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Research Article

Study of Factors of Production on Productivity of Black Pepper and its Sustainability

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Abstract

Black Pepper is a pungent hot-tasting powder spice prepared from dried and ground peppercorns, used to flavor food. It is also known as king of spices because it contains rich anti-oxidants and other nutrients. The high demand for pepper presents an attractive market opportunity for new vendors to enter the market. In present study data related to productivity of black pepper collected for Kerala, Karnataka and whole India. Present investigation effect of different factors showed in productivity of black pepper using step down regression as well as principal component analysis. Productivity found to have linear relationship with developed scores to an extent of 78%, 86%, 77% in Kerala, Karnataka and whole India. Karnataka showing higher sustainability on yield of black pepper.

Keywords: Black Pepper; Regression Analysis; Principal Component Analysis; Sustainability

Introduction

Black pepper has so many medicinal uses. It often used to cure stomach upset, bronchitis, and cancer. It is sometimes applied directly to the skin for treating nerve pain(neuralgia) and a skin disease called scabies. Black peppers are also used typically as a counterirritant for pain. Black pepper market is directly influenced by the growing processed food industry. The rise in consumption of bakery products, confectionery products, and ready-to-eat and ried food in the developed economies is driving the market for the spice. Sustainability is multidimensional, multifariously defined (by various authors for various specific purposes) contested phenomenon. In spite of its contested nature, there is an overall agreement that it is multi-faced and therefore needs to be assessed across several dimensions. In its simplest form, it can be accessed from economic, social and bio-physical aspects. Mishra., *et al.* [1] considered the relationship with wheat productivity using regression analysis. Mishra., *et al.* [2] studied factors like fertilizers, environmental factors etc. affecting the production of cumin in India. In present Investigation, study has been made for the factors like fertilizers, environmental factors etc. affecting the productivity of black pepper in India and its sustainability.

Material and Methods

To analyse the productivity of major spices namely Black pepper in India, national level and by following the relative contribution of each and every states production to total India production, the major growing states. For black pepper the major states are Kerala and Karnataka and data collected for 1970-2012 (From spices board of India).

Regression

Regression is the measure of the average relationship between two or more variables in terms of the original units of the data. If two variables are correlated, unknown value of one of the variables can be estimated by using the known value of the other variable. Estimated value may not be equal to the actually observed value, but it will be close to the actual value. In a wider usage, regression is the theory of estimation of unknown value of a variable with the help of known values of the variables. For a bivariate data on x and y, the regression equation obtained with the assumptions that x is dependent on y is called regression of x on y. the regression of x on y is:

$$(x - \bar{x}) = b_{xy}(y - \bar{y})$$

The regression equation obtained with the assumption that y is dependent on x is called regression of y on x. the regression of y on x is:

$$(y - \bar{y}) = b_{yx}(x - \bar{x})$$

Here, the constants bxy and byx are the regression coefficients. They are:

$$b_{xy} = \frac{r\sigma_x}{\sigma_y} = \frac{n\sum xy - (\sum x)(\sum y)}{n\sum y^2 - (\sum y)^2} \; or \; b_{xy} = \frac{Cov(x,y)}{var(y)}$$

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Step-up and step-down regression

While dealing with a greater number of variables in regression analysis, particularly when all the variables are not equally important or efficient in describing the relationships, it becomes difficult to decide on which are the variables to be retained in the multiple regression equation. We generally follow two procedures (a) stepwise forward and (b) step- down backward regression technique to get the actual relationship.

Step-wise regression

Simultaneous addition and deletion of explanatory variables takes place. The procedure starts off by choosing an equation containing the single best X variable and then attempts to build up with subsequent additions of X's one at a time as long as these additions are worthwhile. The order of addition is determined by using the partial F-test values to select which variable should enter next. The highest partial F-value is compared to a (selected or default) F-to-enter value. After a variable has been added, the equation is examined to see if any variable should be deleted.

Significance of the model

The significance of the regression model was tested using F statistic. Here the null hypotheses were set as, H_0: β = 0

Test statistic

$$F = \frac{RSS/(n-2)}{ESS/(n-k)}$$

where, Regression sum of squares (RSS) = $\sum(b_i)(\sum x_i y)$

Error sum of squares (ESS) = $\sum y^2$ - SSR

Association of the factors of production with productivity

One of the emphases of the present study is to assess the association of factors of production and spices production in India. Production scenarios of the major spices are assumed to be influenced by climatic factors like rainfall, temperature and subsequently would affect the productivity of these crops significantly. Agricultural production depends not only on climate related variables, but also on use of several factors like fertilizer consumption. For the purpose of present study, the following functional model will be assumed.

Y= f (RF, Tmax, Tmin, N, P, K)

where

Y: Black pepper productivity (kg per hectare)

RF: Rainfall (mm)

Tmax: Mean maximum temperature (0C)

Tmin: Mean minimum temperature (0C)

N: Total nitrogen fertilizer consumption

P: Total phosphorous fertilizer consumption

K: Total potash fertilizer consumption

Principal component analysis

One of the major problems in multiple regression analysis is the problem of multicollinearity among the explanatory variables. This problem is compounded when the number of variables is too large. Principal component analysis is a data reduction procedure to develop a smaller number of artificial variables (called principal components) that will account for most of the variances in the dependent variable as per the respective stage development. Based on the theoretical arguments of the PCA described by Hair., et al. [3] the significant factor loading values higher than or equal to 0.7 were used to identify the most important variables and attributes in each dimension, or principal components (PCs).

Often a small number of principal components can be used in place of a huge no. of original variables for plotting, regression, clustering and so on. Principal component analysis can also be viewed as a technique to bypass multicollinearity in the data.

Estimation of the principal component model

Let us assume that with above procedure one has retained r (where r < k) out of all the principal components. For simplicity let r = 2 and k = 4, so that;

$$P_1 = l_{11} Z_1 + l_{12} Z_2 + l_{13} Z_3 + l_{14} Z_4$$
$$P_2 = l_{21} Z_1 + l_{22} Z_2 + l_{23} Z_3 + l_{24} Z_4$$

(Where the Z's are the standardised value of the original X's).

We regress Y on the chosen (extracted) principal components;

$Y = \gamma_1 P_1 + \gamma_2 P_2 + \nu$

(Where v is a random variable satisfying the usual assumption) from which we obtain the OLS estimates $\hat{\Upsilon}_1$ and $\hat{\Upsilon}_2$.

Estimation of the structural parameters, b's

Given the $\hat{\alpha}$'s (or $\hat{l}$'s) and the $\hat{\gamma}$'s one can transform back from the $\hat{\gamma}$'s to obtain estimates of the b's, the coefficients of the standardised X's in the original model.

Let original model be;

$Y = b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + \mu$ and X_1, X_2, X_3 and X_4 are supposed to be multicollinear in nature and as such we form two PC's P_1 and P_2 which explain majority of the variability in the data set.

The principal components model is;

$$Y = \gamma_1 P_1 + \gamma_2 P_2 + v$$

Substituting

$$P_1 = \hat{a}_{11} Z_1 + \ldots\ldots + \hat{a}_{41} Z_4 = \hat{l}_{11} Z_1 + \ldots\ldots + \hat{l}_{14} Z_4$$
$$P_2 = \hat{a}_{12} Z_1 + \ldots\ldots + \hat{a}_{42} Z_4 = \hat{l}_{12} Z_1 + \ldots\ldots + \hat{l}_{24} Z_4$$

into the principal components model, one gets

$$Y = \hat{\Upsilon}_1(\hat{a}_{11}Z_1 + \hat{a}_{21}Z_2 + \hat{a}_{31}Z_3 + \hat{a}_{41}Z_4) + \hat{\Upsilon}2(\hat{a}_{12}Z_1 + \ldots\ldots + \hat{a}_{42}Z_4).$$

After rearranging obtain

$$Y = (\hat{\gamma}_1\hat{a}_{11} + \hat{\gamma}_2\hat{a}_{12})Z_1 + (\hat{\gamma}_1\hat{a}_{21} + \hat{\gamma}_2\hat{a}_{22})Z_2 + (\hat{\gamma}_1\hat{a}_{31} + \hat{\gamma}_2\hat{a}_{32})Z_3 + (\hat{\gamma}_1\hat{a}_{41} + \hat{\gamma}_2\hat{a}_{42})Z_4$$
$$\hat{\gamma}_1\hat{a}_{11} + \hat{\gamma}_2\hat{a}_{12} = \hat{b}_1$$
$$\hat{\gamma}_1\hat{a}_{21} + \hat{\gamma}_2\hat{a}_{22} = \hat{b}_2$$
$$\hat{\gamma}_1\hat{a}_{31} + \hat{\gamma}_2\hat{a}_{32} = \hat{b}_3$$
$$\hat{\gamma}_1\hat{a}_{41} + \hat{\gamma}_2\hat{a}_{42} = \hat{b}_4$$

This $\hat{b}$'s are the principal component estimates of the original variables. If retain all (k=4) principal components the coefficients of the standardised X's would be identical with those obtained by the straight forward application of OLS of Y on the standardised X's.

Sustainability index (SI)

Singh., *et al.* [4] has given the following measures of sustainability. Sustainability Index (SI) = $\frac{\bar{y} - s}{y_{\max}}$, where is the average yield of a treatment, s is the standard deviation of yields over the years and ymaxis the maximum yield of a treatment in any year. Higher the value of the index, higher is the sustainability status.

Sahu., *et al.* [5]: a sustainability index value closer to zero is the most desirable value.

$$SI = \frac{Y_{\max} - \bar{Y}}{\bar{Y}}$$

Pal and Sahu [6]: $SI = \frac{s_i}{\bar{y}_i} \cdot \frac{1}{s_{\max}}$ lower the value of the sustainability index higher is the sustainability.

Proposed method- I (SI- I)

In present study, $SI = \frac{Y_{\max} - Y_{\min}}{\bar{Y}}$ s introduced to measures the sustainability of the major spices. Sustainability index value closer to zero is the most desirable value. The new measure found to be fitted with already existing sustainability measures. It is modified measure that the index given by Sahu., *et al.* [5].

Results and Discussion

Crop productivity not only depends on whether parameters (rainfall, minimum and maximum temperature) but also on management factors (fertilizer application, irrigation, pesticide use, management practices etc.). As these factors play important role in every stage of crop growth, associations of these factors with crop production has greater importance. As production is an aggregate of area and productivity, factors influencing production needs to be correlated with productivity. As it is very difficult to get long term crop wise use of fertilizer, in this study total consumption of nutrient in the particular state have been considered. In this section attempts have been made to work out the degree of linear association and linear relationship of productivity with three major weather factors (*viz.* Rainfall, T_{min}, T_{max}) and totality of major plant nutrients (*viz.* Nitrogen, Phosphorous and Potassium) with productivity of major spices in selected states and India [7].

Regression analysis of factor affecting the productivity of black pepper in major states of India

In order to find out the relationship of black pepper productivity with factors multiple linear regression equations are fitted. The most important factors influencing crop productivity is identified by using step-down regression analysis (Table 1). A significant positive coefficient of potassium fertilizer on productivity of black pepper is noticed in Kerala. A unit change in potassium fertilizers consumption would lead to an increased productivity of black pepper by 1.227 kg per hectare. The T_{max} and T_{min} cause significant positive and negative coefficient on productivity of black pepper in Karnataka. A unit change in T_{max} would lead to an increased productivity of black pepper by 9.064 kg per hectare and T_{min} would lead to decreased productivity of black pepper by -9.095 kg per hectare. In case of whole India use nitrogen, fertilizer is found to have significant positive coefficients on black pepper productivity. A per unit change in use nitrogen fertilizer would leads to increase in black pepper productivity by 0.007 kg per hectare. From the above table it is clearly visible that not all factors are equally effective on productivity of black pepper. Moreover, in different state there exits different factors effecting productivity of black pepper. From the regression analysis it is evident that the factors consider in the analysis can explain the productivities to the extent of 59% in Kerala. That means some more factors are required to be explored to explain the productivity of black pepper and which may be a future extension of this work. In this direction crop wise nutrient consumption data may also help. As such the present study also attempted principal component analysis, as discussed in material and methods section.

Kerala						
Model		**B**	**SE**	**Sig.**	**R^2**	**Adj. R^2**
A	Intercept	4121.96	12749.17	0.75	0.59	0.52
	N	0.31	0.66	0.64		
	P	-1.53	1.17	0.20		
	K	1.56	0.59	0.01		
	RF	0.01	0.01	0.50		
	T_{max}	-545.41	1668.84	0.75		
	T_{min}	554.93	1666.16	0.74		
B	(Constant)	199.76	11.04	0.00	0.55	0.54
	K	1.23	0.17	0.00		
Karnataka						
Model		**B**	**SE**	**Sig.**	**R^2**	**Adj. R^2**
A	(Constant)	-9021.20	4576.50	0.06	0.53	0.51
	N	-0.02	0.03	0.64		
	P	0.05	0.06	0.43		
	K	-0.03	0.07	0.68		
	RF	0.01	0.01	0.63		
	T_{max}	925.76	454.73	0.05		
	T_{min}	-930.10	455.68	0.05		
B	(Constant)	-8834.86	4249.85	0.04	0.52	0.48
	T_{max}	906.04	422.13	0.04		
	T_{min}	-909.35	422.75	0.04		
India						
Model		**B**	**SE**	**Sig.**	**R^2**	**Adj. R^2**
A	(Constant)	217.05	363.66	0.55	0.55	0.48
	N	0.02	0.01	0.02		
	P	-0.01	0.02	0.47		
	K	-0.01	0.03	0.67		
	RF	0.01	0.05	0.83		
	T_{max}	9.29	20.73	0.66		
	T_{min}	-18.44	24.45	0.46		
B	(Constant)	219.38	9.40	0.00	0.51	0.50
	N	0.01	0.00	0.00		

Table 1: Regression analysis of factor affecting the productivity of black pepper in major states of India.

Note: A is full model; B is step-down regression model.

Principal component analysis of factors effecting productivity of black pepper in major states of India:

Results of principal component analysis of factors effecting productivity of black pepper is presented in table 2. From the table it is clearly visible that in Kerala first three PCs explain approximately 98.13 percent of total variability, with PC1 (67.43%), PC2 (16.55%), PC3 (14.16%). Similarly, for Karnataka PC1, PC2, PC3 explains 67.28%, 16.89%, 14.33% respectively of its data variability, altogether explaining 98.50 percent of the total variability of six variables. Considering whole India first three PCs explains 95.53 percent variability with PC1 (52.63%), PC2 (29.27%), PC3 (13.64%) respectively. In all data sets first three PCs explain more than 90 percent of the variability in productivity of black pepper.

	Kerala						Karnataka					
	PC1	PC2	PC3	PC4	PC5	PC6	PC1	PC2	PC3	PC4	PC5	PC6
N	0.94	-0.28	-0.09	0.02	-0.19	0.00	0.95	0.09	-0.26	-0.14	0.10	0.00
P	0.90	-0.39	-0.11	0.16	0.10	0.00	0.93	0.12	-0.32	-0.07	-0.13	0.00
K	0.91	-0.36	-0.06	-0.19	0.07	0.00	0.91	0.04	-0.36	0.20	0.03	0.00
RF	0.44	0.03	0.90	0.01	0.00	0.00	0.07	0.96	0.26	0.02	0.00	0.00
Tmax	0.82	0.56	-0.10	0.00	0.01	0.01	0.85	-0.18	0.50	0.01	0.00	0.01
Tmin	0.82	0.56	-0.10	0.00	0.01	-0.01	0.85	-0.18	0.50	0.01	0.00	-0.01
Eigan Value	4.05	0.99	0.85	0.06	0.05	0.00	4.04	1.01	0.86	0.06	0.03	0.00
% of Variance	67.43	16.55	14.16	1.04	0.83	0.00	67.28	16.89	14.33	1.05	0.44	0.00
Cumulative %	67.43	83.98	98.13	99.17	100.00	100.00	67.28	84.17	98.50	99.55	100.00	100.00
	India											
	PC1	PC2	PC3	PC4	PC5	PC6						
N	0.97	-0.16	-0.10	-0.10	0.13	0.05						
P	0.97	-0.16	-0.14	0.01	0.03	-0.09						
K	0.95	-0.13	-0.18	0.15	-0.14	0.03						
RF	0.50	0.03	0.86	-0.02	-0.02	0.00						
Tmax	0.16	0.94	0.01	0.30	0.06	0.00						
Tmin	0.30	0.90	-0.11	-0.30	-0.05	0.00						
Eigan Value	3.16	1.76	0.82	0.21	0.04	0.01						
% of Variance	52.63	29.27	13.64	3.56	0.72	0.19						
Cumulative %	52.63	81.89	95.53	99.09	99.81	100.00						

Table 2: Principal component analysis of factors effecting productivity of black pepper in major states of India.

Regression analysis between factors scores and yield of black pepper in major states in India

The principal components having Eigen value of more than 0.7 are used to get the principal component scores and productivity of black pepper are regressed on these scores and presented in table 3. Results of analysis revealed that, scores developed from all the selected PCs are found that in Kerala, Karnataka and whole India, the first and second PCs cause significant effect on the productivity of black pepper while third PCs in both states remains insignificant. The black pepper productivity found to have linear relationship with developed scores to an extent of 78%, 86%, 77% in Kerala, Karnataka and whole India.

State	Regression Equation	R^2	Adj. R^2
Kerala	Y= 270.651+31.033PC1**-6.625PC2*+1.779PC3	0.788	0.698
Karnataka	Y=237.674-0.334PC1*+1.5PC2*-0.004PC3	0.864	0.752
India	Y=272.674+29.457PC1**-7.433PC2*+0.402PC3	0.772	0.732

Table 3: Regression analysis between factors scores and yield of black pepper in major states in India.

Note: ** 1% level of significance, * 5% level of significance.

Yield sustainability analysis of black pepper

Sustainability in yield of black pepper in different states along with whole India has been measured with the help of sustainability indices which are already in literature and proposed method i.e., SI- 1 as described in the materials and method section. From the table 4, it is clear that Karnataka showing higher sustainability in yield of black pepper as per the indices of Singh., *et al.* Sahu., *et al.* Pal and Sahu and proposed method. By and large from the table it is clear that results of existing measures and proposed measure are almost in conformity with each other.

Yield Sustainability Index	Kerala	Karnataka	India
Singh *et al.*	0.6200	0.8600	0.6400
Sahu *et al.*	0.3600	0.1000	0.3100
Pal and Sahu	0.0037	0.0014	0.0037
SI- 1	0.7500	0.2100	0.7000

Table 4: Yield Sustainability analysis of black pepper.

Conclusion

Present investigation, significant positive coefficient of potassium fertilizer on productivity of black pepper is noticed in Kerala. Whole India use nitrogen fertilizer is found to have significant positive coefficients on black pepper productivity. Karnataka is the state, which is showing high sustainability in yield of black pepper.

Bibliography

1. Mishra P., *et al.* "Trend and instability analysis of wheat in India and relationship with factors of production on productivity" Accepted: progressive agriculture research – An International Journal 10.6 (2015): 3249-3258.

2. Mishra, P., *et al.* "Statistical Investigation of Production Performance of Cumin in India". *Economic Affairs* 63.2 (2018): 547-555.

3. Hair F., *et al.* "Multivariate DataAnalysis", 5th edition. Prentice Hall, New Jersey (2005).

4. Singh RP., *et al.* "Towards sustainable dryland Agricultural Practices, Technical Bulletin, Central Institute of Dry land Agriculture, Hyderabad, India 106 (1990).

5. Sahu PK., *et al.* "Sustainability of different nutrient combination in a long-term rice- wheat cropping system". *Journal of New Seed* 7.3 (2005): 91- 101.

6. Pal S and Sahu P K. "On assessment of sustainability of crops and cropping system-some new measures". *Journal of Sustainable Agriculture* 31.3 (2007): 43- 54.

7. Anonymous. (Major item wise export 2016).

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