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Farm practices and pepper productivity in Idukki district: An empirical analysis

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Abstract
Idukki situated on the Western Ghats, one of the mountainous districts in Kerala, is well known for producing black pepper (pepper nigrum) as a mono-crop. During around last fifty years of continues and unscientific farming, without preserving soil, the productivity of this crop declined drastically. Now, though the soaring price has been conducive for mitigation, the situation is assumed to have the proportion of a crisis which is not compatible with the present paradigm of sustainable development and the present motto of "Evergreen Revolution" in agriculture. This paper examines various farm practices which are unsustainable to the productivity of black pepper in the Idukki district. A multiple linear regression model has been used to analyse the impact of various farm practices on productivity.

Keywords: long term pepper productivity, farm practices, inorganic fertilizers and manures

1. Introduction
Idukki district that situates on Western Ghats of Kerala State in India is famous for pepper production in Kerala which accounted for about 91 per cent [1] of national pepper production. Though, during 70s and 80s, pepper was a mono-crop, during 90s and the beginning of the 21st century it became a mixed crop in most of the farmlands in the district. Economic Review (2016) estimated that absolute quantum of annual production (national level) has been declining from 75000 tons in 2014-15 to 55000 tons in 2015-16. It remains stagnated around 50 000 tons during last few years [2]. However, in the district where pepper has been grown as a mono-crop or a major crop, productivity per acre has been declining during the last 50 years of cultivation. The productivity loss has been so sever (Swaminathan 2009, Manorama daily). However, primary data collected shows that average production of dried fruits per hectare of farmland is very low at 4 to 5 quintals (1.6 to 2 quintals per acre) per hectare per year.

2. Objectives
The objectives of this study are twofold.
1. To analyse the long term productivity of pepper in the Idukki District.
2. To identify and analyse the farm practices contributing to long term productivity of pepper in the Idukki district.

3. Data and Methodology
Primary data have been collected from among 360 sample farmers who grow pepper as a mono-crop or major crop from five administrative blocks of Idukki district using survey schedules. The analysis involved in estimating long run average productivity and running regression against its predictors, the farm practices, identified.

4. Estimates of Productivity Decline
Productivity deceleration of pepper was so acute. Data released by an Expert Committee appointed by Government of India in this regard show that the down turn was about 44 per cent. Between 2007-08 and 2016-17, the area under production has been roughly more than halved from about 175679 hectares to 85430 hectares. Crop production also registered drastic decline; compared to 2007-08 levels, it dipped about 60.7 per cent from 41.952 tons to the bottom level of 16500 tons in 2011-12 (table 1). In subsequent years, though production improved and centered around 24200 tons (average of five years), it still remains fall short of 2007-08 levels (table 2).

Table 1: Area and Production of Pepper in Kerala

Years	Area in hectares	Production in tons
2007-08	175679	41952
2008-09	153711	33991
2009-10	171489	27500
2010-11	172182	20640
2011-12	172182	16500
2012-13	84710	25000
2013-14	84065	20000
2014-15	85430	30000
2015-16	85430	22000
2016-17	85430	24000

***Source*:** Collected and compiled from official website of Spices Board of India and available at http://indianspices.com/sites/default/files/Major%20spice%20state%20wise%20area%20productionweb%200517.pdf and compiled from Regeena who quoted from http://www.spicesboard.in.

Table 2: Short Fall of Pepper Production in Kerala from 2012-13 to 2016-17 compared to 2007-08 Level

Years	2012-13	2013-14	2014-15	2015-16	201617
Production in tons	25000	20000	30000	22000	24000
As per cent of 2007-08 levels	59.6	47.7	71.5	52.4	57.2
Production loss as per cent	40.4	52.3	28.5	47.5	42.8

***Source*:** Compiled from table 1.

The Spices Board data, however, shows that productivity has been slightly improving in the present decade. This implies that farmers have been concentrating on cultivating pepper in highly suitable land alone and it has been in response to a rally of favourable price change since 2010. Though slightly dipped in 2015 to Rs. 630.31 per kilogram, pepper price rose to Rs. 646. 79 per kilogram in 2014 and further rose to Rs. 669.29 per kilogram in 2016 [2].

The present study employed a different methodology to estimate long term productivity decline. The mean percentage of productivity decline was estimated as the ratio of Mean Range of Productivity Decline to Mean Peak Production (MPP) during the first planting. The Mean Range of Productivity Decline is defined as the difference of Mean Peak Production (MPP) during the first planting and the Current Average Production (CAP). Primary data collected showed that the productivity decelerated about 70 per cent during the last 50 years of cultivation.

$$\text{MRPD} = \frac{\Sigma_1^n PP_{ac}}{n} - \frac{\Sigma_1^n CAP_{ac}}{n} \qquad (1)$$

Where, MRPD = Mean Range of Productivity Decline

$$\text{Per cent of Productivity Decline} = \frac{MPP - MCAP}{MPP} \times 100$$

$$= \frac{366217}{360} - \frac{108980}{360} = 1017 - 303 = 714$$

$$\text{Productivity Loss} = \frac{714}{1017} \times 100 = 70\%$$

***Source*:** Primary Data collected from Idukki district.

The Past Production Glory

Unlike as appeared in official statistics of pepper productivity which is stated to be ranging between 217 kilograms per hectare (87 kg. per acre) and 353 (141 kg. per acre) in 2010 [3], there were instances of annual production about 5 tons per hectare (2 tons per acre). However, production of 2.5 to 3 tons per hectare (1ton to1.2 tons per acre) was common during early years of the history of pepper production in the district. It was reported that there were pepper plants trialed on forest trees giving 142 kg. of fresh fruits [4] (the quantity of dried fruits is 142/3 = 47 .33 kg.). In normal situation, pepper plants of 10 to15m height yield 50 kg. of fresh fruits (16.67 kg. of dried fruits)[4]. Usually 375 to 400 such plants can be trialed on standards in an acre of farmland. Therefore according to the statistics reported by Ravindan, the normal productivity would have been ranging between 6251 kg. and 6667 kg. per acre.

5. Long Term Average Productivity

Pepper being a perennial crop, its output trend in a planting period has four clear but distinct phases (table 3). The first phase, which lasts for three years, is characterized with zero output. In the second phase, crop production gradually begins and shoots up to a peak level. The peak production continues for some years depending on environmental factors, plant nurturing practices like manuring and fertilization. Finally crop production declines and the plants gradually perish. The duration of first and second phases remains the same for all farm lands and for successive planting events. The third phase may range between 2 to 7 years. But there are instances that the third phase lasts for 10-11 years. In usual cases, the fourth phase range up to 10 to 15 years.

Table 3: Phases of Pepper Production Trend

Phases	Phase 1	Phase 2	Phase3	Phase 4
Phase duration	3 years	3 or 4 years	*Varies	*varies
Crop production	Zero	Increases	Peak level continues	Diminishes
* Duration varies depending upon land features, environment potential and farm practices				

The duration of pepper production cycle was not uniform in all the farm-lands surveyed. It lasted for 30 years or so without severe decline in crop production in some lands whereas in some others even the first planting period did not crossed a period of 10 years. There are cases of farm-lands in which production cycle duration diminishes in successive planting events.

The cross section data on crop production do not amply accommodate the aforesaid productivity features. During data enumeration, different pepper plantations are likely to be at different production phases. The complete historical data are also not available as the respondent farmers do not remember the exact quantity produced year by year. However, they recollected the average crop produced during different phases of each successive planting cycle and duration of each phases.

The long run average productivity is defined and estimated to include the output trend features of the last 50 years.

Long term Average Productivity is defined as;

$$LAP = \frac{\Sigma_1^n Y_{pi} P_{pi}}{\Sigma_1^n Y_{pi}} \qquad (2)$$

Where,

Y_p = the duration of a phase of production in years. $p = 1, 2, 3, and\, 4,$ in i^{th} planting period

$i = 1,2,...,m$

P_{pi} = the quantity of pepper yield in a typical year during p^{th} phase of production in the i^{th} planting per acre.

6. Farming Practices Affecting Productivity

The following factors were found to affect the productivity of pepper in the survey area.

1. Soil Erosion
2. Total Quantity of Fertilisers and Manures applied
3. The Proportion of Fertilisers to Manures used in farming.
4. The Proportion of pepper crop to other crops grown.

7. Soil Erosion

Ordinary soil erosion refers to the process of removal of top soil by water and wind. Inappropriate and reckless farm practices accelerate erosion leading to the loss of organic matter, water holding capacity, nutrients, and biodiversity all further leading to reduced crop production. The hill sides of Idukki district where pepper plantations have been grown, unless otherwise prepared, are prone to soil erosion. Many factors both natural as well as manmade contribute to it. The natural factors, land inclination and rain fall are passive in that they do not themselves, but with the presence of other factors lead to washing out of soil. Farm practices like soil tillage, spade oriented weed clearing and its frequency are active factors which accelerate erosion.

8. Soil Tilling

Digging pits, making beds and weed cleaning using tools are essential components pepper cultivation practices which makes the soil with a tillage effect. Pits of 1.5 to 2 cubic feet have been constructed to plant pepper standards. After planting pepper vines on standards, beds of one meter radius and 6 to 12 inches height/depth are constructed. Subsequently, tilled loose soil collected from a distance of one and a half meters away from the plant periodically once in two three years to remake the beds already prepared.

During the initial years of pepper cultivation, tapioca and rice were grown as side crop. The land preparation practice was ‘slash and burn’. The sawing of seed was effected by mildly tilling the land prepared. For growing tapioca also land needs to be tilled.

Another practice having tillage effect is weed cleaning aimed to ensure nutrients and moisture to plants twice a year using spades. The first has been during November to December, just after the south west monsoon showers ends and the harvest period starts. The second has been during April-May before pre-monsoon showers starts. While using spades each time, one inch thick of top soil gets loose. However, soil erosion can be fully checked by land terracing and similar activities. Soil erosion enters the model as a dummy variable, D_i.

9. Application of Fertilisers and Manures

Applying manures or fertilisation intends to boost crop production by making land more fertile. Chemical and natural substances have been applied into soil. Pepper farmers in Idukki began to apply fertilisers as part of the emergence of a new technology, the Green Revolution of 1960s, using the high input based cultivation to reap the advantages of favourable price during the second half of 1980s. The move was further strengthened by;

1. The urge of migrant farmers for larger and larger productivity of pepper.
2. The high output cost ratio. Grams of fertilisers when applied were translated into large quantities of pepper output; the market value of it exceeded many times the input cost of fertilisers.
3. Amazing crop income earned by pepper farmers encouraged them to promote fertiliser based cultivation. The production of manures like cow dung decreased as farmers abandoned cattle rearing which became relatively less attractive.

9.1 Fertiliser Use

Primary data reveals that 64.74 per cent of surveyed farmers use fertilizers such as urea, potash, factom-phose and their mixtures in varying quantities even up to 0.75 Kg per plant per year. However, about 19.44 per cent farmers are moderate users 101-200 grams per plant per year. It is not customary for the remaining 35.26 per cent farmers to use any fertilizers other than manures (table 4).

Table 4: Use of Fertilisers - Distribution of Farmers

Fertiliser Use	Zero Use	1-100g	101-200g		201-300g	301-400g	401-500g	Above 501g
Number of Farmers	127	34	70		44	40	26	19
Percentage of Farmers	35.28	9.44	19.44		12.22	11.11	7.22	5.28

***Source*:** Primary data collected from the Idukki district

9.2 Use of Manures

Cow dung followed by compost and chicken excreta are important organic manures in the region. Approximately 8 per cent of the farmers surveyed do not use organic inputs. About 38.89 per cent annually apply 4 to 6 kg. per pepper plant. Some farmers, who have been ‘progressive’ apply manures to the tune of 14 to 16 kg per plant annually but constitutes only about 1.39 per cent (table 5).

Table 5: Use of Manures among Farmers

Manure Use	Zero Use	Up to 2 kg	2kg-4kg	4kg-6kg	6kg-8kg	8kg-10kg	10kg-12kg	12kg-14kg	14kg-16kg
Number of farmers	27	11	93	140	35	39	9	1	5
Percentage of farmers	7.5	3.06	25.83	38.89	9.72	10.83	2.5	0.28	1.39

***Source*:** Primary data collected from the Idukki district.

Though the application of manures and fertilisers accelerates plant growth and yield, the underlying mechanism is different. Manures like cow-dung, chicken excreta, compost etc. are created through a natural process. Every application of manures accelerates plant growth without reducing nutrients contained in the soil such as phosphorous, nitrogen and potassium [6]. Soil fertility remains more or less undiminished. Fertilisers such as potash, factom-phose, urea and other mixtures are artificially made with pure chemicals in factories and laboratories. Application of fertilisers helps plants to absorb nutrients in the soil without compensating the absorbed nutrients. Thus, in the long run excessive application ended up in nutrient depletion and it adversely affected plant growth. The improper use of fertiliser application causes productivity loss in the long run. [7]

The application of fertilizers without combining manures in sufficient quantities leads to nutrient depletion and accounts for far reaching consequences on crop productivity. "Deficiency of plant nutrients in the soil is the most significant biophysical factor limiting crop production across very large areas in the tropics, where soils are inherently poor."[8]

The actual application of fertilizers and manures in the soil enters into the productivity model in the form of two variables.

1. Total Quantity of Fertilisers and Manures (TQFM)
2. The Intensity of Inorganic Fertilisation (IIF) measured as the proportion of the quantity of fertilisers applied to the total quantity of fertilisers and manures applied as a percentage.

10. Intensity of Pepper Crop

Idukki district has been famous for homestead farming. Farmers always grow mango tree, jackfruit, cocao, coconut and other fruit trees along with pepper. However, in some area, pepper has been cultivated as a mono-crop. Intensity of pepper crop is the approximate number of pepper plants trialed in an acre of land. It was noticed that low productivity compelled farmers to plant so many (more than what was scientifically proved) set of vines per acre.

11. The Model

Primary data on crop yield have been collected in respect of different phases of successive planting periods starting from the beginning of pepper cultivation in the district and estimated the long term average productivity as the weighted average of yield assuming the duration of each phase as the weight. Data on the explanatory variables such as soil erosion, fertilisation and manuring, and intensity of pepper crop in each of the farm land which were identified to be the factors determining productivity were also collected. The explained and explanatory variables are assumed to have the following functional form and linear relationships.

$$Y = f(D_1, X_1, X_2, X_3) \quad (3)$$

Specifically

$$Y_i = \beta_0 + \beta_1 D_{1i} + \beta_2 X_{1i} + \beta_3 X_{2i} + \beta_4 X_{3i} \quad (4)$$

Where, $Y_i =$ long term average productivity in 'i'th farmland

$D_{1i} =$ The dummy for soil erosion; '1' if it is vulnerable to soil erosion and '0' if it is not so.

$X_{1i} =$ Total Quantity of Fertilisers and Manures (TQFM) comprise the quantity of organic manures (OM) and inorganic fertilisers (IF) applied in farming.

$$TQFM = qOM + qIF$$

$X_{2i} =$ Intensity of Inorganic Fertilisation (IIF) which is the ratio of the quantity of Inorganic Fertilisers applied to the Total quantity of Fertilisers/manures expressed as a percentage.

$$IIF = \frac{qIF}{qIF + qOM} \times 100$$

$X_{3i} =$ Intensity of Pepper Crop which is the number of pepper plants trailed per acre.

The subscript $'i'$ denotes a particular farmland

$\beta_0, \beta_1, \beta_2, \beta_3 and \beta_4$ are regression parameters

β_0 is the intercept term.

12. Results

Running regression **(**Y versus D, X_1, X_2 and X_3) the following results were obtained.

$$Y_i = 339 - 104.D_{1i} + 19.3X_{1i} - 3.76X_{2i} + 2.14X_{3i} \quad (5)$$

Table 6

Model Summary (b)				
Model	R square	Adj. R Square	Std. Error of the Estimate	Dubrin - Watson
1	.338	.330	180.268	1.54

Table 7

Coefficients					
Model 1	**Coef.**	**SE Coef.**	**t**	**P value**	**VIF**
Constant	339.26	47.88	7.09	0.000	
D	-104	20.89	-4.98	0.000	1.2
X1	19.321	3.751	5.15	0.000	1.3
X2	-3.7582	0.6471	-5.51	0.000	1.2
X3	2.1424	0.5133	4.17	0.000	1.0

Source**:** Primary data collected from the Idukki District, Kerala

13. Model Analysis

It is evident from the differential intercept coefficient of the dummy that the productivity difference of soil erosion protected farm lands and farmlands which are prone to erosion estimated as 104 Kg. per acre is highly significant. The higher long term average productivity in the erosion protected land is an indicator for policy. The application of Total Quantity of Fertilisers/manures measured in kilograms per plant has significant positive bearing on productivity, (19.3 Kg) per acre. The Intensity of Inorganic Fertilisation/manuring per plant has marginal negative impact; each per cent increase of fertilization out of total fertilization and manuring depressed average productivity to the tune of 3.76 kg. per acre. The number of pepper plants per acre is positively related to pepper productivity per acre. Each number contributes about 2.14 kg. All coefficients of the model are significant as is evident from low P value (approximately equal to zero). The single largest factor that contributes to low productivity is the soil erosion resulting from soil tilling and weeds cleaning.

14. Conclusion and Suggestions

In Idukki, pepper production practices had been unscientific and only useful for short run productivity gains. Reckless tillage and plant protection measures adopted without countering soil erosion washed out the fertile nutrient rich top soil which had been deposited by nature for centuries on the hill sides. Violent fluctuations in the use of chemical fertilizers, which were mostly responsive to crop price, to reap the immediate price dividend ultimately affected crop productivity. Many farmers abandoned pepper cultivation in low yielding land and many others started mixed cropping to curb severe revenue loss and to maintain their livelihood.

The results are instrumental for policy. Downward productivity trend can be reversed by adopting soil erosion preventing measures such as trenching, constructing bunds and land terracing. Organic farming and sustainable resource management system must be substituted in a phased manner but as fast as possible for the present modern chemical fertilizer input based short run output maximizing farming techniques. Even though, switching over from customised farm practices are painstaking, time consuming, and requires huge investments in land and enormous educational campaign, the results would be enduring for the befit of poor pepper farming community in the district.

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