

Evaluation of Growth, Yield and Quality of Turmeric Genotypes (*Curcuma longa* L.)

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Abstract

This study was conducted to find out growth, yield and quality performances of five turmeric genotypes. The experiment was laid out in randomized complete block design with three replications. Results showed that different genotypes significantly influenced on plant growth, yield and quality of turmeric. The highest germination (97 %), number of leaves (8.16), plant height (69.51 cm), weight of rhizome (47.06 g/plant) and yield (6.01 t/ha) was found from "Sinduri Holud" (BARI Holud-2). But this genotype scored the lowest percentage in curcumin (0.30 %) and low dry matter (22.54 %). While local genotype ("Mota Holud") performed the lowest germination (87.57 %) and minimum plant height (53.52 cm), leaf area (127.42 cm²), number of fingers per rhizome (3.73), weight of rhizome (34.16 g/plant) and yield (4.78 t/ha). But this genotype contained the highest curcumin (2.10 %), and "Mala Holud" attained maximum dry matter (25.20%). Based on flesh color, dry matter and curcumin contents local turmeric genotypes performed superior than that of the check varieties. From the findings of this investigation, it can be concluded that local genotypes can be used in breeding program for development of high quality turmeric in Bangladesh.

Keywords: flesh color, dry matter content, curcumin content, finger yield, *Curcuma longa*

Introduction

Turmeric (*Curcuma longa* L.) is a rhizomatous herbaceous perennial plant belongs to the family Zingiberaceae. It is now important in medical science because curcumin and volatile oils of turmeric rhizomes have anti-inflammatory, antimutagen, anticancer, antibacterial, anti-oxidant, antifungal, antiparasitic and detox properties (Hermann et al., 1991; Osawa et al., 1995). Calcium, phosphorus, magnesium, iron, vitamin A, protein and fat are also considered to be important quality parameters of turmeric. Various supplements and drinks derived

from the turmeric are widely used for keeping good health (Hossain et al., 2005a; 2005b).

Turmeric is a popular spice in many countries of Asia (Ishimine et al., 2003). It is an ancient, most valuable, sacred spice of Bangladesh that contains appreciable quantities of proteins (6.3%), lipids (5.1%), carbohydrates (69.4%) and fibre (2.6%). Turmeric is a horticultural root-crop that is important not only as a spice and cosmetic, but also as a medicinal plant worldwide (Nakamura et al., 1998; Ishimine et al., 2003). A bright yellow color producing chemical named 'Curcumin' is available in turmeric. It is a diarylheptanoid, belonging to the group of curcuminoids, which are natural phenols responsible for turmeric's yellow color (Manolova et al., 2014).

Turmeric is originated in South-East Asia. India is the largest turmeric producing country in the world. The area under turmeric cultivation in Bangladesh is 66289 hectares with production of 6.42 t/ha (BBS, 2017). It is reported that Bangladesh produces only 20% of its total demand and the rest amount is imported from neighboring countries especially from India (BBS, 2015). Therefore, cultivation of turmeric should be emphasized to reduce the import of this item. Recently cultivation of turmeric is gaining popularity in Bangladesh mainly because of its demand as a commodity for export.

Production of turmeric depends on many factors such as quality of rhizome, genotype selection, planting methods, soil moisture, plant spacing and proper management practices. Among them, genotype is one of the most important determinants which affect crop growth, yield and quality to a great extent. In Bangladesh, turmeric is grown during April-October when temperature and rainfall remain favorable. However, water stress limits turmeric growth and development and this stress is one of the reasons of low yield of turmeric in the country reported by Mostarin et al. (2005). Therefore, irrigation becomes essential for providing sufficient moisture to the growing crop. Genotype significantly affects the plant growth, yield

and quality. Genotype selection of spice crops is very important because some genotypes yield different in similar environment (Mann and Choke, 1989).

Planting method is another critical factor that affects the yield contributing characters and yield of turmeric which can be manipulated to maximum yield (Kueneman et al., 1979). It is reported that ridge method is suitable to get higher yield than other methods (Ramachandran and Muthuswami, 1984).

Available evidences reveal that genotypes play an important role for turmeric production and genotypes contain variable amount of curcumin. The yield of turmeric may be increased through judicious combination of genotype, planting method, type of soil, using fertilizers, geometrical position and so on. Bangladesh Agricultural Research Institute (BARI) has developed some varieties of turmeric. But most of the farmers of the country are still growing turmeric using local genotypes. Therefore, it is necessary to evaluate the growth, yield and quality performances of local genotypes. Considering the above facts, the present study was under taken in order to evaluate the performance of select genotypes in respect of growth, yield and quality of turmeric.

Materials and Methods

Experimental Site

The investigation was conducted at the Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from April 2017 to March 2018. The soil of the experimental plot was silty loam in texture belonging to the Old Brahmaputra Flood Plain under the Agro-ecological Zone. The experimental area belongs to

sub-tropical climatic zone that is characterized by heavy rainfall, high humidity, high temperature during April-September and scarce rainfall, low humidity, low temperature, high sunshine hour during October to March (Figure 1a,1b) which were favorable for maturity of plants and harvesting of turmeric rhizomes.

Planting Materials

Five turmeric genotypes were used as research materials for this study. Among the five, three local genotypes were collected from Madhupur, Tangail and rests of two varieties were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

Experimental Design and Treatments

This single factor experiment consisted of five turmeric genotypes including BARI released varieties (Figure 2). BARI released varieties were used as check variety (CV). These were CL₁: "Mala Holud", CL₂: "Mota Holud" CL₃: "Patnai Holud", CV₁: "Dimla Holud" (BARI Holud-1), and CV₂: "Sinduri Holud" (BARI Holud-2). The experiment was laid out in a randomized complete block design with three replications. The entire experimental plot was divided into three blocks, each of which contains 5 unit plots. The treatment was assigned randomly to the unit plots of each block. The size of a unit plot was 4 m x 1.5 m. The distance between blocks and plots were 70 cm and 50 cm, respectively.

Land Preparation and Planting of Turmeric Finger

The land was prepared by several deep ploughing and cross ploughing followed by laddering to obtain a good tilth condition for turmeric. The weeds and other stubbles were removed from the experimental plot.

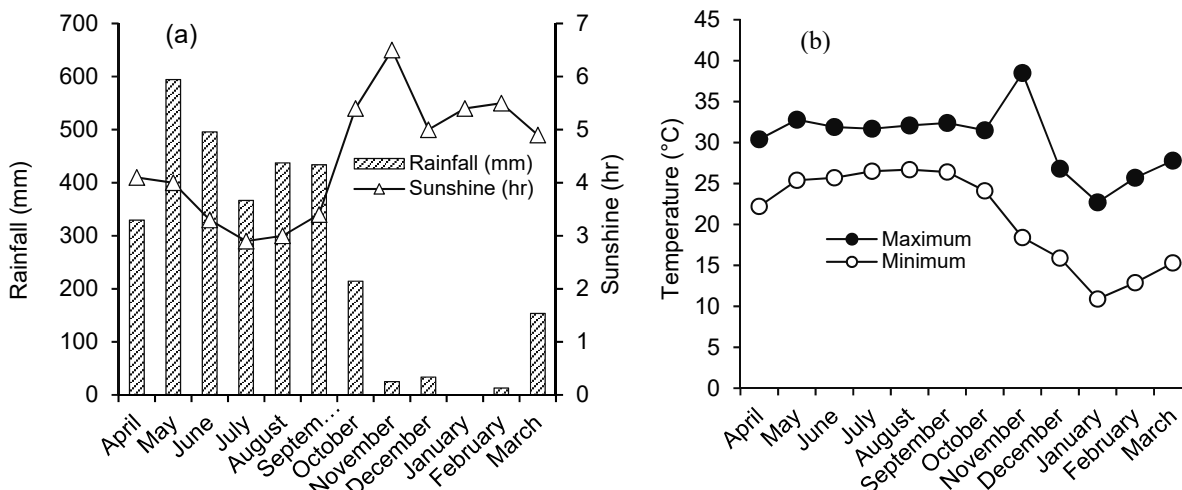


Figure 1. Monthly rainfall, sunshine hour (a) and temperature (b) of experimental site during 2017-2018



Figure 2. Fresh rhizomes with fingers and flesh color of different turmeric genotypes. CL₁: “Mala Holud”, CL₂: “Mota Holud”, CL₃: “Patnai Holud”, CV₁: “Dimla Holud” (BARI Holud-1) and CV₂: “Sinduri Holud” (BARI Holud-2).

The recommended doses of manures and fertilizers (well decomposed cattle dung 5 t.ha⁻¹, Urea 304 kg.ha⁻¹, Triple Super Phosphate (TSP) 267 kg.ha⁻¹ and Muriate of Potash (MoP) 233 kg.ha⁻¹) were applied to the experimental plot (Anonymous, 2013). Total amount of cattle dung, TSP and MoP were applied to the plot during land preparation. Thereafter experimental plots were prepared following the design of the experiment. Turmeric fingers of each genotype were planted in the plots at a spacing of 40cm×25 cm on April 2017 following ridge method. Weeds and other unwanted plants were uprooted from the plot several times during the experiment period. Earthing up and top dressing of remaining urea were applied into two installments at 60 and 120 days after planting (DAP). Flood irrigation was applied after each fertilizer application. Water supply was stopped 2-3 months before harvesting of rhizomes and fingers.

Data Collection

Data on percent germination of turmeric finger was recorded at 10 days intervals from 25 days after planting (DAP) to 65 DAP. Plant height was measured at 30 days intervals from 60 DAP to 180 DAP. It was measured by a measuring scale from selected plants. Data from 5 plants per plot were recorded and expressed in centimeter (cm). Number of leaves per plant was counted at 30 days interval from 60 DAP to 180 DAP. Leaf area (LA) was measured from 5 matured leaves of every plot. LA was measured

by leaf area meter (Model LI-3100C) from Prof. Dr. Mohammad Hossain Central Laboratory, Bangladesh Agricultural University, Mymensingh. Turmeric plants were harvested after 10 months when plants became yellow and leaves were fallen down and dry. Harvesting was done with the help of spade and then lifted manually. Numbers of fingers was counted from 5 selected plants of each plot. Soil particle, dusts and undesired attachments were removed manually from the rhizomes thereafter, weight of rhizome per plant was measured by EJ-250 NEWTON SERIES compact balance at Postgraduate Laboratory, Department of Horticulture, Bangladesh Agricultural University.

Determination of Dry matter Contents

Dry matter content was estimated as the ratio of dry weight (DW) to fresh weight (FW) and is expressed as a percentage (DW/FW×100). For determining the dry matter content, 100 g of fresh turmeric rhizomes was collected from each replication weighted by EJ-250 NEWTON SERIES compact balance. Samples were oven dried at 70°C temperature for 4 days and dry weight was recorded.

Determination of Curcumin Content in Rhizome of Turmeric

Curcumin content of turmeric rhizome was determined at the laboratory of Analytical Service Cell, Bangladesh Council of Scientific and Industrial

Research (BCSIR), Dhaka. In brief, rhizomes from every turmeric genotype from each plot were collected and transferred to the laboratory for determination of curcumin by using UV-Vis-NIR Spectrophotometer (Model No. UV 2600, Shimadzu Corporation, Tokyo, Japan). Hundred milligram (100 mg) of crude turmeric rhizome powder was taken in small glass beaker with 50 ml of 95% alcohol. This solution was poured into 100ml volumetric flask and vibrated for 5 minutes and the volume was made 100 ml by adding 95% alcohol. The absorbance of the solution was taken at 425nm using UV-Vis-NIR Spectrophotometer. In a similar way, the absorbance of five diluted samples of standard curcumin solution (Sigma-Aldrich) was taken and made a calibration curve. Curcumin content in different samples was calculated using a linear regression equation of calibration curve plotted between concentration and absorbance. The equation for curcumin is $y = 170.73x + 0.0430$ with a correlation coefficient of 0.998 where x is the compound analyzed and y is response in absorbance. Curcumin content in test samples was expressed as percentage of total curcumin.

Statistical Analysis

The data obtained from the experiment were statistically analyzed to find out the difference among the turmeric genotypes. The analysis of variance (ANOVA) for all parameters was performed by F-test. The significance of the difference between the pairs of treatment means was compared by the least significant difference test at 5% levels of probability (Gomez and Gomez, 1984).

Results

Germination (%)

Different turmeric genotypes showed significant difference in respect of per cent germination of rhizomes. At 65 days after planting (DAP), the maximum germination (97 %) was obtained from check variety 2 (CV₂- "Sinduri Holud") followed by CL₃ ("Patnai Holud") (94.33 %), CL₁ ("Mala Holud") (92.13 %), check variety 1 (CV₁- "Dimla Holud") (90.37 %) and the minimum germination (87.57 %) was found in CL₂ ("Mota Holud") genotype (Figure 3a).

Plant Height

There was a significant difference found in terms of plant height of different turmeric genotypes. Plant height was increased with time and at 180 DAP, the maximum height of plant (73.51 cm) was found in check variety 2 (CV₂- "Sinduri Holud") followed by CL₁ ("Mala Holud") (66.99 cm), check variety 1 (CV₁- "Dimla Holud") (62.62 cm), CL₃ ("Patnai Holud") (60 cm) and the minimum height (53.52 cm) was found in CL₂ ("Mota Holud") (Figure 2 and 3).

Number of Leaves

Significant difference was noticed in terms of number of leaves per plant of different turmeric genotype. However, at 180 DAP, the maximum number of leaves (8.16) was found in check variety 2 (CV₂- "Sinduri Holud") followed by check variety 1 (CV₁- "Dimla Holud") (7.72), CL₃ ("Patnai Holud") (7.66), CL₂ ("Mota Holud") (7.51) and the minimum number of leaves (6.66) was found in CL₁ ("Mala Holud") (Table 1).

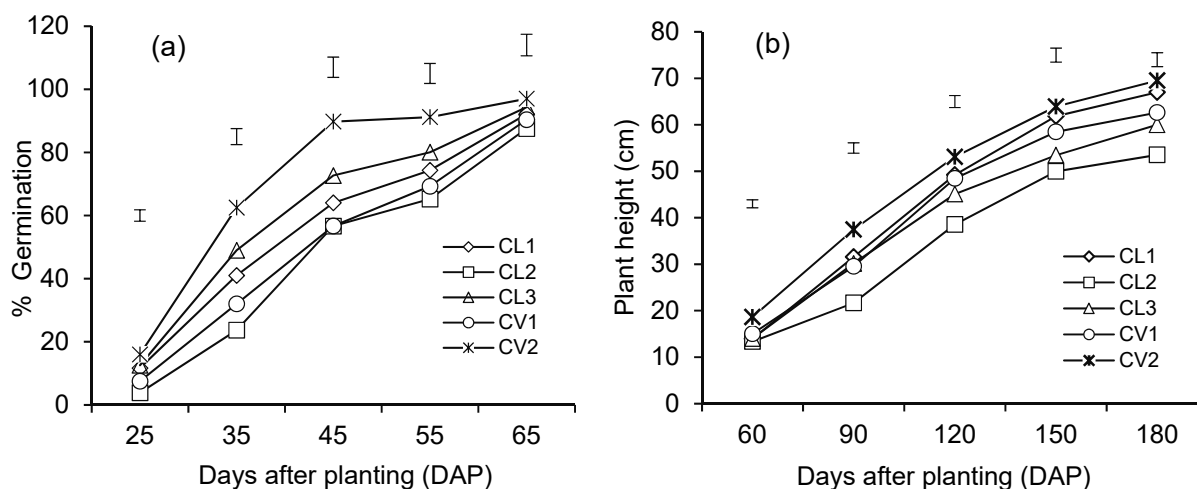


Figure 3. Performance of turmeric genotypes on germination (a) and plant height (b) at different days after planting (DAP). Vertical bars represent LSD at 5% level of significance. CL₁: "Mala Holud", CL₂: "Mota Holud", CL₃: "Patnai Holud", CV₁: "Dimla Holud" (BARI Holud-1) and CV₂: "Sinduri Holud" (BARI Holud-2).

Leaf Area

Significant difference was found in terms of leaf area of different turmeric genotypes. At 180 DAP, the maximum leaf area (239.52 cm²) was found in check variety 1 (CV₁- "Dimla Holud") followed by CL₃ ("Patnai Holud") (214.32 cm²), CL₂ ("Mota Holud") (179.30 cm²), check variety 2 (CV₂ "Sinduri Holud") (142.56 cm²) and the minimum leaf area (127.42 cm²) was found in CL₂ ("Mota Holud") (Table 1).

Number of Fingers

There was significant difference found in terms of number of fingers per rhizome. After harvesting at maturity (10 months after planting), the maximum number of fingers per rhizome (5.87) was found in check variety 2 (CV₂ - "Sinduri Holud") followed by check variety 1 (CV₁- "Dimla Holud") (5.26), CL₃ ("Patnai Holud") (4.40), CL₁ ("Mala Holud") (4.33) and the minimum number of fingers per rhizome (3.73) was found in CL₂ ("Mota Holud") (Table 2).

Weight of Rhizomes

In respect of weight of rhizomes per plant, there was significant difference among the turmeric genotypes.

The maximum weight of rhizome (47.06 g/plant) was found in check variety 2 (CV₂- "Sinduri Holud") followed by CL₃ ("Patnai Holud") (41.53 g/plant), CL₁ ("Mala Holud") (39.50 g/plant), check variety 1 (CV₁- "Dimla Holud") (37.25 g/plant) and the minimum weight of rhizome (34.17 g/plant) was found in CL₂ ("Mota Holud") (Table 2).

Yield of Turmeric

There was a significant difference found in terms of yield of turmeric genotypes. The maximum yield (6.01 t/ha) was found in check variety 2 (CV₂, "Sinduri Holud") followed by CL₁ "Mala Holud" (5.38 t.ha-1), CL₃ "Patnai Holud" (5.19 t.ha-1), check variety CV₁ "Dimla Holud" (5.17 t.ha-1), whereas the minimum yield was found in CL₂ "Mota Holud" (Table 2).

Dry Matter Content

In respect of percent dry matter content, there was a significant difference among the turmeric genotypes. From the result, it was obtained that CL₁ ("Mala Holud") provided the maximum dry matter content (25.20 %) followed by CL₂ ("Mota Holud") (23.91 %), check variety 2 (CV₂ "Sinduri Holud") (22.54 %), CL₃

Table 1. Leaf area and leaf number of turmeric genotypes at different days after planting (DAP)

Turmeric genotypes	No. of leaves per plant at different days after planting (DAP)					Leaf area (cm ²)
	60	90	120	150	180	
CL ₁ ("Mala Holud")	4.29	4.77	5.51	5.82	6.66	179.30
CL ₂ ("Mota Holud")	3.75	4.66	6.15	6.63	7.51	127.42
CL ₃ ("Patnai Holud")	3.20	4.55	5.14	6.03	7.66	214.32
CV ₁ ("Dimla Holud")	3.57	4.94	5.60	6.77	7.72	239.52
CV ₂ ("Sinduri Holud")	4.55	5.58	5.93	7.22	8.16	142.56
LSD _{0.05}	0.58	0.48	0.47	0.51	0.45	1.69
Level of significance	*	*	*	*	*	*

Note: * indicates significant at 5% level of probability; CV= Check variety

Table 2. Yield contributing traits, yield and quality parameters of turmeric genotypes

Turmeric genotypes	Number of fingers/plant	Rhizome weight (g/plant)	Yield (kg/plot)	Yield (t/ha)	Dry matter of finger (%)	Curcumin content (%)
CL ₁ ("Mala Holud")	4.33	39.50	2.92	5.38	25.20	1.71
CL ₂ ("Mota Holud")	3.73	34.16	2.60	4.78	23.91	2.10
CL ₃ ("Patnai Holud")	4.40	41.53	2.82	5.19	22.47	0.91
CV ₁ ("Dimla Holud")	5.26	37.25	2.81	5.17	21.05	0.78
CV ₂ ("Sinduri Holud")	5.86	47.06	3.27	6.01	22.54	0.31
LSD _{0.05}	0.72	1.12	0.33	0.60	0.14	0.19
Level of significance	*	*	*	*	*	*

Note: * indicates significant at 5% level of probability; CV= Check variety

("Patnai Holud") (22.47 %) and the minimum dry matter content (21.05 %) provided by check variety 1 (CV₁ "Dimla Holud") (Table 2).

Curcumin Content

In respect of per cent curcumin content, there was a significant difference observed among the turmeric genotypes. From the analytical results, it was obtained that CL₂ ("Mota Holud") contained the maximum per cent of curcumin (2.10 %) followed by CL₁ ("Mala Holud") (1.71 %), CL₃ ("Patnai Holud") (0.91 %), check variety 1 (CV₁- "Dimla Holud") (0.78 %) and the minimum curcumin content found in check variety 2 (CV₂- "Sinduri Holud") (0.31 %) (Table 2).

Discussion

In this experiment, five turmeric cultivars were used to find out their growth, yield and quality performance considering their germination, plant height, number of leaves per plant, leaf area (LA), number of fingers per rhizome, weight of rhizome per plant, yield, % dry matter content and % curcumin content. The variations among the cultivars under this study were highly significant in all aspects. It was observed that the highest germinated check variety 2 (CV₂ "Sinduri Holud") produced highest yield. The lowest germination and yield were found in CL₂ ("Mota Holud"). But other cultivars did not follow this trend. The second highest germination occurred in CL₃ ("Patnai Holud") but the second highest yield obtained from CL₁ ("Mala Holud"). This might be due to the cultivars had influences over underground biomass production and germination (Mozumder et al., 2005).

The maximum number of leaves per plant was found in check variety 2 (CV₂ "Sinduri Holud") and the lowest number of leaves per plant was found in CL₁ ("Mala Holud"). However, the number of leaves was found closely similar to check variety 1 (CV₁- "Dimla Holud"), CL₃ ("Patnai Holud") and CL₂ ("Mota Holud"). The tallest plants was obtained by check variety 2 (CV₂ "Sinduri Holud") and the lowest by check variety 1 (CV₁- "Dimla Holud"). Kamal et al. (2012) found approximately similar results on plant height, number of leaves and leaf area (LA) in some turmeric cultivars. The highest leaf area (LA) was found in check variety 1 (CV₁ "Dimla Holud") and the lowest LA was found in CL₂ ("Mota Holud").

Turmeric cultivars showed significant variations on yield contributing traits such as number of fingers per rhizome and weight of rhizome per plant (Shashidhar and Sulikeri, 1996). The variations due to cultivars under this study were highly significant in those

aspects. It was observed that the highest number of fingers per rhizome was found in check variety 2 (CV₂ "Sinduri Holud") followed by check variety 1 (CV₁ "Dimla Holud"). In other three cultivars did not show any remarkable variations on the number of fingers per rhizome. Chattopadhyay et al. (1993) noticed the similar differences in their experiment among some turmeric cultivars. On the other hand, the maximum weight of rhizome per plant was found in check variety 2 (CV₂ "Sinduri Holud") and it offered the highest yield per hectare. The minimum weight of rhizome per plant was recorded in CL₂ ("Mota Holud") and subsequently the lowest yield per hectare placed in this cultivar. It indicated that cultivars had proportional influence over weight of rhizome to the total yield (Ramachandran and Muthuswami, 1984). Similar result on yield performance of turmeric was obtained in an experiment at Maharashtra, India regarding the effect of cultivars on planting methods (Mozumder et al., 2005).

The variations among the cultivars under this study were highly significant on % dry matter content and % curcumin content. Similar results among different cultivars were also reported by Reema et al. (2006). They found that curcumin content 3.14% (on average) by analyzing 28 spice products (pure turmeric power). They stated that the cultivars had significant influence on percent curcumin content in rhizome. It was also influenced by growing environment. Guddarangavvanahally et al. (2002) isolated total percentages of curcuminoids were 2.34 to 9.18 by HPLC method. This result was higher than our result because they isolated curcuminoids which consisted of total three components viz., curcumin, dimethoxycurcumin, and bisdemethoxy curcumin. Since flesh color (Plate 1), curcumin and dry matter contents are the key factors for high quality turmeric. In this experiment it was observed that local turmeric cultivars (CL₁, CL₂ and CL₃) contained high curcumin and dry matter content and displayed deep yellow flesh color as compared to check varieties.

Conclusion

Our study has demonstrated that local genotypes contained good potentials in terms of dry matter and curcumin contents. Among the local genotypes, CL₁ ("Mala Holud") showed the best performance in yield, dry matter and curcumin content. This genotypes could be used in food industry. It is concluded that local turmeric genotypes such as "Mala Holud" and "Mota Holud" may be used in breeding program for development of high yielding and high curcumin rich turmeric varieties in Bangladesh.

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