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Morpho-physiological characteristics response of hull-less barley genotypes to water deficit stress

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Key words: Barley, Morpho-physiological characteristics, water deficit stress.

Abstract

In order to investigated the morpho-physiological characteristics response of hull-less barley (*Hordeum vulgare* L.) genotypes to water deficit stress an experiment was conducted in the split plot form based on completely randomized block design with three replications during growing seasons of 2013-2014. Treatments were water deficit stress in five levels contain irrigation each 7, 14, 21 days, cut of irrigation at heading stage and non irrigation (dry land condition). The second factor was 10 hulls-less barley genotypes. The analysis of variance showed that significant effect of water deficit stress on plant height and interaction effect between water deficit stress and genotype on spike length, number of fertile tiller, number of non fertile tiller and spikes number ($P < 0.01$), and leaf number, awn length, spikelet number ($P < 0.05$). The detailed results of the study showed that water deficit stress caused to decrease all of these characteristics and the various genotypes have different reactions in water deficit stress conditions. The correlations results appears that there is a positive correlation between spike number and plant height, the number of fertile tiller and peduncle length.

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Introduction

Water deficit is one of the most yield limiting factors as it affects growth and development (Umebese *et al.,* 2009) by decreasing vegetative development, leaf area, photosynthetic and transpiration rates due to stomatal closure (Anjum *et al.,* 2011). Water deficit in the plant disrupts many cellular and whole plant functions, having a negative impact on plant growth and reproduction. Crop yields are reduced by 69% on average when plants are exposed to unfavourable conditions in the field (Bray, 2001). Availability of water is the most important factor in the environment that reduces the production of our crops. As water is increasingly needed for human populations and prime agricultural lands are used for housing, the availability of water will have a greater impact on our ability to produce crops.

Barley is one of the founder crops of old world agriculture and was one of the first domesticated cereals. It is also a model experimental system because of its short life cycle and morphological physiological and genetic characteristics. Barley ranks fourth in world cereal crop production and is used for, in order of importance, animal feed, brewing malts and human food (Aharizad *et al.,* 2013). For commercial purposes, barley varieties classified into broad classes that are used as a basis for world trade. The major factors used to distinguish barley varieties are hulled or hull-less, and six-, four- or two-row varieties (Komastsuda *et al.,* 2007). In cultivated hull-less barley, which also appeared 8000 years ago, the husks do not adhere to the grain, which falls free on threshing (Komastsuda *et al.,* 2007). Therefore, research into crop management practices that enhance drought tolerance and plant growth when water supply is limited has become increasingly essential.

Thus, the aim of this project was to select the plants for drought tolerance and to evaluate of morphological characteristics of hull-less barley genotypes under water deficit stress their tendency to endure water stress.

Materials and methods

The field experiment was carried out in split plot form by completely randomized block design with three replicates at the Research Station of the Islamic Azad University, Tabriz Branch, north-western Iran, during the 2013 – 2014 growing season.

The first factor was water deficit stress in five levels contain irrigation each 7, 14, 21 days, cut of irrigation at heading stage and non irrigation (dry land condition). The second factor was 10 hulls-less barley genotypes as table 1.

Table 1. characteristics of two and six row varieties of hull-less barley genotypes.

Type	Source	No
Two-row varieties	BSH-19/Atahualpa	b1
	BOLDO/4/RHODES/TB-B/CHZO/3/GLORIA-BAR/COPAL/5/VIRINGA/6/ATACO	b2
	BOLDO/POLEO/4/RHODEC//TB-B/CHZO/3/GLORIA-BAR/COPAL/5/VIRINGA/6/ATACO	b3
	Atahuaipa/3/Harrington/W12291*2/W1269	b4
	Atahuaipa/4/Harrington/3/W12291/Roho/W12269	b5
Six-row varieties	Atahuaipa/6/Man/4/Bal.16/pro//Amp/Dwll-1Y/3/Api/CM67/5/Gaines/Ores	b1
	ICB-115137/ICNBF8-617	b2
	Rt013/PETUNIA2	b3
	Libya/ICNBF8-164	b4
	F6-1-KF/6/CitaS/4/Apm/RI/Manker/3/Maswi/Bon/5/CopaiS/7/icnbf8-617	b5

Each plot consists of 3 rows, 20 cm row spacing and 5 cm plant interval. Flooding irrigation was conducted except non irrigation and all of treatments were irrigated completely prior to heading stage (After this stage flooding irrigation was not conducted). Plant height, leaf number, spike length, awn length, number of fertile tiller, number of non fertile tiller, spikelet number and spikes number were studied.

Statistical analysis

In order to check the normality of data, analysis of variance, and mean comparison MSTAT-C software were used. The means of the treatments were compared using the least significant difference (LSD) test at $P < 0.05$.

Results and discussion

The analysis of variance showed significant effect of water deficit stress on plant height and interaction effect between water deficit stress and genotype on spike length, number of fertile tiller, number of non fertile tiller and spikes number ($P < 0.01$) and leaf number, awn length, spikelet number ($P < 0.05$) (Table 2).

Table 2. Analysis of variance for studied traits of 10 hull less barley cultivars under water deficit stress condition.

S.O.V	df	Means Square								
		spike number m²	spiklet number	number of non fertile tiller	number of fertile tiller	awn length	spike length	peduncle length	leaf number	plant height
replication	2	316.167	33.678	0.981	1.571	1.461	1.665	1.907	128.518	30.252
water stress	4	6406**	14.176	1.079	5.674*	5.343	2.444	12.816	720.451	99.056
error a	8	361.375	10.546	0.544	1.319	2.663	0.915	10.559	387.343	136.951
variety	9	10754.889**	137.598**	0.713**	10.02**	5.821**	14.192**	25.307**	244.519**	510.77**
variety×stress	36	1204.426**	8.763*	0.427**	1.436**	1.715	1.414**	8.951**	72.934*	57.431
error	90	340.852	5.564	0.203	0.56	1.134	0.54	4.947	46.996	47.628
%cv		7.59	14.76	35.56	24.72	7.88	10.43	14.86	20.51	10.87

* and ** significant at 5% &1%, respectively.

Plant height

The results showed that number 1 and 4 genotypes of six-row varieties obtained the highest (69.93 cm) and the lowest (64.92 cm) plant height respectively. In two-row varieties, the highest (65.22 cm) and the lowest (50.13 cm) plant height were found in variety number 5 and 2 respectively (Fig. 1).

Rajala *et al.*, (2009) reported that there is significant difference between different genotypes of barley. Pachepskey *et al.*, (2004) also reported that plant height is different between plants but either is affected by environmental factors. The activation of the apical can be one of the reasons of this difference, because apical dominant is the main reason of the increase of plant height. Apical dominant and development of cells is depends on auxin concentration and the concentration of auxin is different between plants (Bak *et al.*, 2001). Therefor the high concentrations of auxin can cause to create plant height differences in genotypes that studied in this experiment. Furthermore, photosynthetic and intensity of photosynthesis is deferent in various genotypes (Din *et al.*, 2011). Because existence of enough assimilates for plant is one of the important agents of increasing growth, therefor the genotypes that have large amounts of photosynthetic materials can have highest plant height.

Awn length

The results were obtained that water deficit stress had no significant effect on awn length, but there is a significant difference between awn length of various genotypes of hul less barley. In tow-row varieties, variety numbe 5 with 14.72 cm had the highest awn length and variety number 4 with 12.83 cm had the lowest awn length. In six-row varieties, variety numbe 5 with 14.22 cm had the highest awn length and variety number 3 with 13.22 cm had the lowest awn length. It is appear from the results awn length is a genetical caracteristic in hull less barley and water deficit stress dose not have a significant effect on it. Drikvand *et al.*, (2011) reported that awn length dose not affect by water deficit stress.

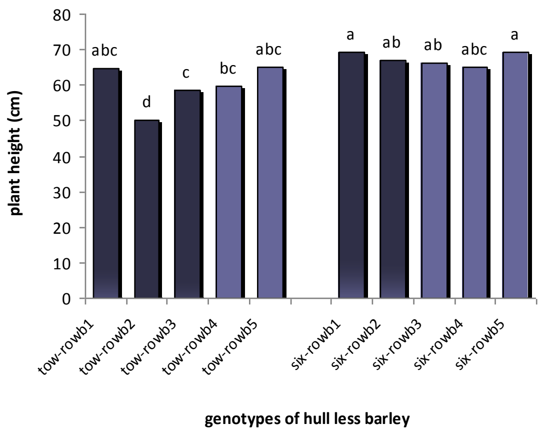

Fig. 1. Mean comparison for plant height in different genotypes of hull less barley.

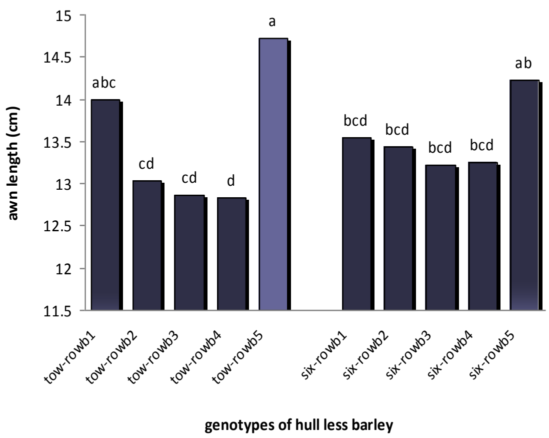

Fig. 2. Mean comparison for awn length in different genotypes of hull less barley.

Leaf Number

Mean comparisons of leaf number showed the significant effect of water deficit stress and genotypes on indicated that in six-row varieties. The highest leaf number (44.5) in irrigation each 7 days and the lowest (22.7) in irrigation each 14 days obtained in variety number 2 and 4 respectively. In two-row varieties, the highest leaf number (22.0) in irrigation each 7 days and the lowest (16.83) in irrigation each 14 days were found in variety number 5 and 1 respectively (Table 3). As seen genotypes that are affected by different water deficient stresses are very different. The leaf number is a genetically factor. To exert the water deficient stress at heading stage dose not cause to a significant effect on leaf number because all leaves of the plant is exist when stress begins and leaves are not falling in because of the water deficient stress.

Number of fertile tiller

Mean comparisons fertile tiller showed the significant effect of water deficit stress and genotypes. In six-row varieties, the highest fertile tiller (4.217) in irrigation each 7 days and the lowest (1.22) in irrigation each 21 days indicated in variety number 2 and 1 respectively. In two-row varieties, the highest fertile tiller (6.8) in irrigation each 7 days and the lowest (1.11) fertile tiller in irrigation each 14 days were obtained by variety number 4 and 2 respectively (Table 3). To exert the water deficient stress in varieties 1.2 and 5 of tow-row hull less barley dose not have a significant effect on number of fertile tiller but in varieties 3 and 4 of tow –row hull less barley cause to a significant effect on number of fertile tiller. So that in variety 3 of tow-row hull less barley to exert the irrigation each 14 and 21 days , cut of irrigation at heading stage and dry land condition decrease the number of fertile tiller 52.96, 50.02, 33.8 and 15.44 percent compared with to irrigation each 7 days respectively. These decreases were 52.18, 31.81, 9.33 and 41.37 percent for the variety number 4 of tow-row hull less barley respectively. There is no significant effect on six-row variations.

Reynolds *et al.*, (2009) suggested that gradual development of water stress after pollination in wheat cause to touch the grains from high levels of water stress at the stage of heading and grain filling period and it may cause to decrease their contribution on yield.

Number of non fertile tiller

Mean comparisons of non fertile tiller indicated the significant effect of water deficit stress and genotypes. In six-row varieties, the highest non fertile tiller (4.2) obtained in irrigation each 7 days and the lowest

(1.22) in irrigation each 21 days by variety number 1 and 4, respectively. In two-row varieties, the highest non fertile tiller (2.22) in irrigation each 14 days and the lowest (0.33) in irrigation each 7 days were found by variety number 4 and 2, respectively (Table 3). To exert the water deficient stress in varieties 1, 3, 4 and 5 of tow-row hull less barley dose not have a significant effect on number of fertile tiller but in variety 2 of tow –row hull less barley cause to a significant effect on number of non fertile tiller. So that in variety 2 of tow-row hull less barley to exert the irrigation each 14 and 21 days, cut of irrigation at heading stage and dry land condition decreased the number of non fertile tiller 87.05, 43.82, 46.41 and 60.76 percent compared with irrigation each 7 days, respectively. There is no significant effect on six-row variations. Because of the results it is provide that genotypes of hull less barley have different reactions about number of non fertile tiller in various environmental conditions. Researchers reported that to have tolerance against the water deficit is the result of interference of morphological, physiological and biochemical caracteristics in plants. For this reason various genotyps probably have different reactions to water deficit stress (Feng *et al.*, 2009).

Spike length

Mean comparisons of spike length indicated that the significant effect of water deficit stress and genotypes. In six-row varieties, the highest spike length (7.34) obtained in irrigation each 7 days and the lowest (4.48) in cut of irrigation at heading stage by variety number 4 and 3, respectively. In two-row varieties, the highest spike length (10.38) in irrigation each 7 days and the lowest (5.41) in cut of irrigation at heading stage were obtained by variety number 5 and 2, respectively (table 3). To exert the water deficient stress in varieties 1, 3 and 4 of tow-row hull less barley dose not have a significant effect on spike length but in varieties 2 and 5 of tow –row hull less barley cause to a significant effect on spike length. In variety 2 of tow-row hull less barley to exert the irrigation each 21 days the spike length 31.5 percent decreased in compare to irrigation each 7 days and in variety 5 of tow-row hull less barley to exert the irrigation each 14 and 21 days, cut of irrigation at heading stage and dry land condition 6.6, 22.77, 9.83 and 28.6 percent decreased in compare to irrigation each 7 days, respectively. There is no significant effect on six-row variations. Fathi and Macdonald (1998) believed that decrease of photosynthesis after heading stage that causes because of water stress, confused the produced dry matter of grain and in result, have negative effect on total grain yield. Researchers reported that the plants with most long plant height have more auxin and gibberlin in their tissues, therefore cell growth in these plants is better and have more cell divisions (Gou *et al.*, 2001 and Hu *et al.*, 2008)

Spiklet number

Mean comparisons of spiklet number showed that the significant effect of water deficit stress and genotypes. In six-row varieties, the highest spiklet number (21.37) indicated in irrigation each 14 days and the lowest (11.33) in dry land condition by variety number 4 and 3, respectively. In two-row varieties, the highest spiklet number (21.4) obtained in irrigation each 7 days and the lowest (10.79) in dryland condition by variety number 5 and 2 respectively (Table 3). To exert the water deficient stress in tow-row hull less barley dose not have a significant effect on spiklet number but in six-row genotypes water stress in varieties 1, 3, 4 and 5 dose not cause to a significant effect on spiklet number. In variety number 2, water stress cause to the significant effect on spike length, so in variety 2 of six-row hull less barley to exert the irrigation each 14 and 21 days, cut of irrigation at heading stage and dry land condition 37.73, 42.35, 29.63 and 37.77 percent decrease the spiklet number in compared to irrigation each 7 days, respectively.

Peduncle length

Mean comparisons of peduncle length showed that the significant effect of water deficit stress and genotypes. In six-row varieties, the highest peduncle length (19.82) indicated in irrigation each 14 days and the lowest (13.34) in dry land condition by variety number 3 and 2, respectively. In two-row varieties, the highest peduncle length (18.49) obtained in irrigation each 7 days and the lowest (10.04) in irrigation each 14 days by variety number 4 and 2, respectively (Table 3). To exert the water deficient stress in varieties 2, 3 and 5 of tow-row hull less barley dose not have a significant effect on length of peduncle but in varieties 1 and 4 of tow –row hull less barley cause to a significant effect on, length of peduncle. So that in variety 1 of tow-row hull less barley to exert the irrigation each 14 days 33.54 percent decrease the number of peduncle length in compared to irrigation each 7 days. This decrease in dry land condition was 37.9 percent in compared to irrigation each14 days for the variety number 4 of tow-row hull less barley. To exert the water deficient stress in varieties 1, 2, 4 and 5 of tow-row hull less barley dose not have a significant effect on length of peduncle but in variety 3 of six –row hull less barley cause to a significant effect on length of peduncle. In this variety, to exert the irrigation each 21 days and dry land condition 27.43 and 27.99 percent decreased the length of peduncle in compared irrigation each 14 days, respectively. Researchers reported that nitrogen absorption intensively decreasing under the water stress condition (Georgian *et al.*, 2009), therefor nitrogen has an importan role at development of cells and in result at increasing the length of different parts of the plant such as peduncle (Lodiero *et al.*, 2000).

Table 3. Mean comparison of interaction between water deficit stress and tow-row genotypes of measured traits in experiment.

varieties	treatment	leaf number	pedancel length (cm)	spike length (cm)	number of fertile tiller	number of non fertile tiller	spikelet number	spikes number m²
	irrigation each 7 days	42.07 a-g	16.69 a-e	7.15 d-k	4.07 b-f	1.40 a-g	16.45 c-l	325 a
	irrigation each 14 days	31.20 c-m	13.95 c-j	7.02 d-l	3.97b-f	0.97 c-g	15.44 e-n	240 e-m
six-row 1 variety	irrigation each 21 days	23.89 b-k	13.98 b-f	8.02 e-m	1.22 b-g	0.72 a-g	19.22 f-n	210 h-n
	cut of irrigation at heading stage	31.00 c-m	16.92 a-e	6.83 d-m	3.04 b-k	1.13 a-g	14.52 g-n	325 a
	dry land condition	45.80 ab	15.76 b-h	6.50 f-m	3.69 b-h	1.26 a-g	12.90 j-n	225 h-n
	irrigation each 7 days	44.55 abc	15.40b-i	6.85 d-m	4.22 b-e	1.00 b-g	21.19 ab	285 a-e
	irrigation each 14 days	32.02 c-m	14.63 c-i	5.93 i-n	3.73 b-h	1.15 a-g	12.21 k-n	243.3 d-m
six-row 2 variety	irrigation each 21 days	32.80 b-l	14.18 c-j	6.46 f-m	3.10 b-j	1.35 a-g	13.19 i-n	240 e-m
	cut of irrigation at heading stage	31.40 c-m	14.86 e-i	6.88 d-l	3.05 b-k	1.38 a-g	14.92 f-n	300 ab
	dry land condition	37.08 b-k	13.35 e-j	6.53 e-m	2.42 d-k	1.17 a-g	13.19 i-n	261.7 b-i
	irrigation each 7 days	31.12 c-m	19.82 ab	6.45 e-m	3.05 b-h	1.10 a-g	12.44 j-n	281.7 a-f
	irrigation each 14 days	28.94g-n	20.69 a	6.39 g-m	3.61 b-h	1.61 a-f	12.55 j-n	241.7 f-m
six-row 3 variety	irrigation each 21 days	30.80 c-m	15.01 c-i	6.08 h-n	3.33 b-i	1.27 a-g	11.54 mn	221.7 h-n
	cut of irrigation at heading stage	27.55 h-n	17.37 a-e	4.49 n	3.27 b-i	0.84 efg	12.56 j-n	236.7 f-m
	dry land condition	38.44 b-j	14.90 c-i	5.21 lmn	3.22b-i	1.39 a-g	11.33 n	248.3 d-l
	irrigation each 7 days	30.80 c-m	15.66 b-h	7.34 d-k	2.80 b-j	1.13 a-g	15.51 e-n	278.3 b-g
	irrigation each 14 days	22.74 lmn	14.59 c-i	7.59 d-k	2.28 b-k	0.84 efg	16.49 b-l	243.3 d-m
six-row 4 variety	irrigation each 21 days	26.33 i-n	15.01 c-i	6.44 f-m	2.96 b-k	0.98 c-g	13.33 i-n	228.3 h-n
	cut of irrigation at heading stage	30.18 e-n	16.11 b-g	6.56 e-m	2.75 d-k	1.53 a-g	15.03 f-n	256.7 b-j
	dry land condition	30.76 c-m	14.76c-i	6.55 e-m	2.12 f-k	0.98 b-g	12.18 lmn	253.3 b-j
	irrigation each 7 days	40.13 a-i	15.18 c-i	6.21 h-n	3.93 bcd	1.20 a-g	12.97 j-n	290 abcd
	irrigation each 14 days	39.51 a-j	14.35 c-j	6.18 e-m	3.91 b-g	1.44 a-g	14.37 g-n	251.7 c-k
six-row 5 variety	irrigation each 21 days	31.67 c-m	15.85 b-h	6.23 h-n	3.03 b-k	0.77 efg	13.60 h-n	268.3 b-h
	cut of irrigation at heading stage	40.87 a-h	14.74 c-i	5.73 j-n	3.40 b-i	1.47 a-g	13.28 i-n	253.3 b-j
	dry land condition	42.11 a-g	13.75 d-j	6.40 g-m	2.85 c-k	2.08 a-d	12.41 j-n	296 f-n
	irrigation each 7 days	26.67 f-n	15.68 b-h	8.25 b-g	2.27 e-k	1.27 a-g	17.88 a-i	233.33 g-n
two-row 1 variety	irrigation each 14 days	16.83 n	10.04 j	7.22 d-k	1.55 ijk	0.78 defg	19.47 a-f	203.33 klmn
	irrigation each 21 days	28.61 g-n	14.63 c-i	8.73 abcd	3.17 b-j	1.36 a-g	20.81 a-d	265 b-I

varieties	treatment	leaf number	pedancel length (cm)	spike length (cm)	number of fertile tiller	number of non fertile tiller	spikelet number	spikes number m^2
	cut of irrigation at heading stage	30.62 c-m	14.57 c-i	8.37 b-f	2.92 b-k	2.18 ab	20.49 a-d	228.33 h-n
	dry land condition	44.20 a-d	13.84 d-j	7.97 b-h	2.57 d-k	2.17 abc	21.03 abc	221.66 h-n
two-row 2 variety	irrigation each 7 days	39.1 a-j	11.10 ij	7.88 b-i	1.50 ijk	1.70 a-f	17.89 a-i	216.66 i-n
	irrigation each 14 days	18.78 mn	16.28 b-f	7.71 c-i	1.11 k	0.22 g	20.72 a-d	196.66 mn
	irrigation each 21 days	29.10 g-n	12.02 f-j	5.42 klmn	1.19 jk	0.96 d-g	17.10 a-j	198.33 mn
	cut of irrigation at heading stage	31.31 c-m	12.10 f-j	7.46 d-j	1.51 ijk	0.91 d-g	20.96 abc	188.33 n
	dry land condition	34.61 b-l	11.67 g-i	7.51 d-j	1.94 g-k	0.67 efg	16.98 a-k	198.33 mn
two-row 3 variety	irrigation each 7 days	38.90 a-j	14.07 c-j	6.91 d-m	3.89 a	1.30 a-g	18.18 a-e	228.33 h-n
	irrigation each 14 days	28.33 g-n	9.21 e-j	7.68 d-k	1.83 h-k	0.50 fg	19.75 a-e	200 lmn
	irrigation each 21 days	32.67 b-m	15.73 b-h	8.45 b-e	1.94 g-k	1.26 a-g	16.20 d-m	223.33 h-n
	cut of irrigation at heading stage	36.38 b-l	14.62 c-i	7.19 d-k	2.58 d-k	1.31 a-g	18.18 a-h	201.66 lmn
	dry land condition	39.82 a-j	16.19 b-g	7.86 c-i	3.29 b-i	1.11 a-g	13.06 a-e	226.66 h-n
two-row 4 variety	irrigation each 7 days	31.00 c-m	18.49 abc	6.83 d-m	5.80 a	1.73 a-e	14.53 g-n	325 a
	irrigation each 14 days	23.73 k-n	16.46 b-f	6.67 e-m	2.77 d-k	1.11 a-g	14.04 h-n	255 b-j
	irrigation each 21 days	30.38 d-n	15.56 b-h	6.94 d-l	3.96 b-f	2.22 a	12.68 j-n	296.66 abc
	cut of irrigation at heading stage	33.87 b-l	14.41 c-j	6.11 h-n	4.87 b	1.80 a-e	12.29 k-n	263.33 b-i
	dry land condition	18.78 j-n	11.48 hij	4.94 mn	3.40 b-i	1.27 a-g	10.79 n	280 a-g
two-row 5 variety	irrigation each 7 days	52.20 a	17.98 abcd	10.38 a	3.00 b-k	1.80 a-e	21.40 a	243.33 d-m
	irrigation each 14 days	26.94 h-n	13.74 d-j	9.69 d-k	2.22 f-k	0.70 efg	21.37 a	211.67 j-n
	irrigation each 21 days	23.89 klmn	13.98 c-j	8.02 b-h	1.22 jk	0.72 efg	19.22 a-f	210 j-n
	cut of irrigation at heading stage	43.40 a-f	16.40 b-f	9.36 abc	3.10 b-j	1.70 a-f	20.30 a-d	195 mn
	dry land condition	43.96 a-e	14.32 c-j	7.41 d-j	2.20 f-k	1.57 a-f	17.74 a-i	218.33 i-n

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