ROLE OF CONSERVATION AGRICULTURE IN IMPROVING PRODUCTION WATER AND NITROGEN EFFICIENCY OF WHEAT UNDER RAINFED CONDITIONS

M. Othman [(1)] M. M. AL-Zoubi [(2)] A. Sh. AL-Ouda[(3)]
Researcher Researcher Prof.
[1]Ph. D. student, Faculty of Agriculture, Field Crops Dept., Damascus University;
[2]Researcher at GCSAR, Damascus, Syria; [3] Prof. Dr. Head of Field Crops Dept., Faculty of Agriculture, Damascus University
aymanalouda@ymail.com

ABSTRACT

The research work was conducted in Izra'a Research station, which affiliated to the General Commission for Scientific Agricultural Research (GCSAR), during the growing seasons (2016 – 2017; 2017 – 2018), in order to evaluate the response of two durum wheat verities (Douma3 and Cham5) and two bread wheat varieties ($Douma_4$ and $Cham_6$) to Conservation Agriculture (CA) as a full package compared with Conventional Tillage system (CT) under rainfed condition using lentils (Variety $Edleb_3$) in the applied crop rotation. The experiment was laid according to split-split RCBD with three replications. The average of biological yield, grain yield, rainwater use efficiency and nitrogen use efficiency was significantly higher during the first growing season, under conservation agriculture in the presence of crop rotation, in the variety $Douma_3$ (7466kg. ha^{-1}, and4162 kg. ha^{-1}, 19.006 kg ha^{-1} mm^{-1}, 39.62 kg N m^{-2}respectively). The two varieties $Douma_3$ and $Cham_6$ are considered more responsive to conservation agriculture system in the southern region of Syria, because they recorded the highest grain yields (2561, 2385 kg ha^{-1} respectively) compared with the other studied varieties ($Cham_5$ and $Douma_4$) (1951 and 1724 kg ha^{-1} respectively). They also exhibited the highest values of both rainwater and nitrogen use efficiency.

Key words: conservation agriculture, conventional tillage, crop residues, crop rotation, Rainwater use efficiency, nitrogen use efficiency, wheat.

مجلة العلوم الزراعية العراقية -2020 :51 (4):1139-1148 عثمان وآخرون

دور الزراعة الحافظة في تحسين كفاءة إنتاجية المحصول والمياه والآزوت في محصول القمح تحت ظروف الزراعة المطرية

منال عثمان محمد منهل الزعبي أيمن الشحاذه العوده
باحثة باحث أستاذ

المستخلص

نُفذ البحث في محطة بحوث إزرع التابعة للهيئة العامة للبحوث العلمية الزراعية، في محافظة درعا، خلال الموسمين الزراعيين (2017/2016)، (2018/2017)، بهدف تقييم استجابة أصناف القمح القاسي [دوما$_3$، وشام$_5$]، وأصناف القمح الطري [دوما$_4$، وشام$_6$]، لنظام الزراعة الحافظة كحزمةٍ زراعيةٍ متكاملة بالمقارنة مع الزراعة التقليدية، تحت ظروف الزراعة المطرية، واعتمد صنف العدس [إدلب$_3$] كمحصولٍ بقولي في الدورة الزراعية. وضعت التجربة وفق تصميم القطاعات العشوائية الكاملة العاملية، بترتيب القطع المنشقة – المنشقة، بمعدّل ثلاثة مكررات. كان متوسط الغلتين الحيوية والحبية، وكفاءة استعمال مياه الأمطار، وكفاءة استعمال الآزوت الأعلى معنوياً خلال الموسم الزراعي الأوّل، تحت ظروف الزراعة الحافظة، في القطع التجريبية التي طُبقت فيها الدورة الزراعية، لدى صنف القمح القاسي دوما$_3$ (7466 كغ. هكتار$^{-1}$، 4162 كغ. هكتار$^{-1}$ ، 19.006 كغ. هكتار$^{-1}$. مم$^{-1}$، 39.62 كغ حبوب. كغ N. م$^{-2}$ على التوالي). يُعد صنف القمح القاسي دوما$_3$، وصنف القمح الطري شام$_6$ أكثر استجابة لنظام الزراعة الحافظة في المنطقة الجنوبية (إزرع) من سورية، حيث كانت الغلتين الحبية والحيوية الأعلى معنوياً لدى هذين الصنفين (2561، 2385 كغ. هكتار$^{-1}$ على التوالي) بالمقارنة مع الصنفين الآخرين (شام$_5$، ودوما$_4$) (1951، 1724 كغ. هكتار$^{-1}$ على التوالي). واتسما أيضاً بكفاءةٍ مرتفعة في استعمال ميه الأمطار والآزوت.

الكلمات المفتاحية: الزراعة الحافظة، الزراعة التقليدية، بقايا المحصول، الدورة الزراعية، كفاءة استعمال مياه الأمطار، كفاءة استعمال الآزوت، القمح.

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INTRODUCTION

In most Arab countries, including Syria population is growing at a fast rate, more than 2.38% per year, so the food demand is increasing too, however, the potentiality for achieving the required yield from the major food crops to bridge the food gap is limited due to climatic changes, deterioration the production capacity of the cropping systems, changes of food preference, lack of improved-high-yielding varieties and inappropriate cultural practices. However, despite a decline in the growth rate of world population, this growth rate is still much higher than the actual increase in food production. Until 2030, food production has to double to satisfy the increasing food demand of a growing world population in qualitative and quantitative terms (9). In the past, production increases were mainly achieved by yield increases and only to a lesser extent by expanding the production area. Unfortunately, in future, the potential for an expansion of agricultural land is globally limited, due to secondary salinization, water scarcity and particularly further deforestation of forests or the use of other natural reserves should be avoided. The available agricultural land per capita will further decline globally (9). Nearly all of the soils under agricultural use show signs of degradation. Erosion, falling ground water tables, drying rivers or floods are only symptoms caused in many cases by soil degradation, represented by a decrease in soil organic matter, and as a consequence, a deterioration in soil structure an also reduced fertilizer efficiency (17). Under limited-water conditions, especially in the arid and semi-arid regions, some of the precious rain water is lost by surface runoff and evaporation instead of being infiltrated and stored in the soil. Degradation is in this context understood as the reduction of the productive potential of a resource, i.e., either a decrease in qualitative terms or a quantitative decrease in the availability of the resource (10). Major reasons for this development are intensification of production while using extractive production methods and overgrazing (4). Yield levels can be maintained only with ever increasing external inputs, such as synthetic fertilizers, pesticides and irrigation water, leading to a remarkable increase in the production costs, caused by increasing prices of fuel and other inputs, keeping in mind that the prices were increased at least ten folds due to the devaluation of the Syrian currency as a result of the crisis, which extended for more than 8 years, which will cut the farm incomes to an extend threatening the survival of many farms. In general, the dry Mediterranean climate located near the sea have relatively mild winter temperatures and hot summers (maritime climate); those located away from the sea within a larger land mass have severely cold winter temperatures and hot dry summers (continental climate). The Central and West Asia and North Africa (CWANA) region was once the breadbasket of civilizations and food production from the region sustained the most powerful empires of the ancient world, such as the Romans. Yet, already during those ancient times tillage-based agriculture led to soil degradation resulting in reduced human carrying capacity of the land (21). Thus, most agricultural soils in the dry climates of the Mediterranean basin today have low organic matter status (less than 1%) with poor soil aggregate structure (4), and the predominant land use practices such as tillage and overgrazing worsen the situation. The need now, therefore, is for farmers to take up more sustainable, productive and profitable ways of production that do not damage the soil, land and environment, thus, no-tillage, along with some complimentary practices such as soil cover with crop residues or green cover crops and crop rotation, which is defined nowadays as Conservation Agriculture (CA) has emerged as a viable option to ensure sustainable food production and maintain environmental integrity (7). CA is mainly defined by three linked principles which have to coincide in time and space and have to be applied permanently to develop synergies. These principles are (10): (1) Continuous minimum mechanical soil disturbance, (2) Permanent organic soil cover and (3) Diversification of crop species grown in sequences and/or associations. CA is receiving greater attention because it can optimize the use of purchased inputs and reduce costs (11). CA is an agricultural practice that keeps at least 30% of the soil surface covered by plant residues (6).

CA has been shown to work successfully in a variety of agro-ecological zones and farm sizes. Indeed, further advantage associated with CA is that it can be applied to different farming systems, with different combinations of crops, sources of power and production inputs (12). Its benefits include: improved soil health thereby improving infiltration; reduced time and labour requirements; reduced weed populations over time and increased yields and farm's income (17). CA system is becoming increasingly relevant for addressing the needs of small resource-poor farmers and the challenges of resource degradation, sustainability, food insecurity, poverty alleviation, climate change, labor shortages and high energy costs. Over the past 40 years, empirical and scientific evidence from different parts of the world in the tropical, sub-tropical and temperate regions has been accumulating to showed that CA principles can work successfully to provide a range of productivity, socio-economic and environmental benefits to the producers and the society at large (19). This is also true for the dry Mediterranean climates in the CWANA region (29). Yield differences resulting from improved soil moisture and nutrient availability have been reported in the range of 20–120 per cent and more between CA systems and tillage systems in the dry Mediterranean climates in different continents (23). In Syria, a study showed that CA increased yields of Wheat (31.43 %), Barley (76.93%) and Lentil (27.45%) compared with conventional tillage system (1). CA has also been observed to increases water-use efficiency, with water savings of 15- 50% in irrigation systems (15). The amount of grain yield produced from 1 mm of rainfall increased from 2.6 kg to 7.4 kg when farmers shifted from conventional practices to conservation agriculture (24). In south western Australia, (8) reported that CA farmers regularly state that their water use efficiency has nearly doubled after 10 years of no-till. Overall, CA systems have a higher adaptability to climate change because of the higher effective rainfall due to higher infiltration and therefore reduced surface runoff and soil erosion as well as greater soil moisture-holding capacity. A field experiment was conducted in Jeleen Research Station, Dara'a governorate, Syria, during two consecutive growing seasons (2008/2009 – 2009/2010), showed that the average of grain yield and biological yield was significantly higher during the first growing season, under conservation agriculture system, with crop rotation, for the durum wheat variety ($Acsad_{1105}$) (309.3, 822.2 Kg . $Donnem^{-1}$ respectively) (16). According to the FAO global data base (10), during the last 11 years CA worldwide has expanded at an average rate of about 7.5 million ha per year, from 45 million ha in 1999 to some 157 million ha in 2013, about 11% of global cropland (18). CA has been shown to be an effective management technique which can improve soil quality and fertility as well as yield and yield stability in the dry Mediterranean climate of Spain (22), Tunisia (5), Iraq (26), Australia (8) and Syria (2). In the Mediterranean basin, the total cropland under CA is still modest in several countries (4). (26) reported from results of trials conducted in Iraq that the average grain yield increases with no-till systems and early sowing when compared to CT and late sowing, were significant, namely 332 kg ha−1 (18%) for wheat, 127 kg ha−1 (20%) for chickpea and 135 kg ha−1 (15%) for lentil, but non-significant, 295 kg ha^{-1} (12%), for barley (26). Implementation of CA in the North East region of Syria at two sites (AL-Hassakha and AL-Raqa'a) over three consecutive growing seasons improved soil quality by increasing soil organic matter (SOM) content and soil fertility (NPK) (4), thereby converting soils from being a source of CO_2 emission into an effective sink by increasing its capacity to sequester CO_2 (3).

OBJECTIVES

1- Evaluating the response of two bread wheat varieties ($Douma_4$, $Cham_6$) and two durum wheat ($Douma_3$, $Cham_5$), to conservation agriculture system under rainfed conditions, in the southern region of Syria (Izra'a province) based on the production capacity.

2- Assessment the relevance of Conservation Agriculture as an integrated package in improving water and nitrogen use efficiency.

MATERIALS AND METHODS

Site of experimentation: A field trial was conducted at Izra'a Research Station, Dara'a province, Syria, during the two consecutive growing seasons (2016 – 2018), Izra'a Research Station is located about 80 km south of Damascus on a longitude of 36.15 ° E and latitude 32.51 ° N. It is approximately 575 m above sea level. The soil is heavy clay dryness, poor organic matter (0.7094%), low mineral nitrogen content (0.07027%), and medium content of phosphorus and potassium (10.67, 390.1 mg . kg^{-1} respectively). Izraa is classified as a B zone, with an annual rainfall of 250-300 mm.

Method of cultivation and treatments: The investigated varieties of bread wheat ($Douma_4$ and $Cham_6$) and durum wheat ($Douma_3$ and $Cham_5$) were planted on rows (17 × 5 cm), in order to evaluate their performance under the Conservation Agriculture conditions as an integrated agricultural package [no-till, 50% of the crop residues or green cover crop (sorghum), which was grown immediately after the harvesting of the main crop (15^{th} of June), and with a crop rotation: (wheat - lentils) compared to conventional tillage (soil tillage, removal of all crop residues or in the absence of green cover crop and without crop rotation: wheat - wheat)]. Two irrigations was given to the green cover crop to ensure the initial vegetative growth of the plants to cover the entire soil surface, and the main crop was grown on the sorghum residues, which usually dies before the optimal date for sowing of the main crop. Conservation Agriculture plots were planted by using a direct double disc drill that put fertilizers first at a depth of 7 cm and then place seeds aside at a depth of 5 cm, while the conventional tillage plots were ploughed twice using the tractor drawn cultivar, double passing each time up to 20 cm depth. Planting during the second growing season was carried out in the same way, but the most appropriate legume crop (lentil) was planted in place of the cereal crop (wheat) of various varieties under conservation agriculture, while the same variety of wheat was repeated under conventional tillage system. Wheat varieties were sown at a rate of 120 Kg. ha^{-1}, and lentils variety ($Idleb_3$) at a rate of 80 kg. ha^{-1} under conservation agriculture, and at a rate of 150 and 120 kg. ha^{-1} respectively under conventional tillage system. The individual plot size was 7.5 m^2. Mineral fertilizers (46% urea and triple superphosphate 46%) were added according to the recommendations of the Ministry of Agriculture and Agrarian Reform (150 kg N. ha^{-1} in three equal splits: at the time of sowing, at the beginning of tillering, and just before flowering), (50 kg P_2O_5 ha^{-1}). Planting date during the first growing season was on 20/11 and it was on 23/12 during the second growing season.

Experimental design and statistical analysis: The experiment was laid according to factorial split-split randomized complete block design (RCBD), with three replicates, where the type of agriculture (conservation or conventional) occupied the main plot, crop rotation in the sub plot, and the type of soil cover (crop residues or green cover crop) in the sub-sub plot- pieces. The data were analyzed using statistical analysis M-stat-C software to calculate the values of (LSD) at the level of significance of 5% and (CV%) (27).

Investigated traits

Biological yield (Kg. ha^{-1}): the average of dry aerial parts with grains per square meter was calculated, then converted to kilograms per hectare

Grain yield (Kg. ha^{-1}): The average of grain weight per square meter was calculated and converted to kg per hectare.

Rainwater use efficiency (RWUE) (kg. mm^{-1} ha^{-1}): RWUE was calculated according to Oweis by dividing the economic yield by growing season precipitation (October to April) (25).

Nitrogen use efficiency (NUE) (kg grain. kg N^{-1}. m^{-2}): It is calculated from the following mathematical equation (20):

$$NUE = \frac{\text{Grain yield}}{\text{amount of added nitrogen}} \times 1000$$

Soil organic matter content (%): Determined by titration, 5 ml of potassium dichromate mixture and 10 ml of concentrated sulfuric acid (H2SO4) were added to 0.5g of soil, and left for the next day, then 100 ml of distilled water added to it, then 3 drops of ferroine, and then calibrated with ferrous sulfate (FeSO4) to turn from yellow to brick red (30).

RESULTS AND DISCUSSION

Biological yield (Kg. ha^{-1}): The biological yield was significantly (P≤0.05) higher during the first growing season (5781 kg. ha^{-1}), compared to the second growing season (4576 kg. ha^{-1}). It was significantly higher under the conservation agriculture conditions (5634 kg. ha^{-1}), compared with the conventional tillage system (4723 kg. ha^{-1}). And it was significantly higher in the presence of the crop rotation (5342 kg. ha^{-1}), compared with the absence of the crop rotation (5015 kg. ha^{-1}). It was also significantly higher for the durum wheat variety Douma$_3$ (5846 kg. ha^{-1}), followed by bread wheat variety Cham$_6$ (5489 kg. ha$^{- 1}$), while it was significantly lower for the bread wheat variety Douma$_4$ (4435 kg. ha^{-1}), followed by Durum wheat variety Cham$_5$ (4946 kg. ha$^{- 1}$) (table, 1). It is noted for the interaction of all the investigated variables that the biological yield was significantly higher during the first growing season, under conservation agriculture, in the presence of the crop rotation, for the durum wheat variety Douma$_3$ (7466 kg. ha^{-1}), while it was significantly lower during the second growing season, under conventional tillage conditions, in the absence of crop residues, for the bread wheat variety Douma$_4$ (3353 kg. ha^{-1}).

Table 1. Mean of Biological Yield (Kg. ha^{-1}).

Growing Seasons / Varieties / variables			First Growing Season 2016-2017					Second Growing Season 2017-2018					Grand Mean
			Cham$_5$	Cham$_6$	Douma$_3$	Douma$_4$	mean	Cham$_5$	Cham$_6$	Douma$_3$	Douma$_4$	mean	
Conservation Agriculture	Crop rotation	Green cover crop	6165	6658	6872	5753	6362	4915	5407	5620	4502	5111	5736
		Crop residues	5517	7169	8060	5498	6561	4267	5918	6810	4248	5311	5936
	without crop rotation	Green cover crop	5983	6610	6730	5345	6167	4732	5360	5480	4095	4917	5542
		Crop residues	6081	6196	6381	5128	5946	4831	4946	5131	3878	4696	5321
Mean			5936	6658	7010	5431	6259	4686	5408	5760	4181	5009	5634
Conventional Tillage	Crop rotation		5033	5677	6223	4773	5427	3875	4518	5066	3615	4269	4848
	Without crop rotation		5285	5372	5547	4512	5179	4126	4212	4388	3353	4020	4599
Mean			5159	5524	5885	4643	5303	4000	4365	4727	3484	4144	4723
Grand Mean			5548	6091	6448	5037	5781	4343	4886	5244	3832	4576	5179

Variable	A	B	C	D	E	AB	AC	BC	AD	BD	CD	AE	BE	CE	DE	ABC
LSD (0.05)	12.60	12.60	12.60	12.60 ns	17.82	17.82	17.82	17.82	17.82	17.82 ns	17.82	25.20	25.20	25.20	25.20	25.20
Variable	ABD	ACD	BCD	ABE	ACE	BCE	ADE	BDE	CDE	ABCD	ABCE	ABDE	ACDE	BCDE	ABCDE	-
LSD (0.05)	25.20	25.20ns	25.20 ns	35.64	35.64	35.64	35.64	35.64	35.64	35.64 ns	50.40	50.40 ns	50.40	50.40	71.28	-
C.V %	8.5%															

Growing Seasons (A), Farming Systems (B), Crop Rotation (C), Cover Type (D), Varieties (E).

Grain yield (Kg. ha^{-1}): Grain yield was significantly higher (P≤0.05) during the first growing season (2607 kg. ha^{-1}), compared with the second one (1704 kg. ha^{-1}). The grain yield was significantly higher under the conservation agriculture conditions (2560 kg. ha^{-1}), compared with the conventional tillage conditions (1751 kg. ha^{-1}). It was also significantly higher in the presence of the crop rotation (2351 kg. ha^{-1}), compared with the absence of the crop rotation (1960 kg. ha^{-1}). The grain yield was significantly higher for the durum wheat variety Douma$_3$ (2561 kg. ha^{-1}), followed by the bread wheat variety Cham$_6$ (2385 kg. ha^{-1}), while it was significantly lower for the bread wheat variety Douma$_4$ (1724 kg. ha^{-1}), followed by the durum wheat variety Cham$_5$ (1951 kg. ha^{-1}) (table, 2). Taken into account the interaction of all the studied variables, the grain yield was significantly higher during the first growing season, under the conservation agriculture conditions, in the presence of the crop rotation, for the durum wheat variety Douma$_3$ (4162 kg. ha^{-1}), while it was significantly lower during the second growing season, under conventional tillage conditions, in the absence or presence of the crop rotation, for the bread wheat variety Douma$_4$ (1054, 1113 kg. ha^{-1} respectively). Results of three consecutive growing seasons (2011–2014) in Syria showed that the productivity of barley, wheat and lentil crops was significantly higher under CA (1,433 kg. ha$^{−1}$) compared with CT (1,113 kg. ha$^{−1}$).

Results also show that the average increase in yield of barley, wheat and lentil under CA compared with CT was 31.3, 27.0 and 27.7%, respectively (4). CA is not a low output agriculture but delivers sustainable yields that are greater than those obtained with modern tillage-based intensive agriculture. Yields tend to improve over the years with a simultaneous decrease in yield variations from one season to another, even under variable rainfall rates. (26) reported from results of trials conducted in Iraq that the average grain yield increases with no-till systems and early sowing when compared to CT and late sowing, were significant, namely 332 kg. ha^{-1} (18%) for wheat, 127 kg. ha^{-1} (20%) for chickpea and 135 kg. ha^{-1} (15%) for lentil, but non-significant, 295 kg. ha^{-1} (12%), for barley (26). These results also point to the importance of introducing legume crops into the crop rotation under both conservation and conventional tillage conditions, preventing the depletion of soil water content at specific depths within the soil sector, which usually occurs when the same crop is cultivated in the same land year after year.in addition to its importance in improving soil fertility and increasing the amount of mineral nutrients, especially the inorganic nitrogen, which is very essential for the growth and development of the vegetative plant parts, thereby increasing the biological yield at maturity.

Table 2. Mean of Grain Yield (Kg. ha^{-1}).

Growing Seasons / Varieties / variables			First Growing Season 2016-2017					Second Growing Season 2017-2018					Grand Mean
			$Cham_5$	$Cham_6$	$Douma_3$	$Douma_4$	mean	$Cham_5$	$Cham_6$	$Douma_3$	$Douma_4$	mean	
Conservation Agriculture	Crop rotation	Green cover crop	2760	3562	3792	2614	3182	1764	2561	2795	1612	2183	2682
Conservation Agriculture	Crop rotation	Crop residues	2480	3736	4533	2611	3340	1481	2740	3534	1611	2341	2841
Conservation Agriculture	without crop rotation	Green cover crop	2852	3223	3419	2388	2970	1854	2224	2422	1387	1972	2471
Conservation Agriculture	without crop rotation	Crop residues	2758	3012	2897	2310	2744	1755	2014	1892	1312	1743	2244
Mean			2713	3383	3660	2481	3059	1713	2385	2661	1481	2060	2560
Conventional Tillage	Crop rotation		2270	2711	2711	2039	2403	1341	1667	1782	1113	1476	1940
Conventional Tillage	Without crop rotation		1870	2000	2096	1661	1907	1274	1286	1262	1054	1219	1563
Mean			2070	2297	2403	1850	2155	1308	1477	1522	1084	1347	1751
Grand Mean			2391	2840	3032	2165	2607	1511	1931	2091	1282	1704	2155

Variable	A	B	C	D	E	AB	AC	BC	AD	BD	CD	AE	BE	CE	DE	ABC
LSD (0.05)	8.42	8.42	8.42	8.42 ns	11.91	11.91	11.91	11.91	11.91	11.91 ns	11.91	16.84	16.84	16.84	16.84 ns	16.84
Variable	ABD	ACD	BCD	ABE	ACE	BCE	ADE	BDE	CDE	ABCD	ABCE	ABDE	ACDE	BCDE	ABCDE	-
LSD (0.05)	16.84	16.84	16.84	23.81	23.81	23.81	23.81 ns	23.81 ns	23.81	23.81 ns	33.67	33.67 ns	33.67	33.67	47.62	-
C.V %	13.6%															

Growing Seasons (A), Farming Systems (B), Crop Rotation (C), Cover Type (D), Varieties (E).

Rainwater use efficiency (kg. ha^{-1}. mm^{-1}): The Rain water use efficiency was significantly higher (P≤0.05) during the first growing season (10.943 kg. ha^{-1}. mm^{-1}), compared with the second one (7.757 kg. ha^{-1}. mm^{-1}). It was significantly higher under the conservation agriculture conditions (11.114 kg ha^{-1} mm^{-1}), compared with the conventional tillage conditions (7.586 kg. ha^{-1}. mm^{-1}). It was significantly higher in the presence of the crop rotation (10.199 kg. ha^{-1}. mm^{-1}), compared with its absence (8.501 kg. ha^{-1}. mm^{-1}). It was significantly higher in the durum wheat variety $Douma_3$ (11.125 kg. ha^{-1}. mm^{-1}), followed by the bread wheat variety $Cham_6$ (10.357 kg. ha^{-1}. mm^{-1}), whereas it was significantly lower in the bread wheat variety $Douma_4$ (7.462 kg. ha^{-1}. mm^{-1}), followed by the durum wheat variety $Cham_5$ (8.457 kg. ha^{-1}. mm^{-1}) (table, 3). Taking into account the interaction of all the studied variables, the rainwater use efficiency was significantly higher during the first growing season, under conservation agriculture conditions, when all the crop residues were left on the soil surface, in the presence of the suitable crop rotation, for the durum wheat variety $Douma_3$ (19.006 kg. ha^{-1}. mm^{-1}), while it was significantly lower during the second growing season, under conventional tillage conditions, when all the crop residues were removed from the soil surface, in the absence of crop rotation, for the bread wheat variety Douma4 (4.775 kg. ha-1. mm-1). This can be attributed to the reduction in water loss by evaporation under CA conditions, so more water was available to the crop, which increased the productive loss of water (transpiration) and reduced the unproductive losses (soil evaporation, surface run-off and deep drainage), enabling crop plants to produce more total dry matter and more dry matter per unit volume of water (higher water productivity). Protecting the soil surface from direct impact of high-energy rain-drops (splash effect) prevents surface-sealing and surface soil particle dislodgement, thus maintaining the soil's water infiltration capacity, while at the same time minimizing water evaporation from the soil surface as reported by (23) in Morocco, and (4) in Syria and Lebanon. Nitrogen with more water in the root zone helps to increase water productivity by increasing the rate of growth and development of aerobic parts, which increases the photosynthetic efficiency of the plants throughout the entire growing season, leading to an increase in the dry matter accumulation, which ensure the allocation of more amount of photo- assimilates during the reproductive stage (flowering, grain filling stage), thus increasing the number of fertile florets in the spike, the ratio of fertile-to-vegetative tillers, the number of grains per spike and plant/m^2, the average individual grain weight, and increasing the source size, which results in a remarkable increase in grain yields and the water productivity (13). These results also go in line with the findings of (28) and (14), where they demonstrated that the implementation of conservation farming system helped to increase soil moisture content and le

Table 3. Mean of Rainwater Use Efficiency (Kg. ha^{-1}.mm^{-1}).

Growing Seasons / Varieties / variables			First Growing Season 2016-2017: Cham$_5$	Cham$_6$	Douma$_3$	Douma$_4$	mean	Second Growing Season 2017-2018: Cham$_5$	Cham$_6$	Douma$_3$	Douma$_4$	mean	Grand Mean
Conservation Agriculture	Crop rotation	Green cover crop	11.572	14.935	15.898	10.962	13.342	8.050	11.690	12.757	7.357	9.963	11.653
		Crop residues	10.398	15.663	19.006	10.948	14.004	6.758	12.504	16.128	7.354	10.686	12.345
	without crop rotation	Green cover crop	11.958	13.512	14.334	10.011	12.454	8.463	10.151	11.053	6.332	9.000	10.727
		Crop residues	11.565	12.629	12.147	9.686	11.507	8.012	9.192	8.637	5.988	7.957	9.732
Mean			11.374	14.185	15.346	10.401	12.827	7.821	10.884	12.144	6.758	9.402	11.114
Conventional Tillage	Crop rotation		9.541	10.897	11.391	8.574	10.101	6.084	7.573	8.097	5.042	6.699	8.400
	Without crop rotation		7.865	8.411	8.811	6.987	8.018	5.777	5.833	5.721	4.775	5.527	6.772
Mean			8.703	9.654	10.101	7.780	9.059	5.931	6.703	6.909	4.909	6.113	7.586
Grand Mean			10.038	11.919	12.724	9.091	10.943	6.876	8.794	9.526	5.833	7.757	9.350

Variable	A	B	C	D	E	AB	AC	BC	AD	BD	CD	AE	BE	CE	DE	ABC
LSD (0.05)	0.3691	0.3691	0.3691	0.3691 ns	0.5221	0.5221	0.5221	0.5221	0.5221	0.5221 ns	0.5221	0.7383	0.7383	0.7383	0.7383 ns	0.7383
Variable	ABD	ACD	BCD	ABE	ACE	BCE	ADE	BDE	CDE	ABCD	ABCE	ABDE	ACDE	BCDE	ABCDE	-
LSD (0.05)	0.7383	0.7383	0.7383	1.0441	1.0441	1.0441	1.0441 ns	1.0441 ns	1.0441	1.0441 ns	1.4766	1.4766	1.4766	1.4766	2.0882	-
C.V %	13.6%															

Growing Seasons (A), Farming Systems (B), Crop Rotation (C), Cover Type (D), Varieties (E).

Nitrogen Use Efficiency (kg grains. kg^{-1} N. m^{-2}): Nitrogen use efficiency was significantly higher ($P \leq 0.05$) under the conservation agriculture conditions (29.48 kg grains. kg N^{-1}. m^{-2}), compared with the conventional farming system (20.67 kg grains. Kg^{-1} N. m^{-2}). It was significantly higher in the presence of the crop rotation (26.12 kg grains. Kg^{-1} N. m^{-2}) compared with the absence of the crop rotation (24.03 kg grains. Kg^{-1} N. m^{-2}). The nitrogen use efficiency was significantly higher for the durum wheat variety Cham$_5$ (27.41 kg grains. Kg^{-1} N. m^{-2}), followed by durum wheat variety Douma$_3$ (25.39 kg grains. Kg^{-1} N. m^{-2}), while it was significantly lower for the bread wheat variety Cham$_6$ (23.51 kg grains. Kg-1 N. m-2), followed By the bread wheat variety Douma4 (24.00 kg grains. Kg-1 N. m-2) (table, 4). It is noted for the interaction of all the investigated variables that nitrogen use efficiency was significantly higher during the first growing season, under the conservation agriculture conditions, in the presence of the crop rotation, when the green cover crop was planted, for the durum wheat variety Douma3 (39.26 kg grains. Kg-1 N. m-2), while it was significantly lower during the second season, under the conventional tillage system, in the absence and presence of the crop rotation, when all plant residues were removed from the soil surface, for the bread wheat variety Douma4 (18.16, 19.18 kg grains. Kg-1 N. m-2respectively).

Table 4. Mean of Nitrogen Use Efficiency (kg grain. kg^{-1} N .m^{-2})

Growing Seasons			First Growing Season 2016-2017					Second Growing Season 2017-2018					Grand Mean
Varieties / variables			$Cham_5$	$Cham_6$	$Douma_3$	$Douma_4$	mean	$Cham_5$	$Cham_6$	$Douma_3$	$Douma_4$	mean	
Conservation Agriculture	Crop rotation	Green cover crop	27.97	20.45	39.26	29.63	29.33	30.82	16.45	30.74	29.63	26.91	28.12
		Crop residues	31.90	34.85	33.33	29.18	32.31	29.91	28.80	34.69	27.87	30.32	31.32
	without crop rotation	Green cover crop	31.57	33.48	37.25	27.22	32.38	32.73	22.12	36.62	26.93	29.60	30.99
		Crop residues	35.15	23.38	24.65	32.45	28.91	30.95	21.94	22.46	28.90	26.06	27.49
Mean			31.65	28.04	33.62	29.62	30.73	31.10	22.33	31.13	28.33	28.22	29.48
Conventional Tillage		Crop rotation	27.09	27.09	18.59	16.99	21.75	27.04	26.44	21.49	18.16	23.28	22.51
		Without crop rotation	21.74	14.70	17.46	21.72	18.91	20.66	19.09	16.05	19.18	18.75	18.83
Mean			23.02	20.89	18.03	19.36	20.33	23.85	22.76	18.77	18.67	21.01	20.67
Grand Mean			27.34	24.47	25.82	24.49	25.53	27.48	22.55	24.95	23. 50	24.62	25.07

Variable	A	B	C	D	E	AB	AC	BC	AD	BD	CD	AE	BE	CE	DE	ABC
LSD (0.05)	1.709 ns	1.709	1.709	1.709 ns	2.417	2.417	2.417 ns	2.417	2.417 ns	2.417 ns	2.417 ns	3.418 ns	3.418	3.418 ns	3.418 ns	3.418
Variable	ABD	ACD	BCD	ABE	ACE	BCE	ADE	BDE	CDE	ABCD	ABCE	ABDE	ACDE	BCDE	ABCDE	-
LSD (0.05)	3.418 ns	3.418 ns	3.418 ns	4.834 ns	4.834 ns	4.834 ns	4.834 ns	4.834 ns	4.834 ns	4.834 ns	6.837 ns	6.837 ns	6.837 ns	6.837 ns	9.669 ns	-
C.V %	23.8%															

Growing Seasons (A), Farming Systems (B), Crop Rotation (C), Cover Type (D), Varieties (E).

Soil organic matter content (%) (SOM): SOM was significantly higher (P≤0.05) during the second growing season (0.5229%), compared with the first one (0.4748%). and it was significantly higher under the conservation agriculture conditions (0.5988%), compared with the conventional tillage conditions (0.3990%). It was also significantly higher in the presence of the crop rotation (0.5454%), compared with the absence of the crop rotation (0.4523%). It was significantly higher when all crop residues were left on the soil surface (0.5946%), compared with the green cover crop (0.4031%). The SOM was significantly higher at the soil depth (0 -20 cm) (0.5510%), compared with the soil depth (20-40cm) (0.4467%) (table, 5). Taking into account the interaction of all the studied variables, the SOM was significantly higher during the second and first growing seasons, under the conservation agriculture conditions, in the presence of the crop rotation, at the soil depth (0-20cm) (0.7483, 0.6983% respectively), while it was significantly lower during the first growing season, under conventional tillage conditions, in the absence of the crop rotation, at the soil depth (20-40cm) (0.285%) (table, 5).

Table 5. Mean of Soil Organic Matter content (%).

Growing Seasons / Varieties / variables			First Growing Season 2016-2017			Second Growing Season 2017-2018			Grand Mean
			(0 – 20 cm)	(20 - 40cm)	mean	(0 – 20 cm)	(20 - 40cm)	mean	
Conservation Agriculture	Crop rotation	Green cover crop	0.5167	0.4600	0.4883	0.5667	0.5100	0.5383	0.5133
		Crop residues	0.8800	0.6567	0.7683	0.9300	0.7067	0.8183	0.7933
	without crop rotation	Green cover crop	0.4600	0.4500	0.4550	0.4967	0.5000	0.4983	0.47667
		Crop residues	0.6533	0.5200	0.5867	0.7033	0.5700	0.6367	0.6117
Mean			0.6275	0.5217	0.5746	0.6742	0.5717	0.6229	0.5988
Conventional Tillage		Crop rotation	0.4667	0.3583	0.4125	0.5167	0.4083	0.4625	0.4375
		Without crop rotation	0.3900	0.2850	0.3375	0.4317	0.3350	0.3833	0.3604
Mean			0.4283	0.3217	0.3750	0.4742	0.3717	0.4229	0.3990
Grand Mean			0.5279	0.4217	0.4748	0.5742	0.4717	0.5229	0.4989

Variable	A	B	C	D	E	AB	AC	BC	AD	BD	CD	AE	BE	CE	DE	ABC
LSD (0.05)	0.02435	0.02435	0.02435	0.02435	0.02435	0.03443	0.03443	0.03443	0.03443	0.03443	0.03443	0.03443	0.03443	0.03443	0.03443	0.04870
Variable	ABD	ACD	BCD	ABE	ACE	BCE	ADE	BDE	CDE	ABCD	ABCE	ABDE	ACDE	BCDE	ABCDE	-
LSD (0.05)	0.04870	0.04870	0.04870	0.04870	0.04870	0.04870	0.04870	0.04870	0.04870	0.06887	0.06887	0.06887	0.06887	0.06887	0.09739	-
C.V %									12.0%							

Growing Seasons (A), Farming Systems (B), Crop Rotation (C), Cover Type (D), Depths (E).

Conclusions

From the experiment, it can be concluded that, adoption of CA as an integrated package system, improves both grain yield and yield stability, enhanced RWUE, NUE and SOM under rainfed conditions in the southern region of Syria, which will increase the adaptive capacity of the cropping system.

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