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Performance of sorghum genotype under dry Iraqi conditions

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Field experiments were conducted at three locations in the south of Iraq for two fall seasons (2008 and 2009). These locations were Thi gar, Al-Muthanna and Al-Basrah, Iraq. The purpose of the study is to investigate the response of forteen sorghum genotypes to the above different locations. The genotypes were (Kaffer-2 , Ingath , Rabeh , Millo , Rox , Korakolla , Dorado , Tub-7, Gt-1 , Gt-2 , Gt-3 , NK6638 , netreefd and KS310). The results of the study showed that Al-Muthanna location gave the highest plant height , leaf area index , dry matter yield , and number of seeds per head for two fall seasons (2008 and 2009) respectively , but Al-Basrah location gave the highest 1000 seeds weight , in addition, Inkath genotype produced the highest number of seeds/head and seed yields (5.38 and 5.18 ton/ha) for two fall seasons (2008 and 2009) respectively. Finally, the study found significant interaction effects between locations and genotypes as follow: Al-Muthanna location * Kaffer-2 gave the highest plant height and dry matter; Thi gar location * Ingath genotype produced the highest number of seeds/head; Al-Basrah location * Ingath gave the highest 1000 seeds weight; Al-Muthanna location * Ingath gave the highest seeds yield (6.33 and 5.88 ton/ha) for two fall seasons (2008 and 2009), respectively.

Key words: Leaf area index , Dry matter yield, Tub-7, Gt-1 , Gt-2 , Gt-3 , NK6638.

Introduction

Sorghum crop ranked the fifth important crop in the world among grain crop productions (Wheat, Barley, Rice and Corn). (Al-Any et al .2006), in addition, sorghum is one of the main crops in feeding people of arid and semi-arid in the world. Sorghum could also be used to make food of high protein for people and feed for poultry moreover, forage and hay from sorghum could be made two times a year (spring and fall) also sorghum and some other forage crops (Barley , alfalfa and clover) could produce enough forage for the country to improve animal productions.

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Sorghum crops could adopt rough environments (high temperature, salty soil, and bad water) better than other crops. These environments could prevent or reduce the growing of most forage crops. Therefore, in mid ninety scientists and government studied the effect of the previous environments on the production of sorghum. They found that some sorghum genotypes significantly produced forage and seeds better than other crops. Therefore, sorghum could be used wildly in Iraq to produce quality forage and grain which are very important to improve the animal productions.

There are shortages in forage production in middle and south of Iraq because of the rough environments, therefore, scientists started to choose the best sorghum varieties to produce more forage (Wade and Douglas, 1990). There were many studies about selecting the sorghum genotype that adapt the environment of south of Iraq such as the study of (Uozumi *et al*., 1992) that found Fs-304genotype produced more dry matter than Fs-290 . Mohammed et al. (1993) found differences among 45 sorghum genotypes regarding leaf area index, forage and grain yields. Also there were many researchers in the world studied the relationship between sorghum genotypes and locations, they found differences among genotypes productions regarding locations,(Wade *et al*., 1993) and (Eric *et al*., 1995) in Australia, (Al-Nagar, 1997), (Kamohita et.al. 1998), (Al-Asadi, 2001), (Faakeer, 2001), (Al-Taher *et al*., 2002), (Nehaya, 2004) , (Al-Rawi, 2005), (Al-Refaee, 2005) , (Al-Bahdely, 2006) , (Al-Tahir et al., 2008) and (Al-Dolaimy, 1998).

Finally, the shortage in the forage crops productions in the south of Iraq encourage researchers to conduct this study to select the best sorghum genotypes that could adapt the rough environments there.

Materials and methods

This study was conducted during two seasons (2008 and 2009) in three locations , the first one in the Al-Nagmi town , Al-Muthanna Provence , the second one in Bathaa town , Provence of Thi gar ,while the third was conducted in Corna city , provence of Basrah . The experimental soil was describes in (table 1).The objective of the study was to evaluate the production of fourteen sorghum genotypes at the above locations . These genotypes were: Kaffer-2 , Ingath , Rabeh , Millo , Rox , Korakolla , Dorado, Tub-7,Gt-2,Gt-2 , Gt-3 , NK6638 , netreefd and KS310. Genotypes were obtained from General Agricultural Research Association, Abu-Ghraib, Baghdad, Iraq. The planting date was during autumn of 2008 and 2009. A field experiment was applied by random complete block design with three replications in each location. The area of each plot was $18m^2$ with four ferrous. The long of the ferrous 6 m and the space between ferrous 75 cm. The seeds were planted by hands on the middle

of July in 2008 and 2009. Four seeds were put in each bed, the space between beds 10 cm, after seedling reached 20 cm height, the plants in each bed were thinned to only one plant. Nitrogen fertilizers (yoria 46%) was applied two times (total amount of fertilizer 150 kg/ha each time).The first 150 kg was applied during the planting while the second 150 was applied after 45 days from planting. Phosphate fertilizer (100 kg/ha supper phosphate 46%) was also applied before planting. The irrigation and harrowing were used as needed. When planting reached 75% blooms, 10 plants from each plot were pulled randomly to measure plant height leaf area index, dry matter, and seeds per head. Leaf area index was measured by width place of leaf x0.75. (Stickler *et al*., 1961). Dry matter was measured after plants of middle row (0.6 m/long) from plot were pulled and dried then weight (ton/ha). Seed per head were calculated from ten plants pulled randomly from each plots , seed yields were calculated by harvesting 3 m long from each plot and got the clean seeds then weight them and converted their weight to the ton/ha .

Data from the three locations were analyzed by using combined analysis. If there were significant differences among genotypes in each location and among locations L.S.D. test was used at the 0.05 level of significant.

Results and discussions

Growth characteristics/ location

The results of this study found significant differences among location for two seasons (2008 and 2009) regarding seed productions, plant height, leaf area index, and dry matter. Muthanaa location produced the highest plant height, leaf area index, and dry matter for two seasons respectively, (Table 2). This results may related to the better environmental conditions in Al-Muthanaa location for example soil salt was lower and irrigation water was available better than in other locations, (Table 1) . This finding just like the results of (Wade and Dougles 1990 and Mohammed *et al*., 1993). who studied the effect of locations on the productions of sorghum genotypes.

Table 1. Some physical and chemical parameters for soil of experiment regarding three locations.

	Locations		
Characteristics	Al-Basrah	Thi gar	Al-Muthanna
Sand(%)	18.49	54.6	38.0
Clay(%)	22.29	15.0	24.0
Silt (%)	59.22	30.4	38.0
Soil texture	Loamy silt	Loamy sand	Sandy clay

pH		7.70	7.8	7.72
E.C	Soil	7.40	5.32	4.45
ds/m	water	3.56	2.79	2.66
Total of Nitrogen (gm/kg)		0.036	15.27	18.65
Available phosphorus		0.021	6.11	8.12
Calcium carbonate		32.40	24.34	28.89
Organic Mater (gm/Kg)		0.44	0.21	0.31

Seed yields and its component/locations

The results of this study showed Al-Muthanna location produced the highest number of seeds/head (750.95 and 718.33) for two seasons respectively, in addition Thi gar location was significantly better than Basrah location regarding number of seeds/head. These results might be related to the high number of blooms that produce a lot of seeds, (Table 2). Similar result was obtained by (Al-Tahir *et al*., 2008). The weight of 1000 seeds was the highest in

Basrah location in the two seasons Table (2) ,this result might be related to the lower number of seeds/head in Basrah location than in order location because fewer seeds mean fewer blooms that gave more food (photosynthesis) to the seeds than in the head of more blooms . This process may produced the highest 1000 seeds weight in Basrah location. The finding also illustrated that Al-Muthanna location produced the highest seed yields (3.15 and 2.96 ton/ha) for two seasons (2008-2009), (Table 2). These results may related to the highest number of seeds/head that obtain from Al-Muthanna location that gave more total of seed weights (Table 2). Almost the same result was obtained by Wad and Dougles (1990), Muhammed *et al*. (1995) and Kamoshita *et al*. (1998).

Table 2. Effect of locations on growth characteristics, yield and its components for sorghum crop for season 2008 and 2009

Location	**Plant Growth and Yield**						
	Year	Plant height (cm)	Leaf area index	Dry matter yield (ton/ha	No. of seeds per head	Weight of 1000 seeds (gm)	Seeds yield (ton/ha)
Al Muthanna	08	114.45	4.25	7.46	750.95	24.23	3.15
	09	116.61	3.98	7.32	718.33	25.59	2.96
Thi qar	08	106.07	3.96	7.12	734.69	25.67	2.82
	09	108.52	3.70	7.02	703.47	26.37	2.89
Basrah	08	98.47	3.60	6.75	725.69	27.28	2.51
	09	97.31	3.35	6.73	678.61	27.24	2.56
L.S.D	08	1.60	0.10	0.10	12.83	0.55	0.08
	09	2.59	0.11	0.12	10.93	0.59	0.07

Growth characteristics/ genotypes

The statistical analysis indicated that there were significant differences among genotypes regarding plant height, leaf area index, and dry matter. Table (3 and 4) showed Kafair-2 genotype gave the highest plant height (165.44 and 186.44 cm) leaf area index (4.22 and 3.88 cm) and dry matter weight (10.81 and 10.34 ton/ha) for the two seasons (2008 and 2009) respectively.

These results may related to the diversity among genetic structure of genotypes that made kafair-2 genotype adapted the environments better than other genotypes. This finding could agree with the results of Uozumi *et al*. (1992), Komashita et al. (1998), Eric *et al*. (1993), Fakira (2001), Al-Tahir *et al*. (2002), Al-Refaa (2005), and Al-Rawi (2005).

Yield and its component/genotypes

The genotypes Ingath produced the highest seeds number/head (1180.66 and 1245.88 seeds/head) for two seasons (2008 and 2009), respectively, while genotype KS310 gave the least seeds number / head for two seasons. These results may also relate to the genetic structure that controlled the yield this finding could agree with results of Al-Nagar (1997) and Kamoshita *et al*. (1999). who explained these differences of genetic structure among them.

Rabah genotype gave the highest 1000 seeds weight of all other genotypes (36.64 and 35.46 gm) for two seasons while KS310 genotypes gave the least 1000 seeds weight. Again these results may relate to the differences in the genetic structure of genotypes the same results and explanations were got by Nahaba (2004) and Al-dolaimy (2009). The genotype Ingath produced the highest seed yield/ha 95.14 and 5.38 ton/ha) for 2008 and 2009 respectively, while KS310 also gave the least seed yields Table (3 and 4) . This result may related to the high number of seeds/head produced by Ingath that gave more seeds weight, this results may agree with results of Wad *et al.* (1995) , Al-Bahadily (2006); Al-Asady (2004) and Al-Tahir (2008) who found some genotypes gaves more seed productions than other genotypes. Table (3 and 4), showed the effect of genotypes on growth characteristics, yield and its components for sorghum crop for season 2008.The effect of interaction between locations and genotypes.

Table 3. The differences among Sorghum genotypes regarding plant growth, Yield and its components for seasons 2008 and 2009

Plant Growth and Yield								
genotypes	Year	Plant height (cm)	Leaf area index	Dry matter yield (ton/ha	No. of Seeds per head	Weight of 1000 Seeds (gm)	Grain Seeds (ton/ha)	
Kaffer-2	08	165.44	4.22	10.87	1208.89	31.18	4.99	
	09	186.44	3.88	10.34	1138.77	31.20	4.79	
Rabeh	08	142.33	3.54	9.34	1139.87	35.46	5.20	
	09	167.66	3.45	8.68	1059.66	36.64	4.68	
Ingath	08	140.11	4.11	10.30	1245.88	31.66	5.38	
	09	136.88	3.87	9.79	1180.66	34.62	5.14	
MILLO	08	94.22	3.13	7.24	735.77	32.48	3.19	
	09	93.88	2.90	6.74	682.22	35.00	3.18	
TUB-7	08	109.11	3.64	5.83	612.44	28.47	2.46	
	09	104.66	3.26	5.72	567.66	30.55	2.33	
ROX	08	111.00	5.26	6.38	605.00	25.05	2.24	
	09	102.44	4.82	6.33	575.11	31.05	2.38	
KORAKOLLA	08	146.66	4.87	7.61	619.22	21.97	2.14	
	09	151.00	4.38	7.36	558.11	21.18	2.14	
DORADO	08	78.77	3.88	6.12	622.00	28.93	2.40	
	09	79.11	3.43	5.76	608.66	29.18	2.38	
GT-1	08	94.44	4.15	5.46	665.66	23.44	2.11	
	09	91.22	3.97	5.21	647.88	22.63	2.08	
GT-2	08	86.33	3.78	5.47	597.33	24.74	2.01	
	09	82.66	3.62	5.63	582.66	24.13	2.04	
GT-3	08	81.44	3.72	5.35	602.00	22.35	1.94	
	09	77.22	3.56	5.75	587.22	21.46	2.06	
NK 6638	08	76.88	3.45	5.84	559.11	19.22	1.91	
	09	72.66	3.28	6.61	541.55	18.24	2.12	
NETREEFD	08	94.11	4.12	5.98	601.22	18.48	1.88	
	09	87.77	3.91	5.95	584.11	17.42	2.00	
KS 310	08	67.77	3.25	7.72	505.11	17.15	1.70	
	09	71.11	3.11	8.49	490.44	14.36	1.95	
L. S. D	08	2.24	0.27	0.28	30.70	1.43	0.20	
	09	6.87	0.29	0.33	28.21	1.49	0.21	

Growth characteristics

There were interaction effect between locations and genotypes, (Table 4). The statistical analysis illustrated that significant differences among locations and genotypes regarding plant height and dry matter production as follow: the interaction effect between Al-Muthanna location and Kafair-2 gave the highest plant height (194 and 180 cm) for the years 2008 -2009 respectively; and dry matter weight (11.01 ton/ha) for the season 2009 only the interaction between Basrah location and Kafair-2 gave the highest dry matter production ton per ha. (11.07) for the season 2008 while the interaction between Basrah location and Ks310 gave the lowest plant height and Basrah with Gt-1 only gave the lowest dry matter production. These results may related to the structure of single genotypes. The study also found no significant effect between locations and genotypes regarding leaf area index.

Table 4. The effect of interaction between location and sorghum Genotypes regarding plant growth and yield and its components

Location	Genotype	Year	Plant Growth and Yield					
			Plant height (cm)	Leaf area index	Dry matter yield (ton\ha)	No. of seeds per head	Weight of 1000 seeds	Seed yields (ton\ha)
Al-muthana	Kaffer - 2	08	180.00	4.64	10.95	1181.33	31.07	4.95
		09	194.00	4.10	11.01	1187.66	32.63	5.48
	Rabeh	08	152.33	3.70	9.54	1174.33	33.63	5.69
		09	183.00	3.53	8.86	1012.00	35.23	4.56
	Ingarh	08	152.66	4.60	10.99	1278.67	28.43	6.33
		09	133.66	4.30	10.78	1147.00	30.83	5.88
	Millo	08	102.27	3.80	7.32	777.66	30.40	3.56
		09	100.67	3.70	6.88	643.00	34.56	3.42
	Tub – 7	08	119.66	3.90	6.29	632.66	27.40	2.88
		09	119.00	3.10	6.25	499.00	30.60	2.48
	Rox	08	115.66	5.56	6.67	612.00	23.30	2.70
		09	108.65	5.20	6.45	545.66	28.53	2.61
	Korakolla	08	164.66	5.10	7.74	609.00	20.50	2.39
		09	173.66	4.66	7.43	553.33	20.20	2.10
	Dorado	08	68.33	4.13	6.59	635.66	27.56	2.59
		09	85.34	3.50	6.03	584.33	26.50	2.56
	Gt – 1	08	100.00	4.56	6.08	674.33	22.33	2.29
		09	96.33	4.33	5.56	632.00	22.33	2.11
	Gt – 2	08	92.00	4.10	5.85	619.00	23.63	2.21
		09	97.00	3.90	5.38	567.66	24.53	2.05
	Gt – 3	08	90.66	4.00	5.75	623.33	21.20	2.11
		09	86.33	3.83	5.96	569.33	21.20	2.11
	Nk 6638	08	80.66	3.70	6.37	555.33	17.70	2.18
		09	78.66	3.53	6.93	529.00	17.70	2.04
	Nerreefd	08	100.00	4.43	6.01	616.66	17.06	2.18
		09	96.33	4.25	5.74	557.66	17.06	2.05
	Ks 310	08	65.23	3.43	8.24	523.33	16.36	2.03
		09	80.00	3.26	9.22	473.00	16.36	2.03
Location	Genotype	Year	Plant Growth and Yield					
			Plant height (cm)	Leaf area index	Dry matter yield (ton\ha)	No. of seeds per head	Weight of 1000 seeds	Seed yields (ton\ha)
Thigar	Kaffer - 2	08	163.66	4.20	10.66	1174.00	31.00	4.85
		09	186.00	3.86	10.24	1101.00	30.46	4.49
	Rabeh	08	138.66	3.90	9.19	1144.33	36.46	5.55
		09	177.00	4.33	8.65	1066.00	36.40	5.30
	Ingarh	08	135.00	4.33	10.57	1250.67	37.30	4.90
		09	152.00	4.00	9.81	1208.66	29.40	5.43
	Millo	08	94.33	2.90	7.46	743.33	35.80	3.19
		09	95.66	2.60	6.75	683.33	32.66	3.17
	Tub – 7	08	116.00	3.76	5.75	617.00	34.86	2.35
		09	113.00	3.36	5.67	593.33	28.50	2.40
	Rox	08	112.00	5.23	6.48	604.66	30.50	2.09
		09	104.00	4.83	6.13	576.66	24.26	2.47
	Korakolla	08	145.00	4.90	7.66	606.33	32.20	2.11
		09	144.66	4.30	7.33	547.66	22.53	2.23
	Dorado	08	73.00	3.93	6.02	619.33	20.40	2.36
		09	75.33	3.60	5.67	610.33	28.66	2.45
	Gt – 1	08	95.33	4.10	5.35	617.00	30.13	2.08
		09	92.66	3.93	5.23	654.00	23.33	2.06

	Gt – 2	08	91.00	3.76	5.33	592.33	21.90	1.98
		09	77.33	3.63	5.90	579.00	24.63	2.03
	Gt – 3	08	79.66	3.73	5.27	603.66	23.10	2.04
		09	77.33	3.56	5.85	587.66	22.53	2.06
	Nk 6638	08	75.33	3.46	5.79	569.67	21.20	2.01
		09	71.66	3.26	6.55	557.33	19.36	2.33
	Nerreefd	08	95.33	4.06	6.16	602.33	17.90	1.98
		09	85.33	3.80	6.11	592.33	18.73	2.06
	Ks 310	08	70.66	3.26	8.08	496.00	17.36	1.95
		09	67.33	3.13	8.45	485.33	16.13	2.01
Location	Genotype	Year	Plant Growth and Yield					
			Plant height (cm)	Leaf area index	Dry matter yield (ton\ha)	No. of seeds per head	Weight of 1000 seeds	Seed yields (ton\ha)
Basrah	Kaffer - 2	08	152.66	4.00	11.07	1271.33	31.46	5.17
		09	179.33	3.70	9.76	1121.66	30.50	4.39
	Rabeh	08	136.00	3.03	9.33	1101.00	36.36	4.38
		09	143.00	2.93	8.55	1101.00	37.40	4.18
	Ingarh	08	132.66	3.40	9.35	1208.33	37.16	4.91
		09	125.00	3.33	8.18	1186.33	37.25	4.10
	Millo	08	86.00	2.70	6.95	695.33	34.40	2.82
		09	85.00	2.40	6.59	720.33	35.56	2.96
	Rub – 7	08	91.66	3.26	5.45	587.67	29.53	2.15
		09	82.00	2.73	5.25	610.66	30.56	2.11
	Rox	08	105.33	5.00	5.98	598.33	27.60	1.93
		09	94.66	4.43	6.42	603.00	32.43	2.07
	Korakolla	08	130.33	4.63	7.42	642.33	22.90	1.93
		09	134.66	4.20	7.32	573.33	22.69	2.08
	Dorado	08	77.00	3.60	5.76	611.00	30.56	2.24
		09	76.66	3.20	5.57	621.00	30.96	2.12
	Gt – 1	08	88.00	3.80	4.96	651.67	24.66	1.94
		09	84.66	3.66	4.85	657.66	23.66	2.07
	Gt – 2	08	76.00	3.50	5.23	580.67	25.96	1.82
		09	73.66	3.33	5.61	601.33	24.76	2.03
	Gt – 3	08	74.00	3.43	5.04	579.00	23.33	1.67
		09	68.00	3.30	5.43	604.66	21.80	2.01
	Nk 6638	08	74.66	3.20	5.36	552.33	20.60	1.56
		09	67.66	3.06	6.37	538.33	19.13	2.00
	Nerreefd	08	87.00	3.86	5.78	584.67	19.66	1.49
		09	81.66	3.70	6.01	602.33	17.80	1.91
	Ks 310	08	67.33	3.06	6.85	496.00	17.73	1.12
		09	66.00	2.93	7.79	513.00	16.60	1.83
L.S.D		08	7.05	NS	0.49	NS	NS	0.34
		09	12.20	NS	0.59	53.50	3.07	0.33

Yield and its component

The study revealed a significant interaction effect between locations and genotypes regarding number of seeds/head and the weight of 1000 seeds during 2009 season only, while seed yields were affected during the two seasons. According to the study, Ingath genotype gave good seeds/head for all locations and the highest seeds/head in the Thi gar location (1208.66 seeds/head) for the season of 2009. The interaction between Rabih genotypes and Al-Muthanna location and with Thi gar location gave the highest 1000 seeds weight for two

seasons. But the interaction between Ingath and Basrah location gave the highest 1000 seeds/head for the seasons 2008 only and the interaction between Basrah location and Rabih gave the highest 1000 seeds/head (37.4 gm) for the season 2009. This results may related to the lower number of seeds/head produced by Rabih genotype in Basrah location that mean lower number of seeds got more food than in the head with high number of seeds /head just like in kafair-2 and Ingath (have higher seeds/head) . The study found the interaction between Al-Muthanna location and Ingath gave the highest seed weights (6.33 and 5.88 ton/ha) and Basrah location and Kafair-2 gave the highest seeds weight (5.17 and 4.33 ton/ha) for the two seasons respectively.

The interaction between Thi gar location and Rabih gave 5.55 ton/ha seeds in 2008 season while Thi gar and Ingath interaction gave 5.43 ton/ha seed productions. The reason for high seed productions for previous genotypes may related to the high seeds/head in Muthanna and Basrah locations while in Thi gar location the 1000 seeds weight were the highest.

Conclusion

The results showed Ingath, Kafair-2 and Rabih genotypes produced the highest seed yields/ha and dry matter production. It could say that those genotypes are the best of all genotypes in all locations. The study recommends to conduct researches regarding the plant breeding to produce better genotypes which could adapt middle and south of Iraq environments.

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