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Optimized Irrigation Model - Rebuild and optimize the food system

Haodi Yan[1], Yan Feng[2], Yelin Ao[3], Jiayi Song[1]

[1]*College of Water Conservancy and Civil Engineering, Inner Mongolia Agricultural University, Inner Mongolia Autonomous Region, 010000, China*

[2]*School of Economics and Management, Inner Mongolia Agricultural University, Inner Mongolia Autonomous Region, 010000, China*

[3]*College of Computer Information and Engineering, Inner Mongolia Agricultural University, Inner Mongolia Autonomous Region, 010000, China*

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Abstract: At present, the global food system is unstable, people are facing serious food shortages, security and environmental damage and other problems.By establishing multiple linear regression model and optimizing irrigation system model, this paper studied the most influential factor of grain yield, namely effective irrigation area, by using analytic hierarchy process, and then analyzed this factor to find the conditions required by crops when the yield is optimal. Thus, the problem of grain yield is optimized. a multiple linear regression model was established. The results showed that to improve wheat yield and profitability, it was necessary to increase the irrigation amount during winter jointing to increase wheat yield.

1. Introduction

At present, China's food is facing serious shortage and security problems. With the outbreak of global epidemics (e. g., the Covid-19 epidemic) and natural disasters, food shortages and security issues have once again received high attention. According to statistics, the impact of the new epidemic on the food sector is deepening, 135 million people around the world previously faced severe food shortages, this year affected by the epidemic, and these figures are expected to increase by about 130 million people this year, to 265 million. Because of the huge demand for food, it also brings many environmental problems when it is produced. Such as: excessive application of chemical fertilizers and pesticides will make water eutrophication, soil acidification, destruction of the ozone layer in the atmosphere and harm Marine organisms. Therefore, it is of great significance to study the problems related to grain.

2. Literature review

From the perspective of influencing factors, Liu Yu et [1] al. used LMDI model to study the influencing factors of county grain production in Huang-Huai-Hai region from the perspective of cultivated land area, multiple cropping index, grain cropping ratio and grain yield per unit area. Zhou Zhi gang and Zheng Ming Liang [2] decomposed the fluctuation of grain yield in China into the following factors: yield per unit area of sowing area, planting structure, multiple cropping index and arable land change by using logarithmic mean DI index method. They found that the yield per unit area of sowing area and multiple cropping index had positive effects on grain yield increase. The change of planting structure and arable land area had negative effect on grain yield increase. Liu Shun and Huang Guo Qin [3] sorted out the statistical data from 1978 to 2010, studied the law of grain yield fluctuation in An Hui Province by using the fluctuation theory and grey correlation degree, and the research results showed that chemical fertilizer was an important factor affecting grain yield increase. Li Jian xia and Wu Yu ming [4] analyzed the influence of various factors on grain yield through the nonlinear BP network model, which proved that the network model had good validity and credibility, could effectively predict grain yield, and had high promotion value.

Through the establishment of multiple linear regression model and the use of analytic hierarchy process (AHP), we sorted the factors affecting grain yield and concluded that the effective irrigation area had the most influence on grain yield. After that, we selected the typical representative wheat to establish the efficient optimization irrigation model and obtained the efficient optimization irrigation system for water-saving wheat.

3. Notations

Table 1 Mathematical Notations

Notations	Description
Y	Explained variable
$X_1X_2....X_k$	Explaining variable
$\beta_0\beta_1\beta_2.....\beta_k$	Be estimated parameters
μ	Stochastic error term
k	Number of explanatory variables
i	Subscript the observed values

4. Multiple linear regression model

Table 2 China's total grain output from 1961 to 2016

Time	Grain output (10,000 tons)	Time	Grain output (10,000 tons)	Time	Grain output (10,000 tons)
1961	10966	1981	28645	2001	39840
1962	12042	1982	31536	2002	40000
1963	13746	1983	34563	2003	37612
1964	15236	1984	36594	2004	41357
1965	16216	1985	33988	2005	42353
1966	17761	1986	35208	2006	49804
1967	18118	1987	35924	2007	50160
1968	17713	1988	35182	2008	52871
1969	17649	1989	36764	2009	53082
1970	20084	1990	40441	2010	54648
1971	21214	1991	39846	2011	57121
1972	20652	1992	40428	2012	58957
1973	22185	1993	40793	2013	60194
1974	23464	1994	39646	2014	60703
1975	24453	1995	41866	2015	62144
1976	25021	1996	45367	2016	61624
1977	24329	1997	44593	2017	61638
1978	27304	1998	45840	2018	62044
1979	29273	1999	45519	2019	62338

5. The establishment of model

5.1 Multiple linear regression model

Regression analysis is an effective method to explore the correlation and dependence between variables. The general regression model reflects the general trend of the relationship between variables. The linear general regression model is the most common general regression model, which is simple in form and relatively easy to estimate and test the parameters. The general form of multiple linear regression model is:

$$\mathrm{Y}_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ...+ \beta_k X_{ki} + \mu_i (\mathrm{i} = 1,2...n) \quad (1)$$

Wherein, Y is the explained variable, $X_1, X_2, \cdots, X_k$ is explaining variable; $0,1,2,\cdots,k$ is the parameter to be estimated is the regression coefficient: s the random error term; k is the number of explanatory variables; i is the index of the observed value; n is sample size.

5.2 Example analysis of multiple linear regression model

Due to the different dimensionality of these four variables, in order to eliminate the impact of dimensionality on the analysis results.

Table 3 Raw figures

year	Area sown to grain crops Per thousand hectares	Effective irrigated area of cultivated land Per thousand hectares	And waterlogged area thousand hectares	Pesticide usage amount ten thousand tons
1997	112912. 10	52139.00	20526.00	119. 55
1998	113787. 40	52296.00	20681.00	123. 17
1999	113160. 98	53158.00	20681.00	132. 16
2000	108462. 54	53820. 33	20989.00	127. 95
2001	106080. 03	54249. 39	21021.00	127. 48
2002	103890. 83	54355.00	21097.00	131. 13
2003	99410. 37	54014.00	21139.00	132. 52
2004	101606. 03	54478.00	21198.00	138. 60
2005	104278. 38	55029. 34	21339.00	145. 99
2006	104958.00	55750. 50	21376.00	153. 71
2007	105638. 36	56518. 34	21419.00	162. 28
2008	106792. 65	58471. 68	21425.00	167. 23
2009	108985. 75	59261. 40	21584.00	170. 90
2010	109876. 09	60347. 70	21692.00	175. 82
2011	110573. 02	61681. 56	21722.00	178. 70
2012	111204. 59	62490. 52	21857.00	180. 61
2013	111955. 56	63473. 30	21943.00	183. 35
2014	112722. 58	64539. 53	22369.00	185. 64
2015	113342. 93	65872. 64	22713.00	187. 25
2016	114536. 84	65913. 53	22925.00	189. 34
2017	124649. 56	66374. 25	23358.00	191. 22
2018	125936. 43	66569. 34	23559.00	194. 36
2019	136055. 59	67594. 37	23849.00	195. 48
2020	136753. 34	68669. 87	24635.00	195. 87

Assume that the multiple linear regression model is:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_4 X_{4i} + \mu_i (i = 1,2,\cdots,n) \quad (2)$$

Multiple linear regression analysis was performed on the data from 1997 to 2010 in Table 3using SPSS,: As can be seen from Table 4, the value of $\overline{R}^2$ in this model is 0. 984, close to 1, indicating that this model has a good fitting effect on sample data:

Table 4 Analysis of variance for regression model

Model	Sum of squares	df	Mean Square	F	Sig
Regression	0. 000	9	0. 000	90.656	0. 000[a]
Residual	0. 000	4	0. 000		
Total	0. 000	13			

Table 4 shows the regression coefficients of each factor, and the multiple regression equation is as follows:

$$Y = 0.018 + 0.754X_1 + 0.043X_2 - 1.01X_3 + 0.383X_4 \quad (3)$$

6. Conclusion

According to the relative optimal fitting precision of graphical multivariate linear regression model can get the factors impact on China's grain output is as follows: on the premise of guarantee food crop farming area, in terms of various factors on the grain yield of: effective irrigation area of cultivated land > pesticide usage > waterlogged area, namely the increase of cultivated land efficient irrigation on crop production has a positive role in promoting.

References

[1] Liu Yu, Gao Bingbo, Pan Yuchun, et al. Analysis of the influencing factors of grain production at county level in Huang-Huai-Hai region based on LMDI model [J]. Transactions of the Chinese Society of Agricultural Engineering, 2013, 29 (21): 1-10.

[2] Zhou Zhigang, Zheng Mingliang. Decomposition of influencing factors of grain yield in China based on logarithmic mean Dittell index method [J]. Transactions of the Chinese Society of Agricultural Engineering, 2015, 31 (2): 1-6.

[3] Liu Shun, Huang Guoqin. Study on Fluctuation of Grain Yield in Anhui Province [J]. Chinese Agricultural Science Bulletin, 2012, 28 (21): 125-130.

[4] Wu Yuming, Li Jianxia, Xu Jianhua. Journal of Central China Normal University, 2002, 36 (4): 419-423. (in Chinese)

[5] Lu Xiaoqiang, Luo Gaoyuan, Yang Junhu. Grey correlation analysis of grain yield influencing factors in Hebei Province [J]. Shanxi Agricultural Sciences, 2012, 40 (2): 164-167. (in Chinese)