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EXPONENTIAL SMOOTHING MODELS FOR AGRICULTURE FOOD GRAINS

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ABSTRACT

In Time series and forecasting, there are wide range of models are there for fitting and prediction. They are regression models like Simple Regression models, Multiple Regression models, Polynomial Regression models, Logistic Regression models, Exponential models etc. Moving average models, Auto regression models, Vector Auto regression models (VAR), Generalised Autoregressive conditional Heteroscadesticity (GARCH), Auto Regressive Conditional Heteroscadesticity (ARCH) etc. In this paper, we are used Exponential Smoothing models like Simple Exponential Smoothing model, Holt linear trend model, Brow's linear trend model and Damped trend models for Agriculture data like Rice, wheat, Nutri Cereals, Pulses, Oilseeds, Sugar cane, cotton and other Food grains of ten years data from 2008 to 2017. By using Root Mean Square Error criteria, We estimate best models for Agriculture data among four Exponential Smoothing models.

KEYWORDS: Agriculture data, exponential smoothing models, root mean square error criteria.

INTRODUCTION

Agriculture plays major role in India. Agriculture employees more than 50 per cent of the Indian workforce and it contributes around 17-18 per cent to country GDP. In India, Agriculture is primary source for 50 per cent of population livelihood. Green Revolution in India was started on 1956 by M.S. Swaminathan for practice of traditional agriculture. Traditional farming included better irrigation systems, mixed cropping and planting of species. Green Revolution focused on two growth of high yielding varieties of plants and grains. This way highly practice spread by states of India like Punjab, Haryana, Western Uttar Pradesh, Tamil Nadu and Kerala. The state of Punjab led India's green Revolution and earned the distinction of being country's bread basket. Indian irrigation is mainly depending upon the canals and rivers and ground water well based system, tanks etc. Around two-third of Cultivation land in India is dependent on Monsoon and only 35 per cent of Agricultural Land in India was reliability irrigated.

The major and important agricultural production in India are Rice, Buffalo Milk, cow milk, Wheat, cotton, Mangoes, guavas, Fresh Vegetables, Chicken meat, potatoes, Bananas, Sugarcane, Maize, Oranges, Tomatoes, Chickpeas, Okra, Soyabeans, Hen Eggs, Cauli flower and Broccoli and onions. As per Agricultural Statistics, India grown is become the world's largest producer of fresh fruits, lemons and limes, Buffalo milk, whole fresh, castor oilseeds, Sunflower seeds sorghum, Millet, Spices, Jute, Beswar, nuts, papayas, chillies, peppers, Goat Milk, Coriander etc. As per old records, India is the second largest products of wheat, Rice, fresh vegetables, sugar cane, groundnuts with shells, lentils, garlic, cauliflowers and broccoli and green peas, sesame seeds, cashewnut with shells, Silkworm cocoons, cow milk, tea, potatoes, onions, cotton lint, cotton seeds, egg plants, nutmeg, cabbages, pumpkins, squash and gourds etc.

REVIEW OF LITERATURE

Ghosh *et al.* (2021) gave "conservational Tillage and weed management practices enhances farmers income and system productivity of Rice-wheat cropping system in central indices. They shifted farmer from conventional tillage practice to conservational tillage practice for crop cultivation of central indices by premix and trunk mix process to yield of rice-wheat cropping system. Khalili (2020) gave "Regression Analysis for yield comparison of saffron as affected by physiochemical properties of the soil case study in Northeast of Iran. They carried out research in two regions of Ghayen and Vamersan of Iran from 2015 to 2017. They taken samples of 30 saffron with three replications i.e. 90 saffrons samples from 3 to 5 years old farms. The parameters of the samples are texture, total nitrogen, available phosphorous and potassium PH, organic matter and electrical conductivity.

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Performed regression analysis by yield as Dependent variable are remaining all are independent variables and method used is least squares method. Govindaraj *et al.* (2020) given "Genetic variables, Diversity and interrelationship for Twelve Grain Minerals in 122 commercial pearl millet cultivators in India". They used Randomized Complete Block design with three replications at two locations of Patancheru and Mandor to aims of profile cultivate nutrition, diversity and interrelationship for grain minerals. Rai *et al*. (2016) gave article on Grain iron and zinc densities in release and commercial cultivators of pearl millet.

METHODOLOGY

For Fitting and Forecasting of Agricultural data, we are using Simple Exponential smoothing, Holt Linear trend model, Brown's linear trend model and Damped trend models for Rice, wheat, NutriCereals, Pulses, oilseeds, sugarcane, cotton and other food grains of ten year data *i.e.* from 2008 to 2017 of percentage share.

Exponential Smoothing Model

It was proposed by Brown, Holt and Winters in late 1950's. It was the most successful forecasting methods. Forecasts produced using exponential smoothing methods are weighted averages of past observations with the weights decaying exponentially as the observations get older. In similar manner as, the more recent observation higher than associated weight. There are many exponentially smoothing models but we are using.

1) Simple Exponential Smoothing model (or)
   Single Exponential Smoothing model.

If forecast is denoted with F_t and our original time series model is Y_t and Forecast Error is $Y_t - F_t$. The method of Simple Exponential Smoothing model for next forecast period becomes

$$F_{t+1} = F_t + á\,(Y_t - F_t)$$

The above equation is new forecast is simpler than old forecast plays an adjustment for the error that occurred in the last forecast. When

Effect of á

i) á is close to 1 – the new forecast will include a substantial adjustment for the error in the previous forecast.

ii) á is close to 0 – the new forecast will include very little adjustment.

Thus the effect of á is large or small is analogous to the effect of including a small or a large number of observations when computating a moving average.

Holt's Linear method

It is extension of simple exponential smoothing model to allow forecasting of data with trends. Holt's linear exponential smooth method contains two constants á and â which takes values from 0 to 1 and their equations are

$$L_t = áY_t + (1-á)(L_{t-1} + b_{t-1})$$

$$B_t = â(L_t - L_{t-1}) + (1-â)b_{t-1}$$

$$F_{t+m} = L_t + b_{t-m}$$

where L_t = an estimate of the level of the series at time t.

B_t = slope of the series at time t.

F_{t+m} = Forecast Equation

Brown's Exponential Smoothing

Brown's Exponential Smoothing is suitable for Linear Trend Model.

The Brown's Equation is

$$F_{t+m} = a_t + b_t^m$$

$$A_t = áy_t + (1-á)A_{t-1}$$

$$A_t'' = áA_t + (1-á)A_{t-1}''$$

$$A_t = 2A_t - A_t''$$

$$b_t = \frac{\alpha}{1-\alpha}\,(A_t - A_t'')$$

where A_t = Simple Exponential smoothed Statistic

A_t'' = Double Exponential Smoothed Statistic

A_t = estimate of $â_0$ at time t and

B_t = estimate of $â_t$ at time t

Damped Trend Exponential method:

The damped trend method can be written in several different forms. The original recurrence form is written as

$$l_t = áy_t + (1-á)(l_{t-1} + öb_{t-1})$$

b_t = â(l_t – l_{t-1}) + (1-â)öb_{t-1}

$y_{t+n/t}$ = l_t + (ö + ö^2+…..ö^n)b_t

where l_t = level

b_t = trend

á = smoothing parameter of level

â = smoothing parameter of trend

ö = damping or autoregressive parameters

These parameters á, â and ö are also lies between 0 d" á d" 1, 0 d" â d" 1 and 0 d" ö d" 1.

Root Mean Square Error Criteria

The difference between original observations (Y_t) and Estimated Observations (F_t) is Error (E_t)

$$\text{Error}(E_t) = Y_t - F_t$$

Positive square root of mean of squared Error observations gives Root Mean Square Error(RMSE).

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(Y_i - F_i)^2}{n}}$$

RESULTS AND DISCUSSION

Empirical Investigations

For 8 items of agricultural data *i.e.* Rice, wheat, Nutricereals, pulses, oilseeds, Sugarcane, Cotton and other food grains for ten years i.e. 2008 to 2017 we fitted Simple Exponential Smoothing model, Holt Linear model, Brown's Linear Trend model and Damped Trend models as follows. Table 1 and Table 2 gives Simple Exponential Smoothing model parameter estimates, Model Statistics is as follows.

Table 1. Exponential Smoothing Model Parameters

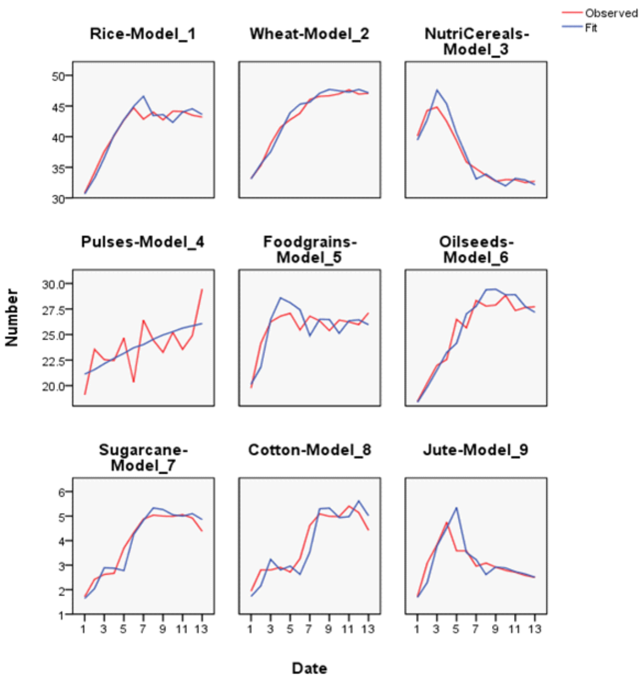
Model	Estimate	SE	t	Sig.
Rice	0.824	0.107	7.733	0.000
Wheat	0.911	0.108	8.418	0.000
NutriCereals	1.000	0.076	13.081	0.000
Pulses	0.261	0.117	2.240	0.045
Foodgrains	0.912	0.088	10.306	0.000
Oilseeds	0.613	0.119	5.159	0.000
Sugarcane	0.908	0.112	8.098	0.000
Cotton	1.000	0.105	9.483	0.000
Jute	0.813	0.110	7.365	0.000

Table 2. Model Statistics

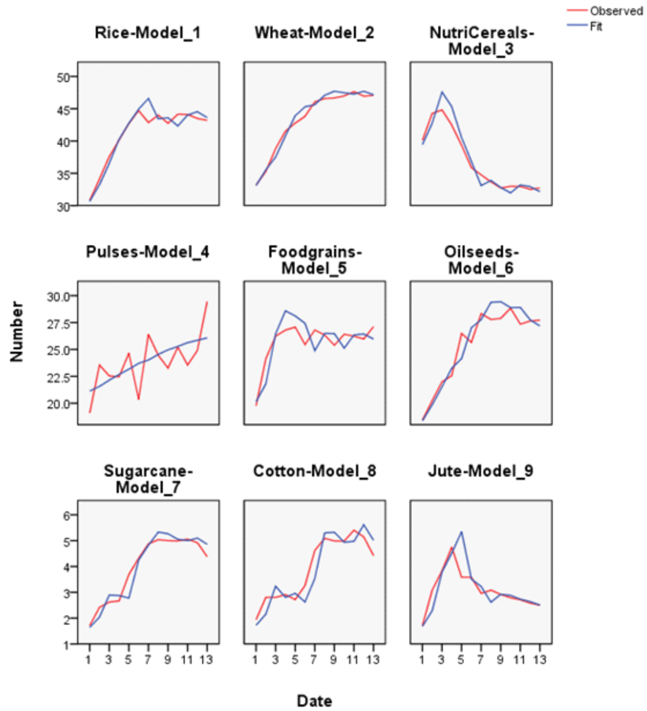
Model	Model Fit statistics			Ljung-Box Q(18)			Number of outliers
	Stationary R-squared	R-squared	RMSE	Statistics	DF	Sig.	
Rice	0.271	0.861	1.618	0	0	0	0
Wheat	0.035	0.959	1.468	0	0	0	0
NutriCereals	-0.049	0.886	2.772	0	0	0	0
Pulses	0.799	-0.044	2.655	0	0	0	0
Food grains	0.077	0.355	6.537	0	0	0	0
Oilseeds	0.625	0.787	2.647	0	0	0	0
Sugarcane	-0.027	0.900	0.382	0	0	0	0
Cotton	-0.060	0.768	1.160	0	0	0	0
Jute	0.269	0.129	0.166	0	0	0	0

The below graphs represents the observed values and fitted values for Rice, Wheat, nutricereals, Pulses, Oilseeds, Sugarcane, Cotton, other grains.

The fitted Holt's Linear model parameter Estimates and Model summary statistics for Rice, Wheat, Nutricereals, Pulses, Oilseeds, Sugarcane, Cotton and other grains is tabulated in below Table 3 and 4.



The observed values and fitted i.e Holt Linear model values for the graph is as follows



Brown's Linear model for Agriculture variables are Rice, Wheat Nutricereals, Pulses, Oilseeds, Sugarcane, Cotton and other grains is listed below with their parameter estimates in Table 5 and Model statistics values in Table 6.

Table 3. Holt's Exponential Smoothing Model Parameters

Model		Estimate	SE	t	Sig.
Rice	Alpha (Level)	0.700	0.291	2.405	0.035
	Gamma (Trend)	1.000	0.749	1.335	0.209
Wheat	Alpha (Level)	0.599	0.259	2.317	0.041
	Gamma (Trend)	1.000	0.679	1.473	0.169
NutriCereals	Alpha (Level)	1.000	0.265	3.772	0.003
	Gamma (Trend)	1.000	0.464	2.157	0.054
Pulses	Alpha (Level)	0.108	0.095	1.135	0.280
	Gamma (Trend)	1.968E-006	0.103	1.914E-005	1.000
Foodgrains	Alpha (Level)	0.788	0.256	3.078	0.011
	Gamma (Trend)	1.000	0.566	1.768	0.105
Oilseeds	Alpha (Level)	0.400	0.281	1.423	0.182
	Gamma (Trend)	1.000	0.932	1.073	0.306
Sugarcane	Alpha (Level)	1.000	0.304	3.292	0.007
	Gamma (Trend)	0.599	0.517	1.160	0.271
Cotton	Alpha (Level)	1.000	0.344	2.909	0.014
	Gamma (Trend)	0.001	0.226	0.003	0.998
Jute	Alpha (Level)	0.794	0.261	3.042	0.011
	Gamma (Trend)	1.000	0.593	1.685	0.120

Table 4. Holt's Exponential Smoothing Model Statistics

Model	Model Fit statistics			Ljung-Box Q(18)			Number of Outliers
	Stationary R-squared	R-squared	RMSE	Statistics	DF	Sig.	
Rice	0.377	0.892	1.490	0	0	0	0
Wheat	0.252	0.966	1.401	0	0	0	0
NutriCereals	-0.050	0.886	2.896	0	0	0	0
Pulses	0.862	0.385	2.129	0	0	0	0
Foodgrains	0.151	0.428	6.434	0	0	0	0
Oilseeds	0.744	0.878	2.094	0	0	0	0
Sugarcane	0.012	0.905	0.389	0	0	0	0
Cotton	0.179	0.800	1.124	0	0	0	0
Jute	0.297	0.254	0.160	0	0	0	0

Table 5. Brown's Exponential Smoothing Model Parameters

Model		Estimate	SE	t	Sig.
Rice	Alpha (Level and Trend)	0.824	0.107	7.733	0
Wheat	Alpha (Level and Trend)	0.911	0.108	8.418	0
NutriCereals	Alpha (Level and Trend)	1.000	0.076	13.081	0
Pulses	Alpha (Level and Trend)	0.261	0.117	2.240	0
Foodgrains	Alpha (Level and Trend)	0.912	0.088	10.306	0
Oilseeds	Alpha (Level and Trend)	0.613	0.119	5.159	0
Sugarcane	Alpha (Level and Trend)	0.908	0.112	8.098	0
Cotton	Alpha (Level and Trend)	1.000	0.105	9.483	0
Jute	Alpha (Level and Trend)	0.813	0.110	7.365	0

Table 6. Brown's Model Statistics

Model	Model Fit statistics			Ljung-Box Q(18)			Number of Outliers
	Stationary R-squared	R-squared	RMSE	Statistics	DF	Sig.	
Rice	0.271	0.863	1.618	.	0	.	0
Wheat	0.035	0.959	1.468	.	0	.	0
NutriCereals	-0.049	0.886	2.772	.	0	.	0
Pulses	0.799	-0.044	2.655	.	0	.	0
Foodgrains	0.077	0.355	6.537	.	0	.	0
Oilseeds	0.625	0.787	2.647	.	0	.	0
Sugarcane	-0.027	0.900	0.382	.	0	.	0
Cotton	-0.060	0.768	1.160	.	0	.	0
Jute	0.269	0.129	0.166	.	0	.	0

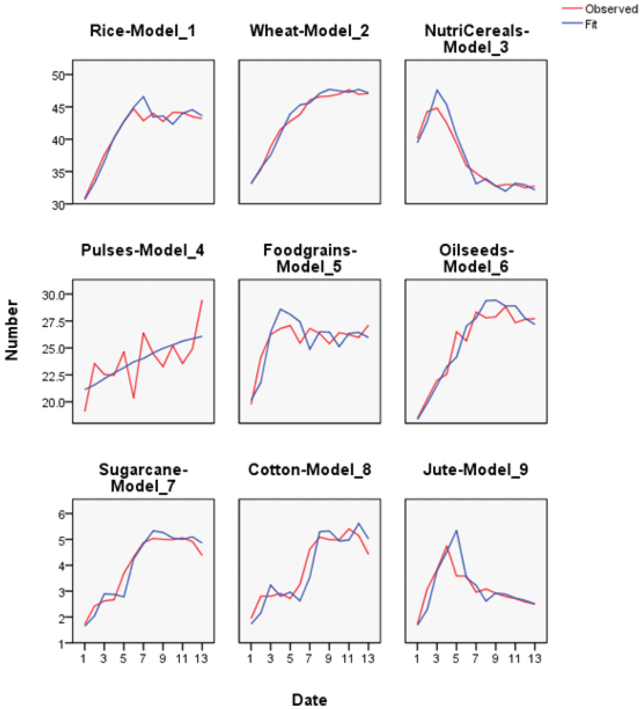
Table 7. Damped Exponential Smoothing Model Parameters

Model		Estimate	SE	t	Sig.
Rice	Alpha (Level)	0.679	0.378	1.793	0.103
	Gamma (Trend)	0.999	1.101	0.907	0.386
	Phi (Trend damping factor)	0.878	0.124	7.103	0.000
Wheat	Alpha (Level)	0.527	0.310	1.701	0.120
	Gamma (Trend)	0.999	0.968	1.032	0.326
	Phi (Trend damping factor)	0.925	0.066	14.092	0.000
NutriCereals	Alpha (Level)	1.000	0.468	2.138	0.058
	Gamma (Trend)	1.000	1.247	0.802	0.441
	Phi (Trend damping factor)	0.800	0.293	2.732	0.021
Pulses	Alpha (Level)	0.028	0.707	0.039	0.969
	Gamma (Trend)	0.999	30.455	0.033	0.974
	Phi (Trend damping factor)	0.961	0.221	4.341	0.001
Foodgrains	Alpha (Level)	0.723	0.379	1.908	0.086
	Gamma (Trend)	1.000	1.318	0.759	0.466
	Phi (Trend damping factor)	0.816	0.214	3.813	0.003
Oilseeds	Alpha (Level)	0.399	0.407	0.981	0.349
	Gamma (Trend)	0.999	1.395	0.716	0.490
	Phi (Trend damping factor)	0.920	0.094	9.802	0.000
Sugarcane	Alpha (Level)	1.000	0.421	2.376	0.039
	Gamma (Trend)	0.616	0.949	0.649	0.531
	Phi (Trend damping factor)	0.838	0.248	3.382	0.007
Cotton	Alpha (Level)	1.000	1.240	0.807	0.439
	Gamma (Trend)	1.000	5.772	0.173	0.866
	Phi (Trend damping factor)	0.500	1.086	0.461	0.655
Jute	Alpha (Level)	0.753	0.520	1.449	0.178
	Gamma (Trend)	1.000	1.798	0.556	0.590
	Phi (Trend damping factor)	0.752	0.312	2.412	0.037

Table 8. Damped Exponential Smoothing Model Statistics

Model	Model Fit statistics			Ljung-Box Q(18)			Number of Outliers
	Stationary R-squared	R-squared	RMSE	Statistics	DF	Sig.	
Rice	0.401	0.904	1.470	.	0	.	0
Wheat	0.518	0.970	1.364	.	0	.	0
NutriCereals	0.438	0.905	2.781	.	0	.	0
Pulses	0.596	0.418	2.172	.	0	.	0
Foodgrains	0.210	0.522	6.166	.	0	.	0
Oilseeds	0.381	0.886	2.121	.	0	.	0
Sugarcane	0.254	0.913	0.391	.	0	.	0
Cotton	0.071	0.814	1.136	.	0	.	0
Jute	0.191	0.376	0.154	.	0	.	0

The observed values and fitted i.e Brown's Linear model values for the graph is as follows

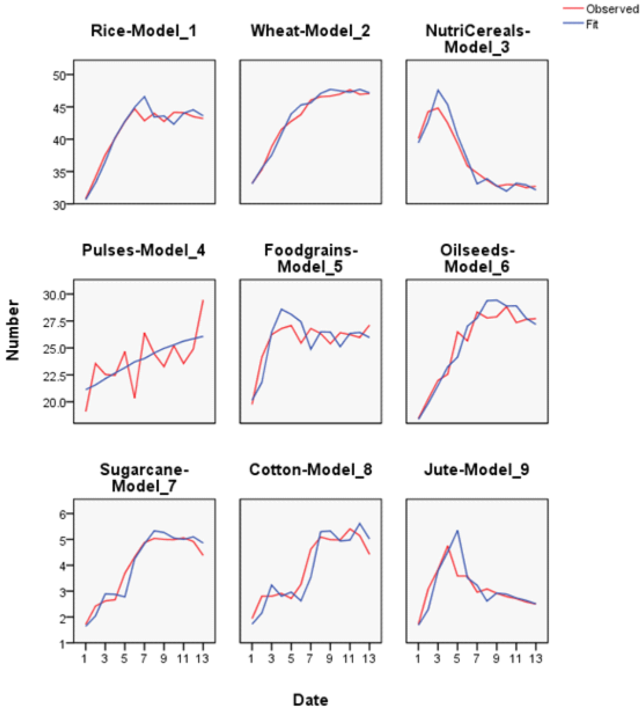


'á', 'â' and 'ö' i.e. level, Trend and Trend damping factor estimates of damped Exponential Smoothing model parameter estimates and its model statistics summary for Rice, Wheat, Nutricereals, Pulses, Oilseeds, Sugarcane, Cotton and other grains are as in Table 7 and Table 8 respectively.

Table 9. RMSE values for food varieties

Varieties	SES	HES	BES	DES
Rice	0.861	0.892	0.861	0.904
Wheat	0.959	0.966	0.959	0.970
Nutricereals	0.886	0.886	0.886	0.905
Pulses	-0.044	0.385	-0.044	0.418
Oilseeds	0.355	0.428	0.355	0.522
Sugarcane	0.787	0.878	0.787	0.886
Cotton	0.900	0.905	0.900	0.913
Other Grains	0.768	0.800	0.768	0.814

The below graph explains the fitted observations and observed values for eight Agricultural products i.e. Rice, Wheat, Nutricereals, Pulses, Oilseeds, Sugarcane, Cotton and other grains is as follows



By observing Root Mean Square Error values, we conclude that Damped Exponential Smoothing(SES) model is the best for Rice, Wheat, Nutricereals and Oilseeds is the best fit for Holt's Exponential model, For Sugar Cane and cotton for DES is the best and Damped Exponential model is the best for other grains.

CONCLUSION

There are mainly some agricultural products such as Rice, Wheat, Nutricereals, Pulses, Oilseeds, Sugarcane, Cotton and other grains. We are fitted Simple Exponential Smoothing model, Holt's Linear Exponential Smoothing models, Brown's Exponential Smoothing model and damped Exponential Smoothing model. The fitted estimated values and Root Mean Square Error values for Best fitted is as follows.

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Model	Variety	RMSE
DES	Rice	**0.904**
DES	Wheat	0.970
DES	Nutricereals	0.905
DES	Pulses	0.418
DES	Oilseeds	0.522
DES	Sugarcane	0.886
DES	Cotton	0.913
DES	Other grains	0.814

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