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Germination Indices and Seedling Growth Parameters in Maize under Salinity Stress with Varying Concentrations of Giberellic Acid (GA)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Salinity stress is one of the factors limiting seed emergence and seedling development in sunflower at New halfa scheme in East of Sudan. A study of two factors pots experiment was conducted during winter season of 2019 to evaluate germination indices and seedling growth characters of maize seeds under salinity stress with varying concentrations of synthetic growth regulator namely (GA_3). The experiment was laid out according RCBD with three replications. Treatments consisted of five levels of salinity (0, 0.5, 1.0, 1.5 and 2%) designated as Na_0, $Na_{0.5}$, $Na_{1.0}$,$Na_{1.5}$ and $Na_{2.0}$,

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and four levels of GA3 were (0, 50,75 and 100 p.pm) designated as G_0, G_{50}, G_{75} and G_{100}, respectively,. The studied parameters include germination indices; daily germination (MDG), daily germination speed (DGS), final germination percentage (FGP), mean emergence time (MET), mean Energy of germination (EE**)**, emergence index **(**EI**)**, coefficient of uniformity of emergence (CUE) and vigour index (SVI). Also, seedling fresh and dry weight, shoot length and root length were measured, and the shoot/root ratio was calculated. The negative effects of salinity stress significantly decreased germination indices and seedlings growth characters in a dose dependent manner. The results showed that, application of GA3 at medium levels concentration (specify those doses) increased all studied parameters. In conclusion, application of high Ga3 levels enhanced all germination indices and seedlings growth characters while high salinity levels reduced these traits of maize seeds. Such result has made the base for further study that should be conducted in different seasons with different growth regulators involving different parameters of other crops.

Keywords: Maize; Gabralline; salinity; germination indices; seedling vigor.

1. INTORODUCTION

"Maize (*Zea mays* L), also known as Indian corn, is one of the most important crops worldwide, and it is a staple cereal crop grown globally under a broad spectrum of soil and climatic conditions in temperate and tropical regions. It is a monoecious annual plant belonging to Maydes tribe of the grass family Gramineae" [1,2.3]. "Also, reported that, the establishment of a crop consists of three sub-phases: sowing through seed germination, seed germination through seedling emergence, and seedling emergence through first competition among young plants. However, seed dormancy and germination are distinct physiological processes, and the transition from dormancy to germination is not only a critical developmental step in the life cycle of higher plants but also determines the failure or success of the subsequent seedling establishment and plant growth" [5]. "Seed germination and seedling establishments are the two critical stages in plant growth. Seedling growth stages are the most vulnerable stages in the life cycle of plants. These stages are the most sensitive to environmental conditions including salinity" [6]. "Plant hormones, especially gibberellins, found in the seeds are responsible for the functioning of this enzyme system. The plant hormones widely take part in determining the physiological state of a seed and regulating the germination process by interacting each other" [7]. "Furthermore, plant hormones, including gibberellins, play an essential and significant role in plant growth and development, such as seed germination and stem elongation" [8]. "Abiotic stress, soil and environmental conditions may reduce seed germination percentage, meanwhile, they can also cause adaptation to induced stress" [9]. "During germination, seeds are subject to various biotic and abiotic stresses that, individually or in concert, inhibit germination and seedling development. Depending on the severity of the stress and the genetic background, germination is either delayed or inhibited" [10]. In this regard, [11] stated that, "increasing concentration of NaCl solution resulted in gradual reduction in seed germination and suppression of early seedling growth in cereals". "Also, the effect due to salinity of sodium chloride on germination is mainly a result of osmotic effects" [12]. "The reduction in the plant growth in the saline environments may be due to either water relations or the toxic effects of Na^+ and Cl- ions on the metabolism. High levels of salinity affect seed germination and plant growth by water deficit (osmotic stress), ion toxity and ion imbalance (ionic stress) or a combination of these factors" [13]. Recently, [14] concluded that, "salinity stress decreases crop growth and development, causing tissue death, flowering abortion, and negatively affects enzymatic activity, protein synthesis, among other processes". Many researchers [15] concluded that, "Plant growth regulators (PGRs) show diverse functions in plants under various stress conditions. Now a days concentrated attempts have been made to mitigate the harmful effects of salinity by application of plant growth regulators. It is thought that the depressive effect of salinity on germination could be related to a decline in endogenous levels of hormones. Also, works regarding the effect of growth regulators on seed germination is very limited worldwide and is either lacking or scanty under the climatic condition of Sudan. Concentrated attempts have been made to mitigate the harmful effects of salinity by application of plant growth regulators. It is thought that the depressive effect of salinity on germination could be related to a decline in endogenous levels of hormones". Therefore, the present investigation has been undertaken to find out ‘the effect of GA3 growth regulators on germination indices and seedling vigour of maize (*Zea mays* L) under salinity stress conditions.

2. MATERIALS AND METHODS

A laboratory experiments (in Petri dishes) of randomized complete blocks design (RCBD) with three replicates were carried out during winter of 2018 at Faculty of Agriculture, Kassala University in New Halfa, Sudan, to evaluate germination indices and seedling parameters of sunflower under salinity stress with varying concentrations of synthetic growth regulator namely GA_3.Treatments were consisted of (four levels of GA3 were 0, 50,75 and 100 ppm) designated as G_0,G_{50},G_{75} and G_{100},respectively, under five levels of salinity (0, 0.5, 1.0, 1.5 and 2%) designated as Na_0, $Na_{0.5}$, $Na_{1.0}$,$Na_{1.5}$ and $Na_{2.0}$. The five levels of salinity were prepared from equal equivalents of NaCl.

2.1 Germination Test

Seeds of maize were sterilized with 3% sodium hypochlorite for three minutes then washed with distilled water. Ten seeds were placed on filter paper in a glass Petri dish of 9 cm diameter and 16 ml saline solution of desired treatment were added. Seed germination was recorded daily at a certain time (A seed was considered to be germinated when its radical emerged by about 2 mm in length).

In this study germination attributes were measured as follows:

2.2 Mean Emergence Time (MET) [Days]

Mean (MET) was calculated according to following equation of Elias et al. [16];

$$MET = \frac{\sum \mathbf{Dn}}{\sum \mathbf{N}}$$

Where N is the number of seeds, emerged on day D from the beginning of emergence.

2.3 Emergence Energy (EE) [%]

Energy of germination (EE) was calculated according to the formula as described by Farooq et al. [17]

EE% = (No of seedling emerged at 4days after sowing)/(Total number of seeds sown) x100

Final emergence percentage (FEP) [%]

Final emergence percentage was calculated as described by Basra et al. [18] using the following formula:

$$\text{FEP\%} = \frac{\text{Final No of seedlings emerged}}{\text{Total number of seeds sown}} x100$$

Emergence index (EI) was calculated as described in the Association of Official Seed Analysis [19] as the following formula:

EI = (No. of germinated seeds)/(Days of first count)+⋯+⋯..+(No. of germinated seeds)/(Days of final count)

2.4 Mean daily germination (MDG)

This is an index of daily germination and calculated by Farooq et al. [17]:

$$\text{MDG} = \frac{\boldsymbol{FGP}}{\boldsymbol{d}}$$

where FGP is final germination percent and d is test period.

2.5 Daily Germination Speed (DGS)

This index is inverse of mean daily germination and calculated by Farooq et al. [17].

$$\text{DGS} = \frac{\mathbf{1}}{\boldsymbol{MDG}}$$

2.6 Coefficient of Uniformity of Emergence (CUE)

The coefficient of uniformity of emergence (CUE) was calculated as described by Bewley and Black [19] using the following formula:

$$\text{CUE} = \sum \boldsymbol{n} / \sum[(\bar{t} - t)^2 \text{ x } n]$$

Where t is the time in days, starting from day 0, the day of sowing, and n is the number of seeds completing emergence on day $\bar{t}$ and t is equal to MET.

2.7 Seedling (plumule) Height (cm)

Seedling (plumule) height (cm) was measured using a meter tape from the base of the stem to the youngest leaf or to the tip of the panicle. The average was determined from the ten seedlings in each plot.

2.8 Radical Length(cm)

Radical length(cm) was measured using a meter tape from the tip to the end of the radical**.**

2.9 Seedling Vigor Index (SVI)

Calculated as described by Farooq et al. [17]as following:

SVI = (Radical length+plumule length) × FEP %

2.10 Shoot Fresh Weight (g)

After separating of radical from seedling, fresh weight of seedlings were taken using electrical weighing balance.

2.11 Shoot Dry Weight (g)

Shoots of seedlings were placed in paper bags, air-dried first and then oven dried at 65±5 °C till constant weight. After that the dry weight will recorded with electrical weighing balance.

2.12 Shoot/Radical Ratio

Calculated as the ratio of Shoot dry weight to radicle dry weight.

2.13 Statistical Analysis

Data of germination indices transferred using ARC Sin equation and then all data were statistically analyzed according to the analysis of variance (ANOVA) for RCBD using computer software package (statistix 9). Mean comparisons were worked out by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3. RESULTS AND DISCUSSION

Analysis of variance showed significant differences in maize seedlings due to application of both growth regulator GA3 and salinity treatments on FGP, MET, MDG, DGS, EE, CUE, EI and SVI. The higher values of (94.50, 94.38) recorded in G_0 and G_{50} growth regulators treatments and least values of FGP (87.27, 87.58 and 88.96) recorded due to application of high salinity levels solely or combined with GA_3 treatments (Table1). The increase of FGP of maize seed, in this study, due to application of GA3 might be due to the role of gibberellic acid to weaken seed coat and this leads to an expression of cell. The higher values of DGS, MDG, MET, EE, and EI resulted in G_{50} treatment might be to the fact that GA3 can break seed dormancy, stimulate seed embryos, thereby promote plant metabolic reaction, repair the integrity of damaged cell and improve seed viability and as a result increased these germination indices of the maize seed. The increased in radical length, SVI, fresh and dry weight of seedling due to application of GA3 in this study were agreed with those reported by Panel et al**.** [20] who reported significant differences in SVI of maize due to application of GA3 and [21] in fresh and dry weight of maize seedling. In surprise, the increase in radical length at lower concentration of GA3 in this study was agreed with the past study reported by Wittwer and Bukovac [22] who reported that GA3 at lower concentration initiate the growth of root. Increasing level of salinity significantly reduced the values of FGP, MET, MDG, DGS, EE, EI, CUE, SVI, fresh and dry weight of seedling (Table). In this regard, salinity is known to have a dual effect on plant growth via the osmotic effect on plant water uptake and the specific ion toxicities [23]. It is well known that salinity has negative completion with FGP, EI, MET and depending on the salt concentration. These findings may explain the results obtained in this investigation. Also, these results were agreed with those reported by Panel et al. [20] who showed significant differences in FGP, EE, EI, CUE, DGS in maize, and seedling length with increasing salinity levels. The decrease in SVI observed in this study due to application of high level of salinity (Table1) because the vigor index of seedling is directly dependent on germination percentage and seedling length where these two characters were reduced in the same treatments. In Table 2, the reduction of radical length due to application of salinity stress because under saline conditions the reduction of seedling root length is a common phenomenon in many plants, because roots are first organs exposed to salinity. The decrease in fresh and dry weight of seedling due to salinity stress were in line with those reported by Sheldon et al. [24] who observed that fresh and dry weight cyan seedling were decreased as salinity levels increased. In general, high salinity inhibits seed germination due to low osmotic potential created around the seed which percent water up take.

Table 1. coefficient of uniformity of emergence (CUE), emergence energy (EE), mean daily germination (MDG), daily germination speed (DGS), final emergence percentage (FEP), mean emergence time (MET), emergence index (EI) and seedling vigor index (SVI) of maize seedling

Treatment	CUE	EE	MDG	DGS	FGP	MET	EI	SVI
G0	0.029	94.50	7.88	0.13	94.51	94.33	11.32	3236.9
G50	0.028	94.36	7.89	0.15	94.52	94.68	10.94	1492.0
G75	0.029	90.54	7.55	0.13	90.54	89.97	7.13	965.6
G100	0.034	91.41	7.62	0.13	91.41	90.48	7.00	621.5
$LSD_{0.05}$	0.02	22.05	1.84	0.54	22.07	28.81	2.23	213
Na0	0.026	96.07	8.01	0.12	96.07	95.78	12.43	3588
Na0.5	0.033	94.36	7.86	0.13	94.38	94.10	10.60	3711.5
Na1.0	0.025	92.93	7.75	0.13	92.95	92.52	9.54	1270.3
Na1.5	0.024	92.92	7.74	0.13	92.92	92.18	8.12	1371.8
Na2.0	0.011	87.25	7.27	0.14	87.27	86.39	4.69	545.5
$LSD_{0.05}$	0.01	23.31	1.94	0.51	23.33	25.06	2.49	543
G0Na0	0.027	97.82	8.15	0.12	97.82	97.74	15.56	3236.9
G0Nao.5	0.027	96.74	8.06	0.12	96.77	96.71	13.90	1492.0
G0Na1.0	0.023	92.27	7.69	0.13	92.31	92.26	9.83	965.6
G0Na1.5	0.026	94.50	7.87	0.13	94.50	94.24	10.93	621.5
G0Na2.0	0.033	90.99	7.58	0.13	90.99	90.46	6.36	454.8
G50Na0	0.025	97.70	8.12	0.12	97.70	97.77	14.46	3711.5
G50Na0,5	0.024	96.32	8.03	0.12	96.34	95.67	11.93	1270.3
G50Na1.0	0.030	97.78	8.15	0.12	97.82	97.77	15.83	1371.8
G50Na1.5	0.029	92.18	7.68	0.13	92.18	90.92	7.86	545.50
G50Na2.0	0.028	87.58	7.30	0.14	87.58	85.54	5.30	383.20
G75Na0	0.029	93.97	7.83	0.13	93.97	93.57	9.60	2389.83
G75Na0.5	0.034	93.97	7.83	0.13	93.97	93.32	9.70	953.81
G57Na1.0	0.031	91.00	7.58	0.13	91.00	90.26	6.73	905.39
G75Na1.5	0.050	92.62	7.72	0.13	92.62	91.72	7.26	557.67
G75Na2.0	0.035	80.36	6.70	0.15	80.36	80.36	2.36	209.97
G100Na0	0.039	94.92	7.91	0.13	94.92	94.46	10.1	1559.18
G100Na0.5	0.037	90.27	7.52	0.13	90.27	90.22	6.90	971.43
G100Na1.0	0.026	90.51	7.54	0.13	90.51	89.96	6.46	644.61
G100Na1.5	0.039	92.29	7.69	0.13	92.29	91.19	6.80	194.451
G100Na2.0	0.040	88.96	7.41	0.13	88.96	86.31	4.73	128.346
$LSD_{0.05}$	0.02	32.96	2.75	0.36	32.99	35.43	4.98	532.11

Table 2. Mean stem diameter (cm), radical length (cm), root length (cm), number of leaves, shoot fresh weight (g), shoot dry weight (g) and shoot/ radical of maize seedling

Treatment	Stem diameter (cm)	Radical length (cm)	Shoot length	No. of leaves	Shoot Fresh wt (g)	Shoot Dry wt (g)	Shoot/ radical
G0	0.1	11.89	4.24	2.06	0.19	0.17	3.2
G50	0.1	12.81	4.26	1.86	0.16	0.16	1.4
G75	0.13	11.66	3.94	2.13	0.17	0.14	1.28
G100	0.16	7.94	2.2	2.2	0.18	0.16	1.38
$LSD_{0.05}$	0.02	3.8	2.28	0.63	0.08	0.06	0.77
Na0	0.12	23.55	5.38	2.58	0.18	0.17	3.9
Na0.5	0.12	12.55	3.43	2.16	0.16	0.15	1.23
Na1.0	0.13	10.3	3.3	2..08	0.16	0.13	1.69
Na1.5	0.11	5.1	1.81	1.75	0.21	0.19	1.27
Na2.0	0.14	3.87	2.35	1.75	0.17	0.16	0.99
$LSD_{0.05}$	0.03	4.25	2.55	0.7	0.09	0.07	0.86
G0Na0	0.1	24.7	6.44	2.66	0.22	0.21	4.3
G0Nao.5	0.1	13.53	3.46	2.33	0.17	0.15	2.5

Treatment	Stem diameter (cm)	Radical length (cm)	Shoot length	No. of leaves	Shoot Fresh wt (g)	Shoot Dry wt (g)	Shoot/ radical
G0Na1.0	0.1	11.33	2.4	2.11	0.19	0.16	2.5
G0Na1.5	0.13	6.06	1.66	1.33	0.14	0.12	2.43
G0Na2.0	0.1	3.83	4.65	2.12	0.24	0.21	1.22
G50Na0	0.1	27.43	11.46	2.33	0.21	0.20	2. 76
G50Na0,5	0.1	11.9	2.86	2.14	0.13	0.12	1.33
G50Na1.0	0.13	13.1	2.96	2.13	0.16	0.14	2.34
G50Na1.5	0.1	5.83	2.03	1.33	0.15	0.12	0.83
G50Na2.0	0.1	5.9	1.96	1.66	0.17	0.16	0.83
G75Na0	0.13	24.36	1.18	2.66	0.18	0.15	2.93
G75Na0.5	0.13	11.96	2.23	2.34	0.17	0.15	0.5
G57Na1.0	0.1	10.9	2.86	2.22	0.16	0.14	1.66
G75Na1.5	0.1	6.76	2.16	2,23	0.2	0.1	0.43
G75Na2.0	0.2	4.33	2.33	2.43	0.14	0.12	0.98
G100Na0	0.16	17.7	2.3	2.66	0.11	0.10	2.66
G100Na0.5	0.16	12.83	5.16	2.33	0.18	0.16	0.6
G100Na1.0	0.2	6.53	532	2.33	0.11	0.23	0.6
G100Na1.5	0.13	1.73	1.4	2.33	0.36	0.31	1.83
G100Na2.0	0.16	1.43	1.1	2.33	0.15	0.13	1.23
$LSD_{0.05}$	0.06	8.5	5.1	1.41	0.19	0.17	1.73

4. CONCLUSION

Application of high GA3 levels enhanced all germination indices and seedlings characters while increase of salinity levels reduced these aforementioned traits of maize seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Guelloubi R., Hamdy A, Sardo V. Maize production under two water saving techniques. El Gamal F. (ed.), Lamaddalen a N.(ed.), Bogliotti C.(ed.), Guelloubi R.(ed.). Nonconventional water use: WASAMED project. Bari; 2005:
1. Xue X, Du S, Jiao F, Xi M, Wang A, Xu H, Jiao Q, Zhang X, Jiang H, Chen J. The regulatory network behind maize seed germination: Effects of temperature, water, photo hormones, and nutrients. Crop J. 2021;9:901–914
2. Yang B, Yin Y, Liu C, Zhao Z, Guo M. Effect of germination time on the compositional, functional and antioxidant properties of whole wheat malt and its end-use evaluation in cookie-making. Food Chem. 2021;349:129125.
3. Aubertot JN, Deguine JP, Lamichhane JR, Robin MH, Sarthou JP, Steinberg C. Vers Une Protection Agroécologique Des Cultures En Phase d'implantation. In Réussir l'Implantation Des Cultures. Enjeux Agroécologiques, Itinéraires Techniques; Quae: Paris, France. 2022; 107–134.
4. Liu Y, Ye N, Liu R, Chen M, Zhang J. H2O2 mediates the regulation of ABA catabolism and GA biosynthesis in Arabidopsis seed dormancy andgermination. Journal of Experimental Botany. 2010;61:2979-2990
5. Ali E, Hussain N, Shamsi IH, Jabeen Z, Siddiqui MH, Jiang L. Role of jasmonic acid in improving tolerance of rapeseed (Brassica napus L.) to Cd toxicity. Journal of Zhejiang University: Science B (Biomedicine & Biotechnology). 2018;19 (2):130-146.
   CIHEAM/EU DG Research, 77-91.
6. Zhang C, Luo W, Li Y, Zhang X, Bai X, Niu Z. Transcriptomic analysis of seed germination under salt stress in two desert sister species (*Populus euphratica* and P. pruinosa). Frontiers in Genetics. 2019; 10:1-16.
7. Bawa G, Feng L, Chen G, Chen H, Hu Y, Pu T, Wang X. Gibberellins and auxin regulate soybean hypocotyls elongation under low light and high temperature interaction. Physiol. Plant. 2020;170(3): 345-356.
   Available:https://doi.org/10.1111/ ppl.1315

8. Pangapanga-Phiri I, Mungatana ED. Adoption of climate-smart agricultural practices and their influence on the technical efficiency of maize production under extreme weather events. Int. J. Disaster Risk Reduct. 2021;61: 102322.
9. Ali AS, Elozeiri AA. Metabolic processes during seed germination. in advances in seed biology; InTech: Vienna, Austria.3. Gummerson, R.J. The Effect of Constant Temperatures and Osmotic Potentials on the Germination of Sugar Beet. J. Exp. Bot. 2017;37:729–741.
10. Hussain S, Khaliq A, Matloob A, Wahid M. Afzal I. Germination and growth response of three wheat cultivars to NaCl salinity. Soil Environ. 2013;32(1):36-43
11. Salehifar M, Torang A, Farzanfar M, Salehifar M. Comparison of Salinity stress effect on germination and seedling growth in 8 lines genotypes of common bean (*Phaseolus vulgaris*). 11th Iranian Crop Science Congress. 2010;3794.
12. Jenks MA (eds.), Advances in Molecular Breeding Toward Drought and Salt Tolerant Crops, 2007:1–32
13. Rodríguez Coca LI, García González MT, Gil Unday Z, Jiménez Hernández J, Rodríguez Jáuregui MM, Fernández Cancio Y. Effects of Sodium Salinity on Rice (*Oryza sativa* L.) Cultivation: A Review. Sustainability. 2023;15:1804. Available:https://doi.org/10.3390/su15031804
14. Dai F, Rong Z, Wu Q, Abduallah EF, Liu C, Shengrui L. Mycorrhiza improves plant growth and photosynthetic characteristics of tea plants in response to drought stress. BIOCELL. 2022;46: 1339–1346. DOI: 10.32604/biocell. 018909
15. Elias SM, Hossain MS, Sikder FS, Ahmed J, Karim MR. Identification of constraints to pulseproduction with special reference topr esent farming systems. Annual Report of t he Agricultural Economic Division, BARI, Joydebpur. 1986:1.
16. Farooq M, Basra SMA, Khalid M, Tabassum R, Mehmood T. Nutrietn homeostasis, reasrvers metabolism and seedling vigor as affected by seed priming in coarse rice. Candadian Journal of Botany. 2006;84:1196–1202.
17. Basra SMA, Iftikhar MN, Afzal I. Potential of moringa (Moringa oleifera) leaf extract as priming agent for hybrid maize seeds. International Journal of Agriculture and Biology. 2011;13:1006–1010.
18. Bewley JD, Black M. Seeds: Physiology of Development and Germination. Plenum Press, New York. 1985:445.
19. Panel ATM, Tinjmul Islam, Thawatchai Koeds, Hayat Ullah, Sujin Jenweerawat, Suriyan Cha-um. Salt tolerance of hybrid baby com genotype in related of growth yield, physiological, and biochemical characters. South African Journal of Botany. 2022;147:808-819.
20. Turkyilmaz B. Effects of salicylic and gibberellic acids on wheat (*Triticum aestivum l.)* under salinity stress. Bangladesh J. Bot. 2012;41(1):29-34.
21. Wittwer SH, Bukovac MJ. The effects of gibberellins on economic crops. Econ.Bot. 1958;12: 213-255.
22. Rodríguez Coca LI, García González MT, Gil Unday Z, Jiménez Hernández J, Rodríguez Jáuregui MM, Fernández Cancio Y. Effects of Sodium Salinity on Rice Cultivation: A Review. Sustainability 2023;15:1804.

    Available:https://doi.org/ 10. 3390/su150 31804
23. Sheldon A, Menzies NW, So HB, Dalal R. The effect of salinity on plant available water. Paper presented at the SuperSoil 2004:3rd Australian New Zealand Soils Conference, University of Sydney, Australia. 2004:5-9.
24. Asad A, Blamey FPC and Edward SDG. Effects of boron foliar applications on vegetative and repro ductile growth of sunflower. Ann Bot. 2003;92: 565- 570.

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