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INCREASING CROP WATER PRODUCTIVITY BY USING THE BEST SCENARIOS OF THE CROPPING PATTERNS UNDER DIFFERENT AGRO-CLIMATIC ZONES

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ABSTRACT

The aim of the present investigation was to improving and maximizing the crop water productivity "CWP" and looking for the optimum Scenario of the crop pattern to achieve more crops per drop concept under different agro-climatic zones in Egypt. Therefore, different scenarios of cropping patterns (33 scenarios) were suggested to examine them. The results could be summarized in the following:-

- In Nile Delta region the highest CWP (9.99 kg m^{-3} water consumption $year^{-1}$) was obtained for the scenario of tomato (w) + potato (s). Nevertheless, the lowest scenario was registered for barley + soybean (1.21 kg m^{-3} water consumption $year^{-1}$).
- In Middle Egypt, the highest scenario gave maximum CWP was found for tomato (w) + potato (s) followed by potato (w) + tomato (s) then sugarcane. On the contrary, the lowest one was registered for barley + sunflower.
- In the same direction, in Upper Egypt CWP ranged from 9.63 kg m^{-3} water consumption $year^{-1}$ with the scenario of tomato (w) + potato (s) to 0.78 kg m^{-3} water consumption $year^{-1}$ with the scenario of barley + soybean.
- Results clearly showed that the cropping pattern at the three main agro- climatic zones in Egypt which include vegetables crops were superior greatly in crop water productivity.
- The obtained results indicated that the values of "CWP" ranged between 9.99 to 1.21 in Delta, 7.91 to 0.85 in Middle Egypt and 9.63 to 0.78 kg m^{-3} in Upper Egypt.

INTRODUCTION

The Egyptian agriculture is entirely based on irrigation and hence in utterly dependent on a tenuous balance between water supply of water and the crops demands. Egypt depends on suitable climate and natural resources (Land and water) for agricultural production and for food supply. Currently, about 85% of water in Egypt is used in the agricultural sector. With expected population increase, water share for capita will decrease and climate change will exert further stress concerning water supply issues. This would mean less food to feed the growing population. Already, the amount of available water per person is below the recommended water poverty line of 1000 cubic meter per capita per year. Crop water productivity (CWP) or water use efficiency (WUE) as Kg m^{-3} is an efficiency term expressing the amount of output marketable product in relation to the amount of input (cubic meters of water)needed to produce that out put, Kijne et al. (2003). The water use efficiency (WUE) for crop production is referred to the combination of water

lost (due to evaporation from the soil surface and that transpired from the plants canopy) and the resultant marketable, Zwart and Bastiaanssen (2004).

Crop rotation plays an important role in effecting water productivity, soil productivity as well as increasing crop production. Many crops are affected and often sensitive to the crop rotation and the preceding crops. Abou- Kersha et al. (1998) pointed out that maize and soybean yields grown after bersem or faba bean were significantly higher than that grown after wheat by 33.4 and 43.0 % for maize and soybean, respectively. Copeland et al. (1993) showed that yield of corn was increased up to 30% when corn followed soybean and up to 11% when soybean followed corn. In connection, Yusuf et al.(2009) stated that maize crop yield, which average, increased by 68 and 49% following soybean and cowpea, respectively, compared to continuous maize.

The aim of this investigation was to study and evaluate the effects of crop pattern of different crops on consumptive use, water requirements and crop water productivity under the three main agro-climatic zones in Egypt i.e. Nile Delta, Middle and Upper Egypt.

MATERIALS AND METHODS

Studies on crop water productivity under different agro -climatic zones in Egypt were done to determine the optimum crop pattern that could achieve the highest yield from irrigation water use unit or more crops per drop. To attain such goal different scenarios of cropping pattern were suggested as follows :-

- wheat + maize
- wheat + rice
- wheat + soybean
- wheat + sunflower
- wheat + tomato (s)
- wheat + potato (s)
- wheat + pepper (s)
- barley+ maize
- barley + rice
- barley + soybean
- barley + sunflower
- barley + tomato (s)
- barley + potato (s)
- barley + pepper (s)
- sugarcane
- Tomato (w) + maize
- Tomato (w) + rice
- * Tomato (w) + soybean
- * Tomato (w) + sunflower
- * Tomato (w) + potato (s)
- * Tomato (w) + Pepper (s)
- * Potato (w) + maize
- * Potato (w) + rice
- * Potato (w) + soybean
- * Potato (w) + sunflower
- * Potato (w) + tomato (s)
- * Potato (w) + Pepper (s)
- * Pepper (w) + maize
- * Pepper (w) + rice
- * Pepper (w) + soybean
- * Pepper (w) + sunflower
- * Pepper (w) + potato (s)
- * Pepper (w) + tomato (s)

It should be notified that w and s letters are referred to winter and summer seasons, respectively.

For estimating crop water productivity or water use efficiency, the potential evapotranspiration "ETp" according to the available meteorological data for Delta, middle Egypt and Upper Egypt were used. Penman Monteith was using crop WAT model, Smith, (1991).

To account the effect of the crop characteristics on crop requirements, crop coefficient "Kc" is used. Thus, ET crop can be estimated for some major field crops as presented in Table 1 according to the following relation:

ET crop = Kc x ETp

Table 1: Yield* (Kg fad^{-1}), ET crop (consumptive use m^3 fad^{-1}) and crop water productivity, Kg m^{-3} of water consumption "CWP")for some major crops in Egypt

Crop	Nile Delta			Middle Egypt			Upper Egypt		
Crop	Yield	ET crop	CWP	Yield	ET crop	CWP	Yield	ET crop	CWP
Wheat	2749	1247	2.20	28321	1425	1.99	2821	1544	1.83
Barley	1737	925	1.88	1358	1099	1.24	1244	1153	1.08
Maize	3557	2118	1.68	3433	2420	1.36	3334	2714	1.23
Rice	4043	3065	1.32	1548	3498	0.98			
Soybean	1223	2307	0.53	936	2640	0.59	1338	2875	0.47
Sunflower	958	1740	0.55	926	2013	0.46	1165	2173	0.54
Sugarcane	37006	5724	6.47	44046	6694	6.58	50039	7452	6.71
Tomato (s)	13974	2519	5.55	18156	2955	6.14	16841	3208	5.25
Tomato (w)	18175	1502	12.10	18158	1782	10.19	24802	2040	12.16
Potato (w)	10812	1035	10.45	10465	1232	8.71	17698	1432	12.36
Potato (s)	12260	1555	7.88	7005	1861	5.62	14634	2061	7.10
Pepper (w)	6877	1189	5.78	8392	1413	5.94	5780	1646	3.51
Pepper (s)	7215	2572	2.81	-	2969	2.83	9146	3224	2,84

Source : Agricultural Economic Bulletin, 2009.

For the determination of water requirements of a specified crop, irrigation efficiency have been taken into consideration. The efficiency of irrigation water is the ratio between the theoretical water consumptive use and actual irrigation requirements. According to **Jensen (1980),** irrigation efficiency values for surface, sprinkler and drip irrigation systems are 60, 75 and 90 %, respectively. Meanwhile, for sub-merged crop, i.e., rice an irrigation efficiency of 50% is used (Dastane, 1972).

Crop Water Productivity (CWP):

According to Smith (2002) Crop water productivity is defined as Crop yield per Water consumptively used (ET).

RESULTS AND DISCUSSION

Results in Table 2 and Figs 1 - 3 indicate the different scenarios of cropping pattern in Nile Delta, Middle and Upper Egypt (to represent different agroclimatic zones in Egypt) and the optimum ones.

Table (2): Crop water productivity (CWP) under different scenarios of cropping pattern in Nile Delta, Middle and Upper Egypt

Cropping pattern	CWP, Kg m^{-3} $year^{-1}$		
	Nile Delta	Middle Egypt	Upper Egypt
wheat + maize	1.94	1.68	1.53
wheat +rice	1.76	1.49	-
wheat + soybean	1.37	1.29	1.15
wheat + sunflower	1.38	1.23	1.19
wheat + tomato (s)	3.84	4.39	3.54
wheat + potato (s)	5.04	3.81	4.47
wheat +pepper (s)	2.51	2.41	2.34
barley+ maize	1.78	1.30	1.16
barley +rice	1.60	1.11	-
barley + soybean	1.21	0.92	0.78
barley + sunflower	1.22	0.85	0.81
barley + tomato (s)	3.68	4.01	3.17
barley + potato (s)	4.88	3.43	4.09
barley + pepper (s)	2.35	2.04	1.96
Sugarcane	6.47	6.58	6.71
Tomato (w) + maize	6.89	5.78	6.70
Tomato (w) + rice	6.71	5.59	-
Tomato (w) + soybean	6.32	5.39	6.32
Tomato (w) + sunflower	6.33	5.33	6.35
Tomato (w) + potato (s)	9.99	7.91	9.63
Tomato (w) + Pepper (s)	7.46	6.51	7.50
Potato (w) + maize	6.07	5.04	6.80
Potato (w) + rice	5.89	4.85	-
Potato (w) + soybean	5.49	4.65	6.42
Potato (w) + sunflower	5.50	4.59	6.45
Potato (w) + tomato (s)	7.97	7.75	8.81
Potato (w) + Pepper (s)	6.63	5.77	7.60
Pepper (w) + maize	3.73	3.16	2.37
Pepper (w) + rice	3.55	2.97	-
Pepper (w) + soybean	3.16	2.78	1.99
Pepper (w) + sunflower	3.17	2.71	2.03
Pepper (w) + potato (s)	6.83	5.29	5.31
Pepper (w) + tomato (s)	5.63	5.87	4.38

Note : Due to the absence of rice cultivation in Upper Egypt, the scenarios of cropping patterns dropped five scenarios which including rice crop.

In Nile Delta region, the highest CWP (9.99 kg m^{-3} water consumption $year^{-1}$) was obtained for the scenario of tomato (w) + potato (s), meanwhile, the lowest scenario was registered for barley + soybean (1.21 kg

m^{-3} water consumption $year^{-1}$), fig. 1. Generally, CWP can be arranged in descending order as follows :-
Tomato (w) + potato (s) > potato (w) + tomato (s) > tomato (w) + Pepper (s) > tomato (w) + maize > pepper (w) + potato (s) > tomato (w) + rice > potato (w) + pepper (s) > sugarcane > tomato (w) + sunflower > tomato (w) + soybean > potato (w) + maize > potato (w) + rice > pepper (w) + tomato (s) > potato (w) + sunflower > potato (w) + soybean > wheat + potato (s) > barley + potato (s) > wheat + tomato (s) > pepper (w) + maize > barley + tomato (s) > Pepper (w) + rice > Pepper (w) + sunflower > pepper (w) + soybean > wheat +pepper (s) > barley + pepper (s) > wheat + maize > barley+ maize > wheat +rice > barley +rice > wheat + sunflower > wheat + soybean > barley + sunflower > barley + soybean.

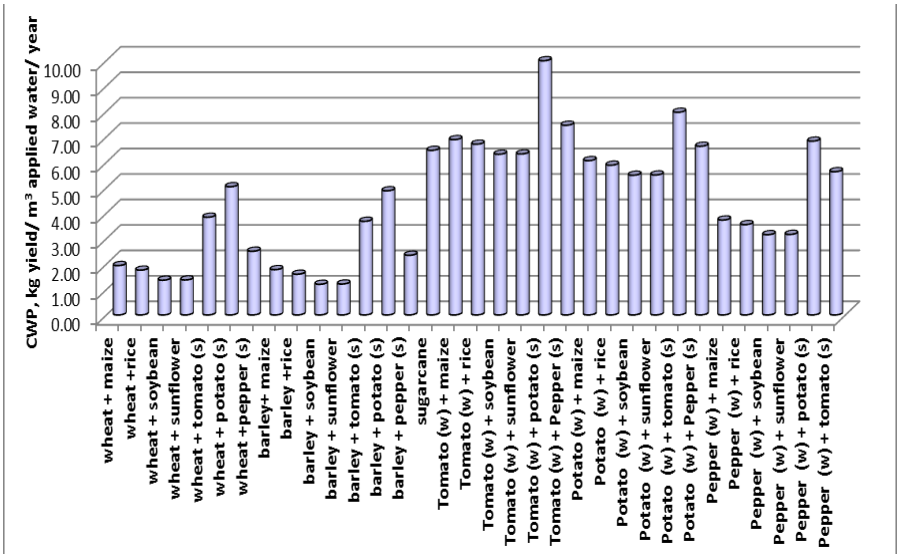

Fig. 1 :Average crop water productivity (CWP) under different crop patterns in the Nile Delta region.

In Middle Egypt, the highest scenario gave maximum CWP was found for tomato (w) + potato (s) followed by Potato (w) + tomato (s) then sugarcane, while the lowest one was registered for barley + sunflower, (fig. 2). Generally, it can be arranged the different scenarios of cropping patterns in Middle Egypt in descending order as follows:-
Tomato (w) + potato (s) > Potato (w) + tomato (s) > sugarcane > Tomato (w) + Pepper (s) > Pepper (w) + tomato (s) > Tomato (w) + maize > Potato (w) + Pepper (s) > Tomato (w) + rice > Tomato (w) + soybean > Tomato (w>) +

sunflower > Pepper (w) + potato (s) > Potato (w) + maize > Potato (w) + rice > Potato (w) + soybean > Potato (w) + sunflower > wheat + tomato (s) > barley + tomato (s) > wheat + potato (s) > barley + potato (s) > Pepper (w) + maize > Pepper (w) + rice > Pepper (w) + soybean > Pepper (w) + sunflower > wheat +pepper (s) > barley + pepper (s) > wheat + maize > wheat +rice > barley+ maize > wheat + soybean > wheat + sunflower > barley +rice > barley + soybean > barley + sunflower.

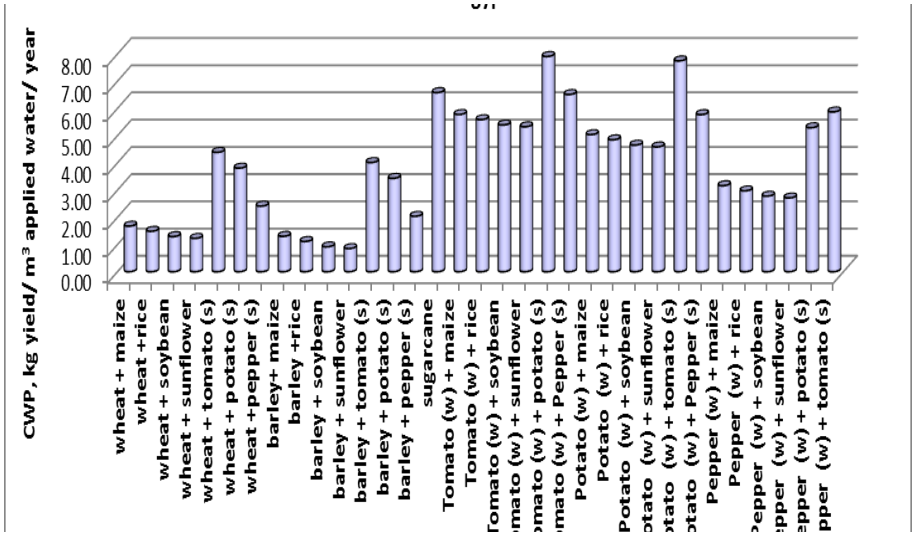

Fig. 2 :Average crop water productivity (CWP) under different crop patterns in Middle Egypt .

In the same direction, in Upper Egypt, CWP ranged from 9.63 kg m^{-3} water consumption $year^{-1}$ with the scenario of tomato (w) + potato (s) to 0.78 kg m^{-3} water consumption $year^{-1}$ with the scenario of barley + soybean, Fig.3. Generally, the scenarios of cropping patterns in Upper Egypt can be arranged in descending order as follows:-

Tomato (w) + potato (s) > Potato (w) + tomato (s) > Potato (w) + Pepper (s) > Tomato (w) + Pepper (s) > Potato (w) + maize > sugarcane > Tomato (w) + maize > Potato (w) + sunflower > Potato (w) + soybean > Tomato (w) + sunflower > Tomato (w) + soybean > Pepper (w) + potato (s) > wheat + potato (s) > Pepper (w) + tomato (s) > barley + potato (s) > wheat + tomato (s) > barley + tomato (s) > Pepper (w) + maize > wheat +pepper (s) > Pepper (w) + sunflower > Pepper (w) + soybean > barley + pepper (s) > wheat + maize > wheat + sunflower > barley+ maize > wheat + soybean > barley + sunflower > barley + soybean.

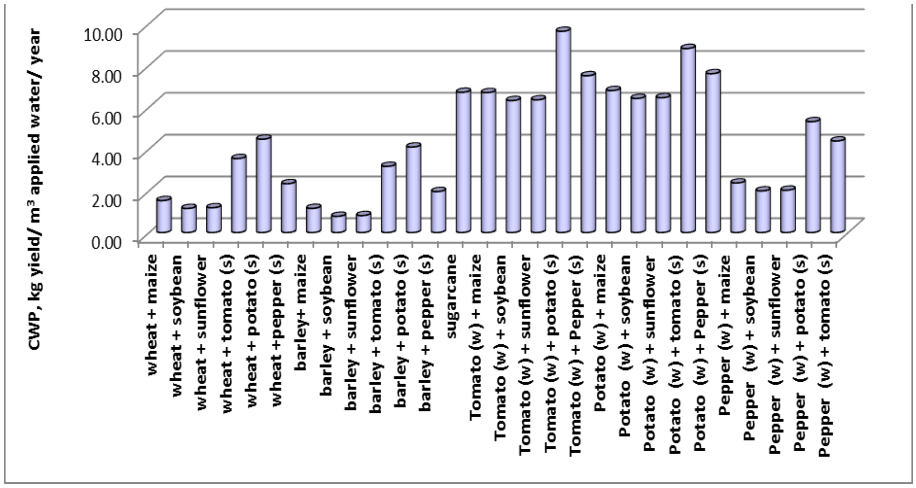

Fig. 3:Average crop water productivity (CWP) under different crop patterns in Upper Egypt .

Finally, the results indicated that higher crop water productivity, under different scenarios of cropping patterns at the three main agro -climatic zones in Egypt, were recorded with the cropping patterns which include vegetable crops.

From the previous results it can be concluded that values of CWP, as Kg m^{-3} , ranged between 9.99 to 1.21 in Nile Delta, 7.91 to 0.85 in Middle Egypt and 9.63 to 0.78 in Upper Egypt.

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زيادة إنتاجية وحدة المياه باستخدام أفضل التراكيب المحصولية في المناطق المناخية الزراعية بمصر

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***قسم بحوث المقننات المائية والرى الحقلى- معهد بحوث الاراضى والمياه والبيئة- مركز البحوث الزراعية.**

****المعمل المركزى للمناخ الزراعى- مركز البحوث الزراعية.**

تهدف هذه الدراسة إلى تعظيم إنتاجية وحدة المياه وذلك باستخدام ٣٣ سيناريو من التراكيب المحصولية والوصول إلى أنسب هذه السيناريوهات في المناطق المناخية الزراعية في مصر (دلتا النيل – مصر الوسطى – مصر العليا).
ويمكن تلخيص االنتائج المتحصل عليها في التالى:

- حقق التركيب المحصولى طماطم شتوى يعقبها بطاطس صيفى أعلى عائد من وحدة المياه فى منطقة الدلتا (٩.٩ كجم/م^3 من المياه المستهلكة) في حين أقل إنتاجية من وحدة المياه (١.٢١ كجم/م^3) من زراعة الشعير وفول الصويا على التوالى.
- في مصر الوسطى كانت أعلى قيمة لانتاجية المياه من اتباع التركيب المحصولى (زراعة الطماطم الشتوى مع البطاطس الصيفى).
- في مصر العليا كان نفس الاتجاه كما فى الدلتا حيث تم الحصول على أعلى قيمة لإنتاجية وحدة المياه من زراعة الطماطم الشتوى ثم البطاطس الصيفى ٩.٦٣ كجم/م^3 وكانت أقل قيمة (٠.٧٨ كجم/م^3) من زراعة الشعير ثم فول الصويا.
- تشير النتائج بوضوح أن التراكيب المحصولية التى تشمل محاصيل الخضر تفوقت بدرجة كبيرة فى المناطق المناخية االثلاثة فى مصر.
- أوضحت النتائج المتحصل عليها أن قيم الانتاجية المحصولية من وحدة االمياه تراوحت بين ٩.٩٩ - ١.٢١ في الدلتا ، ٧.٩١- ٠.٨٥ في مصر االوسطى وفى مصر العليا تراوحت بين ٩.٦٣- ٠.٧٨ كجم/م^3 .

قام بتحكيم البحث

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