Optimization of Indian CarpSeed Production Factors Using RSM Based Model and Genetic Algorithm

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Abstract: ***The aim of this study is to find the optimum factors for the maximization of the Indian carp production rate. The experiment is carried out to record the different parameters that influence the production of carp seed. The investigation was carried with some commercially important fish species of various freshwater ponds of Ramsagar town, Bankura, West Bengal studied for twelve months. The RSM model is build using the experimental data. The RSM model is used as an objective function in the genetic algorithm (GA) to find the maximum production rate. ANOVA test shows that the RSM model for Catla carp is 99.96% accurate. Whereas, RSM model for the Labeo carp modelis99.86%accurate. Significance F values for both Catla and Labeo model is < 0.001. The optimum values of Age of female carp, the weight of female carp, length of female carp, the first dose for female carp, the second dose for female carp, age of male carp, the weight of male carp, length of male carp, and second dose for male carp are reported.***

Keywords: Optimization, Genetic Algorithm, RSM model, Indian carp, Ramsagar town, Bankura

1. Introduction

In recent years, there has been a significant expansion in commercial pond carp culture in India. India is the second - largest aquaculture production of fish, next to China. In India, this sector comprises about 5% of the global fish production and 3% of the worldwide fish deal. In the world, capture fisheries and aquaculture supplied about 158 million tons of fish in 2012, of which about 136.2 million tons were utilized as food. However, the global population is increasing, and in order to maintain at least the current level of per - capita consumption of aquatic foods (19.7 kg in 2013, FAO, 2016). Quality fish seed is the prime factor for the increase of aquaculture production [1]. Annual Asian production of the three Indian major carps, namely Rohu (*Labeo Rohita*), Catla (*Catla Catla*), and Mrigal (*Cirrhinus Mrigala*), was 4412078 tonnes, of which rohu comprised 1133233 tonnes; Catla 2976820 tonnes and mrigal 302025 tonnes [2]. The Indian major carps, with their ability to filter feed by harvesting the natural plankton produced in the system through fertilization, provide the opportunity for low - cost aquaculture systems with reduced risk to farmers [3]. Indian major carps are generally practiced in fertilized ponds. These fish are fed with added mash feed comprised mostly of rice bran, Mohua oil cake, and mustard oil cake [4]. The three major Indian carps, namely, Catla (*Catla Catla*), rohu (*Labeo Rohita*), and mrigal (*Cirrhinus Mrigala*), contribute the majority of the national carp production. Increased production of fish depends mainly on the accessibility of good quality fish seed. For the last two decades, farmers had to depend entirely on seeds from natural breeding grounds, which supplied more than 85% of the total seed requirement.

Many researchers are proposed many techniques to increase the production rate and growth of carp. Jha et al. [5] studied the effect of cow dung and poultry excreta on water quality and growth of carp. The investigation was carried out for 90 days on a concrete tank. They examined the growth rate of Koi carp for different applications of cow dung and poultry excreta. Manomaitis et al. [6] examined the growth rate of Rahu carp using ASA feed - based technology and the traditional India National Package (NP) methodology. They found that the less labor and time required to culture Rahu carp using the ASA technology. Veerina et al. [7] analysed production factors incarp farming in Andhra Pradesh, India. Kumar et al. [8] studied the evaluation of optimal species ratio to maximize fish polyculture production.

In the last few decades, optimization techniques are used in many fields, like Engineering, Science, finance, etc. The optimization technique is used to find the optimum values among the limited resources. In optimization techniques, Metaheuristic algorithms are inspired by nature. The genetic algorithm is one of the oldest metaheuristic technique. GA was proposed by John Holland and his students and colleagues in 1960 [9]. Since then, it is used in many fields. Some other proposed meta heuristic techniques are particle swarm optimization (PSO) [10] [11] [12], Artificial bee colony (ABC) algorithm [13] [14] [15], differential evolution (DE) [16] [17], ant colony optimization [18] [19], antlion optimization (ALO) algorithm [20] [21], grey wolf optimization (GWO) [22] [23], killer whale algorithm [24] [25] [26], bat algorithm (BA) [27], etc. Some optimization studies are done by the researcher using different mathematical techniques [28] [29] [30] [31]. Tumuluru and Shahab [32] used a genetic algorithm to optimize the aquafeed pellet properties. Bhakta et al. [33] studied the optimization of fertilizer dose for the rearing stage production of carps. They have presented the cost - benefit analysis offish production. Sanusi et al. [28] examined resource optimization in small - scale fish farming in the Minna Agricultural Zone of Niger State, Nigeria. They have used the traditional response approach for building the model. Miah et al. [34] studied the optimization of pituitary gland hormonedos to induce bata fish breeding. They concluded that 1.0 mg of first dose and 4.5 mg of the second dose per kg bodyweight is recommended. Literature reviews reveal that maximization of production of Indian carp seed using the RSM model and GA is a novel approach in this field. The analysis of variance (ANOVA) is studied to check the accuracy of the RSM model. In the second section of this paper, methodology such as experimental details, design of experiment, and genetic algorithm are discussed. In the result and discussion part, the formulation of the RSM model and optimization results using GAare discussed. In the end, section based on our optimal study, some conclusions are made.

2. Methodology Experimental details

Fish specimens were procured from the different ponds in the Ramsagar town in Bankura, WB, regularly, and measurement was carried out from February 2011 to January 2012 [35]. Sampling was done twice a month, twenty - four times for twelve months, using different fishing gears such as hook and line, long line, cast nets, gill nets, and traps. Total1319 fishes (i. e., 682 specimen of *Labeo Rohita*, 637 specimens of *Catla Catla*) were collected from the ponds of Ramsagar town in Bankura [35]. After cleaning and blot drying with a piece of clean hand towel, all the parameters (i. e., the age of female carp, the weight of female carp, length of female carp, age of male carp, the weight of male carp, length of male carp) are measured using some electronic measuring device. After recording all data, the female carp is injected with the first dose of pituitary gland hormone (Wova - FH), and at that time, male carp kept uninjected. At the time of the second dose of pituitary gland hormone (Wova - FH) to female carp, the male carp are also injected. For this study, carp is considered as 1: 1 ratio (i. e., one male carp for one female carp). The first dose for the female is very minimal compared to the second dose. The Experimental data for Catla carp is shown in Table 1, and experimental data for Labeo is presented in Table 2.

Table 1: Experimental data for Catla carpseed production.

S. No.	Female					Male					Production ()
	Age (Year) (Yf)	Wt. (g) (Wf)	Size (cm) (Lf)	1st Dose (ml) (D1f)	2nd Dose (ml) (D2f)	Age (Year) (Ym)	Wt. (g) (Wm)	Size (cm) (Lm)	1st Dose (ml) (D1m)	2nd Dose (ml) (D2m)	
1	5	4250	61	2.5	40	4	2500	50.8	0	25	594000
2	5	5700	62.2	2.5	50	4	3150	60.9	0	30	600600
3	4	4300	54.6	2	40	3	1750	45.7	0	20	594000
4	3	3050	50.8	1.5	30	3	1500	40.6	0	15	567600
5	3	2050	48.3	1	20	3	2050	48.2	0	20	528000
6	5	6000	64.8	3	65	3	2100	48.2	0	20	603900
7	4	3500	50.8	1.5	35	3	1500	40.6	0	15	577500
8	3	1700	43.2	1	20	3	2000	48.2	0	20	508200
9	4	3500	53.3	1.5	40	4	2550	53.3	0	25	580800
10	4	3050	50.8	1.5	30	5	3500	63.5	0	35	574200
11	3	2700	50.8	1.5	30	3	1050	35.5	0	10	544500
12	3	2250	45.7	1	20	3	1400	40.6	0	15	524700

Table 2: Experimental data for Labeo carpseed production

S. No.	Female					Male					Production ()
	Age (Year) (Yf)	Wt. (gm) (Wf)	Size (cm) (Lf)	1st Dose (ml) (D1f)	2nd Dose (ml) (D2f)	Age (Year) (Ym)	Wt. (gm) (Wm)	Size (cm) (Lm)	1st Dose (ml) (D1m)	2nd Dose (ml) (D2m)	
1	4	1750	50.8	1.5	15	5	2050	63.5	0	18	224400
2	4	1800	61	2	15	4	1100	40.6	0	9	224400
3	4	1200	47	1	9	4	1700	45.7	0	10	191400
4	4	1700	50.8	2	15	4	1700	45.7	0	10	214500
5	4	1000	40.6	1	9	4	1200	40.6	0	10	174900
6	4	1000	41.9	1	9	4	1500	45.7	0	13	171600
7	4	1200	47	1	9	4	2000	61	0	18	191400
8	4	1550	48.2	1.5	13	4	1000	40.6	0	9	194700
9	4	1400	47	1.5	13	4	800	35.6	0	9	184800
10	4	1400	48.2	1.5	13	4	1300	45.7	0	10	184800
11	4	1150	43.1	1	9	4	1250	43.1	0	10	181500
12	4	1250	44.5	1	9	4	1250	45.7	0	10	194700
13	4	1050	42	1	9	4	1300	45.7	0	10	174700
14	4	1150	42	1	9	4	1250	43.1	0	10	188100
15	4	1750	53.3	2	13	4	1100	40.6	0	9	221100
16	4	1250	45.7	1	10	4	800	35.6	0	9	191400
17	4	900	40.6	1	9	4	1700	45.7	0	10	165000
18	4	1000	40.6	1	9	4	2000	61	0	18	168300
19	4	1300	44.5	1.5	10	4	1250	45.7	0	10	191400
20	4	1000	41.9	1	9	4	1200	40.6	0	10	174900
21	4	900	40.6	1	9	4	1000	40.6	0	9	168300

22	4	600	38	1	6	4	1700	45.7	0	10	148500
23	5	2200	63.5	2	18	4	1500	45.7	0	13	204600
24	4	1250	45.7	1	10	5	2050	63.5	0	18	191400

Design of Experiment

In the RSM model [36] [37], the process parameters are considered independent variables (input), and response parameters are regarded as dependent variables (output). The basics of the regression model can be written as following from [38] [39]

Where is the regress and is the regressor and represent normally distributed statistical error, and represents intercept and represents slopes. Here Minimization of the sum of the square of error (SSE) gives the estimates of values. The first - order mathematical model can be written as follows In this article, a first - order mathematical model is formulated to establish a relationship between the factors that affect Indian carp production. Further, an analysis of variance (ANOVA) test is carried out to select and exclude the statically non - significant terms from the RSM model. The accuracy of the data - driven model coefficient of determination or R2 is checked using the following equation.

Where is known as the magnitude of the residual error associated with the dependent variable with respect to mean and is the sum of residuals around the regression line. output values from the experiment and is the output values from the predicted model. is known as the coefficient of determination. The limit of value is in between 0 and 1. So a value of 0 means there is no improvement, which means no reduction of error by describing the data in a straight line. A value of 1 gives a perfect fit that means the line explains 100% of the variability of the data.

Genetic Algorithm

The linear equation formulated by the RSM method is optimized using a genetic algorithm. GA is a nature - inspired search heuristic. The algorithm works on Charles Darwin's theory of natural evolution [40]. It imitates the process of genetic and natural selection. The five primary operations of the genetic algorithm are the initial population, fitness function, selection, crossover, and mutation [9]. GA selects fitness individuals from a set of data called the population. One individual is called a chromosome. Each chromosome is the solution to the problem. Set of variables called Genes to characterize each chromosome. The algorithm selects the fittest individuals from the population. They produced offspring which have a similar character to the parents and send them to the next generation. The parents having better fitness value produce better offspring than them and have a high chance of surviving. This iterative process goes on, and in the end, a generation with a better chromosome will be found. GA can solve constrained and unconstrained types of problems. GA can search for optimal parameters and predict the solution from a vast search space. It does not get trapped in local optima as it searches parallel from the population of points [41]. The pseudo – code of the meta - modeling and optimization technique used in this study is given below [38].

```
1. Identify input and output parameters.
2. Build the RSM model.
3. Perform ANOVA
   {
   Check and Significance F
   If it is desirable, then use the model
   Else model reduction and repeat ANOVA
   }
4. Use RSM model as an objective function in GA.
```

```
Set GA parameters Initializer
and omopulation
Evaluate fitness and perform non-dominated sorting
  {
  Selection, Crossover, Mutation Update fitness of each
  individual Record best individual so far
  If the generation limit exhausted Then predict optimal
  parameters
  Else repeat from selection, crossover, and mutation
  }
  End
```

3. Result and discussions Formulation of RSM model

Using experimental data inTable1andTable2, a first - order linear RSM model is formulated. The Age of female carp (), weight of female carp (), length of female carp (), first dose for female carp (), second dose for female carp (), age of male carp (), weight of male carp (), length of male carp () and second dose for male carp () is considered as process parameters and production rate (P) is considered as response parameters. The liner RSM model for production rate is given by the equation (8)

(8)

Where, are coefficient of intercept.

The ANOVA table for different carp is given in Table 3. The R2 values for different carp are also shown. From Table 3, it is found that for the Catla carp model, the R2 value is 0.9996, which means the predicted model is 99.96% accurate. Same for the Labeo carp model is 99.86% accurate. The actual production rate vs predicted production rate for Catla and Labeo is shown in Figure 1 and Figure 2. Also, R2 Adj. and Significance F values for the different models are shown inTable3. The Significance F is minimal (i. e., <0.001) for all the models. So, the model is very accurate. The predicted model for Catla and Labeo are shown below (9) (10)

Table 3: ANOVA table for the design of RSM model for different carp

Coefficient of Intercept	Catla	Labeo
	0	0
	8923.615	-5938.49183
	3.038154	51.398402
	6982.74	1471.8326
	-52218.8	10548.4602
	956.9665	-5080.74031
	34232.81	27424.7331
	-173.817	-9.84823
	6108.093	1078.516
	7662.718	-2478.66
R2	0.9996	0.9986
R2Adj.	0.6655	0.9313
Significance	0.000991	1.00929E - 18

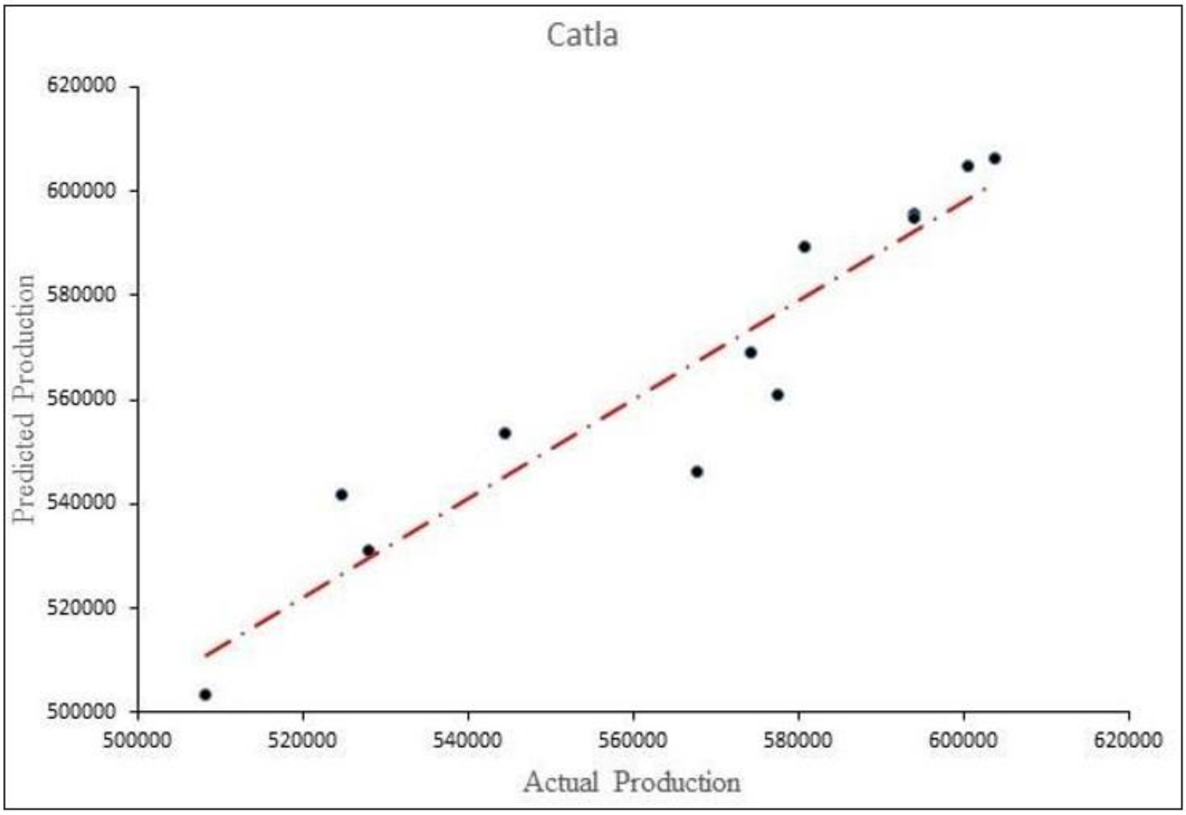

Figure 1: Actual vs Predicted production plot for Catlacarp.

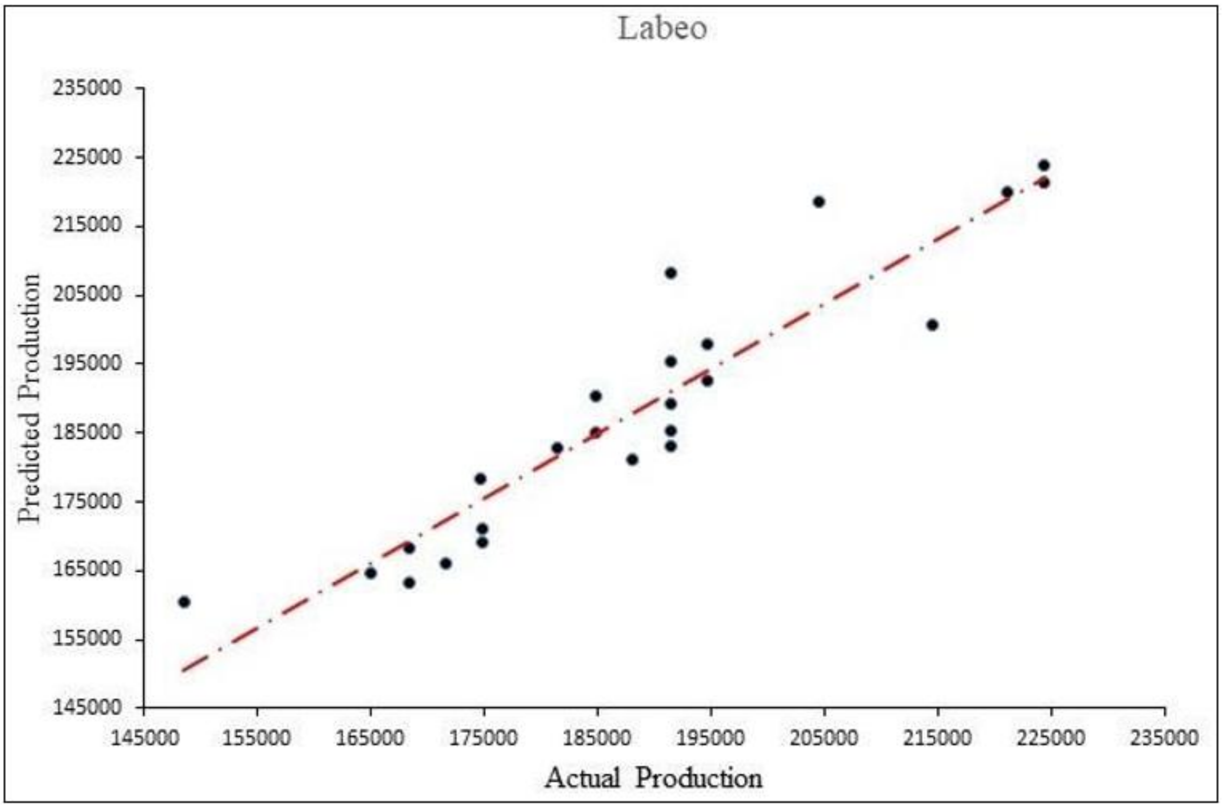

Figure 2: Actual vs Predicted production plot for Labeocarp.

Optimization using GA

The RSM models are used as an objective function in the genetic algorithm to find the maximum production rate and optimal decision variables for Catla and Lebeo carp. The genetic algorithm is used to optimize the production rate of Indian carp considering the age of female carp (), the weight of female carp (), length of female carp (), the first dose for female carp (), the second dose for female carp (), age of male carp (), the weight of male carp (), length of male carp () and second dose for male carp () as variables. From the experimental table, it is found that the first dose for male carp is not given. Sothefirst dose for males is not considered for the design of the predicted model. The genetic algorithm optimization technique is performed using MATLAB R2018asoftware. For GA analysis, a population size of 50, generation of 500, and selection function as a Roulette is considered. The single point crossover function and constraint - dependent mutation function are considered in GA. Again, a crossover probability of 0.8 and a mutation probability of 0.05 are considered.

The objective of the present work is to maximize the production rate of Indian carp. Maximization, *Production () Subjected to the limits, 3≤≤5; 1700≤≤ 6000; 43.2≤≤ 64.8; 1≤≤3; 20≤≤ 65; 3≤≤ 5; 1050≤≤3500; 35.5≤≤ 63.5; 10≤≤ 35.* Maximization, *Production () Subjected to the limits, 4≤≤ 5; 600≤≤ 2200; 38≤≤63.5; 1≤≤ 2; 6≤≤ 18; 4≤≤ 5; 800 ≤≤ 2050; 35.6≤≤ 63.5; 9≤≤ 18;*

Table 4: Optimum table for maximization of production rate

Type	Female					Male				Optimum Production Rate
	Age (Year) (Yf)	Wt. (gm) (Wf)	Size (cm) (Lf)	1st Dose (ml) (D1f)	2nd Dose (ml) (D2f)	Age (Year) (Ym)	Wt. (gm) (Wm)	Size (cm) (Lm)	2nd Dose (ml) (D2m)	
Catla	5	5606.29	64.79	1.047	64.95	5	1050.02	63.50	35	1165839
Labeo	4	2200	63.5	2	6.003	5	800.004	63.5	9.001	348798

In *Table 4*, the optimum values of design variables and maximum production rate are reported. From *Table 4*, it is clear that for maximization of Catla carp production, the maximum amount of age, weight, and length and minimum values of the first dose but the maximum amount of the second dose of female carp is required. For male carp maximum age and size and second dose but a minimum weight is required. At the end of the 397thgeneration, it gives a maximum value for Catla carp production. For maximization of Labeo carp production, maximum amount age, weight, and length and first dose but a minimum amount of the second dose of female carp are required. For male carp maximum age and size but a minimumweight and second dose is needed. At the end of the 251thgeneration, it gives a maximum value for Labeo carp production.

4. Conclusion

In this paper, the genetic algorithm is used to find the maximum production rate of Indian carp seed. The RSM model is built from the experimental data, and optimal conditions are calculated considering the RSM model as an objective function. ANOVA test shows that the R2 value for the Catla RSM model is 0.9996. Whereas, R2 value for the Labeo RSM model is 0.9986. Significance F values for both Catla and Labeo model is<0.001. So, both the models are accurate. From the present study, it is observed that to maximize the production rate of Catla carp, the age, weight, length, and the second dose for the female carp should be maximum, and a minimum value of the first dose is required. For male carp, age, size, and the second dose should be maximum, but minimum weight is required. To maximize Labeo carp production rate, high values of age, weight, length, and the first dose for the female carp should be maximum and minimum values of the second dose are required. For male carp, a high value of age, size is needed, but a minimum value of the weight and the second dose is needed.

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