, magnesium, carbonate, bicarbonate and chloride were measured by titration (Jackson, 1973). Cation exchange capacity (CEC) was determined by (1molar Na OAc) method (Rhoades, 1982). Soluble sodium and potassium were determined by flame photometer according to Sparks (1987) and Jackson (1973). Total nitrogen (TN) was determined by Microkjeldehl method (Bermner and Mulvaney, 1982). Soil organic carbon (SOC) was determined by the modified Walkley-Black method as described by Nelson and Sommers (1982). Available potassium K was extracted by 1 N ammoniumacetate solution and measured by the flame photometer according to Jackson, (1973). Total dissolved organic carbon (TDOC) was determined, using the TOC analyzer (multi-N/C UV3100, Analytikjena product, Germany) at 1100 °C. Available micronutrients (zinc, copper, iron, manganese and boron) were extracted by di ethylene triamenpenta acetic acid (DTPA) solution as explained by Lindsay and Norvell (1978) then measured with inductively coupled plasma (ICP) atomicemission spectroscopy. Total P was determined by colorimetric measurement after digestion with $HClO^{4-}H2SO4$. Available phosphorus (Av.P) was extracted with 0.5 N $NaHCO_3$ according to Olsen and Sommers (1982).

Plant analyses

The plant analysis and measurements at the end of the experiment: the plants were harvested and washed using deionized water, air dried, and oven dried at 70 °C for 48 h and fresh yield, dry weight after 15, 100 day, ear weight, ear height, ear width, plant length, biological yield/F, 100 seeds weight, seeds yield /plant and harvest index were calculated as described by the Association of Official Seed Analysts (AOSA, 1983).

Statistical analysis

To test the statistical difference among means, variance analysis (ANOVA) was conducted followed by Least Significant Difference (LSD) at a 5% level of significance for mean comparisons. The obtained data were statistically processed using SPSS software (SPSS Statistics, 2007).

RESULTSAND DISCUSSION

Chemical properties, including total nitrogen (TN), available phosphorus (Av.P), available potassium ($Av.K^+$), Ca^{2*}, Mg^{2+}, Na^+, K^+, of the calcareous soil has been determined. The data of analysis of the tested agro-industrial wastes are presented in (Table 4 and Figure 1). Spent grain and *Azospirillum* had least and similar values of C/N ratio and they also had relatively high TN and Av.P, spent grain had higher value of TN, compost and control with higher C/N had relatively high organic matter and total organic carbon. Spent grain and *Azospirillum* had higher value of available K.,(El-Desoky and Ragheb, 1993 and Goyal et al., 2005), had successfully used organic wastes as a source of K in maize production. Considering the low values of organic matter, total N, available P, available K^+ and total organic carbon in the slightly calcareous soil at experimental site, the agro-industrial wastes, especially the spent grain with *Azospirillum*bacteria, are expected to improve soil fertility and availability of macronutrients to corn plant. Hence it was shown in (Table 2) that agro-industrial wastes enhanced nutrient status of calcareous soil significantly (P> 0.05), especially in case of soil macronutrients (TN, Av.P and $Av.K^+$) .

Soil macronutrients (TN, Av. P, and Av. K^+) were significantly increased by all agro-industrial wastes and *Azospirillum* inoculation compared to the control$^-$ and control$^+$ and followed the order T2 >, A1 >, C1T1 >, A1T1>, T1 >, C2 >, A1C1>, C1, Control+ >Control - respectively suggesting that all agro-industrial treatments were effective at adding TN, Av.P and Av.K to study soil (Table 4). The application rates of spent grain and *Azospirillum* inoculation (T2 and A1) were superior compared to the same rate of compost and *Azospirillum* inoculation for soil TN, Av.P, and Av.K^+. The high rate of spent grain (T2) and *Azospirillum* inoculation (A1).was produced significantly greater increases of TN and Av.P in soil thanin other organic amendment, while A1T1 was statistically similar to C1T1 and both significantly increased soil K^+ compared to other organic amendments. Soil TN, Av.P and Av.K^+ increased as the application rate of spent grain or *Azospirillum* inoculation increased mineralization of agro-industrial wastes in soil as well as the nutrients present in the spent grain and *Azospirillum* were responsible for increasing the availability of plant macronutrients in soil. The effect of *Azospirillum*on the metabolism of corn and common bean germination and growth rate increased respiration and transpiration rates (Plaza et al., 2008 and Vedder-Weiss et al., 1999). Furthermore, spent grain or *Azospirillum* should be applied after planting to give sufficient time for natural oxidation of organic matter, which in turn enhances the available soil macronutrients. Similar to the results of the present study, addition of agro-industrial wastes resulted in high TN, Av.P and Av.K^+ for calcareous soil (Goyal et al., 2005;Eghball, 2002, Melero-Sanchez et al., 2008).

Figure.1 shows soluble macronutrients concentration, Ca^{2+}, K^+,Mg^{2+} and Na^+. Generally, application of spent grain or compost with *Azospirillum* bacteria increased Ca^{2+}, K^+ and Mg^{2+}. The macronutrients (Ca^{2+}, K^+ and Mg^{2+}) concentrations were C2 >, C1 >, C1T1 >, T2>, T1 >, A1C1 >, A1 >, A1T1>, Control+ >, Control - respectively. The differences in the concentrations of macronutrients were significant among the treatments used. The contribution of compost treatment to Ca^{2+}, K^+ and Mg^2 was greater than the contribution of spent grain and *Azospirillum* bacteria at the both levels of application rates. This might due to the high be concentration of EC in the compost or to dissolving some $CaCO_3$ present in soil (El-Desoky and Ragheb, 1993; Rashad et al., 2016). The presented results were in agreement with the work done by Aboukila, et al., (2018); Frempong et al., (2006) and Goyal et al., (2005). They reported that addition of organic manure increased the levels of macronutrients in soil.

The soluble sodium concentration, Na^+, is shown in Figure (1). The concentration of sodium behaved similarly to the calcium concentration among treatments. But, the concentration of sodium in all treatments was lower than that of calcium. This lower value of sodium concentration may be due to the low inherent concentration in both of soil; and the used *Azospirillum* bacteria inoculation with organic source. The additions of organic matter affected the concentration of sodium significantly in the calcareous soil. The contribution of compost source in the Na^+ was greater than the spent grain and *Azospirillum* contribution. Soluble Na^+ increased as the compost and spent grain application rate compared to *Azospirillum* bacteria in calcareous soil. Generally, it is obvious that the high organic percentages are consistent with the low pH values in the present study. Similarly, Fremponget et al., (2006) and Goyal et al., (2005) reported that addition of organic wastes increases organic matter content which in turn increases the levels of Ca^{2+}, K^+ and Mg^{2+}. In a study to evaluate the effects of organic matter and nutrients in compost soil organic matter dynamics and crop production, Allen, (2014);Eghball et al., (2002) and Aboukila, et al., (2018)reported significantly great soil organic matter levels in plots treated with organic manure. The addition of organic source (spent grain or compost) might provide supplemental exchangeable ions such as Ca^{2+}, Mg^{2+} and Na^+ in the incubated calcareous soil.

Table 5 shows macronutrients for corn plant after 120-days since sowing. Total nitrogen (TN), total phosphorus (TP) and total potassium (TK) had similar trend. TN, TP and TK concentrations followed the order T2 > A1T1> C1T1> A1 >C2 >A1C1 >T1 >C1 > Control- > Control+ > initial conditions. For all studied macronutrients, the largest increases were observed with the spent grain (T2) and spent grain with *Azospirillum* (A1T1) inoculation treatments while the lowest increases were observed with compost and control treatments. Available macronutrients were significantly increased by T2 and A1T1 treatment compared to control. Generally, it is obvious that the high organic percentages are consistent with the higher N values in soil in the present study.

Table 4. Soil analysis for necessary nutrients for plants (N, P, K,) in calcareous soil after 120-days since sowing:

Treatments	Total N	Available P	Available K^+	C:N	N:P
	(%)	($mgkg^{-1}$)			
Initial	0.038	4.271	320.2	14.29	228.62
Crt-	0.019	2.680	178.62	23.04	202.77
Crt+	0.048	4.690	266.76	10.15	268.64
T1	0.087	12.228	369.85	11.51	183.99
T2	0.228	17.672	647.40	5.974	335.09
C1	0.062	6.784	310.70	11.92	239.03
C2	0.144	8.459	416.00	7.887	441.96
C1T1	0.164	16.415	486.20	8.629	258.41
A1	0.179	12.437	449.47	2.307	379.25
A1T1	0.167	16.834	389.02	5.223	257.25
A1C1	0.140	9.925	303.22	5.158	365.88
$LSD_{0.05}$	0.023	0.023	113.45	…….	…….

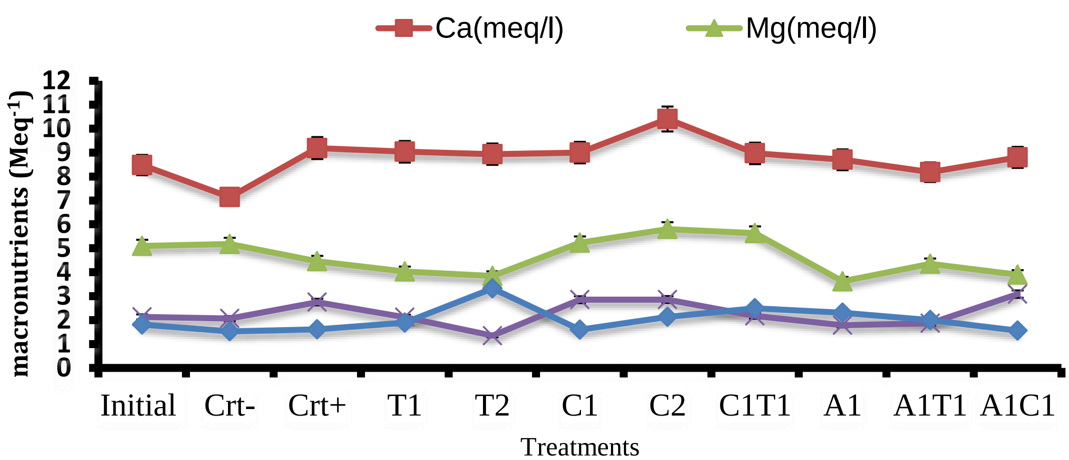

Figure (1): Effect of agro -industrial wastes and *Azospirillum* on soluble (Ca^{2+}, K^+, Mg^{2+} and Na^+) for calcareous soil after 120 days.

Table 5: Plant analysis for necessary nutrients in corn plant after 120-days since sowing :

Treatments	Total N	Total P	Total K^+	Total seed protein
	(%)			
Crt-	1.267	0.120	1.167	8.417
Crt+	1.627	0.177	1.513	8.875
T1	2.160	0.213	2.058	9.604
T2	2.873	0.283	2.741	13.750
C1	1.847	0.183	1.745	9.083
C2	2.253	0.257	2.093	12.458
C1T1	2.450	0.243	2.656	11.875
A1	2.393	0.147	2.025	12.750
A1T1	2.773	0.197	2.584	12.229
A1C1	1.910	0.133	2.101	8.667
$LSD_{(0.05)}$	0.125	0.055	0.316	1.155

Table 6: Effect of agro -industrial wastes on: fresh weight, dry weight, seed weight, ear weight for corn plant.

Treatments	Fresh weight	Dry weight	100 seed weight	Ear weight
	(gm)			
Crt-	197.667	29.650	17.710	76.667
Crt+	280.333	43.233	29.093	187.333
T1	443.333	66.667	32.010	289.333
T2	511.667	76.750	39.853	483.000
C1	311.333	46.700	30.807	200.667
C2	372.000	55.800	36.087	333.333
C1T1	464.000	69.600	38.000	390.333
A1	423.333	63.833	34.290	296.000
A1T1	492.333	73.983	35.957	287.333
A1C1	362.333	54.363	29.400	253.000
$LSD_{(0.05)}$	26.43	3.89	8.27	37.93

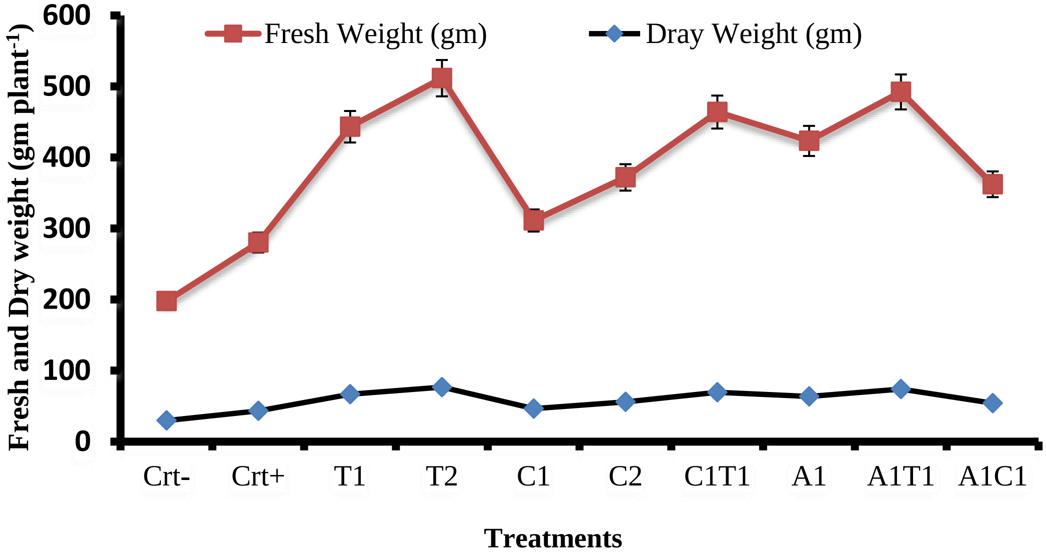

Figure 2: Effect of agro -industrial wastes and *Azospirillum*on fresh and dry weight for corn plant after 120 days.

Table 7: Effect of agro -industrial wastes on: plant height, ear length, ear width, ear number and seed yield for corn plant.

Treatments	Plant height	Ear length	Ear width	Ear No	Seed yield
	Cm	Cm		per plant	gm $plant^{-1}$
Crt-	128.333	10.667	7.833	0.667	49.833
Crt+	154.367	22.667	15.167	1.333	162.283
T1	175.167	28.333	18.667	1.667	313.083
T2	189.167	36.500	21.333	2.333	735.800
C1	171.667	25.000	16.667	1.000	130.433
C2	176.333	28.433	17.333	1.667	361.833
C1T1	183.667	31.000	19.000	2.667	675.783
A1	182.667	29.667	19.333	2.000	384.800
A1T1	188.733	30.000	18.067	1.333	247.433
A1C1	167.667	26.333	17.000	1.000	164.450
$LSD_{(0.05)}$	7.90	5.47	5.47	0.82	176.0

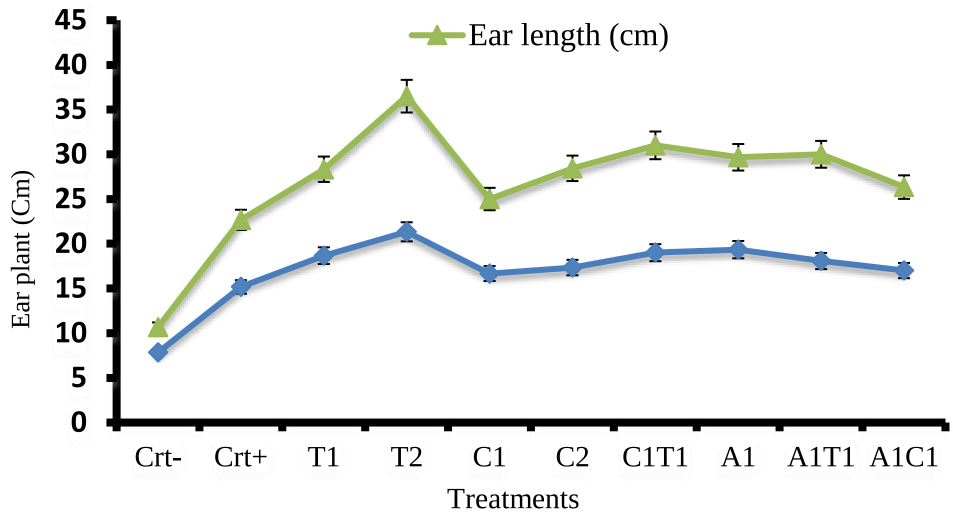

Figure 3.Effect of agro -industrial wastes and *Azospirillum*onear length and ear width for corn plant after 120 days.

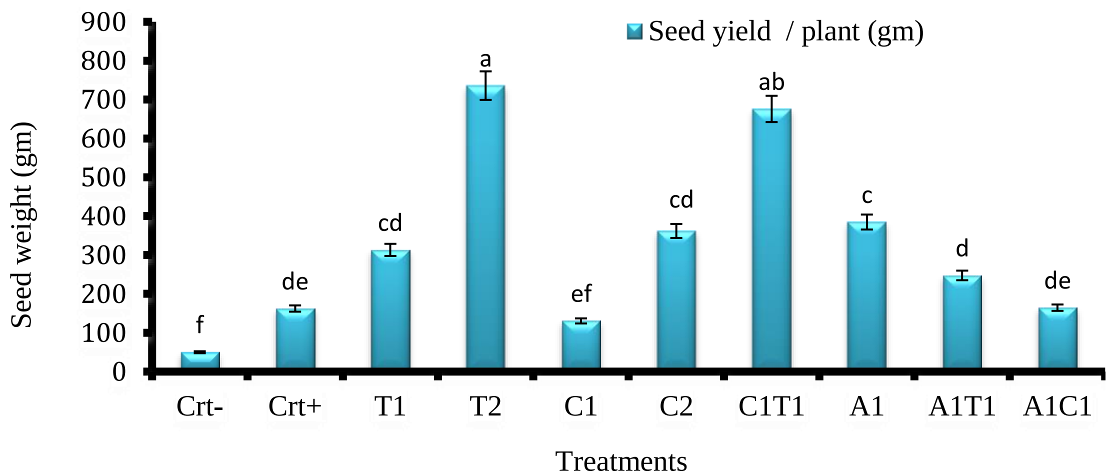

Figure 4: Effect of agro -industrial wastes and *Azospirillum on* seed yield for corn plant after 120 days.

Similarly, Chan et al., (2007) reported that agro-organic wastes added to soil increases organic matter content which in turn increase the levels of N, P and K^+ in plant.

In a study to evaluate the effects of organic matter and nutrients in compost, soil organic matter dynamics and crop production, Chauhan and Singh (2013); Eghball et al., (2002) reported significantly great plant growth levels in soil treated with organic wastes added.

Reduced rates of agro-industrial wastes amended with *Azospirillum* inoculation increased fresh weight, dry weight, ear weight and 100 seed weight (Table 6) significantly (P> 0.05) although control with NPK fertilizer (Control$^+$) increased fresh weight and dry weight (Figure 2) more than control without NPK fertilizer (Control-), compared to increase by agro-industrial wastes and *Azospirillum* . The mean ear weight for amended spent grain (T2) , *Azospirillum* with spent grain (A1T1) and Compost (C2) (Table 5) was 483 gm, 296 gm, and 333 gm respectively compared to

187 gm and 76.66gm for Control$^+$ and control$^-$ respectively. Amendment with *Azospirillum* increased seed yield more than amendment with compost which gave similar yield. This result is consistent with the finding of Ali et al., (2017) that organic wastes with bacteria had higher TN, TP, lower C/P ratio and C/N ratio for plant compared to goat and cattle droppings. Mean fresh and dry weight was recorded for T2 and A1 irrespective of amendment material T2 >, A1 >, C1T1 >, A1T1>, T1 >, C2 >, A1C1>, C1, Control$^+$> Control$^-$ respectively. The spent grain and *Azospirillum* was more significant than mean fresh weight, dry weight, ear weight and 100 seed weight for compost similarly it is indicated above that A1T1 gave higher fresh weight, dry weight, ear weight and 100 seed weight than control- and control+. *Azospirillum* was found greater only without NPK fertilizer greater, while fertilization with urea reduced its presence below the detection threshold of a molecular probe, and *Azospirillum* with organic wastes was greater than the absorption of nitrogen, phosphorus and potassium by the plant and also increased fresh and dry weight of a corn (Atiyeh et al., 2000 and Ceccherini et al., 2001).

Spent grain, *Azospirillum* and compost increased plant height, ear length, ear width, ear number and seed yield per a plant (Table 7 and Figures 3,4) in the following the order: T2 (spent grain 2%) >, C1T1 (Mix T1C1) >,C2 (Compost 2%) >, A1 (*Azospirillum* inoculation) >, A1T1(Mix A1T1) >, A1C1(Mix A1C1) >, T1 (spent grain 1%) > C1 (Compost 1%). The spent grain, *Azospirillum* increased in number of seed yield per a plant were 130% and 88% respectively. The increases given by spent grain and *Azospirillum* were statistically similar. This is consistent with similar values of leaf TN, TP and TK$^+$, recorded for the organic wastes and *Azospirillum*. Control$^-$ and control$^+$ had lower values of seed yield, leaf TN and TP in plant and soil. Spent grain (T2) and *Azospirillum* that gave the highest seed yield also gave the highest leaf TP and TK$^+$. These observations highlighted the importance of availability of N, P and K in determining corn plants after harvesting, and important of spent grain with *Azospirillum* and compost as a source of TN, TP and TK$^+$. The control$^+$ treatment did not highly increase plant height, ear width, ear length and ear number, although it decreased seed yield and ear weight insignificantly. Therefore control$^+$ is no recommended for direct application in calcareous soil. Ali et al., (2017), had reported that incorporation of highly signified mineral fertilizers reduced growth and yield of maize and uptake of TN and Av.P. This is especially so in case of spent grain, *Azospirillum* and compost (Table 7).*Azospirillum* produced growth regulators, such as auxins, gibberellin and cytokinins as well as polyamines and amino acids (Thuler et al., 2003; Chauhan and Singh 2013).The leading theory concerning its growth promotion capacity lies in its ability to produce various phytohormones that improve growth root, adsorption of water and organic minerals that eventually increase seed yield larger, and in many cases give more productive corn plants (Dobbelaere et al., 2001; Joardar and Rahman, 2018).

CONCLUSION

Ever increasing human population, size of confined animal operations and agricultural activities potentially increase the quantity of organic amendments that include organic wastes (spent grains and compost). Organic amendments with *Azospirillum* improve soil quality by enhancing soil fertility such as macronutrients and biological properties (microbial biomass/function and mineralization potential). The spent grains and *Azospirillum* treatments led to the increase of the necessary nutrients for plants such as (N, P, K) in calcareous soil. It also led to the increase of soluble macronutrients (Ca^{2+}, Mg^{2+} and K^+) in calcareous soil. Spent grain and *Azospirillum* may be used in calcareous soil to enhance plant nutrients, increase plant growth, ear length, ear width, seed yield, ear number per a plant, increase soil fertility and enhance corn plant growth in calcareous soil. In addition, spent grain with *Azospirillum* is non-expensive compared to compost or any other mineral fertilizers.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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REFERENCES

Ali, K., Arif, M., Shah, F., Shehzad, A., Munsif, F., Mian, I.A., Mian, A. A., (2017). Improvement in maize (*Zea mays* L) growth and quality through integrated use of biochar. BioresourTechnol 49(1):85–94

Allen, J.M., (2014).The effects of poultry litter biochar and water source on radish growth and nutrition.Crop, Soil and Environmental Sciences. Undergraduate Honors Theses-9, pp. 3-4. University of Arkansas, Fayetteville. http://scholarworks.uark.edu/csesuht/9.

Association of Official Seed Analysts (AOSA), (1983).Seed vigor testing handbook.Contribution to the handbook on seed testing, vol. 32.AOSA, Ithaca, NY, USA.

Atiyeh, R.M., Edwards, C.A., Subler, S., Metzger, J.D., (2000). Earthworm processed organic waste as components of horticultural potting media for growing marigold and vegetable seedlings. ComptSci Utility 8:215–223. https://doi.org/10.1080/1065657x.2000.1070 1994.

Avnimelech, Y. (1980). Calcium-carbonate-phosphate surface complex in calcareous systems. Nature, 288: 255-257.

Bermner, J.M. and Mulvaney C.S.(1982). Total–Nitrogen,pp.595-624. In page, et al.(ed).Methods of Soil Analysis .Part 2Book series No.9AmSoc.of Agron.and SOIL SCI.Soc.AM.Madison,Wisconsin.U.S.A.

Bhattacharyya, R., Kundu, S., Prakash, V.,and Gupta, H.S.(2008).Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean-wheat system of the Indian Himalayas.Eur J Agron 28: 33-46.

Cartmill, A.D., Valdez-Aguilar, L.A., Bryan, D.L. and Alarcón, A. (2008).Carbuncularmycorrhizal fungi enhance tolerance of vinca to high alkalinity in irrigation water. Sci. Hort. 115:275–284. https://doi.org/10.1016/j.fcr.2008.10.008

Ceccherini, M.T., Castaldini, M., Azzini, A., Fancelli, S., Bazzicalupo, M., and Miclaus, N. (2001). Occurrence of *Azospirillum*brasilense in soils amended with swine manure. Ann. Microbiol. 51: 29–37.

Chan KY, Van Zwieten L, Meszaros I, Downie A, Joseph S (2007[b]). Agronomic values of green waste biochar as a soil amendment. Aust J Soil Res 45:629–634. https://doi.org/10.1071/sr07109

Chauhan HK, Singh K (2013).Efect of tertiary combinations of animal dung with agro-wastes on the growth and development of earthworm Eiseniafetida during organic waste management.Int J Recy Org Agric 2:11. https://doi.org/10.1186/2251-7715-2-11

Climate-Data.org, (2016). Climate: Madinat Mubarak. <http://en.climate data.org/location/478837/> (accessed 15.05.16).

Dobbelaere, S., Croonenborghs, A., Thys, A., Ptacek, D., Vanderleyden, J., Dutto, P., Labandera-Gonzalez, C., Caballero Mellado, J., Aguirre, J.F., Kapulnik, Y., Brener, S., Burdman, S., Kadouri, D., Sarig, S., Okon, Y. (2001).Responses of agronomically important crops to inoculation with *Azospirillum*. Aust. J. Plant Physiol. 28: 871–879. trification. Plant and Soil. 96: 369-376.

Eghball, B. (2002).Soil properties as influenced by phosphorus and nitrogen based manure and compost applications. Agron. J. 94:128-135.

El-Desoky, M.A., and Ragheb, H.M.(1993).Availability of phosphorus in sandy calcareous soils.- Effect of organic matter and added phosphorus. Assiut J. Agric.Sci. 24 (1) 137-153

FAO, (2016). FAO Soils Portal: Management of Calcareous Soils <http://www.fao.org/soils-portal/soil-management/managementof-some-problem-soils/calcareous-soils/ar/> (accessed 01.04.16).

Frempong, A., Ebertseder, Weber, A., Schraml, M. and. Schmidhalter, U. (2006).Short-term and residual availability of nitrogen after long-term application of organic fertilizers on arable land, J. Plant Nutr. Soil Sci. 168: 439–446.

Goyal., S., Dhull, SK.,Kapoor, KK.(2005). Chemical and biological changes during composting of different organic wastes and assessment of compost maturity.Bioresour Technol,96:1584–1591. https://doi.org/10.1016/j.biortech.2004.12.012

Guerinot, M.L. (2001). Improving rice yields - ironing out the details. Nat. Biotechnol.19, 417–418.

Aboukila, E. F., Nassar, I. N., Rashad, M.,Hafez, M., Jay B. Norton, (2018).Reclamation of calcareous soil and improvement of squash growth using brewers' spent grain and compost.J. of the Saudi Soci of AgricScie (2018) 17, 390–397.

Joardar JC, Rahman, M.M., (2018). Poultry feather waste management and effects on plant growth. Int J Recycl Org Waste Agric. https ://doi.org/10.1007/s40093-018-0204-z

Liu, J., Xie, Q., Shi, Q., Li, M. (2008).Rice uptake and recovery of nitrogen with different methods of applying 15N-labeled chicken manure and ammonium sulphate. Plant Prod Sci.11: 271-277.

Manzoni, S., Jackson, R. B., Trofymow, J. A. and Porporato, A. (2008).The Global Stoichiometry of Litter Nitrogen Mineralization.Science, 321: 684-686.

Melero Sanchez, S., Madejon, E., Herencia, J.F. and Ruiz-Porras, J.C (2008).Long term study of properties of a Xerofluvent and Guadalquivir River Valley under organic fertilization .Agron J 100:611-618.

Mhindu, R.L., Menas, W, Esther, N., (2013). Composting of selected organic wastes from peri-urban areas of Harare, Zimbabwe. Int J Recycl Org Waste Agricult 2:14. https://doi.org/10.1186/2251-7715-2-14

Nelson, D.E.and Sommers, L.E.(1982).Total carbon organic carbon and organic matter.339-577.InPage,A.L.Methods of Soil Analysis.Part 2.Chemical and MicrobilogicalProperties.ASA/SSSA. Madison, WI, USA.

Olsen, S.R. and Sommers,L.E.(1982).Phosphorus .pp.403-430.In A.L. Page al. (ed.) Methods of SoilAnalysis ,Part 2,2nd Ed .Agron.Monogr.9.ASAand SSSA, Madison WI.

Pan, G., Zhou, P., Li, Z., Pete, S., Li, L., Qiu, D., Zhang, X., Xu, X., Shen, S. and Chen,X.(2009).inorganic/organic fertilization enhances N efficiency and increases rice productivity through organic carbon accumulation in a rice paddy from the Tai Lake region, China. AgricEcosyst Environ 131: 274-280.

Plaza C, Nogales R, Senesi N, Benitez E, Polo A (2008). Organic matter humifcation by vermicomposting of cattle manure alone and mixed with two-phase olive pomace. BioresourTechnol 99:5085– 5089. https://doi.org/10.1016/j.biortech.2007.09.079.

Rashad, M.,Hafez, M., Aboukila, E.F., Emran, M., and Nassar, I. N. (2016).Influence of environment-friendly organic wastes on the properties of sandy under growing corn (Zea maize L.) in arid regions. World Academy of Sci, Eng and Tech InterJou of Agric and BiosystEngVol:10, No:9, 2016

Romanenko, V.A., (1961). Computation of the autumn soil moisture using a universal relationship for a large area. In: Proc. Ukrainian Hydrometeorological Research Institute, No. 3, Kiev, Ukraine. SAS Institute, 2013. The SAS system for windows.Release 13.1.SAS Inst., Cary, NC.

Shen, J., Li, R., Zhang, F., Fan, J., Tang, C. and Rengel, Z. (2004).Crop yields, soil fertility and phosphorous fractions in response to long-term fertilization under the rice monoculture system on a calcareous soil. Field Crops Res. 86, 225–238.

Šimek, M., and Cooper, J. (2002). The influence of soil pH on denitrification: progress towards the understanding of this interaction over the last 50 years. Eur J Soil Sci; 53: 345–54.

Sparks, D.L. (1987). (Eds.), Methods of soil analysis, Part 3- chemical methods .Agronomy Monograph, vol. 9. ASA and SSSA, Madison, WI, 869-920.

Thuler, D.S., Floh, E.I.S., Handro, W., Barbosa, H.R. (2003). Plant growth regulators and amino acids released by *Azospirillum*sp in chemically defined media. Lett. Appl. Microbiol. 37: 174–178.

Tiquia, S.M., (2005).Microbiological parameters as indicators of compost maturity. J ApplMicrobiol 99:816–828. https://doi.org/10.1 111/j.1365-2672.2005.02673.x.