Can Applied ABA be Used in Desert Turfgrass Management?

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Introduction

ABA (abscisic acid) is a naturally occurring hormone in plants which interacts with other hormones in the regulation of plant growth and stress responses.

ABA is expensive to produce commercially and has been predominately studied from the standpoint of plant responses to environmental conditions and internal plants stress physiology. Since ABA is an integral part of stomatal regulation in plants, then exogenous ABA applications may affect stomatal closure and thus affect water use. Secondly this also may impose growth reduction from decreases in carbon dioxide flux through stomata.

With this in mind, replicated tests were conducted with two production formulations of ABA to determine;

(1) potential affects of ABA as a PGR for bermudagrass turf, and
(2) potential affects of ABA as a transpiration reduction agent (to reduce consumptive water use).

Materials and Methods

Test I

Test one was devised to measure responses of fairway height Tifway bermudagrass to sources and rates of ABA as a plant growth regulator. This was assessed by taking clipping weights of mowed plots between application series of ABA treatments in the field.

The turf was sprayed with ABA on the following dates in 2004 using a Co2 back sprayer :
(1) August 11, (2) Aug 26, (3) Sept 7 and (4) Sept 21.

Treatments were as follows:

UTC	control	
VBC-30025	100 ppm	Every two weeks for 8-9 weeks
VBC-30025	500 ppm	Every two weeks for 8-9 weeks
VBC-30030	10 ppm	Every two weeks for 8-9 weeks
VBC-30030	50 ppm	Every two weeks for 8-9 weeks
Primo	0.30 ounce	Prod/ 1000 ft^2 repeat at 14 day intervals
VBC-30025	100 ppm	Every 2 weeks + Primo

The same plots received the same treatments over the span of the test. ABA concentrations were prepared according to VALENT protocol using pre-weighed product amounts and ethyl alcohol volumes. The respective ppm treatment delivery amounts were applied at the rate of 500 cc, per each 5 X 7 foot plot (identical to Kansas state field applications). Tween surfactant at 0.0025% was added to the spray solution mix.
Plots were sprayed in the late afternoon hours about 1.5 hours before sunset, and allowed to dry for 30 hours between the next irrigation cycle and mowing events. Plots were mowed at 5/8" three times weekly unless noted otherwise.

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Plots were harvested for clippings by mowing one reel width of a triplex mower, dumping the clippings in large plastic pan, followed by bagging the clippings. The clippings were then placed in a convection drying oven for 4-5 days at 135 F, and then weighed. Clipping weight was normalized (expressed) as gram dry weight / day. Clippings were harvested on 20 August, 1 September, 13 September, and 30 September. Visual turfgrass responses were assigned for turfgrass color and quality using the NTEP visual score system (1-9), 1= dead, 5= marginal, 6= fully acceptable, 9= best possible. Visual assessments of the degree of scalping (1-6 , 1= none, 4= moderate 6= severe) (typical of Tifway during the humid rainy season), as well as degree of plot chlorosis (leaf yellowing) were also assigned plot on an as needed basis.

Data was subjected to the analysis of variance ANOVA option using SAS software. The significance for the P value for the overall treatment main affect was selected at P=0.05. If the main treatment affect was statistically significant, than LSD values were calculated as the treatment mean separation statistic. Treatments were analyzed as formulation/rate combinations, since rates for each formulation were *not* identical.

<u>Test II</u>

Since treatments did not show any difference in the field for soil moisture conservation, a second greenhouse test was conducted to measure water use of two turf grasses. Tifway 419 and Sea Isle 2000 Seashore Paspalum were grown as mature turfs in PVC lysimeters. The lysimeters were 4.0 " diameter x 12 " in depth, and filled with a screened calcined clay root zone mixture. Mowing height was 1.5 inches .

Because there were no responses of soil moisture conservation in the field and only one source of ABA remained available in stock, the following treatments were devised to study directly ABA on water use of these two grasses.

LEVEL A	VBC-30025	500 ppm	Tifway bermuda
LEVEL A	VBC-30025	500 ppm	Sea Isle 1 Paspalum
LEVEL B	VBC-30025	1000 ppm	Tifway bermuda
LEVEL B	VBC-30025	1000 ppm	Sea Isle 1 Paspalum
Level C UTC		untreated control	Tifway bermuda
Level C UTC		untreated control	Sea Isle 1 Paspalum

The test was a RCBD with four replications. Because the clipping weights in the field were not significant, the "high rate" of VBC-30025 ABA (500 ppm) was doubled, in a logical effort to determine any potential ABA affect for water use.

ABA was applied on five (5) occasions, and water use (ET mm day^{-1}) was measured by weighing lysimeters each day. Treatments were applied to the same lysimeters throughout the span of the test. The difference in gravimetric weight represented water use (synonymous with grass ET). Lysimeters were weighed at day 0, and again at days 1,2,3 to obtain 3 days of individual ET values. Analysis was performed on each of the 15 individual weighing days, for the sum of each 3 day cycle (the cycle Et total mm) and for the sum of 15 days of total ET. All 24 lysimeters were maintained at a 1.5 inch mowing height.

Results and Discussions

<u>Test 1: PGR Via Clipping Growth Reduction</u>

The F ratio for dry clipping weight production was significant one of four clipping harvests (30 Sept) after four repeat applications of all treatments were made. (Table 1).

On 20 August, (harvest one), there was a slight (but not statistically significant) response for both products as ABA rates increased. Primo produced the least amount of clippings at this time, about 50% of that of the controls.

On 1 Sept, the drastic reduction in clippings arose from harvest reductions when another tri-plex mower using smooth rollers was used (same 5/8"height). Differences in weight and the affect of smooth rollers most probably caused this bias, which all plots experienced at this harvest. Again, there was a slight (but not statistically significant) response for both products as rates increased. The UTC did produce similar clipping amounts, however.

On 13 September, (after application number three), There still was no significant affect of treatments for clipping weight production. Primo plus VBC 30025 @ 100 ppm produced the least clippings among treated plots. It should be noted that scalping of the UTC, (which occurs frequently and readily on Tifway 419 during the humid rainy season, even when mowed 3 times weekly) most likely was the cause of low clipping harvest weights. Rate responses for each chemical did not occur (even in treatment rank).

On 30 September, the treatment main affect was significant, mainly from the fact that the tank mix of VBC 30025 @ 100 ppm plus Primo produced low clipping weights compared to other treatments. Again, the UTC had low harvest weights. Again, rate responses for each chemical did not occur (even in treatment rank).

Mean turfgrass color responses were not significantly different on any of the four evaluation dates. However, mean color response among treated turfs did improve after the first application series. (Table 2).

Percent plot scalping and percent plot straw turf values were assigned to plots in August and September, respectively These responses were also not related to treatments (Table 3).

Overall turfgrass quality scores were assigned to plots in August and September. All treatments and the UTC produced acceptable quality turfs. Although the treatment main effect was not statistically significant, VBC 30030 @ 50 ppm ranked numerically highest for turf quality on two of three evaluation dates (Table 4).

Visual turf density scores were also fully acceptable, with no significant response to applied ABA formulation/rate combinations. The degree and extent of plot yellowing (chlorosis) was also not related to treatments. (Table 5).

In conclusion, ABA applications did not affect growth reduction (as measured via dry weight clipping production). Primo had the most impact after the first application, but did not do so afterwards. ABA formulations and rates did not produce adverse color or quality attributes, but again, did not suppress growth.

<u>Test II: ABA Affects on Reduction of Water Use - Grass Affect</u>

When averaged over both ABA ppm levels of VBC-30025, the <u>grass</u> main affect (Bermuda vs. paspalum) was significant on 9 of 15 individual "ET days" for water use. The water use value is given in terms expressed as ET mm day $^{-1}$. In all cases, the seashore paspalum had a higher ET than the bermuda. Differences averaged from 8-14% for water use between paspalum vs. Bermuda. Seashore paspalum used significantly more water than Bermuda on days 1,2,3,7,8,9,13,14,15, (Table 6).

For the total water use per cycle (ET mm), the grass affect (averaged over all ABA levels and controls) was significant on 3 of the five cycles. This occurred on cycles 1,3, and 5. Again, paspalum used more water than the Bermuda (Table 7).

The grand sum (mean sum Table 7) is the total ET for all of the 15 measurement days. When averaged over all ABA affects (no ABA, 500 ppm, and 1000 ppm), Bermuda used 50.8 mm water, and seashore paspalum used (statistically significant) more water 54.5 mm water.

<u>ABA Affect</u>

When averaged over both of the grasses, the affect of ABA was significant on 11 of 15 ET measurement days. This occurred on days, 1,2,3,4,5,7,8,9,13,14,15 (Table 6).

On most days 1-8, both rates of ABA (500 and 1000 ppm) had less water use than the non treated controls, and both rates were equal in affect . That is to say, they caused a lower water use rate compared to the control, AND the reduction was equal in affect (no significant rate response between both the 500 and 1000 ppm ABA treatments). This was true on days, 1,2,3,7,8 and 14 (Table 6).

On other days when ABA caused a water use reduction, it was the high rate alone of ABA at 1000 ppm which only which caused a significant reduction in water use. This was the case on days 4 and 5 (Table 6).

Still remaining, is the fact that there were days when the higher application rate of 1000 ppm ABA caused a greater decrease in water use, than the 500 ppm rate. This was true on days 9, and 13 and 15 (Table 6). Note as well on these dates that both the high AND low rates of ABA caused lower ET rates compared to untreated controls.

In comparison review of the rate affects for reduction in water use (averaged over both grass species):

1. ABA significantly decreased water use on 11 of 15 ET measurement days compared to untreated controls.

2. Of these 11 days, the 500 ppm = 1000 ppm for water use, on 6 of these days.

3. Of these 11 days, the high rate of 1000 ppm ABA caused a greater reduction in ET (water use) than the low rate of 500 ppm on 3 of the 11 days.

4. Of these 11 days, *only* the high rate of ABA (1000 ppm) caused a significant reduction in ET (water use) on two days.

The grand sum (mean sum Table 7) is the total ET for all of the 15 measurement days. When averaged over both grasses, it was the *high rate* alone of ABA (1000 ppm) which caused a significant reduction in water. The mean ET sum for UTC (no applied ABA) was 64.2 mm, while ABA at 500 ppm had an ET sum of 60.0 mm. The high ABA rate of (1000 ppm) had the lowest ET sum of 57.0 mm. Compared to non-treated turfs, the high rate of ABA resulted in lowering the ET by almost 12%, averaged across both grasses , while the low rate (500 ppm) resulted in a lower ET of 7% averaged across both grasses.

Grass X ABA Interactions

Interactions are the comparison of the affects of different levels of treatments, when combined with the levels of other treatments. In this study, we had 2 grass species, and 3 levels of chemical treatment (none, 500 and 1000 ppm). If grasses behave relatively "the same" in response to ABA levels, as we look at the responses from "one grass to another' than there is no interaction. The implication is, when there is no interaction, than the relative responses are the same. If an interaction exists, than one grass is responding in a different way to either one or both levels (rates) of ABA. In this study, a particular interaction causes one to look at the response to ABA *for each grass individually*. In essence it is desirable NOT to have interactions, since the "product spectrum" includes the same relative affect on both grasses.

Based on the 15 daily individual ET measurement events, a significant statistical interaction occurred on only 2 of 15 days (Table 7). In these cases, it was the non- treated paspalum turf (Pasp C) which caused the interaction, because of its high water use . Its ET was relatively greater than BOTH the ABA treated turf, and also that of the non treated bermudagrass. Thus, the statistical interaction occurred. More importantly, are the affects of "ABA" discussed previously.

Based on the summed cycle ET totals , and the total ET sum for all 15 days of measurement, There were no statistical interactions detected.

Based on the total ET sum for all days of measurement (mean sum: Table 2), one can still compare ABA levels within grass for discussion.

Bermudagrass had a total ET in this study of 54.5 mm, while paspalum had 58.6 mm total water use. The percent reduction in overall water use for ABA level for each individual grass was as follows :

Bermuda = (ABA 500 ppm : 4.5 %) (ABA 1000 ppm : 10%)
Paspalum = (ABA 500 ppm : 9 %) (ABA 500 ppm : 13%)

Note again the ABA source was VBC-30025, which was available in a quantity that made this extra testing possible. VBC-30030 should be tested at multiple (and most likely higher application rates) as a potential ET reduction use agent. Once a "rate" is established, then the length of affect can be defined which is critical to determine application intervals.

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Table 1. Clipping weights, grams/ m^2 (normalized) of a Tifway Bermudagrass Fairway as affected by select plant growth regulators. Summer 2004. University of Arizona, Karsten Turfgrass Research Facility, Tucson, AZ.

Treatments	*20-Aug*	*1-Sep*	*13-Sep*	*30-Sep*
VBC-30025 @ 100 ppm	43.9	2.5	23.2	8.4 a
VBC-30025 @ 500 ppm	50.6	2.0	28.5	7.6 a
VBC-30030 @ 10 ppm	45.4	4.3	26.2	7.1 ab
VBC-30030 @ 50 ppm	53.3	2.9	24.0	8.4 a
PRIMO @ 0.3 oz prod. /M	29.6	3.2	28.6	5.7 abc
VBC-30025 @ 100 ppm + PRIMO	45.7	1.4	17.9	3.3 cb
UTC	63.5	2.0	10.2	1.9 c
test mean	**47.4**	**2.6**	**22.6**	**6.0**
LSD	ns	ns	ns	3.9

Table 2. Visual COLOR of a Tifway Bermudagrass Fairway as affected by select plant growth regulators. Summer 2004. University of Arizona, Karsten Turfgrass Research Facility, Tucson, AZ.

Treatments	*21-Aug*	*30-Aug*	*8-Sep*	*22-Sep*
VBC-30025 @ 100 ppm	6.0	6.3	6.8	6.5
VBC-30025 @ 500 ppm	5.5	6.5	7.3	7.5
VBC-30030 @ 10 ppm	5.3	6.0	6.5	6.8
VBC-30030 @ 50 ppm	5.8	6.8	7.3	6.3
PRIMO @ 0.3 oz prod. /M	4.5	6.0	6.0	6.3
VBC-30025 @ 100 ppm + PRIMO	5.3	6.3	6.8	7.8
UTC	6.5	6.8	6.5	7.8
test mean	**5.5**	**6.4**	**6.7**	**7.0**
LSD	ns	ns	ns	ns

Table 3. %-Scalping and %-straw of a Tifway Bermudagrass Fairway as affected by select plant growth regulators. Summer 2004. University of Arizona, Karsten Turfgrass Research Facility, Tucson, AZ.

	%-scalp		%-straw
Treatments	***21-Aug***	***30-Aug***	***22-Sep***
VBC-30025 @ 100 ppm	8.8	2.5	3.0
VBC-30025 @ 500 ppm	18.8	6.8	4.8
VBC-30030 @ 10 ppm	11.3	5.5	2.3
VBC-30030 @ 50 ppm	9.5	2.5	2.3
PRIMO @ 0.3 oz prod. /M	5.0	1.3	2.3
VBC-30025 @ 100 ppm + PRIMO	10.0	5.5	2.5
UTC	13.3	3.8	1.0
test mean	**10.9**	**4.0**	**2.6**
LSD	ns	ns	ns

Table 4. Overall Turf <u>QUALITY</u> of a Tifway Bermudagrass Fairway as affected by select plant growth regulators. Summer 2004. University of Arizona, Karsten Turfgrass Research Facility, Tucson, AZ.

Treatments	***30-Aug***	***8-Sep***	***22-Sep***
VBC-30025 @ 100 ppm	6.5	7.0	7.3
VBC-30025 @ 500 ppm	6.3	7.8	7.5
VBC-30030 @ 10 ppm	6.3	7.3	6.5
VBC-30030 @ 50 ppm	7.5	8.3	7.3
PRIMO @ 0.3 oz prod. /M	6.3	7.0	6.5
VBC-30025 @ 100 ppm + PRIMO	6.3	6.0	7.5
UTC	6.8	7.3	8.0
test mean	**6.5**	**7.2**	**7.2**
LSD	ns	ns	ns

Table 5. Canopy DENSITY, DEGREE CHLOROSIS and %-PLOT CHLOROSIS on Sept. 8 of a Tifway Bermudagrass Fairway as affected by select plant growth regulators. Summer 2004. University of Arizona, Karsten Turfgrass Research Facility, Tucson, AZ.

Treatments	density	degree CHL	%-CHL
VBC-30025 @ 100 ppm	7.0	2.0	5.0
VBC-30025 @ 500 ppm	7.0	1.8	7.5
VBC-30030 @ 10 ppm	6.8	2.0	13.8
VBC-30030 @ 50 ppm	7.3	1.5	8.8
PRIMO @ 0.3 oz prod. /M	7.0	2.3	10.0
VBC-30025 @ 100 ppm + PRIMO	7.0	2.5	10.0
UTC	7.3	1.8	3.8
test mean	**7.0**	**2.0**	**8.4**
LSD	ns	ns	ns

Figure 1. Clipping wt.(g) of a Tifway Bermudagrass Fairway as affected by select PGRs. Summer 2004, Univ. of AZ Karsten Turfgrass Facility. Tucson, AZ.

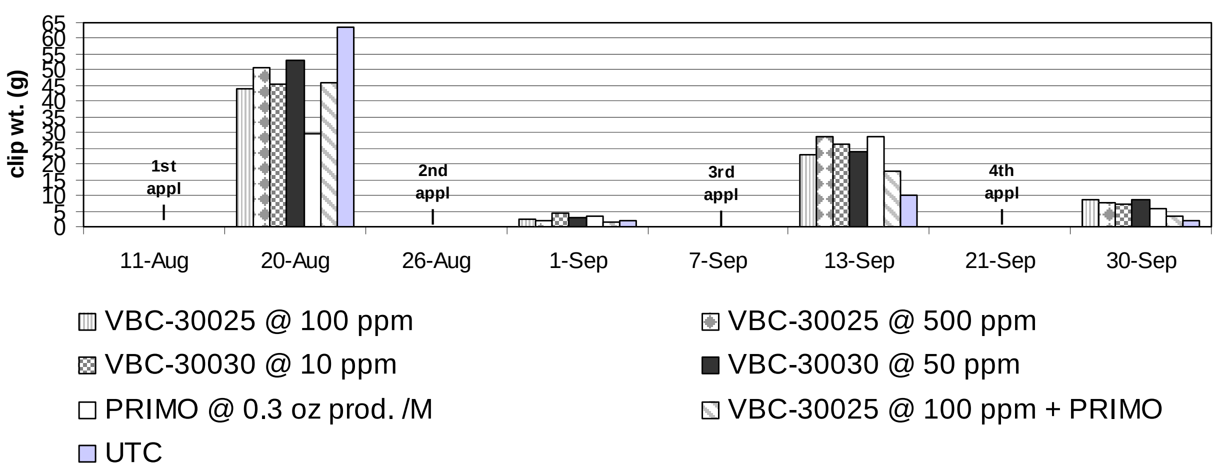

Table 6. Mean ET (mm day $^{-1}$) values over 15 days for two grasses after exogenous applications of ABA. University of Arizona, 2004.

		Day Number														
Grass[1]		**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**
Bermuda		2.7		3.9		3.5		4.3		4.1		3.8		2.6		3.5
Paspalum		3.1		4.3		3.8		4.3		4.4		4.0		2.9		3.9
Significance[2]		***		**		*		NS		NS		NS		*		***
Test Mean[3]		2.9		4.1		3.6		3.5		4.3		3.9		2.8		3.7
Treatment[4]		**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**
ABA low		2.8	b[5]	4.0	b	3.6	b	4.5	a	4.2	ab	3.9		2.6	b	3.6 b
ABA high		2.7	b	3.8	b	3.4	b	4.0	b	4.0	b	3.7		2.5	b	3.5 b
Ctrl		3.2	a	4.5	a	3.9	a	4.5	a	4.5	a	4.1		3.2	a	4.0 a
Significance[2]		***		***		***		**		*		NS		**		***
Grass x Treatment		**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**
Bermuda	A	2.6		3.8		3.4		10.3	a	4.1		3.8		2.3		3.3
Bermuda	B	2.5		3.6		3.2		9.3	b	3.8		3.5		2.4		3.3
Bermuda	C	3.0		4.3		3.8		11.1	ab	4.5		4.2		3.0		3.8
Pasp	A	3.0		4.2		3.7		10.9	ab	4.3		4.0		2.7		3.9
Pasp	B	3.0		4.0		3.6		10.6	ab	4.3		3.8		2.6		3.6
Pasp	C	3.3		4.7		4.0		12.0	ab	4.5		4.1		3.4		4.2
Significance[2]		NS		NS		NS		*		NS		NS		NS		NS

[1] Tifway Hybrid Bermudagrass Sea Isle 1 and Seashore Paspalum. Mow height = 3.8 cm.
[2] NS is non significant; *,** and *** significant at $P \leq 0.05$, 0.01 and 0.001 respectively.
[3] Mean of all lysimeters on each ET measurement date.
[4] ABA applied exogenously at 500 ppm (A; low) and 1000 ppm (B; high) solution concentration. Treatment C is the control were no ABA was applied.
[5] Mean Separation by Tukey HSD at P= 0.05.

Table 6 (Continues)

Grass[1]		Day Number 9		10		11		12		13		14		15	
Bermuda		3.3		4.0		3.2		4.1		4.0		2.2		3.0	
Paspalum		3.5		3.6		3.0		4.0		4.7		2.5		3.3	
Significance[2]		**		NS		NS		NS		***		**		*	
Test Mean		3.4		3.8		3.1		4.0		4.5		2.3		3.1	
Treatment[4]		**9**		**10**		**11**		**12**		**13**		**14**		**15**	
ABA low		3.4	b	3.7		3.0		4.1		4.3	b	2.3	b	3.1	b
ABA high		3.1	c	4.0		3.3		4.1		4.0	c	2.1	b	2.8	c
Ctrl		3.7	a	3.6		3.0		4.0		4.9	a	2.6	a	3.5	a
Significance[2]		***		NS		NS		NS		***		***		***	
Grass x Treatment		**9**		**10**		**11**		**12**		**13**		**14**		**15**	
Bermuda	A	3.2		3.8		3.1		4.1		3.9	cd	2.1		3.2	
Bermuda	B	3.0		4.7		3.6		4.3		3.8	d	2.0		2.7	
Bermuda	C	3.6		3.5		2.9		3.8		4.5	bc	2.4		3.3	
Pasp	A	3.5		3.7		3.0		4.1		4.6	b	2.4		3.2	
Pasp	B	3.2		3.4		2.9		3.9		4.2	c	2.2		2.9	
Pasp	C	3.8		3.7		3.1		4.2		5.4	a	2.9		3.7	
Significance[2]		NS		NS		NS		NS		*		NS		NS	

Table 7. Mean Sum ET (mm[1]) for five ET Cycles after treatment with ABA. Values are the mean of four observations summed over 3 days ET period. University of Arizona, 2004.

	Cycle Number[6]					
	1	2	3	4	5	Mean Sum[7]
Grass[8]						
Bermuda	10.1	11.4	9.3	11.2	8.8	50.8
Paspalum	11.2	11.9	10.3	10.7	10.4	54.5
Significance[9]	***	NS	**	NS	**	**
Test Mean[10]	10.7	11.7	9.9	11.0	9.7	52.6
Treatment[11]						
ABA low	10.5 b[12]	11.5 b	9.5 b	10.9	8.9 b	60.0 ab
ABA high	9.9 b	10.9 b	9.1 b	11.4	8.8 b	57.0 b
Ctrl	11.6 a	12.5 a	10.9 a	10.6	11.0 a	64.2 a
Significance[4]	***	**	***	NS	**	**

Grass x Treatment		1	2	3	4	5	
Bermuda	A	9.9	11.2	8.8	11.0	8.4	52.1
Bermuda	B	9.3	10.3	8.7	12.6	8.5	49.4
Bermuda	C	11.1	12.7	10.4	10.1	10.2	54.5
Paspalum	A	10.9	11.8	10.1	10.8	10.2	53.8
Paspalum	B	10.6	11.6	9.4	10.3	9.2	51.1
Paspalum	C	12.0	12.3	11.4	11.0	11.9	58.6
Significance[4]		NS	NS	NS	NS	NS	NS

[6] Cycles with 3 days between watering.
[7] Total ET sum in mm after 15 days.
[8] Tifway Hybrid Bermudagrass Sea Isle 1 and Seashore Paspalum. Mow height = 3.8 cm.
[9] NS is non significant; *,** and *** significant at $P \leq 0.05$, 0.01 and 0.001 respectively.
[10] Mean of all lysimeters on each ET measurement date.
[11] ABA applied exogenously at 500 ppm (A; low) and 1000 ppm (B; high) solution concentration. Treatment C is the control were no ABA was applied.
[12] Mean Separation by Tukey HSD at P= 0.05.