RESEARCH PAPER | Economics | Volume : 5 | Issue : 5 | May 2015 | ISSN - 2249-555X

Examining the Strength and Direction of Association between Wheat Crop Productivity Status and Soil Nutrient Deficiency: A Non Parametric Analysis of Selected Districts of Punjab

KEYWORDS: Wheat Crop Productivity, Soil Nutrient Deficiency, Non Parametric Statistical Measures

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ABSTRACT *Since crop productivity status of a given area is contingent upon the presence of soil nutrient deficiency, therefore the present study examines the strength and direction of association between wheat crop productivity status of districts of Punjab and soil nutrient deficiency using non parametric statistical measures of Pearson's chi-square, Cramer's V and Kendall's tau-b. The results validated the existence of significant moderate negative relationship between wheat productivity status and the deficiencies of potassium, zinc and boron. The findings confirmed that low wheat productivity of a district is significantly related with presence of high amount of soil nutrient deficiency and vice versa, which reflects the presence of significant negative association between wheat productivity status of a district and soil nutrient deficiency. Both remedial and preventive agricultural measures should be undertaken so as to reduce and overcome soil nutrient deficiencies and achieve high wheat productivity status.*

Introduction

Agricultural productivity is largely governed by fertile soils that contain essential soil nutrients in adequate amounts. Crop productivity status of a given area is contingent upon the presence and absence of soil nutrient deficiency with the latter having sizeable deterring effect on productivity levels of food crops (Henao and Baanante, 1999). The soil deficiency represents a condition characterized by depletion of soil nutrients, which are essential for crop growth and productivity (Schreiner and Sullivan, 1909). The assessment of soil nutrient deficiency involves the application of standard soil tests for the estimation of available levels of essential nutrients present in the Indian soils and comparing it with their respective critical limits advocated by the Ministry of Agriculture, Government of India (2011). When the available levels of essential soil nutrients are below the critical values, then it is considered that the essential nutrients are in low concentrations, thereby indicating the existence of soil nutrients deficiency.

Numerous research studies are indicative towards the emergence of widespread soil nutrient deficiencies in various districts of the dominant wheat producing state of Punjab. Since, food security needs of India can be met substantially by enhancing the wheat crop productivity levels of the leading wheat growing state of Punjab, therefore it is imperative to examine whether or not there exists significant association between wheat crop productivity status of the districts of Punjab and soil nutrient deficiency. Of the various soil nutrients, the deficiencies of potassium, zinc and boron are posing a serious threat to the crop productivity and agriculture sustainability of Punjab state as pointed by the research evidence (Tiwana *et al.*, 2007 and Government of India, 2008). Therefore, in this backdrop, the present study attempts to examine the existence, strength and direction of association between wheat crop productivity status of the districts of Punjab and the deficiency of these three important soil nutrients.

Objectives of the Study

The primary objective of the study is to examine the existence, strength and direction of association between the wheat productivity status of districts of Punjab and soil nutrient deficiency. As a secondary objective, the study also aims to compare the soil deficiency pattern across different wheat yield districts of Punjab.

Hypothesis

The following hypothesis was framed.

Null Hypotheses (H_0): Wheat productivity status of a district is independent of soil nutrient deficiency.

Alternate Hypotheses (H_1): There exists a significant association between wheat productivity status of a district and soil nutrient deficiency.

Methodology

Following the multistage sampling procedure, the state of Punjab was divided into selected high, medium and low wheat yield districts on the basis of per hectare wheat yield data procured from Statistical Abstract of Punjab for the year 2010-11. Accordingly, Sangrur and Moga were identified as the top two high wheat yield districts; Nawanshahr and Jalandhar as medium wheat yield districts (the two districts closest to the overall wheat yield of the Punjab state); Gurdaspur and Rupnagar as the bottom two low wheat yield districts. In the successive stage of sampling, twenty soils samples were randomly collected from different farming sites located in each identified district, thus making a total of 120 soil samples, which were then sent to Panjab University research laboratory for the purpose of estimation of available levels of soil nutrients through standard soil tests. The available levels of each of the soil nutrients were compared with their respective critical levels so as to assess the presence of soil deficiency across the low, medium and high wheat yield districts.

The non parametric statistical technique of Pearson Chi-Square test was used to assess whether or not there exists a significant association between wheat productivity status of the districts and the deficiency of a soil nutrient. Further, Cramer's V and Kendall's tau-b tests were employed to examine the strength of association (effect size) between these two attributes.

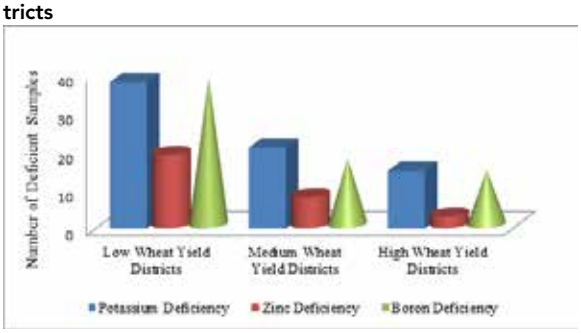
Analyses and Discussion

1. Comparing the Soil Deficiency Pattern across different Wheat Yield Districts of Punjab

Volume : 5 | Issue : 5 | May 2015 | ISSN - 2249-555X

As shown in figure 1 and table 1, the deficiencies of potassium, zinc, and boron were observed to be highest in low wheat yield districts (38, 19 and 38 samples respectively), while it was comparatively observed to lowest in high wheat yield districts of Punjab (15, 3 and 14 samples, respectively). Hence, soil nutrient deficiency showed a decreasing trend as we move from low to high wheat yield districts, which indicates that apparently there exists a negative relationship between wheat crop productivity status of a district and deficiency of a soil nutrient. However, validation of this relationship was examined through Pearson's chi-square test and associational statistics.

Figure 1: Soil Deficiency Pattern across Wheat Yield Districts



Source: Graph constructed on the basis of survey data.

2. Result of the Chi-Square test

As shown in table 1, the values of Pearson's chi-square tests (30.106, 17.867 and 34.987, respectively) were observed to be statistically significant ($p<0.01$), which is indicative of existence of significant association between wheat productivity status of a district and soil nutrient deficiency of potassium, zinc and boron. Though, chi-square test helps examine the existence of significant relationship between the two variables, however it does not reveal any information about the strength of such relationship (Morgan et al. 2004), which in the present study has been examined by non parametric associational statistics namely Cramer's V and Kendall's tau-b (Field, 2005).

3. The Strength and Direction of Association between Wheat Productivity Status of a District and Soil Nutrient Deficiency

Table 1 shows that the value of Cramer's V, which ranges from 0 to 1 was observed to be statistically significant ($p<0.01$), thereby indicating the presence of strong relationship between wheat productivity status of a district and deficiency of potassium and boron on one hand (coefficients of 0.501 and 0.54 respectively) and relatively moderate relationship between wheat productivity status and zinc deficiency (coefficient of 0.386) on the other hand. Further, Kendall's tau-b test whose value in general ranges from –1 to +1 was used to study both the strength and direction of relationship between wheat productivity status of a district and soil nutrient deficiency. The coefficients of Kendall's tau-b test indicated the presence of significant moderate negative relationship between wheat productivity status of a district and deficiency of potassium, zinc and boron (correlation of −0.455, −0.356 and −0.467 respectively). Thus, Kendall's tau-b coefficients confirmed that lower wheat productivity status of a district is significantly related with presence of high amount of soil nutrient deficiency and vice versa, which reflects the presence of significant negative association between wheat productivity status of a district and soil nutrient deficiency.

Table 1: Cross-Tabulation, Result of Chi-Square Test and Associational Statistics

Soil Nutrients	Number of Deficient/ Non-Deficient Samples	Wheat Yield Status of the Districts			Pearson's Chi-Square	Associational Statistics	
		Low Wheat Yield	Medium Wheat Yield	High Wheat Yield		Cramer's V	Kendall 's tau-b
Potassium	Deficient	38	21	15	30.106**	0.501**	−0.455**
	Non-Deficient	02	19	25	(0.000)	(0.000)	(0.000)
Zinc	Deficient	19	08	03	17.867**	0.386**	−0.356**
	Non-Deficient	21	32	37	(0.000)	(0.000)	(0.000)
Boron	Deficient	38	17	14	34.987**	0.540**	−0.467**
	Non-Deficient	02	23	26	(0.000)	(0.000)	(0.000)

Note: i) ** denote that the test statistic is statistically significant at 1% level
ii) Figures in the parentheses denote p-values.
Source: Author's Calculations.

Conclusion and Suggestions

The results of the present study clearly reflect that soil nutrient deficiency followed a decreasing trend as we move from low to high wheat yield districts of Punjab. The Pearson's chi-square test results lead us to reject the null hypothesis in favour of alternate hypothesis that there exists a significant association between wheat productivity status of a district and deficiency of a soil nutrient. Kendall's tau-b coefficients further validated the existence of significant moderate negative relationship between wheat yield status and deficiency of potassium, zinc and boron. These observations substantiated that low wheat productivity status of the districts is significantly related with the presence of relatively high soil nutrient deficiency, while the high wheat productivity status of the districts is significantly related with the presence of relatively low soil nutrient deficiency. Since, districts with high amount of soil deficiency were observed to have low wheat productive status, therefore, both remedial and preventive agricultural measures such as integrated nutrient management, balanced fertilization, green manuring and creating awareness among the farmers about the economic advantages of the periodical soil testing of their farmlands should be undertaken so as to reduce and overcome soil nutrient deficiencies and achieve high wheat productivity status.

Volume : 5 | Issue : 5 | May 2015 | ISSN - 2249-555X

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