Effect of soil moisture stress and foliar application of zinc on some maize varieties

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SUMMARYThe present investigation was carried out to study theeffect of irri gat ion at different ava i1abl e soil mo isturestress, maize cultivars and foliar application of zincsulphate on growth, yield and its components, chemicalcomposition and the water relation of maize plants.Three field experiments were conducted at Sakha AgriculturalResearch Station, Kafr El-Sheikh Governorate. Egypt in1988, 1989 and 1990 seasons. The selected areas were studiedto determine field capacity. wilting point, bulk density,mechanical and chemical analysis.The experimental design was split-split plot with fourreplications. The main plots were randomly assigned to threeirrigation levels, the sub-plots to three maize cultivars andthe sub-sub plots to the three zinc sulphate concentration.The area of each plot was 33.6 ~ (6 x 5.6 m) with a ridgeswhich were 70 cm apart and 6 m length. The treatments were asfollows:I. Irrigation treatments:1. Irrigated when 40% of the avai lable soil moisture wasdepleted.2. Irrigated when 60% of the available soil moisture wasdepleted.3. Irrigated when 80% of the available soil moisture wasdepleted.II. Maize cultivars:1 . G; za 2.2. T.W.C.310.3. Karnak.III. Zinc sulphate levels:1 . 0.0%2. 0.3%.3. 0.6%.Maize plants were sprayed twice when aged 30 and 45 daysat a rate of 400 liters solution/feddan. All cultural practicesexcept factors under study were carried out as commonpractices in the area.To study the growth analysis, samples of maize plantswere taken at random from the second and seventh rows at 60.75 and 90 days from sowing. Yield and yield components weredete rmined from a central area of each plot, equa 11/300/feddan.Characters studied:I. Growth attributes:1. Dry matter accumulation and distribution/plant.2. Leaf area/plant (drrf)’3. Total chlorophyll and earotenoids.5. Crop growth rate.6. Relative growth rate.7. Net assimilation rate.8. Time of silking.9. Plant height (em) at harvest.10. Ear height (em) at harvest.11. Stem diameter (em) at harvest.II. Yield and yield components:1 . Percentage of plants carried more than one ear.2. Percentage of infection with late wilt disease.3. Ear length (em).4. Ear diameter (em).5. Ear wei ght (g).6. Number of rows/ear.7. Number of grains/row.8. Grain yield/plant (g).9. Weight of 100-grain (9)·10. Grain yield (kg/feddan) adjusted to 15.5% moisture.11. Straw yield (ton/feddan).III. Chemical composition:1. Crude protein percentage.2. Protein yield (kg/feddan).3. Oil percentage.4. Oil yield (kg/feddan).5. Zinc content of ma,~e grains (ppm).IV. Soil-water relations:1 • Water consumptive use.2 . Water use and yield relationship.3. Water uptake patterns of maize.4. water use efficiency.5. Crop coefficient (Kc).V. Simple phenotypic correlations:The important results of this study could be summarizedas follows:I.. Growth. attri butes: .A. Effect of years:1. All characters were significantly affected due to yearsexcept stem diameter. The average values of dryweight/plant, leaf area/plant and leaf area index in thethree stages, carotenoi ds, time of s i1king and plantheight were high values in the third season.2. The high mean values for chlorophyll a, b, (a+b), cropgrowth rate, relative growth rate, net assimilation ratewere detected in the first season.B. Effect of water stress:1. The averaS6 values of dry weight/plant at 60, 75 and 90days after sowing, the percentage of ears at 90 days fromplanting, leaf area/plant and leaf area index at 60, 75and 90 days from sowi ng, ch 1or ophy 11 a. carotenoi ds I cropgrowth rate, net assimilation rate, plant height, earheight and stem diameter were significantly decreased byincreasing available soil moisture depletion from 40% to80% in the combined analysis of 1988, 1989 and 1990seasons.2. There was a significant delay of silking time by ;ncreasingthe 50;1 moisture depletion. Earlier silking wasobserved when maize plants were i

rrigated at 40% so; 1moisture depletion.3. The mean values of the percentage of leaves and stem at60 days from sowing, the percentage of leaves, stem, earsand tassel at 75 days after planting, chlorophyll b ,(a+b), the ratio of chlorophyll (a+b) to carotenoids andrelative growth rate were not significantly affected bywater deficit.C. Varietal differences:1. T.W.C.310 cultivar surpassed significantly Giza 2 andKarnak cultivars in dry weight/plant at 60, 75 and 90days from sowing, the percentage of stem at 75 and 90days after sowi ng, 1eaf area/pl ant and 1eaf area index at75 and 90 days after planting, crop growth rate, plantheight, ear height and stem diameter in the combineda~3lysis over the three seasons.2. Karnak cultivar gave the highest values for the percentageof leaves/plant at 75 and 90 days from sowing,chlorophyll (a) and number of days to 50% silking.3. Giza 2 cultivar surpassed significantly the othercultivars in the percentage of ears and stem/plant at 75and 90 days from sowing.4. The differences between the three cultivars under studywere not sign i f icant in 1eaf area/p 1ant and 1eaf areaindex at 60 days from sowing, chlorophyll b, (a+bLcarotenoids, the ratio of chlorophyll (a+b) to carotenoids,relative growth rate and net assimilation rate.D. Effect of zinc levels:1. The average values of dry weight/plant at 60 and 75 daysfrom sow; n9, the percentage of stem and 1eaves at 60 daysfrom planting, the percentage of stem, ears, and tasselat 75 and 90 days after sowing time, leaf area/plant andleaf area index at 90 days after sowing, chlorophyllcontent, carotenoids, crop growth rate, relative growthrate, net assimilation rate, plant height and ear heightwere not significantly affected by zinc levels in thecombined analysis over the three seasons.2. The mean value of dry weight/plant at 90 days from sowingtime, leaf area/plant and leaf area index at 60 and 75days after sowing and stem diameter were significantlyincreased by incr-eas ing 1eve 1 of zinc su 1phate up to0.3%.3. Number of days to 50% s ilk in9 was sign if icant 1y decreasedby application zinc sulphate as foliar up to 0.3%.E. Interaction effect:1. The percentage of stem and ears at 90 days from sowingwere highly significantly affected by the interactionbetween water stress and maize cultivars in the combinedanalysis over the three seasons. The highest percentageof 5tern was 40. 54% , obta ined from i rriga tion at 40%depletion in available water with T.W.C.310 cultivar,while the lowest one was 28.96%, obtained from wateringat 60% soil moisture depletion with Giza 2 cultivar. Thehighest percentage of ears was (50.41 or 50. 11), obtainedfrom watering at 40% or 60% depletion of soil moisture,respectively, with Giza 2 cu1tivar. whereas the othercharacters of growth anal ys is were not significant 1yaffected by the interaction between water stress andmaize cultivars.2. The max imum mean va 1ues of the rat i0 of ch 1orophy 11 (a+b)to carotenoids was 1.80 mg/dm2 leaf area, obtained from0.3% zinc sulphate and 40% depletion of soil moisture,whereas the lowest one was 1.69 mg/drrf 1eaf area, obtainedfrom 40% soil moisture depletion and foliarapplication of zinc sulphate at 0.6%. However, no” significant difference was obtained from the effect ofthe interaction between water stress and zinc level onthe other growth characters.3. There were sign ificant differences between the meanva 1ues of ch 1orophy 11 a, carotenoi ds and the ratio ofchlorophyll (a+b) to carotenoids due to the interactionbetween maize cultivars and zinc levels in the combinedanalysis between the three seasons. T.W.c.3i0 cultivarwith applied 0.3% zinc sulphate gave the highest value ofchlorophyl 1 a and the ratio of ch 1orophyll (a+b) tocarotenoids (2.39 and 1.82) mg/d~ leaf area, respective-1y. The highest mean val ue of carotenoi ds was 2.37 mg/dnfleaf area. obtained from applied 0.3% zinc sulphate withKarnak cultivar.4. The differences between the percentage of 1eaves and stemat 60 days from sowing a~d stem percentage at 75 daysfrom sowing were significantly affected by the interactionbetween water stress, cult;vars and zinc levels inthe combined analysis over the three seasons. The othercharacters of growth analysis were not significantly dueto the interaction between water stress, maize cultivarsand zinc levels.II. Yield and yield components:A. Effect of years:1. All characters were differed significantly from year toanother except ear length.2. The high mean values were detected for ear diameter, earweight, 100-grain weight, grain yield per plant and grainyield/feddan in the first season, and plants carry morethan one ear percentage, late wilt disease percentage,number of grains/row and straw yield ton/feddan in thesecond season, number of rows/ear in the third season.B. Effect of water stress:1. The effect of water stress treatments on the averagevalues of plants carried more than one ear percentage,ear length, ear diameter, ear weight, number of rows/ear,number of grains/row, 100-grain weight and grainweight/plant were significant in the combined analysisover the three seasons.2. Irrigation after

40% soil moisture depletion gave thehighest value of plants carried more than one ear %(5.22%), ear length (20.94 cm), ear diameter (5.03 em),ear wei ght (304.94 g), number of rows/ear (13.80). numberof grains/row (44.70), 100-grain weight (41.27 g) andgrain yield/plant (191 .30g).3. The average values of grain and straw yield/feddan weresignificantly decreased by increasing available soilmoisture depletion up to 80% in 1988, 1989 and 1990seasons as well as the combined analysis over the threeseasons. The highest decreas~ in the percentage of grainyield/feddan was 26.41~, obtained from irrigation at 80%soil moisture depletion when compared with 40% depletionof available soil moisture in the combined analysis.3. On the other hand, the percentage of late wilt diseasesignificantly increased by increasing soil moisturedepletion up to 80%.c. Varietal differences:1. The percentage of plants carried more than one ear, latewilt disease %, ear length, ear diameter, ear weight,number of rows/ear, number of grains/row, grainyield/plant, grain yield and straw yield per feddan weresignificantly affected by maize cultivars in the combinedanalysis over the three seasons.2. T.W.C.310 cultivar gave the highest values of thepercentage of plants carried more than one ear (6.65%),ear length (22.34 cm), ear weight (313.27 g), number ofgrains/row (48.59), 100-grain weight (41.67 g). grainyield/plant (191.51 g), grain yield feddan (3792 kg) andstraw yield/feddan (6.83 ton).3. Giza 2 cultivar gave the highest percentage of infectionwith late wilt disease. whereas T.W.C.310 cultivar gavethe lowest percentage of infection with late wiltdisease.4. Karnak cultivar gave the maximum values of ear diameter(5.15 em) and number of rows/ear (14.59).5. The differences between Giza 2 and Karnak cultivars werenot signi f -j cant in number of gra insf row. grainyield/plant and per feddan.D. Effect of zinc levels:1 . The differences between the mean values of plants ear r i edmore than one ear%, ear diameter, number of rows/ear andnumber of grains/row were not significant due to zinclevels in the combined analysis over the three seasons.2. The mean values of ear length. ear weight, 100-grainweight, grain yield/plant, grain yield/feddan and strawyield/feddan were significantly increased by increasingfoliar application of zinc sulphate up to 0.3%.3. However, no significant difference was obtained byapplication zinc levels at 0.3% and 0.6% on the meanvalues of 100-grain weight, grain yield/plant and strawyield/feddan.4. The average values of infection with late wi lt diseasepercentage 5igni fi cant 1y increased by ;ncreas in9 1eve 1 ofzinc sulphate as foliar up to 0.6%.E. Interaction effects:1. Insignificant effect of water stress and maize cultivarsinteract ion and water stress and zinc 1eve 1s ; nteract ion,were obtained for yield and yield components.2. The average values of 100-grain weight, grain yield/plantand gra in y ie 1d/feddan were sign if icant 1y affected by theinteract ion between cul t ivars and zinc 1eve 1s 1n thecomb ined anal ys is over the three seasons. The highestmean values of 100-grain weight, grain yield/plant andper feddan were 42.46, 195.25 g and 3867 kg, respectively,obtained from T.W.C.310 cultivar with applied 0.6%zinc sulphate as foliar application.3. There was a significant difference between the averagevalues for number of grains/row due to the interactionbetween water stress, maize cultivars and zinc sulphate.The highest value for number of grains/row of T.W.C.310cultivar was 49.63, obtained from irrigation after 40%soil moisture depletion with zinc sulphate at 0.6%. Whilethe lowest one was 39.75, obtained from 80% depletion ofsoil moisture and zero sulphate with Karnak cultivar.III. Chemical composition:A. Effect of water stress:1. The mean values of protein percentage was increased byincreasing depletion of soil moisture from 40% to 80minimum one was 129.33 kg, obtained from irrigation at80% soil moisture depletion with Karnak cultivar.2. The highest mean value of protein and oil yield were 342kg and 225.83 kg/feddan, respectively, obtained fromirrigation at 40% soil moisture depletion and applied0.3% zinc sulphate as foliar. whereas the lowest oneswere 254 kg and 131.17 kg/feddan. respectively, gained_from irrigation at 80% depletion in available waterwithout application of zinc sulphate.3. The average values of protein and oil yield/feddan weresignificantly affected by the interaction between maizecultivars and zinc levels. Karnak and T.W.C.310 cultivarswith applied 0.3% zinc sulphate as foliar gave thehighest mean values of protei nand oi 1 yie 1d/feddan,respectively.4. The interaction between irrigation after 40% depletion inavailable water with T.W.C.310 cultivar and applied 0.6%zinc sUlphate as foliar gave the highest mean values ofprotein and oil yield/feddan.5. Insignificant effect of interaction between water stressand cultivars was obtained for protein yield per feddan.IV. Soil-water relations:1. Seasonal consumptive use amounts increased as theavailability of soil moisture increased in the root

zone.The highest value of consumptive use was 64.43 em whenplants were irrigated at 40% depletion in availablewater, while the lowest one was 49.12 cm when watering at80% soil moisture depletion. Maize cultivars and zincapplied had no obvious effect on water consumptive use.2. The highest value of seasonal consumptive use rate was0.53 em/day accompanied by irrigation at 40% depletion inavailable water. Whil~ the lower value was 0.41 em/dayrelated to irrigation at 80% depletion of soil moisture.The daily consumptive use increased gradually as plantgrowth increased and reached its maximum at about silkingand seed formation. Monthly consumptive use reached itsmaximum values during August which represent the periodof maximum demand for water by maize.3. The relation between consumptive use in cm eX) and maizegrain yield in kg/feddan (Y) for all moisture treatmentswas linear and could be described by the following linearequation:y = -420.68 + 65.24 XThe grain yield of mai ze increased 65.24 kg/feddan byincreasing one unit (em) of seasonal consumptive use ofmaize.4. The correlation coefficient for the two variables wassignificant positive and equal 0.999.5. Maize plants extracted about 83.33% and 16.67% of itswater needs from the upper and the second foot, respectively,when maize plants were irrigated at 40% depletionin available water. Increasing the soil moisture stress,i.e.t 80% soil moisture depletion resulted in increasingthe percentage of moisture extracted by maize roots fromthe second foot (26.44%).6. The highest water use efficiency value was 1 .40 kg/m3 ofwater consumed recorded when maize plants were irrigatedat 40% depletion in available water. whereas the lowestone was 1.35 kg/m3 produced from wateri ng at 80% soi 1moisture depletion. T.W.C.310 cultivar utilized watermore efficiency than the other cultivars. Applying zincsulphate at 0.3% resulted in producing the highest wateruse efficiency than the other concentration.7. Potentia 1 evapotransp irat ion was estimated by methodsnamely modified Penman. Radiation. modified Blaney-Criddle and the class A pan. Values of potential evapotranspirat ion obta ined by the 1ast two methods were lowerthan those obtained from Penman and Radiation methods.8. The crop coefficient (Kc) of maize was estimated by theprevious methods. It was low at the beginning of thegrowing season. the increased as a result of the increasein crop cover. At the end of the season. a reduction inevapotranspiration rates was noticed as the plants weregoing to maturity. Crop coefficient (Kc) values calculatedby using modified Slaney Criddle and the class A panmethods were hi ghe r than that obta ined by mod if ied Penmanand Radiation methods.It could be concluded that the calculated value of 0.88for (Kc) could be used in calculating the consumptive useof maize in North Delta area as estimated by the aid ofPenman or Radiation methods.v. Simple phenotypic correlations:1. Significant positive correlation values were detectedbetween grain yield/feddan and each of straw yielq(t/feddan), grain yield/plant, the percentage of plantscarried over one ear, i0C-grain weight, ear length, earweight, number of grains/row, plant height, ear height,stem diameter and dry matter/plant, leaf area/plant andleaf area index at 75 days from sowing, crop growth rate,relative growth rate and net assimilation rate.2. Insignificant positive correlation coefficients weredetected between grain yield/feddan and chlorophyll a, b ,(a+b) and carotenoids.3. Insignificant negative correlation value was foundbetween grain yield/feddan and days to 50% silking.4. Significant negative correlation value was found betweengrain y;eld/feddan and late wilt disease percentage.It could be recommended from this work that the bestwater level for irrigating maize plants when 40% ASt-il.) isder1eted, applying zinc sulphate as foliar at a rate of 0.3%W” ;.C.310 cultivar produced higher grain yield/feddan.