Ijaz Rasool Noorka et al. / Iranian Journal of Earth Sciences 3 (2011) /204- 208

Principal Component Analysis for Soil Conservation Tillage vs Conventional Tillage in Semi Arid Region of Punjab Province of Pakistan

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Received 28 January 2010; accepted 29 March 2010

Abstract

Principal component analysis is a valid method used for data compression and information extraction in a given set of experiments. It is a well-known classical data analysis technique. There are a number of algorithms for solving the problems, some scaling better than others. Wheat ranks as the staple food of most of the nations as well as an agent of poverty reduction, food security and world peace. Due to limited sowing time and conventional cropping pattern the wheat yield suffers. Efficient tillage methods maintain soil health and crops response. The present investigations were carried out to study the effects of different tillage systems on yield and yield contributing traits, using Randomized Complete Block Design. Two tillage systems i.e. conservation tillage and conventional tillage were used. Three principal components were sufficient to explain the variations. The traits plant height, number of leaves, number of tillers, peduncle length, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike and grain yield were affected significantly under conservation tillage as well as conventional tillage systems. The graphic representation showed that yield contributing traits behaved best in conservation tillage practice. The present study revealed that conservation tillage method produced optimum yield for wheat production.

Keywords: *Conventional tillage, Conservation tillage,Yield;Crop response and Principal component analysis.*

1. Introduction

Wheat (*Triticum aestivum* L.) cultivation started during the Neolithic period, probably as early as 6,000 to 7,000 years ago. It is a very versatile plant and can be grown under a vast range of land and agro-climatic conditions. Wheat is one of the most important food crops grown in the world. It ranks first in the world cereal crops accounting for 30% of all cereal food worldwide and is a staple food for over 10 billion people in as many as 43 countries of the world. It provides about 20% of the total food calories for the human race [1]. Pakistan’s economy is mainly based on its agriculture, having different agro-ecological zones. Two cropping patterns are mainly used e.g. cotton-wheat and rice-wheat. In both the cotton and rice zones of Pakistan, the wheat crop is almost practiced as late sowing, i.e., in late November and month of December, which is the main cause of less grain formation because the grain filling is normally completed under high temperature prevailing during the hot months of March and April. So approximately 80 % of the wheat crop is being planted under late-sown conditions and planting time is the practice most affecting grain yield. Early sowing always produces a higher yield than late sowings.

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Ibrahim and Abdallah [2] observed that delay in sowing of wheat by one month reduced the grain yield by 27 %. The other limiting factor is the time period normally needed for land preparation after the rice and cotton harvesting and before planting of wheat, which is sometimes as long as three weeks. It has been estimated that wheat yields can be reduced up to 50 kg/ha/day if there is late sowing [3]. The other important factor is that the wheat crop requires a well-pulverized but compact seedbed for good and uniform germination. In conventional tillage method, three ploughings followed by planking, immediately before sowing produce a good and firm seedbed. The sustainability in crop production can be ensured by judicious management of soil resources by maintaining physical properties of soil [4, 5]. An essential tillage operation is a need of the hour while unnecessary conventional tillage operation system leads to soil degradation as well as deterioration of soil structure [6]. By definition, tillage is a mechanical manipulation of soil to raise the crop[7]. However, excessive tillage may affect soil physical properties [8]. In Pakistan there is more than a twofold gap between demand and supply which should be overcome to feed the burgeoning population by cumulative efforts [9]. The major limiting factor in rice-wheat cropping system is low yield, due to the unflooded and unpuddled soils [10]. The conservation tillage technology is considered as an integrated approach that can overcome the wheat yield stagnation in the rice-wheat zone by reducing planting time and enhancing fertilizer and water use efficiency [11].

2. Objectives of the study

- To study the effect of conservation tillage in rice-wheat cropping system
- To study the response of different yield and yield contributing traits in conservation tillage as compared to conventional tillage operation
- To study the difference of both tillage operations by principal component analysis under the given set of soils.

Keeping in view the above facts, the present study was conducted to determine the effect of conventional and conservation tillage methods in wheat yield and yield components.

3. Materials and Methods

The field experiment was conducted at the research area of the University College of Agriculture, University of Sargodha, Pakistan during the year 2008-09, to evaluate effects of two tillage methods on wheat yield and yield contributing traits. The physical characteristics of the experimental area soil are presented in Table 1 [12, 13]. There are two treatments. The conventional tillage treatment comprises three ploughings followed by planking, while the conservation tillage included zero tillage and zero planking. Soil under this treatment was sown only by zero tillage drill soon after cutting of rice crop, skipping land preparation practices. The other inputs like seed, fertilizer, irrigation and plant protection measures were applied at optimum. Ten guarded plants were selected randomly from each treatment at maturity. The yield and yield contributing traits like plant height, number of leaves per plant, number of tillers per plant, peduncle length, spike length, spikelets per spike, grains per spike, grain weight per spike, and grain yield per plant were recorded and statistically analyzed.

3-1 Statistical analysis

The recorded data were statistically analyzed using statistical package [14] and the principal component analysis was performed [15, 16 and 17].

4. Results and Discussion

4-1 Principal Component Analysis for Conventional Tillage

Principal component analysis was used to analyze the data. It is a classic technique in data analysis [18,19]. It is used for compressing higher dimensional data sets to lower dimensional ones for data analysis, visualization, feature extraction, or data compression. Principal component analysis can be derived from a number of starting points and optimization criteria [19,20]. As shown in Table 1 three principal components were found sufficient to explain approximately 65% of the variation. It was further noted that with conventional tillage system PC1 explains 32% of the variation indicated by wheat plant traits plant height, peduncle length, number of spikelets per spike and number of grains per spike. These traits are major components to explain the variations. In PC2 17% variations were explained. These variations were explained by the following traits: number of leaves, number of spikelets per spike and grains weight per spike. The third and last PC3 explained 15% variation, which were influenced by the traits number of tillers per plant and grain yield.

The results are shown in Fig 1, The Bi plot of the first two principal components for conventional tillage.

Table 1. Physical characteristics of soil under study

Sand	%	54.0
Silt	%	20.76
Clay	%	25.24
Bulk density	Mg m^{-3}	1.42
EC_e	dS m^{-1}	1.40
pH		8.0
Saturation percentage	%	40.0

4-2 Principal Component Analysis for Conservation Tillage

Principal Component analysis was again performed for conservation Tillage; under these observations first three principal components explained maximum 60% of the variation. The PC1 explained 27% of the variation which were contributed by spike length, number of grain and grain yield whose scores were 0.399, 0.459 and 0.498 respectively. The PC2 determined traits like plant height, number of leaves and number of spikelets per spike; this PC explained 20% of the variations. The scores of these traits were 0.492, 0.435 and 0.504 respectively. The PC3 explained 12% of the variations for the traits peduncle length with highest score 0.724. The results are depicted in Fig 2, the Biplot of the first two principal components for conservation tillage. The conventional tillage practices after the harvesting of rice involved a lot of ploughing followed by planking for the efficient preparation of a seedbed used for wheat planting which is laborious as well as time consuming. The cost of production is also increased. In order to save the sowing time and the tillage costs, the present study was initiated, which was in practice and under production since 1980s. The drill used to sow the seed directly was named as zero-tillage drill and the method of wheat sowing with this drill called as conservation-tillage technology. The results of this experimentation showed that the crop stand as well as the yield, sown with zero-tillage drill revealed 10 to 40 percent higher yield as compared to that obtained under conventional systems [21]. The crop yield of wheat differed significantly under both tillage methods (Table 1&2). As a result of this study, the energy consumption was also reduced. The energy and fuel savings were achieved by conservation tillage as compared to conventional tillage.

The soil physical properties needed for proper crop growth can reduce labor, fuel and energy resources under wheat-rice cropping system in Pakistan. The conservation tillage operations can be used for soil conservation and particularly for energy savings. The results of this study showed that the crop stand is improved for wheat sown with conservation-tillage as compared to conventional systems under semi-arid climatic conditions of Pakistan. These results are in accordance with the findings of Du et al. [12]. However, the findings of Barzegar et al. [23] are not in line with the present findings; they reported that different tillage systems did not affect the yield significantly. On the contrary, it has been stated that different tillage systems did not affect the yield significantly [24]. The principal component analysis method is used to check the difference between tillage operation methods and similar findings were reported by Zhou et al. [25].

Table 2. Eigen analysis of the Correlation Matrix

Eigen value	2.931	1.545	1.348	0.996	0.749	0.583	0.474	0.243	0.128
Proportion	0.326	0.172	0.150	0.111	0.083	0.065	0.053	0.027	0.014
Cumulative	0.326	0.497	0.647	0.758	0.841	0.906	0.959	0.986	1.000

Variable	**Plant Height**	**No of leaves**	**No of Tillers**	**Peduncle length**	**Spike length**	**No. of spikelet**	**No. of grains**	**Grain wt/spike**	**Grain yield**
PC1	0.495	-0.031	0.084	0.504	0.204	0.524	0.419	-0.007	-0.009
PC2	0.193	0.423	0.047	-0.217	0.406	-0.177	0.076	0.525	-0.507
PC3	-0.041	0.248	0.702	-0.056	-0.220	0.005	0.112	0.365	0.497

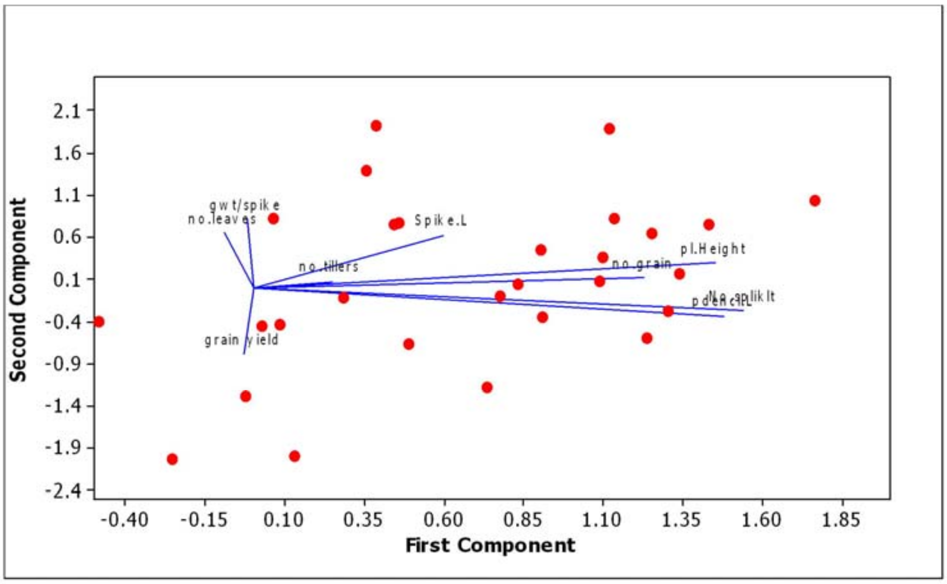

Fig. 1. Biplot of the first two principal components for conventional tillage

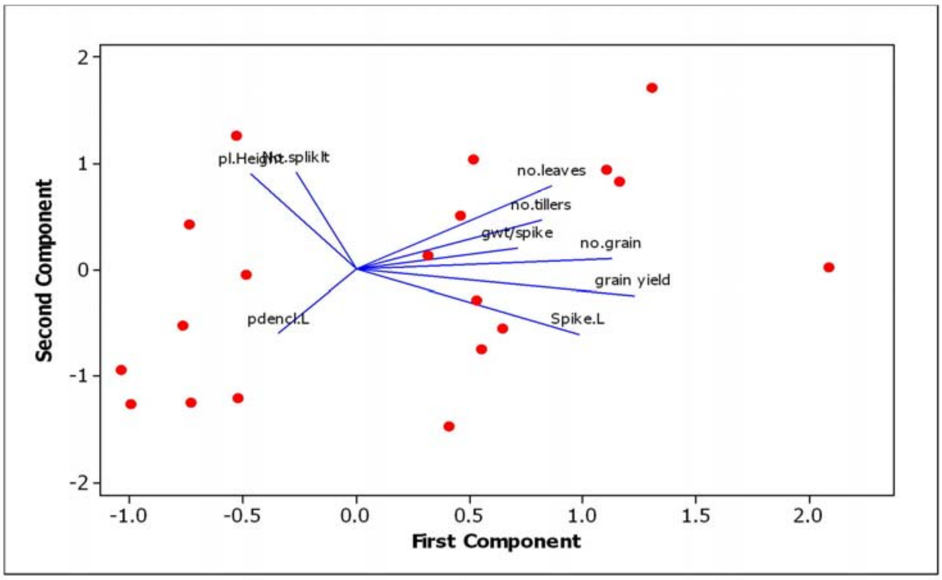

Fig .2. Biplot of the first two principal components for conservation tillage

Table 3. Eigen analysis of the Correlation Matrix

Eigen value	2.463	1.832	1.146	0.965	0.789	0.685	0.600	0.380	0.137
Proportion	0.274	0.204	0.127	0.107	0.088	0.076	0.067	0.042	0.015
Cumulative	0.274	0.477	0.605	0.712	0.800	0.876	0.942	0.985	1.000

Variable	Plant Height	No of leaves	No of Tillers	Peduncle length	Spike length	No. of spikelet	No. of grains	Grain wt/spike	Grain yield
PC1	-0.188	0.350	0.332	-0.139	0.399	-0.107	0.459	0.290	0.498
PC2	0.492	0.435	0.256	-0.328	-0.329	0.504	0.059	0.113	-0.131
PC3	0.168	-0.055	0.248	0.724	0.247	0.390	-0.279	0.279	0.118

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