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OPTIMIZING YAM PLANTING DATE AND POTASSIUM FERTILIZER LEVELS UNDER EGYPTIAN CONDITIONS

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Abstract

Yam is one of the agricultural crops known and has great economic importance in many African and Asian countries, the most important of which is the production of starch and flour. Therefore, it is an alternative to wheat in the manufacture of bread, and successful cultivation of yam crop in warm areas, which means the possibility of growing large-scale in Egypt to contribute significantly to bridging the food gap in wheat. To study the effects of application of gibberellic acid (GA_3) and benzyladinine (BA) on yam tubers dormancy and subsequent sprouting, pot experiment was done. To determinate the most appropriate dates for planting in Egypt and the best level of potassium for the highest productivity field experiment was conducted at the Experimental farm of Vegetable Crops and Medicinal and Aromatic plants Research Institute. Agriculture Research Center. Dokki, Giza, during the period of 2016/2017 and 2017/2018. The experimental design a split plot design with three replicates was used. The main plot was three different planting dates (1st May, 1st June and 1st July. The sub plot was three levels of potassium fertilizer (96, 144, 192 K_2O) in the form of potassium sulphate (48% K_2O) and control treatment (without adding potassium fertilizer). The highest sprouting % (100%) was obtained with 1.0 mg/l BA. The combination between K_2O at 144 kg/fed with 1st June swing date gave the highest vine length, leaf area, Total chlorophyll, total yield/fed and total yield/ha of both seasons.

Key words: Yam, Sprouts, Gibberellic acid, Benzyl adenine, Planting Date, potassium, yield

Introduction

Yams belong to the family Dioscoreaceae within the order Dioscoreales and are members of the genus Dioscorea, which produce tubers and bulbils that are economically important (Ayensu, 1972). Yam is cultivated for the consumption of their starchy tubers in Africa, Asia and Latin America (Chandrasekara and Kumar 2016). Yams are the third most important tropical root and tuber crop after cassava and sweet potato (Fu *et al.,* 2005). Nigeria produces about 74% of the total world annual output of about 25million tones of yam (Olasantan 1999). Besides being a staple consumed by 155 million people, yam is grown as a cash crops and a medicinal plant (Lebot, 2009; Sangakkara and Frossard, 2014). The long dormancy period of dormancy and the lack of uniform germination are a big problem in yam propagation (Donnelly *et al.,* 2003. Taha and Abd Elaziz 2017). In order to develop a competent method for sprouting in tuber crops, application of plant growth regulator (PGR) is a previously established technique (Paul and Ezekiel, 2003). During storage of tubers, especially at higher temperatures, ageing takes place gradually and this is associated with an increase in abscisic acid (ABA) content and a decrease in gibberellic acid (GA_3) content, as reported in potato by Burton *et al*., (1992). Muthuraj *et al.,* (2016) revealed that elephant foot yam tubers treated with GA3 (200 ppm) resulted in uniform sprouting with 88.69% at 60 days after planting. The role of BA might be primarily in regulation of cell division (Vreugdenill 2004) which is a necessary step for both tuberization and sprouting.

Yam plants are sensitive to variations in photoperiod, changes in the planting date may affect plant growth and tubers yield (Marcos *et al.,* 2011). Yams require about 8 months from planting to maturity, and need, depending on soil conditions, 1500 to 1800 mm of rain during the growing period. They have a shallow root system. In Western Nigeria, where the dry season occurs from November until March, early planting is generally done during the period from November to February. It has been shown that yams planted from November to January give 30% higher yield than those planted at the onset of rains (Costas *et al.,* 1968). (Tobih and Emuh, 2016) showed that yam tuber setts planted in 3rd, 4th, and 5th planting dates (April and May) had higher growth parameters, (plant height, girths, number of internodes, nodes and leaves than in planning dates of 1st, 2nd and 6th in the months of March and June. Tuber yield were higher in the first three planting dates (March and early April).

Many plant physiologists consider potassium second only to nitrogen in importance for plant growth. Potassium is second to nitrogen in plant tissue levels with ranges of 1 to 3% by weight. Potassium is vital to many plant processes (Prajapati and Modi 2012). Potassium plays a role in sugar translocation and starch synthesis in plants. Due to the high starch of the potato tuber, K is an important nutrient in tuber development (Rhue *et al.,* 1986). Potassium has a vital role in photosynthesis process that favours high energy status, regulates opening and closing of leaf stomata, nutrients translocation, water uptake, vitamin contents and organic acid concentration in plants (Bergmann, 1992). Potassium increases the size but not the total number of tubers (Trehan *et al.,* 2003). Potassium helps to increase the content of carbohydrate significantly which ultimately helps to increase the tuber size Al-Moshileh & Errebi, (2004). Potassium enhances storage life and improves shipping quality of potato as well as extends their shelf life (Martin-Prevel, 1989). Potassium influences synthesis, location, transformation and storage of carbohydrates, tuber quality and processing characteristics as well as plant resistance to stress and diseases (Ebert, 2009).

This study was aimed to investigate the effect of some growth regulators treatments on sprouting of yam tubers as well as the effect of planting date and different levels of Potassium fertilizer on yam growth and yield.

Materials and Methods

The investigate was carried out at the Experimental farm of Vegetable Crops, Medicinal and Aromatic plants Research Institute, Agriculture Research Center. Dokki, Giza, during the period from 2016/2017 and 2017/2018. Yam tuber tubers source was the Embassy of Nigeria in Egypt.

The experiment 1

Plant Material

Yam suspected sample was subjected to molecular analysis. High-quality genomic DNA was extracted from fresh yam leaves (100 mg) using a DNA easy Plant Mini Kit (QIAGEN, Santa Clarita, CA) and according to the manufacturer's protocol. The DNA was quantified with Nano Drop Spectrophotometer (Thermo Fisher Scientific Inc.). The samples were adjusted to a concentration of 10 ng/µl for subsequent analyses.

DNA-barcoding

a-DNA -barcoding PCR reactions :

For *rbc*L: The *rbc* L-PCR reactions were performed in a total volume of 25 µl containing 1X reaction buffer, 1.5 mM $MgCl_2$, 0.2 mM of each dNTP, 0.4 µM of a single primer; 30ng genomic DNA and 2U of Taq DNA polymerase. Amplifications conditions were: 5 min initial denaturation step (94ºC), 35 cycles of (30 s at 94ºC, 1 min at 50ºC and 1 min at 72ºC). The reaction was completed by a final extension step of 7 min at 72ºC. Amplification products were checked on 2% Agarose gels in 1x TBE buffer and stained by ethidium bromide and finally visualized under UV light.

For *mat* K: The *matK*-PCR reactions were performed in a total volume of 25 µl containing 1X reaction buffer, 1.5 mM $MgCl_2$, 0.2 mM of each dNTP, 0.4 µM of a single primer; 30ng genomic DNA and 2U of Taq DNA polymerase. Amplifications conditions were: 5 min initial denaturation step (94ºC), 35 cycles of (30 s at 94ºC, 1 min at 50ºC and 1 min at 72ºC). The reaction was completed by a final extension step of 7 min at 72ºC. Amplification products were checked on 2% Agarose gels in 1x TBE buffer and stained by ethidium bromide and finally visualized under UV light.

b.Purification and Sequencing of Barcoding PCR Products

The DNA-Barcode specific fragments obtained from PCR amplification profiles with selected primers were eluted from agarose gels and purified using ZYMO DNA Clean & Concentrator (Zymo Research, USA) according to the manufacturer's instructions. Purified PCR products were Sanger sequenced in both directions (forward and reverse) with the primers used for PCR amplification.

Sequence Analysis of DNA Barcodes

The generated DNA-Barcode Sequences were aligned to Gen Bank databases in order to examine and filtrate and exclude both sequences with low base quality score and sequences which identified incorrect species. Validation of successfully passed DNA-Barcodes were done through compare the DNA barcode sequences with those existed in the international DNA-Barcodes database.

Experiment 2:

This study aimed to test the effects of application of

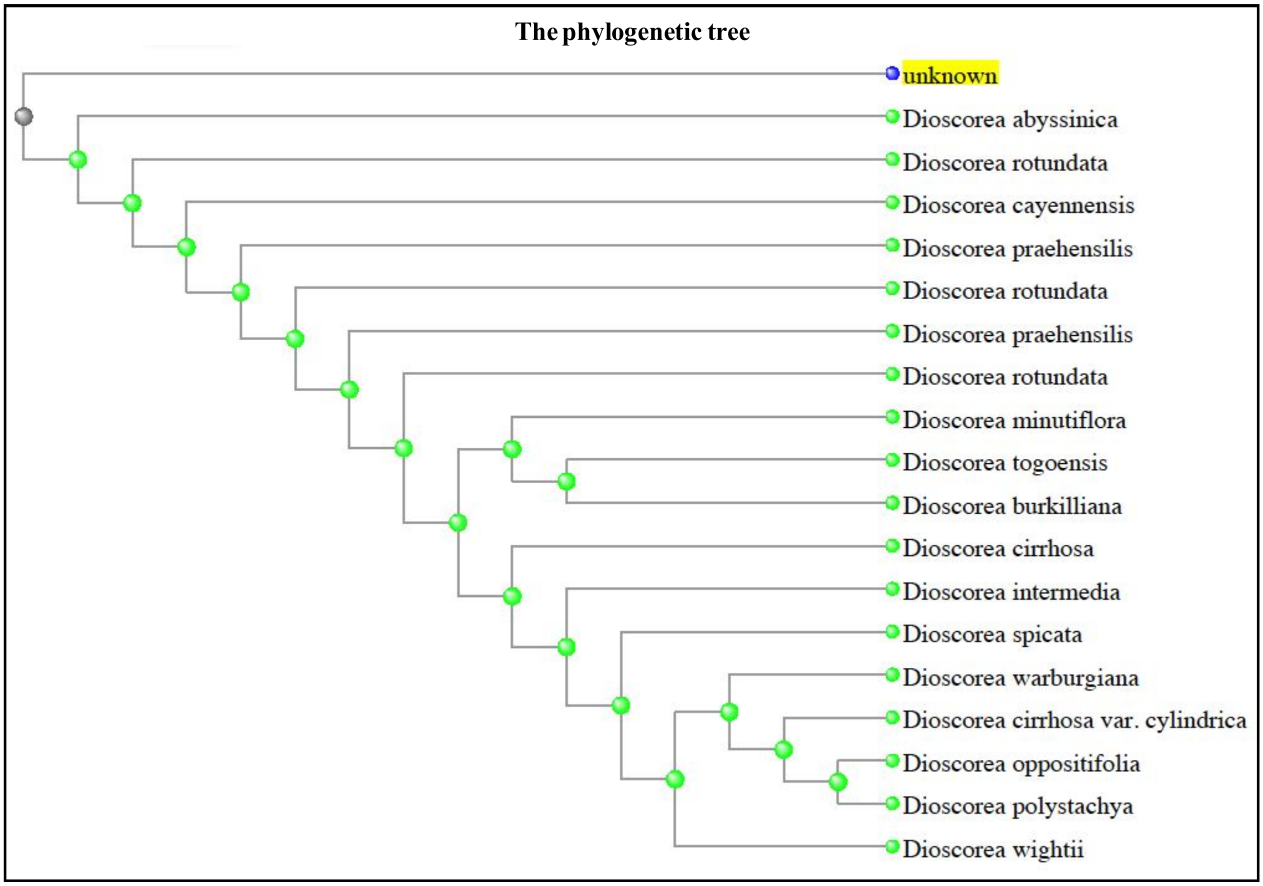

Fig. 1: Phylogenetic tree of the unknown yam species based on the Matk gene sequence compression

gibberellic acid (GA_3) and benzyl adenine (BA) on yam tuber's dormancy and subsequent sprouting .The pots experiment was conducted at Experimental farm of Vegetable Crops, Medicinal and Aromatic plants Research Institute. Agriculture Research Center. Dokki, Giza, during the period of 2016/2017 and 2017/2018. One set for each treatment collected in march 2016 were placed in each plastic pots (16 cm wide × 20 cm deep) contain peat moss.yam tuber size of 100g were irrigated with BA (0.5, 1.0 and 1.5mg/l) and GA3 (0.5, 1.0 and 1.5mg/l) and control treatment (irrigation with tap water) every week for 75 days. The experimental laid out in a randomized complete block design (RCBD) with three replications.

Data recorded

Sprouting %, Sprouting rats, Sprout length, Numbers of noodle and sprouting duration

Experiment 3:

The sprouting tuber yam setts were transferred to the open field and cultured at a distance of 1 m^2 and were inserted under the soil for about 10 cm and covered up with soil. Recommended doses of Nitrogen (240kg/ha), Phosphorous (11 kg/ha) and different doses of Potassium were applied in each plot. The fertilizer was prepared using urea and triple super phosphate, 50% of predetermined level was applied at 60 days after planting (DAP) and the remained fertilizer was applied at 100 DAP .The application was carried out using the side band method. The experimental design a split plot design with three replicates was used. The main plot was three different planting dates (1st May, 1st June and 1st July. The sub plot was three levels of potassium fertilizer (96, 144, 192 K_2O) in the form of potassium sulphate (48% K_2O) and control treatment, potassium fertilizer were applied at age 90 and 120 days, from sowing. The plot area was 10 m^2 consisting of two rows one meter in width and 5 meters in length.

Data recorded

The following growth characters were recorded on three plants taken randomly after five months from planting from each treatment for every replicate from each sub plot: Vine length - Leaf area – Total Chlorophyll . While the fresh weight of tubers yield \ fed. and fresh weight of tubers yield\ha. (at the end of season) about nine month of culturing.

Climatic Conditions

Present investigation was done at the Agriculture

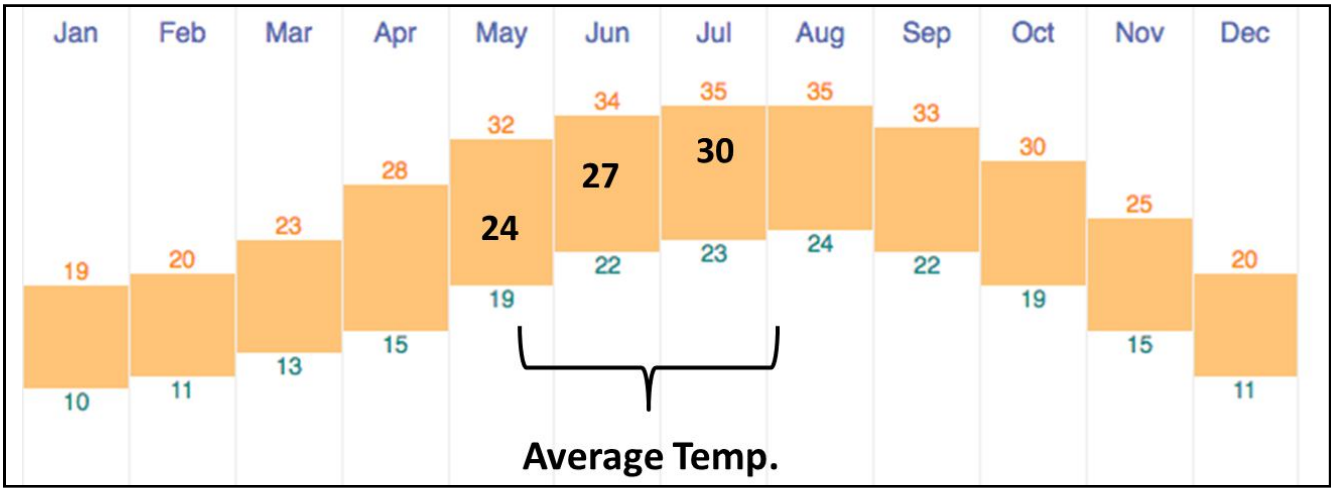

Fig 2: The temperature data in Egypt during yam growth period

Table 1: Effect of growth regulators treatments on the sprouting of yam tubers.

Duration to sprouting(day)	No. noodle	Sprout length	Sprouting rats	Sprouting %	Treatment mg/l
0 F	0.0D	0.0F	0.0F	0.0D	Control
3 E	5.0 C	6.0 D	3.50 E	35.0C	0.5BA
15 D	8.0B	20.3 B	17.0 D	100.0A	1.0 BA
34 A	1.3 D	3.8E	35.0A	36.7 C	1.5 BA
30 BC	4.3 C	5.2 E	33.5 BC	38.0C	0.5 GA_3
32 C	6.7B	15.3C	32.3C	37.0C	1.0 GA_3
34 AB	11.3 A	25.7 A	34.3AB	70.0 B	1.5 GA_3

Means followed by different letters are significantly different at Pd≤ 0.5 level; Duncan's multiple range test.

Table 2: Effect of planting date on vegetative growth parameters and yield of yam plants.

Planting date	Vine length (cm)	Leaf area (cm)	Total chlorophyll (SPAD)	Total yield\ plant(g)	Total yield\ ha(Kg)
			1st Season		
1st May	242.3 B	29.9 A	32.7 B	434.0 B	4376.4 B
1st June	281.5 A	23.1 C	35.0 A	572.5 A	5770.8 A
1st July	225.7 B	25.7 B	31.8 B	350.3 C	3528 C
			2nd Season		
1st May	248.2B	32.3 A	37.4 A	462.5 B	4662 B
1st June	290.0 A	24.0 B	36.8 A	558.8 A	5644.8 A
1st July	231.1 C	26.2 C	37.0 A	408.8 C	4132.8 C

Means followed by different letters are significantly different at Pd≤0.5 level; Duncan's multiple range test.

Research Center, Dokki, Giza is situated, with the latitude of 30.021074 and the longitude is 31.173145. Category with the Gps of 30°1' 15.8664'' N and 31° 10' 23.3220'' E. Elevation is a 24 meters height, Egypt. For two con-tinues repeated seasons during 2017 and 2018. It has a subtropical climate with hot and summer where maximum temperature exceeds 30°C in May to July. The winters are cold and the minimum temperatures reaches as low as 2°C in December and January. The meteorological parameter during the crop season maximum temperature were recorded and presented in Fig 2.

Statistical analysis

Data collected were analyzed using Analysis of variance. Significantly different means were separated using Duncan Multiple Range Test.

Results

This study was carried to establish an optimal concentration of growth regulators for sprouting of yam (*Dioscorea abyssinica*) as shown in Fig. 1 using different concentrations of BA and GA_3. As shown in table 1, the highest sprouting % (100%) was obtained with 1.0 mg/l BA. Regarding sprouting rats, 1.5 mg/l BA and 1.5 mg/l GA_3 produced highest rates of sprouting respectively than other concentrations. Longer sprout and greatest number of noodle recorded with 1.5 mg/l GA_3. Tubers of yam which were treated with 0.5 mg/l BA took 3 days to give visible sprouts but died after emergence. Lowest duration to sprouting recorded using lowest concentration of BA 1.0 mg/l BA (15 days). On contrast the tubers treated with highest concentration of BA or GA_3 had longer duration to sprouting (34 days). Due to the high tubers demand, it may be necessary to break dormancy, or rest period, soonest after harvesting tuber yam, Cytokines is the primary factor in the switch from innate dormancy to non-dormant state in the potato tuber buds but probably do not control the subsequent sprout growth, while gibberellins have a stimulating role in sprout development (Suttle 2004).

Table 3: Effect of potassium rates on vegetative growth parameters and yield of yam plants, in the two seasons.

K_2O Kg/fed.	Vine length (cm)	Leaf area (cm)	Total chlorophyll (SPAD)	Total yield\ plant(g)	Total yield\ ha(Kg)
1st Season					
Control	172.8D	21.5C	26.0 D	160.0 D	1612.8 D
96	277.6B	26.5B	33.7B	465.6 B	4737.6 B
144	322.1 A	33.5 A	41.3 A	877.8A	8870.4 A
192	237.4 C	23.4 C	31.7 C	300.0 C	3024 C
2nd Season					
Control	165.4 D	21.2 C	30.9 C	180.3 D	1612.8 D
96	277.2 B	27.1 B	37.5 B	547.8 B	5544 B
144	297.2 B	35.2 A	44.3 A	902.8 A	9094.3 A
192	242.4 C	22.8 C	35.5 B	297.8 C	3001.7 C

Means followed by different letters are significantly different at Pd≤0.5 level; Duncan's multiple.

Vine length, leaf area, total chlorophyll (SPAD) , total yield/plant and total yield/ha were influenced significantly by the dates of sowing. Yam sown on 1st June achieved highest vine, total chlorophyll (SPAD), total yield \ plant and total yield \ ha, being significantly higher than that sown in 1st May and 1st July in the two seasons (Table 2). Concerning the effect of swing date in leaf area, date in the same table appeared that the culturing yam plants early in May produced highest leaf area as compared to the other two times. This might be attributed to temperature at this time ranged from 22 at night to 34 at day with low humidity. This indicates that 1st June is the most suitable for optimal production of fresh yield yam in Egypt. It has been reported by Autsin (1986) that high yield production of tuber crops my depended to a large extent of the crop having sustained rapid rate of photosynthesis and responding to environment to optioning better growth and subsequent yield.

Table 4: Effect of planting date and potassium rates on vegetative growth parameters and yield of yam plants.

Planting date	K_2 Orates	Vine length (cm)	Leaf area (cm)	Total chlorophyll (SPAD)	Total yield\plant (g)	Total yield\ha (kg)
1st Season						
1st May	Control	173.0 HI	25.6 C-F	23.2 H	190.0 F	1915.2 f
	96	280.3 CD	28.0 CD	33.5 D	486.7 D	4939.2 D
	144	300.0 BC	39.1 A	41.8 B	750.0 B	7560 E
	192	239.8 EF	26.9 CDE	32.267 DE	310.0 E	3124.8 E
1st June	Control	192.3 GH	15.6 H	28.6 F	205.0 F	2116.8 F
	96	313.6 B	26.3 C-F	33.5 D	546.7 D	5503.7 F
	144	364.3 A	29.387 BC	45.7 A	1233.3 A	12398.4 A
	192	255.67 DE	21.0 G	32.1 DE	320.0 E	3225.6 E
1st July	Control	153.00 I	23.3 EFG	26.167 G	150.0 G	1512 G
	96	238.7 EF	25.1 DEF	34.0 D	363.3 E	3628.8 E
	144	302.0 BC	32.1 B	36.2 C	650.0 C	6552 C
	192	217.0 FG	22.4 FG	30.6 EF	240.0 F	2419.2 F
2st Season						
1st May	Control	160.0 EF	24.2 D	28.1 F	153.3 GH	1545.36 GH
	96	271.7 C	29.5 BC	39.0 B	543.3 CD	5476.6 CD
	144	311.0 B	40.0 A	45.6 A	846.7 B	8534.6 B
	192	250.0 CD	26.1 E	36.7 BC	306.7 E	3091.4 E
1st June	Control	187.0 E	15.9 H	32.5 DE	216.7 FG	2184.2 FG
	96	315.0 B	27.9 E	36.4 BCD	610.0 C	6148.8 C
	144	380.0 A	29.1 E	44.1 A	1078.3 A	10853.0 A
	192	254.0 C	21.9 E	34.4 CDE	330.0 E	3326.4 E
1st July	Control	149.3 F	23.1 D	32.2 E	105.0 H	1058 H
	96	245.0 CD	29.2 C	37.1 BC	490. D	4939.2 D
	144	306.7 B	33.1 B	43.1 A	783.3 B	7891 B
	192	223.3 D	22.6 DE	35.3 CDE	256.7 EF	2587.4 EF

Means followed by different letters are significantly different at Pd" 0.5 level; Duncan's multiple range test.

Data in table 3 clearly indicated that the vine length, leaf area, total chlorophyll, total yield\plant and total yield\ha of yam plants was responded significantly due to different levels of potassium. The significantly highest plant vine length, leaf area, Total chlorophyll, total yield\plant and total yield\ha were recorded in treatment 144 kg K_2O /fed. in both seasons. Application of potassium fertilizer plays vital role in yield of yam. Increasing the levels of potassium increases the potato tubers yield (Humadi, F. 1986). Such increases in yield of yam tubers are either due to the formation of large size tubers or increasing of the number of tubers per plant or both.

In respect to effect of interaction between planting date and potassium fertilizer levels on vine length, leaf area, Total chlorophyll, total yield\plant and total yield\ha. Data collected in table 4 showed that, addition K_2O at

144 kg/fed at 1st June swing date gave the highest vine length, leaf area, Total chlorophyll, total yield\plant and total yield\ha of both seasons. However, the lowest values were recorded with the highest potassium concentration (192 K_2O/fed) combined with 1st July swing in both seasons.

Conclusion

Spraying yam tubers with 1.5 mg/l BA produced highest rates of tuber sprouting. Addition K_2O at 144kg/fed at 1st June planting date are recommended under Egyptian condition.

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