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Investigation of Water Deficit Stress on Agronomical Traits of Soybean Cultivars in Temperate Climate

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***Abstract*—**In order to investigate water deficit stress on 24 of soybean (*Glycine Max. L*) cultivars and lines in temperate climate, an experiment was conducted in Iran Seed and Plant Improvement Institute. Stress levels were irrigation after evaporation of 50, 100, 150 mm water from pan, class A. Randomized Completely Block Design was arranged for each stress levels. Some traits such as, node number, plant height, pod number per area, grain number per pod, grain number per area, 1000 grains weight, grain yield and harvest index were measured. Results showed that water deficit stress had significant effect on node number, plant height, pod number per area, grain number per pod, grain number per area, 1000 grains weight and harvest index. Also all of agronomic traits except harvest index influenced significantly by cultivars and lines. The least and most grain yield was belonged to Ronak X Williams and M41 x Clark respectively.

***Keywords*—**Soybean, water deficit stress, Agronomic traits, Yield

I. INTRODUCTION

THE soybean is one of the most important crops in the world. it is an important source of protein in the human food and has been utilized in the formulation of the animals' rations, besides utilization of the grain oil. The most worldwide yield is belonged USA, followed of Brazil, Argentina and China, they are responsible for about 90% of the world yield [1]. It's the most important oil crop after canola as seed production. Abiotic stresses can damage *Glycine max L.* Merrill, extremely. It is more sensitive than other food legumes, as *vigna unguiculata* [2; 3] and also with other crops as *Gossypium hirsutum* and *sorghum bicolor* [4; 5].

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Agriculture worldwide is heavily dependent on water availability, making water management one of the most important components of modern agriculture. Good water management in the field and a quick decision in response to soil water availability usually determine profit or failure for many farmers employing irrigation [6].Water deficit stress during the growth and development stages can be reduced yield, strongly [7]. Number of ovules that fertilized and developed to grains decreased rapidly when drought occurred during flowering [8]. Moreover, yield and grain number were reduced as a result of water deficit stress during grain filling period . The most sensitive stages for soybean plants are pod development to seed filling. It needs adequate water in the soil to produce suitable yield. As the soybean plant develops from R1 (beginning bloom) through R5 (seed enlargement), the ability of plant decrease to tolerate the water deficit and produce low yield [9]. Water deficit during late reproductive development stage accelerates leaves aging and seed filling [10]. Decreasing of the seed filling period may have a greater impact on yield than the direct effect of stress, such as reduced rate of photosynthesis. Although, the abortion of pods and seeds are occurred by water deficit during flowering and early pod development that may result in reducing of reproductive demand or critical assimilate reserves. Water deficit during reproductive development stages often decreases the seed size in soybean [11]. Reduction in seed size is primarily due to a shortening of the seed filling period rather than an inhibition of seed growth rate [12]. Irrigation can significantly increase soybean seed yield. Stress conditions such as high temperature and moisture deficiency reduce soybean yield because of reduction in one or more yield components. Drought stress occurrence during flowering and early pod development stage increases the rate of pod abortion, significantly [13]. As the soybean plant develops from R1 (beginning bloom) through R5 (seed enlargement), its tolerance decrease to drought. Some research showed that water deficit during flowering (R2 stage) had little effect on seed yield whereas during pod elongation (R3 stage) and seed filling (R5 stage) they were significant [14]. Reports showed that water deficit at either R2 or R3 stages significantly reduced yield. They also reported that water deficit stress at the flowering stage resulted in greater yield loss than the one at pod elongation stage. Drought stress occurrence during the early reproductive development stage increase the flower and pod abortion [14] and decreasing the seed number in plant, but plant may produce high seed weight.

II. Methodology

Soybean (*Glycine Max* L) cultivars and lines response to water deficit stress were studied in temperate climate. An experiment was conducted in seedling and seed Research institute, Karaj, Iran in 2008. A Randomized Completely Block Design was arranged for each stress levels in two years. Stress levels were irrigation after 50, 100, 150 mm of water from pan, class A (S1, S2, S3 respectively). 24 cultivars and lines were evaluated in this experiment. Standards cultivation practices were carried out until maturity. Planting date was in the early summer after wheat harvesting. First irrigation was done a day after planting. Weeding was done in three stages. Planting density was arranged as 35-40 pl.m^{-2} in all plots. Plants in four middle hills (excluding of border hills) were randomly selected for measuring of morphological traits, yield and its' components in all plots. Grain yield was determined from harvest area of 4 m^2. Some agronomical traits such as node number, plant height, pod number per area, grain number per pod, grain number per area, 1000 grains weight, yield and harvest index were determined. All statistical analysis were done by the Statistically Analysis Software [15] and mean values were compared by Duncan Multiple Range Test (DMRT).

III. Result and Discussion

Results indicated that stress levels and cultivars and lines had significant effect on node number and height at 0.01 probability level (Table 1). Stress reduced node number by growth decreasing. Among cultivars and lines, TNS56 had the highest in node number and height. It had high growth rate. This line belonged to IV maturity group and produced the most node number in the main stem and inter-nodes distance. Early maturity cultivar like Boutny had the least height for low inter-node and node number. All cultivars and lines had the similar response to water deficit in height. In moderate water stress the most decreasing was related to M7 cv. that node decreasing was in amount of 30% [Table 2]. In intensive stress, the node of M7 cv. was decreased in amount of 35.5%. Clark cv. had the most reduction in plant height.

There was a depletion of grain number per pod, when water deficit occurred. Cultivars and lines had different grain number in pods, but they almost had similar response to water deficit. The least changes in grain number per pod in moderate stress were related to Sepideh, Ronak X Williams, Williams X Chippewa and L17, Boutny and Davis X Williams in severity stress, Linford, 18, L91-8915, TMS and L17 were produced the least changes in grain number per pod [Table 3,4].

Water deficit stress had significant effect on pod and seed production, although, there were different responses in cultivars and lines to soil water depletion (Table 1). Charleston cv. had the most pod number per area and the least one was achieved by L91-8915. The least changes in pod number was related to Hamilton X Essex Line and the most reductions in the trait were obtained by L17, Boutny L91-8915 and M41 x Clark with 35% decreases in severity water stress conditions .

Charleston, TNS56, and M41 x Clark had the most grain number per square meter (Table 2). These cultivars and lines had maximum pod number. and grain number per pod decreasing The amounts in depletion varied in cultivars and lines, for example, Clark (12%), Interprise (13%), Hamilton x Essex (7%) and 18 (11%) had the least reduction.

Grains weight was affected by cultivars and lines to water deficit (Table 1). In severity stress condition, decreasing percent in all of cultivars and lines were more than 20%. The most reduction in of grains weight percent were belonged to L17. TMS and Davis x Williams line in amount of 28%, 26% and 26%, respectively. Results of this study are in agreement with those Foroud etal (1993) and Doss etal (1974) were obtained [16, 17].

Response of cultivars and lines to water deficit stress were different in grain yield. The least yield was belonged to Davis X Williams because of low production in seed number per m^2. The most grain yield (4.4 t ha^{-1}) was related to M41 x Clark. This line had more node number, internodes distance, pod number per plant, grain number per m^2 and 1000 grains weight than the others. Severity stress caused to decrease grain yield in amount of 70%. The most grain yield decreasing percent were related to L17, L71-920, Hamilton x Essex, L91-8915, M41 x Clark, Williams and linford. Cultivars and lines that had more grain yield in well water condition had least yield in severity stress.

Stress had negative effect on harvest index. Clark, Sepideh and TMS had more sustainability in HI than the other cultivars and lines (Table 2). The most reduction in harvest index was belonged to Charleston and LH-2500. In the severity stress, L17, Interprise, TMS, Clean, Hamilton x Essex, M41 x Clark and Davis x Williams had the most depletion in grain yield. It can reduce HI, significantly.

It seems that M41*Clark, Hamilton*Essex and Boutny were the superior cultivars. It produce suitable yield in the control condition and reduction the yield in stress conditions were the least.

TABLE I VARIANCE ANALYSIS OF SOYBEAN AGRONOMIC TRAITS AT DIFFERENT LEVELS OF WATER STRESS

S.O.V	df	Node number	Plant height	Pod number per area	Grain number per pod	Grain number per area	1000 grains weight	Grain yield	Harvest index
stress	2	240.2**	20756**	3450123**	3.48**	9842370**	38790.8**	7644120	4921.**
Error	6	0.533	132.673	66494.8	0.11	230241	64.166	117132	47.13
Cultivar	23	15.22**	624.75**	75847.9**	0.261**	273448**	722.718**	237424**	45.76
Cultiva x stress	46	2.044	152.983	45285**	0.07	191890	191.89	289185**	35.10
Error	138	1.447	116.589	23656.7	0.09	138455.7	244.118	97535	54.67
CV		8.333	18.25	19.86	13.91	21.99	13.38	19.76	19.75

**, *: Significant at 1% and 5% probability level.

TABLE II MEAN COMPARISON OF SOYBEAN AGRONOMIC TRAITS IN DIFFERENT WATER DEFICIT STRESS CONDITIONS AT 5%

Cultivar and line	Node number	Plant height (cm)	Pod number per m^2	Grain number per pod	Grain number per m^2	1000 grains weight(g)	Grain yield (kg. ha^{-1})	Harvest index (%)
S1	16.4 a	78.2 a	1006 a	2362 a	2.37 a	139.5 a	2908 a	45.4 a
S2	14.1 b	53.6 b	747 b	1636 b	2.21 b	117.7 b	1332 b	38 b
S3	12.8. c	45.7 c	571 c	1078 c	1.94 c	93.1 c	501 c	28.9 c

Mean with similar letters in each column are not significantly different at 0.05 probability level according to DMRT

TABLE III MEAN COMPARISON OF SOYBEAN CULTIVARS AND LINES AGRONOMIC TRAITS AT 5% PROBABILITY LEVEL BY DUNCAN

Cultivar and line	Node number	Plant height (cm)	Pod number per m^2	Grain number per pod	Grain number per m^2	1000 grains weight(g)	Grain yield (kg. ha^{-1})	Harvest index (%)
Charleston	14.3 dg	52.5 e-i	1031 a	2240 a	2.16 abc	94.3 f	1661bcd	35.3 bcd
Sepideh	15.6 bc	70 ab	731 de	1638 bc	2.26 abc	114.3a-e	1468bcd	35.5 bcd
Zane	13.7 efg	52.9 e-i	739 de	1592 bc	2.13 abc	129 ab	1516bcd	38.8 bcd
Clark	14.7 bf	68.5 bc	793 be	1693 bc	2.13 abc	119.9a-e	1698 bc	37.5 bc
L17	15.7 b	59.8 b-g	798 be	1666 bc	2.10 abc	113.9a-e	1557bcd	35.3 bcd
Interprise	13.3 ghi	50.4 f-i	938 ab	1604 bc	1.66 d	117.7a-e	1647bcd	37 bcd
Tms	13.1 ghi	48.5 ghi	814 be	1860 bc	2.30 ab	105.2 ef	1582bcd	41.6 bcd
Boutny	12.4 i	46.7 hi	913 abc	1845 bc	1.93 cd	124.2 ad	1776 ab	41.6 ab
Clean	14.3 cg	65.9 bcd	783 be	1634 bc	2.07 abc	117.3a-e	1617bcd	34.1 bcd
M7	12.9 hi	56.9 cg	750 cde	1567 bc	2.04 bc	111.8cde	1620 cd	37.7 bcd
M9	13.7 efg	57.8 cg	725 de	1721 bc	2.32 ab	113.3a-e	1575bcd	38.0 bcd
M11	13.4 f-i	54 di	792 be	1704 bc	2.11 abc	121.6a-e	1710 bc	40.2 bc
L71-920	15.9 b	60.9 bf	727 de	1688 bc	2.33 ab	120.5a-e	1369 cd	37.1 cd
Hamilton*Essex	15 be	62 bf	751 cde	1855 bc	2.41 a	118.4a-e	1808 ab	35 ab
Ronak*Williams	12.3 i	44.4 i	771 be	1497 bc	1.93 cd	112.3 be	1354 cd	37.7 cd
LH-2500	13.3 ghl	53.8 di	767 be	1676 bc	2.13 abc	106.1 ef	1614 cd	38.3 bcd
L91-8915	14.7 bf	62.3 bf	646 e	1511 bc	2.30 ab	128.abc	1543bcd	38.4 bcd
M41*Clark	16 b	66.7 bc	778 be	1929 ab	2.39 ab	107 def	2066 a	37.4 a
Williams	14.7 be	61.4 bf	718 e	1556 bc	2.20 abc	130.3 a	1536bcd	35 bcd
18	15.2 bcd	54.5 di	682 e	1551 bc	2.24 abc	120.5a-e	1501bcd	39.5 bcd
Tns56	17.9 a	80 a	896 ad	1917abc	2.11 abc	105.5 ef	1495bcd	32.5 bcd
Linford	14.8 be	64 be	710 e	1618 bc	2.28 ab	122.5a-e	1481bcd	38.3 bcd
Davis*Williams	14.8 be	58.5 b-g	671 e	1494 c	2.22 abc	129.1abc	1332 d	37.6 d
Williams*Chippewa	14.9 be	67.9 bc	664 e	1555 bc	2.34 ab	119.8a-e	1400 cd	39.7 cd

Mean with similar letters in each column are not significantly different at 0.05 probability level according to DMRT

TABLE IV MEAN COMPARISON OF SOYBEAN CULTIVARS AND LINES AGRONOMIC TRAITS IN DIFFERENT WATER DEFICIT STRESS CONDITIONS AT 5% PROBABILITY LEVEL BY DUNCAN TEST

Water deficit	Cultivar and line	Node number	Plant height (cm)	Pod number per m^2	Grain number per pod	Grain number per m^2	1000 grains weight(g)	Grain yield (kg. ha^{-1})	Harvest index (%)
S1	Charleston	17.2 b-g	64.7 ho	1310 ab	2.27 al	3021 al	120.2bo	2951 be	47 be
S1	Sepideh	17.8bcd	91.9 a-e	866.3cm	2.47 cm	2097 ag	128.3 bl	2262 fg	403 fg
S1	Zane	15.6 cn	67.9 cl	817.7 en	2.37 en	1968 ai	146.5ad	2634 dg	48 dg
S1	Clark	17.4 b-g	101 a	903.7 ck	2.33 aj	2097 aj	135.8 aj	2785 cf	42.7 cf
S1	L17	18.9 ab	89 b-g	1299 ab	2.13 bl	2708 bl	144.5a-e	3317 bc	47 bc
S1	Interprise	14.8 hr	61.5 dn	1141 ad	1.97 el	2188 el	135.6 aj	2758 cf	46.5 cf
S1	Tms	14 ju	61.9 ck	947.3 cj	2.47 ag	2324 ag	136.3 aj	3077bcd	49.5bcd
S1	Boutny	14.3 hs	59.8 dn	1334 a	2.07 cl	2751 cl	134.1 bj	3128bcd	49.1bcd
S1	Clean	16.4 cj	91.7 ab	1037 be	2.30 ak	2427 ak	145.3a-e	2914 be	41.6 be
S1	M7	16.6 cg	84.9 a-e	1003 cf	2.40 ai	2401 ai	133.5 bj	3074bcd	44.5bcd
S1	M9	15.8 cm	83.5abc	902 ck	2.70 ab	2455 ab	138.1 ag	3106bcd	46.3bcd
S1	M11	14.5 hs	63.9cl	1169abc	2.33 aij	2720 aij	138.9 ag	2630 dg	49.2 dg
S1	L71-920	17.5 bf	75.8 cm	891.7 cl	2.50 af	2205 af	145.5a-e	2559 dg	44 dg
S1	Hamilton*Essex	15.4 do	70.7 cj	819.3 en	2.83 a	2313 a	151 abc	3468 b	44.5 b
S1	Ronak*Williams	13.2 nx	53.9 eo	995 cg	2 dl	1993 dl	136.9 ai	2442efg	45.9 efg
S1	LH-2500	15.3 eo	71 bi	988.7 cg	2.37 ai	2348 ai	124.3bm	2867 bf	46.2 bf
S1	L91-8915	17.9 bc	91.2 a-e	951 cj	2.40 ai	2314ai	151.7 ab	2803 cf	44.8 cf
S1	M41*Clark	19 ab	95.7 af	1138 ad	2.67abc	3040abc	139.3 ag	4397 a	45.4 a
S1	Williams	16.1 cl	82 ad	801.7 eo	2.50 af	1979 af	151.8 ab	2592 dg	40.6 dg
S1	18	16.6 cg	68.4 do	841.3dm	2.37 ai	1993 ai	133.4a-e	2937 be	47.4 be
S1	Tns56	20.2 a	98.6 ag	1345 a	2.23 al	2971 al	115.5 dp	2773 cf	39.7 cf
S1	Linford	17.3 b-g	90.1 ad	1001 cf	2.40 ai	2393 ai	143.4a-e	3022 be	44.8 be
S1	Davis*Williams	16 cl	72.1 ck	884.3 cl	2.30 ak	2040 ak	166.5 a	2577 dg	49.3 dg
S1	Williams*Chippewa	16.5 ci	86.4 abc	758.7 ep	2.57 a-e	1946 a-e	141.6 af	2719 cf	46.4 cf

Mean with similar letters in each column are not significantly different at 0.05 probability level according to DMRT

TABLE IV - CONTINUED

Water deficit	Cultivar and line	Node number	Plant height (cm)	Pod number per m^2	Grain number per pod	Grain number per m^2	1000 grains weight(g)	Grain yield (kg. ha^{-1})	Harvest index (%)
S2	Charleston	13.1 oy	47.4 ho	902.7 ck	2.20 bl	1948 bl	92 nt	1336 il	28.5 il
S2	Sepideh	15.1 fq	67.5 ck	672 hr	2.50 af	1645 af	119.6 co	1469 ijk	38.1 ijk
S2	Zane	14.1 iu	48.6 ko	708.7 fr	2.07 cl	1423 cl	137.3 ag	1154 ip	37.4 ip
S2	Clark	13.7 lw	55.2 fo	869 cm	2.13 bl	1840 bl	128.0 bl	1685 hi	41.8 hi
S2	L17	14.7 hr	46.4 no	681.3 gr	2.13 bl	1461 bl	104.5 jr	992 kt	33.9 kt
S2	Interprise	13.4 mx	46.1 ko	974.7 ci	1.93 fl	1904 fl	131.8 bk	1706 hi	39.1 hi
S2	Tms	12.8 py	44.8 jo	820 en	2.20 bl	1762 bl	101.6 ks	1129 ip	48.7 ip
S2	Boutny	11.7 ty	43.9 ho	817.7 en	2.07 cl	1830 cl	132.6 bk	1524 ijk	43.2 ijk
S2	Clean	13.4 mx	53.7 go	716.7 fr	2.17 bl	1510 bl	114.7 dq	1485 ijk	37.9 ijk
S2	M7	11.5 vy	43.2 ho	730.7 eq	1.87 gl	1365 gl	110.8 fq	1247 in	37 in
S2	M9	13.2 ox	49.6 ho	690.7 fr	2.23 al	1513 al	105.2 ir	1118 iq	37.1 iq
S2	M11	13.4 mx	53.1 go	774.7 eo	1.97 el	1521 el	121.5 bn	2099 gh	41.8 gh
S2	L71-920	16.2 ck	60.5 ho	731 eq	2.27 al	1619 al	116.6 dp	1273 in	35.7 in
S2	Hamilton*Essex	15.7 cm	64.8 do	828.7 en	2.57 a-e	2145 a-e	121.2 bn	1503 ijk	37.7 ijk
S2	Ronak*Williams	12 sy	42 jo	711.3 fr	2.10 bl	1463 bl	108.2 gr	1052 js	34.3 js
S2	LH-2500	12.7 qy	48.4 go	705 fr	2 dl	1448 dl	105.0 ir	1262 in	32.0 in
S2	L91-8915	13.7 lw	52.2 ho	579.7 lr	2.33 aj	1354 aj	135.9 aj	1494 ijk	40.3 ijk
S2	M41*Clark	15.3 eo	53.3 jo	739.7 eq	2.43 ag	1804 ag	114 eq	1242 in	41.2 in
S2	Williams	15.8 cm	64.8 do	659 ir	2.27 al	1493 al	134.2 bj	1628 hij	37 hij
S2	18	15.3 ep	50.6 lo	798.7 eo	2.23 al	1781 al	122.3 bn	1211 io	36 io
S2	Tns56	17.6 be	72.7 dn	886 cl	2.17 bl	1892 bl	109.2 gr	1307 im	33.7 im
S2	Linford	14.2 it	53.8 ho	682 gr	2.20 bl	1503 bl	118.4 do	1098 ir	39.6 ir
S2	Davis*Williams	14.4 hs	56.3 go	629 kr	2.30 ak	1448 ak	122.6 bn	996 kt	37 kt
S2	Williams*Chippew	15.1 gg	67.3 ck	615.3 kr	2.60 ad	1590 ad	118.6 do	948 ku	42 ku

Mean with similar letters in each column are not significantly different at 0.05 probability level according to DMRT

TABLE IV - CONTINUED

Water deficit	Cultivar and line	Node number	Plant height (cm)	Pod number per m^2	Grain number per pod	Grain number per m^2	1000 grains weight(g)	Grain yield (kg. ha^{-1})	Harvest index (%)
S3	Charleston	12.6 ry	45.4 io	881 cl	2 dl	1750 dl	70.6 st	607 mv	30.4 mv
S3	Sepideh	14 ju	50.5 io	655 jr	1.8 il	1172 il	95 mt	671 nv	28 nv
S3	Zane	11.3wxy	42.3 ho	689.7 fr	1.97 el	1385 el	106 hr	760 lv	30.9 lv
S3	Clark	13.1 oy	49.2 ho	607 kr	1.93 fl	1140 fl	95.9 mt	625 ov	28 ov
S3	L17	13.7 lw	43.8 o	414 r	2.03 dl	831 dl	92.7 mt	363 uv	25.1 uv
S3	Interprise	11.7 uy	43.4 ho	698 fr	1.07 m	721 m	85.7 pt	477 rv	25.6 rv
S3	Tms	12.5 ry	38.8 no	675.3 hr	2.23 al	1493 al	77.6 rst	542 pv	26.6 pv
S3	Boutny	11.1 xy	36.3mno	587.7 kr	1.67 l	953 l	106.1 hr	676 nv	32.4 nv
S3	Clean	13.1 oy	52.1 go	595.3 kr	1.73 jkl	966 jkl	91.9 nt	450 sv	22.7 sv
S3	M7	10.7 y	42.6 go	516.3 nr	1.87 gl	934 gl	91.1 nt	538 pv	31.6 pv
S3	M9	12.1 sy	40.2 lo	583 lr	2.03 dl	1194 dl	96.5 lt	499 qv	30.6 qv
S3	M11	12.4 ry	44.9 io	431.7 qr	2.03 dl	872 dl	104.4 jr	401 tuv	29.6 tuv
S3	L71-920	14 ju	46.3 lo	559.7mr	2.23 al	1240 al	99.3 ls	274 v	31.5 v
S3	Hamilton*Essex	13.8 lw	50.6 ho	606 kr	1.83 hil	1106 hil	82.9 qt	453 sv	22.7 sv
S3	Ronak*Williams	11.7 ty	37.2 no	606.3 kr	1.70 kl	1036 kl	91.9 nt	567 pv	32.7 pv
S3	LH-2500	11.8 ty	42.1 jo	607.7 kr	2.03 dl	1233 dl	89 ot	714 mv	36.7 mv
S3	L91-8915	12.5 ry	43.6 ko	408.3 r	2.17 bl	865 bl	96.4 lt	332 uv	30 uv
S3	M41*Clark	13.7 lw	51.2 ho	456.7pqr	2.07 cl	943 cl	67.7 t	559 pv	25.5 pv
S3	Williams	12.4 ry	37.3 o	694 fr	1.83 hl	1195 hl	105 ir	387 tuv	27.3 tuv
S3	18	13.8 kv	44.6mno	406 r	2.13 bl	881 bl	94.7 mt	355 uv	35 uv
S3	Tns56	16 cl	68.6 cm	458.3pqr	1.93 fl	889 fl	91.8 nt	405 tuv	24.1 tuv
S3	Linford	13 oy	48.2 ho	447.3pqr	2.23 al	958 al	105.7 hr	322 uv	30.4 uv
S3	Davis*Williams	13.9 kv	47 ko	499.7 or	2.07 cl	993 cl	98.3 lt	422 tuv	26.3 tuv
S3	Williams*Chippewa	13 oy	49.9 go	618.3 kr	1.87 gl	1130 gl	99.1 ls	531 pv	30.7 pv

Mean with similar letters in each column are not significantly different at 0.05 probability level according to DMRT

IV. CONCLUSION

In this study, the most node number, plant height, pod number per m^2, grain number per pod. Grain number per m^2, 1000 grains weight, grain yield and harvest index were obtained in irrigation after 50mm of water evaporation from pan class A (s_1). This level of water deficit had significant effect on grain yield and the most grain yield was obtained in this level.

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