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Evaluation of the Productivity of Two Soils Using Productivity Index

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CORN productivity data is needed to sustain the farm production. This research was conducted to evaluate soil productivity of two different soil texture, clay loam ($soil_1$) and loam ($soil_2$) using three productivity index models (PI_1, PI_2 and PI_M). Five soil properties were chosen to calculate the productivity index for the model PI_1 namely, soil available water, soil bulk density, pH, EC, and root depth. Two more parameters, clay content and organic matter, were included in the original PI_1 model to calculate PI_2. The calculation of PI_M index was depending on different irrigation treatments; *i.e.* 50%, 70%, 80% and 100% of available soil moisture and on crop evapotranspiration besides the soil properties used in the original PI_1 model. Obtained results showed that the estimated values of PI_1 were 0.57 and 0.52, whereas, for PI_2 were 0.28 and 0.22 for $soil_1$ and $soil_2$, respectively. On the other hand, values of PI_M increased as soil moisture increased. The highest PI_M (0.46 and 0.45) were obtained with 80% irrigation treatment, whereas, the lowest PI_M (0.34 and 0.33) were obtained with 50% irrigation treatment of $soil_1$ and $soil_2$, respectively. The results revealed that $soil_1$ has higher productivity potential than $soil_2$, where the calculated values of PI_1, PI_2 and PI_M were higher for $soil_1$ than for $soil_2$. When comparing the calculated values of PI_1, PI_2 and PI_M with the relative values of soil productivity, the PI_1 values showed that both soils are very high productive soils. Whereas, PI_2 showed that both soils have moderate productivity. In contrast, the PI_M values under all irrigation treatments indicated that both soils have high soil productivity. The higher and lower corn yields corresponded to higher and lower productivity indices values, respectively in both soils. A highly significant correlation between seed yield and PI_M (R^2 = 0.97) was obtained. Whereas, the relationship between seed yield and actual evapotranspiration explained about 84% of the variation in corn yield (R^2 =0.84). These results concluded that PI_1 and PI_M models were effective in quantifying soil productivity and seem to be good prediction models of corn yield.

Keywords: Productivity index, Models, Corn yield, Irrigation regimes, Soil properties.

Soil productivity is the capacity of a soil to produce a certain amount of crop per hectare per annum, Riquier *et al.* (1970). In most parts of agriculture land of Egypt, the information on productive potential of different soils is not enough. It is very important to assess the soil productivity through simple and effective method based on available data. Milner *et al.* (1996) mentioned that methods of predicting soil productivity have been a topic of much heated discussion since the early 1990s. Accurate estimates of future soil productivity are essential in making agricultural decisions. Brady and Weil (1999) reported that productivity emphasizes the capacity of soil to produce crops and should be expressed in terms of yield. Milner *et al.* (1996) also indicated that to assess soil productivity, soil information must be used. Nwite and Nandobi (2008) stated that using productivity index model in assessing the relative productive potential of soils enables periodic evaluation of the productivity of these soils.

The productivity can be quantified as a mathematical function of a soils ability to sufficiently sustain plant. Neill (1979) introduced the productivity index (PI) model, which is a derived measure of soil productivity. Its basic assumption according to Pierce *et al.* (1983) is that crop yield is a function of root development, which in turn is controlled by the soil environment. De wit and Van Kuelen (1987) indicated that simulation models enabled quantitative estimates of the growth and production of the main agricultural crops in many soils. Productivity indices (PI) provide a single scale on which soils may be rated according to their suitability for crop production (Imoro *et al*.,2012).

The PI model used an integrated approach to describe the relationship between plant productivity and soil properties on optimum vertical root distribution (Kiniry *et al.,* 1983). The properties of soil within the rooting zone are major factors constraining crop growth and yield, (Gantzer & McCarty, 1987 and Lindstrom *et al.,* 1992). In the PI model sufficiencies are assigned to soil properties. The original PI contained sufficiencies for potential available water capacity, bulk density, PH and electrical conductivity (Neill, 1979 and Delgado & Lopez, 1998).

Mc Cormack *et al.* (1982) indicated that the production capacity of a soil depends on available water capacity, soil tilth, plant nutrient storage, soil organic carbon and rooting depth. The PI was also modified adding clay content and organic matter content in parameters (Xingwu *et al.,* 2009).

Garcia-Paredes *et al.* (2000) indicated that the sufficiency of PI model is effective in predicting productivity of agronomic crops. The sufficiency of a particular soil factor was based on a response curve relating the measured value for the factor to a dimensionless sufficiency between 0.0 and 1.0 (Pierce *et al*., 1983).

One of the most important factors in agriculture is water availability. Rhoads and Bennett (1990) indicated that soil moisture is an extremely important factor in determining soil productivity as excessive water can reduce corn yield as well as water deficits. Stocking & Pain (1983) and Timlin *et al.* (1986) introduced the water budget model using the equation developed by Doorenbos and Kassam (1979), to link evapotranspiration with soil productivity. Yang *et al.* (2003) found that productivity index (PI) tends to predict crop yields better for dry than wet years. Thus, soil water dynamics must be incorporated into the PI models to improve their predictive ability.

Kiniry *et al.* (1983) reported that the modified soil productivity index model is a hybrid of the productivity index (PI) and the models simulating soil moisture availability to plants and yield relationships. Modification should be made based on the soil properties and the relationships between different physicochemical properties of the study area (Gale *et al*., 1991 and Uadawatta & Henderson, 2003). Establishing an appropriate and accurate soil productivity assessment model is very important. The objectives of this study was to evaluate and compare the productivity of two soils using three productivity index models, introduced by Pierce *et al*. (1983) and Stocking & Pain (1983) and to demonstrate the relationship between productivity index models and yield of corn.

Material and Method

A study was carried out at the Agriculture Experiment Station, Faculty of Agriculture, Cairo University during the 2013 season using corn (*zea mays* L.) as an indicator crop . The experiment was laid out in a randomized complete block design with three replications. Plot area was 3.5 × 20.0 m. Soil samples were collected from three depths (0-20, 20-40 and 40-60cm) of the experimental soil to analyze the physical and chemical soil properties required for evaluating productivity models. Particle size distribution, bulk density and available water capacity were determined according to Klute (1986). The EC and the pH were measured according to Page *et al.* (1982). Mineral fertilizers (NPK) and the agricultural practices to all plots were applied according to recommendation of the Ministry of Agriculture. For the determination of PI_M model, four irrigation treatments were applied 100%, 80%, 70% and 50% of soil available water. The irrigation application was calculated based on the average initial soil moisture content of the experimental area. Treatments were isolated by ditches of 2.0 m in width to avoid lateral movement of water. Soil samples were taken before and 48hr after each irrigation with auger to determine soil moisture content and calculating irrigation amounts to a depth of 60cm. Actual evapotranspiration was calculated accordingly (Hansen *et al*., 1979) using the following equation:

$$ETa = ((\theta_2 - \theta_1) /100) \times D$$

where, ETa is the actual evapotranspiration, mm/day. The θ_2 and θ_1 are the volumetric soil moisture content after and before irrigation and D is soil depth, mm. Corn single cross 101 was planted on June 5th using a spacing of 25 cm and 75 cm within and between rows, respectively.

At harvest, 120 days after planting, representative samples of corn plants were collected from each treatment to study total seed yield (Kg/fed.).

Relationships between productivity index and seed yield of corn were determined using multiple regression analysis according to Steel and Torrie (1980).

The productivity index models

Productivity index model (PI_1)

The productivity index (PI_1) introduced by Pierce *et al.* (1983) was expressed as follows:

$$PI_1 = \sum_{i=1}^{n}(A_i * C_i * D_i * E_i * RI_i)$$

where:

PI_1 is productivity index.

A_i is sufficiency of soil available water in the i th layer,

C_i is sufficiency of soil bulk density in the i th layer,

D_i is sufficiency of soil pH of the i th layer,

E_i is sufficiency of soil electrical conductivity in th i the layer,

RI_i is root weighting factor of the i th soil layer

n is the number of soil layers of the root zone depth.

Productivity index (PI_2)

The productivity index (PI_2) was a modification of PI_1 by adding clay content (CLi) and organic matter (OMi). Therefore, the parameters of the model included AWC, Bd, PH, EC, OM, CL and RI. The modified PI model (PI_2) was as follows:

$$\mathbf{PI_2} = \sum_{i=1}^{n}(A_i * C_i * D_i * E_i * Oi * CLi * RI_i)$$

where:

Oi the sufficiency of OM in the *i*th layer;

CLi the sufficiency of clay content in the *i*th layer and other terms have the same meaning as in PI_1

Modified productivity index (PI_M)

The modified productivity index ($PI_\mathbf{M}$) introduced by Stocking and Pain, (1983) was applied using Bd, pH , EC , root weighting factor and actual and potential evapotranspiration values of the different irrigation treatments, by removing parameter A_i from the PI_1 model and combining these parameters with the equation developed by Doorenbos and Kassam (1979). The $PI_\mathbf{M}$ equation is expressed as follows:

$$PI_M = \left(1 - K_y\left(1 - \frac{ETa}{ETm}\right)\right)\sum_{i=1}^{n}(C_i * D_i * E_i * RI_i)$$

where:

K_y is empirical yield response factor.

ETa is actual crop evapotranspiration.

ETm is potential evapotranspiration.

and other terms have the same meaning as in PI_1

Sufficiency for studied soil properties

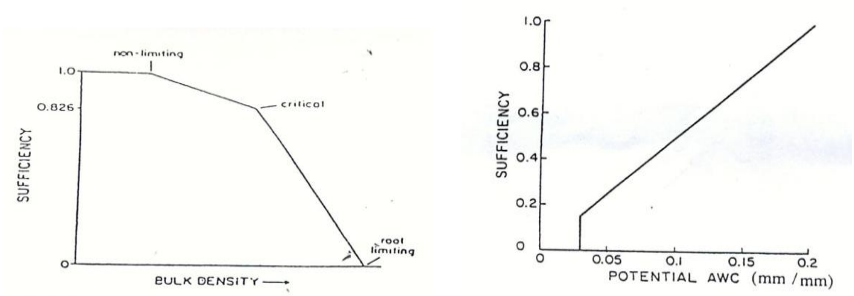
The sufficiencies for available water capacity (A_i), bulk density (C_i), pH (D_i) and root weighting factor (RI_i) were determined according to Pierce *et al.* (1983). The A_i sufficiency was determined using Fig. (1b). The determination of bulk density C_i sufficiency, one has to obtain no limiting, critical and root limiting bulk densities which depend on soil texture classes given in Table 1 and then determine bulk density sufficiency value on the X-axis of Fig. (1a), the sufficiency value is then adjusted to take into account permeability rates by equation:

$$C_i = 1 - (1 - suff_g) * \beta,$$

where: $suff_g$ is sufficiency of bulk density obtained from Fig. (1a) and β is adjustment factor obtained from Table 2.

TABLE 1. Non limiting, critical and root-limiting bulk densities (Bd) for different texture classes (Pierce *et al*., 1983).

Family texture class	Non limiting Bd ($g.cm^{-3}$)	Critical Bd ($g.cm^{-3}$)	Root limiting Bd ($g.cm^{-3}$)
Sandy	1.60	1.69	1.85
Coarse loamy	1.50	1.63	1.80
Fine loamy	1.46	1.67	1.78
Coarse silt	1.43	1.67	1.79
Fine Silt	1.34	1.54	1.65
Clayey			
35-45%	1.40	1.49	1.58
	1.30	1.39	1.47



(a) (b)

Fig. 1. Sufficiency of bulk density (a) and available water capacity (B) (Pierce *et al.*, 1983).

TABLE 2. Adjustment factors (β) for sufficiency of bulk density (Pierce *et al*., 1983).

Family texture class	Permeability (mm/h)				
	< 1.5	1.5-5.1	5.1-15.2	15.2-50.8	>50.8
Fine loamy	1.0	1.0	0.9	0.7	0.5
Coarse silt	1.0	1.0	1.0	0.9	0.7
Fine silt	1.0	1.0	0.9	0.7	0.5
Clay 35-60%	1.0	0.9	0.7	0.6	0.5

The pH sufficiency D_i is determined using the following equations.

$$D_i = \begin{cases} 0.75 & \text{for pH} > 8.0 \\ 2.086 - 0.167\,\text{pH} & \text{" } 6.5 < \text{pH} \leq 8.0 \\ 1.0 & \text{" } 5.0 < \text{pH} \leq 6.5 \\ 0.12 + 0.16\,\text{pH} & \text{" pH} = 5.0 \text{ to } 5.5 \\ 0.44\,\text{pH} - 1.31 & \text{" pH} = 2.9 \text{ to } 5.0 \end{cases}$$

The sufficiency of electrical conductivity, E_i , is determined using the following equation (Kiniry *et al*., 1983): E_i = 1.14 – 0.07 EC. where, EC is electrical conductivity (dS/m).

The sufficiency of weighting factor RI_i is equal to 1.0 because weighting factor expresses an ideal corn root distribution to 100 cm depth therefore; it is normalized to 1.0 (Pierce *et al*., 1983).

The sufficiency of clay content *CLi* (%) at the ith soil layer is according to Wan *et al*. (2001), as follows:

$$CLi = \begin{cases} 1 \ldots\ldots\ldots\ldots & 20 \leq clay_i \leq 40 \\ clay_i/20 \ldots\ldots\ldots & 0 < clay_i < 20 \\ \dfrac{100 - clay_i}{60} \ldots\ldots & 40 < clay_i < 100 \\ 0 \ldots\ldots\ldots\ldots & clay_i = 0 \end{cases}$$

The sufficiency of OM*i* (%) at the ith soil layer is according to Wan *et al*. (2001) as follows:

$$OMi = \begin{cases} OMi/4 \ldots\ldots\ldots\ldots & 0\% \leq OMi < 4\% \\ 1 \ldots\ldots\ldots\ldots & 4\% \leq OMi \end{cases}$$

Result and Discussions

Soil properties of the studied soils

The physicochemical properties of the studied soils (Table 3) were used to quantify the productivity of $soil_1$ and $soil_2$. Sufficiencies of these properties are given in Tables 4 & 5. The sufficiency for each depth was multiplied and summed to the number of depth increments (n) to estimate the PI_1, PI_2 and PI_M, where, a value of zero indicates an absolutely limiting level of a soil property and a value of 1.0 indicates the optimum level (Kiniry *et al*., 1983). Sufficiency values of available water capacity were generally high at all depths of the two soils. These values ranged between 0.98 – 1.0 for $soil_1$ and between 0.94 – 1.0 for $soil_2$. Gantzer & McCarty (1987) and Pierce *et al*. (1983) stated that values of AWC less than 0.2 m^3/m^3, were defined as the critical level for crop production in the PI. Consequently, AWC is considered a stress factor in the (0-20 and 40-60 cm layers) of the first soil and in (20-40 and 40-60 cm layers) of the second soil. Sufficiency values of bulk density consistently remained the same (0.7) in all depths of the two soils. This may be due to the non limiting Bd values and the moderate permeability of the two soils. The sufficiency values of clay content and EC indicated that these properties were not limiting factors in the studied PI models.

TABLE 3. Soil physicochemical properties of the studied soils.

Soil properties	**Soil depth**					
	Soil (1)			**Soil (2)**		
	0-20	20-40	40-60	0-20	20-40	40-60
Sand %	41.56	42.31	48.85	42.40	58.24	62.50
Silt %	31.10	29.42	29.76	35.39	22.60	21.19
Clay %	27.34	28.27	21.39	22.21	19.16	16.31
Texture	C.L.	C.L.	L.	L	S.L	S.L
AWC vol %	19.64	21.45	19.48	20.45	19.47	18.81
Bd $g.cm^{-3}$	1.16	1.26	1.30	1.29	1.31	1.42
OM%	2.14	1.87	1.81	1.94	1.89	1.69
pH	7.37	7.62	7.90	7.80	7.94	8.20
EC dS/m	1.54	1.71	1.45	2.35	1.84	1.72
RI (cm)	100	100	100	100	100	100

The sufficiency values of OM are obviously low and decreased with increasing soil depth. Therefore, OM is a stress factor in both soils. Also, the sufficiency values of pH did not indicate the optimum level as they ranged between 0.77 and 0.86 for $soil_1$ and between 0.75 and 0.78 for $soil_2$.

The productivity indices (PI_1&PI_2)

Values of the productivity indices (PI_1 and PI_2) are given in Table 4. The data showed that the mean value of PI_1 calculated for $soil_1$ was 0.57 whereas, for $soil_2$ was 0.52. The variation in PI_1 values is depending on the initial properties of each soil, within the root zone, which affect the sufficiency of each soil property. The lower PI_1 of $soil_2$ is due mainly to the lower efficiencies of OM, pH and AWC comparing with $soil_1$. The PI_2 values were, 0.28 and 0.22 for $soil_1$ and $soil_2$, respectively. The PI_1 values were obviously higher than those values of PI_2 . These results showed that when two more parameters, *i.e.* organic matter content (OM) and clay content (CL) were included in the model, the values of PI_2 decreased as compared with PI_1 values. Contribution of OM to the soil productivity is increasing with its content. The sufficiency of OM is Low therefore, restricted the soil productivity.

TABLE 4. Ascribed sufficiencies and calculated productivity indices of the studied soils.

Soil properties	Soil depth					
	Soil (1)			Soil (2)		
	0-20	20-40	40-60	0-20	20-40	40-60
AWC	0.98	1.00	0.97	1.00	0.97	0.94
Bd	0.70	0.70	0.70	0.70	0.70	0.70
CL	1.00	1.00	1.00	1.00	0.96	0.82
OM	0.54	0.47	0.45	0.49	0.47	0.42
PH	0.86	0.81	0.77	0.78	0.76	0.75
EC	1.00	1.00	1.00	0.98	1.00	1.00
RI	1.00	1.00	1.00	1.00	1.00	1.00
Calculated PI_1	0.59	0.57	0.54	0.54	0.52	0.49
Mean PI_1	0.57			0.52		
Calculated PI_2	0.32	0.27	0.24	0.26	0.23	0.17
Mean PI_2	0.28			0.22		

The results also showed that the mean PI_2 for $soil_1$ were higher than $soil_2$. High productivity index indicated soil with improved soil properties, therefore, $soil_1$ is more productive than $soil_2$.

The modified productivity index (PI_M)

The modified productivity index PI_M values are given in Table 5. The results showed that the variation in soil moisture content reflected on PI_M values. The PI_M increased as soil moisture increased. The PI_M values followed the order of irrigation treatments of 80% > 70%> 50%. Irrigation with 80% of available water corresponds to PI_M value of 0.46 and 0.45 whereas, irrigation with 50% of available water corresponding to, 0.34 and 0.33 for $soil_1$ and $soil_2$, respectively. These results concluded that PI_M increased as soil water depletion decreased.

TABLE 5. The reduction in relative yield, relative evapotranspiration and PI_M values of the two soils as affected by the different irrigation treatments.

Irrigation treat.	$Soil_1$				$Soil_2$			
	1-Ya/Ym	1-ETa/ETm	Ky	PI_M	1-Ya/Ym	1-ETa/ETm	Ky	PI_M
50%	0.40	0.35	1.14	0.34	0.37	0.33	1.12	0.33
70%	0.28	0.23	1.22	0.41	0.24	0.20	1.20	0.40
80%	0.19	0.15	1.27	0.46	0.15	0.12	1.25	0.45

Seed yield of corn and productivity indices

Seed yields of corn of the different irrigation treatments of both soils are shown in Fig. 2. Seed yield of corn increased and / or decreased with the productivity index values. The highest and the lowest seed yield of corn correspond to the highest and the lowest productivity index values, respectively. Higher productivity indices explained higher mean seed yield of corn. The productivity indices values decreased with the decrease in seed yield. These data suggest that differences in crop yield can be represented by productivity indices values. This finding agreed with Nwite (2002) and Anikwe (1999) who found that corn yield increased with the increase of PI and decreased with the decrease of it. The results concluded that as PI_1, PI_2 and PI_M values decreased a general decline in seed yield of corn is recorded. Corn yield recorded with $soil_1$ was higher than that recorded with $soil_2$.Concerning the effect of different irrigation treatments on yield of corn and on productivity indices values, the results revealed that, the highest corn yield was obtained with 80% irrigation treatments, corresponding to PI_M values of 0.46 and 0.45 with $soil_1$ and $soil_2$, respectively. Whereas, the lowest corn yield was obtained when irrigate with 50% of available water, corresponding to PI_M values of 0.34 and 0.33 for $soil_1$ and $soil_2$, respectively. Seed yield declined when irrigation water decreased from 80% to 50% of available water in both soils. Galbiatti *et al.* (2004) concluded that yield of corn and its attributes were gradually increased as a result of increasing in the availability of soil moisture content. The data also showed that the mean seed yield of corn was higher with $soil_1$, which recorded the highest PI values, as compared with $soil_2$. Crop yields are usually used as a measure of soil productivity, therefore, the relationship between corn yield and productivity index was obtained. A significant relationship (R^2 = 0.97) was found between seed yield of corn and PI_M values as follows:

$$\text{Yield}= 49.74+7483.0\ PI_M$$

From the regression results, PI_M model could explain about 97% of seed yield variation. This result proves that PI_M model is a good yield prediction model.

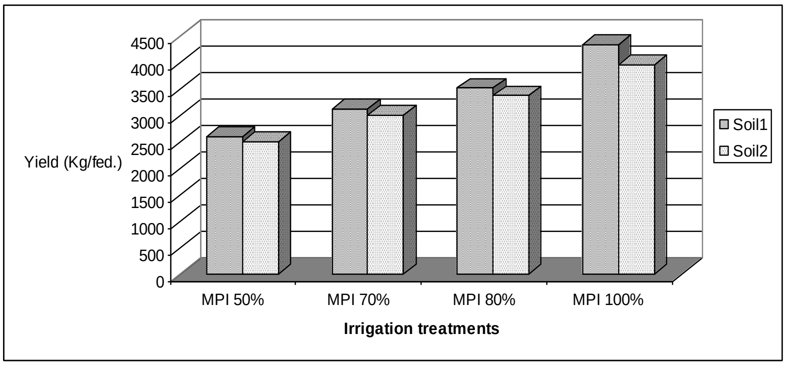


Fig. 2. Seed yield of corn under different irrigation treatments of the two soils.

Actual evapotranspiration and seed yield

The actual evapotranspiration (ETa) values under different irrigation treatments are shown in Fig. 3. The ETa values varied according to the variation in irrigation treatments. Values of ETa under irrigation by 50% of available water were lower than those under 70% and 80% of available water as compared with the control treatment (100% of available water).The highest value of ETa corresponded to the highest and the lowest values of PI_M index of $soil_1$ and $soil_2$.

When using ETa as an indicator of PI_M, a significant correlation (R^2 = 0.78) was found between ETa and PI_M .The regression equation is as follows:

$$ETa = 27.72 + 961.70\ PI_M$$

The relationship between ETa and seed yield of corn was also obtained and the regression equation was as follows:

$$Yield = 435.5 + 6.32\ ETa$$

The result showed that ETa could explain about 84% of the variations in corn yield (R^2 = 0.84). The relationship between seed yield of corn and ETa could be used to predict seed yield of corn. However, the relationship between PI_M and corn yield indicated a better relationship (R^2 = 0.97). Mulengera and Payton, (1999) reported that PI model incorporating ETa explained about 87% of the variability.

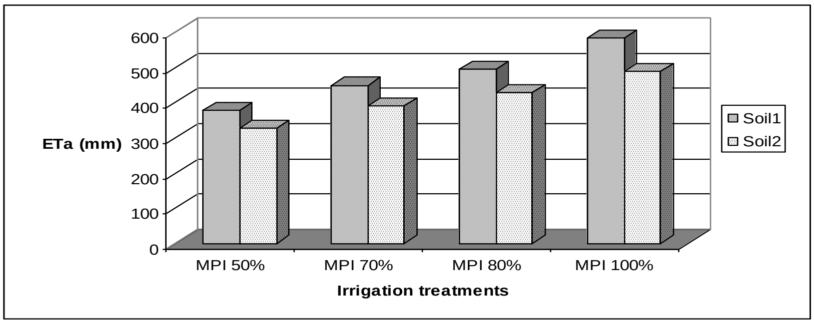


Fig. 3. Evapotranspiration under different irrigation treatments of the two studied soils.

Evaluation of soil productivity

Evaluation of soil productivity was done according to Fernando (2002), (Table 6). Comparing the calculated PI_1 , PI_2 and PI_M values with the relative data of productivity index in Table 6, the productivity of both soils obtained with PI_1 is very high (> 0.51) whereas, with PI_2 both soils have moderate productivity (0.11-0.30). The productivity of the two soils according to PI_M values was depending on the irrigation treatments. Values of PI_M represented high productive soils under the studied irrigation treatments.

TABLE 6. Evaluation of soil productivity in terms of the values of productivity index (Fernando, 2002).

Productivity index	Soil productivity
≤ 0.10	Low
0.11 – 0.30	Moderate
0.31 – 0.50	High
≥ 0.51	Very high

The results showed that PI_1 and PI_M values were higher than PI_2 values; therefore, the PI_2 model didn't reflect the actual productivity level. Productivity index (PI) provides a single scale on which soils may be rated according to their suitability for crop production. The results indicated that soil physical and chemical properties could be limiting or non- limiting factors on the productivity of soils. The changes in soil moisture content influenced PI_M values. The PI_M model was able to demonstrate 97% of the variations in seed yield (R^2=0.97). The PI_M permits direct comparison between different soil moisture regimes on crop yield and can reflect the productivity level with different irrigation treatments.

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تقييم إنتاجية بعض الأراضى بإستخدام دليل الأنتاجية

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الهدف من هذه الدراسة هو تقييم إنتاجية بعض الأراضى لمحصول الذرة بإستخدام النماذج الرياضية وإجراء مقارنة بين هذه النماذج الرياضية .وقد إستخدمت ثلاثة نماذج لتقدير إنتاجية التربة هي : دليل إنتاجية التربة PI_1 ودليل إنتاجية التربة PI_2 حيث تم إضافة نسبة الطين وكمية المادة العضوية لهذا الدليل والدليل المعدل لإنتاجية التربة PI_M وهو يعتمد على حساب قيمة أنتاجية التربة بناء على معاملات رى مختلفة هى (50%، 70%، 80%، 100% من الماء الميسر). أجريت الدراسة على نوعين من الأراضى مختلفة القوام (طينية طميية ، وطميية). وأظهرت النتائج تأثر قيم إنتاجية التربة بإختلاف خواص التربة المدروسة. وقد زادت قيم الدليلPI_1 بالمقارنة بقيم الدليل PI_2 .وتأثرت قيم PI_M بإختلاف معاملات الرى حيث كانت أعلى قيمة هى لمعاملة الرى 80% من الماء الميسر واقل قيمة هى لمعاملة الرى 50% من الماء الميسر لكل من الأرضين. وجد إرتفاع لقيم PI_1 وPI_2 للتربة الأولى بالمقارنة بالتربة الثانية. وبمقارنة قيم الأنتاجية المقدرة بإستخدام الأدلة السابق ذكرها بتلك القيم النسبية لدليل إنتاجية الأرض ، وجد أن قيم PI_1 تدل على أن معدل إنتاجية التربة عالى جداً لكل من الأرضين، بينما قيم PI_2 تظهر أنتاجية متوسطة للتربة الأولى و الثانية. وكانت إنتاجية التربة عالية تبعاً لقيم لـ PI_M وذلك تحت معاملات الرى المختلفة . وجد أيضا أن أعلى وأقل محصول ذرة تم الحصول عليه كان مصاحباً لأعلى وأقل قيمة محسوبة باستخدام النماذج الرياضية على التوالى . ووجدت أيضا علاقة ارتباط معنوي بين محصول الذرة لكل من الأرضين وقيم كل من PI_Mو ETa وكانت الأرتباط بين محصول الذرة وقيم PI_M أعلى منها فى حالة ETa. وبناء على ذلك فإن النماذج الرياضية PI_1 وPI_M هى أدلة جيدة على إنتاجية التربة وتعطى وصف جيد لإنتاجية التربة لمحصول الذرة . ويسمح النموذج PI_M بالمقارنة المباشرة بين معاملات الرى المختلفة .