Ensuring Food Security via Improvement in Crop Water Productivity in arid and semiarid environments

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- **Total food crop production still needs to increase**

  To: Feed a growing world population,

and

This increase needs to be accomplished under increasing scarcity of water

- **The interventions that can contribute to the dual goal of :**

  increasing food production

  saving water.

  Are needed

- **On-farm level irrigation management in water scarcity regions requires innovative interventions for sustainable agricultural production**

- **Irrigation scheduling " application of desired depth of water at right time" is a good method to achieve these goals**

- **This paper is focusing on how to increase crop yield per unit of scarce water**

- **Through : better cultivar selection**
  better water management

- Irrigation Schedule Combination Regimes (ISCR)

as a modified, simple, cheap and easy tool is selected for producing more food from less water

by : increasing crop water productivity (CWP)

which holds the greatest potential to improve food security and reduce poverty in arid and semi-arid regions.

- An experiment was conducted during 2007 and 2008 growing seasons at the Agricultural faculty Research Station, Sana'a University, Yemen
- To:

I) Examine the ability of producing more food from less water through application of ISCR to enhance CWP in dry land environments

with no need for : complicated measuring and monitoring soil-plant-climate factor changes.

II) Evaluate the performance of some wheat genotypes under ISCR treatments to select high yielding genotype which is positively responsive to the better agronomic irrigation management treatments.

Material and Methods

- The treatments were organized on the field site following a randomized complete block split-plot design with three replicates.

- The treatments were comprised of :
  - Factorial combinations of two factors, Regulated deficit irrigation depths (D_{30} ,D_{40} , D_{50} , and D_{60} mm) and irrigation periods (P_{10}, P_{15}, and P_{20} days),

And

  - Two wheat genotypes (Bhooth14 and Bhooth15).

- Irrigation schedule combination regime (ISCR) treatment was the main plot factor and the wheat genotype was the sub-plot factor. Each subplot measured 2 x 2 meters

Table (1): ISCR treatments (irrigation water depth x irrigation period) and their equivalent water volumes m^3ha^{-1} $season^{-1}$(EWV)

ISCR	$D_{30}P_{10}$	$D_{30}P_{15}$	$D_{30}P_{20}$	$D_{40}P_{10}$	$D_{40}P_{15}$	$D_{40}P_{20}$	$D_{50}P_{10}$	$D_{50}P_{15}$	$D_{50}P_{20}$	$D_{60}P_{10}$	$D_{60}P_{15}$	$D_{60}P_{20}$
EWV (m^3ha^{-1} $season^{-1}$)	3000	2100	1500	4000	2800	2000	5000	3500	2500	6000	4200	3000

Results and Discussion

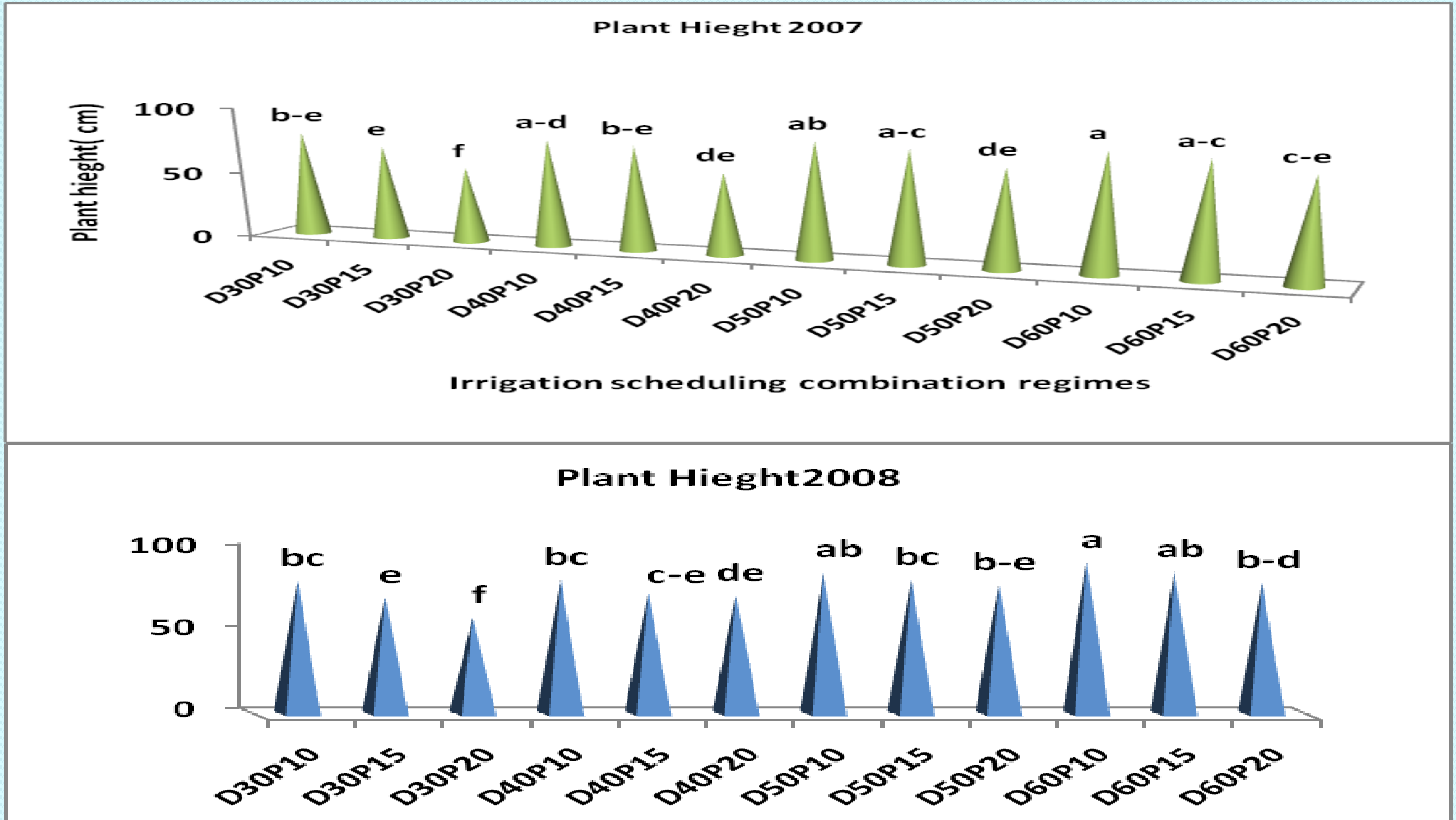

Fig.(1):The effects of irrigation schedule combination regimes in plant height of wheat in 2007and 2008 growing seasons

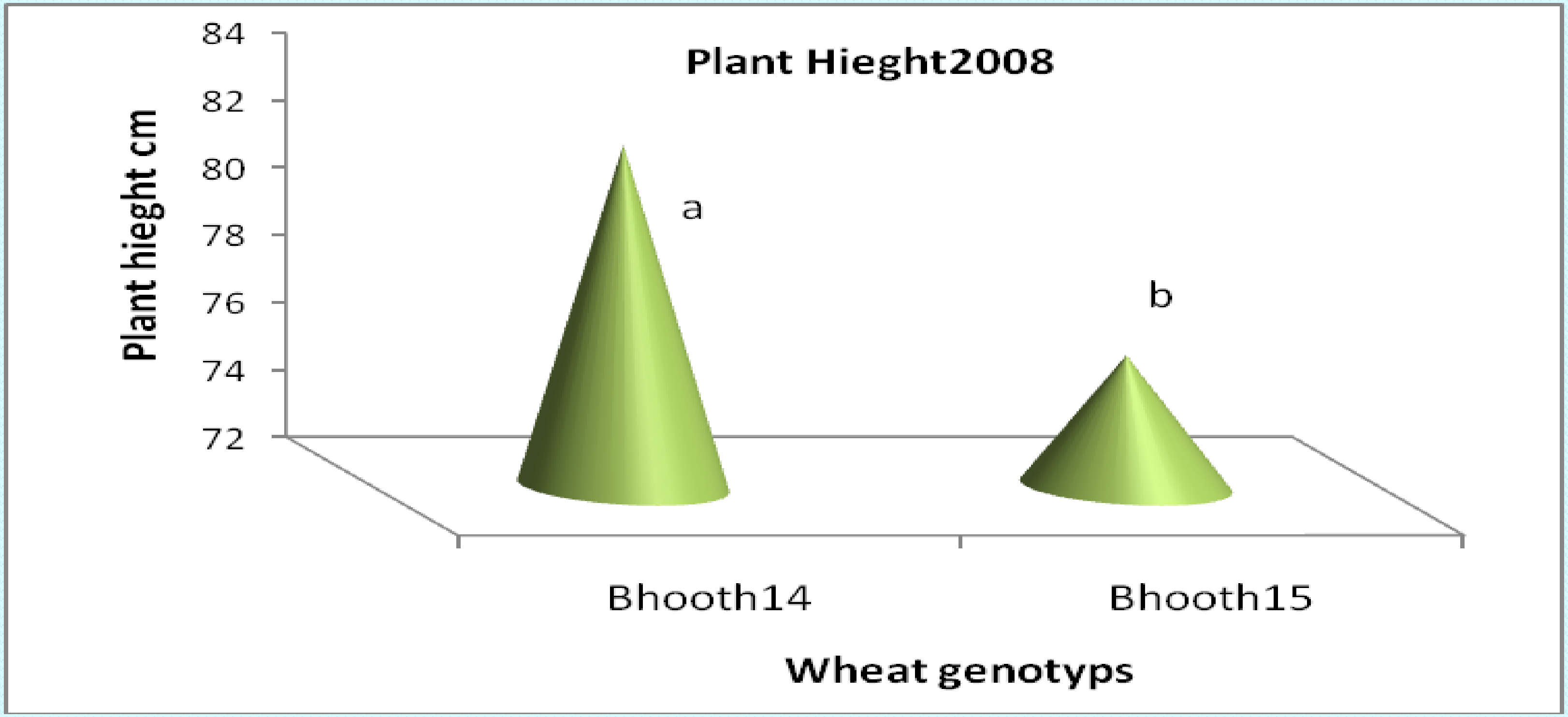

Fig.(2): plant height means of two wheat genotypes under the effects of ISCR in the 2008 growing season

Biomass Yield :

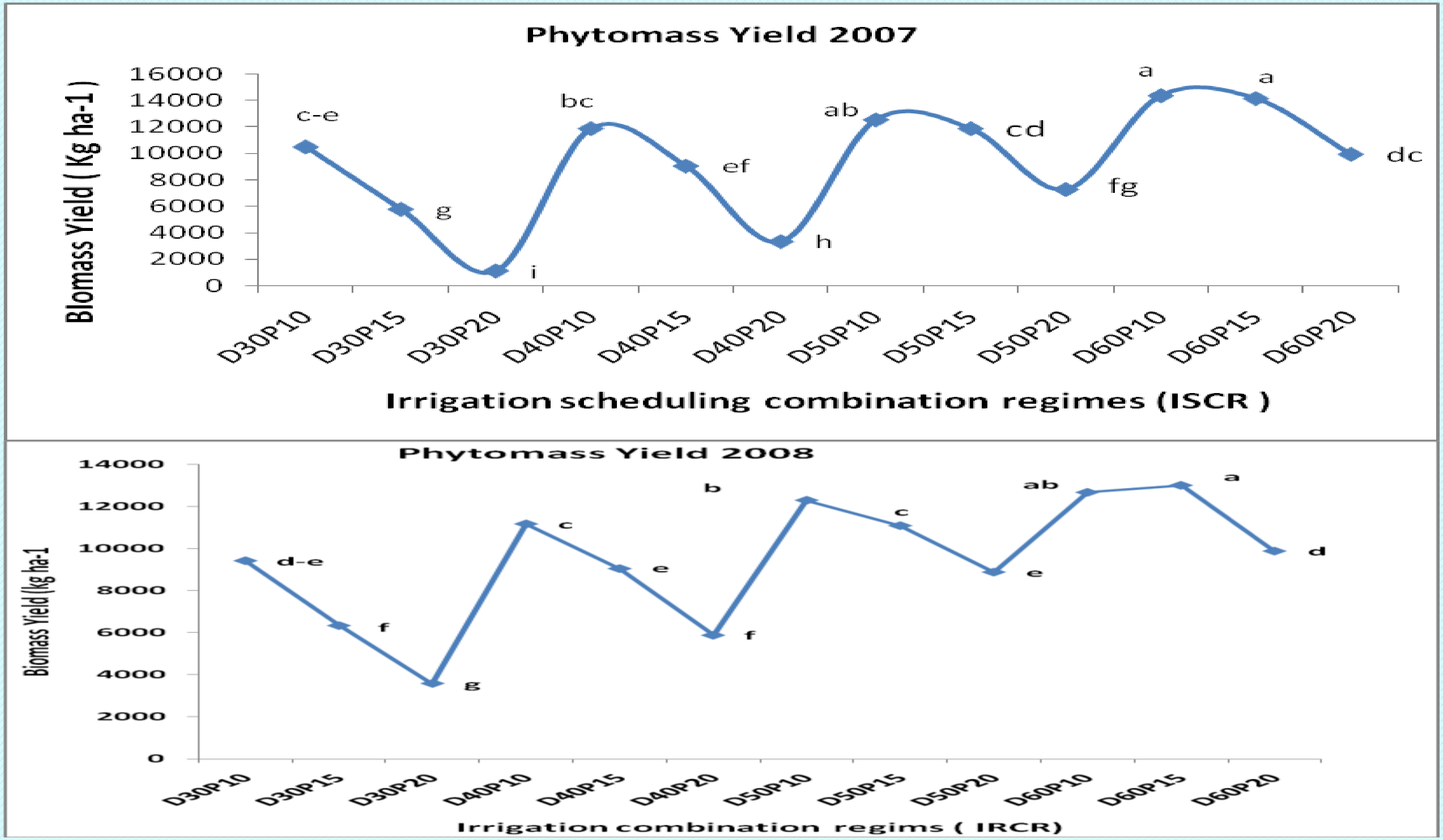

Fig.(3): The effects of ISCR on biomass yield of wheat genotypes in 2007 and 2008 growing seasons

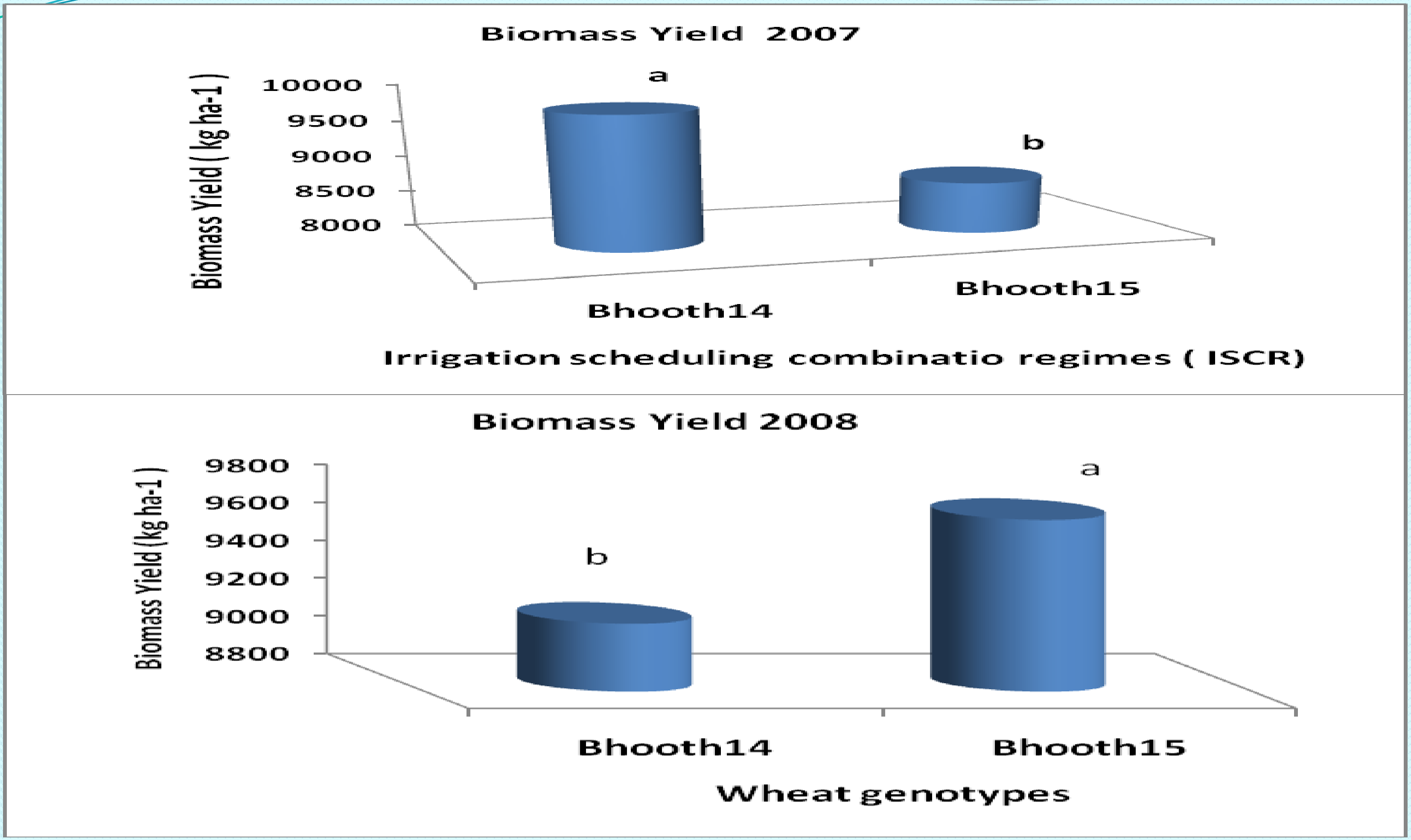

Fig.(4): Biomass yield means of two wheat genotypes under ISCR in 2007 and 2008 growing seasons

Table (3) The interaction between genotypes and ISCR on BMY in 2007 growing season.

ISCR	EWV ($m^3 ha^{-1}$ $season^{-1}$)	Bhooth14	Bhooth15
$D_{30}P_{10}$	3000	10555.6	10444. 4
$D_{30}P_{15}$	2100	7555.6	4000.0
$D_{30}P_{20}$	1500	1111.1	1111.1
$D_{40}P_{10}$	4000	11555.6	13555.6
$D_{40}P_{15}$	2800	9777.8	8333.3
$D_{40}P_{20}$	2000	3111.1	3555.6
$D_{50}P_{10}$	5000	14444.4	9555.6
$D_{50}P_{15}$	3500	12000	11777.8
$D_{50}P_{20}$	2500	8333.3	6222.2
$D_{60}P_{10}$	6000	13777.8	15000.0
$D_{60}P_{15}$	4200	14555.6	13777.8
$D_{60}P_{20}$	3000	10555.7	9111.1
LSD0.05		2289.2	

Grain Yield

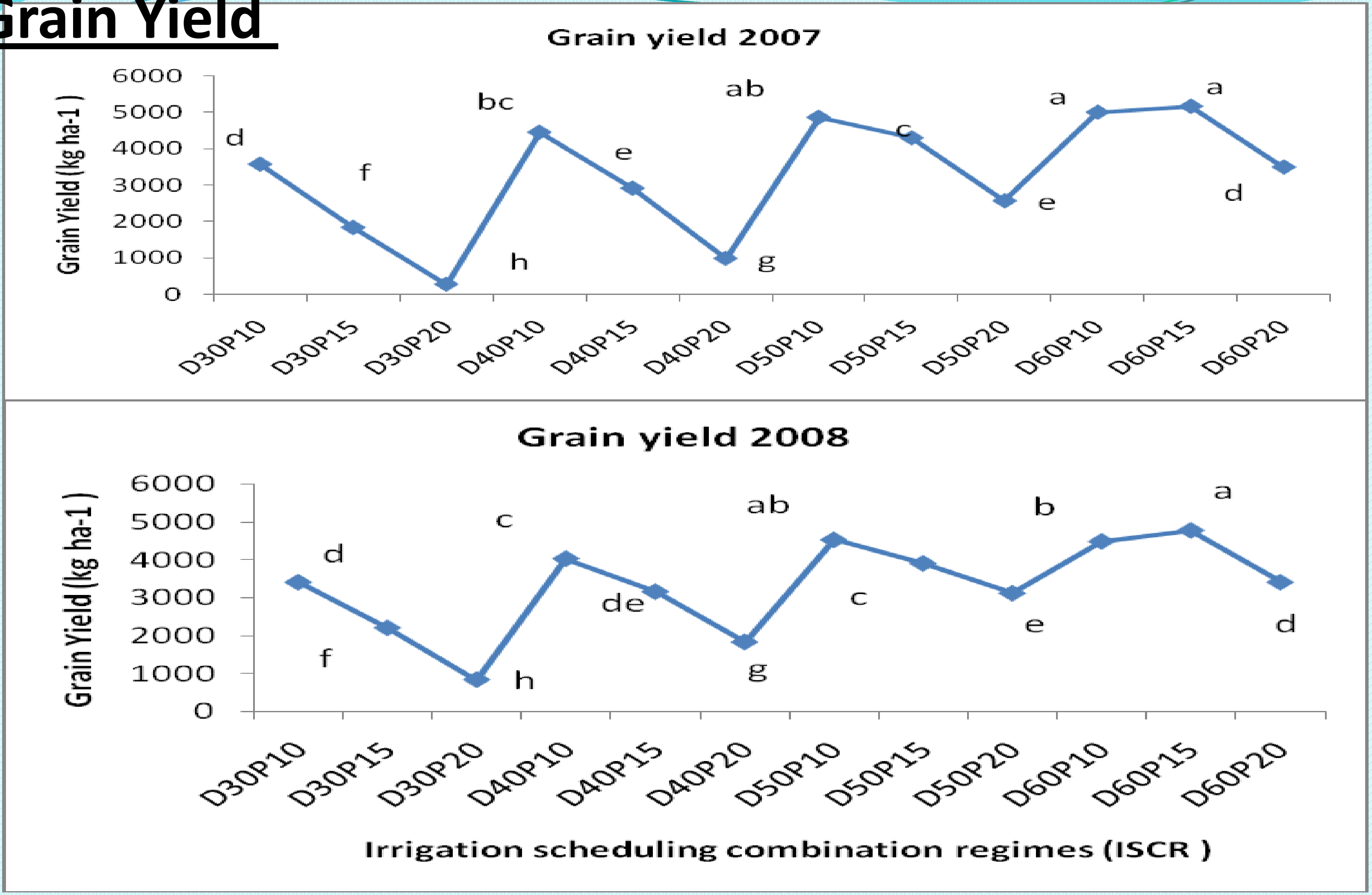

Fig.(5): The effects of ISCR on grain yield of wheat genotypes in 2007 and 2008 growing seasons

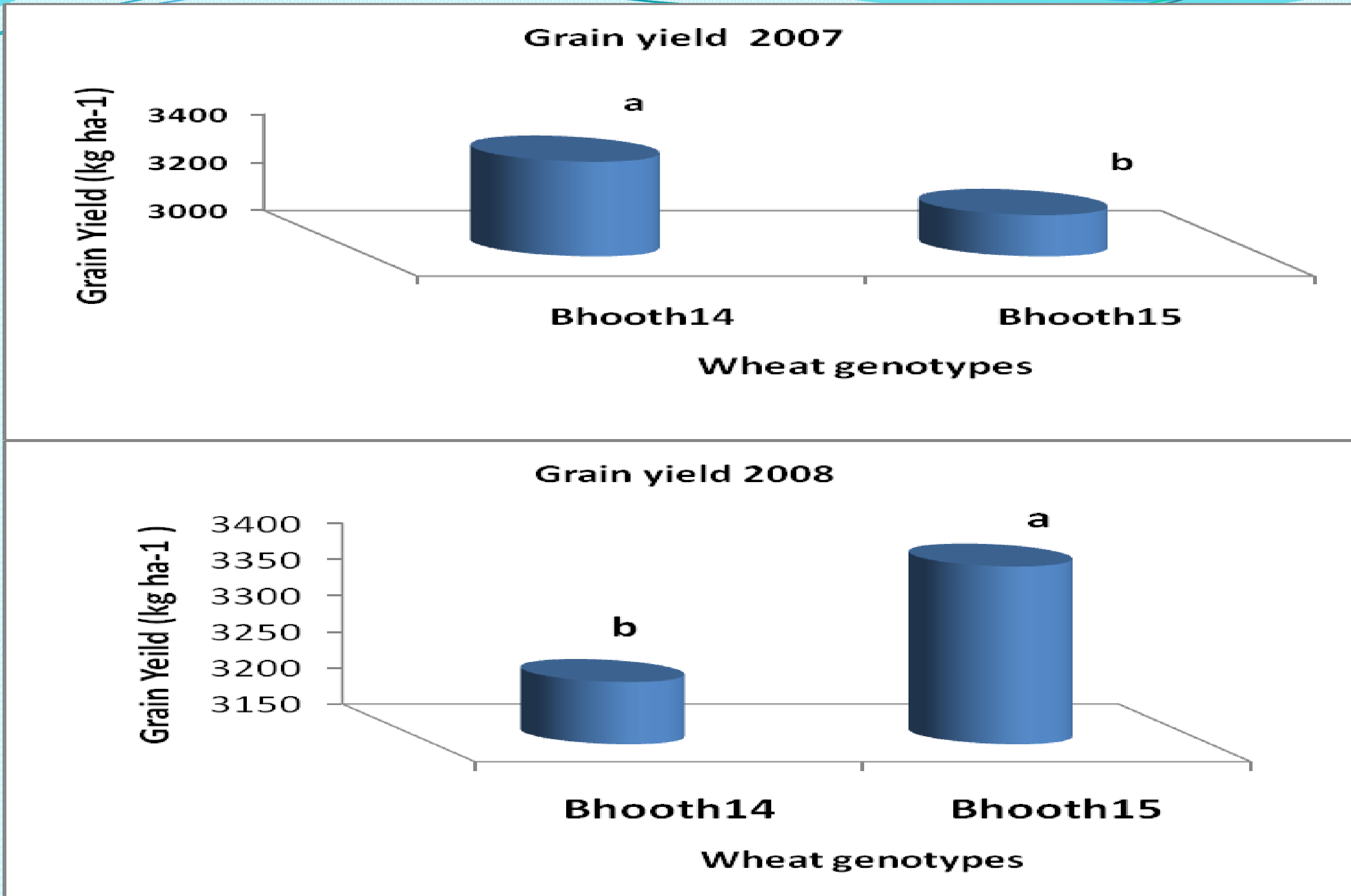

Fig.(6):Grain yield means of two wheat genotypes under ISCR in 2007and 2008 growing seasons

Table (4) The interaction of genotypes x ISCR in grain yield in season 2007

ISCR	EWV (m^3ha^{-1} $season^{-1}$)	Bhooth14	Bhooth15
D30P10	3000	3666.7	3477.8
$D_{30}P_{15}$	2100	2300	1361.1
$D_{30}P_{20}$	1500	300	250
$D_{40}P_{10}$	4000	4055.6	4844.4
$D_{40}P_{15}$	2800	3255.5	2566.7
$D_{40}P_{20}$	2000	988. 9	977.8
$D_{50}P_{10}$	5000	4944.4	4777.7
$D_{50}P_{15}$	3500	4377. 8	4211.1
$D_{50}P_{20}$	2500	2866.6	2261.1
$D_{60}P_{10}$	6000	4983.3	5020
$D_{60}P_{15}$	4200	5155.6	5166.7
$D_{60}P_{20}$	3000	3833.3	3150
LSD0.05		607.84	

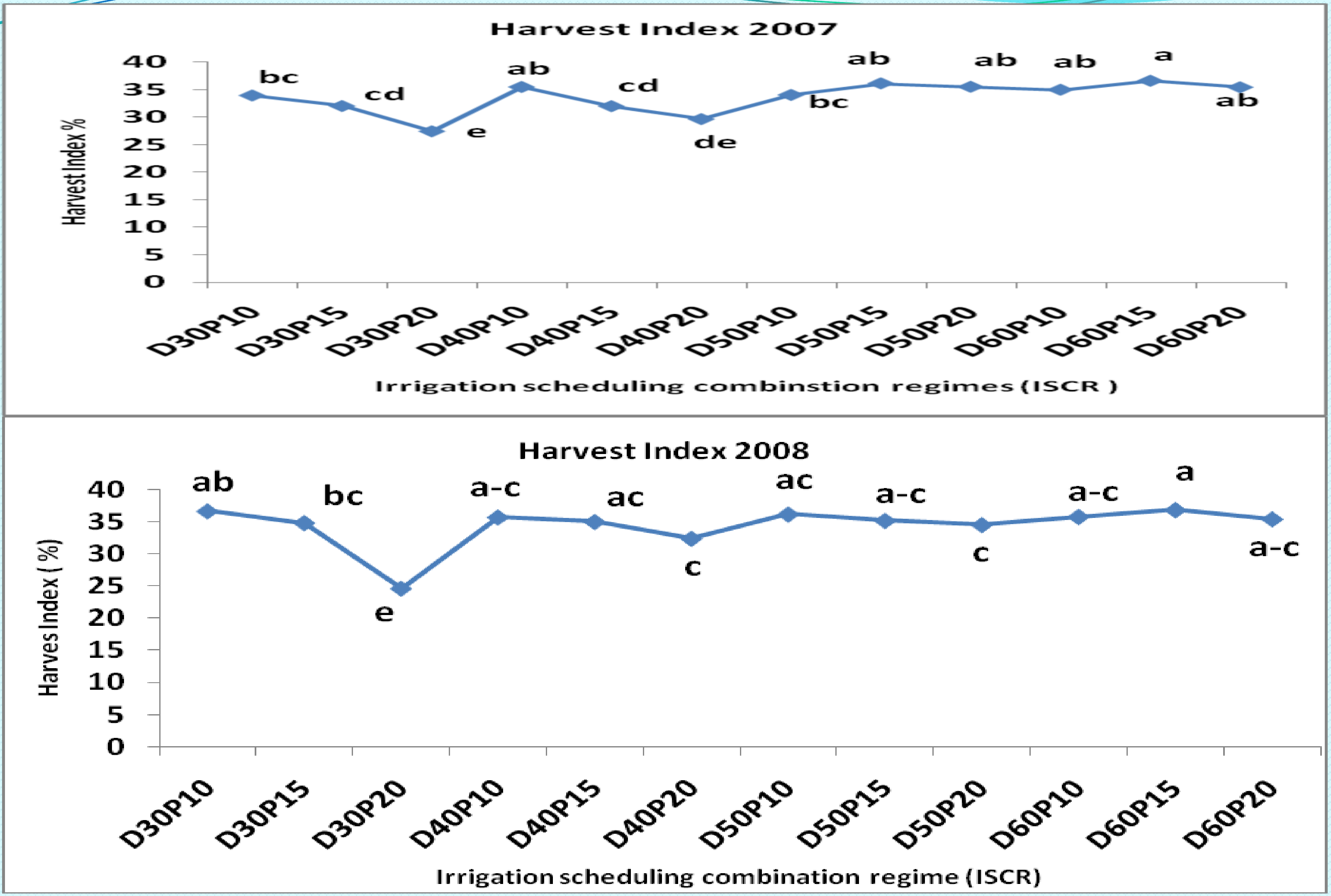

Fig.(7):The effects of ISCR on harvest index of wheat genotypes in 2007 and 2008 growing seasons

Table (5)The means of spikes m-2, kernels spike-1 and a hundred kernel weight of two wheat genotypes under ISCR in 2007 and 2008 growing season.

treatments	No. Of Spikes/m2		No. Of Kernels spike-1		100-kernal weight	
	2007	2008	2007	2008	2007	2008
ISC						
$D_{30}P_{10}$	388^{ab}	321^{c-e}	31.8^{a-d}	49.2^{cd}	4.4	4.1
$D_{30}P_{15}$	293^{de}	300^{d-f}	30.0^{b-e}	42.8^{fg}	3.6	3.9
$D_{30}P_{20}$	230^{f}	244^{g}	20.2^{e}	32.8^{h}	4.1	4.0
$D_{40}P_{10}$	402^{a}	339^{b-d}	40.3^{a}	55.2^{ab}	3.7	4.0
$D_{40}P_{15}$	330^{c}	314^{c-f}	37.7^{a-c}	48.2^{c-e}	3.9	3.7
$D_{40}P_{20}$	277^{e}	271^{fg}	27.7^{de}	41.4^{g}	4.0	4.0
$D_{50}P_{10}$	407^{a}	398^{a}	37.4^{a-d}	57.0^{a}	3.9	4.2
$D_{50}P_{15}$	356^{bc}	284^{a-c}	41.5^{a}	51.0^{c-d}	4.2	4.0
$D_{50}P_{20}$	284^{e}	286^{e-g}	28.8^{c-e}	46.5^{d-f}	4.5	4.1
$D_{60}P_{10}$	379^{ab}	319^{c-f}	39.4^{ab}	54.7^{ab}	4.4	4.1
$D_{60}P_{15}$	342^{c}	373^{ab}	40.0^{a}	52.5^{a-c}	4.6	4.2
$D_{60}P_{20}$	326^{cd}	234^{e-g}	32.6^{a-d}	44.1^{e-g}	4.1	*3.8*
$LSD_{0.05}$	36.4	48.94	9.91	5.09	0.74	0.38
Genotypes						
Bhooth14	347^{a}	309^{a}	33.8^{a}	48.2^{a}	4.1^{a}	4.1^{a}
Bhooth15	321^{b}	325^{a}	34.0^{a}	47.7^{a}	4.1^{a}	3.9^{b}
$LSD_{0.05}$	18.16	23.40	3.19	2.46	0.27	0.16

Table (6):The interaction of ISCR x genotype in a 100-kernel weight in 2008 growing season

ISCR	EWV (m^3ha^{-1} season^{-1}	Bhooth14	Bhooth15
$D_{30}P_{10}$	3000	4.34	3.80
$D_{30}P_{15}$	2100	3.48	4.26
$D_{30}P_{20}$	1500	4.16	3.78
$D_{40}P_{10}$	4000	4.12	3.86
$D_{40}P_{15}$	2800	3.78	3.54
$D_{40}P_{20}$	2000	4.32	3.72
$D_{50}P_{10}$	5000	4.24	4.20
$D_{50}P_{15}$	3500	4.00	4.02
$D_{50}P_{20}$	2500	4.24	3.88
$D_{60}P_{10}$	6000	4.32	3.76
$D_{60}P_{15}$	4200	4	3.94
$D_{60}P_{20}$	3000	3.60	3.92
LSD0.05		0.92	

Table (8):Mean values and orders of the ISCR effects on CWP ($kg\ ha^{-1}m^{-3}$) of wheat genotypes in 2007 and 2008 growing seasons

ISCR	EWV (m^3ha^{-1} $season^{-1}$	CWP ($kg\ ha^{-1}m^{-3}$)			
		2007		2008	
		Value	order	Value	order
$D_{60}P_{20}$	3000	1.19^{a}	1	1.13^{b}	3
$D_{60}P_{15}$	4200	1.17^{ab}	2	1.14^{ab}	2
$D_{50}P_{15}$	3500	1.16^{ab}	3	1.14^{ab}	2
$D_{30}P_{10}$	3000	1.14^{ab}	4	1.12^{ab}	4
$D_{40}P_{10}$	4000	1.09^{abc}	5	1.01^{dc}	6
$D_{50}P_{20}$	2500	1.06^{abc}	6	1.25^{a}	1
$D_{40}P_{15}$	2800	1.02^{abc}	7	1.13^{b}	3
$D_{50}P_{10}$	5000	0.97^{abc}	8	0.91^{d}	8
$D_{30}P_{15}$	2100	0.91^{bc}	9	1.05bc	5
$D_{60}P_{10}$	6000	0.86^{c}	10	0.76^{e}	9
$D_{40}P_{20}$	2000	0.56^{d}	11	0.94^{cd}	7
$D_{30}P_{20}$	1500	0.33^{d}	12	0.55^{f}	10
$Lsd_{0.05}$		0.266		0.112	

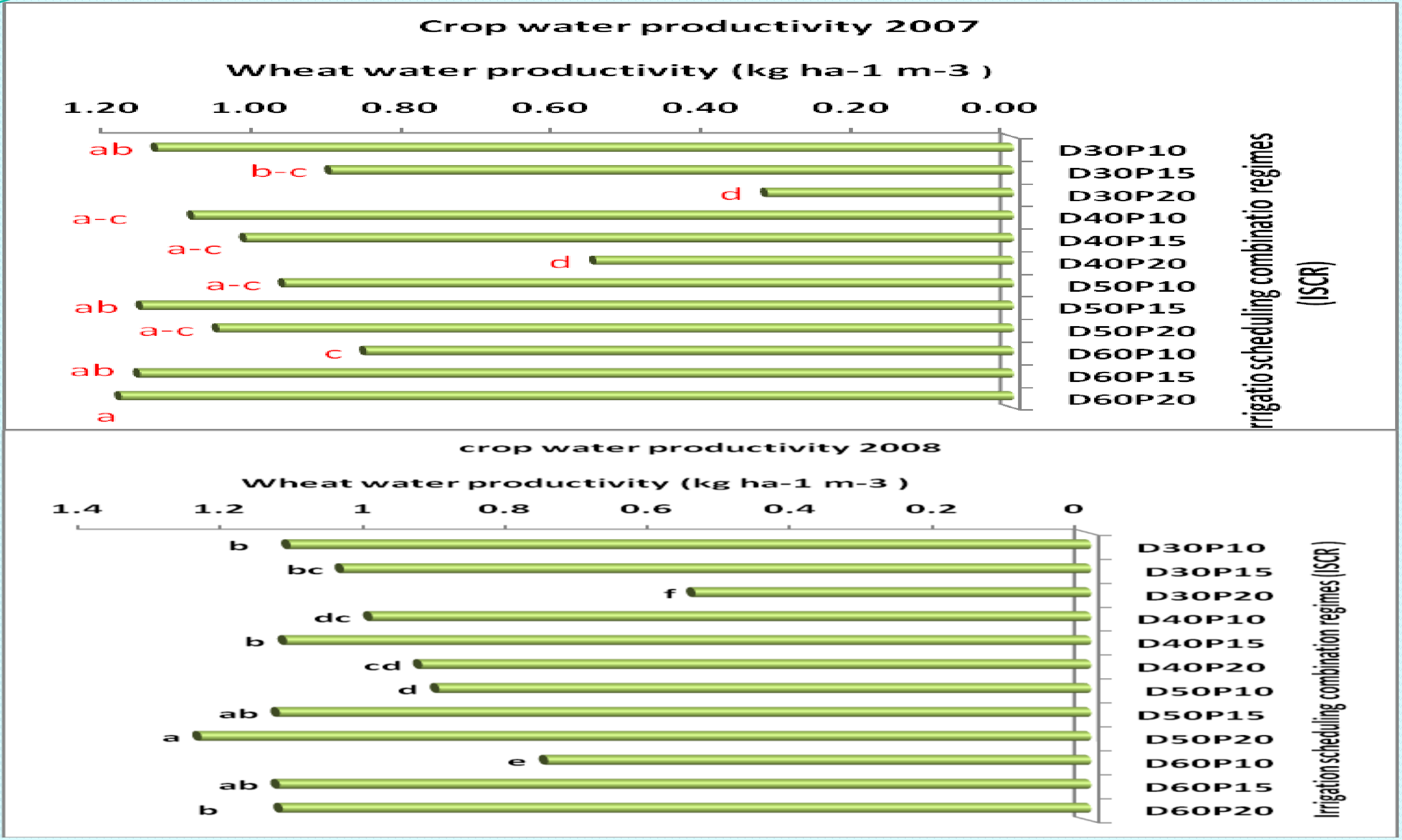

Fig.(8):The effects of ISCR on crop water productivity of tow wheat genotypes in 2007 and 2008 growing seasons

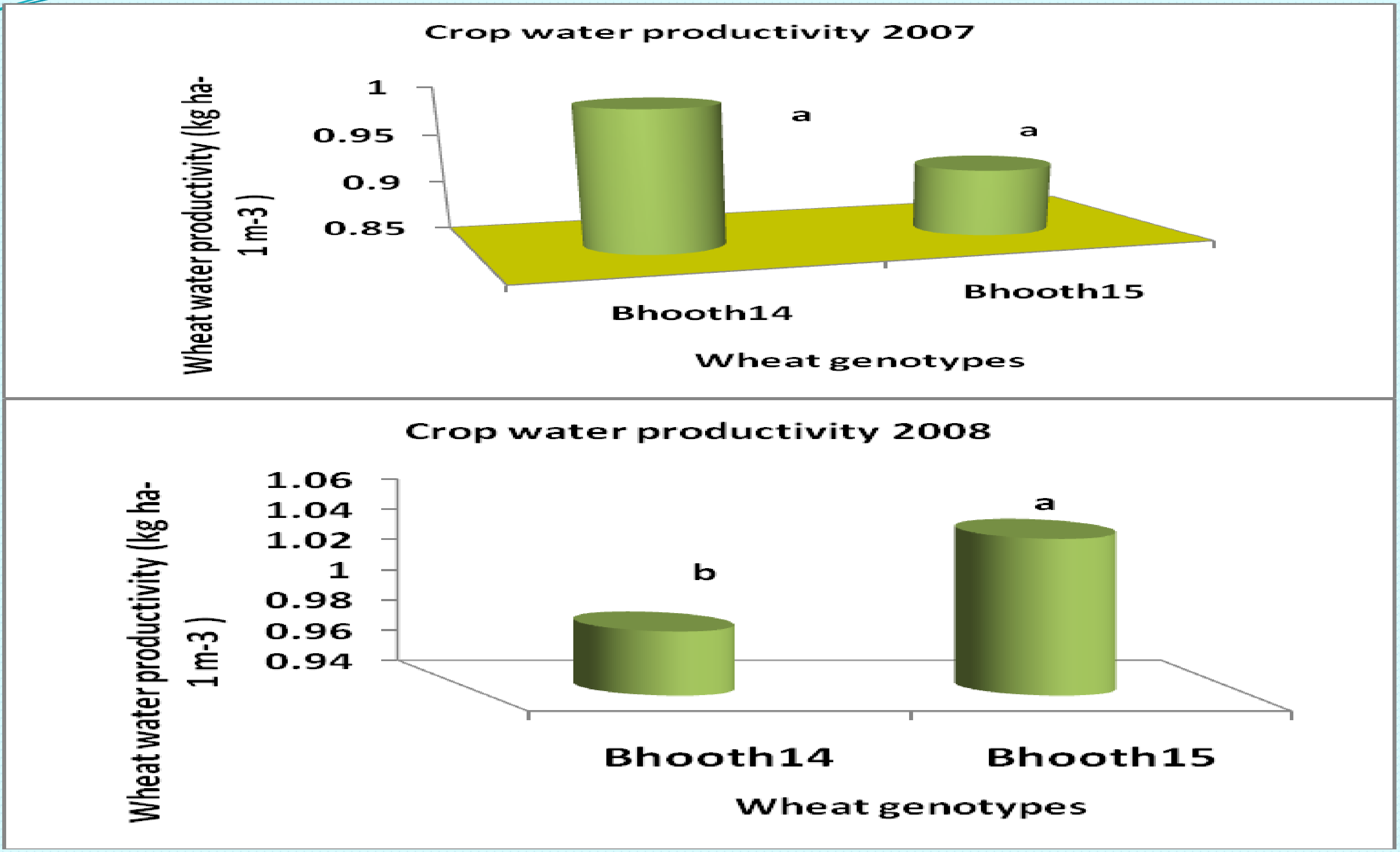

Fig.(9):The differences between two wheat genotypes in crop water productivity under ISCR in 2007 and 2008 growing seasons

Conclusion

- ✓ ISCR affected significantly in PH, BOY, GRY, HI, spikes m-^{2}. Kernels spike^{-1}, and WWP in both seasons. But 100-kernal weight was not varied significantly under ISCR in both seasons.

- ✓ Delaying irrigation application period from 10 to 20 days with the depth of 30, 40, 50 and 60 mm caused statistically reduction in PH, BMY, GRY, spikes m^{-2}and kernels spike^{-1} in both season, but HI and was affected only under the sever water stress (low depths 30 and 40 mm with long period of irrigation).

- ✓ As well as shortening irrigation application period from 20 to 10 days with the depths of 60 and 50 mm failed to achieve significant increment in WWP in comparing with that obtained by the depth 40 and 30 mm every 10 days in both season.

- ✓ The genotype performed differently only in BMY, GRY, spikes m^{-2} in the 1st season and in PH, BMY, GRY, 100-kernal weight and WWP in the 2nd season.

- **In comparing the grain yield produced by the combination $D_{60}P_{15}$ = 4200 m^3 ha^{-1} which was 5161 and 4792 kg ha^{-1} in the 1^{st} and 2nd seasons respectively with that produced by $D_{60}P_{10}$ = 6000 m^3 ha^{-1} which was 5002 and 4500 kg ha^{-1} in the 1^{st} and 2^{nd} seasons respectively**
- **These results denoted that there is a high potential to save large amount of irrigation water (1800 m^3ha^{-1}) and gain significant increment in grain yield, about 159 (= 3.18 %) and 292 kg ha^{-1}(6.48%) in the 1^{st} and 2^{nd} seasons respectively.**

- **It could be concluded that " ISCR " is an excellent procedure provide a proven of existing high potential to attained food security by producing more food with using less water through enhancing CWP.**
- **This procedure is highly relevant tool to be used in many practical applications at field level under each country conditions, with low cost and easy to implement by any farmer for promoting the potential of increasing grain yield with less water, then attain food security in water scarcity country environments**
- **But it is needed to expand to include more combinations of depths, periods and genotypes and replicate enough under the conditions of each agro ecological level, then it well provide a good guidelines to make ‹‹more crop per drop›› as fact.**


Thank you
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