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Full Length Research Paper

Effect of Two Sprinkler Irrigation Types on Coefficient of Variation (CV) and Some Quality Properties of Grain Wheat

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Two field experiments were conducted in two successive season at two sites El-Emam Malek Village and NRC Farm (according to the cultivation periods), Nubaria, Behaira Governorate to study the effect of two types of sprinkler irrigation system and three water amount on Coefficient of variation (CV) and water productivity (WP) of wheat crop (*Triticumaestivum L. cv. Gemmaiza 9, Varity*). The results could be summarized as following: Coefficient of variation (CV) had been practical evaluated in the two experimental fields for two irrigation systems types under studying and resulted were 16.7 and 32.5 under using Permanent and Simi portable sprinkler irrigation systems, respectively. The effects of the sprinkler irrigation type on all studied of quality parameters were significant at the 5% level except seed index. Decreasing the irrigation water from I_{100} to I_{75} or I_{50} had positive effects on % net flour, % of grain protein, % of fat and % of total sugar. Differences in most parameters among treatments were significant at the 5% level. Moving the lateral lines in SPS system after irrigation each 4 days in a wet soil caused soil compaction, poor aeration and root growth impedance. The better production of in grain wheat quality under experiment conditions was in the second season 2012/2013. The permanent sprinkler system gave the highest grain wheat quality.

Keywords: Sprinkler, Semi-portable, Permanent, CV, Wheat, quality.

INTRODUCTION

The coefficient of variation (CV) in application volume can be computed as the standard deviation of all catch can measurements divided by the average catch can volume for a test. Both DU_{lq} and CU have been related to the CV analytically (Warrick, 1983) and verified experimentally on center pivot and linear move irrigation machines (Heermann et al., 1992; Dukes, 2006).

The uniformity of sprinkler irrigation is a central design goal (Keller and Bliesner, 2000). Uniformity of water application is sought to minimize variability of crop yield, or plant quality in the case of turfgrass and landscapes. The catch can test is a commonly used measurement tool to assess the uniformity of sprinkler systems. Standards have been developed for center pivot and linear move irrigation machines (ASAE, 2001) and testing protocols have been developed for turfgrass and landscape irrigation (IA, 2005). Once the data are collected by catch cans, a number of different calculations can be performed. A common measurement of variability in water application on turfgrass

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and landscapes include the low quarter distribution uniformity (DU_{lq}).

Mateos et al. (1997) found that the CV of infiltrated water was one-third of the applied water as measured by catch cans under sprinkler irrigation. Sprinkler uniformity below the canopy of winter wheat was improved compared to the uniformity of application as measured above the canopy (Li and Rao, 2000). This finding indicates that the canopy can redistribute water to achieve improved uniformity before redistribution within the root zone is considered. Stern and Bresler (1983) found that the CV of catch can data was two to three times higher than soil water CV in the top 40 cm one day after sprinkler irrigation on sand and sandy loam soils. Since there was no runoff, the authors speculated that the high soil water uniformity was due to redistribution within the soil profile. Li and Kawano (1996) evaluated sprinkler uniformity and soil water uniformity on a bare volcanic soil (0.74 g/cm3 bulk density, saturated water content of 0.64 m3 /m3) and a bare sandy loam (1.2 g/cm3 bulk density, saturated water content of 0.40 m3 /m3).

Although there has been much work relating irrigation uniformity to yield analytically (Letey et al., 1984; Stern and Bresler, 1983; Varlev, 1976; Seginer, 1979 to name a few) or with simulation models (Mantovani et al., 1995; Pang et al., 1997), there are fewer studies that have measured the influence of uniformity on crop yield. Application CV as high as 0.48 did not influence yield of cotton compared to uniformly irrigated (CV = 0.20) plots (Mateos et al., 1997). Although the authors speculated that part of the reason for no influence on yield was because cotton is a drought tolerant crop, the CV of applied water was 2-4 times higher than the CV of infiltrated water. The yield of winter wheat did not vary when irrigated with different sprinkler irrigation uniformity treatments with seasonal CU ranging from 72% to 84% Li et al. (2005). The authors speculated that uniformity of sprinkler irrigation may have not impacted results in this project due to redistribution of applied water via canopy interception, redistribution of water in the soil, the extensive root system of wheat, and adequate rainfall over the crop season. However, these results may not apply to shallow rooted crops. In another study on winter wheat, Li and Rao (2003) found that yield was not influenced by sprinkler CU ranging from 62% to 82%. Ayers et al. (1990) found that nonuniformity as low as CU = 60% in a width of six to nine rows was insufficient to negatively impact sugar beet yield on a silty clay loam soil due to water redistribution within the soil. However, they found that nonuniformity at the same level (CU = 60%) across 16 to 24 rows reduced average yield.

Ortega Alvarez et al. (2004), in study of set sprinkler irrigation system in semi-arid region of the Spain reported that economic benefit for barely, maize, garlic, onion crops will attain with high uniformity coefficient (90 %). Colaizzi et al. (2005) in study of water use efficiency in sprinkler and trickle irrigation systems reported that trickle irrigation is the best system according to this index. Grassini et al. (2011) in study of agronomic practices impacts on maize yield reported that applied irrigation water was 41 and 20% less under pivot and conservation tillage than under surface irrigation and conventional tillage, respectively.

Aim of this research work is evaluating the effect of two types of sprinkler irrigation systems and different water amounts through two growing seasons on coefficient of variation for quarter distribution uniformity and some wheat yield quality parameters at western Egyptian desert.

MATERIALS AND METHODS

Two field experiments were carried out in two successive season at two sites El-Emam Malek village and NRC Farm (according to the cultivation periods), Nubaria, Behaira Governorate, the study area located to the west of the Nile Delta between latitudes 30° 31'44" & 30°36'44"N and longitudes 30°20'19" & 30°26' 50"E to study the effect of two types of sprinkler irrigation system and different water amount on vegetative growth, WUE, and yield of wheat crop (*Triticumaestivum* L. *cv. Gemmaiza 9,* Varity)

Coefficient of variation (CV)

The uniformity of sprinkler irrigation system can be expressed using the coefficient of variation (CV).

The statistical uniformity (SU) can be expressed by (ASAE, 1993b):

$$SU = 100\,(1 - CV) \qquad (1)$$

The SU is usually used to represent the uniformity of micro-irrigation systems, such as drip and micro-spray systems. The CU and DUlq can also be expressed in terms of CV if a normal distribution is assumed for the distribution of water. These are the statistically derived estimates for the uniformity.

The statistical estimates for the coefficient of uniformity (SCU) and the low quarter distribution uniformity (SDUlq) are given by (Burt et al., 1997):

$$SCU = 100\,(1 - 0.798\,CV)\ \% \qquad (2)$$

$$SDU_{lq} = 1 - 1.27\,CV \qquad (3)$$

In Eq. (2) and Eq. (3) the CV is a ratio and not a percentage.

Table 1: Soil properties of the studies sites.

Site	pH	EC dSm^{-1}	OM	$CaCO_3$	(Soil water content %vb)		
			%		FC	WP	AW
Emam Malek	**8.1**	**2.3**	**0.5**	**5.6**	**9.5**	**3.6**	**5.9**
NRC Farm	**8.2**	**2.6**	**1.3**	**3.8**	**12.6**	**4.7**	**7.9**

pH: (1.25), EC: electrical conductivity in the extracted soil paste, OM organic matter, FC: field capacity, WP: wilting point, AW available water, vb volume basis.

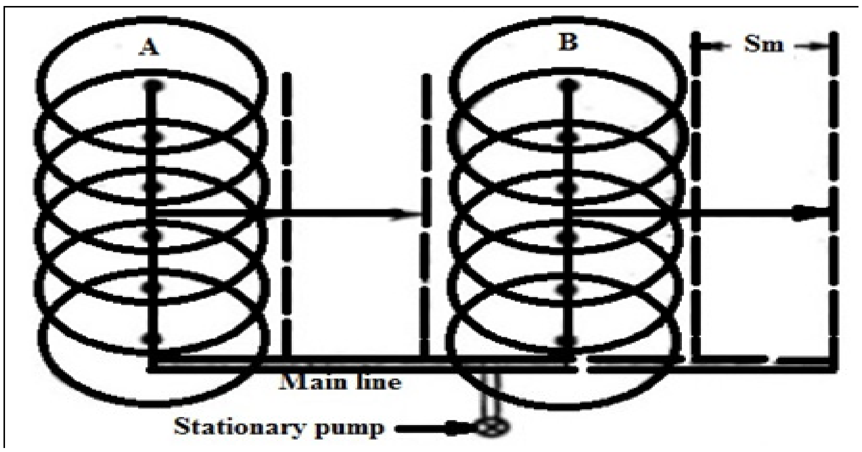

Figure 1: Semi portable sprinkler irrigation system

Evaluation steps of two types of sprinkler irrigation systems under studying

Every sprinkler irrigation system under study was practical evaluated in the two different farms using 20 catch can containers. The depth caught in each container is given below as showing in Table (3) in results partition.

Soil, Water, Plant Properties Measurements

Some soil physical, chemical and water properties of the studied soil are carried out after (Klute, 1986) and moisture retention at field capacity and wilting point after(Rebecca, 2004). Soils of both investigated sites were sandy loam in texture. Some soil chemical characteristics of the studied two sites were recorded in Table 1. Analysis farmyard manure used in the experiments was as follow: 4.85 dSm^{-1} (EC, 1:20), 7.77 (pH, 1:20), 11.2% (OM), 5.4, 0.85 and 1.12% total (N, P and K) and 1:16.5 (C:N ratio).

Wheat Farming Operations

The experiment design was randomized complete block in two factors with three replicates. The area of the experimental plot was 12 × 14 m^2 (0.04 feddan). Farm-yard manure had been added at the rate of 10 m^{3}fed^{-1}. The organic manure was thoroughly mixed with 0 - 30 cm of the surface soil layer before planting. Applied fertilizers were 100 kg Superphosphatefed^{-1} (15.5% P2O5) and 50 kg K2Ofed^{-1} (potassium sulphate 48% K2O) were added and mixed well before planting as well as addition recommended dose of nitrogen (100 kg Nfed^{-1}) in two equal doses, 4 and 10 weeks after completely germination. Wheat grains (*Triticumaestivum* L. *cv.* Gemmaiza 9) were broadcasted on the soil at the rate of 100 kg/fed. At the maturity stage, the plants were harvested and separated into grains and straw.

Production was recorded and prepared for analysis. Soil samples 0 - 20 cm) were taken after wheat harvest for determine some soil hydro-physical and chemical characteristics such as soil bulk density (gm/cm^{-3}), (Rebecca, 2004). Soil hydraulic conductivity (HC) was measured in the laboratory under a constant head technique (Klute and Dirksen, 1986) using the following formula:

Components of sprinkler irrigation system

The components of portable sprinkler system used are shown through Figure No.1 sprinkler system usually consists of the following components

(i) A pump unit(50 m^3/h)

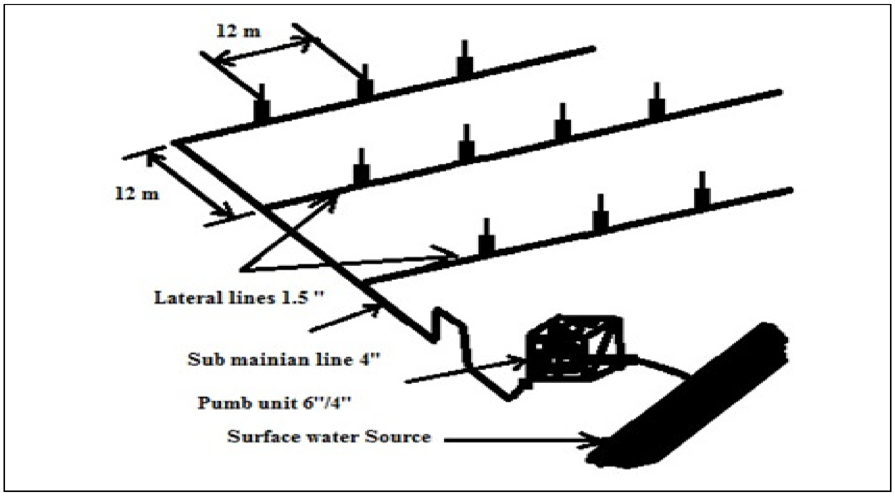

Figure 2: Permanent sprinkler irrigation system

Table 2: Water requirements for wheat crop at Nubaria sites, Egypt

Month	**Dec**	**Jan**	**Feb**	**March**	**April**	**May**
Days	**31**	**31**	**29**	**31**	**30**	**31**
ET (mm/day)	2.8	6.3	5.9	4.2	7.4	2.0
Kc	0.4	0.4	0.8	1.3	0.5	0.4
ETc(mm/day)	1.1	2.5	4.7	5.4	3.7	0.8
Growth stage	**Planting (Establishment)**	**Rapid vegetative growth**		**Flowering seed fill**	**Maturity and harvesting**	
IRn(mm/month)	33.1	77.6	136.4	167.5	111.1	24.9
IRg (mm/month)	36.4	85.3	150.0	184.4	122.0	27.4

IRn= Net irrigation requirements, IRg= Gross irrigation requirements

(ii) Tubings- main/submains and laterals (inside diameters are 150, 110, 90 mm, respectively.

(iii) Couplers

(iv) Sprinker head (l/h)

(v) Other accessories such as valves, bends, plugs and risers.

Semi portable system: The semi portable system used is similar to the portable one except that the location of water source and pumping plant is fixed.

Permanent system: A fully permanent system consists of permanently laid mains, sub mains and laterals and a stationery water source and pumping plant.

Sprinkler Irrigation System and water requirements

Irrigation water was applied using sprinkler irrigation system by fixed lateral lines 1.5 inch in diameter distances between sprinkles on the same lateral and among lateral lines were 12 m, Risers height were 1.0 m, sub main and main lines were 4 and 6 inches diameter, respectively. Mean of sprinkler discharge was1.2 m^3h^{-1}at mean operating pressure head of 2 bars. Mean of wind speed was 1.5 m sec^{-1}.

Number of sprinklers on every lateral line were 14. Irrigation Efficiency of systems used were 78 % for Semi portable system and 83% for permanent system. Irrigation water amounts were estimated using the reference evapotranspiration and crop coefficients after (Allen et al, 1998) while the irrigation timing was determined using a water balance, a common practice among. Intervals were 4 days for all treatments; calculated amount of water requirements was (550mm $season^{-1}$) 2310 $m^3fed^{-1}season^{-1}$.

Data were subjected to analysis of variance in randomized complete block design as factorial (two factors) and means were separated according to LSD test, correlation and multiple regressions were estimated after computer's program provided by using the SAS program (SAS Institute, 2001).

RESULTS AND DISCUSSION

1-Coefficient of variation (CV) of Permanent sprinkler irrigation system

Data in Table (3) showing the practical evaluation and collected data of sprinkler systems under study, we can using the data from Table (3) and Equations 1 and 4 as following to calculate % UC and % DU of permanent and Simi portable sprinkler irrigation systems.
d_{LQ} (Number of quarter cans ranked) = average of cans (1-5) of ascending ranked = 3.40
M = average of cans (1-20) = 4.46
D = average absolute |di-dz| = 0.6
Applying in Equation (1): UC = 100 (1-[D/M])
UC (%) = 100 (1 - [0.6 / 4.5] = 100 * 0.867 = 86.7 %
DU = Distribution Uniformity (%)
Applying in Equation (4): DU = (1.59) (UC) - 59 = (1.59 * 86.7) – 59 = 78.8 %
SDU_{lq} = 1 – 1.27 CV
0.788 = 1 – 1.27 CV
1.27 CV = 0.212
CV Permanent sprinkler irrigation system = 16.7

2-Coefficient of variation (CV) of Simi portable sprinkler irrigation system

d_{LQ} (Number of quarter cans ranked) = average of cans (1-5) of ascending ranked = 2.98
M = average of cans (1-20) = 3.91
D = average absolute |di-dz| = 1.0
Applying in Equation (1): UC = 100 (1-[D/M])
UC (%) = 100 (1 - [1.0 / 3.91] = 100 * 0.74 = 74.0 %
DU = Distribution Uniformity (%)

Applying in Equation (4)

DU = (1.59) (UC) - 59 = (1.59 * 74.0) – 59 = 58.7 %
SDU_{lq} = 1 – 1.27 CV
0.587 = 1 – 1.27 CV
1.27 CV = 0.413
CV of Simi portable sprinkler irrigation system = 32.5
Coefficients of variation (CV) had been practical evaluated in the two experimental fields for irrigation systems types under studying and resulted were 16.7 and 32.5 under using Permanent and Simi portable sprinkler irrigation systems, respectively. These acceptable results for the two sprinkler irrigation systems types under study according to Kunde, (1985), Solomon, (1983) and Solomon, (1987).

3-Main effects of treatments on the studied parameters

Data of Table (4) showed the main effect of wheat quality season 2011/2012, sprinkler system, and irrigation treatment on % net flour, % of grain protein, % of fat, % of total sugar.

According to the values of all the studied parameters, the growing seasons could be put in the following ascending order: 2011/2012 < 2012/2013. Differences in the parameters values between the two seasons were significant at the 5% level. Also, the irrigation systems types could written in the following ascending order: SPS < PS. The effects of the sprinkler irrigation type on all studied parameters were significant at the 5% level except seed index.

Decreasing the irrigation water from I_{100} to I_{50} had positive effects on (% net flour, % of grain protein, % of fat, % of total sugar). Irrigation treatments could be arranged in the following ascending order: $I_{100}< I_{75}< I_{50}$ and $IR_{50}< IR_{75}< IR_{100}$ for (% net flour, % of grain protein, % of fat, % of total sugar) and the other parameters, respectively. Differences in most parameters among treatments were significant at the 5% level. The exceptions were between irrigation treatments (I_{100} ; I_{75}) and (I_{75} ; I_{50})in the case of seed index and $(WUE)_g$, respectively.

4. Interaction effects of the treatments

Table (5) indicated that the interaction: Sprinkler irrigation type X water amount 5 of ETo have significant effects on % net flour, % of grain protein, % of fat and % of total sugar the 5% level. The maximum and the minimum values were obtained from the interactions: PS X I_{100} and SPS X I_{50} in both seasons 2012 and 2013, respectively. Taking in to consideration the effect of irrigation treatments on soil moisture stress before the next irrigation they could be arranged in the following ascending order: $I_{100}< I_{75}< I_{50}$ and the cumulative effect of soil moisture stress increased with time from germination to maturity. These acceptable results for the two sprinkler irrigation systems types under study according to Tayel *et al.,* 2014, Mansour, 2006, Mansour, 2012, Mansour, H. A., M. Abd El-Hady (2014) and Mansour *et al.* 2015b.

Therefore the date on hand could be due the following factors

The increase in soil moisture stress in the root zone has a depressive effect on lower leaves firing and tillering, Lower leaves firing and decreasing tillering led to lower photosynthesis process and subsequently all the studied parameters, At the time of flowering root growth may be very much reduced by soil moisture stress and may even cease and considerable damage can be caused leading to yield loss. Farmers have to put in mind that this loss cannot be recovered by providing adequate water supply during the later growth period.

Pollen formation and fertilization can be seriously affected under heavy soil moisture stress, During the time of head development and flowering, water shortage will reduce both heed No./plant, head length and grain No./head, Water deficit during the yield formation caused

Table 3: Practical evaluation parameters of permanent and Simi portable sprinkler irrigation systems

CAN No.	Permanent sprinkler irrigation system			Simi portable sprinkler irrigation system		
	Water depth(cm)	di (Ascending Ranked)	Absolute |di-dz|	Water depth(cm)	di (Ascending Ranked)	Absolute |di-dz|
1	4.5	2.8	1.7	5.1	2.4	0.6
2	4.9	3.3	1.2	3.3	2.8	0.2
3	4.1	3.5	1.0	4.2	3.2	0.2
4	5.3	3.6	0.9	3.8	3.2	0.2
5	4.7	3.8	0.7	4.1	3.3	0.3
6	3.5	4.1	0.4	4.7	3.5	0.5
7	5.6	4.2	0.3	2.8	3.6	0.6
8	3.8	4.3	0.2	2.4	3.7	0.7
9	4.8	4.4	0.1	4.5	3.8	0.8
10	4.4	4.5	0.0	3.6	3.8	0.8
11	4.6	4.6	0.1	3.7	4.1	1.1
12	5.3	4.7	0.2	4.2	4.1	1.1
13	3.3	4.8	0.3	3.2	4.2	1.2
14	2.8	4.8	0.3	5.1	4.2	1.2
15	5.1	4.9	0.4	3.8	4.2	1.2
16	4.2	5.1	0.6	4.2	4.5	1.5
17	4.3	5.3	0.8	3.5	4.7	1.7
18	4.8	5.3	0.8	4.8	4.8	1.8
19	3.6	5.6	1.1	4.1	5.1	2.1
20	5.6	5.6	1.1	3.2	5.1	2.1
Average	**4.46**	**Quarter Avg. (1-5)=3.4**	**0.6**	**3.91**	**Quarter Avg. (1-5)=2.98**	**1.0**

Table 4: Effect of different sprinkler irrigation systems and different water amounts on wheat flour quality properties 1st season (2012)

Sprinkler System (%)	Water amount (% from ETo)	% of net flour	% of grain protein	% of fat	% of total sugar
Semi portable system	**100**	71.21	8.03	1.81	0.92
	75	70.65	8.16	1.7	0.88
	50	69.32	11.02	1.64	0.64
Mean		**69.83**	**9.61**	**1.67**	**0.74**
Permanent system	**100**	73.35	9.25	2.13	1.24
	75	72.42	9.36	2.05	1.15
	50	71.36	12.45	1.82	0.72
Mean		**71.83**	**9.71**	**1.86**	**0.93**
Mean		**70.83**	**9.66**	**1.77**	**0.84**
Mean	**100**	**72.28**	**8.64**	**1.79**	**1.08**
	75	**71.54**	**8.76**	**1.88**	**1.02**
	50	**70.34**	**11.76**	**1.73**	**0.68**
$LSD_{0.05}$ for Irrigation Systems Mean		**1.24**	**0.53**	**0.25**	**0.18**
$LSD_{0.05}$ for WR Mean		**0.52**	**0.11**	**0.08**	**0.05**
$LSD_{0.05}$ for Interaction		**1.36**	**1.03**	**0.11**	**0.09**

Table 5: Effect of different sprinkler irrigation systems and different water amounts on wheat flour quality properties 2nd season (2013)

Sprinkler System (%)	Water amount (% from ETo)	% of net flour	% of grain protein	% of fat	% of total sugar
Semi portable system	**100**	72.65	9.15	2.58	1.28
	75	71.58	9.56	2.14	1.15
	50	70.32	12.25	1.86	0.97
Mean		**71.12**	**10.86**	**2.08**	**1.07**
Permanent system	**100**	74.69	10.36	2.96	1.43
	75	73.58	10.74	2.64	1.26
	50	72.24	13.59	2.12	1.09
Mean		**72.51**	**10.94**	**2.38**	**1.2**
Mean	**100**	**73.67**	**9.76**	**2.77**	**1.36**
	75	**72.58**	**10.15**	**2.39**	**1.21**
	50	**71.28**	**12.92**	**1.99**	**1.03**
$LSD_{0.05}$ for Irrigation Systems Mean		**1.25**	**0.87**	**0.28**	**0.08**
$LSD_{0.05}$ for WR Mean		**0.76**	**0.31**	**0.12**	**0.07**
$LSD_{0.05}$ for Interaction		**1.11**	**1.21**	**0.12**	**0.02**

Table 6: Main effect of sprinkler system and water amount on wheat flour quality

Treatments	% of net flour	% of grain protein	% of fat	% of total sugar
2012	70.83e	9.66e	1.77e	0.84f
2013	71.82d	10.90b	2.23b	1.14b
SPS	70.78f	10.24d	1.88d	0.91d
PS	72.17b	10.33c	2.12c	1.07c
100	72.98a	9.20g	2.28a	1.22a
75	72.06c	9.46f	2.14c	1.12b
50	70.81e	12.34a	1.86d	0.86e

SPS: Simi portable sprinkler irrigation system and PS: Permanent sprinkler irrigation system.

grains shriveling and grain weight reduction, The climate was hot in addition to hotter and stronger wind during the yield formation in season 2012 relative to season 2013, The residual effect of the manure added in the 1st year extended to the 2nd one, The SPS system resulted in undesirable mechanical damage of some wheat plants, Moving the lateral lines in SPS system after irrigation each 4 days in a wet soil caused soil compaction, poor aeration and root growth impedance, Under both SPS and dense and to some extent high wheat plant we do expect lower water distribution uniformity due to the difficulty in straight forward lateral lines a lining and watching water leakage from the joints, and % net flour, % of grain protein, % of fat and % of total sugar of SPS < PS.

CONCLUSION

It could be concluded that:

Coefficients (CV) had been practical evaluated in the two experimental fields for irrigation systems types under studying and resulted were 16.7 and 32.5 under using Permanent and Simi portable sprinkler irrigation systems, respectively. The effects of the sprinkler irrigation type on all studied of wheat flour quality parameters were significant at the 5% level. Decreasing the irrigation water from I_{100} to I_{75} or I_{50} had positive effects on % net flour, % of grain protein, % of fat and % of total sugar. Differences in most parameters among treatments were significant at the 5% level. Moving the lateral lines in SPS system after irrigation each 4 days in a wet soil caused soil compaction, poor aeration and root growth impedance. The better production of in grain wheat quality under experiment conditions was in the second season 2012/2013. The permanent sprinkler system gave the highest grain wheat quality.

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