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Effect of Skipping One Irrigation on Growth and Yield of Two Sorghum Hybrids

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TWO FIELD experiments were conducted during the two summer seasons of 2000 and 2001. The trial was carried out in a private farm at Ebshway district, El Fayoum Governorate, Egypt. The effect of skipping one irrigation at 35,50 ,65 or 80 days after planting on physiological and yield characters of two sorghum (*Sorghum bicolor* (L.) Moench) hybrids was examined. Horus hybrid surpassed significantly Mena in all studied characters except for harvest index. Normal treatment which gave 6 irrigations (control) produced significantly the tallest plants, the heaviest TDW, highest leaf area (LA), leaf area index (LAI), and seed index , also, the greatest grain and biological yields /fed. The greatest harvest index was recorded by skipping the 5^{th} irrigation. Concerning growth characters (RGR), (CGR) and (NAR), skipping the 3^{rd} irrigation gave the best results. Interaction between hybrids and skipping irrigation recorded significant differences for all studied characters except for (LAI). Interaction between Horus hybrid and control which gave 6 irrigations significantly surpassed the other interactions for all studied characters except for harvest index. Interaction between Mena hybrid and skipping 5^{th} irrigation gave the best harvest index.

Keywords: Sorghum hybrids, Skipping irrigation, Growth analysis characters, Yield.

Sorghum (*Sorghum bicolor* L.. Moench) is the fifth leading cereal crop in total world production after rice, wheat, corn and barley and is typically grown under hot- dry conditions. The global sorghum cultivated area were 44.23, 42.13 and 43.91 million hectare in the latest three years 2001, 2002 and 2003 (FAO-Faostat, 2004).

It provides the staple diet for low income groups of Africa. In Egypt sorghum is widely cultivated in 390, 357 and 384 thousand feddan in 2000, 2001 and 2002 seasons, 70% of these areas are cultivated in El Fayoum, Assiut and Sohag Governorates. Sorghum is a versatile plant which is grown for human consumption, animal feeds, poultry nutrition and for some industrial products (Gomaa, 1996). In Egypt the green plants after panicle harvest are used as animal forage in double use of short hybrids and varieties Also stems in tall varieties are used as inexpensive fuel, making farm wall and traverse wind.

The structure of the sorghum grains has been reviewed by Rooney & Clark, (1968). Neucere and Sumrell., 1980, it contained moisture 12-13.67% ; crude fat 2.66 –3.49% ; protein 9.9-14.32% and carbohydrate 67.91-73.3%.

The aim of work in Egyptian agriculture for sorghum was the expansion of growing short varieties and hybrids which have double use (grain + forage) and tolerate drought, salinity and low water requirements in low fertility soil. The Ministry of Agriculture in Egypt registered eight varieties and hybrids in 1999, season which contained 2 promising hybrids for double use (grain + forage) named Mena and Horus.

Under Egyptian conditions sorghum take six irrigations during the growing season which are greater than 2400 m^3/ feddan. So, selecting the appropriate hybrids to cultivated area and reducing water requirements for sorghum plants is one of the main objectives under Egyptian conditions.

Thus, the aim of this work was to examine the promising hybrids Mena and Horus under skipping one irrigation at different vegetative growth stages-booting- flowering or grain formation stages at El Fayoum, the first Governorate in Sorghum cultivated area in Egypt.

Material and Methods

Two field experiments were conducted in a private farm at Ebshway district, El-Fayoum Governorate, Egypt, during the summer season of 2000 and 2001.

Soil mechanical and chemical analyses are presented in Table 1 according to Chapman & Pratt (1978).

TABLE 1. Physical and chemical analysis of the experimental site at Ebshway district, El-Fayoum Governorate .

Sand %	Silt %	Clay %	Texture	Organic matter %	Ca Co_3 %	Ec m mhos /cm^3	P^H	N	P	K (ppm)	Na
52.5	20	27.5	Sandy Clay loam	0.84	20.9	2.9	8.02	74	4	0.28	15.62

Planting date was the first week of June in both seasons, the soil was ploughed twice, ridged and divided into experimental plots containing 5 rows 7m long and 0.60 m apart , the total area of each plot was 21m^2. The grains were planted in hills 0.20 m apart by afeer method (dry grain in dry soil).

At complete emergence (21 days after planting), plants were thinned and two plants per hill were left to grow. Nitrogen was applied at the rate of 90kg N/fed. in the form of ammonium nitrate 33% N in two portions before first and second irrigation. Phosphorus was applied at the rate of 31kg P_2O_5/fed. in the form of superphosphate during bed preparation. Potassium added at the rate of 24kg K_2O/fed. In the form of potassium sulphate before second irrigation. Irrigation was practised out at fifteen days intervals and stopped 20 days before harvest. Harvest date was 115 days after planting.

The treatments were the combinations between two factors, hybrids and skipping irrigation

Hybrids were Mena and Horus.

Skipping irrigation treatments were :

1. control - given 6 irrigations (21-35-50-65-80-95 days from sowing).
2. Skipping 2^{nd} irrigation at 35 DAP (vegetative growth stage).
3. Skipping 3^{rd} irrigation at 50 DAP (booting stage-panicle extended into flag leaf sheath).
4. Skipping 4^{th} irrigation at 65 DAP (flowering stage – half bloom stage).
5. Skipping 5^{th} irrigation at 80 DAP (grain formation stage–soft dought stage).

The experimental design was split plot design with four replicates, hybrids were adopted in the main plots and skipping irrigation treatments in the sub plots (Table 2).

TABLE 2. Hybrids specification .

Charactes Hybrid	Plant height (cm)	Use	Panicle size	Flowering date(DAP)	Maturity date(DAP)	Grain colour	1000grain weight
Mena	150	Grain+ forage	Medium	65	110	White creamy	21-23g
Horus	165	Grain+ forage	Medium	75	120	Creamy	23-25g

TDW was determined at 90 DAP. For blade leaf area measurements, the disk method was used and calculations depended on the area- weight relationship.

The growth characters, *i.e.*, LA, LAI, NAR (mg/dm^2/ week), RGR (mg/g/week) and CGR (g/g/week) were computed according to the following formula (Watson, 1958).

LA = Total dry weight of leaves/plant X area of disk sample/dry weight of the same disk sample- at 90 DAP.

LAI = Unit leaf area/ unit ground area – at 90 DAP .

$NAR = (W_2 - W_1)(\log_e A_2 - \log_e A_1) / (A_2 - A_1)(T_2 - T_1)$.
$RGR = (\log_e W_2 - \log_e W_1) / (T_2 - T_1)$.
$CGR = (W_2 - W_1) / (T_2 - T_1)$

Where W_1, A_1 and W_2, A_2 refer to dry weight of the whole plant and leaf area at time T_1 and T_2 in week, respectively.

At harvest time 100 DAP the whole plot of main treatment were harvested to determine biological yield/fed. grain yield/ fed and harvest index (grain yield/ biological yield).

Statistical analysis

The standard analysis of variance for split plot design, combined analysis was conducted for the data of the two seasons according to Snedecor & Cochran (1990), means were compared by LSD at 5% level.

Abbreviations

DAP = Days After Planting (day). TDW = Total Dry Weight (g).
LA = Leaf Area (dm^2). LAI = Leaf Area Index.
RGR = Relative Growth Rate(mg/g/week). CGR=Crop Growth Rate(g/g/week).
NAR= Net Assimilation Rate (mg/dm^2/week) .

Results and Discussion

A- Effect of hybrids

Data presented in Table 3 show comparison between Mena and Horus sorghum hybrids in growth and yield .

Growth characters

Table 3 clear that Horus hybrid surpassed significantly Mena in all studied growth characters except for harvest index. LA of Horus was 28.70 dm^2 compared to 26.23 dm^2 for Mena also, LAI of Horus was 2.39 compared to 2.18 for Mena . Plants of Horus was taller than those of Mena. The supremacy of taller plants in LA and LAI in sorghum plants were also reported by El-Aref (1988) and Selim (1995), these results indicated that the tallest sorghum plants had the longest vegetative development period, which conclude that sorghum is suitable as grain and forage crop.

The data in Table 3 show differences in plant growth analysis characters between both hybrids. It is clear that regardless of irrigation skipping Horus surpassed Mena in RGR, CGR and NAR at 60-75 and 75-90 DAP. It might be concluded that the superiority in plant growth analysis of Horus may be due to the increment in leaf area and dry matter accumulation compared to Mena hybrid.

TABLE 3. Growth and yield of Mena and Horus Sorghum hybrids combined of 2000 and 2001 seasons.

Characters / Hybrid	Plant height cm	TDW g	Seed index	Garin yield ton/fed	Bio-yield ton/fed	Harvest index	LA dm^2	LAI	RGR mg/g/week		CGR g/g/week		NAR mg/dm^2/week	
									60-75 DAP	75-90 DAP	60-75 DAP	75-90 DAP	60-75 DAP	75-90 DAP
Mena	148.74	235	31.22	3.26	20.01	15.81	26.23	2.18	189.67	142.82	19.26	18.29	703.65	512.05
Horus	155.30	245	34.59	3.31	22.01	15.13	28.70	2.39	199.45	150.57	22.26	20.17	724.51	659.75
Mean	152.02	240	32.90	3.28	21.01	15.47	27.47	2.28	194.56	146.69	20.76	19.23	714.08	585.90
LSD 0.05	4.27	6.21	3.10	0.04	1.12	NS	0.81	0.03	3.70	2.90	2.20	1.30	8.50	50.21

Yield and yield components

Data presented in Table 3 show the same trend recorded in growth characters concerning the effect of hybrids on the yield and yield components. Plants of Horus significantly surpassed plants of Mena in seed index (g) also, they produced grain yield and biological yield greater than Mena hybrid with significant differences. On the other hand, Mena recorded greater harvest index than Horus with insignificant differences.

Superiority of Horus plants in yield and yield components may be due to their excellence in growth analysis characters, *i.e.*, RGR; CGR and NAR and the increment in leaf area and dry matter accumulation which in turn increased grain and biological yields.

B- Skipping irrigation

Growth characters

Table 4 and Fig.1 show that there were significant differences among skipping irrigation treatments for all studied characters. Skipping the third irrigation at 50 DAP gave the best result in RGR, CGR and NAR followed by control and the second irrigation. The decrease in growth characters due to skipping one irrigation were very small ranged from 0.18% to 5.47% in both periods 60-75 and 75-90 DAP. These result may be due to the tolerant of sorghum to drought especially Mena and Horus hybrids as a short and early mature hybrids.

Regardless of hybrids, data in Table 4 and Fig. 1 indicated significant differences in LA and LAI. Plants of control which gave 6 irrigations recorded the best LA and LAI, skipping the 4^{th} irrigation at 65 DAP came in the second order and skipping the 3^{rd} at 50 DAP the third. These results were in agreement with those obtained by Tarantino *et al.* (1992) and Ebel *et al.* (1994) who found that leaf area generally decreased as the amount of irrigation decreased but Bakheit (1990) and Mastroilli *et al.* (1995) reported that LAI was influenced by water stress before and during flowering period only, on the other hand, Refay (1989) stated that LA was not affected by irrigation rates.

Yield and yield components

Plant height · Data in Table 4 clear that normal irrigation treatment which gave 6 irrigations produced the tallest plants 157 cm followed by the treatment of skipping the 4^{th} and the 3^{rd} irrigation Bakheit (1990) stated that the most effective moisture stress in reducing plant height was during the flowering stage.

Total dry weight TDW: The data in Table 4 show the same trend of plant height in TDW, control treatment produced the heaviest plants, skipping the 4^{th} irrigation was second and 3^{rd} irrigation was the third . The clear-cut reduction in TDW was recorded in sorghum plants at skipping 2^{nd} irrigation, whereas skipping the 5^{th} irrigation gave an intermediate reduction. These result was agree with those obtained by El-Hattab *et al.* (2000); Ihtisham *et al.*(2000) and Singh *et al.* (2002).

TABLE 4. Growth and yield of Sorghum as affected by date of skipping one irrigation combined of 2000 and 2001 seasons .

Characters / Hybrid	Plant height cm	TDW g	Seed index	Garin yield ton/fed	Bio-yield ton/fed	Harvest index	LA dm^2	LAI	RGR mg/g/week		CGR g/g/week		NAR mg/dm^2/week	
									60-75 DAP	75-90 DAP	60-75 DAP	75-90 DAP	60-75 DAP	75-90 DAP
2^{nd} (growth)	147.01	222	34.30	3.27	21.19	15.44	22.73	1.88	186.51	128.01	19.23	17.34	687.34	562.79
3^{rd} (booting)	150.20	235	33.10	3.39	21.64	15.36	26.91	2.24	200.09	154.92	21.88	20.06	715.43	619.81
4^{th} (flowering)	153.80	246	31.00	3.24	20.70	15.65	29.22	2.44	-	-	-	-	-	-
5^{th} (g. formation)	149.10	229	30.90	3.08	19.53	15.77	23.91	2.00	-	-	-	-	-	-
Control	157.10	258	35.20	3.34	21.75	15.35	31.01	2.59	194.56	146.69	20.76	19.23	714.08	585.90
LSD 0.05	3.19	3.82	5.40	0.05	1.12	NS	3.07	0.40	6.37	7.60	1.20	1.60	1.03	11.70

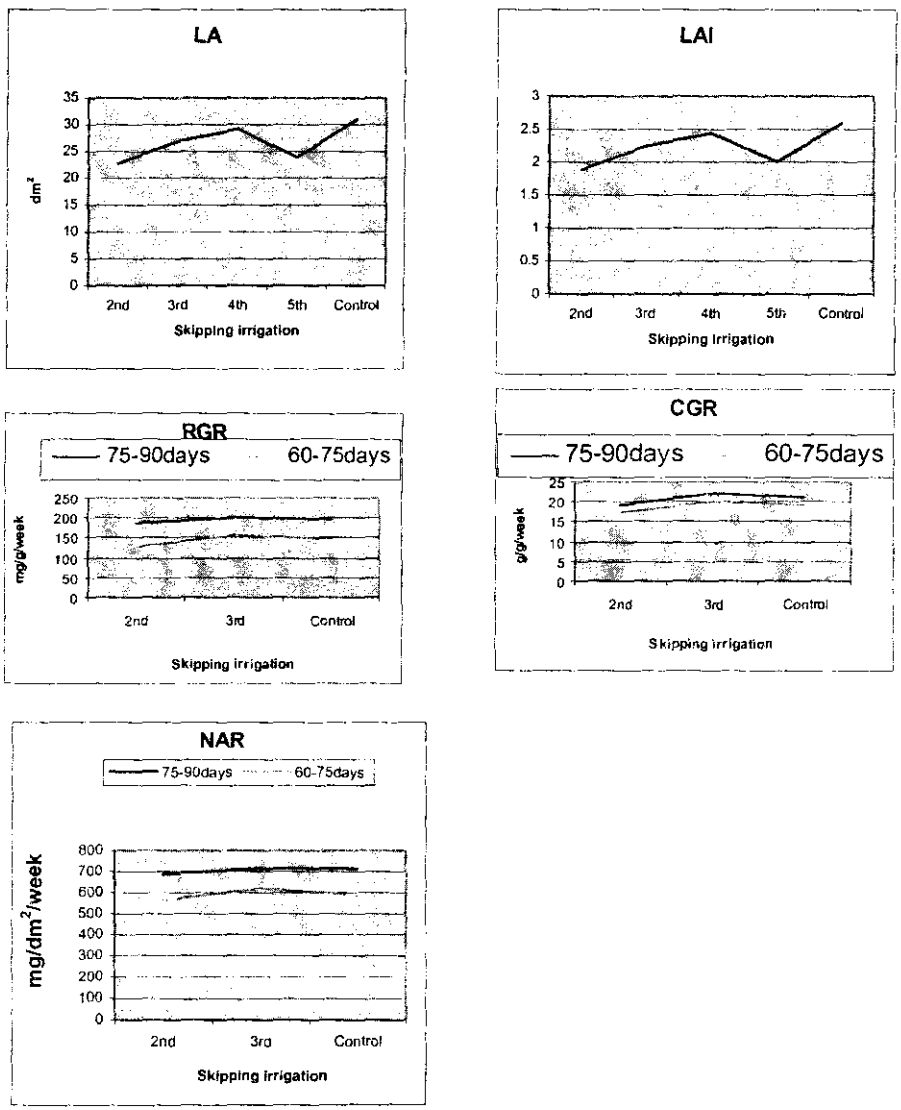

Fig. 1. Effect of skipping one irrigation on growth analysis characters of sorghum hybrids.

Seed index: The normal treatment which gave 6 irrigations produced the heaviest 1000 grains(seed index) followed by treatment of skipping the 2^{nd} and 3^{rd} irrigation at the growth or booting stage. Treatment of skipping the 5^{th} irrigation during grain formation gave the lowest seed index as indicator to grains weight thus it can be concluded that skipping irrigation during grain formation reflected on grains weight. These result was in accordance with Musick & Dusek (1971) and Singh *et al.* (2002).

Grain yield- biological yield: Data presented in Table 4 show that the same trend pointed in growth and yield components was clear in both grain and biological yields. Normal irrigation treatment which gave 6 irrigations was the best 3.24 ton grains/fed. and 21.75 ton biological yield/fed. Skipping the 3^{rd} irrigation (booting stage) came in the second order, 2^{nd} irrigation (growth stage) was the third in grains yield /fed. and interchange their orders in biological yield/fed. Skipping the 4^{th} irrigation (flowering stage) gave an intermediate reduction in both characters but skipping the 5^{th} irrigation (grain formation) was the last in both characters. Eck & Musick (1979); El-Bagoury *et al.* (1984); Ihtisham *et al.*(2000) and Singh *et al.*(2002). reported that grain formation was susceptible stage for grain and biological yields of sorghum.

Although there were reduction in grain yield/fed. by skipping one irrigation but the reduce was 0.89% (booting stage) and 7.78% (grain formation).Thus, it is very important to make economic study to compare the cost of grain yield reduction due to skipping one irrigation and the cost of one irrigation in sorghum crop especially in Horus and Mina hybrids. Shipley & Regier (1970) stated that sorghum yield was reduced by 35-45% when stress occurred at booting and heading stages. Also Eck & Musick (1979) pointed that 28 days at heading reduce 27% grain yield and reduce 45% at booting stage, moreover, El Bagoury *et al.* (1984) found that increasing interval length from 4 to 16 days caused a progressive and consistent depression in biological yield and harvest index and sharp reduction in grain yield.

Harvest index : Skipping the 5^{th} irrigation at 80 DAP gave the best harvest index compare to other irrigation treatments. These result may be due to the tall period between the 4^{th} irrigation at 65 DAP and the 6^{th} irrigation 95 DAP which reflect on reducing biological yield – the denominator in the formula of harvest index (harvest index = grain yield / biological yield)

C- Interaction between hybrids and skipping one irrigation

Growth characters

Data presented in Table 5 show that the interaction between Horus hybrid and the control which gave 6 irrigations recorded the first order in LA, RGR , CGR and NAR at both periods 60-75 and 75-90 DAP by significant differences. Skipping the 3^{rd} irrigation –during booting stage – for Horus hybrid came in the second order in RGR,CGR, and NAR. It can be concluded that skipping irrigation

TABLE 5. Effect of interaction hybrids X skipping irrigation on growth and yield of sorghum (combined of 2000 and 2001 seasons).

		Plant height cm	TDW g	Seed index	Garin yield Ton/fed	Bio-yield ton/fed	Harvest index	LA dm^2	LAI	RGR mg/g/week		CGR g/g/week		NAR mg/dm^2/week	
										A	B	A	B	A	B
Mena	2^{nd}	146	227.6	29.84	3 06	20.91	14.63	22.1	1.8	183.4	128.4	17.13	16.74	665	450
	3^{rd}	145.83	218.4	33.0	3.25	20.17	16.11	21.13	1.73	189.7	142.8	19,3	18.3	702	486
	4^{th}	148.36	231.62	31.18	3.25	20.32	15.99	25.86	2.15						
	5^{th}	149.27	240.19	29.25	3.22	19.13	16.83	28.09	2.34						
	control	151.51	250.88	32.87	3.33	21.1	15.78	29.84	2.49	194	148.8	20.4	19.2	704	512
Horus	2^{nd}	152.27	236.97	31.87	3.1	22.3	13.9	25.72	2.14	189.7	127.6	21.33	17.94	710	639
	3^{rd}	148.23	224.75	35.72	3.35	21.23	15.77	24.33	2.0	199.5	150.5	22.2	20.2	725	659
	4^{th}	152.12	237.68	35.06	3.27	22.06	14.82	27.95	2.33						
	5^{th}	158.26	252.45	32.84	3.23	19.93	16.2	30.34	2.53						
	control	162.61	264.78	37.5	3.38	22.38	15.13	32.17	2.68	206	161.4	23.4	21	728	699
LSD .05		3.22	9.21	3.41	0.08	1.2	0.09	3.82	NS	5.7	4.2	1.3	0.3	2.4	13.8

A: 60-75 DAP and B:75-90 DAP

during the latter stage of sorghum Horus hybrid had less effect on LA and LAI but skipping irrigation during booting stage had less effect on RGR, CGR, and NAR. These result was in accordance with those obtained by Tarantino *et al.*, (1992) and Ebel *et al.* (1994) who reported that LA generally decreased as the amount of irrigation decreased. Bakheit (1990) and Mastroilli *et al.* (1995) stated that LAI was influenced by water stress before and during flowering period only.

Yield and yield components

Table 5 clear that the interaction effect on yield and yield related characters was significant. Interaction between Horus hybrid and control which gave 6 irrigations was the best compare to other interactions for yield and yield components except for harvest index it gave the tallest plants , heaviest TDW , the greatest seed index and the greatest grain and biological yields .

Interaction between Mena hybrid and skipping the 5^{th} irrigation recorded the best harvest index with significant differences.

Interaction between Horus hybrid and skipping the 5^{th} irrigation –during grain formation- came in the second order in plant height and TDW.

Skipping the 3^{rd} irrigation during booting stage for Horus hybrid plants recorded the second order in seed index and grain yield/fed.

Due to biological yield/fed. skipping one irrigation during growth stage for Horus hybrid came in the second order .

Interaction between Horus hybrid and skipping the 5^{th} irrigation recorded the second order in harvest index. Skipping the 2^{nd} irrigation of Horus hybrid recoded the best results due to RGR, CGR and NAR at both periods 60-75 and 75-90 DAP but skipping 5^{th} irrigation for Horus hybrid produce the greatest LA and LAI, the differences were significant in LA only.

Yield and yield components

Table 5 clear that the interaction effect on yield and yield related characters was significant. Omitting the 5^{th} irrigation for Horus plants gave the tallest plants; heaviest TDW and the heaviest 1000 grains (seed index).

From the results in Tables 3, 4, 5 and Fig . 1 it could be concluded that Horus hybrid had supremacy under trial condition in Ebshway district, El-Fayoum Governorate if compared to Mena hybrid. Thus Horus hybrid was more suitable for these condition. Also, it can be concluded that although sorghum hybrid Horus produce 3.38 ton /fed. grains when it gave 6 irrigations it can produce 3.35 ton/fed. grains by skipping the 3^{rd} irrigation with shortage (0.88%) only. The same hybrid produce 22.30 ton/fed. biological yield by skipping the 2^{nd} irrigation (0.35%) reduce compare to 22.38 ton/fed. by 6 irrigations . Also, seed index of Horus hybrid was 37.5 with 6 irrigations and reduce (4.74%) to 35.72 by skipping the 3^{rd} irrigation. Thus it

can be irrigate plants of Horus hybrid with 5 irrigations and provision the sixth of irrigation amount under trial conditions.

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تأثير اسقاط رية واحدة على النمو و المحصول فى هجينين من الذرة الرفيعة

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أجريت تجربتان حقليتان فى الموسم الصيفى لعامى ٢٠٠٠، ٢٠٠١ بمزرعة خاصة بمركز أبشواى – محافظة الفيوم لدراسة تأثير إسقاط رية عند ٣٥ أو ٥٠ أو ٦٥ أو ٨٠ يوم من الزراعة على الصفات الفسيولوجية و المحصول لهجينين من الذرة الرفيعة هما مينا وحورس.

أظهرت النتائج تفوق الهجين حورس معنويا على مينا فى جميع الصفات المدروسة فيما عدا صفة دليل الحصاد. تفوقت معاملة المقارنة التي أعطيت ٦ ريات خلال الموسم علي باقي المعاملات في صفات ارتفاع النبات- الوزن الجاف الكلي – دليل البذرة – مساحة الأوراق – دليل مساحة الأوراق – محصول الحبوب للفدان و المحصول البيولوجي للفدان بينما أعطت معاملة اسقاط الرية الخامسة عند ٨٠ يوم من الزراعة أفضل دليل حصاد. تفوقت معاملة اسقاط الرية الثالثة عند ٥٠ يوم من الزراعة بفروق معنوية في صفات معدل النمو النسبي – معدل نمو المحصول و معدل الكفائة النسبية علي باقي معاملات الري. اعطي التفاعل ما بين الهجين حورس و معاملة المقارنة التي أعطيت ٦ ريات خلال موسم النمو أعلي القيم في جميع الصفات المدروسة ما عدا صفة دليل الحصاد التي تفوق فيها التفاعل ما بين الهجين مينا و اسقاط الرية الخامسة عند ٨٠ يوم من الزراعة.