Phenotypic Correlations and Integration of Nitrogen, Potassium and Press Mud Fertilizers in Relation to Sugarcane Yield and Quality

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ABSTRACT

The present work was carried out at Mallawi Agricultural Research Station, El-Minya Governorate, Egypt (latitude of 28° 10' N, longitude of 30° 75' E and altitude of 55 m above sea level) in 2017/2018 and 2018/2019 seasons to study the influence of nitrogen, potassium as inorganic fertilizers and press mud as an organic fertilizer on yield and quality of sugarcane variety G.2003-47 (Giza 3). The field experimental work was carried out in a randomized complete blocks design in a split-split plot arrangement in three replications in both seasons. The results showed that the application of 4 tons of press mud/fed significantly increased plant length, diameter, number of millable canes/fed, stalk weight, cane and sugar yields/fed, as well as brix, sucrose and sugar recovery percentages in both seasons. Increasing nitrogen levels from 150 up to 210 kg N/fed resulted in a significant increase in stalk height, diameter, weight, number of millable canes cane and sugar yields/fed, as well as brix, sucrose, purity and sugar recovery percentages in both seasons. Applying 48 kg K_2O/fed resulted in a significant increase in cane length, diameter, number of millable canes, stalk weight and cane and sugar yields/fed, as well as brix, sucrose and sugar recovery percentages in both seasons. The correlation analysis showed that the stalk diameter, number of stalks per meter, and weight of the cane contributed most to cane yield at the harvest.

Keywords: sugarcane, correlations, press mud, nitrogen, potassium, yield and quality

INTRODUCTION

Sugarcane is a robust, tillering, and perennial crop. It occupies the soil for more than 5 years. It is considered one of the most efficient C4 plants in utilizing water, CO2, and solar radiation in producing a great amount of dry matter. Meanwhile, it depletes tremendous amounts of macro and microelements from the soil. Moreover, occupying the soil so a long period of time harms the soil environment, with respect to aeration, drainage, texture, and water holding capacity. Therefore, this work was conducted aiming at using press mud, having some advantages, as an organic source of nutrients and as a soil amendment, in combination with inorganic nitrogen and potassium fertilizers in sugarcane fertilization.

Press mud or filter cake, a by-product waste after sugar extraction in sugar factories mills, is delicate, spongy, amorphous, and dark brown stuff. It contains fiber, coagulated colloids, including cane wax, albuminoids, inorganic salts, and dirt particles (Ghulam *et al.,* 2010). Press mud (PM) is organic effluents from sugar factories used to supply nutrient-rich, high-quality organic manure. It also includes plant growth regulators, auxins, enzymes, vitamins, and hormones resulting in maintaining the tilth, fertility, and productivity of agricultural soils (Solaimalai *et al.,* 2001). They also protect the soils from wind and water erosion, thus preventing nutrient losses through runoff and leaching. Press mud or filter cake is one of the important organic wastes capable of providing a sufficient amount of plant nutrients due to its favorable effects on soil texture, structure, organic matter contents, water holding capacity, and aeration of soil (Ghulam *et al.,* 2010). Santos *et al*., (2010) Pakkiyappan and Saminathan (1999) suggested that application of press mud at 37.5 ton/ha to sugarcane grown on tannery effluent polluted soils of Coimbatore improved the quality of sugarcane. Application of press mud significantly increased brix, sucrose and commercial cane sugar percent (CCS). Press mud application increased sugar yield by 78.5 % over the control. Kalaimani Giridharan (2001) reported that the tiller population and number of millable canes also exhibited the same trend. Yield differences between press mud soil than non-press mud soil ranged from 4 to 20 tons/ha.

It is known that nitrogen has a close relationship with yield and its components, where it plays a direct role in the growth behavior and juice quality of sugar cane. Nitrogen unites with carbonic compounds to produce different organic compounds like chlorophyll, protoplasm, proteins, nucleic acids, vitamins and enzymes. Nitrogen is responsible for growth and development of all living tissues of cane plants. Regarding nitrogen fertilization effect, Mokadem *et al.*, (2008) revealed that increasing N levels attained positive and significant effects on stalk height, millable canes/fed, cane yield/fed, sugar yield/fed and sugar recovery%. El-Geddawy *et al*., (2012) found that increasing N levels from 170 to 230 kg N/fed produced

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higher values of stalk height, stalk diameter, stalk fresh weight, millable canes/fed, cane and sugar yields, as well as brix %, sucrose % and sugar recovery %. Neana and Abd El-Hak (2014) concluded that stalk length and diameter, cane and sugar yields and sucrose % significantly increased by increasing N levels from 140 up to 200 kg N/fed in both seasons. Abd El-Aal *et al.,* (2015) reported that increasing N fertilization levels from 180 to 210 and 240 kg N/fed resulted in a significant increase in millable diameter and cane yield of sugarcane. On the contrary, sucrose and sugar recovery percentages significantly decreased. Bekheet and Abd El-Aziz (2016) found that raising N fertilization level from 180 to 220 kg N/fed led to a significant increase in cane stalk height, millable diameter, number of millable canes, cane and sugar yields/fed. Santos *et al*., (2010) added filter cake at 0, 0.5, 1.0, 2.0 and 4.0 tons/ha and phosphorus fertilizer doses of 0, 50, 100 and 200 kg P_2O_5/ha. They found that stalk yield and tillering were influenced by the filter cake rates applied to the soil. Abd-El-Kader (2017) found that number of millable canes /fed, single millable cane weight, length and stalk diameter, brix, sucrose, sugar recovery as well as cane and sugar yields increased significantly by the applied filter cake with NPK. Santos *et al.,* (2014) found that supplying sugarcane with a combination of 1.0 and 2.0 mg with 100 to 200 kg/ha soluble phosphate gave higher stalk and sugar yields Girma (2015) indicated that the main effect of filter cake and the interaction effect of filter cake by mineral fertilizer were highly significant for cane and sugar yields, while the main effect of mineral fertilizer was not significant. He cleared that the application of filter cake highly improved nutritional quality.

The study of the correlation between phenotypic characteristics may reflect biological processes of significant evolutionary value, a correlation may result from genetic, functional, and physiological or developmental traits (Wagner and Schwenk, 2000). Falconer (1989), meanwhile, suggested that the interaction between two or more characters is due to the action or linkage of apheliotropic genes. Abu-Ellail *et al.,* (2019) found that it is important to study the characteristics of sugarcane associated with yield, also reported that crop cycles had a negative effect on cane and sugar yields. The phenotypic association between cane yield and its components, was demonstrated by Abu-Ellail *et al.,* (2017), over the seasons, stalk diameter, stalk weight, and the number of stalks/fed were extremely important in the positive direction. The aim of this study was to find out the appropriate levels of nitrogen, potassium integrated with press mud to get the highest yield and quality traits of sugarcane. Also to estimate the correlations among yield and quality traits.

MATERIALS AND METHODS

Two field experiments were carried out at Mallawi Research Station, El-Minia Governorate (latitude of 28° 10' N, longitude of 30° 75' E and altitude of 55 m above sea level) in 2017/2018 and 2018/2019 seasons to study the effect of nitrogen, potassium and press mud on yield and quality of sugar cane under conditions of El-Minia Governorate. The field experimental work was carried out in a randomized complete block design using split-split plot arrangement in three replications in both seasons. Press mud levels (0, 2 and 4 ton/fed) were allocated at random in the main plots. Nitrogen fertilization levels (150, 180 and 210 kg N/fed) were distributed randomly in the sub plots, while potassium levels (24 and 48 kg K_2O/fed) were applied in the sub-sub plots of press mud was applied during land preparation. Nitrogen fertilizer was applied in the form urea 46% and divided into equal doses; after 60 days from planting and 30 days later, while potassium fertilizer was added with the second nitrogen dose. The experimental unit area was 35 m^2 (1/120 fed) including 5 rows of 1 m and 7 m in length. Sugarcane G. 2003-47 (commercially called Giza 3) was planted during the 1st week of March and harvested after 12 months in both seasons, using the dry method of planting with 3-budded cane cuttings, which were drilled in each furrow. The mechanical and chemical properties of the upper 40 cm of the experimental soil are presented in (Table 1), Also, the chemical composition of the filter cake used in the experiments is presented in Table 2.

Table 1. Soil properties of the experimental sites in 2017-2018 and 2018-2019 seasons

Soil property	2017/2018	2018/2019
Particule size distribution :		
Sand%	55.34	51.57
Silt%	29.34	26.30
Clay%	15.32	22.13
Soil texture	Sandy loam	
OM (%)	0.21	0.29
Available Nitrogen mg/kg soil	0.19	0.22
Available P_2O_5 mg/kg soil	2.91	3.74
Available K_2O mg/kg soil	0.89	0.93
EC (dS/m)	0.23	0.21
pH at (1:2.5) soil : water suspension	7.6	7.5
Cations (meq/l)		
Mg^{++}	0.26	0.22
Na^{+}	1.19	1.13
Ca^{++}	0.51	0.48
K^{+}	0.14	0.12
Anions (meq/l)		
HCO_3^{-}	0.29	0.22
Cl^{-}	0.85	0.75
$SO4^{-}$	0.96	0.98

Table 2. Chemical composition of press mud used in the experiments

Season		2017/2018	2018/2019
Macro elements (%)	Total N (%)	2.75	2.96
	Total P (%)	1.43	1.47
	Total K (%)	0.66	0.72
Micro elements (mg/kg)	Fe	29.5	33.3
	Mn	279	287
	Zn	105	109
	Cu	129	132
Organic matter %		28.7	30.5
Organic C %		19.1	21.2
pH (1:5) Susp.		7.61	7.82
EC (dS/m) (1:5)		1.01	1.03
C/N ratio		10:3	13:8
Humidity %		51.0	52.2

At harvest, the following data were recorded:

1. Millable cane length (cm).
2. Millable cane diameter (cm).
3. Millable cane weight (kg).
4. Number of millable canes in (thousand/fed) was counted in one square meter, then converted into a number per feddan (4200 m^2).

Juice quality characteristics:

At harvest, a sample of 20 millable canes from each treatment was taken at random, cleaned and crushed and analyzed to determine the following traits:

1. Brix% was determined in the laboratory using "Brix Hydrometer" according to the method described by "The Chemical Control Lab" of Sugar and Integrated Industries Company (Anonymous, 1981).
2. Sucrose% was determined using "Sacharemeter" according to A.O.A.C. (1995).
3. Juice purity% was calculated using the following equation:

Purity% = (sucrose% x100)/brix%

4. Sugar recovery percentage was calculated as follows:

Sugar recovery% = richness% x purity%/100

Where: richness was estimated using the following equation:

Where Richness = (sucrose in 100 grams x factor) / 100.

Factor = 100 - [fiber % + physical impurities % + percent water free from sugar].

Cane and sugar yields:

1. Cane yield/fed (ton) was counted from the weight of the three middle rows of each plot (kg) and converted into ton/fed.
2. Sugar yield/fed (ton) was estimated according to the following equation:

Sugar yield/fed (ton) = cane yield/fed (ton) x sugar recovery%.

Statistical analysis:

The collected data were statistically analyzed according to Gomez and Gomez (1984) using the computer "MSTAT-c" statistical analysis package by Freed *et al.,* (1989). The least significant differences (LSD) at 0.05 level of probability were calculated to compare the differences among treatment means. SPSS version 10 was used for assessing the magnitudes of correlation among variables (Spearman's Correlation). Phenotypic correlation coefficients were calculated among all the traits according to (Falconer, 1989).

RESULTSAND DISCUSSION

Millable cane length and diameter:

The results in Table 3 indicated that increasing quantity of press mud supplied to sugarcanes from 2 to 4 tons/fed increased stalk height and diameter of sugar cane significantly by 6.81and 16.83 cm and 0.03 and 0.06 cm compared to the check treatment (without press mud), respectively, in the 1st season, corresponding to 8.82 and 18.16 cm and 0.03 and 0.04 cm, in the 2nd one. These results could be referred that press mud contains some organic matter and nutrients (Table 2), which had a positive role in sugarcane growth. This finding is in accordance with those reported by Kumar and Verma (2002), Shankaraiah and Murthy (2005) and Abd-El-Kader (2017).

Data in Table 3 showed that increasing nitrogen fertilization levels from 180 to 210 increased millable cane length significantly by8.40 and 22.43 cm, respectively in the 1st season, corresponding to 11.56 and 24.75 cm, in the 2nd one, as compared with that recorded when N-fertilizer was given at 150 kg N/fed. Likewise, an increase of 0.02 and 0.05 cm in millable cane diameter was detected in the 1st season, corresponding to 0.03 and 0.05 cm in the 2nd one. These results fairly proved that supplying sugarcanes with 210 kg nitrogen was physiologically needed for better growth and efficient performance of plants to attain their highest potential, compared to those given the lowest N-level. These results are in harmony with those reported by and Nassar *et al.,* (2005), Ahmed and El-Shafai (2007), Mokadem *et al.,* (2008), El-Gedawwy *et al*., (2012), Neana & Abd El-Hak (2014), Abd El-Aal *et al*., (2015) and Bekheet and Abd El-Aziz (2016).

Results in Table 3 showed that increasing levels of potassium fertilizer level from 24 to 48 kg/fed K_2O resulted in significant increases in millable cane length and diameter in both seasons. Applying 48 kg K_2O/fed gave higher values of these two traits. These results may be due to the role of potassium in the meristemic activity of plant tissues. These results are similar to those obtained by El-Sogheir *et al*., (2003), Osman *et al*., (2004) and El-Sayed *et al*., (2005).

The interaction between nitrogen levels and potassium fertilizers (N x K) had a significant influence on stalk length in the 1st season only. The longest stalk was recorded when sugarcane was fertilized with 210 kg N/fed + 48 kg K_2O/fed. The interaction between nitrogen levels and press mud (N x PM) significantly affected millable length in the 2nd, and millable diameter in the 1st one. The interaction between K x PM had a significant effect on millable length in both seasons and diameter in the 1st one. The longest stalk by adding potassium at 48 kg K_2O/fed 4 tons press mud/fed in both seasons. The 2nd order interactions among the three studied factors had a significant effect on millable length and diameter in the 1st season only. Fertilizing sugar cane with 210 kg N + 48 kg K_2O + 4 tons press mud/fed gave the highest millable length and diameter in the 1st season.

Millable cane weight and number:

Data in Table 4 manifested that increasing level of press mud supplied to sugarcanes from 2 to 4 tons/fed increased stalk weight and a number of millable canes/fed by (0.03 and 0.05 kg/plant) and (0.6 and 1.14 thousand canes/fed) compared to that recorded by canes left without press mud, respectively, in the 1st season, corresponding to (0.02 and 0.04 kg) and (0.64 and 1.2 thousand canes/fed) in the 2nd season. These results could be referred to that the press mud added some organic matter and nutrients (Table 2) to the soil used by cane plants. These findings in agreement with those obtained by Kalaimani and Giridharan (2001), Kumar and Verma (2002), Shankaraiah and Murthy (2005) and Abd-El-Kader (2017).

Table 3. Effect of press mud, nitrogen, potassium levels and their interactions on millable length and diameter in 2017/2018 and 2018/2019 seasons

Traits		Millable cane length (cm)						Millable cane diameter (cm)					
Press mud/fed, ton (PM)	N level (kg /fed)	2017/2018 season			2018/2019 season			2017/2018 season			2018/2019 season		
		K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean
		24	48		24	48		24	48		24	48	
0	150	250.16	257.45	253.81	249.85	255.24	252.55	2.47	2.49	2.48	2.48	2.53	2.51
	180	258.09	265.69	261.89	262.51	268.54	265.53	2.51	2.54	2.53	2.52	2.54	2.53
	210	269.83	279.94	274.89	272.01	281.22	276.62	2.54	2.61	2.58	2.56	2.57	2.57
Mean		259.36	265.26	262.31	261.56	266.64	264.10	2.51	2.55	2.53	2.52	2.55	2.53
2	150	259.35	261.25	260.30	256.50	262.84	259.67	2.51	2.54	2.53	2.51	2.55	2.53
	180	265.05	271.06	268.06	270.75	278.99	274.87	2.51	2.62	2.57	2.54	2.61	2.58
	210	277.71	289.44	283.58	283.41	289.75	286.58	2.56	2.65	2.61	2.59	2.68	2.64
Mean		267.37	273.28	270.33	270.22	277.19	273.71	2.53	2.60	2.57	2.55	2.61	2.58
4	150	270.11	275.19	272.65	271.39	274.86	273.13	2.54	2.57	2.56	2.54	2.61	2.58
	180	273.62	281.25	277.44	275.55	283.74	279.65	2.56	2.65	2.61	2.56	2.64	2.60
	210	285.31	296.71	291.01	292.29	300.51	296.40	2.58	2.72	2.65	2.62	2.73	2.68
Mean		276.35	284.38	280.37	279.74	286.37	283.06	2.56	2.65	2.60	2.57	2.66	2.62
Mean of (N×K)	150	259.87	261.57	260.72	259.25	264.31	261.78	2.51	2.53	2.52	2.51	2.56	2.54
	180	265.59	272.67	269.13	269.60	277.09	273.35	2.53	2.60	2.57	2.54	2.60	2.57
	210	277.62	288.70	283.16	282.57	290.49	286.53	2.56	2.66	2.61	2.59	2.66	2.63
Mean of K		267.69	274.31		270.51	276.73		2.53	2.60		2.55	2.61	
LSD at 0.5 level for:													
Nitrogen levels (N)				2.16			3.87			0.02			0.02
Potassium levels (K)				1.71			2.19			0.01			0.01
Press mud (PM)				2.31			1.24			0.01			0.03
(N) x (K)				3.11			NS			NS			NS
(N) x (PM)				NS			2.09			0.03			0.02
(K) x ((PM)				2.99			1.63			0.01			0.02
(N)x (K)x((PM)				5.23			NS			0.01			0.01

Results in Table 4 showed that increasing nitrogen fertilization levels from 180 to 210 led to a significant increase in the single stalk weight and a number of millable canes/fed amounted to (0.04 and 0.07 kg/plant) and (0.39 and.0.81 thousand canes/fed), respectively in the 1st season, corresponding to (0.04 and 0.09 kg) and (0.52 and 0.84 thousand canes/fed), in the 2nd one, successively as compared with those recorded when sugarcane was given 150 kg N/fed. These results may be due to the role of nitrogen in promoting tillering, canopy development and the stalk formation. These results are in line with those reported by Nassar *et al.*, (2005), Ahmed and El-Shafai (2007), Mokadem *et al.*, (2008), El-Gedawwy *et al*., (2012) and Bekheet and Abd El-Aziz (2016). Supplying sugarcane with 48 kg K_2O/fed gave the highest stalk weight and a number of millable canes/fed in both seasons. These results may be due to the vital role of potassium in dry matter translocation from leaves to be stored in stalks and hence improving their weights. These results are similar to those obtained by El-Sogheir *et al.,* (2003), Osman *et al*., (2004), El-Sayed *et al*., (2005) and Abd-El-Kader (2017).

The interaction of N x K had a significant influence on stalk weight in the 2nd season and the number of millable canes/fed in the 1st one. The heaviest stalks and the greatest number of millable canes/fed resulted from sugarcane plants fertilized with 210 kg N/fed + 48 kg K_2O/fed. The interaction between levels of nitrogen fertilizer and press mud had a significant effect on stalk weight in both seasons, while the number of millable canes/fed was influenced by the same interaction in the 2nd season.

Stalk weight has significantly affected the interaction between K and PM in both seasons. The highest mean value of stalk weight by adding 48 kg K_2O potassium with 4 tons of press mud /fed, in both seasons. The number of millable cane/fed was significantly affected by an interaction between K and PM in the 1st season. The highest number of millable canes/fed was recorded by applying 48 kg K_2O and 4 tons of press mud/fed. The 2nd order interaction among

Table 4. Effect of press mud, nitrogen, potassium levels and their interactions on millabe cane number (thousand/fed) and stalk weight (kg/stalk) 2017/2018 and 2018/2019 seasons

Traits		Millable cane number/fed (thousand)						Millable cane weight (kg)					
Press mud/fed, ton (PM)	N level (kg /fed)	2017/2018 season			2018/2019 season			2017/2018 season			2018/2019 season		
		K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean
		24	48		24	48		24	48		24	48	
0	150	40.19	40.13	40.16	39.76	40.18	39.97	1.17	1.20	1.19	1.16	1.18	1.17
	180	40.26	40.62	40.44	40.39	40.81	40.60	1.22	1.23	1.23	1.21	1.22	1.22
	210	40.69	41.00	40.85	40.73	41.03	40.88	1.25	1.26	1.26	1.25	1.25	1.25
Mean		40.38	40.60	40.49	40.44	40.68	40.56	1.21	1.23	1.22	1.21	1.22	1.21
2	150	40.66	40.84	40.75	40.55	40.86	40.71	1.20	1.21	1.21	1.19	1.21	1.20
	180	41.88	41.92	41.90	40.94	41.42	41.18	1.25	1.28	1.27	1.22	1.25	1.24
	210	42.33	42.71	42.52	41.31	41.64	41.48	1.33	1.35	1.34	1.34	1.36	1.35
Mean		41.62	41.76	41.69	40.93	41.31	41.12	1.26	1.28	1.27	1.25	1.27	1.26
4	150	41.92	41.83	41.88	40.97	41.52	41.25	1.23	1.25	1.24	1.20	1.24	1.22
	180	42.42	42.91	42.67	41.46	42.94	42.20	1.26	1.30	1.28	1.23	1.28	1.26
	210	42.91	42.21	42.56	41.92	43.26	42.59	1.41	1.38	1.40	1.39	1.41	1.40
Mean		42.42	42.32	42.37	41.45	42.57	42.01	1.30	1.31	1.31	1.27	1.31	1.29
Mean of (N×K)	150	40.92	40.89	40.91	40.43	40.85	40.64	1.20	1.22	1.21	1.18	1.21	1.20
	180	41.52	41.82	41.67	40.93	41.72	41.33	1.24	1.27	1.26	1.22	1.25	1.24
	210	41.98	41.97	41.98	41.32	41.98	41.65	1.33	1.33	1.33	1.33	1.34	1.33
Mean of K		41.47	41.56		40.94	41.52		1.26	1.27		1.24	1.27	
LSD at 0.5 level for:													
Nitrogen levels (N)				0.053			0.073			0.003			0.003
Potassium levels (K)				0.064			0.039			0.003			0.001
Press mud (PM)				0.98			0.032			0.003			0.002
(N) x (K)				0.105			NS			NS			0.001
(N) x (PM)				NS			0.065			0.004			0.004
(K) x ((PM)				0.138			NS			0.003			0.002
(N)x (K)x((PM)				NS			NS			0.004			0.005

the three studied factors had a significant influence on millable weight in both seasons. Fertilizing sugar cane with 210 kg N 48 kg K_2O 4 tons of press mud/fed gave the highest stalk weight in both seasons.

Juice quality traits:

Data in Tables 5 and 6 cleared that increasing level of press mud supplied to sugarcanes from 2 up to 4 tons/fed increased brix, sucrose and sugar recovery percentages significantly by (0.59 and 1.00%), (0.46 and 0.77%) and (0.32 and 0.53%) compared to those recorded by canes left without press mud, respectively, in the 1st season, corresponding to (0.56 and 0.87), (0.35 and 0.66%) and (0.21 and 0.45%) in the 2nd season. These findings may be attributed to that press mud is a good source of organic matter, NPK and important micronutrients (Table 2). Moreover, it may contribute to improving fertility, productivity and other physical properties of agricultural soils, which positively reflected on the previous quality characteristics. These results are in line with those reported by Pakkiyappan and Saminathan (1999), Kumar and Verma (2002) and Abd- El-Kader (2017). However, purity % was not significantly affected by the levels of press mud, in both seasons.

The results showed that nitrogen levels had a significant effect on juice quality traits under study, in both seasons except purity% in the 2nd season. Gradual increases in brix, sucrose and sugar recovery percentages values were noticed as nitrogen rate increased from 150 up to 210 kg N/fed, thereafter tended to decrease as nitrogen fertilization level was raised to 210 kg N/fed. Similar results were observed by Nassar *et al.*, (2005), Mokadem *et al*., (2008), El-Geddawy *et al*., (2012) and Neana and Abd El-Hak (2014).

The results in the same Tables showed that increasing the level of potassium from 24 to 48 kg K_2O/fed caused a significant increase in the brix, sucrose and sugar recovery percentages in both seasons, and purity % in the first one. However, increasing K fertilizer level given to sugarcane from 24 to 48 kg/fed decreased purity percentage. These results are in agreement with those mentioned by El-Sogheir *et al.*, (2003), Osman *et al*. (2004), El-Sayed *et al*., (2005) and Abd-El-Kader (2017).

The interaction between nitrogen fertilization level and press mud significantly affected brix and sucrose percentages in both seasons as well as purity and sugar recovery percentages in the 1st one. Brix and sucrose percentages were significantly affected by the interaction between levels of potassium and press mud in both seasons, while purity and sugar recovery percentages were significantly influenced by the respective interaction in the 1st season only.

Table 5. Effect of press mud, nitrogen, potassium levels and their interactions on brix and sucrose percentages in 2017/2018 and 2018/2019 seasons

Traits		Brix %						Sucrose%					
Press mud/fed, ton (PM)	N level (kg /fed)	2017/2018 season			2018/2019 season			2017/2018 season			2018/2019 season		
		K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean
		24	48		24	48		24	48		24	48	
0	150	17.18	17.45	17.32	17.54	17.84	17.69	14.13	14.33	14.23	14.54	14.79	14.67
	180	17.40	18.77	18.09	18.73	18.91	18.82	14.54	15.45	15.00	15.56	15.66	15.61
	210	18.78	19.06	18.92	19.11	19.37	19.24	15.49	15.87	15.68	15.89	16.11	16.00
Mean		17.79	18.34	18.06	18.34	18.49	18.41	14.72	15.22	14.97	15.33	15.52	15.43
2	150	18.48	18.86	18.67	18.60	18.86	18.73	15.39	15.75	15.57	15.40	15.69	15.55
	180	18.88	19.08	18.98	19.03	19.17	19.10	15.48	15.87	15.68	15.75	15.94	15.85
	210	19.40	19.80	19.60	19.46	19.88	19.67	16.18	16.47	16.33	15.88	16.50	16.19
Mean		18.92	19.12	19.02	19.03	19.30	19.17	15.68	16.03	15.86	15.68	16.04	15.86
4	150	18.86	19.09	18.98	18.86	19.14	19.00	15.69	15.91	15.80	15.74	15.80	15.77
	180	19.25	19.38	19.32	19.37	19.55	19.46	16.06	16.16	16.11	16.13	16.16	16.15
	210	19.89	20.09	19.99	19.91	20.06	19.99	16.40	16.71	16.56	16.51	16.69	16.60
Mean		19.33	19.52	19.43	19.38	19.58	19.48	16.05	16.26	16.16	16.13	16.22	16.17
Mean of (N×K)	150	18.17	18.25	18.21	18.33	18.61	18.47	15.07	15.33	15.20	15.23	15.43	15.33
	180	18.51	19.08	18.79	19.04	19.21	19.13	15.36	15.83	15.59	15.81	15.92	15.87
	210	19.36	19.65	19.50	19.49	19.77	19.63	16.02	16.35	16.19	16.09	16.43	16.26
Mean of K		18.68	18.99		18.92	19.12		15.48	15.84		15.71	15.93	
LSD at 0.5 level for:													
Nitrogen levels (N)				009			0.02			0.1			0.13
Potassium levels (K)				0.03			0.03*			0.03			0.12
Press mud (PM)				0.02			0.05			0.04			0.10
(N) x (K)				0.05			0.07			NS			NS
(N) x (PM)				0.06			0.05			0.05			0.17
(K) x ((PM)				0.04			0.06			0.06			0.16
(N)x (K)x((PM)				0.11			0.08			0.07			0.23

Table 6. Effect of press mud, nitrogen, potassium levels and their interactions on purity and sugar recovery percentages in 2017/2018 and 2018/2019 seasons

Traits		Purity%						Sugar recovery%					
Press mud/fed, ton (PM)	N level (kg /fed)	2017/2018 season			2018/2019 season			2017/2018 season			2018/2019 season		
		K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean	K level (kg /fed)		Mean
		24	48		24	48		24	48		24	48	
0	150	82.25	82.12	82.19	82.90	82.90	82.90	10.15	10.35	10.25	9.77	10.21	9.99
	180	83.56	82.31	82.94	83.08	82.81	82.95	10.22	10.29	10.26	10.47	10.50	10.49
	210	82.48	83.26	82.87	83.15	83.17	83.16	10.36	10.70	10.53	10.69	10.85	10.77
Mean		82.76	82.61	82.69	82.83	82.74	82.79	10.24	10.45	10.35	10.31	10.52	10.42
2	150	83.28	83.51	83.40	82.80	83.19	83.00	10.38	10.66	10.52	10.33	10.56	10.45
	180	81.99	83.18	82.59	82.76	83.15	82.96	10.27	10.69	10.48	10.56	10.72	10.64
	210	83.40	83.18	83.29	81.60	83.00	82.30	10.93	11.10	11.02	10.50	11.10	10.80
Mean		82.89	83.21	83.05	82.39	83.11	82.75	10.53	10.82	10.67	10.46	10.79	10.63
4	150	83.19	83.34	83.27	83.46	82.55	83.01	10.57	10.74	10.66	10.64	10.57	10.61
	180	83.43	83.38	83.41	83.27	82.66	82.97	10.85	10.91	10.88	10.88	10.82	10.85
	210	82.45	83.18	82.82	82.92	83.20	83.06	10.94	11.26	11.10	11.09	11.25	11.17
Mean		83.02	83.30	83.16	83.22	82.80	83.01	10.79	10.97	10.88	10.87	10.88	10.88
Mean of (N×K)		83.48	83.53	83.51	83.05	82.74	82.90	10.37	10.58	10.48	10.25	10.45	10.35
		82.75	82.96	82.86	83.04	82.87	82.96	10.45	10.63	10.54	10.64	10.68	10.66
		82.78	83.21	83.00	82.56	83.12	82.84	10.74	11.02	10.88	10.76	11.07	10.92
Mean of K		82.89	83.04		82.81	82.89		10.52	10.74		10.55	10.73	
Interactions LSD at 0.5 level for:													
Nitrogen levels (N)				0.14			NS			0.06			0.16
Potassium levels (K)				0.11			NS			0.03			0.13
Press mud (PM)				NS			NS			0.03			0.12
(N) x (K)				0.18			NS			NS			NS
(N) x (PM)				0.20			NS			0.04			NS
(K) x ((PM)				0.19			NS			0.06			NS
(N)x (K)x((PM)				0.29			1.17			0.07			NS

Cane and sugar yields:

The results in Table 7 revealed that increasing level of press mud supplied to sugarcane from 2 up to 4 tons/fed increased cane and sugar yields/fed significantly by (2.07 and 3.71tons/fed) and (0.36 and 0.63 tons/fed), compared to those recorded without press mud, respectively, in the 1st season, corresponding to (1.8 and 3.34 tons/fed) and (0.28 and 0.57 tons/fed), in the 2nd one. These results could be referred to as the increase in the single stalk weight and a number of millable canes (Table 4) and juice quality characteristics as sucrose % (Table 5), purity % and sugar recovery% (Table 6) as affected by the applied press mud. These results are in agreement with those obtained by Pakkiyappan and Saminathan (1999), Kumar and Verma (2002), Babu *et al*., (2005), Shankaraiah and Murthy (2005), Santos *et al.*, (2010), and Abd-El-Kader (2017).

The results in Table 7 pointed out that cane and sugar yields /fed were increased significantly by raising nitrogen fertilization level from 180 and to 210 kg N/fed by (2.41 and 4.21 tons/fed) and (0.25 and 0.62 tons/fed) in the 1st season, corresponding to (1.95 and 4.35 tons/fed) and (0.36 and 0.75 tons/fed) in the 2nd one, compared to those produced by supplying canes with 150 kg N/fed. These results are probably referred to a positive effect of raising N-levels given to sugarcane on growth traits, in respect to the single stalk weight and a number of millable canes (Table 4) and juice quality characteristics as sucrose % (Table 5), purity % and sugar recovery% (Table 6). These results are in agreement with those reported by Santos *et al.*, (2014), Girma Abejehu (2015), Ahmed and El-Shafai (2007), Mokadem *et al*., (2008), EL-Gedawwy *et al*., (2012) Neana and Abd El-Hak (2014) and Bekheet and Abd El-Aziz (2016).

Data in the same table showed that cane and sugar yields were significantly affected by potassium application levels. The results cleared that applying 48 kg K_2O/fed produced the highest cane and sugar yields /fed, where increases of (51.12 and 50.86 tons/fed) and (5.53 and 5.48 tons/fed) in the 1st and 2nd season were gained, respectively compared to canes given 24 kg K_2O/fed. These results are in line with those reported by El-Sogheir *et al*. (2003), Osman *et al.*, (2004), Santos *et al*., (2010) and Santos *et al*., (2014).

In the same table, the interaction of N x K had a significant influence on cane yield /fed in the 2nd season and sugar yield/fed in the 1st one. The highest cane and sugar yields were produced when obtained by applying 210 kg N/fed and 48kg K_2O/fed. Cane and sugar yields were significantly affected by the interaction between N and press mud levels in both seasons. The highest yields of cane and sugar /fed were produced when 210 kg N with 4 tons of press mud/fed were added. The interaction between potassium and press mud had a significant effect on cane yield/fed in the 2nd season. The highest yield of cane has been obtained with the addition of 24 kg K_2O and 4 tons of press mud/fed. The 2nd order interaction among the three studied factors had a significant effect on cane and sugar yields/fed in both seasons. Fertilization of sugar cane with 210 kg N + 48 kg K_2O + 4 tons of press mud/fed gave the highest cane and sugar yields in the 1st and 2nd seasons.

Phenotypic correlations among yield and their traits:

Data in Table 8 showed that stalk height and diameter gave a positive and highly significant correlation with stalk diameter, cane yield (ton/fed), and sugar yield (ton/fed). Meanwhile, they gave a positive and non-significant correlation with the number of stalks and purity percentage. A positive association of cane length and diameter with cane yield has been reported by several investigators (Chaudhary *et al.*, 2003, Singh and Sharma, 1997). A number of stalks showed positive and significant phenotypic correlations with each of cane yield and sugar yield.

Table 7 .Effect of press mud, nitrogen, potassium levels and their interactions on cane and sugar yields/fed in 2017/2018 and 2018/2019 seasons

Traits		Cane yield ton /fed						Sugar yield ton/fed					
Press mud/fed, ton (PM)	N level (kg /fed)	2017/2018 season K level (kg /fed)		Mean	2018/2019 season K level (kg /fed)		Mean	2017/2018 season K level (kg /fed)		Mean	2018/2019 season K level (kg /fed)		Mean
		24	48		24	48		24	48		24	48	
0	150	46.03	47.65	46.84	45.67	47.26	46.47	4.67	4.93	4.80	4.46	4.83	4.64
	180	48.79	49.83	49.31	48.56	49.41	48.98	4.99	5.13	5.06	5.08	5.19	5.14
	210	50.63	51.55	51.09	50.42	51.13	50.77	5.25	5.52	5.38	5.39	5.55	5.47
Mean		48.48	49.14	48.81	48.34	48.86	48.59	4.97	5.19	5.08	4.98	5.19	5.08
2	150	48.69	49.30	48.99	47.84	48.60	48.22	5.05	5.26	5.15	4.94	5.13	5.03
	180	50.60	51.71	51.16	49.62	50.75	50.19	5.20	5.53	5.36	5.24	5.44	5.34
	210	52.31	53.27	52.79	51.88	53.65	52.77	5.72	5.91	5.82	5.45	5.96	5.70
Mean		50.53	51.22	50.88	49.78	51.00	50.39	5.32	5.57	5.44	5.21	5.51	5.36
4	150	50.19	51.57	50.88	49.06	51.07	50.07	5.31	5.54	5.42	5.22	5.40	5.31
	180	51.76	52.92	52.34	50.74	52.14	51.44	5.62	5.77	5.69	5.52	5.64	5.58
	210	54.14	54.53	54.33	53.61	54.93	54.27	5.92	6.14	6.03	5.95	6.18	6.06
Mean		52.03	53.01	52.52	51.14	52.71	51.93	5.62	5.82	5.71	5.56	5.74	5.65
Mean of (N×K)	150	48.30	48.76	48.53	47.52	48.98	48.25	5.01	5.24	5.12	4.87	5.12	4.99
	180	50.38	51.49	50.94	49.64	50.77	50.20	5.27	5.48	5.37	5.28	5.42	5.35
	210	52.36	53.12	52.74	51.97	53.24	52.60	5.63	5.86	5.74	5.60	5.90	5.74
Mean of K		50.35	51.12		49.75	50.86		5.30	5.53		5.25	5.48	
Interactions LSD at 0.5 level for:													
Nitrogen levels (N)				0.17			0.24			0.043			0.118
Potassium levels (K)				0.16			0.069			0.031*			0.078*
Press mud (PM)				0.12			0.10			0.024			0.074
(N) x (K)				NS			0.12			0.055			NS
(N) x (PM)				0.19			0.18			0.042			0.127
(K) x ((PM)				NS			0.15			NS			NS
(N)x (K)x((PM)				0.29			0.21			0.059			0.180

Table 8. Phenotypic correlation coefficients among the yield and its components of sugar cane variety during two seasons

Traits	1	2	3	4	5	6	7	8	9
1.Stalk Length	1								
2. Stalk diameter	0.972**	1							
3.Number of stalks	0.722	0.446	1						
4. Stalk weight	0.951**	0.955**	0.561	1					
5. Brix%	0.744*	0.960*	0.778*	0.880**	1				
6. Sucrose%	0.889**	0.915*	0.833*	0.856**	0.944**	1			
7. Purity%	0.013	0.008	0.167	- 0.028	0.156	0.112	1		
8. Sugar recovery%	0.889*	0.715*	0.833*	0.873**	0.944**	0.974**	0.123	1	
9. Cane yield	0.954**	0.972**	0.722**	0.986**	0.944**	0.889**	0.009	0.889**	1
10. Sugar yield	0.833**	0.857**	0.889**	0.817**	0.889**	0.944**	0.167	0.933**	0.833**

*, ** Significant at 5% and 1% probability levels, respectively.

On the other hand, the number of stalks had a positive and non-significant correlation with stalk weight and purity percentage. Masri *et al.,* (2015) found that a number of millable canes had negative correlations with all the other traits except cane yield. A strong negative correlation between cane weight and purity percentage was recorded. Cane yield (ton/fed) had a positive and highly significant correlation with sugar yield. However, such correlations were positive and insignificant with purity %. Results are in agreement with those mentioned by Sanghera *et al.,* (2015), they reported that cane yield correlated positivity with morphological and cane characters. The cane yield, considered as the most important character of sugarcane, had a positive correlation with sucrose%, (Masri *et al.,* 2015). Abu-Ellail *et al.,* (2017) found that sucrose content in the juice was positively and significantly associated with sugar recovery percentage and sugar yield.

CONCUSION

Under conditions of the present work, supplying sugarcane with 4 tons of press mud/fed, added to the soil through seed-bed preparation, combined with 210 kg nitrogen (as urea) and 48 kg K_2O (as potassium sulfate) can be recommended to get the highest cane and sugar yields/fed. The correlation analysis showed that the stalk diameter, number of stalks per meter, and weight of the cane contributed most to cane yield at the harvest.

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الملخص العربي

الإرتباطات المظهرية وتكامُل التسميد النيتروجيني والبوتاسى وطينة المُرشِحات وعلاقته بحاصل وجودة قصب السكر

أنور حامد ساسي و فرّاج فرغل برعى أبوالليل

أجريت هذه الدراسة فى محطة بحوث ملوى بمحافظة المنيا (دائرة عرض ٢٨,١٠درجة شمالاً وخط الطول ٣٠,٧٥درجة شرقاً وإرتفاع ٤٩ متر عن مستوى سطح البحر) خلال موسمى الزراعة ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ لدراسة تأثير التسميد بطينة المرشحات كسماد عضوى، و النيتروجين والبوتاسيوم غير العضوى علي انتاجية وجودة الصنف جيزة ٤٧- ٢٠٠٣ (المسمى تجاريا جيزة ٣) من قصب السكر. تم تصميم التجربة بنظام القطع كاملة العشوائية فى توزيع القطع المنشقة مرتين في ثلاث مكررات خلال موسمى الزراعة، حيث أُضيفت كميات طينة المرشحات (بدون ، ٢ و ٤ طن/فدان) فى القطع الرئيسية، ووزعت مستويات السماد النيتروجينى (١٥٠، ١٨٠ و ٢١٠ كجم ن / فدان) فى القطع الشقية الأولى ، وشغل مستويى البوتاسيوم (٢٤ و ٤٨ كجم بو٢أ / فدان) القطع الشقية الثانية.

- أعطى استخدام المخصب العضوى (طينة المرشحات) زيادة معنوية في طول وقطر النبات وعدد العيدان ووزن العود وحاصلى العيدان والسكر بالفدان، وكذلك نسبة البركس والسكروز وناتج السكر النظرى فى كلا الموسمين.
- أوضحت النتائج المتحصل عليها أن زيادة التسميد النيتروجينى من ١٥٠ إلى ٢١٠ كجم/ للفدان أدت إلى زيادة معنوية فى وقطر ووزن عيدان القصب وحاصلى العيدان والسكر بالفدان وكذلك النسبة المئوية لكلٍ من البركس والسكروز والنقاوة وناتج السكر النظرى في كلا الموسمين .
- أدت إضافة البوتاسيوم بمعدل ٤٨ كجم/ للفدان لزيادة معنوية في طول وقطر وعدد عيدان القصب وحاصلى الفدان من العيدان والسكر وأيضاً النسبة المئوية للبركس والسكروز وناتج السكر النظرى في كلا الموسمين.

تحت ظروف هذه الدراسة، يمكن التوصية بتسميد قصب السكر بإضافة طينة المرشحات أثناء تجهيز التربة للزراعة بمعدل ٤ طن/فدان، والتسميد بالنيتروجين بمعدل ٢١٠ كجم/ فدان و التسميد البوتاسي بمعدل ٤٨ كجم بو٢أ /فدان للحصول على أعلي إنتاجية من العيدان والسكر للفدان. أظهر تحليل الارتباط أن قطر العود وعدد السيقان للمتر ووزن العود ساهم بشكل كبير في إنتاجية محصول العيدان.