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Improving Yield Components and Competitive Indices of Dill and Onion Components As Influenced By Intercropping System and Phosphorus Fertilization Level

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ABSTRACT

This experiment was conducted on intercropping of onion (*Allium cepa* L.) with dill (*Anethum graveolens* L.) at different ridge ratios (sole crop system of each component, 1: 1, 1: 2, 2: 2 and 2: 3 of dill: onion, respectively) combined with different phosphorus fertilization levels (0, 32 and 48 kg P_2O_5/fed.) during two consecutive winter seasons of 2018/2019 and 2019/2020 at Agricultural Research Farm, Fac. Agric., Zagazig Univ., Sharkia Governorate, Egypt. The study aim was to improve yield components and competitive indices of each crop by using the best treatment of intercropping system in combination with the optimum level of phosphorus fertilizer. The obtained results showed that yield components of dill or onion were significantly affected by intercropping systems. The highest values of fruit and volatile oil yields per dill plant were recorded with 2: 3 intercropping system during both seasons. While, the highest values of onion yield components (grade 1, grade 2, exportable yield, marketable yield and total yield) were achieved by sole crop compared to intercropping systems under study. Land equivalent ratio (LER), area time equivalent ratio (ATER), land utilization efficiency (LUE) with 2: 3 cropping system and phosphorus fertilization level at 32 kg /feddan reached 31.8 and 25.1, 22.1 and 15.8 as well as 26.95 and 20.45 % in the first and second seasons, respectively, compared to the other treatments.. In general, the best combination treatment was 2: 3 system combined with 32 kg P_2O_5/feddan to improve the yield and maximize the land utilization efficiency.

Keywords: Dill, Onion, intercropping, phosphorus, yield, competitive indices

INTRODUCTION

Dill plant (*Anethum graveolens* L.) specie is cultivated extensively in many countries of Asia, USA and Europe, for it does utilize as a medical uses and aromatic herb (Singh *et al*., 2005). It is an annual and sometimes biennial herb belongs to the family Apiaceae (Umbellfera), which has been planted since ancient times (Bailer *et al*., 2001). Dill is used as a vegetable, an aromatic, an antispasmodic and a carminative (Hornok, 1992; Sharma, 2004) as well as an inhibitor of sprouting in stored potatoes (Score *et al*., 1997). The dill plant contains volatile oils such as B-camphene, anethole, umbelliferone, α-pinene, carvone and lonone (Dhalwal *et al*., 2008). The other specie that studied in this work was onion (*Allium cepa* L.) which belonging to the *Alliaceae* family. Onion is one of the commercial spice and vegetable crop in Egypt, for local consumption as well as for exportation. It considered a high cash value crop for many Egyptian farmers. This is because the international market demands on the Egyptian fresh, dry and processed onions.

Intercropping is the cropping system involving the growth and productivity of two or more components in the same piece of land at the same time. Intercropping supply valuable ecosystem services such as enhanced pest control (Mitchell *et al*., 2002), increased use efficiency of different resources (Hauggaard-Nielsen *et al*., 2001) in different crop livestock mixed farming system. Through the most important advantages of intercropping systems is increasing the productivity per unit area than sole cropping of each crop (Banik *et al*., 2006).

Phosphorus (P) is considered as a one of the fundamental macro-nutrients for the plant growth, development and yield (Harrison *et al*., 2002). Phosphorus is an important ingredient of bio-molecules like phospholipids, nucleic acids and ATP. Usually the soils are phosphorus deficient because of fixation problems, which makes it minimal available to the crops especially in clays soils. To overcome the P deficiency, different kinds of phosphate fertilizers (as calcium super phosphate in Egypt) are applied to the soil (Gentili *et al*., 2006 and Rotaru and Sinclair, 2009).

Among the constraints for low productivity in onion, imbalanced nutrition is the main limiting factor (Shedeed *et al*., 2015). Improving yield and bulb weight uniformity are the two important parameters in determining the marketable and exportable proportion of onion performance (Krishnamuthy and Sharanappa, 2005).

The main purpose of this study was to determine the best intercropping system between dill and onion under different levels of phosphorus for improving yield components and total productivity of both crops.

MATERIALS AND METHODS

The present study was conducted at the Experimental Farm, Faculty of Agriculture, Zagazig

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University, Sharkia Governorate, during the two consecutive winter seasons of 2018/2019 and 2019/2020 to study the effect of intercropping system and phosphorus fertilization on yield components and competitive indices of dill and onion . Seeds of dill were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza and were sown on 15th October during both seasons. After three weeks from sowing, dill seedlings were thinned to be two plants per hill; fruits of dill were sown at space of 30 cm in one side of the ridge just after irrigation. Onion transplants (cv. Behary Improved) of nearly 42 days old were transplanted in the same time (15th October). Onion was transplanted at space of 10 cm between hills, on the two sides of the ridge. The physical and chemical properties of the experimental farm soil site are shown in Table 1 according to Chapman and Pratt, (1978). Experimental plot was 27 m^2 (3 × 9 m) included 15 ridges; each ridge was 60 cm apart and 3 m in length.

Table 1. Physical and chemical properties of experimental soil (average two seasons)

Physical analysis										**Soil texture**	
Clay (%)		**Silt (%)**		**Fine sand (%)**			**Coarse sand (%)**			**Clay**	
56.36		9.26		17.62			16.76				
Chemical analysis											
pH	E C m.mohs /cm	Organic mater (%)	Soluble cations (meq./L)			Soluble anions (meq./L)			Available (ppm)		
			Mg^{++}	Ca^{++}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.82	0.98	0.58	2.7	1.6	4.1	4.5	1.7	3.5	18	20	71

This experiment included fifteen treatments, which were the combinations between five intercropping patterns (sole crop of each component, 1:1, 1: 2, 2: 2 and 2: 3 of dill: onion, respectively) and three phosphorus fertilization levels which were; control (without phosphorus fertilization), 32 and 48 kg P_2O_5 / feddan (fed. Equal 0.42 ha.) as calcium superphosphate (16 % P_2O_5).

All dill or onion plants were fertilized with nitrogen and potassium fertilization at the rate of 300 kg/fed., of ammonium sulphate (20.5% N) and 100 kg/faed., of potassium sulphate (48% K_2O). Phosphorus fertilizer was added during soil preparation as a soil dressing application. While, nitrogen and potassium fertilizers were divided into three equal portions and were added to the soil after 30, 55 and 80 days from sowing and transplanting of dill and onion, respectively. The two tested plants received the normal agricultural practices whenever they needed during both seasons.

Parameters Studied

The following plant parameters in both crops were estimated according to the recommended methods as follows:

A. Yield and its components:

At maturity stage (125 days after sowing for dill and 150 days after onion transplanting):

For dill plants, fruit yield per plant (g/plant) were determined and then total fruit yield per feddan (kg/fed.) was calculated. The volatile oil percentage from air-dried fruits of dill plant was isolated by hydro distillation for 3 hr., in order to extract the essential oils according to Guenther (1961) and the oil yield per plant (ml) and per feddan (l) was calculated.

For onion plants, from each experimental unit, plants were manually lifted, field-cured for 15 days, in shady place before assessing bulb yield parameters. Onion bulbs were weighed, and then sorted into four grades according to the Ministry of Economic for onion exportation as follows: Grade 1: bulbs with diameter more than 6 cm, grade 2: bulbs with diameter more than 4.5 to 6 cm, grade 3: bulbs with diameter more than 3.5 to 4.5 cm, grade 4: bulbs with diameter less than 3.5 cm. In addition, the following data were recorded: marketable yield as ton/feddan (yield of grades 1 + 2 + 3), also, the exportable yield as ton/ fed., (yield of grades 1 + 2) and total yield as ton /fed., (yield of grades 1 + 2 + 3 + 4).

B. Competitive indices

1. Land equivalent ratio (LER)

It was calculated for dill and onion yields recorded per feddan according to Mead and Willey (1980) equation as follows:

$$\textbf{LER = Ld + Lo}$$

Where:

$$\text{Ld (relative yield of dill)} = \frac{\text{Intercrop yield of dill fruits}}{\text{Sole yield of dill fruits}}$$

$$\text{Lo (relative yield of onion)} = \frac{\text{Intercrop yield of onion bulbs}}{\text{Sole yield of onion bulbs}}$$

This parameter gives an indication to the relative land area required, as sole cropping, to produce the same yields achieved by intercropping. When the LER is greater than one, the intercropping favors the yield of the species. In contrast, when LER is lower than one the intercropping negatively affects the yield of the crops grown in mixture.

2. Area-Time Equivalent Ratio (ATER):

It was calculated according to Hiebsch and McCollum (1987) equation as follows:

$$ATER = \frac{Ydo / Ydd \times td + Yod / Yoo \times to}{T}$$

Where: **Ydo: intercrop yield of dill, Ydd: sole yield of dill, Yod: intercrop yield of onion, Yoo: sole yield of onion, td: the duration of dill in days (125 days), to: the duration of onion in days (150 days) and T: time taken by whole intercropping system in days.**

3. Land Utilization Efficiency (LUE):

By using LER and ATER values, the land utilization efficiency (LUE) was calculated according to Mason *et al.* (1986) as follows:

$$LUE = \frac{LER \times ATER}{2} \times 100$$

4. Aggressivity (A):

It was calculated according to Mc Gilchrist (1965) equation as follows:

a. For combinations of 1: 1 and 2: 2, they were calculated according to the following equations:

$$Agdo = Ld - Lo\,, \quad Agod = Lo - Ld$$

b. For the other combination ratios (1: 2 and 2: 3 systems), the equations used were:

$$Ag\ od = \frac{Ydo}{Ydd \times Pdo} - \frac{Yod}{Yoo \times Pod}$$

$$Ag\ od = \frac{Yod}{Yoo \times Pod} - \frac{Ydo}{Ydd \times Pdo}$$

Where: Ydo: yield of dill intercrop with onion, Yod: yield of onion intercrop with dill, Ydd: sole yield of dill, Yoo: sole yield of onion, Pod: sowing proportion of onion and Pdo: sowing proportion of dill.

5. Competitive ratio (CR):

The CR is calculated according to the following formula:

$$CR\ dill \times onion = \frac{LER dill}{LER\ onion} \left(\frac{Pod}{Pdo}\right)$$

$$CR\ onion \times dill = \frac{LER\ onion}{LER\ dill} \left(\frac{Pdo}{Pod}\right)$$

The CR gives a better measure of competitive ability of the crops and is also advantageous as an index over aggressivity (Willey and Rao, 1980). The CR gives simply the ratio of single LERs of the two component crops (dill and onion) and takes into account the crops proportion in which they are initially sown.

Statistical Analysis

The statistical layout of this experiment was split-plot experiment in completely randomized block design. Where, intercropping systems were randomly distributed in the main plots, while phosphorus levels were randomly arranged in sub-plots. Each treatment was included three replicates. Data were analyzed according to Gomez and Gomez (1984). The means were compared using computer program of Statistix version 9 (Analytical software, 2008).

RESULTS AND DISCUSSION

Effect of intercropping system and phosphorus fertilization level on yield and its components of dill and onion:

The data described in Tables (2 and 3) indicate that all intercropping system increased dill fruit yield per plant compared to sole dill crop during both seasons. Also, alternating two rows of dill with three rows of onion significantly increased volatile oil percentage and fruit yield and volatile oil yield per dill plant compared to sole crop and the other ones under study. In contrast, total yield of fruits or volatile oil per feddan was increased with sole dill cropping system compared to intercropping system treatments under study.

Table 2. Impact of intercropping system and phosphorus level and their combinations on yield components of dill during 2018/2019 and 2019/2020 seasons

Intercropping systems (dill: onion) (I)	Phosphorus level (kg P_2O_5/ feddan) (P)							
	0.0	32	48	Mean (I)	0.0	32	48	Mean (I)
	2018/2019 season				2019/2020 season			
	Fruit yield / plant (g)							
Sole dill	12.13	13.06	13.98	13.05	11.71	12.98	14.39	13.03
1 row: 1 row	14.34	16.48	17.96	16.26	14.15	16.05	17.80	16.00
1 row: 2 rows	15.61	18.35	19.53	17.88	15.11	18.05	19.20	17.45
2 rows: 2 rows	16.13	17.56	19.05	17.58	15.60	17.34	18.67	17.20
2 rows: 3 rows	17.14	18.92	20.91	18.99	16.71	18.21	20.40	18.44
Mean (P)	15.07	16.87	18.29		14.66	16.53	18.09	
LSD at 5 %	(I) = 0.245	(P) = 0.219		(I×P) = 0.469	(I) = 0.296	(P) = 0.237		(I×P) = 0.524
	Fruit yield / feddan (kg)							
Sole dill	565.93	609.33	652.42	609.22	546.48	605.91	671.40	607.93
1 row: 1 row	334.61	384.54	419.16	379.44	330.25	374.59	415.27	373.37
1 row: 2 rows	242.87	285.38	303.84	277.36	234.98	280.77	298.71	271.49
2 rows: 2 rows	376.30	409.82	444.59	410.24	364.01	404.61	435.72	401.45
2 rows: 3 rows	319.95	353.18	390.33	354.49	311.99	339.99	380.74	344.24
Mean (P)	367.93	408.45	442.07		357.54	401.17	440.37	
LSD at 5 %	(I) = 6.134	(P) = 5.893		(I×P) = 12.373	(I) = 8.980	(P) = 6.901		(I×P) = 15.456

Moreover, using intercropping systems decreased onion yields especially grade one and two as well as exportable, marketable and total yield compared to sole cropping of onion during both seasons (Tables 4 and 5).

Furthermore, increasing rows number of onion under one or two rows of dill significantly increased exportable, marketable and total yield during the first and second seasons. However, Thavaprakash *et al.* (2005) reported that intercropping system results in optimum crop growth compared to sole cropping, which is one of the important factors for higher production by utilizing the different underground resources efficiently and harvesting solar radiation as much as possible and in turn resulting in better yield components. Moreover, these results are in agreement with those found by Ansari *et al.* (2015) on citronella plant based in different intercropping system and Talukder *et al.* (2015) on onion when intercropped with coriander. Also, Gendy *et al.* (2018) on black cumin when intercropped with fenugreek had reported similar results. Ali *et al.* (2019) pointed out that the highest values in total fresh weight of herb per plant and volatile oil yield per plant of sweet basil and rosemary were recorded with 1:3 and 1:4 systems compared to sole crop of each one. In addition, Thirukumaran and Kavitha (2020) revealed that the higher gross return and net return was received with castor + onion intercrop.

Table 3. Impact of intercropping system and phosphorus level and their combinations on volatile oil yield components of dill during 2018/2019 and 2019/2020 seasons

Intercropping systems (dill: onion) (I)	Phosphorus level (kg P_2O_5/ feddan) (P)							
	0.0	32	48	Mean (I)	0.0	32	48	Mean (I)
	2018/2019 season				2019/2020 season			
	Volatile oil percentage							
Sole dill	2.267	2.333	2.530	2.377	2.093	2.367	2.593	2.351
1 row: 1 row	2.283	2.510	2.910	2.568	2.153	2.480	2.877	2.503
1 row: 2 rows	2.443	2.727	3.047	2.739	2.410	2.680	2.917	2.669
2 rows: 2 rows	2.417	2.517	3.193	2.709	2.167	2.367	3.133	2.556
2 rows: 3 rows	2.653	3.070	3.270	2.998	2.593	2.870	3.333	2.932
Mean (P)	2.413	2.631	2.990		2.283	2.553	2.971	
LSD at 5 %	(I) = 0.059	(P) = 0.042	(I×P) = 0.097		(I) = 0.101	(P) = 0.053	(I×P) = 0.140	
	Volatile oil yield / plant (ml)							
Sole dill	0.275	0.305	0.353	0.311	0.245	0.307	0.373	0.308
1 row: 1 row	0.328	0.414	0.523	0.421	0.305	0.398	0.512	0.405
1 row: 2 rows	0.328	0.500	0.595	0.492	0.364	0.484	0.560	0.469
2 rows: 2 rows	.0.390	0.442	0.608	0.480	0.338	0.410	0.585	0.444
2 rows: 3 rows	0.455	0.581	0.684	0.573	0.434	0.523	0.680	0.546
Mean (P)	0.366	0.448	0.553		0.337	0.424	0.542	
LSD at 5 %	(I) = 0.013	(P) = 0.010	(I×P) = 0.023		(I) = 0.017	(P) = 0.011	(I×P) = 0.026	
	Volatile oil yield / feddan (l)							
Sole dill	12.827	14.210	16.507	14.514	11.440	14.330	17.413	14.394
1 row: 1 row	7.640	9.650	12.200	9.830	7.117	9.293	11.947	9.452
1 row: 2 rows	5.937	7.783	9.253	7.658	5.660	7.523	8.710	7.298
2 rows: 2 rows	9.097	10.313	14.197	11.202	7.890	9.573	13.653	10.372
2 rows: 3 rows	8.490	10.847	12.763	10.700	8.090	9.760	12.690	10.180
Mean (P)	8.798	10.561	12.984		8.039	10.096	12.883	
LSD at 5 %	(I) = 0.225	(P) = 0.244	(I×P) = 0.513		(I) = 0.381	(P) = 0.244	(I×P) = 0.586	

Regarding the impact of phosphorus fertilization level on yield components of both crops, Tables (2, 3, 4 and 5) reveal that the two levels of P_2O_5 (32 and 48 kg/fed.) recorded a significant increase concern fruit yield per plant and per feddan as well as dill volatile oil percentage, yield per plant and per feddan compared to control during both seasons. Where, increasing phosphorus fertilization level gradually increased yield components of dill and onion plants during the two seasons. Moreover, the superior effects of phosphorus fertilizer application on yield components of dill and onion plants are due to that, phosphorus is a part of molecular structure of vitally important compounds (ATP and ADP), RNA and DNA. In addition, phosphorus plays an fundamental role in meristim tissues and cell division as well as for photosynthesis (Marschner, 1995). Similar results were stated by Kwon *et al.* (2019) on bellflower, Fahmy and Mohsen (2020) on dill and Amare *et al.* (2020) on onion plants.

Table 4. Impact of intercropping system and phosphorus level and their combinations on different grades of onion yield during 2018/2019 and 2019/2020 seasons

Intercropping systems (Dill: onion) (I)	Phosphorus level (kg P_2O_5/ feddan) (P)							
	0.0	32	48	Mean (I)	0.0	32	48	Mean (I)
	2018/2019 season				2019/2020 season			
	Yield of grade one							
Sole onion	3.263	3.575	3.772	3.537	3.333	3.694	3.914	3.647
1 row: 1 row	1.458	1.618	1.821	1.632	1.518	1.634	1.859	1.670
1 row: 2 rows	1.784	2.099	2.421	2.101	1.929	2.234	2.479	2.214
2 rows: 2 rows	1.534	1.730	2.026	1.764	1.487	1.679	1.937	1.701
2 rows: 3 rows	1.851	2.715	2.918	2.494	1.887	2.643	2.876	2.469
Mean (P)	1.978	2.347	2.591		2.031	2.377	2.613	
LSD at 5 %	(I) = 0.069	(P) = 0.039	(I×P) = 0.099		(I) = 0.062	(P) = 0.063	(I×P) = 0.130	
	Yield of grade two							
Sole onion	1.668	1.848	2.203	1.906	1.717	2.016	2.275	2.003
1 row: 1 row	0.963	1.220	1.507	1.230	1.035	1.208	1.473	1.240
1 row: 2 rows	1.426	1.484	1.677	1.529	1.472	1.523	1.765	1.587
2 rows: 2 rows	1.131	1.297	1.599	1.342	1.151	1.252	1.507	1.303
2 rows: 3 rows	1.267	1.298	1.401	1.322	1.225	1.285	1.371	1.294
Mean (P)	1.290	1.429	1.677		1.320	1.457	1.679	
LSD at 5 %	(I) = 0.057	(P) = 0.025	(I×P) = 0.073		(I) = 0.044	(P) = 0.031	(I×P) = 0.071	
	Yield of grade three							
Sole onion	0.214	0.347	0.394	0.318	0.246	0.322	0.374	0.314
1 row: 1 row	0.367	0.345	0.225	0.322	0.428	0.302	0.270	0.333
1 row: 2 rows	0.318	0.411	0.262	0.330	0.336	0.394	0.262	0.331
2 rows: 2 rows	0.194	0.204	0.224	0.207	0.252	0.195	0.190	0.212
2 rows: 3 rows	0.271	0.304	0.281	0.285	0.291	0.288	0.305	0.295
Mean (P)	0.273	0.322	0.283		0.310	0.300	0.280	
LSD at 5 %	(I) = 0.011	(P) = 0.013	(I×P) = 0.026		(I) = 0.017	(P) = 0.020	(I×P) = 0.040	
	Yield of grade four							
Sole onion	0.194	0.199	0.201	0.198	0.205	0.194	0.193	0.197
1 row: 1 row	0.088	0.185	0.198	0.157	0.100	0.166	0.201	0.156
1 row: 2 rows	0.102	0.467	0.131	0.233	0.090	0.144	0.074	0.103
2 rows: 2 rows	0.095	0.175	0.187	0.152	0.105	0.147	0.175	0.142
2 rows: 3 rows	0.065	0.088	0.104	0.085	0.048	0.077	0.093	0.072
Mean (P)	0.109	0.223	0.164		0.110	0.146	0.147	
LSD at 5 %	(I) = N.S	(P) = N.S	(I×P) = 0.268		(I) = 0.025	(P) = 0.016	(I×P) = 0.038	

Similarly, regarding the impact of combination treatments between intercropping systems and phosphorus fertilization levels, the data presented in Tables 2, 3, 4 and 5 suggest that, the best combination treatment for increasing fruit and oil yield components as well as bulb yields (most grades under study) per feddan of dill as well as onion, respectively, was that of the treatment of sole crop system combined with phosphorus fertilizer at 45 kg P_2O_5 per feddan compared to the other combination treatments, in most cases. On the other hand, fruit and volatile oil yield/dill plant was significantly increased with all combination treatments between intercropping systems and phosphorus fertilization levels compared with control (dill growing alone and without phosphorus application) in both seasons. Moreover, under each treatment of intercropping systems, yield components of both crops increased with increasing phosphorus fertilization levels.

Furthermore, Mohammed *et al.* (2016) reported that both intercropping system and fertilization treatments (each alone) increased yield components, in turn, they together might maximize their effects leading to more seed and oil yields of coriander intercropped with fenugreek.

These results agreed with those reported by Carpici and Tunali (2012) on vetch intercropped with barley and fertilized with phosphorus and Abdelkader and Hassan (2016) on dill intercropped with fenugreek and fertilized with phosphorus.

Table 5. Impact of intercropping system and phosphorus level and their combination on yield components (ton/fed.) of onion during 2018/2019 and 2019/2020 seasons

Intercropping systems (dill: onion) (I)	Phosphorus level (kg P_2O_5/ feddan) (P)							
	0.0	32	48	Mean (I)	0.0	32	48	Mean (I)
	2018/2019 season				2019/2020 season			
	Exportable yield (grade 1 + grade 2)							
Sole onion	4.931	5.423	5.974	5.443	5.050	5.711	6.189	5.650
1 row: 1 row	2.420	3.022	3.328	2.923	2.553	3.005	3.335	2.964
1 row: 2 rows	3.210	3.583	4.098	3.630	3.402	3.758	4.245	3.801
2 rows: 2 rows	2.665	3.027	3.626	3.106	2.637	2.931	3.443	3.004
2 rows: 3 rows	3.118	4.013	4.318	3.816	3.112	3.928	4.246	3.762
Mean (P)	3.269	3.813	4.269		3.351	3.867	4.291	
LSD at 5 %	(I) = 0.068	(P) = 0.058	(I×P) = 0.136		(I) = 0.108	(P) = 0.082	(I×P) = 0.185	
	Marketable yield (grade 1 + grade 2+ grade 3)							
Sole onion	5.145	5.770	6.368	5.761	5.296	6.023	6.563	5.964
1 row: 1 row	2.787	3.367	3.583	3.246	2.981	3.308	3.605	3.298
1 row: 2 rows	3.528	3.994	4.360	3.961	3.738	4.152	4.507	4.132
2 rows: 2 rows	2.859	3.231	3.850	3.313	2.889	3.127	3.633	3.216
2 rows: 3 rows	3.389	4.317	4.599	4.102	3.403	4.216	4.551	4.057
Mean (P)	3.542	4.126	4.552		3.661	4.167	4.572	
LSD at 5 %	(I) = 0.083	(P) = 0.063	(I×P) = 0.141		(I) = 0.102	(P) = 0.077	(I×P) = 0.174	
	Total yield (grade 1 + grade 2+ grade 3+ grade 4)							
Sole onion	5.338	5.696	6.569	5.959	5.502	6.226	6.755	6.161
1 row: 1 row	2.875	3.551	3.781	3.402	3.081	3.474	3.806	3.454
1 row: 2 rows	3.630	4.461	4.491	4.194	3.827	4.296	4.581	4.235
2 rows: 2 rows	2.954	3.406	4.037	3.466	2.994	3.274	3.808	3.359
2 rows: 3 rows	3.454	4.404	4.703	4.187	3.451	4.293	4.644	4.129
Mean (P)	3.650	4.358	4.716		3.771	4.313	4.719	
LSD at 5 %	(I) = 0.173	(P) = 0.111	(I×P) = 0.267		(I) = 0.097	(P) = 0.074	(I×P) = 0.165	

Effect of intercropping system and phosphorus fertilization level on yield competitive indices between dill and onion components:

The data in presented in Table 6 indicate that, the land equivalent ratio (LER), area time equivalent ratio (ATER) and land utilization efficiency (LUE) values were greater for dill and onion in mixture of 2: 3 system There was an advantage of intercropping for exploiting the resources of the environment. Indeed, intercropping of dill and onion at all intercropping systems under study were more productive than growing them alone (sole crop), as can be seen from the below mentioned values which were greater than 1.00. Results were true for all determined cases in both seasons. In this concern, Natarajan and Willey (1980) indicated that the most commonly designed reason for use growth resources rather differently, so that when grown together they " integral " each other and make better overall use of resources than when grown separately.

Moreover, El-Tantawy (2017) suggested that the intercropping of tomato with cowpea recorded maximum LER, ATER and LUE. Also, Nigussie (2020) indicated that intercropping of onion with rosemary at 80 % population density enhanced yield advantage and Competitiveness as indicated by higher land equivalent ratio.

Concerning aggressivity values as shown in Table 7, it is clear that dill component crop was the dominant, whereas onion was the dominated one. Also, the advantage of growing species (dill and onion) in association depends primarily on the degree of inter crop versus intra crop competition. Lower inter crop comparison with intra crop competition occurs when companion crops differ in their use of plant growth resources (for example light, water and nutrients). Such aggressivity reached to its maximum values (2.620 and 2.530) by using combination treatment of 2: 3 intercropping system treatment in the first and second seasons, respectively. Similar results were reported by Meawad *et al*. (2013) who found that roselle component crop was the dominant, whereas guar was the dominated one. Also, Mohammed *et al.* (2016) stated that positive aggressivity values for coriander demonstrate that coriander was the dominant specie whereas the negative values for fenugreek indicate that it was the dominated one.

Table 6. Impact of intercropping system and phosphorus level and their combinations on LER, ATER and LUE% indices between dill and onion components during 2018/2019 and 2019/2020 seasons

Intercropping systems (dill: onion) (I)	Phosphorus level (kg P_2O_5/ feddan) (P)							
	0.0	32	48	Mean (I)	0.0	32	48	Mean (I)
	2018/2019 season				2019/2020 season			
	Land equivalent ratio (LER)							
1 row: 1 row	1.130	1.226	1.218	1.192	1.164	1.177	1.182	1.174
1 row: 2 rows	1.109	1.216	1.149	1.158	1.126	1.154	1.123	1.134
2 rows: 2 rows	1.219	1.244	1.296	1.253	1.210	1.194	1.212	1.205
2 rows: 3 rows	1.213	1.318	1.314	1.281	1.199	1.251	1.254	1.235
Mean (P)	1.168	1.251	1.244		1.175	1.194	1.193	
LSD at 5 %	(I) =0.034	(P) =0.025	(I×P) =0.053		(I) = 0.018	(P) = N.S	(I×P) = 0.041	
	Area time equivalent ratio (ATER)							
1 row: 1 row	1.032	1.121	1.111	1.088	1.064	1.074	1.079	1.072
1 row: 2 rows	1.038	1.138	1.071	1.082	1.054	1.077	1.049	1.060
2 rows: 2 rows	1.108	1.131	1.182	1.140	1.099	1.083	1.104	1.095
2 rows: 3 rows	1.119	1.221	1.215	1.184	1.103	1.158	1.160	1.140
Mean (P)	1.074	1.153	1.145		1.080	1.098	1.098	
LSD at 5 %	(I) =0.033	(P) =0.025	(I×P) = 0.052		(I) = 0.018	(P) = N.S	(I×P) = 0.037	
	Land utilization efficiency (LUE%)							
1 row: 1 row	108.09	117.38	116.44	113.97	111.42	112.57	113.04	112.34
1 row: 2 rows	107.35	117.72	111.05	112.04	108.98	111.52	108.57	109.69
2 rows: 2 rows	116.31	118.76	123.93	119.67	115.49	113.85	115.77	115.03
2 rows: 3 rows	116.54	126.95	126.43	123.31	115.10	120.45	120.73	118.76
Mean (P)	112.07	120.20	119.46		112.75	114.60	114.53	
LSD at 5 %	(I) = 3.35	(P) = 2.50	(I×P) = 5.26		(I) = 1.82	(P) = N.S	(I×P) = 3.93	

Table 7. Impact of intercropping system and phosphorus level and their combination on aggrissivity values (Ag) between dill and onion components during 2018/2019 and 2019/2020 seasons

Intercropping systems (dill: onion) (I)	Phosphorus level (kg P_2O_5/ feddan) (P)							
	0.0	32	48	Mean (I)	0.0	32	48	Mean (I)
	2018/2019 season				2019/2020 season			
	Aggrissivity values for dill (Ag_{do})							
1 row: 1 row	+ 0.052	+ 0.036	+ 0.067	+ 0.052	+ 0.044	+ 0.061	+ 0.055	+ 0.054
1 row: 2 rows	+ 2.309	+ 2.529	+ 2.423	+ 2.420	+ 2.334	+ 2.427	+ 2.352	+ 2.371
2 rows: 2 rows	+ 0.111	+ 0.103	+ 0.067	+ 0.094	+ 0.122	+ 0.142	+ 0.086	+ 0.117
2 rows: 3 rows	+ 2.492	+ 2.679	+ 2.689	+ 2.620	+ 2.473	+ 2.554	+ 2.563	+ 2.530
Mean (P)	+ 1.241	+ 1.337	+ 1.311		+ 1.244	+ 1.296	+ 1.264	
LSD at 5 %	(I) = 0.035	(P) = 0.025	(I×P) = 0.054		(I) = 0.037	(P) = 0.028	(I×P) = 0.060	
	Aggrissivity values for onion (Ag_{od})							
1 row: 1 row	- 0.052	- 0.036	- 0.067	- 0.052	- 0.044	- 0.061	- 0.055	- 0.054
1 row: 2 rows	- 2.309	- 2.529	- 2.423	- 2.420	- 2.334	- 2.427	- 2.352	- 2.371
2 rows: 2 rows	- 0.111	- 0.103	- 0.067	- 0.094	- 0.122	- 0.142	- 0.086	- 0.117
2 rows: 3 rows	- 2.492	- 2.679	- 2.689	- 2.620	- 2.473	- 2.554	- 2.563	- 2.530
Mean (P)	- 1.241	- 1.337	- 1.311		- 1.244	- 1.296	- 1.264	
LSD at 5 %	(I) = 0.035	(P) = 0.025	(I×P) = 0.054		(I) = 0.037	(P) = 0.028	(I×P) = 0.060	

Furthermore, competitive ratio (CR) of dill and onion crops was significantly influenced by intercropping systems (Table 8). Furthermore, intercropped dill had higher competitive ratios in all proportions with onion, indicating that dill plants was more competitive (CR dill> one) than onion (CR onion < one). However, in all intercropping systems the values of CR for dill were greater than for onion indicating the dominance of dill. Also, Javanmard *et al*. (2018) on sunflower and soybean also have reported similar results.

In addition, the maximum increase in LER, ATER and LUE were obtained from the treatment of 32 kg P_2O_5 /feddan (1.251 and 1.194), (1.153 and 1.098) and (120.20 and 114.60 %) compared with the other ones under study in the first and second season, respectively. Phosphorus rates had significant effect on all competitive indices (LER, ATER, LUE and CR) in the two seasons. Concerning aggressivity values, it is clear that dill component crop was the dominant, whereas onion was the dominated one under effect of different phosphorus levels (Tables 6, 7 and 8).

However, data illustrated in Tables 6, 7 and 8 reveal that LER, ATER, LUE and CR were increased with all combination treatments between intercropping systems and phosphorus fertilization levels compared with combination treatment of 1:2 system and without phosphorus application in the first and second seasons. However, the combination treatment between intercropping system of two row of dill + three rows of onion (2:3 system) and 32 kg P_2O_5 /feddan was superior in this connection compared to the other ones under study.

These results are in line with those reported by Abdelkader and Hassan (2016).

Table 8. Impact of intercropping system and phosphorus level and their combination on competitive ratio (CR) between dill and onion components during 2018/2019 and 2019/2020 seasons

Intercropping systems (dill: onion) (I)	Phosphorus level (kg P_2O_5/ feddan) (P)							
	0.0	32	48	Mean (I)	0.0	32	48	Mean (I)
	2018/2019 season				2019/2020 season			
	Competitive ratio for dill (CRd)							
1 row: 1 row	1.098	1.062	1.116	1.092	1.080	1.109	1.098	1.095
1 row: 2 rows	1.265	1.270	1.364	1.300	1.238	1.347	1.316	1.300
2 rows: 2 rows	1.202	1.179	1.109	1.163	1.224	1.272	1.153	1.216
2 rows: 3 rows	1.311	1.179	1.253	1.248	1.336	1.224	1.238	1.276
Mean (P)	1.219	1.172	1.211		1.227	1.238	1.201	
LSD at 5 %	(I) = 0.059	(P) = N.S		(I×P) = 0.102	(I) = 0.041	(P) = N.S		(I×P) = 0.087
	Competitive ratio for onion (CRo)							
1 row: 1 row	0.911	0.942	0.896	0.917	0.928	0.902	0.911	0.914
1 row: 2 rows	0.792	0.799	0.733	0.775	0.807	0.743	0.761	0.770
2 rows: 2 rows	0.833	0.848	0.902	0.861	0.817	0.788	0.867	0.824
2 rows: 3 rows	0.763	0.849	0.798	0.803	0.733	0.820	0.808	0.787
Mean (P)	0.825	0.859	0.823		0.821	0.813	0.837	
LSD at 5 %	(I) = 0.040	(P) = N.S		(I×P) = 0.071	(I) = 0.025	(P) = N.S		(I×P) = 0.057

CONCLUSION

The above mentioned results demonstrate that advantage of competitive indices between dill and onion plants (LER, ATER and LUE%) supported using combination treatment of 32 kg P_2O_5 /feddan as calcium super phosphate and 2:3 system (dill: onion association) to more advantageous than other treatments and seems promising in the development of sustainable both crops production with a limited use of external inputs.

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تأثير نظام التحميل ومستوى التسميد الفوسفاتي على تحسين المكونات المحصولية ومؤشرات التنافس بين الشبت والبصل

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أجريت التجربة على تحميل البصل مع الشبت بنسب مختلفة (الزراعة المنفردة لكل محصول ، 1: 1 ، 1: 2 ، 2: 2 و 2: 3 من الشبت: البصل ، على التوالي) مع مستويات مختلفة من التسميد الفوسفاتي (صفر ، 32 و 48 كجم فو$_2$أ$_5$ / فدان) خلال موسمي 2019/2018 و 2020/2019 في مزرعة البحوث الزراعية، كلية الزراعة ، جامعة الزقازيق ، مصر. تهدف الدراسة إلى تحسين المكونات المحصولية ومؤشرات التنافسية لكل محصول باستخدام أفضل معاملة لنظام التحميل بالتداخل مع المستوى الأمثل من الأسمدة الفوسفاتية. وأظهرت النتائج المتحصل عليها أن نظم التحميل أثرت معنويا على كل من ارتفاع النبات والمكونات المحصولية لنباتات الشبت والبصل .تم الحصول على أطول النباتات من الشبت والبصل من نظامي التحميل 1: 2 و 2: 2 ،على التوالي. تم تسجيل أعلى قيم من محصول الثمار والزيت العطري للشبت لكل نبات مع نظام التحميل 2: 3 في كلا الموسمين. بينما، تم الحصول على أعلى القيم لمكونات محصول البصل (الرتبة الأولى، الرتبة الثانية، المحصول القابل للتصدير، المحصول القابل للتسويق والمحصول الكلي) من خلال الزراعة المنفردة مقارنةً بأنظمة التحميل تحت الدراسة. زادت قيم كل من نسبة المكافئ الأرضي، ونسبة المكافئ الأرضي لوحدة الزمن، وكفاءة استخدام الأراضي مع نظام التحميل 3:2 والتسميد الفوسفاتي بمعدل 32 كجم فو$_2$أ$_5$ / فدان بنسبة 31.8 و 25.1 ، 22.1 و 15.8 و26.95 و 20.45 ٪ خلال الموسمين الأول والثاني، على التوالي. أوضحت نسبة التنافس والعدوانية بين الشبت والبصل أن الشبت كان أكثر قدرة على المنافسة من البصل والشبت المحصول السائد في حين أن البصل هو المحصول المسود عليه في جميع أنظمة التحميل. بشكل عام، كان أفضل معاملة تداخل هي استخدام نظام تحميل 2: 3 بالتداخل مع 32 كجم فو$_2$أ$_5$ / فدان لتحسين المحصول وزيادة كفاءة استخدام الأراضي إلى الحد الأمثل.