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Effect of Center Pivot Irrigation System Speed and Tillage Methods on Lucerne (*Medicago sativa*) Productivity under Dryland Conditions, River Nile State, Sudan.

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Abstract: The experiment was carried out at the Jordanian Bashair project located south of Eldamar city, River Nile State (longitude 33^0 50' Latitude 17^0 20'N in an area of 2.25 ha during two successive seasons 2018/2019 and 2019/2020 with a view to evaluating the production of alfalfa under three different center pivot system speeds (50%, 70%, and 100%) and three different tillage operations, chisel ploughing with disc harrowing and laser levelling T1, chisel ploughing with disc harrowing followed by traditional levelling T2 and chisel ploughing with traditional levelling T3. The experiment was arranged in a split plot procedure with complete randomized block design replicated three times with the system speeds assigned to the main plots and the tillage operations to the subplots. The results showed that the number of leaves per plant and stem diameter were significantly affected ($p \leq 0.05$) with no effect on plant density and height. Generally all plant growth parameters were profoundly affected under the lowest system speed of 50% compared to the other two system speeds. On the other hand, different tillage methods showed highly significant effects on all crop growth parameters and in similar trend during both seasons, where treatment T1rankedfirst and T3 came last. With regard to alfalfa yield attributes, the system speeds had

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highly significant effects ($p \leq 0.01$) on the fresh and dry weights during both seasons with the effects being more pronounced with decreasing speed. In as far as the tillage methods were concerned, the treatment T1 recorded the highest yield (15.05 ton/ha) as compared to other tillage methods. Moreover, the water use efficiency was statistically affected by system speeds and tillage methods the highest value was observed under the system speed 50% and tillage method T1.Nevertheless,the interaction between different system speeds and tillage methods showed no significant effects on water use efficiency, growth and yield parameters of alfalfa crop.

Keywords: Center pivot, speed, tillage, Lucerne.

INTRODUCTION

As technology has improved, the technology of modern irrigation has come about with the invention of sprinklers which reduced the amount of water being lost to the environment through evaporation and increased production of irrigated crops. Proper irrigation systems are essential for maximum production of crops with ideal land preparation systems. Unevenness of the soil surface has a major impact on germination, stand and yield of crops through nutrients, water interaction and salt and soil moisture distribution pattern. Land leveling is precursor to good agronomic, soil and management practices. Soil physical and biological characteristics are influenced by tillage practices, which in turn lead to alter plant growth and yield (Wasaya *et al*., 2011; Rashidi and Keshavarzpour, 2007). Effective land leveling reduces the work involved with crop establishment and management (Kumari. *et al*., 2017). The technology of laser land leveling is not only very effective, but also is meant to optimize water-use efficiency, better distribution of soil moisture, improve crop establishment, reduce the irrigation time and save irrigation water and effort required to manage crop and reduce spatial variability (Rickman, 2002). Laser Land leveling is one such important technology for using water efficiently as it reduces irrigation time and enhances productivity not only of water but also of other non-water farm inputs. leveling of farmer's field is an important process in the preparation of land. It enables efficient utilization of scarce water resources through elimination of unnecessary depression and elevated contours (Nareshz *et*

al., 2014). It has been noted that poor farm design and uneven fields are responsible for 30% water losses (Asif *et al*., 2003).Virupakshagowda*et al*. (2015) reported that water use of alfalfa is very high because it has a long growing season. It is undeniable that alfalfa production requires large amounts of water (Oroff, *et. al.*, 2005). Therefore, the objectives of this study were to evaluate the effect of different system speeds and tillage methods using some plant-growth parameters and yield.

MATERIAL AND METHODS

The experimental work was carried out at the Jordanian Bashair Project located 15 km south of Eldamar city, River Nile State (longitude 33º 50' E, latitude 17º20′ N) in an area of 2.25 ha during two consecutive seasons (2018/2019) and 2019/2020. The region is arid with great variation in temperature and rainfall. The historical weather data indicated that the weather is very hot (maximum temp. 44^0) in summer and very cold (minimum temp. 13^0) in winter. The soil of the location of the experiment is sandy clay loam with high percentage of sand. Weather data, including wind speed, temperature, relative humidity, and solar radiation, were collected from Hudeiba meteorological station approximately 15 km away from the study field.

The experiment was arranged in a split plot design with three replications. The indicator plant used was alfalfa. Three system speeds (50%, 70%, and 100%) were assigned to the main plots and the subplots being tillage operations which were chisel ploughing with disc harrowing and laser levelling T1, chisel ploughing with disc harrowing followed by traditional levelling T2 and chisel ploughing with traditional levelling T3.

A nine spans 120 hp diesel engine493 m long centre pivot irrigation system of El Khureif make was supplied with water by an Italian 90 kW electric motor pumpfrom the River Nile through an earth channel.

Agronomic data collected were: plant height, number of leaves per plant, fresh and dry yield per hectare.
The statistical package SAS™ (Statistical Analysis System computer program Software) (SAS Institute, Cary, NC, USA), version 2004 was used to analyse the collected data. The treatments were subjected to the

analysis of variance (ANOVA) procedure, while the difference among the means of the treatments was determined using the least significant differences (LSD) procedure at 0.05 probability level.

RESULTS AND DISCUSSION

Number of leaves per plant and stem diameter were significantly affected by system speeds (Tables1 and 2) while no effect was shown on plant density and height. Generally, the positive effect on plant parameters increased with the decrease of the center pivot system speed. The highest stress was clearly observed with 100% speed of the system and the lowest with 50% speed. These results were in conformity with the findings of Olanrewaju *et al*. (2009) who found that plant growth was highest under the 50% system speed.

Table (3) exhibits clearly that the different tillage methods had highly significant effect on all crop growth parameters where treatmentT1 was ranked first and treatment T3 came last. On the other hand, soil leveling and low system speed exhibited favorable role on the uniformity of irrigation distribution inside the field and high water use efficiency (Fig.1) thereby, resulting in highly significant effect ($P \leq 0.01$) on crop growth and yield parameters where treatment T1 was ranked first and T3 the lowest (Table 4).These results were in agreement with the findings of Ali *et al*., (2018).

These results may be due to the unevenness of land caused by traditional leveling of fields which leads to inefficient use of irrigation water with more spatial variability of moisture and nutrients.

Table 1. Effect of center pivot system speed on alfalfa growth parameters

System speeds (%)	Plant density (No. of plant/m^2		Plant height (cm)		No. of leaves/plant		Stem diameter (mm)	
	Season 1 (Ns)	Season 2 **	Season 1 **	Season 2 **	Season 1 **	Season 2 **	Season 1 **	Season 2 **
50	709.78	714.67	44.667	46a	113.556a	109.556a	2.4078a	2.4078a
70	694.22	709.78	43.556	43.333ab	102.778b	108.333a	2.0878b	2.0878b
100	684.89	693.33	43.444	40.778b	99.333b	96.111b	2.0167b	2.0167b
LSD	91.65	77.42	3.57	3.36	11.71	10	0.21	0.21
C.V	12.81	10.67	7.93	7.54	10.84	9.31	12.2	12.2

Means followed by the same letters (in a column) are not significantly different at P≤ 0.05.
*, ** Significant at P≤ 0.05 and P≤ 0.01, respectively.
NS = not significantly different at P≤ 0.05.

Table 2. Effect of the system speed on fresh and dry weight of alfalfa (ton/ha).

System speeds (%)	Fresh weight **		dry weight **	
	Season 1	Season 2	Season 1	Season 2
50	14.827a	12.1111a	2.9378a	2.88a
70	10.969b	11.3911a	2.5022b	2.8578a
100	8.316b	7.2533b	2.0444c	1.8933b
LSD	2.61	1.62	0.39	0.37
C.V	22.37	15.46	15.48	14.18

Similar significant (P>0.01) effects of tillage methods on the fresh and dry weight are also presented in Table (4). The various tillage methods had significant effects on the fresh and dry weight where treatment T1 was ranked first then with a descending order to treatment T3. The higher value recorded by (T1) may be attributed to intensive crop canopy which enhanced water infiltration and promoted root growth and reduced water losses through evaporation. On the other hand, treatment T3 was observed to contribute to soil roughness and low number of crop tillers. These results were in line with those found by Halvorson, *et al*. (2001) who revealed that soil tillage practice was one of the most important factors which had a positive influence on the crop yield. Furthermore, similar results were reported by Bahnas and Bondok (2008) in that, the crop yield was affected significantly by the laser land leveling.

Table 3. Effect of tillage methods on alfalfa growth parameters

Tillage	Plant density (No. of plant/m^2		Plant height (cm)		No. of leaves/plant		Stem diameter (mm)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
T1	834.67a	848.89a	50a	49.22a	125.11a	123.56a	2.48a	2.49a
T2	704b	669.78b	44.78b	42.33b	104.89b	106.89b	2.3a	2.3 a
T3	550.22c	599.11b	36.89c	38.56c	85.67c	85.56c	1.73b	1.73b
LSD	91.65	77.42	3.57	3.36	85.67	10	0.27	0.27
C.V	12.81	10.67	7.93	7.54	85.667	9.31	12.2	12.2

(T1) = Chisel plough with disc harrow and laser levelled
(T2) = Chisel plough with disc harrow followed by traditional levelling and,
(T3) = chisel plough with traditional levelling.

Table 4. Effect of tillage methods on the yield parameters of alfalfa.

Tillage	Fresh weight (ton/ha)		dry weight (ton/ha)	
	Season 1	Season 2	Season 1	Season 2
T1	15.938a	14.1778a	3.2711a	3.3422a
T2	10.649b	9.6978b	2.2978b	2.3511b
T3	7.524c	6.88c	1.9156b	1.9378c
LSD	2.61	1.62	0.39	0.37
C.V	22.37	15.46	15.48	14.18

Analysis of variance showed that tillage methods had significant effect on water use efficiency during the two growing seasons as presented in Fig.(2). The higher water use efficiency was obtained by the tillage method T1 while tillage method T3 had little effect on the crop water use efficiency. In general, the higher values of water use efficiency under T1 are attributed to the availability of moisture by the improved soil water storage capacity. This result was in line with the findings of Johnson, *et al*. (2018), Attafy, *et al*., (2017) and Reddy (2013) who stated that water use efficiency was significantly affected by tillage methods.

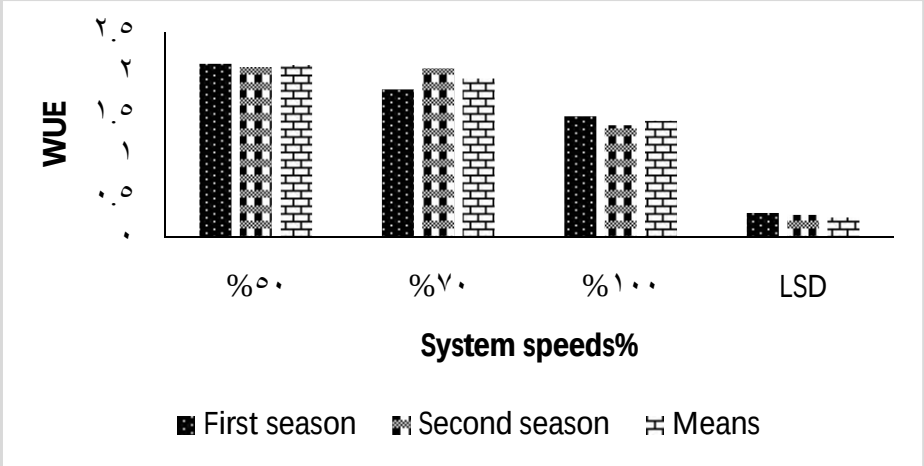

Fig.1. Effect of system speeds% on water use efficiency

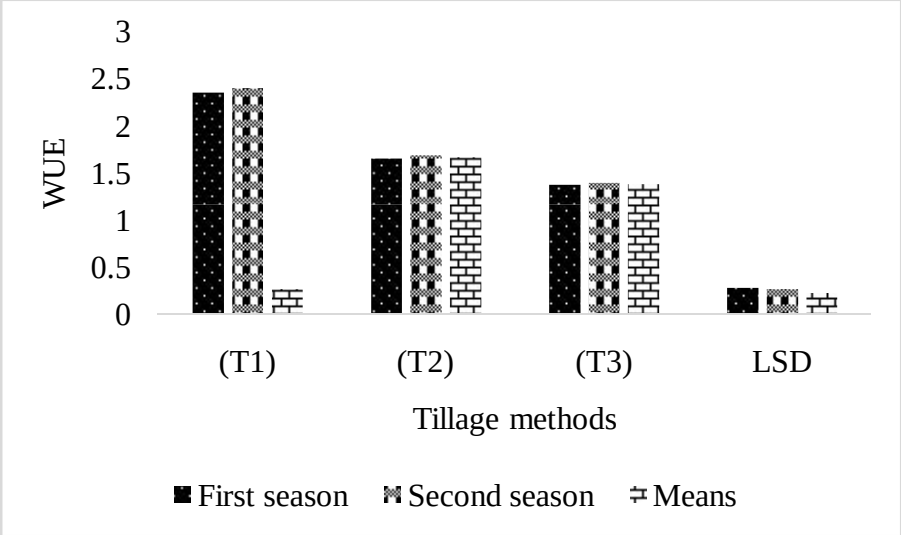

Fig. 2. Effect of tillage methods on water use efficiency

CONCLUIONS

From this study the following points of conclusion can be drawn:

1- Alfalfa fodder crop can be grown successfully under center pivot irrigation system in dry condition such as that of the River Nile State of Sudan.

2- The general trend observed that all measured parameters were increased as the system speed% decreased except scheduling coefficient which increased as the system speed% increased.

3- The crop growth and yield parameters will be improved substantially provided that :

   i- The center pivot system is run at low speed within the range of 50% after the crop is well established to ensure provision of optimum crop water requirement and high water use efficiency.

   ii- Precise land leveling after tillage operation is a precursor for best crop establishment.

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تأثير سرعات جهاز الرى المحورى و طرق الحراثةعلى انتاجية البرسيم (*Medicago sativa*) تحت ظروف الاراضى الجافة بولاية نهر النيل – السودان

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مستخلص البحث :اجريت التجربة بمشروع بشائر الاردنية الذي يقع جنوب مدينة الدامر لولاية نهر النيل (خط طول 33°_50 ق ، خط عرض 17°_20ش) وبارتفاع 314 متر فوق متوسط سطح في مساحة 2,25 هكتار لموسمين متتاليين (2018-2019) و(2019-2020). وقد كانت اهداف البحث دراسة تأثير السرعات المختلفة وطرق الحراثة علي نمو وانتاج البرسيم. اشتملت المعاملات علي سرعات مختلفة (50% ، 70% ، 100%) وطرق حراثة مختلفة (محراث ازميلي مع امشاط قرصية تم تسوية بالليزر (T1) ومحراث ازميلي مع امشاط قرصية وتسوية تقليدية (T2) ومحراث ازميلي مع تسوية تقليدية (T3). رتبت المعاملات بنظام القطع المنشقة وفق تصميم القطاعات العشوائية الكاملة و بتكرار تداخل العوامل 3 مرات حيث خصصت القطع الرئيسية لسرعات النظام الرى المحورى بينما القطع المنشقة لطرق الحراثة . ولاظهار النتائج تم تحليل البيانات باستخدام برنامج الحاسوب للحزم الاحصائية (SAS) بينما تم استخدام اختبار أقل فرق معنوي لفصل المتوسطات اظهرت النتائج عدم تأثر كثافة وطول النباتات بسرعات النظام بينما تأثرت عدد الاوراق في النبات وقطر الساق معنوياً عند مستوي معنوية ($p \leq 0.05$)بسرعات النظام .في كل معايير النمو النباتية سجلت سرعة النظام 50% اعلي قيم. طرق الحراثة المختلفة كان لها اثر معنوي كبير علي كل قياسات نمو النبات خلال الموسمين وبنفس المؤشر طريقة الحراثة (T1) تصدرت المرتبة الاولي بينما طريقة الحراثة (T3) اتت في المؤخرة .من خلال نتائج البحث اتضح ان سرعات النظام لها تأثير معنوي كبير عند مستوي معنوية ($p \leq 0.01$) علي الوزن الرطب والجاف لنبات البرسيم في كل موسم اعطت سرعة النظام 50%اعلي قيمة للوزن الرطب والجاف ، عموما يزداد الانتاج كلما قلت السرعة

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بالاضافة الي ذلك تأثرت معايير الانتاج السابقة معنويا بانظمة الحراثة ، نظام الحراثة (TI) ، اعطي اعلي قيمة مقارنة بطرق الحراثة الاخري. كفاءة استخدام المياه تأثرت احصائياً بسرعات النظام % وطرق الحراثة . اعلي قيمة لكفاءة استخدام المياه تم الحصول عليها عند سرعة 50% وطريقة الحراثة (TI).