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Influence of Manure and Nitrogenous Fertilizer Applications on Corn Yield and Quality Characteristics

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Abstract: Two field experiments were conducted at Sids research station, BeniSuef Governorate during 2014 and 2015 seasons, to study the effect of three manure levels (M_1= zero, M_2= 10 and M_3= 20 m^3 fed^{-1}) and four nitrogen (N) application times (T_1= $^1/_5$ N at planting, $^2/_5$ N at 1st irrigation and $^2/_5$ N at 2nd irrigation, T_2= $^1/_5$ N at planting, $^2/_5$ N at 1st irrigation and $^2/_5$ N at 3rd irrigation, T_3= $^1/_3$ N at 1st irrigation, $^1/_3$ N at 2nd irrigation and $^1/_3$ N at 3rd irrigation and T_4= $^1/_2$ N at 1st irrigation and $^1/_2$ N at 2nd irrigation) on white corn (hybride single cross 130) growth, yield components and grain yield. The resultant corn grains were estimated with respect to some physicochemical and technological properties. Manure levels and N application times significantly affected days to 50% tasseling, plant and ear height, ear length, rows per ear and kernels per row in both seasons. Manure levels significantly affected days to 50% silking in season 2015 while, N application times significantly varied days to 50% silking, grain yield in both seasons and ear diameter in season 2015. The highest grain yield was obtained with M_3 in both seasons while, T_2 reached flowering stage earlier than the other N application times and it had the highest value in plant ear height, yield components and grain yield. Results of interaction indicated that M_3 had the highest grain yield when it was used with T_2. 1000-grain weight significantly increased with increasing manure levels. M_3T_2 and M_3T_3 had the highest values in 1000-grain weight for both seasons. The endosperm and germ percentages were significantly increased in M_3T_2 and M_3T_3. Protein, ash, iron and zinc slightly higher in season 2014 at different manure levels. While, fat contents were higher in season 2015. Protein digestibility and availability of iron and zinc increased with increasing manure levels in both seasons. The lightness (L*) values of muffins crumb color insignificantly decreased while, yellowness (b*) values increased with increasing manure levels. In general, it could be concluded that, corn flour could be used to produce good quality gluten-free muffins with acceptable physical and sensory characteristics.

Keywords: Corn, manure, nitrogen application times, yield, quality characteristics, muffin

INTRODUCTION

Corn (*Zea mays* L.) is one of the oldest crops and it cultivated in Egypt and many areas of the world. It is used in human food, animal feed and it is an important source of many industrial products such as corn sugar, oil, flour, starch, syrup, brewer's grit and alcohol (Dutt, 2005). Egypt annually produces about 8.00 million tons of corn (FAO, 2016). To obtain high yields in most crops, as is particularly true in maize, it is necessary to apply mineral fertilizers to the soil. However, the applications of agricultural inputs, especially in non-leguminous crops, cause an imbalance in natural ecosystems. Also, it is one of the most expensive practices in agriculture (Kennedy *et al.*, 2004).

Manures, such as cow dung, poultry manure and crop residues can be used as an alternative for the inorganic fertilizers. Nutrients contained manures are slowly released and are stored for a long time in the soil, thereby ensuring a long residual effect, supporting better root development, maintaining physical, chemical and biological conditions of soil, supply macro and micronutrients to crops, conservation of nutrients, water use efficiency, improve soil organic matter and water-holding capacity leading to higher crop yields (Nofal *et al*., 2005). Soliman *et al*. (2001) observed that addition of farm yard manure markedly decreased days to mid-tasseling and silking. Nofal *et al.* (2005) and Hellal *et al*. (2014) pointed that corn yield and its components were significantly and positively affected by the addition of organic matter to the soil which could increase yields through increasing soil productivity and higher fertilizer use efficiency.

Nitrogen (N) is the most important nutrient supplied to most non-legume crops, including corn. It influences cell size, leaf area and photosynthetic activity (Uribelarrea *et al*., 2009). The maximum N uptake by corn occurs during the month prior to tasseling and silking (Alley *et al*., 2009). Time of N applications plays an important role in its efficient utilization (Blankenau *et al*., 2002). Sitthaphanit *et al*. (2009) reported that split application and delayed basal application are effective fertilizer strategies to reduce nutrient leaching. Corn starts to rapidly take up N at the middle vegetative growth period and the maximum rate of N uptake occurs near to silking stage. Adhikari *et al*. (2016) reported that maize growth, yield and its components was significantly and positively affected by N application times.

Using of inorganic fertilizers (*i.e.*, N:P:K ratios 175:100:50 and 350:200:100 kg ha^{-1}) increase protein content while manure levels at 15 and 30 ton manure ha^{-1} increase oil content in corn grains (Esmailian *et al.*, 2011). Faisal *et al.* (2013) indicated that higher thousand grain weight that was found in nitrogen/phosphorus (NP) treatment (180:120).

The change in lifestyle, busy consumers are increasingly purchasing convenient baked goods, such as muffin, biscuit, cake, bread, pastries and pies. Muffins are a popular baked product that enjoys wide consumption in different countries (Cauvain and Young, 2007 and Mondal and Datta, 2008). Celiac

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patients cannot tolerate the gliadin fraction of wheat, rye, barley and oat. The demand for gluten-free products has been raised and many studies used gluten-free flour (such as rice, corn, soya, quinoa and amaranth) to produce gluten-free bakery products. The gluten-free bakery products have become available in the market (Sarabhai and Prabhasankar, 2015). The corn kernel main structures consist of pericarp, endosperm, germ and the tip. Corn flour is useful for celiac disease patients since it lacks gluten and contains 8-11% protein and 2.17-4.43% oils. This open the possibility to produce muffins from corn flour, which is lacking in gluten (Baixauli *et al.*, 2008 and Enyisi *et al.*, 2014).

The aim of this study was to investigate the effect of different manure levels and nitrogen application times on corn growth, yield components, yield and some physicochemical characteristics of grains. Estimation of the resulted corn flour in the muffin formulations was also extended.

MATERIALS AND METHODS

1. Field experiments

The field experimental site for white maize (*Zea mays* L.) hybride single cross 130 was located at Sids Research Stations, Field Crops Research Institute, Agricultural Research Center, BeniSuef Governorate, Egypt during summer seasons of 2014 and 2015. Table (1) illustrates the physical and chemical properties of the experimental soil according to Black (1982). Soil was clay, non-saline, slightly alkaline in reaction, low in organic matter. Available N, P and K were 112.60, 10.70, 263.30 ppm in season 2014 and were 116.50, 10.50, 275.30 ppm in season 2015, respectively. The previous crop at the experiment site in both seasons was wheat crop. Three manure (farm manure, which was obtained from animal farms in the located area) levels, *i.e.*, zero, 10 and 20 m^3 manure fed^{-1} and were added to soil before the sowing. The chemical analysis of used manure according to Fulhage (2000) in the two seasons showed in Table (2). The recommended dose of nitrogen was added at four application times as showed in Table (3). The analysis of soil and manure were conducted in Soil, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt.

A split plot design with four replications was used. The main plots were randomly assigned to the three manure levels and the subplots were assigned to the four nitrogen application times. The size of sub plot was (4 x 4.20 m) = 16.80 m^2 consisting of 6 ridges each was 4.0 m in length and 0.70 m in width. Two grains per hill were planted at 25 cm apart. Recommended doses of superphosphate (15.50%) and potassium fertilizers (48%) (71 kg P_2O_5 and 57 kg K_2O ha^{-1}, respectively) were applied during land preparation. Recorded data were number of days to 50% tassiling (DTT), days to 50% silking (DTS), plant height (PHT) cm, ear height (EHT) cm, ear length (EL) cm, ear diameter (ED) cm, number of rows per ear (RPE), number of kernels per row (KPR) and grain yield (GY) ton ha^{-1} adjusted to 15% grain moisture.

Table (1): Physical and chemical properties of the experimental soil in 2014 and 2015 seasons*

Physical properties	Seasons	
	2014	**2015**
Coarse sand (%)	1.30	1.50
Fine sand (%)	20.30	14.70
Silt (%)	27.40	32.10
Clay (%)	51.00	51.70
Texture	Clay	Clay
Chemical properties		
Available nitrogen (ppm)	112.60	116.50
Available phosphorus (ppm)	10.70	10.50
Available potassium (ppm)	263.30	275.30
pH	7.70	7.80
EC (dsm)	0.52	0.48
Organic matter (%)	1.53	1.52
$CaCO_3$ (%)	1.83	1.80

* EC: Electrical conductivity

Table (2): Chemical composition of the used manure in field experiments (on dry weight basis)

Parameters	Seasons	
	2014	**2015**
Moisture (%)	24.20	26.10
Density (g/cm^3)	0.24	0.21
pH (1:10)	7.21	7.24
EC (1:10) dsm	2.09	2.12
N-NO_3 (ppm)	36.00	38.00
N-NH_4 (ppm)	48.00	52.00
Total nitrogen (%)	2.20	2.23
Total phosphorus (%)	0.52	0.54
Total potassium (%)	1.18	1.22
Total carbon (%)	36.20	36.13
C/N Ratio*	16.45	16.20
Available phosphorus (%)	0.35	0.36
Available potassium (%)	1.28	1.28
DTPA-Iron (ppm)	1760	1760
DTPA-Manganese (ppm)	0.74	0.75
DTPA-Zinc (ppm)	5.80	5.75

*C/N ratio= Carbon/Nitrogen ratio, DTPA= Diethylene triamine penta acetic acid

Table (3): Nitrogen application times

Treatments	**Nitrogen application times (120 kg urea fed^{-1})**			
	at planting	**at 1st irrigation**	**at 2nd irrigation**	**at 3rd irrigation**
T_1	$^1/_5$	$^2/_5$	$^2/_5$	0
T_2	$^1/_5$	$^2/_5$	0	$^2/_5$
T_3	0	$^1/_3$	$^1/_3$	$^1/_3$
T_4	0	$^1/_2$	$^1/_2$	0

T= Nitrogen application time

2. Physicochemical and quality characteristics of corn

Ingredients and chemicals

Baking ingredients *e.g.* corn starch, sugar, full fat milk (3% fat), milk butter, whole egg, baking powder, salt and vanilla were obtained from local markets at Giza, Egypt. Amylose, pepsin, pancreatin, α-amylase and lipase were purchased from Sigma-Aldrich Chemical Co., St. Louis, USA. The bile extract from Win Lab Laboratory Chemical Reagents (Mumbai, India). All other used chemicals were analytical grade.

Corn preparation

Corn grains were carefully inspected from broken grains and extraneous matters and milled using laboratory mill (IKA-Laboratechnic, Janke and Kunkel Type: MFC, Germany) to get whole meal for chemical analysis. 60 mesh sieve was used to get fine flour (the most particle sizes range are around 250 microns) for muffin preparation and then packed in polyethylene bags and kept in a freezer until further analyses.

1000-grain weight, density and component parts of corn grains

The weight of 1000-grain, density and component parts (endospern, germ and pericarp) percentages of corn grains were determined according to Hussein (1981).

Proximate analysis

Moisture, protein, fat, crude fibers, ash, iron and zinc contents of corn samples were measured according to the AOAC (2005). Amylose content (as g/100g dry weight) was determined using the method outlined by Juliano (1971).

In vitro protein digestibility

In vitro protein digestibility of samples was determined according to the method of Akeson and Stahmann (1964). After enzymatic digestion of samples with pepsin and pancreatin, the protein in the resultant supernatant was estimated using the Kjeldahl method (AOAC, 2005). The percentage of protein digestibility was calculated by the ratio of protein in the supernatant to protein in the sample as the following equation:

$$In\ vitro\ \text{protein digestibility (\%)} = \frac{\text{N in supernatant} - \text{N in Blank}}{\text{N in sample}} \times 100$$

N= Nitrogen

In vitro availability of iron and zinc

The availability of iron (Fe) and zinc (Zn) was determined by the *in vitro* digestion method described by Kiers *et al.* (2000). Five grams of sample were suspended in 30 ml distilled water and digested under simulated gastro-intestinal conditions, subsequently using α-amylase solution, stomach medium consisting of lipase and pepsin and pancreatic solution consisting of pancreatin and bile salts. After digestion, the suspension was centrifuged at 3600 xg for 15 min. The supernatant was decanted and the pellet was discarded. The supernatants were pooled and filtered through a 0.45 µm pore filter. A blank was included consisting of 30 ml distilled water digested and filtered as described above. Fe and Zn contents in the filtered supernatants were measured using Atomic Absorption Spectrophotometer (Perkin Elmer, Model 3300, USA). The amounts of Fe and Zn in the supernatant were regarded as soluble minerals. Percentage of soluble Fe was calculated as availability (%).

$$\text{Availability of Fe or Zn (\%)} = \frac{\text{Fe or Zn in supernatant} - \text{Fe or Zn in blank}}{\text{Fe or Zn in undigested sample}} \times 100$$

Gluten-free muffin preparation

The gluten-free muffin was prepared according to the method described by Nicol (1995) with some modifications. The formula was consisted of 100 g corn flour, 50.0 g corn starch, 89.0 g sugar, 50.0 g milk butter, 69.0 g whole egg, 3.30 g baking powder, 0.90 g salt, 0.50 g vanilla and 75.0 ml of whole fat milk. Briefly, sugar and butter were blended together at high speed for 2 min with a wire whip in an electric mixer, then egg and milk were added and mixed at the same speed for 2 min. The dry ingredients were added to the mixture and mixed at low speed for 2 min. The muffin batter (the batter weight was 59.0-61.0g) was baked in cup papers at 180°C for 20 min, cooled, packed in polyethylene bags, then subjected to physical properties, textural profile and sensory evaluation.

Sensory evaluation of muffins

Sensory evaluation of fresh baked muffin was carried out at Food Technology Research Institute, by ten panelists according to Sanz *et al.* (2009). A 9-point hedonic scale was used for determining the variation of the tested attributes (appearance, color, texture, taste, flavor and overall acceptability) of muffins. The panelists were provided with muffin on a white plate at ambient temperature.

Physical measurements of muffins

Muffin weight (g) was recorded after cooling for 1h. Muffin volume (cm^3) was determined by using rapeseed displacement method according to the AACC (2002). Specific volume (cm^3/g) of muffin was calculated by dividing the volume by weight. Density (g/cm^3) was calculated by dividing weight by volume.

Color measurement of muffins crumb

The color of muffin crumb samples was measured by a hand-held Tristimulus reflectance colorimeter Minolta Chromameter (model CR-400, Konica Minolta, Japan). Results recorded in lightness with *L** = 100 for lightness, and *L** = zero for darkness), *a** [chromaticity on a green (-) to red (+)] and *b** [chromaticity on a blue (-) to yellow (+)]. Values reported are the means of triplicate determinations.

Textural profile analysis of muffins

Texture of fresh whole baked muffin was determined by universal testing machine provided with software as described by Bourne (2003). An aluminum (25 mm diameter) cylindrical probe was used in a Texture Profile Analysis (Cometech, B type, Taiwan) double compression test to penetrate perpendicular to 50% depth relative to the sample height, at 1 mm/s speed tests (based on pre-test). Hardness (N), gumminess (N) chewiness (N), cohesiveness and springiness were calculated from TPA graphic of the instrument.

Statistical analysis

The collected data of samples at 2014 and 2015 seasons were statistically analyzed for mean values and standard deviation according to procedures outlined by Gomez and Gomez (1984). The obtained data were subjected to one-way analysis of variance (ANOVA) at $P<0.05$ followed by Duncan's new multiple range tests to assess differences between samples mean.

RESULTS AND DISCUSSION

Effect of manure levels on growth studies, yield components and grain yield

1. Growth studies

Table (4) illustrates the number of days to 50% tassiling (DTT), days to 50% silking (DTS), plant height (PHT) and ear height (EHT). DTT and DTS were significantly affected by manure applications except DTS in the first season. Increasing the rate of applied manure up to 20 m^3 manure fed^{-1} significantly decreased the number of days to flowering in 2014 and 2015 seasons. Table (2) showed that, increasing of manure in the soil led to increase the soil content from macro and micronutrients, especially, nitrogen content and the role of nitrogen is promoting meristemic activity towards earlier tasseling and silking. Yadav (1990) observed that the more level of nitrogen used, resulted the earliest in days to tasseling and silking due to the rapidness in a growth period. This result is in harmony with those recorded by Soliman *et al*. (2001) and Nofal *et al*. (2005).

Both plant and ear heights were significantly affected by manure application levels in both seasons. Data in Table (4) showed that plant and ear height were significantly increased with increasing manure application levels from 10.0 to 20.0 m^3 manure fed^{-1}. The third level of manure achieved the highest significant values of PHT (251.30 and 247.80 cm) and EHT (154.10 and 138.10 cm) in both seasons. The increase in plant height can be attributed to the fact that nitrogen promotes plant growth, increases the number and length of the internodes which results in a progressive increase in plant and ear height. Ewais *et al*. (2015) reported that the favorable effect of mixed compost with chemical fertilizers may be due to the effect of compost on increasing the efficiency of chemical fertilizer. The application of the manure also, enhances microbial activity that releases different organic acids which helps in solubilization of the native soil nutrients and makes them available for the uptake by plants. The present results agree with those obtained by Nofal *et al*. (2005) and Verma *et al.* (2015).

2. Yield components

Data in Table (5) showed that ear length (EL) cm and number of kernels per row (KPR) in both seasons were significantly increased by increasing the manure level up to 20 m^3 manure fed^{-1} in both seasons. The highest values of EL (21.90 and 20.30) and KPR (42.00 and 40.20) were obtained by 20 m^3 manure fed^{-1}. These results may be attributed to plants that received 20 m^3 manure fed^{-1} of superior plants that received lower rates, 20 m^3 manure fed^{-1} was not only compatible with the crop requirement in the agro-ecological area, but also released plant nutrients, water and exchangeable potassium and magnesium which enhances crop yield. This is consistent with the findings of Ibeawuchi *et al*. (2007), who reported that higher rates of manure led to increase the water-soluble and exchangeable potassium and magnesium which enhances grain yield and dry matter of maize. The present results agree with those obtained by Enujeke (2013) and Ewais *et al.* (2015). On the other hand, manure did not significantly affect ear diameter and number of rows per ear in both seasons.

3. Grain yield

Data in Table (5) indicated that grain yield (GY) per hectare was significantly increased by increasing manure levels in both seasons. Increasing manure fertilizer rates from zero to 10.0 m^3 and 20.0 m^3 manure fed^{-1} increased grains yield from 10.23 to 10.66 and 10.99 ton ha^{-1} in 2014 season and from 9.71 to 10.27 and 10.63 ton ha^{-1} in 2015 season. The response of yield increase manure application levels until 20 m^3 fed^{-1} indicates a progressive increase in growth and yield components. These results may be due to that the enhance soil fertility, in turn, enhance nutrient provision for optimum plant growth (Ali *et al*., 2011). Absorb essential nutrients such as Fe^{2+}, Mg^{2+} and NH^{4+} cations which are indispensable for enzymes activation and chlorophyll formation (Elhindi, 2012). That improved soil properties, increased yield components and hence the grain yields (Khan *et al*., 2016). The increased in grain yield with increasing levels of manure was also reported by Verma *et al.* (2015). Cheema *et al.* (2010) found that various organic and inorganic treatments significantly influenced on grain yield, while interaction was found non significant effects.

Effect of N application times on growth characters, yield components and grain yield

1. Growth studies

Table (4) illustrates the number of days to 50% tassiling (DTT), days to 50% silking (DTS), plant height (PHT) and ear height (EHT) at four nitrogen (N) application times. Data revealed that there were highly significant differences among nitrogen application times for DTT and DTS in 2014 and 2015 seasons. These results are in agreement with Sharifi and Namvar (2016). Significant decrease in DTT and DTS were found at T_2 followed by T_3 compared with the other N application times (T_1 and T_4). PHT and EHT were also significantly affected by N application time. The present results agreed with those obtained by Adhikari *et al*. (2016). The second N application time (T_2) showed the highest values of PHT (255.80 and 247.10) and EHT (153.30 and 139.60) while, the lowest values of PHT (241.30 and 236.60) and EHT (140.40 and 131.30) was found in the fourth N application time (T_4) in 2014 and 2015, respectively. These results may be attributed to increasing of nitrogen efficiency by T_2 N application time which was more than the other N application times (T_1, T_3 and T_4), which led to promoting meristemic activity towards early tasseling and silking and increasing number and length of the internodes which results in progressive increase in plant and ear height. Ceretta *et al*. (2002) reported that applying N at later stages, thus avoiding losses by leaching and volatilization, and increasing the efficiency of absorption and use of the nitrogen fertilizer by the plant.

Table (4): Effect of manure, nitrogen application time and their interactions effect on days to 50% tasseling (DTT), days to 50% silking (DTS), plant height (PHT) and ear height (EHT) in 2014 and 2015 seasons

Trait	**DTT (days)**		**DTS (days)**		**PHT (cm)**		**EHT (cm)**	
Seasons	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
				Manure levels				
M_1 (Zero m^3fed^{-1})	67.43^a	66.37^a	68.06	67.12^a	241.70^b	239.40^b	137.80^c	132.50^b
M_2 (10 m^3fed^{-1})	66.81^b	65.70^{ab}	67.50	66.31^{ab}	248.00^{ab}	240.00^b	147.50^b	136.30^a
M_3 (20 m^3fed^{-1})	66.81^b	65.00^b	67.18	65.75^b	251.30^a	247.80^a	154.10^a	138.10^a
F. test	*	*	NS	*	*	*	**	*
				Time of nitrogen application				
T_1	67.33^a	65.80^b	68.00^a	66.50^b	242.50^c	240.40^{bc}	145.00^b	135.40^b
T_2	66.25^c	65.00^c	66.91^c	65.66^c	255.80^a	247.10^a	153.30^a	139.60^a
T_3	66.75^b	65.50^{bc}	67.41^b	66.33^b	248.30^b	245.40^b	147.10^b	136.30^{ab}
T_4	67.75^a	66.41^a	68.00^a	67.08^a	241.30^c	236.60^c	140.40^c	131.3^c
F. test	**	**	**	**	**	**	**	**
M x T	NS	NS	NS	NS	NS	NS	NS	NS

M= Manure T= Nitrogen application time NS= Nonsignificant
Means (n=4) designated by the same letter in the same column are not significantly different at the 5% level according to Duncan's multiple range test

2. Yield components

Table (5) presents ear length (EL), ear diameter (ED), number of rows per ear (RPE) and number of kernels per row (KPR) at four nitrogen (N) application times. Data showed that the differences among four N application times were highly significant for corn yield components (EL, ED, RPE and KPR) in both seasons except ED in the first season. Similar results were reported by Nemati and Sharifi (2012). The highest values of yield component characters (EL, ED, RPE and KPR) were recorded when N was added in split doses with T_2 followed by T_3. Whereas, the lowest values of yield component characters were observed when N applied in T_1 and T_4. These results may be due to increasing of nitrogen uptake efficiency by the method of T_2 = $^1/_5$ at sowing, $^2/_5$ at first irrigation and 2/5 at the third irrigation. Lu *et al*. (2012) reported that treatment of $^1/_5$ at sowing, $^2/_5$ at first irrigation and $^2/_5$ at the third irrigation led to increasing of nitrogen uptake efficiency and it should be one of the best ways of supplying nitrogen to meet this high demand, which was positively reflected on the yield components of corn.

3. Grain yield

Data in Table (5) showed that the differences between the four nitrogen (N) application times were highly significant for corn grain yield (ton ha^{-1}) in 2014 and 2015 seasons. The highest grain yield ton ha^{-1} (GY) was recorded when using T_2 followed by T_3. Whereas, the lowest values of grain yield ton ha^{-1} (GY) was observed when N applied in T_1 and T_4. The grain yield varied between 10.06 and 9.77 ton ha^{-1} in T_4 nitrogen application time to 11.31 and 10.66 ton ha^{-1} in T_2 nitrogen application time 2014 and 2015, respectively. A similar trend in grain yield due to the differences in nitrogen (N) application time has been reported by Nemati and Sharifi (2012) and Tadesse *et al*. (2013). These results may be due to the increase of nitrogen uptake efficiency by the method of T_2 = $^1/_5$ at sowing, $^2/_5$ at first irrigation and $^2/_5$ at the third irrigation.

Venterea and Coulter (2015) found a negative correlation between the splitting of nitrogen doses to three times and a positive correlation with grain yield. Applying nitrogen as $^1/_5$ N at sowing, $^2/_5$ N at 1st irrigation and $^2/_5$ N at 3rd irrigation led to increase of nitrogen uptake efficiency and should be one of the best ways of supplying nitrogen to meet this high demand, which was positively reflected on the grain yield of corn (Lu *et al.*, 2012).

Table (5): Ear length (EL), number of rows per ear (RPE), number of kernels per row (KPR) and grain yield (GY) as affected by manure levels, N application times and their interactions in 2014 and 2015 seasons

Trait	EL (cm)		ED (cm)		RPE		KPR		GY (ton ha^{-1})	
Season	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
					Manure levels					
M$_1$ (Zero m^{3}fed^{-1})	19.20^b	18.50^b	4.42	4.12	13.53	14.19	38.80^b	36.80^b	10.23^b	9.71^b
M$_2$ (10 m^{3}fed^{-1})	20.80^a	19.70^{ab}	4.60	4.17	14.11	14.51	40.90^a	38.00^b	10.66^{ab}	10.27^a
M$_3$ (20 m^{3}fed^{-1})	21.90^a	20.30^a	4.57	4.22	14.27	14.27	42.00^a	40.20^a	10.99^a	10.63^a
F. test	*	*	NS	NS	NS	NS	*	*	*	*
					Time of nitrogen application (T)					
T$_1$	21.10^a	18.90^c	4.50	4.08^b	13.50^c	14.41^b	38.90^c	37.00^c	10.32^c	9.98^b
T$_2$	21.50^a	20.30^a	4.58	4.33^a	14.65^a	15.00^a	43.30^a	41.30^a	11.31^a	10.66^a
T$_3$	21.00^a	19.60^b	4.56	4.23^a	14.15^b	14.61^b	41.10^b	39.50^b	10.80^b	10.39^a
T$_4$	19.90^b	19.10^{bc}	4.48	4.05^b	13.60^c	14.32^b	38.90^c	35.60^c	10.06^c	9.77^b
F. test	**	**	NS	**	**	**	**	**	**	**
					Interaction					
M x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	*

M= Manure T= Nitrogen application time
Means (n=4) designated by the same letter are not significantly different at the 5% level according to Duncan's multiple range test

The effect of manure levels and nitrogen (N) application times interaction

The interaction effects between manure levels (M) and nitrogen application times (T) were not significant for all studied treatments in both seasons, except for grain yield in the second season. The highest grain yield (ton ha^{-1}) was obtained by the third level of manure (M_3) with the second N application time (T_2) whereas, the lowest value was recorded by the first level of manure (M_1) and the first N application time (T_1) (Table 6).

Table (6): Effect of interaction between manure levels and nitrogen application time on grain yield (ton ha^{-1})

Manure	Time of nitrogen application			
	T$_1$	**T$_2$**	**T$_3$**	**T$_4$**
M$_1$	9.38^f	10.10^{cde}	9.75^{def}	9.59^{ef}
M$_2$	10.11^{cde}	10.90^{ab}	10.56^{abc}	9.40^f
M$_3$	10.44^{abc}	10.98^a	10.85^{ab}	10.32^{bcd}

M= Manure T= Nitrogen application time
Means (n=4) designated by the same letter are not significantly different at the 5% level according to Duncan's multiple range test

1000-grains weight, density and component parts of corn grains

1000-grains weight, density and component parts (endosperm, germ and pericarp) of corn grains after using different manure levels and nitrogen application times at seasons 2014 and 2015 are shown in Table (7). There was a significant increase (p<0.05) in 1000-grain weight by increasing the manure levels. Higher 1000-grains weight was found in M_3T_2 and M_3T_3 treatments in both seasons (being 369.81 and 368.00 g for season 2014 and 336.67 and 338.0 g for season 2015, respectively). These results are higher than those of Farnia and Torkaman (2015) who reported that 1000-grain weight of corn ranged from 237.0 to 332.0 g. Mainly indicates an improve in grain weight. The increase in grain weight was mainly due to balanced supply of nutrients. These results are in the same trend with those reported by Niaz *et al.* (2015) who found that nitrogen fertilizer rates and its application timing schemes significantly affected maize production, grains quality and nitrogen use efficiency indices. Cheema *et al.* (2010) mentioned that various organic and inorganic treatments had significantly influenced on grain yield.

Regarding to corn grain density, samples at season 2014 and 2015 were not significantly different (p>0.05).

Endosperm and germ percentages increased as a result of using 10 and 20 m^3 manure fed^{-1} which could be useful for production of corn products such as oil, flour and starch. The highest endosperm percentage observed in season 2014. Moreover, there was a decrease in pericarp percentage in most of samples with increasing manure levels and season 2014 had a slightly higher pericarp percentage compared with season 2015. Corn kernel is constituted by three principal parts, where the endosperm represents 80.0-85.0%, germ 10.0-12.0% and pericarp 5.0-6.0% (Berger and Singh, 2010).

Table (7): 1000-grains weight, density and grain component parts of corn at season 2014 and 2015 at different manure levels and nitrogen application times

Treatments	2014					2015				
	1000-grains Weight (g)	Density (g/cm^3)	Endosperm (%)	Germ (%)	Pericarp (%)	1000-grains weight (g)	Density (g/cm^3)	Endosperm (%)	Germ (%)	Pericarp (%)
M_1T_1	344.47^{e} ±2.40	1.17^{a} ±0.11	81.45^{e} ±0.19	10.87^{ab} ±0.19	7.67^{ab} ±0.04	317.27^{d} ±5.05	1.15^{a} ±0.11	81.12^{e} ±0.10	10.83^{abc} ±0.23	8.04^{a} ±0.24
M_1T_2	348.20^{de} ±1.00	1.17^{a} ±0.02	81.79^{de} ±0.17	10.88^{ab} ±0.29	7.34^{bcd} ±0.14	318.10^{d} ±2.60	1.16^{a} ±0.09	81.60^{cd} ±0.35	10.84^{abc} ±0.05	7.57^{ab} ±0.40
M_1T_3	348.17^{de} ±5.45	1.18^{a} ±0.03	81.56^{e} ±0.11	11.18^{a} ±0.13	7.26^{bcd} ±0.13	318.27^{d} ±1.85	1.18^{a} ±0.10	81.90^{abcd} ±0.48	10.60^{bc} ±0.60	7.48^{abc} ±0.49
M_1T_4	345.50^{e} ±2.80	1.16^{a} ±0.26	81.59^{e} ±0.36	10.56^{bc} ±0.19	7.86^{a} ±0.17	317.50^{d} ±4.77	1.16^{a} ±0.11	81.54^{de} ±0.39	10.66^{abc} ±0.06	7.80^{ab} ±0.44
M_2T_1	354.00^{cde} ±10.00	1.18^{a} ±0.14	82.06^{cd} ±0.11	10.38^{c} ±0.09	7.56^{abc} ±0.17	322.50^{c} ±3.30	1.19^{a} ±0.04	81.77^{bcd} ±0.24	10.64^{bc} ±0.40	7.59^{ab} ±0.56
M_2T_2	358.10^{bcd} ±5.85	1.17^{a} ±0.01	82.12^{cd} ±0.08	10.52^{bc} ±0.21	7.36^{bcd} ±0.18	326.47^{bcd} ±5.53	1.19^{a} ±0.10	81.86^{bcd} ±0.26	10.54^{bc} ±0.05	7.60^{ab} ±0.19
M_2T_3	355.87^{cde} ±11.95	1.18^{a} ±0.06	82.20^{bc} ±0.06	10. 59^{bc} ±0.24	7.22^{bcd} ±0.19	325.00^{cd} ±7.00	1.16^{a} ±0.11	82.16^{ab} ±0.06	10.50^{c} ±0.08	7.34^{bc} ±0.09
M_2T_4	354.27^{cde} ±3.75	1.17^{a} ±0.02	82.34^{abc} ±0.30	10.60^{bc} ±0.20	7.06^{d} ±0.49	324.07^{cd} ±1.80	1.15^{a} ±0.01	82.03^{abcd} ±0.12	10.51^{bc} ±0.36	7.46^{abc} ±0.45
M_3T_1	362.20^{abc} ±3.30	1.17^{a} ±0.13	82.30^{bc} ±0.13	10.56^{bc} ±0.24	7.15^{cd} ±0.11	330.70^{abc} ±2.70	1.17^{a} ±0.08	82.01^{abcd} ±0.06	10.80^{abc} ±0.05	7.18^{bcd} ±0.04
M_3T_2	369.80^{a} ±1.30	1.18^{a} ±0.02	82.52^{ab} ±0. 30	10.90^{ab} ±0.38	6.60^{ef} ±0.31	336.67^{ab} ±14.57	1.15^{a} ±0.12	82.20^{ab} ±0.05	10.94^{ab} ±0.07	6.86^{cd} ±0.10
M_3T_3	368.10^{ab} ±5.50	1.21^{a} ±0.08	82.65^{a} ±0.05	10.83^{abc} ±0.42	6.54^{f} ±0.46	338.00^{a} ±5.00	1.15^{a} ±0.08	82.40^{a} ±0.40	10.91^{ab} ±0.06	6.69^{d} ±0.36
M_3T_4	365.14^{abc} ±7.29	1.20^{a} ±0.05	82.02^{cd} ±0.20	10.95^{ab} ±0.06	7.03^{de} ±0.24	332.59^{abc} ±1.86	1.18^{a} ±0.03	82.07^{abc} ±0.16	11.08^{a} ±0.14	6.85^{cd} ±0.23

M= Manure T= Nitrogen application time

Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

Proximate composition of corn

Proximate composition of corn at different manure levels and nitrogen application times are presented in Tables (8 and 9). The results indicated that corn in season 2014 slightly higher in protein, ash, iron and zinc at different manure levels. While, in season 2015 there was a significant difference in protein and fat contents. Furthermore, there was a non significant difference among all treatments in crude fibers, iron and zinc in both seasons. Besides, it could be observed that protein content increased as a result of increasing manure levels.

These results are in the same trend with those found by Goldberg (2003) who reported that cereals contain 6-15% protein and most corn protein (75%) comes from the endosperm (Shewry, 2007). Corn lipid content ranged from 5 to 9% on a dry-matter basis (Southgate, 1993). The increase in protein content in grain could be attributed to the fact that N is a component of protein (Haque *et al*., 2001). Similarly, Ayub *et al*. (2002) and Al-Bakeir (2003), reported that inorganic nitrogen application could increase the nutritive value of grain due to increase in grain crude protein concentration. The increase in protein content might be due to the fact that nitrogen is an integral part of amino acid which then builds up nitrogen content. Saeed (2010) found that a sufficient N supply is necessary for oil biosynthesis in maize. However, Mohamed *et al.* (2005) found that the interaction between manure and corn blends had non significant differences in all chemical composition.

From the same Table, amylose content was slightly increased with increasing manure levels and the values ranged from 27.26-27.66 to 27.09-27.58% in seasons 2014 and 2015, respectively. Normal starch consists of two types of polysaccharide: amylose and amylopectin. Amylose occupies approximately 15-30% of starch (Pandey *et al.*, 2000). The results are in accordance with McKevith (2004), who reported that amylose content in common corn varities were ranged from 25-27%.

Table (8): Proximate composition of corn flour in season 2014 at different manure levels and nitrogen application times (on dry weight basis)

Treatments	Moisture (%)	Protein (%)	Fats (%)	Ash (%)	Crude fibers (%)	Amylose (%)	Iron (mg/100g)	Zinc (mg/100g)
M_1T_1	10.65^{bc} ±0.17	10.53^{a} ±0.45	3.56^{a} ±0.49	1.61^{ab} ±0.01	1.97^{a} ±0.12	26.52^{a} ±0.79	3.54^{a} ±0.21	1.87^{a} ±0.02
M_1T_2	10.64^{bc} ±0.15	10.58^{a} ±0.59	3.87^{a} ±0.21	1.49^{cd} ±0.01	2.01^{a} ±0.23	26.79^{a} ±1.49	3.60^{a} ±0.40	1.95^{a} ±0.05
M_1T_3	10.52^{bc} ±0.18	10.49^{a} ±0.54	3.31^{a} ±0.04	1.50^{cd} ±0.07	1.89^{a} ±0.12	26.94^{a} ±1.43	3.49^{a} ±0.07	1.89^{a} ±0.03
M_1T_4	10.53^{bc} ±0.10	10.30^{a} ±0.37	3.44^{a} ±0.15	1.54^{bcd} ±0.01	1.98^{a} ±0.38	26.76^{a} ±0.80	3.52^{a} ±0.48	1.84^{a} ±0.40
M_2T_1	10.43^{c} ±0.16	10.86^{a} ±0.05	3.41^{a} ±0.36	1.48^{d} ±0.06	1.99^{a} ±0.46	26.78^{a} ±0.99	3.63^{a} ±0.15	1.89^{a} ±0.05
M_2T_2	10.15^{d} ±0.05	10.92^{a} ±0.02	3.79^{a} ±0.09	1.52^{cd} ±0.03	1.96^{a} ±0.04	27.27^{a} ±0.82	3.49^{a} ±0.02	1.93^{a} ±0.03
M_2T_3	10.00^{d} ±0.05	10.75^{a} ±0.19	3.77^{a} ±0.47	1.48^{d} ±0.04	1.85^{a} ±0.05	27.12^{a} ±0.35	3.51^{a} ±0.39	1.99^{a} ±0.14
M_2T_4	10.20^{d} ±0.25	10.71^{a} ±0.38	3.34^{a} ±0.22	1.55^{bcd} ±0.01	1.96^{a} ±0.06	27.34^{a} ±0.68	3.62^{a} ±0.19	1.96^{a} ±0.02
M_3T_1	10.71^{ab} ±0.06	10.92^{a} ±0.07	3.58^{a} ±0.28	1.54^{bcd} ±0.09	1.84^{a} ±0.12	27.26^{a} ±0.27	3.64^{a} ±0.07	1.92^{a} ±0.03
M_3T_2	10.92^{a} ±0.06	10.99^{a} ±0.14	3.52^{a} ±0.50	1.55^{bcd} ±0.02	1.90^{a} ±0.02	27.66^{a} ±0.94	3.68^{a} ±0.10	1.99^{a} ±0.12
M_3T_3	10.46^{c} ±0.06	11.01^{a} ±0.84	3.70^{a} ±0.39	1.64^{a} ±0.05	1.91^{a} ±0.07	27.63^{a} ±0.60	3.70^{a} ±0.15	1.98^{a} ±0.05
M_3T_4	9.60^{e} ±0.05	10.76^{a} ±0.22	3.70^{a} ±0.32	1.58^{abc} ±0.03	1.86^{a} ±0.04	27.35^{a} ±0.47	3.62^{a} ±0.38	1.86^{a} ±0.14

M= Manure T= Nitrogen application time

Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

In vitro protein digestibility of corn

Protein digestibility (%) of corn at different manure levels and nitrogen application times was presented in Table (10). Protein digestibility increased with increasing levels of manure in both seasons [at level 10 m^3 manure fed^{-1} (M_2) values ranged between 52.45-54.08 and 52.73-57.98% for 2014 and 2015 seasons and at 20 m^3 manure fed^{-1} (M_3) values ranged between 55.13-59.70 and 55.55-59.64% for 2014 and 2015 seasons, respectively]. This may be due to that organic acids in manure enhanced solubilization of soil nutrients and improve its availability and made them available for the uptake by plants (Ewais *et al*., 2015). *In vitro* digestion models are widely used to study the structural changes, digestibility and release of food components under simulated gastrointestinal conditions (Hur *et al.*, 2011). Weaver *et al.* (1998) indicated that the differences in protein digestibility were related to enzyme susceptibility of the major storage protein (zein).

The protein digestibility was higher in M_3T_3 and M_3T_4 treatments in both seasons. Results are in accordance with those reported by Bilgiçli *et al.* (2006) who reported that protein digestibility is an essential factor when evaluating the protein quality and nutritional status of a food product.

Table (9): Proximate composition of corn flour in season 2015 at different manure levels and nitrogen application times (on dry weight basis)

Treatments	Moisture (%)	Protein (%)	Fats (%)	Ash (%)	Crude fibers (%)	Amylose (%)	Iron (mg/100g)	Zinc (mg/100g)
M_1T_1	9.54^{ab} ±0.08	9.77^{c} ±0.41	3.59^{ab} ±0.15	1.45^{a} ±0.22	2.01^{a} ±0.01	26.46^{a} ±0.19	3.31^{a} ±0.20	1.77^{a} ±0.06
M_1T_2	9.07^{c} ±0.05	9.74^{c} ±0.43	3.99^{ab} ±0.24	1.40^{a} ±0.05	2.11^{a} ±0.09	26.70^{a} ±0.06	3.46^{a} ±0.14	1.62^{a} ±0.18
M_1T_3	9.11^{c} ±0.17	9.91^{bc} ±0.12	3.65^{ab} ±0.34	1.42^{a} ±0.13	2.10^{a} ±0.20	26.64^{a} ±1.39	3.39^{a} ±0.28	1.81^{a} ±0.21
M_1T_4	9.70^{a} ±0.32	9.95^{bc} ±0.06	3.64^{ab} ±0.11	1.37^{a} ±0.07	2.16^{a} ±0.21	26.70^{a} ±0.51	3.57^{a} ±0.13	1.88^{a} ±0.05
M_2T_1	8.96^{c} ±0.13	9.91^{bc} ±0.09	3.51^{b} ±0.24	1.33^{a} ±0.18	2.16^{a} ±0.29	26.63^{a} ±0.30	3.67^{a} ±0.33	1.85^{a} ±0.07
M_2T_2	9.27^{bc} ±0.13	10.09^{abc} ±0.06	3.88^{ab} ±0.26	1.35^{a} ±0.08	2.09^{a} ±0.09	26.73^{a} ±1.42	3.48^{a} ±0.36	1.80^{a} ±0.16
M_2T_3	8.88^{cd} ±0.11	10.07^{abc} ±0.10	3.77^{b} ±0.48	1.35^{a} ±0.20	1.94^{a} ±0.08	27.37^{a} ±0.28	3.47^{a} ±0.06	1.88^{a} ±0.02
M_2T_4	9.19^{bc} ±0.50	10.07^{abc} ±0.23	3.58^{ab} ±0.12	1.33^{a} ±0.02	2.14^{a} ±0.10	27.28^{a} ±1.24	3.61^{a} ±0.14	1.91^{a} ±0.02
M_3T_1	8.50^{d} ±0.09	10.01^{bc} ±0.06	3.76^{ab} ±0.06	1.38^{a} ±0.04	2.15^{a} ±0.13	27.09^{a} ±0.36	3.62^{a} ±0.15	1.79^{a} ±0.02
M_3T_2	9.01^{c} ±0.12	10.48^{a} ±0.15	3.83^{ab} ±0.35	1.32^{a} ±0.02	1.96^{a} ±0.16	27.42^{a} ±0.37	3.63^{a} ±0.27	1.92^{a} ±0.02
M_3T_3	9.06^{c} ±0.26	10.49^{a} ±0.20	3.75^{ab} ±0.54	1.50^{a} ±0.05	2.12^{a} ±0.03	27.58^{a} ±0.18	3.53^{a} ±0.47	1.87^{a} ±0.34
M_3T_4	9.27^{bc} ±0.03	10.33^{ab} ±0.30	4.15^{a} ±0.08	1.46^{a} ±0.17	2.04^{a} ±0.02	27.20^{a} ±0.40	3.67^{a} ±0.19	1.93^{a} ±0.11

M= Manure T= Nitrogen application time
Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

Table (10): *In vitro* protein digestibility (%) of corn flour with different manure levels and nitrogen application times

Treatments	*In vitro* protein digestibility (%)	
	2014	2015
M_1T_1	50.74^{c} ± 0.19	49.92^{d} ± 0.14
M_1T_2	51.31^{c} ± 0.38	53.73^{bcd} ± 1.58
M_1T_3	52.31^{bc} ± 1.09	51.63^{cd} ± 1.47
M_1T_4	50.69^{c} ± 0.27	51.35^{cd} ± 0.35
M_2T_1	52.45^{bc} ± 1.45	55.16^{abc} ± 1.05
M_2T_2	52.97^{bc} ± 1.12	52.73^{cd} ± 1.27
M_2T_3	53.13^{bc} ± 1.93	55.72^{abc} ± 1.40
M_2T_4	54.08^{abc} ± 1.16	57.98^{ab} ± 1.03
M_3T_1	55.13^{abc} ± 1.89	58.52^{ab} ± 1.66
M_3T_2	57.89^{ab} ± 1.32	58.74^{ab} ± 1.35
M_3T_3	55.71^{abc} ± 1.94	55.55^{abc} ± 1.18
M_3T_4	59.70^{a} ± 0.53	59.64^{a} ± 0.62

M= Manure T= Nitrogen application time
Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

***In vitro* iron and zinc availability of corn**

Iron and zinc availability of corn at different levels of manure and nitrogen application times was illustrated in Table (11). It could be noticed that the availability of iron at levels of 10 m^3 manure fed^{-1} (M_2) ranged between 7.34-9.52 and 8.90-9.48% and at 20 m^3 manure fed^{-1} (M_3) ranged between 8.41-9.07 and 9.02-9.35% for 2014 and 2015 seasons, respectively. While, the availability of zinc ranged between 7.64-8.33 and 8.88-9.95% for 2014 and 2015 seasons and at 20 m^3 manure fed^{-1} (M_3) ranged between 8.56-9.85 and 8.94-9.84% for 2014 and 2015 seasons, respectively. Iron and zinc availability increased with increasing the levels of manure in both seasons, especially for season 2015 which recorded the highest iron and zinc availability percent.

The bioavailability of minerals such as iron, zinc, calcium, magnesium in cereal grains, is low because they are present as insoluble complex with food components such as phytic acid (Coulibaly *et al.*, 2011). Iron absorption from vegetarian diets is estimated to be 2 to 8%, which may lead to risk of iron deficiency if daily iron intakes are lower. The variation in dietary iron absorption from meals is due to the differences in the bioavailability of the iron, which can lead to a many-fold variation in iron absorption, than to a variation in iron content (Hallberg and Hulthén, 2000 and Troost, 2003).

Vegetarian meals have a poor bioavailability of zinc, and these diets may or may not have low zinc content. At low zinc intakes and with an absence of inhibitors, zinc absorption can be greater than 50%. The manures enhance microbial activity that releases different organic acids which helps in solubilization of the native soil nutrients and makes them available for the uptake by plants (Ewais *et al.*, 2015).

Table (11): Iron and zinc availability (%) of corn flour with different manure levels and nitrogen application times

Treatments	*In vitro* iron availability (%)		*In vitro* zinc availability (%)	
	2014	2015	2014	2015
M_1T_1	$7.00^{d} \pm 0.20$	$8.74^{a} \pm 0.70$	$7.72^{bc} \pm 0.61$	$8.12^{b} \pm 0.08$
M_1T_2	$7.87^{bcd} \pm 0.63$	$8.73^{a} \pm 0.63$	$7.30^{c} \pm 0.05$	$8.83^{ab} \pm 0.77$
M_1T_3	$8.57^{abc} \pm 0.48$	$8.76^{a} \pm 0.15$	$7.72^{bc} \pm 0.56$	$8.12^{b} \pm 0.80$
M_1T_4	$7.00^{d} \pm 0.94$	$8.70^{a} \pm 0.67$	$7.59^{bc} \pm 0.69$	$8.42^{ab} \pm 1.24$
M_2T_1	$7.34^{cd} \pm 1.22$	$8.97^{a} \pm 0.22$	$7.64^{bc} \pm 0.24$	$9.51^{ab} \pm 1.19$
M_2T_2	$8.28^{abcd} \pm 0.80$	$8.99^{a} \pm 0.24$	$8.09^{bc} \pm 0.80$	$8.88^{ab} \pm 0.92$
M_2T_3	$9.52^{a} \pm 0.27$	$9.48^{a} \pm 0.64$	$8.12^{bc} \pm 0.73$	$8.90^{ab} \pm 1.31$
M_2T_4	$8.66^{ab} \pm 0.72$	$8.90^{a} \pm 0.46$	$8.33^{bc} \pm 0.71$	$9.95^{a} \pm 0.05$
M_3T_1	$8.41^{abc} \pm 0.46$	$9.34^{a} \pm 0.60$	$8.56^{abc} \pm 0.30$	$8.94^{ab} \pm 0.36$
M_3T_2	$9.07^{ab} \pm 0.39$	$9.25^{a} \pm 0.43$	$9.00^{ab} \pm 0.81$	$9.32^{ab} \pm 0.49$
M_3T_3	$8.72^{ab} \pm 0.75$	$9.02^{a} \pm 0.38$	$9.85^{a} \pm 1.23$	$9.84^{a} \pm 0.76$
M_3T_4	$8.79^{ab} \pm 0.77$	$9.35^{a} \pm 0.55$	$9.02^{ab} \pm 0.44$	$9.34^{ab} \pm 0.14$

M= Manure T= Nitrogen application time
Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

Sensory evaluation of gluten-free corn muffins

Appearance, color, texture, taste, flavor and overall acceptability data of corn muffins at different manure levels and nitrogen application times are listed in Table (12). The results showed that, there were non significant differences in appearance, texture, taste, flavor and overall acceptability between all muffin samples. The crumb color score insignificantly decreased with the increasing of the manure levels up to 20 m^3 manure fed^{-1} at different nitrogen application times. Decreasing in overall acceptability may be due to the decrease in texture, flavor and taste scores. Generally, the produced muffins from corn flour at different manure levels and nitrogen application time were acceptable according to the panelists.

Purnomo *et al.* (2012) reported that the characteristics of 100% corn flour-muffin were strong aroma, uniform cell structure and moderate in size. Regarding to hedonic score for overall attribute at 100% substitution level of corn, the muffin was preferred by panelists. Gluten-free flours, such as rice or corn ones, the greater hardness of the initial grains make these flours have a higher particle size, which can cause problems in the product quality (Gómez *et al.*, 2010).

Physical and color characteristics of corn muffins

Physical characteristics (weight, volume, specific volume and density) values of muffins prepared from corn flour at different manure levels and nitrogen application times are demonstrated in Table (13). From the results, it could be noticed that values of weight, volume and specific volume of corn muffins were not influenced by the tested treatments. There were non significant differences ($p>0.05$) in muffins density among samples in all treatments. M_3T_2 and M_3T_3 had the highest values in specific volume, whereas, they had the lowest density.

Concerning the data of muffin crumb color, the lightness ($L*$) value of muffins decreased insignificantly (p>0.05) from 78.27-79.35 to 74.54-76.86 by increasing the manure levels to 20 m^3 manure fed^{-1}. The yellowness ($b*$) value of muffins partially significantly increased ($p<0.05$) (from 30.44-31.94 to 32.18-33.11) with increasing the manure levels to 20 m^3 manure fed^{-1}. Muffin produced from 100% corn flour has yellow color and slightly less compact texture (Purnomo *et al.*, 2012).

Texture characteristics of corn muffins

Texture parameters (hardness, cohesiveness, gumminess, chewiness and springiness) of muffin prepared from corn flour at different manure levels and nitrogen application times are listed in Table (14). The results showed that using of corn flour in the formulation of muffin affected its textural properties. Values of muffin hardness and gumminess increased as the level of manure increased up to 20 m^3 manure fed^{-1}. Hardness ranged between 1.64-2.80 N and the M_3T_1 treatment had the highest value while M_1T_4 was the lowest. In the case of chewiness, there were a non significant effect was observed with increasing manure levels. In addition, increasing manure levels up to 20 m^3 manure fed^{-1} resulted in a significant reduction in springiness. M_3T_1 had the highest values in hardness and gumminess while, M_1T_4 had the highest value in springiness. The interaction between starch and other macromolecular constitutes may be important for structural changes occurring in muffin.

Texture measurements can be very valuable for the quality control and process optimization as well as for the development of new products with desirable properties and characteristics. One of the main problems with gluten-free products is their lack of cohesiveness and resilience (Matos and Rosell, 2012). Corn muffin samples required greater force and they are harder in most of the samples (Purnomo *et al.*, 2012). Springiness is a vital quality characteristic of muffin which indicates the ability of the sample to recover its height during the time that elapses before the end of the first compression and the start of the second. The decrease in springiness has been related to reduce number of muffin air bubbles and the presence of a denser matrix (Sanz *et al.*, 2009). Springiness and resilience were found to be decreased with a higher level of corn incorporation (Anis Jauharah *et al.*, 2014).

Table (12): Sensory evaluation of corn muffins at different manure levels and nitrogen application time

Muffin samples	Appearance	Color	Texture	Taste	Flavor	Overall acceptability
M_1T_1	$8.55^a \pm 0.44$	$8.40^{abcd} \pm 0.56$	$8.30^a \pm 0.48$	$8.25^a \pm 0.43$	$8.65^{ab} \pm 0.41$	$8.46^{ab} \pm 0.20$
M_1T_2	$8.60^a \pm 0.66$	$8.65^{ab} \pm 0.49$	$8.55^a \pm 0.55$	$8.40^a \pm 0.66$	$8.50^{ab} \pm 0.45$	$8.48^{ab} \pm 0.41$
M_1T_3	$8.20^a \pm 0.59$	$8.50^{abc} \pm 0.47$	$8.55^a \pm 0.69$	$8.05^a \pm 0.80$	$8.50^{ab} \pm 0.47$	$8.33^b \pm 0.34$
M_1T_4	$8.23^a \pm 0.70$	$8.63^{abc} \pm 0.48$	$8.60^a \pm 0.81$	$8.38^a \pm 0.64$	$8.60^{ab} \pm 0.46$	$8.52^{ab} \pm 0.34$
M_2T_1	$8.40^a \pm 0.66$	$8.50^{abc} \pm 0.58$	$8.50^a \pm 0.78$	$8.48^a \pm 0.56$	$8.90^a \pm 0.21$	$8.54^{ab} \pm 0.39$
M_2T_2	$8.45^a \pm 0.42$	$8.80^a \pm 0.35$	$8.55^a \pm 0.55$	$8.55^a \pm 0.44$	$8.90^a \pm 0.40$	$8.67^a \pm 0.22$
M_2T_3	$8.70^a \pm 0.42$	$8.60^{abc} \pm 0.39$	$8.40^a \pm 0.46$	$8.30^a \pm 0.35$	$8.45^{ab} \pm 0.50$	$8.53^{ab} \pm 0.18$
M_2T_4	$8.58^a \pm 0.50$	$8.35^{abcd} \pm 0.66$	$8.25^a \pm 0.60$	$8.05^a \pm 0.53$	$8.55^{ab} \pm 0.44$	$8.35^b \pm 0.31$
M_3T_1	$8.55^a \pm 0.49$	$8.30^{abcd} \pm 0.42$	$8.35^a \pm 0.40$	$8.45^a \pm 0.44$	$8.50^{ab} \pm 0.47$	$8.48^{ab} \pm 0.20$
M_3T_2	$8.50^a \pm 0.47$	$8.25^{bcd} \pm 0.54$	$8.35^a \pm 0.53$	$8.10^a \pm 0.52$	$8.55^{ab} \pm 0.45$	$8.58^{ab} \pm 0.18$
M_3T_3	$8.48^a \pm 0.51$	$8.10^{cd} \pm 0.61$	$8.20^a \pm 0.48$	$8.00^a \pm 0.62$	$8.40^b \pm 0.70$	$8.40^{ab} \pm 0.26$
M_3T_4	$8.60^a \pm 0.46$	$7.95^d \pm 0.60$	$8.30^a \pm 0.63$	$8.00^a \pm 0.72$	$8.56^{ab} \pm 0.50$	$8.46^{ab} \pm 0.34$

M= Manure T= Nitrogen application time Color= crumb color.
Values are means ± SD (n=10), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

Table (13): Physical and color characteristics of corn muffins at different manure levels and nitrogen application time

Muffin samples	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Density (g/cm^3)	*L**	*a**	*b**
M_1T_1	53.48^{a} ±1.39	123.15^{a} ±1.95	2.30^{a} ±0.04	0.436^{a} ±0.03	78.31^{ab} ±0.54	-2.57^{c} ±0.17	30.44^{c} ±0.94
M_1T_2	52.55^{a} ±1.84	122.50^{a} ±2.50	2.33^{a} ±0.04	0.431^{ab} ±0.01	79.35^{a} ±0.72	-2.37^{abc} ±0.03	30.45^{c} ±1.50
M_1T_3	51.64^{a} ±2.29	122.33^{a} ±4.62	2.36^{a} ±0.02	0.423^{ab} ±0.01	78.63^{ab} ±3.62	-2.49^{bc} ±0.03	31.94^{abc} ±0.34
M_1T_4	51.72^{a} ±1.95	121.22^{a} ±3.34	2.34^{a} ±0.03	0.427^{ab} ±0.02	78.27^{ab} ±1.06	-2.45^{abc} ±0.13	31.14^{bc} ±1.78
M_2T_1	52.00^{a} ±0.60	122.76^{a} ±1.20	2.36^{a} ±0.03	0.424^{ab} ±0.01	75.41^{ab} ±1.09	-2.38^{abc} ±0.28	31.64^{abc} ±0.56
M_2T_2	52.68^{a} ±0.38	123.89^{a} ±1.92	2.35^{a} ±0.09	0.423^{ab} ±0.02	76.37^{ab} ±2.31	-2.27^{abc} ±0.12	32.55^{ab} ±0.91
M_2T_3	52.57^{a} ±1.21	122.67^{a} ±4.93	2.33^{a} ±0.02	0.429^{ab} ±0.01	76.71^{ab} ±1.67	-2.39^{abc} ±0.04	32.21^{abc} ±0.63
M_2T_4	52.83^{a} ±0.21	123.33^{a} ±6.51	2.33^{a} ±0.05	0.429^{ab} ±0.03	77.25^{ab} ±1.49	-2.25^{abc} ±0.24	32.17^{abc} ±0.60
M_3T_1	52.62^{a} ±1.07	123.17^{a} ±4.54	2.34^{a} ±0.04	0.426^{ab} ±0.02	74.54^{b} ±3.77	-2.23^{ab} ±0.20	32.18^{abc} ±1.17
M_3T_2	52.20^{a} ±1.74	124.00^{a} ±4.58	2.37^{a} ±0.05	0.417^{b} ±0.01	74.97^{ab} ±3.61	-2.21^{ab} ±0.06	32.94^{ab} ±0.46
M_3T_3	52.46^{a} ±0.28	125.00^{a} ±4.00	2.38^{a} ±0.03	0.419^{b} ±0.01	76.21^{ab} ±1.25	-2.16^{a} ±0.31	33.11^{a} ±0.77
M_3T_4	53.70^{a} ±0.35	124.67^{a} ±5.03	2.32^{a} ±0.08	0.430^{ab} ±0.02	76.86^{ab} ±2.10	-2.14^{a} ±0.03	32.25^{abc} ±0.25

M= Manure T= Nitrogen application time

L* (lightness with *L = 100 for lightness, and *L** = zero for darkness), *a** [(chromaticity on a green (-) to red (+)] and *b** [(chromaticity on a blue (-) to yellow (+)].

Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

Table (14): Texture characteristics of corn muffins at different manure levels and nitrogen application times

Muffin samples	Hardness (N)	Cohesiveness	Gumminess (N)	Chewiness (N)	Springiness
M_1T_1	2.01^{d} ± 0.11	0.67^{a} ± 0.02	1.35^{bc} ± 0.11	0.86^{ab} ± 0.08	0.64^{a} ± 0.01
M_1T_2	1.67^{ef} ± 0.03	0.61^{ab} ± 0.01	1.01^{de} ± 0.04	0.63^{bc} ± 0.07	0.62^{ab} ± 0.05
M_1T_3	1.77^{ef} ± 0.03	0.52^{bcd} ± 0.03	0.92^{e} ± 0.07	0.57^{c} ± 0.06	0.62^{ab} ± 0.02
M_1T_4	1.64^{f} ± 0.12	0.62^{ab} ± 0.10	1.01^{cde} ± 0.20	0.66^{bc} ± 0.17	0.65^{a} ± 0.01
M_2T_1	2.60^{b} ± 0.05	0.62^{ab} ± 0.01	1.61^{ab} ± 0.06	0.97^{a} ± 0.05	0.60^{ab} ± 0.01
M_2T_2	1.81^{e} ± 0.11	0.60^{ab} ± 0.09	1.09^{cde} ± 0.24	0.62^{bc} ± 0.15	0.57^{ab} ± 0.02
M_2T_3	2.26^{c} ± 0.04	0.48^{cd} ± 0.06	1.08^{cde} ± 0.20	0.51^{c} ± 0.09	0.47^{cd} ± 0.02
M_2T_4	1.76^{ef} ± 0.04	0.59^{abc} ± 0.02	1.04^{cde} ± 0.06	0.56^{c} ± 0.07	0.54^{bc} ± 0.04
M_3T_1	2.80^{a} ± 0.19	0.62^{ab} ± 0.01	1.74^{a} ± 0.13	0.99^{a} ± 0.26	0.57^{ab} ± 0.10
M_3T_2	2.35^{c} ± 0.05	0.56^{abcd} ± 0.10	1.31^{cd} ± 0.24	0.60^{c} ± 0.17	0.46^{cd} ± 0.04
M_3T_3	2.70^{ab} ± 0.09	0.45^{d} ± 0.07	1.22^{cde} ± 0.13	0.55^{c} ± 0.15	0.45^{d} ± 0.05
M_3T_4	2.06^{d} ± 0.05	0.55^{bcd} ± 0.05	1.13^{cde} ± 0.13	0.46^{c} ± 0.11	0.41^{d} ± 0.05

N= Newton M= Manure T= Nitrogen application time.

Values are means ± SD (n=3), mean number in the same column bearing different superscript letter are significantly different at $p < 0.05$

CONCLUSION

Manure levels significantly affected on days to 50% tasseling, plant and ear height, ear length, rows per ear, kernels per row, 1000-grains weight and grain yield in both seasons and days to 50% silking in 2015 season. The highest grain yield was obtained by 20.0 $m^3$of manure fed^{-1} in both seasons. Furthermore, the third level of manure (20.0 m^3 manure fed^{-1}) had the highest grain yield when it was applied with T_2 N application time. Protein and fat contents increased with increasing the manure levels. Moreover, protein digestibility and availability of iron and zinc increased with increasing manure levels up to 20 m^3 manure fed^{-1}. Corn muffin samples at different levels of manure and nitrogen application time had acceptable scores for most sensorial parameters. Corn flour could be used to produce good quality gluten-free muffins with acceptability in terms of texture, taste and flavor.

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تأثير إستخدام السماد العضوي والنيتروجينى على إنتاجية وخصائص جودة الذرة

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قسم بحوث الذرة الشامية - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية – الجيزة - مصر
قسم بحوث تكنولوجيا المحاصيل - معهد بحوث تكنولوجيا الأغذية - مركز البحوث الزراعية – الجيزة - مصر

أجريت تجربتان حقليتان بمحطة بحوث سدس في محافظة بني سويف خلال موسمي ٢٠١٤ و٢٠١٥ لدراسة تأثير ثلاثة مستويات من السماد العضوي (M_1= صفر، M_2= 10 ، M_3= ٢٠ م^3/فدان) وأربعة مواعيد لإضافة السماد النيتروجينى (التوقيت الأول: ٥/١ نيتروجين عند الزراعة، ٥/٢ نيتروجين عند الرية الأولى، ٥/٢ نيتروجين عند الرية الثانية، التوقيت الثاني: ٥/١ نيتروجين عند الزراعة، ٥/٢ نيتروجين عند الرية الأولى ، ٥/٢ نيتروجين عند الرية الثالثة، التوقيت الثالث: ٣/١ نيتروجين عند الرية الأولى، ٣/١ نيتروجين عند الرية الثانية و ٣/١ نيتروجين عند الرية الثالثة والتوقيت الرابع: ٢/١ نيتروجين عند الرية الأولى، ٢/١ نيتروجين عند الرية الثانية) للذرة البيضاء (هجين فردى ١٣٠) على صفات النمو، مكوناته وكمية المحصول وكذلك تم تقييم بعض الخصائص الفيزيائية والكيميائية والتكنولوجية لحبوب الذرة الناتجة. أظهرت النتائج أن مستويات السماد العضوي والنيتروجينى أثرت معنويا على عدد الأيام للوصول إلى ٥٠% نورة مذكرة، إرتفاع النبات والكوز، طول الكوز، عدد الحبوب بالسطر ومحصول الحبوب في كلا الموسمين. أثرت مستويات السماد بشكل ملحوظ على عدد الأيام للوصول إلى ٥٠% حريره خلال موسم ٢٠١٥ بينما توقيتات إضافة النيتروجين اختلفت معنويا في صفات عدد الأيام للوصول إلى ٥٠% حريره، عدد السطور بالكوز فى كلا الموسمين وقطر الكوز في موسم ٢٠١٥. كان المستوى الثالث من السماد العضوي الأعلى فى محصول الحبوب في كلا الموسمين بينما توقيت الإضافة الثاني كان أبكر من باقي توقيتات الإضافة الأخرى في عدد الأيام للوصول إلى ٥٠% نورة مذكرة وحريره كما أعطى قيم مرتفعة في إرتفاع النبات والكوز، طول وقطر الكوز، عدد السطور بالكوز، عدد الحبوب بالسطر، محصول الحبوب. وقد أشارت نتائج التفاعل إلى أن المستوى الثالث من السماد العضوي كان الأعلى في محصول الحبوب عندما أستخدم مع توقيت الإضافة الثانى. زاد وزن الألف حبة زيادة معنوية بزيادة مستويات السماد العضوي. كان المستوى الثالث من السماد العضوى مع توقيت الأضافة الثاني والثالث الأعلى في قيم وزن الألف حبة لكلا الموسمين. زادت النسبة المئوية للإندوسبرم والجنين زيادة معنوية عند إستخدام المستوى الثالث من السماد العضوي مع توقيت الأضافة الثاني والثالث. أرتفع محتوي حبوب الذرة من البروتين، الرماد، الحديد، الزنك والأميلوز في موسم ٢٠١٤ عند مستويات السماد العضوي المختلفة. في حين أن موسم ٢٠١٥ كان الأعلى في محتوى الدهون. حدث زيادة في قابلية البروتين للهضم وإتاحة الحديد والزنك بزيادة مستويات السماد العضوي في كلا الموسمين. إنخفضت قيم اللمعان (L*) في اللبابة الداخلية للمافن بشكل ملحوظ في حين أرتفعت قيم اللون الأصفر(b*) مع زيادة مستويات السماد العضوي. وعامة يمكن إستنتاج أنه يمكن إستخدام دقيق الذرة لإنتاج مافن خال من الجلوتين ذو خصائص فيزيائية وقيم حسية مقبولة.

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