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Optimization Crops Pattern in Variable Field Ownership

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Abstract: This study was conducted to optimize the cropping pattern in Northern Province of Khuzestan in south west of Iran. Problem formulated the crop-planning problem as an optimization model and solves it using genetic algorithm. A simulation and optimization model was developed and applied to optimize the economic benefit, by searching for the best allocation of planted crop areas in fall and spring season. Optimal planning was projected to produce the maximum economic benefit. Result shows that current crops pattern must be change from cereals such as wheat and corn to moderate areas of cereals and intensive crops such as potato, tomato and patches crops. Apply optimum pattern caused increase in profit and production 987$.ha^{-1} and 6.15ton.ha^{-1} at mean.

Key words: Crops Pattern · Optimization · Planning · Genetic Algorithm

INTRODUCTION

Crop area planning is essential for agricultural production systems management and it can decide how much resources allocated to different cropped areas in obtaining certain goals such as the maximization of return from cultivated land under the limitation of resources [1]. In Agricultural systems one of major challenges is crop selection. Given a farmland, a water resource and a list of crops, the objective is to determine the optimal (or near optimal) cropping patterns [2].

Crop-Planning Problem: Planning is related to many factors such as the type of lands, yield rate, weather conditions, of the agricultural inputs, crop demand, capital availability and the cost of production. Some of these factors are measurable and can be quantified. However, factors like rainfall, weather condition, flood, cyclone and other natural calamities are difficult to predict [3]. Resources shortage makes the problem generally as a constrained optimization problem. An important issue in those problems is the optimization objective(s). Based on one or multi objective optimization, one or more goal to be considered. Maximization of net return [4], [5], Maximization gross margin [3], minimization water use [6], soil conservation [7] are some of goals that are desired.

Optimization Methods: Soft computing has been extensively studied and applied in the last three decades for scientific research and engineering computing. In agricultural and biological engineering, researchers and engineers have developed methods of fuzzy logic, artificial neural networks, genetic algorithms(GA), decision trees and support vector machines to study soil and water regimes related to crop growth, analyze the operation of food processing and support decision-making in precision farming [8].

Using Soft computing optimization methods has been outspread to solve problems in agricultural systems such as crop selection [9], crop planning [3], irrigation planning [10], water resources management [11-13], vegetable production [14], beef production [15], wildlife and livestock management [16] and sugarcane transportation [17].

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Genetic Algorithms: Genetic algorithms (GAs) are stochastic optimization techniques that mimic the Darwinian evolution by modeling the natural selection process and genetic modifications [18]. They act on a population of individuals that evolve under the effect of three basic operations: selection, crossover and mutation. The parents with high 'fitness' survive and reproduce in order to create individual again more adapted. In the case of standard unimudal GAs, the population quickly converges toward a promising zone of the search space [19].

Genetic algorithm (GA) optimization procedures belong to the family of heuristic evolutionary algorithms that mimic the natural evolutionary processes to search optimal solutions for diverse, complex and globally distributed problems. Heuristic optimization methods provide near optimal solutions by searching a global variable space. In brief, a GA consists of a population (represented as chromosome with genes as variables) of solutions that are initialized randomly and their fitness is estimated by evaluating the objective functions. In the selection process, the fittest individuals are duplicated and the weak ones are discarded. [20].

The objective of this study is to optimize the crop planning model using the genetic algorithm to improve economic benefit from field crops production.

MATERIAL AND METHODS

Area Description: The research zone is located in north of Khuzestan province in south west of Iran. It comprises 220000 hectare and extends between 31°39' to 32°41'N latitude and 47°48' to 48°55' E longitude. Climate conditions in research zone is a warm, dry with annual rainfall of 270 mm which could produced crops twice in both spring and fall seasons. There are flat plain areas with abundant water resources that are provided for three rivers include Karoon, Dez and Karkheh. Most of the current cropping pattern in the region includes cereals and vegetables.

Crop Planning Model: Production planning was modeled with constraints for solving optimization based on genetic algorithm. The goal was maximizing the net profit from the production.

Objective: Maximization of Total Net Income: The economic benefits result from production activities. Economic profit function includes the sum of economic benefits arising from the production of a set of crops. Profit is difference between revenue from sales off arm products and the cost of production for each crop. Production cost per hectare for crops planted area is calculated from the estimated annual cost which are include variable and fixed cost. Field inputs include seed, fertilizers, pests control, irrigation, machine fuel and repairs (operating costs) are variables costs which calculated per hectare. Fixed costs includethe machine costs which calculate annually. Annual machine costs or ownership costs are depreciation, insurance, taxes, interest and hangar.Cost per hectare is calculated Retractable for fixed costs and variable costs, division of crops. Based on the mathematical structure will function as follows:

$$MAX\ Z_1 = \sum_{i}^{n} PRF_i . X_i$$

$$PRF_{ij} = Y_i . P_i - \sum_{l_1}^{u_1} VCI_{l_1} - \sum_{l_2}^{u_2} \left(VCM_{l_2} + \frac{FCM_{l_2}}{X_i} \right)$$

where z_l is the total net income for the planting crops *($)*, n the number of cropsplanted, *PRFi* the production profit for crop*i* *(Ha^{-1})*, X_i planted area for cop *i (Ha)*, y_i yield crop *i (Kg)*, p_i crop price *(Kg^{-1})*, o_l number of production inputs, *VCI* and *VCM*, variable costs of inputs and farm machines and *FCM* is farm machines fixed costs. Variablecost in this equation is related to the crop planted area, butthe fixed costs offarm machines are independent of area and calculate Annual.

Constraint 1: Total Planting Area: The sum of all planting areas for the crops should be less than or equal to the total planting area. Total arable area in study zone is 220000ha.

$$\sum_{i}^{n} x_i \le A$$

Where A is the total planting area in ha.

Constraint 2: Human working Day: Labor work required for production of crops dependent on farming operations in various stages of planting and harvest. Labor need is not the same in all operations. Due to the diversity of cultivated plants and the operation time of each product requires laboris different in seasons. The labor work required for each product based on manual labor required per hectare was estimated on the basis of question naire data. Total labors needed in the following equation are showed.

$$\sum_{i}^{n} l_i x_i \leq L$$

Where *li* is of working-days required to produce each product, X_i planted area for cop *i* (Ha) and*L* is total available laborwok-day.

Population statistics were used to calculate the total available labor work. Active and unemployed people in rural areas calculated from population statistics.

Constraint 3: Irrigation water Constraint: Water is one of the most important factor and limitation for agricultural production. Annual water needed to produce any crop has been determined based on other studies. Total annual water availability. Water availability is dependent on the land that is available to farmers. Calculating the amount of water available per capita water in the irrigation net work is achieved. For farmers who have water wells also based on the amount of land exploitation licenses hall be transferred to the farmer. But most of the study are a lands are benefited from the irrigation and drain age network. Normal rainfall in the area calculations of total available water was added.

$$\sum_{i}^{n} w_i x_i \leq W$$

Where, the crop water requirements for crop I (m^3/ha) in growth season,X_i planted area for cop I (Ha) and W istotalavailablevolume of Water.Waterrequirements are provided from threeriversflowingin the region. Volumeof water indifferentseasonswasconsideredseparately.

Constraint 4:capital Constraint: The totalamount of money thatcan be used tocover thevariablecost ofall crops productionshouldbeless thancapitalavailable tofarmers. Capital required to produce each product is calculated in the region. This investment is part of current costs is that the farmer should have to be able to produce the desired crop. Total investment in farmers, based on their livelihood and culture of banking facilities, which provide loans to farmers, is being considered.

$$\sum_{i}^{n} c_i x_i \leq C$$

Where, c_i is variable production cost for crop I, X_i planted area for cop I (Ha) and C istotalavailableinvestment in research region.

Constraint 4: Machines working hour: Some of field operations have been done by mechanized system. So machines work is one of important constraint. Each crop has different machine operation from tillage to harvest. Weather and soil condition denote machines workability.

$$\sum_{i}^{n} mh_i x_i \leq MH$$

Where, mh_i is working machines hours for field operations for crop i, X_i planted area for cop I (Ha) andMH istotalworkable hour in season. Workable day calculated base on weather condition in research region.

Data Collection: Data requirement was collected in research zone by 730 questionnaires which complete with government data include agriculture ministry, meteorology organization and central bank time series data. Those data used to compose mathematical model and levels of constraints.

RESULTS AND DISCUSSION

Data collected from questionnaires shows the current crops pattern in research zone (Table 1). Current crops pattern in research zone is based on cereals especially wheat and corn so about 50 to 60% of area assign for this two crops. Low production cost, high level of mechanization and government protégé persuade farmers to put those crops as main pattern crops.

Genetic Algorithm Performance: Figure 2 shows the best performance of geneticalgorithmontheMATLABsoftware. To quantify of GA, we carried out set of experiments for a total of 26 runs.Theperformanceswere observed improvement results by increase in populationfrom 500 but further increase in population size result no appreciable improvement in the result from population 320. Some crossover operation was compared and uniform crossover show better result. By increase crossover operation from 0.1 to 0.95 and better result observed at 0.8 however no improvement showed further. There was moderately sensitiveto changemutation probably operator from 0.002 to 0.05 but the best result observed at 0.25 value.

Optimum Crops Pattern for Fall Season: Optimization results show that optimum cropping pattern is different from current pattern. Despite to currentculture is based on cereals such as wheat and cornthe proposed optimum model recommends replacing intensivecropsratherthan extensive crops. Resultsoffered reduction wheat area and increase areas of potato, onion andpatchescrops (Table 2). Pattern has been based on

Table 1: Current crops pattern in research zone

	Crops Area(ha)							
Field ownership (ha)	wheat	corn	rice	tomato	onion	Winter patchs	summerpatchs	Summer beans
<5	2.6	3.4	-	0.5	-	2.1	1.1	-
5-10	3.7	3.6	-	-	1.2	3	2.8	3
10-15	6	4.8	-	1.5	-	4.2	3	4
15-20	7	5.3	-	2.1	20	4.8	1.5	-
20-25	12	10	-	-	20	6	2	8
25-30	18	12	3	2	20	8	9	-

Table 2: Optimize cropping pattern for fall season

	Crops Area(1000ha)							
Field ownership (ha)	wheat	potato	canola	onion	beans	patchs	Sugar beet	Benefit ($)
<5	1.5	1.5	-	1	-	0.5	-	8442
5-10	1	3	-	2	-	1.5	-	17707
10-15	3	4	0.5	2.5	1.5	2.5	0.5	25106
15-20	3	7	3.5	2.5	2	2.5	-	33368
20-25	4	7	3.5	3.5	1.5	5	0.5	43288
25-30	2	10	2	3.5	2	4.5	1	60774

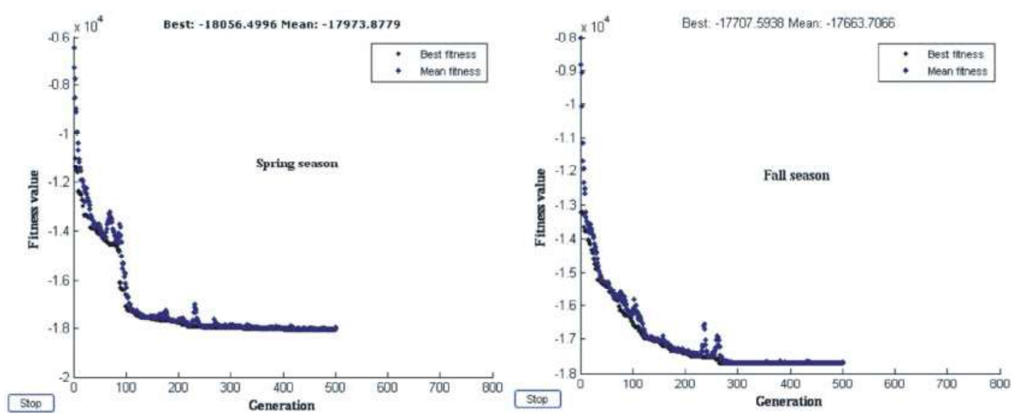

Fig. 1: Research zone at south west of Iran

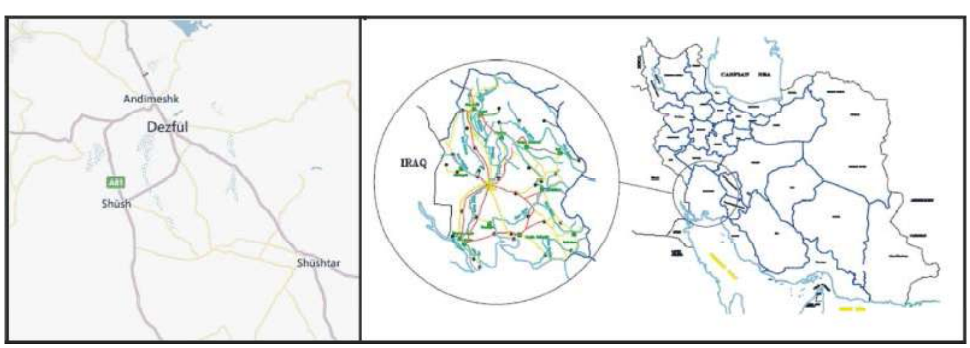

Fig. 2: GA performance of optimization function

Table 3: Optimize cropping pattern for spring season

	Crops Area(1000ha)								
Field ownership (ha)	corn	sorghum	alfalfa	beans	rice	tomato	patchs	cotton	Benefit ($)
<5	1	-	-	-	-	1.5	2	0.5	12854
5-10	2	-	-	0.5	-	5	1	-	18056
10-15	2	-	-	1	-	0.5	6.5	-	26930
15-20	2	-	-	2.5	-	3	9	-	44616
20-25	3	-	-	3	-	3.5	11.5	-	55546
25-30	6	-	-	0.5	-	5.5	18	-	88393

Table 4: Comparison between current and optimum crops pattern parameters

		level of field ownership (ha)						
Field ownership (ha)		<5	5-10	10-15	15-20	20-25	25-30	mean
Crops production (ton)	Current pattern	76	114	189	179	275	364	11.88
	optimum pattern	108	192	281	346	394	468	18.03
Benefit ($)	Current pattern	16812	28744	31257	57402	81027	126871	3110
	optimum pattern	21296	40336	52036	77984	98834	149167	4097
Increase production ($ton.ha^{-1}$)		32	78	92	167	119	104	6.15

high profit crops such as potato in low level of field ownership but in large fields (up to 10 hectare) other crops such as canola and beans have been justifiable. Profitability was different between various field ownership, so maximum profit caused in 5-10 hectare level of ownership by 2447$\$ha^{-1}$ and minimum profit by 1710$\$ha^{-1}$caused in 20 hectare level.

Optimum Crops Pattern for Spring Season: Similar to fall season for spring season optimum crops pattern has been change from cereals to intensive crops such as tomato and patchs crops, so corn area from 52% at 5 hectare level of ownership area in current pattern has been changed to 20% in optimal pattern (Table 3). Extensive crops such as beans have been justifiable at high level of ownership (up to 10 hectare).In comparisonversatilecultivar in spring pattern has been lower than fall season pattern. Maximum profit caused in 25-30 hectare level of ownership by 2797$\$ha^{-1}$ and minimum profit by 2570$\$ha^{-1}$caused in 0-5 hectare level of ownership.

Comparison Optimum and Current Pattern: Comparison between current and optimum crops pattern show large change in crops pattern, crops production and profits (Table 4).There are different changes in production parameters but in addition all parameters increased by apply Optimization. Crops production increased in different level of ownership field at all which mean was 6.15 $ton.ha^{-1}$ and Maximum growth caused in 15-20 level of ownership. Profit increased from current pattern 987$\$ha^{-1}$ at mean.

CONCLUSION

Genetical gorithm gave acceptable results to optimize crops planning. We have demonstrated the use of genetic algorithmin solving constrained crop-planning problem.The study demonstrated that crops production in study area could be increased by using optimization planning model.The optimization model developed in this study can be easily extended to any other crop planning model and a suitable model for any other agricultural production which have multi objection constraint nature.

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