

## TRAVELLING SALESMAN PROBLEM (TSP) OPTIMIZATION SEED DISTRIBUTION USING GENETIC ALGORITHM

Vera Wati<sup>1\*</sup>, Yuliana<sup>2</sup>, Paradise<sup>3</sup>, Kusri<sup>4</sup>

<sup>1</sup> Smart City Information System, Tunas Pembangunan University

<sup>2</sup> Information Technology, Shanti Bhuana Institute

<sup>3</sup> Informatics Engineering, Telkom Institute of Technology Purwokerto

<sup>4</sup> Masters in Informatics Engineering, Amikom University Yogyakarta

Email: \*vera.w@lecture.utp.ac.id

**Abstract:** Distribution is an important the business sector, the agricultural sector for distributing seeds to ensure the location of customers selling seeds. Problems that are often encountered seed distribution process are the efficiency of the time and distance distribution. Re search will build software entering initial location data and several dynamically added consumer agents. The distance parameter uses latitude-longitude integrated on google maps and detects varying store locations, the generation of chromosomes or the best distribution path with the minimum distance route. The heuristic approach using the Genetic Algorithm imitates the concept of biological evolution of random exchange structure series. This study is to distribute 3 types of seeds with a choice of weights that have been divided into 3 areas located on the map of Indonesia using land routes. The results of the test of the population of the average fitness value tend to remain from the previous value of 1-10 the fitness value and the optimum iteration with 9-12 with an average fitness value of 44.2. Optimal results are obtained when  $Mr$  is higher than the  $Cr$  values. Thus, the Genetic Algorithm can be used for TSP seed distribution paths. 1:2 fitness evaluation compared with the usual estimates used.

**Keywords:** Genetic Algorithm; Route Optimization; Seed Distribution; TSP

**Abstrak:** Distribusi menjadi hal penting berwirausaha, salah satunya pada bidang pertanian untuk pendistribusian benih sampai lokasi tujuan. Permasalahan sering ditemui dalam proses pendistribusian adalah efektifan, efisiensi waktu dan jarak tempuh. Sehingga penelitian akan membangun perangkat lunak dengan memasukan data titik lokasi awal dan beberapa lokasi tujuan agen konsumen ditambahkan secara dinamis. Parameter jarak menggunakan *latitude-longitude* terintegrasi pada *google maps* yang mendeteksi keberadaan lokasi, selanjutnya diketahui generasi kromosom atau jalur distribusi terbaik dengan rute minimum. Pendekatan *Heuristic* menggunakan Algoritma Genetika meniru konsep evolusi biologis deretan struktur pertukaran informasi secara acak. Tujuan dalam penelitian ini dapat mendistribusikan jenis benih dengan pilihan bobot yang telah terbagi dalam wilayah lokasi. Satu wilayah lokasi terdapat beberapa lokasi toko ditambahkan secara dinamis, dengan proses yang sudah ditentukan titik awal keberangkatan. Penelitian ini menekankan pada proses penentuan rute lokasi saja. Hasil pengujian jumlah populasi rata-rata nilai fitness cenderung bersifat tetap dari nilai sebelumnya selisih 1-10 nilai fitness dan iterasi optimum dengan 9-12 dengan rata-rata nilai fitness 44,2. Hasil optimum didapatkan ketika *Mutation rate (Mr)* lebih tinggi dibanding nilai *Crossover rate (Cr)*. Maka, Algoritma Genetika bisa digunakan untuk TSP jalur distribusi benih pengujian menghasilkan evaluasi fitness 1:2 untuk Algoritma Genetika dibandingkan dengan estimasi jarak biasa digunakan.

**Kata kunci:** Algoritma Genetika; Distribusi Benih; Optimalisasi Rute; TSP



## INTRODUCTION

According to the Indonesian State Regulation Law no. 12 of 1992 concerning Plant Cultivation Systems are plant parts used to reproduce and reproduce plants, either tangible seeds or other materials in micro propagation [1]. Seeds contribute to the improvement of food crops [2].

Distribution activities are a process so that seeds reach consumers quickly and can be well received. The route of seed distribution location by changing locations via land transportation will consider time and cost as efficient as possible so it is necessary to find an alternative shortest path to be achieved [3]. This problem is known as the Traveling Salesman Problem (TSP), which is a trip to all the intended locations by finding a solution to calculate the shortest path or minimum travel route of all paths [4], [5].

Genetic Algorithm (GA) is a search algorithm based on natural selection and genetics mechanisms, for complex optimization solutions and can be formulated into genetic terminology [6], [7], [8], [9]. There are several terms that are often used in this method, such as individuals, namely problem solving [10], population is the set of solutions [11], [12], fitness is the quality of the solution, chromosomes are representations, and genes are part of the representation of the solution. [13]. Even some genetic operators such as crossover, mutation and natural selection are often used in research [14],[15],[16]. Performance optimization of GA adopts the concept of evolution Biology with natural selection is to combine a series of random information exchange structures to form a search algorithm with changes in talent in humans [17], [18], [19].

Research on the application of GA is

used in fertilizer distribution which only focuses on short distances [20]. Another study, modified use of GA in minimizing the distance total salesman traveling, with a *crossover* process for each operator with a better position than the partial *one cut point* and *cycle* [21]. This algorithm approach is indeed influenced by the crossover and mutation processes used, but the GA. technique good for Traveling Salesman Problem [22]. The application of TSP GA in other studies is used as a distribution method by paying attention to route efficiency, but has not paid attention to the initial initialization of user needs [23], [24].

Solving TSP can use other algorithms such as research by utilizing *hyperheuristic c* adopted by bees, namely *Artificial Bee Colony* (ABC), which does not can be applied in discrete optimization with a combination process [25]. *Ant Colony Optimization* (ACO) algorithm in local location search is utilized in other studies, resulting in less computational time and less efficient performance for dynamic problems [26]. Grouping with GA and Neural Network (NN) for classification results is very optimal, but NN can work well by paying attention to parameters [27]. The use of the Branch and Bound method in searching for the shortest route with landmarks based on characteristics and lodging places was also used in other studies, the obstacles in this study were that the starting point could not be determined and the processing was relatively long [28].

The purpose of this study, processing emphasizes the distance parameter of a distributed series of locations. But paying attention to the user's wishes by initiating the initial departure location, so that the system remains dynamic and works as needed. The genetic operator used is position-based GA recombination with *lati-*

*tude-longitude* distance parameters integrated on *google maps* which detects the presence of store locations. GA was chosen because it is better in the operational process of discrete distribution, always paying attention to the order to avoid repetition of locations, because it will add time. So that the final result is known for the generation of chromosomes or the best distribution path with the minimum distance route for seed distribution using the land route.

**METHOD**

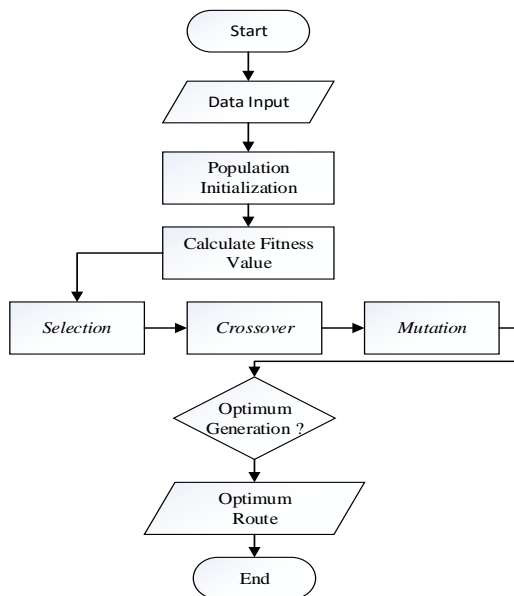


Image 1 . GA Research Scheme

**Input Data**

input data is in the form of area data, point of departure location, choice of goods and weights, as well as input of store location data to be distributed. The list of distributed stores stored in the database can be added dynamically.

**Population Initialization**

Determine parameters and enter gene values from the initial population formed. The parameter used is the location of the

customer to be distributed as a gene on the chromosome. Each chromosome in a generation represents a combination of seed distribution lines. The representation of the *value encoding number* or the value of the distance between location points is a determinant of optimization.

**Calculate Fitness Value**

The process of evaluating each population until the criteria are met, if not met then form a new generation by getting the highest fitness value in a row to find the most minimal value. Equality(1) (2)

$$fitness = \frac{\sum_{j=1}^N f_j}{N} \tag{1}$$

Then the probability is maintained:

$$P_i = \frac{f_i}{\sum_{j=1}^N f_j} = \frac{f_i}{f_N} \tag{2}$$

In finding the minimization value of the *fitness function with the inverse equation*

**Selection**

The selection process takes advantage of the performance of the roulette wheel. Selection is needed to form a new generation for quality chromosomes. Equality(3)

$$P_i \frac{f_i}{\sum_{j=1}^N f_j} = \frac{f_i}{f_N} \rightarrow fitness = total\ jarak \tag{3}$$

Where:

*P<sub>i</sub>*: probability to i

*f<sub>i</sub>*: declare fitness value

Chromosomes with lower *fitness values* need to use *inverse* so that the chromosomes have a greater probability of being selected.

**crossover**

Determination of the crossover probability based on the probability value of producing a new chromosome. Recombination stages:

Chromosome[x] <> Chromosomes[y] = [S→B→C→D→E→A] <> [S→C→D→E→A→B]  
 Crossover result = [S→D→C→E→A→B]

This technique pays attention to the value of the crossover probability (PC), for example the PC value of 50%, it is expected that in 1 generation there will be 50% multiplied by 6 chromosomes so that 3 chromosomes from the population undergo *crossover*.

**Mutation**

A mutation involves a change in one or more genes in an individual, a change involving the reordering of a string with a transient bit reversal in the chromosome representation. Gene mutation stages:

Chromosome[x] = S→A→B→C→D→E  
 Mutation result [x] = S→A→B→C→E→D

The mutation process uses *swapping mutation completion*, with the total length of the gene equal to the number of genes in one chromosome and the shift adjusts.

**Optimum Route**

The final stage, if the genetic operator processes have obtained the most optimum fitness value with the iteration process carried out several times, it will resulting distribution line with the most optimum route .

**RESULTS AND DISCUSSION**

The addition of location points will be entered in the regional database (see Image 2)

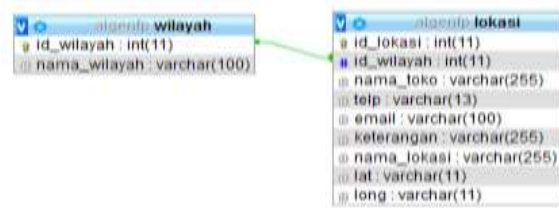


Image 2 . Database Design

The research sample, for example in the Yogyakarta area, is the starting point of PT. Source (S) with the aim of distributing PT. Adityo (A), CV Indoatri (B), CV Tani (C), Garden Shop (D), Maju Store (E). Location points are added dynamically according to the description requested on the location addition page as shown in Image 3. Then in Image 4 add a location with *latitude* and *longitude* according to the data on *google maps* .

The screenshot shows a web form for adding a location. It includes a dropdown menu for 'Wilayah', and input fields for 'Jenis', 'Nama Pelanggan', 'Nama Toko', 'No. Hp', 'Keterangan', and 'Alamat'.

Image 3 . Add Location Page

This screenshot shows a portion of the 'Add Location Page' form, specifically the input fields for 'Latitude' and 'Longitude', and a green 'Simpan' (Save) button at the bottom.

Image 4 . Add Location Page

Table 1 . Distance Between Locations

LK.	S	A	B	C	D	E
	(km)	(km)	(km)	(km)	(km)	(km)

S	25	29	22	19	13
A	25	24	16	85	25
B	29	24	22	32	39
C	22	16	22	25	32
D	19	85	32	25	19
E	13	25	39	32	19

So that in the Yogyakarta area, a description of the location distance is obtained in the form of Table 1.

In several populations in one generation, to illustrate the calculations in this study, 5 chromosomes were obtained:

Chromosomes [1] = S → A → B → C → D → E

Chromosome [2] = S → B → C → D → E → A

Chromosome [3] = S → C → D → E → A → B

Chromosome [4] = S → D → E → A → B → C

Chromosome [5] = S → E → A → B → C → D

After initialization of the initial population is generated, then calculate the fitness value according to the data in Table 1. The process is carried out for the next genetic operation, namely

$$Fitness [1]: \tag{4}$$

$$SA + AB + BC + CD + DE + EA \\ 25 + 24 + 22 + 25 + 19 + 25 = 140$$

$$Fitness [2]: \tag{5}$$

$$SB + BC + CD + DE + EA + AB \\ 29 + 22 + 25 + 19 + 25 + 24 = 144$$

$$Fitness [3]: \tag{6}$$

$$SC + CD + DE + EA + AB + BC \\ 22 + 25 + 19 + 25 + 24 + 22 = 137$$

$$Fitness [4]: \tag{7}$$

$$SD + DE + EA + AB + BC + CD \\ 19 + 19 + 25 + 24 + 22 + 25 = 134$$

$$Fitness [5]: \tag{8}$$

$$SE + EA + AB + BC + CD + DE \\ 13 + 25 + 24 + 22 + 25 + 19 = \mathbf{128}$$

From the results obtained, the chromosome with a smaller fitness so that the chromosome has a greater probability will be re-elected with the *inverse function* . inverse equation(9)

$$Q_i = \frac{1}{Fitness(i)} \tag{9}$$

$$Q_1 = \frac{1}{140} = 0,007142$$

$$Q_2 = \frac{1}{144} = 0,006944$$

$$Q_3 = \frac{1}{137} = 0,007299$$

$$Q_4 = \frac{1}{134} = 0,007462$$

$$Q_5 = \frac{1}{128} = 0,007812$$

$$Total Q_{12345} = 0,036659$$

Probability of chromosomes to be selected a new generation, the probability value will be calculated with the following equation:(10) Probability equation:

$$P_i = \frac{Q_i}{Total Q_i} \tag{10}$$

$$P_1 = \frac{0,007142}{0,036659} = 0,1948 \rightarrow \text{Chromosome 1}$$

$$P_2 = \frac{0,006944}{0,036659} = 0,1894 \rightarrow \text{Chromosome 2}$$

$$P_3 = \frac{0,007299}{0,036659} = 0,1991 \rightarrow \text{Chromosome 3}$$

$$P_4 = \frac{0,007462}{0,036659} = 0,2035 \rightarrow \text{Chromosome 4}$$

$$P_5 = \frac{0,007812}{0,036659} = 0,2130 \rightarrow \text{Chromosome 5}$$

Based on probability calculations, chromosome 5 has the smallest fitness value and has a greater probability value than other chromosomes. This then becomes a reference if chromosome 5 must also be greater than the probability of the next generation.

with the *Roulette method* is carried out as many as the number of chromosomes to get a random value, which is 5 chromosomes. Cumulative value search with equation(11)

$$C[1] = 0,1948 \\ C[2] = 0,1948 + 0,1894 = 0,3842 \\ C[3] = 0,3842 + 0,1991 = 0,5833 \\ C[4] = 0,5833 + 0,2036 = 0,7869 \\ C[5] = 0,7869 + 0,2131 = 1,0000 \tag{11}$$

Then select a random value (R) according to the specified interval, with the value in the function(12)

$$R[1] = 0,1800$$

$$\begin{aligned}
 R[2] &= 0,4001 \\
 R[3] &= 0,2842 \\
 R[4] &= 0,5346 \\
 R[5] &= 1,1869
 \end{aligned}
 \tag{12}$$

Furthermore, the cumulative probability of C[i] is compared with the random value of R[j]. After comparison, the latest population is obtained:

Chromosome[ 1] : [2] = S →B →C →D →E →A  
 Chromosome[2] : [1] = S →A →B →C →D →E  
 Chromosome[3] : [3] = S →C →D →E →A →B  
 Chromosome[4] : [5] = S →E →A →B →C →D  
 Chromosome[5] : [4] = S →D →E →A →B →C

If a new population has been obtained, the next genetic operation is *crossover* or recombination of 2 (two) chromosomes. The requirement for crossing is to multiply the PC value with the chromosome, then 3 chromosomes are recombined. *Crossover* process :

Chromosomes[2] :  
 Chromosome[2] << Chromosome[3 ] =  
 [SB C DEA << SCDEAB]= [SDCEAB]

Chromosomes [3] :  
 Chromosomes[3] << Chromosomes[5]=  
 [SCD E AB<< SEABCD]= [SABCED]

Chromosome[5] :  
 Chromosome[5] << Chromosome[2]=  
 [ SE ABCD << SBCDEA ]= [SECDBA]

So that the population value is obtained after the *crossover*:

Chromosomes[1]= S →A →B →C →D →E  
 Chromosome[2]= S →B →C →D →E →A changed  
 S →D →C →E →A →B  
 Chromosome [3]= S →C →D →E →A →B changed  
 S →A →B →C →E →D  
 Chromosome [4]= S →D →E →A →B →C  
 Chromosome [5]=S →E →A →B →C →D changed  
 S →E →C →D →B →A

For example, the PC value or *Crossover rate* (Cr) is 0.5 or 50%, which results in 3 chromosomes being recombined. Of course, this process in the system will be iterated until it finds the optimum result.

The last genetic operator, namely *swapping mutation*, determines the mutation process, namely if the probability or *Mutation rate* (Mr) is 100% then all chromosomes in the population undergo mutations. So this study uses 50% or the equivalent of Mr. 0.5 so that half of the gene exchange process is selected at random to be exchanged.

Chromosomes[1]= S →A →B →C →D →E  
 Chromosome[1]= S →A →B →C →E →D

Chromosome[2] = S →D →C →E →A →B  
 Chromosome[ 2 ] = S →D →C →E →A →B

Chromosome[3] = S →A →B →C →E →D  
 Chromosome[ 3 ] = S →A →B →C →E →D

Chromosome[4] = S →D →E →A →B →C  
 Chromosome[ 4 ] = S →D →B →A →E →C

Chromosome[5] = S →E →C →D →B →A  
 Chromosome[ 5 ] = S →E →A →D →B →C

Similar to other genetic operators, the system will iterate until it finds the most optimum route.

### Population Quantity Test

The population size test starts from the generation of 5-10 populations and is carried out 10 times.

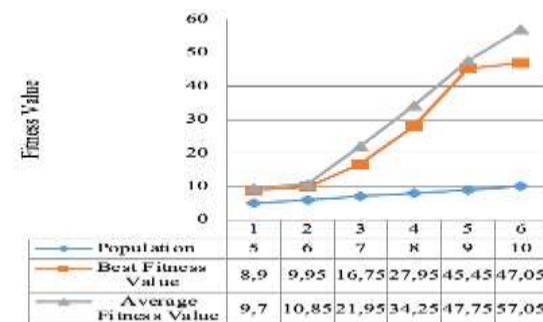


Image 4. Test Results n Population Initialization

The results are compared with the population results from the generation value of the most optimum distribution line. The combination of values used are Cr 0.5 and Mr 0.5. According to the

graph in Image 4, the population generation test shows that the highest average fitness value is found in population generation 10, this is of course due to the distribution path to be traversed. However, it should be noted that the average fitness value tends to be fixed from the previous value.

### Testing the Number of Iterations in Generations

Calculation by doing iterations randomly on the generation of up to 10 times the experiment with the generation of a population of customers who are raised as many as 8 stores including the starting point. The values of Cr and Mr used are 0.5 and 0.5. In Image 5 the average value of the most optimum fitness value is 41.9 with 9 iterations, but in knowing which iteration in the range is more optimal, the researcher divides by 3 categories, the calculation is carried out by the formula(13)

$$\text{Average value fitness} = \frac{\text{Value fitness of iteration}}{\text{entity of iteration}} \quad (13)$$

$$\text{Iterasi 1 - 4} = \frac{45,4+55,2}{2} = 50,3$$

$$\text{Iterasi 5 - 8} = \frac{41,9 + 44,65 + 46,05}{3} = 48,76$$

$$\text{Iterasi 9 - 12} = \frac{41,9 + 44,65 + 46,05}{3} = 44,2$$

Testing with iterations in the generation according to the equation proves that GA performance will be more optimum if the iterations are more than the iterations in fewer generations.

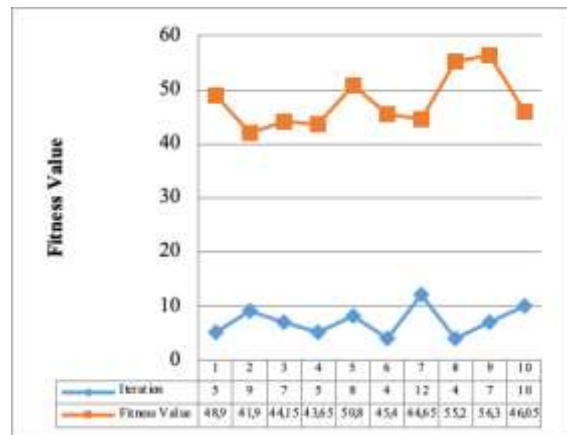


Image 5. Testing the Number of Generations

Then the most optimum results are found in iterations with 9-12 with an average fitness value of 44,2 .

### Combination Test for Determination of Cr and Mr

Calculations by setting the crossover rate and mutation rate in multiples of 0.1 starting from 0 to 1 , with the experiment carried out 10 times (see Image 6). The population generation of the distributed path is 6 stores including the starting point. The most optimal *fitness value* is found in the combination of Cr 0.4 and Mr. 0.6 with an average fitness value of 13.95. However, to find out the range of combinations of Cr, Mr, which is more optimal, the researchers divided it into 2 categories of combinations carried out by the formula(14)

$$\text{Average value fitness} = \frac{\text{Value fitness of Cr Mr}}{\text{entity of Cr Mr}} \quad (14)$$

$$\text{Nilai cr 0,1 - 0,5 \& mr 0,5 - 0,9}$$

$$= \frac{23 + 15,85 + 17,85 + 13,95 + 19,1}{5} = 17,95$$

$$\text{Nilai cr 0,5 - 0,9 \& mr 0,1 - 0,5}$$

$$= \frac{19,1 + 15,15 + 24,95 + 19,1 + 20,4}{5} = 19,74$$

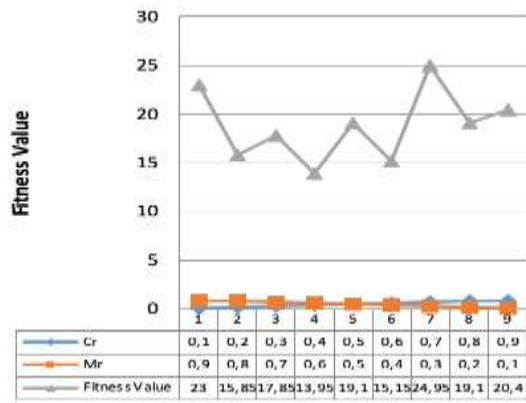


Image 6. Results of the Combination of Cr and Mr

The test results (Image 6) with a combination of Cr lower than 0.1-0.5 and higher Mr 0.5-0.9 are more optimal, because this study seeks to evaluate the value with minimization. A high Cr value will produce a generation of offspring that are similar to the parent, this makes the GA process unable to widen the search area, but with a higher Mr, it causes the mutation process to learn to shift children or distribution lines to find the most optimal without changing generations in the distribution of seed distribution lines. However, it can be concluded that in this test the difference is not so significant.

**Testing the Number of Iterations in Generations**

This test is carried out by comparing the route results with real conditions and the composition of the GA calculation. The test scenario is based on the results calculated with the usual distribution path by estimating the closest distance and the results obtained using GA. The population that was raised was 11 locations with a combination value of Cr 0.4 and Mr. 0.6. The available distribution channels are in Table 3.

Table 2 . Distributed Location Comparison

Solution	Distribution Location (km)
Estimated results	PS →PL →PET →JB →PT →KT →TT →PD →PN →ABT →PTU 3.3 →0.25 →0.25 →4.0 →2.6 →12.0 →1.6 →8.9 →9.3 →16.3 →21.6 =1 <b>04.85</b>
GA Hasil results	JB →PS →PD →PT →PET →PL →PN →PTU →KT →TT →ABT 1.3 →1.5 →3.1 →3.8 →0.25 →12.0 →6.0 →17.5 →1.6 →4.7 =52.75

In Table 3, the test presents the average *fitness value* using GA, resulting in a more optimum solution than the estimated distribution path that is usually passed. The results compare 1:2 in favor of the more optimum GA for TSP.

**CONCLUSION**

The use of GA with population generation testing produces a constant tendency from the previous value with a difference of 1-10 fitness values and if the generation iteration process experiences more iterations between 9-12 iterations, the distribution line results are more optimum. The effect of the combination of Cr and Mr also affects the testing process, optimum results are obtained when the Mr value is higher than Cr because it undergoes more *mutation processes* in the distribution path for better results. The use of GA is more optimum with the results of a *fitness value* of 1:2 compared to the estimation results that are usually passed through the distribution. So, it can be concluded that GA is optimum in solving the *Traveling Salesman Problem* for seed distribution lines.



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