P. ISSN: 0971-8184 II E. ISSN: 0976-1926
DOI: 10.61949/0976-1926.2023.v36i02.01

Indian Journal of Plant Genetic Resources

RESEARCH ARTICLE

Assessment of Genetic Diversity in Elephant Foot Yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson var. *campanulatus* (Decne.) Sivad.]

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Abstract

Wide range of genetic variability was observed in morphological characters like the surface of the pseudo stem, pseudo stem color, leaf spot, stalk of the leaflet, nature of rachis, shape of rachis, color of corm surface top, the color of corm surface bottom and color of flesh while there are no variation were observed for traits *viz*; the number of secondary partition/primary partition, number of primary partition/secondary partition, leaflet spot and stalk of a leaflet. Out of 18 accessions, only two accessions *viz;* Selection -2 and C3 were found to be diverse type in respect to traits viz; surface of pseudo stem and corm shape which having tubercled pseudo stem, respectively. The thickness of the pseudo stem base had also exhibited a highly significant correlation with the fresh weight of corm/ plant, height of the corm and diameter of corm. Leptokurtic and positive skewness were exhibited for traits weight of cormel/plant and diameter of corm it indicating that these traits are governed by dominant-based complementary gene action and involving fewer numbers of genes having an increasing effect in the inheritance of these traits. The highest loaded variables in PC1, PC2, PC3 and PC4 were pseudo stem height (cm), weight of cormel /plant (g), length of primary partition (cm) and diameter of corm (cm), respectively. Tuber character i.e., diameter of corm as well as foliage characters, especially pseudo stem height and length of primary partition, is an important trait in distinguishing various accessions of elephant foot yam.

Keywords: Elephant foot yam, Accessions, Principle component analysis, Skewness, Kurtosis and Correlation coefficient.

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Received: 05/07/2021 **Revised:** 06/01/2023

Accepted: 09/01/2023

How to cite this article: Choudhary, A.K., Mishra, S.B., Bhushan, S. (2023). Assessment of Genetic Diversity in Elephant Foot Yam [*Amorphophallus paeoniifolius* (Dennst.) Nicolson var. *campanulatus* (Decne.) Sivad.]. *Indian J. Plant Genetic Resources*. 36(2), 200-207. **DOI:** 10.61949/0976-1926.2023.v36i02.01

Introduction

Elephant foot yam [Amorphophallus *paeoniifolius* (Dennst.) Nicolson var. *Campanulatus* (Decne.) Sivad] was considered for a detailed morphological characterization mainly due to its economic importance. Elephant foot yam is chiefly valued for its edible tuber and profound medicinal properties (Hanelt and IPK 2001); (Ochse and Van der Brink 1980). Elephant foot yam has its distribution in Madagascar eastwards via India to *Malesia*, southern China, Indo-China, Polynesia, northern Australia Hetterscheid and Ittenbach (1996); Lebot (2009). Nicolson (1987) has identified the cultivated form as elephant foot yam. In India, it is cultivated in the state like West Bengal, Andhra Pradesh, Tamil Nadu, Bihar, Chattisgarh, Karnataka, Kerala, Jharkhand, Madhya Pradesh, Jammu & Kashmir and produced about 816.75 m tons (National Horticulture Board, 2021-22).

The corms of elephant foot yam are rich source of carbohydrates and minerals like calcium and phosphorus. The corm is used as a vegetable as well as for the preparation of chips. The corms and cormels of elephant foot yam are usually boiled or baked and eaten as vegetables. The sprouts and petioles, which resemble asparagus sprouts,

are used as vegetables in some parts of Asia (Misra *et al.*, 2007). Genetic variability of breeding materials may lead to the success of the crop improvement program (Prabhu *et al.* 2009). Selection through morphological characters greatly influences on the success of the crop improvement program (Prabakaran 2010). The application of PCA tool provides a useful means for estimating morphological diversity within and between germplasm (Maji and Shaibu 2012). The present study is carried to find out the genetic diversity and selection of elite lines from the existing variability of elephant foot yam.

Materials and Methods

The present investigation was conducted at Tirhut College of Agriculture (Bihar) without replication each plot measuring 14.25 x 1.5 meters in size, row to row as well as plant to plant distance were kept at 0.75 and comprising eighteen elephant foot yam accessions, each of them planted in pit. According to the passport data, these accessions are cultivated in nature and have some ethnobotanical uses (Table 1). Observations were recorded on five randomly selected plants at full growth stage based on elephant foot yam descriptors developed by ICAR-National Bureau of Plant Genetic Resources for elephant foot yam (Abraham *et al.* 2006) for 14 morphological qualitative and 16 quantitative characters (Tables 2 and 3), respectively. The morphological qualitative traits were converted into descriptor scores used for comparing variance analysis with quantitative traits. For the selection of some elite genotypes combining multiple traits with each other on certain limits *viz*;. pseudo stem height (70.66–30.00 cm), length of primary partition (22.67–12.00cm), breath of primary partition (10.00–7.00), no. of leaflets per primary partition (70.00–17.00), length of largest leaflet (14.33–11.20 cm), breath of largest leaflet (6.00–4.00 cm), thickness of pseudo stem base (20.00–12.00 cm), fresh weight of corm/plant (3.50–1.20 kg), height of corm (13.00–9.00 cm) and diameter of corm (40.00–14.00 cm) in excel software. Yield is dependent upon a number of component characters which is quantitatively inherited and considerably affected by the environment. Therefore, direct and indirect selection for yield may not be effective. The selection efficiency under such circumstances can be improved by considering other component characters. Component characters care combined together into a score or index and selection is applied to the index Hazel (1943) and Choudhary *et al.* (2020). All qualitative traits were categorized in different grouped based on the frequency distribution of germplasm in the excel software and principal coordinate analysis (PCoA) for quantitative traits were analysed in SPSS software, whereas correlation

Table 1: Passport data of 18 accessions of elephant foot yam and their accession number

Name of the accessions	*Mission code*	*Accession number*	*Collectors number*	*Particulars*	
C1	O20120003Z08	593138	TCAEFY-1	Species Name (Botanical)	*Amorphophallus paeoniifolius*
C2	O20120003Z08	593139	TCAEFY-2	Common name (English)	Oal, Suran
C3	O20120003Z08	593140	TCAEFY-3	Cultivar/Vernacular name	Elephant foot yam
C4	O20120003Z08	593141	TCAEFY-4	Source	Institution/market/ farmers field
C5	O20120003Z08	593142	TCAEFY-5	Status	Cultivated
C6	O20120003Z08	593143	TCAEFY-6	Frequency	Frequent
C7	O20120003Z08	593144	TCAEFY-7	Material collected	Tuber
C8	O20120003Z08	593145	TCAEFY-8	Sample type	Individual plant
C9	O20120003Z08	593146	TCAEFY-9	Sample method	Random
C10	O20120003Z08	593147	TCAEFY-10	Habitat	Cultivated
C11	O20120003Z08	593148	TCAEFY-11	Disease symptoms	leaf virus
Deshi	O20120003Z08	593149	TCAEFY-12	Insect/Nematode	termite
Trivendrum	-	-	-	Cultural practices	Irrigated
Selection -1	-	-	-	Season	Spring-Summer
Santra Gachhi	-	-	-	Associated crops	Sole
Gajendra	-	-	-	Agronomic scope	Good
BCA -1	-	-	-	Ethnobotanical uses	Yes
Selection -2	-	-	-	Parts	Root
				Kind	Food

Table 2: Frequency (%) distribution of fourteen qualitative characters of elephant foot yam

Sl. No.	*Characters*	*Descriptor score adopted*	*No. of accessions*	*Frequency (%)*
1.	Number of primary partition	3	18	100
2.	Number of secondary partition/primary partition	6	18	100
3.	Number of primary partition/secondary partition	12	18	100
4.	Leaflet nature	1(entire)	18	100
5.	Leaflet margin	2 (undulate)	18	100
6.	Surface of pseudo stem	1 (smooth)	7	38.89
		2 (tubercled)	1(Selection -2)	5.56
		3(spiny)	10	55.56
7.	Pseudo stem color	1(green mottled)	8	44.44
		2(dark greenmottled)	10	55.56
8.	Leaf spot	0 (absent)	0	0
9.	Stalk of leaflet	0 (absent)	0	0
10.	Nature of rachis	1(winged)	11	61.11
		2 (not winged)	9	50.00
11.	Corm shape	1 (depressed)	1(C3)	5.56
		2(flat and globose)	17	94.44
12.	Color of corm surface top	1(black)	4	22.22
		2 (dark brown)	14	77.78
13.	Color of corm surface bottom	1(black)	4	22.22
		2(dark brown)	2(C4 and C10)	11.11
		3 (white)	12	66.67
14.	Color of flesh	1(light yellow)	9	50.00
		2(dark yellow)	7	38.88
		3(reddish yellow)	2 (C11 and Selection -2)	11.11

Table 3: Selection of superior lines by combination of different traits at certain multiple traits range limit

Sl. No.	*Traits*	*Selection Criteria of elite line with multiple traits range limit*	*Selected lines*
1.	Pseudo stem height (cm)	70.66–30.00	C1, C4, C5, C7, C8 and BCA-1
2.	Length of primary partition (cm)	22.67–12.00	
3.	Breath of primary partition (cm)	10.00–7.00	
4.	No. of leaflets per primary partition	70.00–17.00	
5.	Length of largest leaflet (cm)	14.33–11.20	
6.	Breath of largest leaflet (cm)	6.00–4.00	
7.	Thickness of pseudo stem base (cm)	20.00–12.00	
8.	Fresh weight of corm/plant(kg)	3.50–1.20	
9.	Height of corm (cm)	13.00–9.00	
10.	Diameter of corm (cm)	40.00–14.00	

Table 4: Descriptive statistics of different traits of elephant foot yam accessions

Sl. No.	*Traits*	*Mean*	*Range*	*Standard deviation*	*Std. error*	*Skewness*	*Kurtosis*
1.	Pseudo stem height (cm)	49.27	33.00–70.66	11.79	1.68	0.61	-1.00
2.	Length of primary partition (cm)	13.96	8.73–22.66	3.13	0.84	1.25	2.81
3.	Breath of primary partition (cm)	7.59	5.23–9.50	1.12	0.41	-0.33	0.04
4.	No. of leaflets per primary partition	37.15	11.66–79.66	24.42	4.01	0.77	-1.10
5.	Length of largest leaflet (cm)	12.44	11.16–14.33	0.93	0.26	0.40	-0.75
6.	Breath of largest leaflet (cm)	5.09	4.16–6.02	0.55	0.24	0.01	-1.01
7.	Thickness of pseudo stem base (cm)	15.67	11.00–25.00	4.06	1.03	0.89	-0.23
8.	Fresh weight of corm/plant(kg)	1.75	0.83–3.63	0.81	0.62	1.14	0.42
9.	Height of corm (cm)	10.96	8.83–14.33	1.34	0.41	0.97	1.03
10.	Thickness of cormel (cm)	5.52	0.00–10.50	3.45	1.47	-0.54	-0.53
11.	Weight of cormel /plant (g)	47.47	0.00–250.00	68.27	9.91	2.37	5.06
12.	Length of cormel (cm)	2.67	0.00–8.16	2.21	1.35	0.91	0.97
13.	Diameter of corm (cm)	18.75	13.50–80.33	15.42	3.56	4.19	17.71

- coefficient as well as skewness and kurtosis analysis were performed by using online OP stat.

Results and Discussion

Frequency Distribution of Major Qualitative Traits

Vegetative characters

Characterization of 18 elephant foot yam accessions had been done based on its morphological traits such as number of secondary partition/primary partition, number of primary partition/secondary partition, leaflet nature, leaflet margin, the surface of the pseudo stem, pseudostem color, leaf spot, a stalk of a leaflet, nature of rachis, shape of rachis, the color of corm surface top, color of corm surface bottom, corm shape and color of flesh and other, quantitative traits which helps effective utilization of germplasm in crop improvement programmes.

Wide range of genetic variability were observed in morphological characters like the surface of the pseudo stem, pseudo stem color, leaf spot, the stalk of a leaflet, nature of rachis, shape of rachis, color of corm surface top, color of corm surface bottom and color of flesh while there are no variation were observed for traits viz; number of secondary partition/primary partition, number of primary partition/secondary partition, leaflet spot and stalk of a leaflet. Out of 18 accessions, only two accessions *viz;* Selection -2 and C3 were found to have diverse type in respect to traits viz; surface of pseudo stem and corm shape which having tubercled pseudo stem, respectively (Table 2). Thus, the present study suggested that these traits may be useful for the identification of various morphotypes of elephant foot yam Anil *et al.* (2011).

Variation in Quantitative Traits

Out of 18 accessions, only six superior lines *viz,* (C1, C4, C5, C7, C8 and BCA-1) were selected by fixing the certain limits of each quantitative traits *viz;* pseudo stem height (70.66–30.00 cm), length of primary partition (22.67–12.00cm), a breath of primary partition (10.00–7.00), no. of leaflets per primary partition (70.00–17.00), length of a largest leaflet (14.33–11.20 cm), a breath of largest leaflet (6.00–4.00 cm), thickness of pseudo stem base (20.00–12.00 cm), fresh weight of corm/plant(3.50–1.20 kg), height of corm (13.00–9.00 cm) and diameter of corm (40.00-14.00 cm) (Table 3). These traits may be used full for further selection in a breeding programme. (Choudhary *et al.* 2020).The study on the frequency distribution of traits using skewness and kurtosis helps extract the available information on the nature of gene action (Fisher *et al.*, 1932) and the number of genes controlling the traits (Robson, 1956). Leptokurtic and positive skewness were exhibited for traits like weight of cormel/plant and diameter of corm (Table No. 4) it indicated that these traits governed by dominant-based complementary gene action and involving fewer number of genes having an increasing effect in the inheritance of these traits. Maximizing the genetic gain in respect of these traits required intense selection from the existing variability. The correlation coefficient is a statistical measure to determine the extent of association, whether positive or negative, between various plant characters, which help to identify the character on which selection can be imposed for improvement in associated characters (Table 5). Pseudo stem height had exhibited highly significant correlation with breath of primary partition, no. of leaflets per primary partition, thickness of pseudostem, height of corm and diameter of corm. Breath of primary partition was also found to have a highly significant correlation with no. of leaflets per primary partition, pseudostem base thickness and corm height. The thickness of the pseudostem base had also exhibited highly significant correlation with the fresh

Table 5: Correlation coefficient among qualitative traits of the elephant foot yam accessions

Sl. No.	*Traits*	*Pseudo stem height (cm) Recorded at full foliage*	*Length of primary partition (cm)*	*Breath of primary partition (cm)*	*No. of leaflets per primary partition*	*Length of largest leaflet (cm)*	*Breath of largest leaflet (cm)*	*Thickness of pseudo stem base (cm)*	*Fresh weight of corm/ plant(kg)*	*Height of corm (cm)*	*Thickness of cormel (cm)*	*Weight of cormel/ plant (g)*	*Length of cormel (cm)*	*Diameter of corm (cm)*
1.	Pseudo stem height (cm) recorded	1.000	0.282	0.833**	0.808**	-0.113	0.088	0.903**	0.474*	0.742**	-0.559*	-0.458	-0.412	0.503*
2.	Length of primary partition (cm)		1.000	0.352	-0.153	0.217	0.412	0.098	-0.072	0.163	0.202	-0.114	0.122	0.006
3.	Breath of primary partition (cm)			1.000	0.742**	0.053	0.056	0.768**	0.273	0.698**	-0.403	-0.385	-0.296	0.152
4.	No. of leaflets per primary partition				1.000	-0.251	-0.359	0.900**	0.337	0.593**	-0.577*	-0.195	-0.300	0.333
5.	Length of largest leaflet (cm)					1.000	0.540*	-0.247	-0.167	-0.246	-0.126	-0.350	-0.230	-0.211
6.	Breath of largest leaflet (cm)						1.000	-0.117	0.075	0.042	-0.125	-0.469*	-0.342	0.251
7.	Thickness of Pseudo stem base (cm)							1.000	0.513*	0.696**	-0.517*	-0.211	-0.280	0.621**
8.	Fresh weight of corm/plant (kg)								1.000	0.535*	-0.276	-0.236	-0.226	0.605**
9.	Height of corm (cm)									1.000	-0.229	-0.365	-0.179	0.443
10.	Thickness of cormel (cm)										1.000	0.688**	0.880**	-0.403
11.	Weight of cormel/ plant (g)											1.000	0.883**	-0.176
12.	Length of cormel (cm)												1.000	-0.293
13.	Diameter of corm (cm)													1.000

Table 6: Mean values of 13 characters of the five clusters for the 18 elephant foot yam germplasm.

Cluster	Pseudo stem height (cm) Recorded at full foliage	Length of primary partition (cm)	Breath of primary partition (cm)	No. of leaflets per primary partition	Length of largest leaflet (cm)	Breath of largest leaflet (cm)	Thickness of pseudo stem base (cm)	Fresh weight of corm/plant (kg)	Height of corm (cm)	Thickness of cormel (cm)	Weight of cormel/ plant (g)	Length of cormel (cm)	Diameter of corm (cm)
I	33.00	8.73	5.23	26.00	11.23	4.16	11.83	.83	8.83	9.83	200.00	6.00	13.83
II	64.11	13.00	9.13	74.33	12.33	4.62	20.38	2.03	12.44	2.28	7.22	1.39	16.66
III	60.66	22.66	8.66	48.00	12.00	4.90	19.16	1.50	11.66	10.06	86.66	5.50	15.50
IV	38.66	13.33	7.50	38.00	11.83	4.43	16.33	1.70	10.16	10.50	250.00	8.16	16.00
V	43.36	14.33	7.16	19.40	12.80	5.36	12.94	1.61	10.60	6.22	29.61	2.43	14.61

Table 7: Distribution of elephant foot yam germplasm in different cluster groups

Cluster	*Number of germplasm*	*Name of the germplasm*
I	10	C9, Santra Gachhi (14), C8, C5, C11, C1, C4, C10, C6 and Selection-2(17)
II	01	C2
III	04	Selection -1(13), Gajendra (13), BCA -1(16), Ttrivendrum (collected from Trivendrum 12)
IV	01	C3
V	02	C7 and Deshi (18)

weight of corm/plant, height of corm and diameter of corm. Indicating that these traits may be given more importance for further improvement in breeding programmes. Similar findings were corroborated by Abraham *et al.* (2008) and Anil *et al.* (2011).

Cluster analysis of variance due to accessions of all the traits were found to be highly significant except for the trait i.e. weight of corm/plant, which indicated a sufficient amount of variability present in the population. Mean values of 13 characters of the five clusters for the 18 elephant foot yam germplasm (Table 6).

The maximum number of accessions falls under cluster I (10) followed by cluster III (4) and the minimum number in cluster II and IV (1) (Table 7). The maximum cluster mean value was recorded for traits i.e. weight of cormel/plant (g) in cluster I, III and IV whereas in cluster II and V for traits number of leaflets per primary partition and pseudo stem height (cm), respectively (Table 6).

PCA is a well-known method of dimension reduction that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set Massay (1965) and Jolliffie (1986). The result of the PCA explained the genetic diversity of the elephant foot yam genotypes (Table 8). The PC4 accounted maximum cumulative variability (85.37%) among all the components which had been contributed by trait like diameter of corm (cm) followed by fresh weight of corm/plant. Similarly PC3 component had shared (75.35%) of the variability with dominance foliage characters such as length of primary partition (cm) and breath of largest leaflet (cm) as well as tuber traits viz; height of corm (cm), thickness of cormel (cm) and length of cormel (cm). The PC2 contributed for (62.31%) of the variability by the characters such as weight of cormel/plant (g), length of cormel (cm), number of leaflets per primary partition and thickness of cormel (cm). PC1 had contributed minimum variability (42.56%) for foliage traits *viz*; pseudo stem height (cm) breath of primary partition, no. of leaflets per primary partition, thickness of pseudo stem base (cm) and height of corm (cm). The highest loaded

Table 8: Principal components for 13 yield contributing traits of elephant foot yam

Traits	*Principal components*			
	PC1	*PC2*	*PC3*	*PC4*
Pseudo stem height (cm)	0.937	0.095	0.211	-0.099
Length of primary partition (cm)	0.104	-0.234	0.867	-0.053
Breath of primary partition (cm)	0.793	0.062	0.365	-0.408
No. of leaflets per primary partition	0.813	0.399	-0.154	-0.333
Length of largest leaflet (cm)	-0.084	-0.755	0.183	-0.198
Breath of largest leaflet (cm)	0.116	-0.773	0.363	0.361
Thickness of pseudo stem base (cm)	0.900	0.34	0.086	-0.025
Fresh weight of corm/plant (kg)	0.587	0.145	-0.039	0.586
Height of corm (cm)	0.765	0.237	0.287	0.097
Thickness of cormel (cm)	-0.722	0.351	0.505	0.129
Weight of cormel/plant (g)	-0.589	0.691	0.145	0.079
Length of cormel (cm)	-0.602	0.612	0.451	0.057
Diameter of corm (cm)	0.603	0.074	-0.052	0.684
Eigen value	5.533	2.568	1.691	1.306
Percentage of variation	42.565	19.753	13.009	10.043
Cumulative (%)	42.565	62.318	75.327	85.370

Table 9: Proximity dissimilarity matrix (euclidean distance) between elephant foot yam accessions

Cluster	*I*	*II*	*III*	*IV*	*V*
I	00.00	201.684	119.864	52.301	171.035
II		00.00	84.799	247.080	63.528
III			00.00	165.440	67.149
IV				00.00	221.374
V					00.00

variables in PC1, PC2, PC3 and PC4 were pseudo stem height (cm), weight of cormel/plant (g), length of primary partition (cm) and diameter of corm (cm), respectively. Hence tuber character i.e. diameter of corm as well as foliage characters, especially pseudo stem height and length of primary partition, is an important trait in distinguishing various accessions of elephant foot yam. Similar findings corroborated with Anil *et al.* (2011) and Singh *et al.* (2020).

Cluster Analysis and Dissimilarity Matrix of Elephant foot Yam Accessions

Dendrogram (Ward's method) for 18 accessions of elephant foot yam using 13 morphological traits which were represented in Figure 1. Dendrogram represented the fairly and simply interpreted relationship among the accessions. The horizontal axis of the dendrogram represented the dissimilarity. The vertical axis represents the objects and clusters. Each joining (fusion) of two clusters on the graph is represented by splitting a horizontal line into two. The

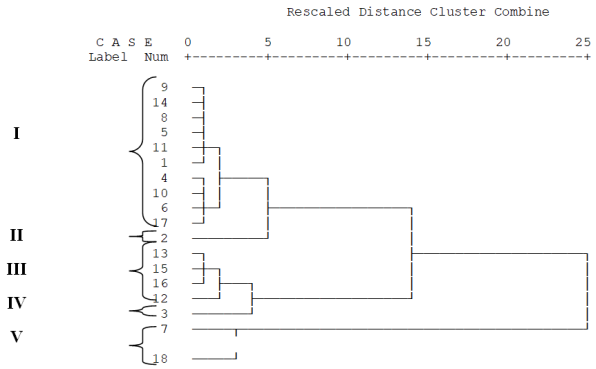

Figure 1: Dendrogram showing hierarchical clusters of 18 elephant foot yam accessions (UPGMA) based on quantitative characters

horizontal position of the split, shown by the short vertical bar, gives the distance (dissimilarity) between the two clusters. C7 and Deshi were in cluster-V while C3 was found in cluster-IV. The dissimilarity analysis recorded highest inter-cluster distance between cluster II and IV (247.08) followed by cluster IV and V (221.37). The lowest cluster distance was exhibited between cluster I and IV (52.30) (Table 9). Genetic diversity evaluation can be used full for selecting promising genotypes. Similar finding reported by Shekar *et al.* (2012); Kumar *et al.* (2013); Arivalagan *et al.* (2013). Touhiduzzaman *et al.* (2016), Sikder *et al.* (2015), Mehraj *et al.* (2017), Rahim *et al.* (2010), and Hoque and Rahman (2007) showed that hybrid genotypes with maximum inter-cluster distance resulted in high yielding, the crossing between these genotypes can be used in breeding programmes to

achieve maximum heterosis. Hence, it may be concluded that a wide range of genetic variability were observed for qualitative and quantitative traits which might be useful for further breeding program me or it may be directly used in cultivation. Tuber character i.e. diameter of corm as well as foliage characters, especially pseudo stem height and length of primary partition, is an important trait in distinguishing various accessions of elephant foot yam.

Acknowledgment

Highly thankful AICRP on tuber crops (other than potato) who have given financial support for conducting the trial.

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