Plant Archives Vol. 19 No. 2, 2019 pp. 3129-3136 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

THE DOUBLE EFFECT OF REDUCING TRANSPIRATION AND REVERSING INFRARED WAVES IN SOME TRAITS OF GROWTH AND YIELD OF THE SUN FLOWER PLANT

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Abstract

A field experiment was carried to reduce the damage of heat stress and moisture stress, by increasing the reflection rate in infrared radiation by dispersing the reflective material on the plants, in addition to treatment ofcommercial anti-transpiration which represented a reduction factor of moisture stress damage. This was considered as a double objective in drought resistance. The experimental treatments were divided according to the Randomized Complete Block Design (RCBD) with three replicates. The main irrigation treatments represented the control treatment water reclamation ratio 100, 75 and 50% of the irrigation water for the comparison treatment. Stress tolerances treatment were represented by the secondary plots, which wasspraying with distilled water, black sand, red sand, anti-transpiration and aluminum foil.The obtained results of the experiment showed that the stress increasing has reduced all growth indicators at each increase in the level of moisture stress and decreased the seed yield in irrigation by 50% treatment by 68.56% compared to the comparison treatment. The treatment of aluminum foil has exceeded the other treatments in most of thestudied growthindicators, such as plant height, weight of the stem, weight of leaves, weight of 1000 seeds and seed yield, in proportions of 8.90, 26.13, 54.18, 35.12 and 55.46% respectively. Additionally, a significanteffect was detected in the interaction between irrigation treatments and stress tolerancetreatments on some growth, yield and components characteristicsexcept for disc diameter.

Key words:

Introduction

Thermal stress is one of the most non vital stresses in the plant and it has two types: high temperature stress and low temperature stress. Thermal stress reduces vegetative growth, inhibits photosynthesis, reaches the point of compensation, and loses the plasma membranes of their physiological functions which leads to non-filtration for the ions resulting in drought stress, which adds an imbalance in nitrogen metabolism and an increase in the production of free radicals ROS (oxidation stress) that causing protein destroying and weaken cellular membranes and imbalance of nutrient elements. (Rao *et al.,* 9, 2006 and Gupta, 2011).Infrared radiation is an electromagnetic radiation whose wavelengths range between 0.7 and 300 micrometers. It covers a wide area of the solar spectrum, known as infrared radiation. It is a heat radiation that raises body temperature when falling on it, including plants. In addition, infrared reflection method was used to reduce building heat and increase its energy efficiency for cooling.Anti-transpiration are substances that reduce the loss of water from plants by transpiration in different ways such as a partial closure of the gaps which resulting in a reduction of water lossor change in the internal hormonal balance by increasing the ABA (catalyst to close the gaps) and inhibition of production of cytokinein (catalyst to open the gaps). Masoud, (2015) demonstrated that plant spraying with anti-transpiration armorax led to a significant increase in grain yield, biologic yield, weight of 500 grains, harvest index, and water use efficiency compared to control treatment in wheat plant as well as decreased water stress in most vegetative and wheat growth indicators (Ibrahim, 2017).

Aluminum is one of the materials used to reverse infrared and considered as the most abundant element in the earth's crust, and it is the most common metal in the industry today. It has a great ability to reverse infrared, acting as a mirror reflecting the heat of the sun (infrared) to especial pipes in solar thermal complexes for electric power generation when painted. It is also found in refrigeration equipment to reverse heat waves and thermal insulation. Some companies have used the method of reversing heat waves to outside buildings to reduce their temperature and reduce their need for cooling. The efficiency of the solar heater has increased by 68.8% (Al Asadi *et al.,* 2013). The red and black sand is a natural granule made up of rock particles crumpled by weathering and erosion. Its diameter ranges between 0.05 mm - 2 mm. Silicon dioxide (SiO_2) is the basic component of sand and it is usually in the form of quartz metal, which is the most common metal due to its hardness and resistance to weathering factors (John, 2000).The present study aims to reduce the damage of thermal stressby reversing infrared radiation from plants using some of the compounds (reflective infrared) and allow the penetration of visible light to the plant and this represents the first goal, the second goal is to reduce the loss of water by partial closure of the gaps practiced by the carrier (Commercial anti-transpiration). This is a double goal in the resistance to drought, as the heat and moisture are combined and increase each other's impact, so it is necessary to face the two together because the treatment of damage to each other may not return to the plant with a benefit.

Materials and Methods

A field experiment was conducted in the 2018 spring season in the field of Field Crops Department–Faculty of Agricultural Engineering Sciences - University of Baghdad (Jadriya) with the aim of reducing thermal and moisture damage by increasing the reflection of infrared waves through dispersion of reflective materials on plantsas well as the commercial anti-transpiration treatment which represented a reduction factor of moisture stress damage which consider as a dual aim in drought resistance. The experiment was of a Randomized Complete Block Design (RCBD) with three replicates. The main plates included three levels of irrigation water: a comparison treatment(reset the ratio of ready water to 100%), 75% and 50% of the amount of water added to the comparison treatment). The secondary plots contained the following treatments: Spraying the plant with distilled water (comparison), Spraying with 3 ml/l^{-1} of Armourax, Spraying with 3 ml/l^{-1} and dispersing the red sand, and spraying with 3 $ml/l^{-1}$of Armourax and spreading the black sand, spraying the plant with 3 $ml/l^{-1}$of Armourax and dispersing the very small aluminum foil.

Agricultural operations

The experimental area consisted of five lines with length of 2 m, the distance between the lines was 75 cm and the distance between hole and the other 20 cm with a plant density of 66666 plant h^{-1}. An intervals (1 m) were left between the replicates and the main treatments to prevent water leakage between experimental units. The soil of the experiment was fertilized with the Dab fertilizer before planting at a rate of 220 $kg/hectare^{-1}$ and the urea fertilizer was added at a rate of 260 kg/he^{-1} in two equal increments, in the first stage of the emergence of four real leaves when the length of the paper was at least 4 cm and the second stage after the emergence of floral buds (Al Rawi, 2001). Sun flower seeds (Akmar class)were planted on 20^{th} of Marc 2018 manually inclay loam soil under climatic conditions at a depth of 3-5 cm and a rate of 3-5 seeds per hole. Two weeks after the emergence, the number of plants was reduced to one plant in one hole. The bushes, weeding and the crop service were combated as needed as well asthe plants were harvested on 5 of July 2018.

Measurement of soil moisture content

The moisture content of the soil was calculated by using weight method by taking samples of soil at a depth of 30 cm continuously during the experiment period before irrigation of the comparison treatment by core sample and weighed to take the wet weight of the soil, and then placed in microwave for ten minutes for drying and then weighed to calculate the moisture content according to the following equation (Hillel, 1980):

$$Pw = \left(\frac{Msw + Ms}{Ms}\right)100$$

As:

Pw = percentage of weight of moisture

Msw = wet soil mass (g)

Ms = dry soil mass (g)

Volumetric moisture content was calculated based on the virtual density according to the following equation

$$Qv = Qw \times \partial b$$

As:

Qv = moisture content based on size

Qw = moisture content based on weight

∂b = soil density ($Megagram/m^{-3}$)

The added water depth was calculated according to the following equation (Allen *et al.,* 1998)

$$d = (\theta\ fc - \theta\ w) \times D$$

As:

d = depth of water added (cm)

θ fc= volumetric humidity at field capacity ($cm^3\ cm^{-3}$)

θ w= volumetric humidity before irrigation (cm^3 cm^{-3})

D = Soil layer depth (cm)

To determinewater size allocated to the line, the depth of the irrigation was converted to the volume (L) in the unit area to determine the water volume added for each experimental unit and according to the following equation:

d = A * VW

As:

d = depth of water added (cm)

A = experimental unit area (m^2)

VW = Water Volume (L)

Irrigation method

Irrigation was applied using a fixed discharge pump equipped with a meter to measure the amount of water added to each unit joined to plastic pipes with a diameter of 1.5 inch joined with secondary plastic pipes equipped with a closure to open and close the water in the blocked ends according to the approved measurements. The field was irrigated in equal quantities of water when planting to the field capacity to ensure the emergence, germination and the emergence of the field.The process of irrigation was continued until the arrival of the plant to the stage of 4 real leaves (not less than 4 cm) as the plants were treated with water stress treatments, which included the treatment of comparison (Irrigation when depletion of 50% of the ready water and return the proportion of ready water to 100%), 50 and 75 % of the comparison treatment according to calculated water quantities (391.5, 293.62 and 195.75 l) respectively and the plants were treated with secondary treatments when 75% of the plants reached the stage of 10 papers and then treated for the second time at the emergence stage of 75% floral bud.

Table 1: Some physical and chemical properties of the soil.

Trait		Value	Unit
Soil separators	Sand	21.8	g/kg^{-1}
	Silt	47.6	
	Clay	30.6	
Soil texture	Clay loam		
Soil reaction degree (pH)		7.53	
Electrical conductivity EC		2.6	Desm^{-1}
Ready nitrogen		84.0	ml/kg^{-1}
Ready phosphorus		22.5	
Ready potassium		55.2	
Ready calcium		5.18	Meq/l^{-1}
Virtual density		1.5	mg/m^{-3}
Field capacity		25.80	
Permanent wilting point		12.76	

Studied attributes

First: Growth characteristics

1- Plant height (cm): Measured from the soil surface until the base of the disc at physiological maturity.

2- Weight of the stem (g/plant^{-1}): The leaves and disc were removed and the stem was dried in the electric oven until the weight was stable and then weighed.

3- The weight of the leaves (g): Dry leaves were weighed after separating from the stem and dried until the weight was stable.

Second: Yield characteristics and components

1- Number of seeds in the flower disk: The seeds number was calculated manually for the plants that were harvested and then the mean was measured.

2- Weight of 1000 seeds (g): The weight of 1000 seeds was calculated by taking a random sample of the plants and then modified the weight on the basis of 8% moisture (Al Sahuki, 1994).

3- Disc diameter (cm): Flower disc diameter was calculated by measuring the part that includes disc flowers (Knowels, 1978).

4- Total seed yield (Mega gram h^{-1}): Total seed yield was calculated by multiplying the experimental unit by plant density.

Results and Discussion

Plant height (cm)

Table 2 indicated that there was a significant effect of irrigation treatments and stress tolerance and their interaction on plant height. The treatment of 50% of the comparison treatment gave the lowest mean height of the plant with decrease proportion of 22.79% compared to treatment of 100% of the ready water. It can be attributed to the decrease in irrigation factors due to the lack of water, which may affect the lack of division, expansion and elongation of stem cells due to the low water stress of plant cells associated with the lack of soil water readiness, which in turn does not allow a large spread of roots in the early stages of plant growth (Esmaeilian, 2011). The treatment of aluminum foil was superior in plant height trait. The treatment of aluminum foil did not differ significantly from the red sand and anti-transpiration treatments with an increase of 8.90, 7.74 and 2.95% respectively compared with comparison and black sand treatments which gave the lowest height of the plant. It can beattributed to the importance of reversing infrared radiation IR, which was shown by aluminum foil and red sand with anti-transpiration that provided some protection for treated plants to withstand the damage of

Table 2: Effect of irrigation treatments, stress tolerance and their interaction on the height of the sun flower plant (cm) for the spring season 2018.

Irrigation treatments	Stress tolerant treatments					Mean
	Control	Black sand	Red sand	Anti-transpiration	Aluminum foil	
100% of ready water (control)	226.0	188.2	231.3	229.7	235.0	222.0
75% of control treatment	180.7	201.0	205.5	197.0	204.2	197.7
50% of control treatment	162.5	178.2	176.3	159.3	180.5	171.4
L.S.D.	23.50					12.02
Mean	189.7	189.1	204.4	195.3	206.6	
L.S.D	14.15					

moisture and thermal stress. The obtained result showed that treatment of the aluminum foil with the irrigation treated 100% was superior in plant height of the ready water as well as the treatment of the red sand with the irrigation 100% of the ready water, while when the irrigation was of 50% of the comparison treatment the mean height of the plant was less. This demonstrates the importance of treating aluminum foil and red sand in providing support to the plant against drought stress and its associated stresses. Combining the lack of water content of plant tissues with high heat causes complex effects that result in reduced plant height.

Weight of stem (g)

Table 3 showed significant differences between irrigation treatments. The treatment of 100% of the ready water recorded the highest mean weight of the stem, while 75% and 50% of the comparison treatment showed a lower mean stem weight with a decrease of 14.65% and 22.05% respectively. It can be attributed to low dry weight of the stemwhich was due to the decrease in the plant height values table 2, which was reflected in the amount of dry material manufactured for the stem. Water stress causes the plant to be less able to absorb water and nutrients due to the reduction of root growth, reducing vital factors in the total vegetative (Hoogenboom *et al.,* 1987). Table 3 indicated that significant differences between stress tolerance treatments in mean stem weight were found where the treatment of aluminum foil significantly exceeded the other treatments, giving the highest mean weight of the stem with an increase of 26.13% compared to the control treatment that had the lowest stem weight. This may be explained by the importance of reversing the infrared (IR) radiation shown by the aluminum foil which provided some protection from thermal stress damage, which is reflected in reducing the damage of moisture stress. Due to the heat and moisture binding,increasing heat stress increases evaporation and transpiration, which increases themoisture stress and if the heat stress increases, the plant's chance of moderating and moderating its temperature decreased to prevent coagulation of the cell protoplasm, as well as the accompanying heat stress and moisture stress in the environment. The treatment of red sand and black sand in the second rank was superior to the anti-transpiration and comparison, which gave the lowest mean weight of the stem, which may indicates the importance of two types of sand and the compounds that reverse IR radiation, as contributed to reduce the stress suffered by anti-transpiration and comparison. This can be calculated in favor of IR reflectors since the treatments (aluminum foil and sand) contain antiperspirant as an adhesive material on the surface of the plant and superior to the antiperspirant treatment which can be attributed to the effect of thermal reflectors used in this study (Aluminum and sand in both types). This may be explained by the selective effect of the beam.Additionally, the results of table 3 showed a significant correlation between irrigation coefficients and stress tolerances in the mean stem weight. The treatment of the aluminum flakes and the red sand was treated with 100% of the ready water recorded the highest mean of the stem

Table 3: Effect of irrigation treatments, stress tolerance and their interaction on the stem weight of the sun flower plant (g) for the spring season 2018.

Irrigation treatments	Stress tolerant treatments					Mean
	Control	Black sand	Red sand	Anti-transpiration	Aluminum foils	
100% of ready water (control)	187.5	187.1	202.3	199.4	209.7	197.2
75% of control treatment	146.9	177.7	176.3	145.5	195.3	168.3
50% of control treatment	127.5	163.9	160.5	140.1	177.1	153.7
L.S.D.	23.50					209.7
Mean	153.8	195.3	179.7	161.6	194.0	
L.S.D	10.21					177.1

Table 4: Effect of irrigation treatments, stress tolerance and their interaction on the leaves weight of the sun flower plant (g) for the spring season 2018.

Irrigation treatments	Stress tolerant treatments					Mean
	Control	Black sand	Red sand	Anti-transpiration	Aluminum foils	
100% of ready water (control)	71.30	75.14	87.22	74.97	94.41	80.61
75% of control treatment	52.28	71.33	69.55	66.16	87.73	69.41
50% of control treatment	44.00	62.63	68.93	60.63	76.25	62.49
L.S.D.	7.94					5.63
Mean	55.86	69.70	75.23	67.25	86.13	
L.S.D	4.36					177.1

weight while the comparison treatment in irrigation with 50% of the comparison treatment recorded the lowest value of stem weight. The obtained result supports the importance of radiation reflectors with anti-transpiration in reducing the heat and moisture.

Leaves weight (g)

Table 4 showed that the effect of water stress increasing on the leaves weight of the plant. Significantly, increasing water stress level reduced the weight of the leaves. The treatment of 100% of the ready water detected the highest mean weight of the leaves while the treatment of 50% of the comparison treatment was less mean for the weight of the leaves. The obtained result was consistent with the other characteristics which decreased significantly with increasing wet stress. The moisture and thermal stress in the leaves may affect more than the rest of the other parts of the plant may show fewer or fall at certain stages of growth and reduce the paper area and thus the weight of the leaves. The treatment of aluminum foil significantly exceeded all treatments by giving the highest weight to the leaves followed by the treatment of red sand, black sand and anti-transpiration without significant difference between them, however, they exceeded the treatment of the comparison, giving the lowest mean weight of the papers with an increase rate of 54.18, 34.67, 24.77 and 20. 39% respectively. Papers are the target part of these treatments and it seems that the reverse of infrared waves (thermal) has emerged in the difference found in the weight of the leaves, reducing the heat with the reduction of transpiration appears to be a double repair process of the wet and thermal stress, noting that damage one of them may not return with little benefit of because there was another obstacle to the natural growth of maize (Abraheem and Majeed, 2018). A significant interaction between irrigation treatments and stress tolerances in the mean weight of leaves was revealed (Table 4). The ratio of the aluminum foil to the irrigation was treated with 100% of the prepared water showed the highest mean of leaves weight while the comparison with irrigation with 50% of the comparison treatment gave the lowest mean weight of the leaves. The aluminum foil has the ability to reverse thermal radiation therefore it was used in many industrial fieldssuch as cooling devices, satellites, solar thermal and other fields. In terms of sand, a good ability in reversing thermal radiation, whether red or black was acknowledged.

Number of seeds in the flower disc

The results of table 5 showed that the increasing water stress has reduced the number of seeds as well as a significant difference at each level of stress was noted. The treatment of 100% of the prepared water recorded the highest mean number of seeds in the flower disk while 75% and 50% detected the lowest mean seeds number with a decreased of 32.67 and 44.48% respectively which indicates a water stress damage of the plant growth in both vegetative and fruit. The reduction in the number of seeds may result in a reduction in the number of flowers and the percentage of fertilization and thus the number of seeds in the disk. Stress is known to cause damage to various biological processes, which are reflected in the slow and the possibility of rapid drying of the seasons and the death of grain as well as indirect effects such as hormonal disorder, which has a large role in determining the number of seeds in the disk. Additionally, high temperature and low relative humidity during the stage of fullness of the seed, which affected the number of seeds in the disk (Table 5). All treatments (aluminum, red and black sand and anti-transpiration) were significantly higher compared to control with means of 21.76, 21.52, 19.72 and 17.26% respectively, indicating the importance of these treatments in reducing heat and moisture losses. Moreover, a significant correlation between irrigation treatments and stress tolerance treatments in the number of seeds in the flower disk. The treatment of red sand with irrigation treated 100% of the prepared water recorded the highest value of the seed, while the comparison treatment with irrigation treated with 50% of the comparison treatment had the lowest seeds number. This is in line with previous data where the moisture tensilereduced all growth indicators, in contrast to the comparison treatment and the treatment of red sand, which increased the mean number of seeds.

Table 5: Effect of irrigation treatments, stress tolerance and their interaction on the seed number of the sun flower plant (g) for the spring season 2018.

Irrigation treatments	Stress tolerant treatments					Mean
	Control	Black sand	Red sand	Anti-transpiration	Aluminum foils	
100% of ready water (control)	1615	1924	2011	2008	2009	1913
75% of control treatment	1164	1323	1357	1283	1314	1288
50% of control treatment	886	1051	1086	1097	1141	1052
L.S.D.	119.9					63.0
Mean	1222	1433	1485	1463	1488	
L.S.D	71.9					

Table 6: Effect of irrigation treatments, stress tolerance and their interaction on the weight of 1000 seeds of the sun flower plant (g) for the spring season 2018.

Irrigation treatments	Stress tolerant treatments					Mean
	Control	Black sand	Red sand	Anti-transpiration	Aluminum foils	
100% of ready water (control)	33.07	35.10	35.27	34.80	37.39	35.13
75% of control treatment	25.27	31.61	34.92	35.96	36.86	32.92
50% of control treatment	19.99	25.07	26.21	22.67	31.58	25.10
L.S.D.	119.9					2.92
Mean	26.11	30.59	32.13	31.14	35.28	
L.S.D	2.13					

Weight of 1000 seeds (g)

The results of table 6 showed that increasing stress level resulted in a significant decrease in the weight of 1000 seeds. The treatment of 100% of the prepared water gave the highest mean weight of 1000 seeds while the treatment of 50% of the comparison treatment was less mean for this characteristic by a decrease of 28.55%. This result was consistent with the number of seeds in the disk (Table 5). Low weight of 1000 seeds can be attributed to the effect of water stress on the speed of dryness of leaves and stem, which is accompanied by water shortage, high temperature and low relative humidity, which led to the reduction of photosynthetic process and other vital functions within plant tissues due to the aging of leaves (Rauf and Sadaqat, 2007) as well as slow down transport to the seeds due to the lack of moisture and high concentration of viscosity of liquids inside the conveyor vessels. This may indicates the severity of the stress damage in reducing the components of the crop, which is the desired end result of plant cultivation. The stress damage is cumulative from the vegetative growth stage and continues during a period full of seeds. It may affect the fullness and duration of the plant, which means low seed weight at the end. Table 6 indicates a significant difference between the stress tolerance treatments in the weight of 1000 seeds trait. The ratio of aluminum foil was significantly higher than the other treatments, giving the highest mean weight of 1000 seeds with an increase of 35.12% compared to control treatment which recorded the lowest mean. Additionally, aluminum foil treatment had a significant effect on weight of leaves and stem (Tables 3 and 4) which may reflected on the increase of the weight of 1000 seeds. Red, black, and anti-transpiration treatments did not differ significantly from each other. However, they were significantly higher than the comparison treatment, indicating the importance of these substances in reducing the damage of stress on the plant in general and on the weight of the seed in particular. Table 6 showed that there was a significant effect of the interaction between irrigation treatments and stress tolerance treatments in the weight of 1000 seeds. The treatment of aluminum foil when treated with 100% of prepared waterrecorded the highest value and did not differ significantly from the treatment of red sand when irrigation with 100% of prepared water treatment while the comparison treatment was the lowest value in the weight of 1000 seeds when irrigation treated with 50% of the comparison treatment which revealed the stress damage and the importance of the materials used to face it, including aluminum foil.

Disc diameter

The results of table 7 showed thatthere was no significant differences between irrigation treatments and stress tolerant treatments and their interaction on the diameter of the flower disc.

Table 7: Effect of irrigation treatments, stress tolerance and their interaction on the disc diameter of the sun flower plant (cm) for the spring season 2018.

Irrigation treatments	Stress tolerant treatments					Mean
	Control	Black sand	Red sand	Anti-transpiration	Aluminum foils	
100% of ready water (control)	19.67	22.00	20.33	19.67	20.33	20.40
75% of control treatment	18.33	18.67	20.00	20.00	19.67	19.33
50% of control treatment	19.33	18.67	20.67	20.00	20.33	19.60
L.S.D.	N.S					N.S
Mean	19.78	19.11	20.33	19.89	19.78	
L.S.D	N.S					

Table 8: Effect of irrigation treatments, stress tolerance and their interaction on the total seed yield of the sun flower plant (Meg h^{-1}) for spring season 2018.

Irrigation treatments	Stress tolerant treatments					Mean
	Control	Black sand	Red sand	Anti-transpiration	Aluminum foils	
100% of ready water (control)	3935	4194	5196	4886	6080	4858
75% of control treatment	3193	3755	4383	4017	4662	4002
50% of control treatment	948	1513	2060	1300	1814	1527
L.S.D.	492.5					349.1
Mean	2692	3154	3880	3401	4185	
L.S.D	270.5					

Total seed yield

Table 8 indicated significant differences between irrigation treatments and stress tolerance treatments and their interaction in total seed yield trait. Increasing level of water stress resulted in a decrease in seed yield. The treatment of 100% of the prepared water gave the highest meanof seed yield, while the treatment of 50% of the comparison treatment gave the lowestmeanof seed yield with a decrease of 68.56%which indicates the magnitude of the damage caused by wet stress and other stresses. The reason for the decrease in seed yield under water stress conditions was due to the growth and development of the crop that reflected in the low number of seeds in the disk table 5 and the weight of 1000 seeds table 6 which negatively affect the seed yield. The aluminum treatment was significantly higher in the mean seed yield, with an increase of 55.46% compared to other treatments (red sand, Anti-transpiration, black sand and comparison), which gave the lowest mean seed yield. It can be attributed to the efficiency of aluminum foil in reversing the heat waves and increase the treatment of the anti-transpiration with the reversal of heat waves. This argument is supported by the observation of the difference in the treatment of anti-transpiration significantly from the treatment of aluminum foil. The ratio of aluminum foil with irrigation treated with 100% of prepared water was higher than the prepared water. The highest value was obtained for the seed yield, while the comparison treatment with irrigation of 50% of the comparison treatment recorded the lowest value of the seed yield. This indicates the importance of reducing the transpiration and heat to overcome the stress in orderto obtain satisfactory results.

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