



## RESEARCH PAPER

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## A case study on long-term financial benefits of using biochar and zeolite amendments for wheat crop in rainfed area of Pakistan

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### Abstract

Nutrients and moisture loss are basic limiting factor of crop production in rainfed areas. Improving farm income is one of the primary aim of commercial wheat grower all over the world. As the prices of commercial fertilizers are increasing day by day, therefore the fertilizer use efficiency must be monitored. Biochar and zeolite as soil amendments have potential to maintain soil health and can enhance crops yields. A two year research (2015-16) was conducted at koont research farm in north potohwar region of Punjab, Pakistan to evaluate the benefit cost ratio. Sixteen different biochar and zeolite (sole and combine) doses were applied to soil by using RCBD design with three replications which are B0Z0=control, B3=biochar (3 tons/ha), B6=biochar (6 tons/ha), B9=biochar (9 tons/ha), Z1=zeolite (1 tons/ha), Z3=zeolite (3 tons/ha), Z5=zeolite (5 tons/ha), B3Z1=biochar (3 tons/ha) + zeolite (1 tons/ha), B3Z3=biochar (3 tons/ha) + zeolite (3 tons/ha), B3Z5=biochar (3 tons/ha) + zeolite (5 tons/ha), B6Z1=biochar (6 tons/ha) + zeolite (1 tons/ha), B6Z3=biochar (6 tons/ha) + zeolite (3 tons/ha), B6Z5=biochar (6 tons/ha) + zeolite (5 tons/ha), B9Z1=biochar (9 tons/ha) + zeolite (1 tons/ha), B9Z3=biochar (9 tons/ha) + zeolite (3 tons/ha), B9Z5=biochar (9 tons/ha) + zeolite (5 tons/ha). Wheat was planted for two consecutive years and benefit cost ratio was calculated. It was observed in two years all biochar and zeolite treatments somewhat contributed in increasing benefit cost ratio among which the most beneficial treatment was combine application of biochar @ 9 ton/ha and zeolite @5 ton/ha (B9Z5) in second year.

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## Introduction

Agriculture accounts for 19.53 percent of GDP and employed bulk of the total work force. Agriculture sector recorded a growth of 3.46 percent in financial year 2017 as compared to the growth of 0.27 percent last year. The crops subsector comprises of 37.22 percent of agriculture sector and is the basic driver of growth of the agriculture sector as well as GDP on the whole. Crops sub sector recorded a growth of 3.02 percent as compared to the growth of (-4.97) percent last year. Important crops accounting for 23.85 percent of value added of agriculture, its share in GDP is 4.66 percent (GOP 2017). Economic return from crop land is one of the basic interest of farmer. Crop production can be increased by using organic and inorganic soil amendments, which leads to better economic return to farmer.

In Pakistan, 80% of land area is semi-arid or arid, where 8% is humid and about 12% is dry sub humid. Lack of management practices, desertification and degradation are leading problems of Pakistani soil. The soils of Pakistan are deficient in micro and macro nutrients. According to a report, soils of Pakistan are deficient in NPK about 100%, 80-90% and 30% respectively (GOP 2014-15). Poor nutrient management practices are declining the fertility of soil. In rainfed agriculture, moisture stress due to erratic rainfall pattern during critical crop growth stage reduces grain yield and nutrient availability (Ren *et al.*, 2003). Moisture conservation is currently one of the critical issues in low rainfall regions. Water stress reduces the growth and development of crops (plants) in rain fed areas (James *et al.*, 2001).

Biochar is a carbon rich compound derived from the pyrolysis of feedstock (crop residues, wood chips, branches, twigs, poultry manure, farm yard manure etc) at high temperature (450- 750°C) in low oxygen environment in a close container (Brown *et al.*, 2006). Biochar soil amendment has the potential to improve soil chemical, physical and biological properties like bulk density, porosity, cation exchange capacity, pH, moisture holding capacity, nutrients retention and microbial growth which ultimately

enhance plant growth (Atkinson *et al.*, 2010; Lehmann, 2007; Lehmann and Rondon, 2005; Glaser *et al.*, 2002). Zeolite is a Greek word, which means boiling stone. A Swedish mineralogist Baron Alex Frederick introduced it in year 1756. It can hold 60 percent of water of its weight due to high porosity. One of the interesting properties of zeolite is its thermo stability and it can absorb and de-absorb water without change its structure. Therefore, zeolite promises continuous supply of moisture during dry spell, which protects the plant from harsh climatic conditions (Kocakusak *et al.*, 2001). Zeolite can be used as soil amendment to conserve moisture in rainfed areas where rain fall is limited and agronomic crops are subjected to water stress, so by using zeolite this stress can be lowered which support the plant at critical stages of growth and development (Zamanian, 2008). Zeolite can improve phosphorous availability, Nitrogen utilization (by enhancing availability of N-NH<sub>4</sub><sup>+</sup> and N-NO<sub>3</sub><sup>-</sup> ions) and reduced leaching of exchangeable cations, especially K<sup>+</sup> (Pickering *et al.*, 2002). Areas with probably low annual rainfall can be managed by incorporating biochar and zeolite. It helps in improving soil structure, water-holding capacity, retaining moisture and fertilizer use efficiency in rizosphere, which ultimately enhance plant growth.

Biochar have porous structure and contain stable compounds by nature, which remains in soil over long period of time, which makes it special (Woolf *et al.*, 2010). Therefore our aim is to calculate Benefit cost ratio based on production of wheat crop by using biochar and zeolite amendments under rain fed area.

## Materials and methods

Field experiment was established at *Pir Mehr Ali Shah*, Arid Agriculture University, Koont Research Farm (Chakwal, Punjab, Pakistan) in year 2013-14 and 2014-15. The field site was located at 32 56' 0" North and 72 52' 0" East. The annual rainfall in potohwar region ranges from 35-254 mm and most of the rainfall is (monsoon season) in June-July (PMD, 2011). Average daytime temperature in Rabi season ranges from 25-32 C in year 2013-14 and 2014-15.

While, Texture of soil was sandy clay loam. Plot size was 24m<sup>2</sup>. Plot to plot distance was 1 meter and 2 meters between replications. Randomized complete block design (RCBD) with sixteen treatments and three replications were used which are as follow BoZo=control, B3=biochar (3 tons/ha), B6=biochar (6 tons/ha), B9=biochar (9 tons/ha), Z1=zeolite (1 tons/ha), Z3=zeolite (3 tons/ha), Z5=zeolite (5 tons/ha), B3Z1=biochar (3 tons/ha) + zeolite (1 tons/ha), B3Z3=biochar (3 tons/ha) + zeolite (3 tons/ha), B3Z5=biochar (3 tons/ha) + zeolite (5 tons/ha), B6Z1=biochar (6 tons/ha) + zeolite (1 tons/ha), B6Z3=biochar (6 tons/ha) + zeolite (3 tons/ha), B6Z5=biochar (6 tons/ha) + zeolite (5 tons/ha), B9Z1=biochar (9 tons/ha) + zeolite (1 tons/ha), B9Z3=biochar (9 tons/ha) + zeolite (3 tons/ha), B9Z5=biochar (9 tons/ha) + zeolite (5 tons/ha). Biochar used in this experiment was produced in department of soil Science PMAS-AAUR. Clinoptilolite Zeolite used in this experiment was purchased from local market imported from Iran.

#### Seedbed preparations

Soil was ploughed before onset of monsoon to conserve moisture with chisel plough in the start of June 2013. Seedbed was prepared by tine plough (3 times) with plunker to improve soil tilth. Biochar and zeolite treatments were applied as mentioned above into soil before three months of planting. Wheat (*Triticum aestivum*) variety *Chakwal-50* was sown at the rate of 130kg/ha by using manual seed drill. Recommended rate of NPK fertilizers (N: 150, P<sub>2</sub>O<sub>5</sub>:100, and k<sub>2</sub>O:60 kg/ha) were used in this experiment. All other cultural practices were kept normal in all plots to evaluate the effect of biochar and zeolite in different proportion on production of wheat crop. There were sixteen different sole and combine doses of biochar and zeolite were incorporated in soil which are as follow: BoZo=control, B3=biochar (3 tons/ha), B6=biochar (6 tons/ha), B9=biochar (9 tons/ha), Z1=zeolite (1 tons/ha), Z3=zeolite (3 tons/ha), Z5=zeolite (5 tons/ha), B3Z1=biochar (3 tons/ha) + zeolite (1 tons/ha), B3Z3=biochar (3 tons/ha) + zeolite (3 tons/ha), B3Z5=biochar (3 tons/ha) + zeolite (5 tons/ha), B6Z1=biochar (6 tons/ha) + zeolite (1 tons/ha), B6Z3=biochar (6 tons/ha) + zeolite (3 tons/ha), B6Z5=biochar (6 tons/ha) + zeolite (5 tons/ha), B9Z1=biochar (9 tons/ha) + zeolite (1 tons/ha), B9Z3=biochar (9 tons/ha) + zeolite (3 tons/ha), B9Z5=biochar (9 tons/ha) + zeolite (5 tons/ha).

tons/ha), B6Z1=biochar (6 tons/ha) + zeolite (1 tons/ha), B6Z3=biochar (6 tons/ha) + zeolite (3 tons/ha), B6Z5=biochar (6 tons/ha) + zeolite (5 tons/ha), B9Z1=biochar (9 tons/ha) + zeolite (1 tons/ha), B9Z3=biochar (9 tons/ha) + zeolite (3 tons/ha), B9Z5=biochar (9 tons/ha) + zeolite (5 tons/ha).

#### Wheat crop yield and economic analysis parameters

##### Seed Yield

Three samples of 1m<sup>2</sup> from each plot was harvested manually and threshed after sun drying manually and the seed yield plot<sup>-1</sup> so obtained was converted into seed yield hectare<sup>-1</sup> (SYH).

##### Total biomass

Three samples of 1m<sup>2</sup> from each plot was harvested manually and exposed to sunlight for five days. Dried samples were weighted by using digital balance. Average weight was calculated from the obtained values and converted into kg/ha.

##### Benefit Cost Ratio

Benefit cost ratio was calculated by using the following formula (Prakash and Mitchell, 2015). Cost of all inputs and outputs from sowing to harvesting was converted in Pakistani rupees to find out BCR.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Pv benefit}}{\text{Pv cost}}$$

Where,

Pv = present value of benefit

Pv cost= present value of cost

##### Profit calculation

Profit was calculated by using the following formula

$$\text{Profit} = \text{SP} - \text{CP}$$

Where,

SP = Sale price

CP= Cost price

## Results

Two year crop production cost from sowing to harvesting including all input were shown in table 3-4, Data for year 1 and year 2.

Effect of biochar and zeolite sole and in combination on Biological and grain yield of wheat areas under.

#### Biological yield

Biological yield of the crop mainly depend upon the availability of nitrogen during growth, which decides the rate of photosynthesis in plant. Greater the canopy of plant, greater will be the surface area for light interception and production of synthates. According to the analysis of variance, sole biochar application (shown in Table 1) at the rate of B<sub>3</sub>, B<sub>6</sub> and B<sub>9</sub> gave 3 to 13 % increase in first year and 5 to 14% increase in biological yield over control. Whereas sole zeolite application also follow the similar increasing

trend. It was observed that zeolite treatment Z<sub>1</sub>, Z<sub>3</sub> and Z<sub>5</sub> enhanced biological yield by 4, 6 and 9% during first experimental year and 5, 7 and 10% respectively in second year over control.

Maximum increase (21 and 25%) in biological yield was observed in B<sub>9</sub>Z<sub>5</sub> treatment over control followed by treatment B<sub>9</sub>Z<sub>3</sub> in both experimental years. It was observed that combined application of biochar and zeolite performed better then sole application. Saarnio *et al.* (2013) found that biochar amendment stimulated carbon and nitrogen mineralization and enhance nutrients and moisture uptake by the plant, which ultimately increase plant growth. Vaccari *et al.* (2011).

**Table 1.** Impact of biochar and zeolite amendment on biological yield (kg/ha) of wheat crop.

Treatments		Year 1	Year 2		
Biochar	Control	6454 d	6482 d		
	B <sub>3</sub>	6657 c	6793 c		
	B <sub>6</sub>	6947 b	7038 b		
	B <sub>9</sub>	7279 a*	7366 a*		
Zeolite	Control	6536 d	6562 d		
	Z <sub>1</sub>	6765 c	6887 c		
	Z <sub>3</sub>	6901 b	7037 b		
	Z <sub>5</sub>	7135. a*	7192 a*		
Biochar*Zeolite	Year 1	Z <sub>0</sub>	Z <sub>1</sub>	Z <sub>3</sub>	Z <sub>5</sub>
	B <sub>0</sub>	6375 i	6446 hi	6464 g-i	6533 f-h
	B <sub>3</sub>	6566 fg	6559 fg	6636 f	6865 e
	B <sub>6</sub>	6582 f	6783. e	7011 d	7410 b
	B <sub>9</sub>	6619 f	7271 c	7493 b	7733 a*
Biochar*zeolite	Year 2	Z <sub>0</sub>	Z <sub>1</sub>	Z <sub>3</sub>	Z <sub>5</sub>
	B <sub>0</sub>	6251 k	6490 j	6569 h-j	6619 hi
	B <sub>3</sub>	6546 ij	6745 fg	6922 e	6958 e
	B <sub>6</sub>	6654 gh	6972 e	7089 d	7436 c
	B <sub>9</sub>	6796 f	7341 c	7567 b	7757 a*

Where

BoZo=control, B3=biochar (3 tons/ha), B6=biochar (6 tons/ha), B9=biochar (9 tons/ha), Z1=zeolite (1 tons/ha), Z3=zeolite (3 tons/ha), Z5=zeolite (5 tons/ha), B3Z1=biochar (3 tons/ha) + zeolite (1 tons/ha), B3Z3=biochar (3 tons/ha) + zeolite (3 tons/ha), B3Z5=biochar (3 tons/ha) + zeolite (5 tons/ha), B6Z1=biochar (6 tons/ha) + zeolite (1 tons/ha), B6Z3=biochar (6 tons/ha) + zeolite (3 tons/ha), B6Z5=biochar (6 tons/ha) + zeolite (5 tons/ha), B9Z1=biochar (9 tons/ha) + zeolite (1 tons/ha), B9Z3=biochar (9 tons/ha) + zeolite (3 tons/ha), B9Z5=biochar (9 tons/ha) + zeolite (5

tons/ha). \* Means not sharing a letter in common within column differ significantly at 5% probability level. performed an experiment and 30% increase in biomass of wheat crop was found in biochar amended soil. Nogueraa *et al.* (2012) found that addition of biochar increased shoot biomass by increasing (87%) number of leaves and leaf turn over in rice plant. Similarly Smimeh *et al.* (2013) found that application of zeolite significantly increased biological yield of sunflower.

#### Economic yield

Obtaining high grain yield often called economic yield is the ultimate objective of growing cereal crops.

On the basis of analysis of variance of the data collected in both experimental years it was observed that biochar and zeolite significantly affected grain yield as shown in Table 2. Maximum increase of 25% was observed in treatment B<sub>9</sub> followed by B<sub>6</sub> with 14% and B<sub>3</sub> with 9% increase during first year over control. While maximum increase of 32% was observed B<sub>9</sub> in 2<sup>nd</sup> year following by treatment B<sub>6</sub> and B<sub>3</sub> with 26% and 16% increase, respectively. In sole zeolite treatment maximum increase of 15% and 22% was observed in treatment Z<sub>5</sub> while treatment Z<sub>3</sub> has increase grain yield by 10 to 20% and treatment Z<sub>1</sub> by 6 to 13% in both experimental years. Interaction of biochar and zeolite was also significant.

Maximum increase in grain yield (2602 and 2648kg/ha) was observed in treatment B<sub>9</sub>Z<sub>5</sub> with 41% increase in first year and 48% increase in second year with respect to control followed by treatment B<sub>9</sub>Z<sub>3</sub>. Whereas the minimum (1955 and 2062kg/ha) grain yield was found in control.

On the basis of results, it was concluded that interaction of biochar and zeolite performed better than sole application. These results are in line with the findings of Maria *et al.*, (2011), it was concluded that the application of zeolite with nitrogen fertilizer increase grain yield of wheat. Application of zeolite (clinoptilolite) has the potential to increase.

**Table 2.** Impact of biochar and zeolite amendment on economical yield (kg/ha) of wheat crop.

	Treatments	Year 1	Year 2		
Biochar	Control	2108 c	2154 d		
	B <sub>3</sub>	2291 b	2344 c		
	B <sub>6</sub>	2394 a	2428 b		
	B <sub>9</sub>	2418 a*	2479 a*		
Zeolite	Control	2132 d	2221 c		
	Z <sub>1</sub>	2294 c	2341 b		
	Z <sub>3</sub>	2337 b	2365 b		
	Z <sub>5</sub>	2449 a*	2477 a*		
Biochar*Zeolite	Year 1	Z <sub>0</sub>	Z <sub>1</sub>	Z <sub>3</sub>	Z <sub>5</sub>
	B <sub>0</sub>	1955 h	2106 fg	2138 ef	2233 d
	B <sub>3</sub>	2064 g	2312 c	2363 bc	2424 b
	B <sub>6</sub>	2199 de	2413 b	2427 b	2538 a
	B <sub>9</sub>	2308 c	2344 c	2420 b	2602 a*
Biochar*zeolite	Year 2	Z <sub>0</sub>	Z <sub>1</sub>	Z <sub>3</sub>	Z <sub>5</sub>
	B <sub>0</sub>	2061 h	2134 g	2178 g	2245 f
	B <sub>3</sub>	2150 g	2377 e	2380 e	2468 c
	B <sub>6</sub>	2278 f	2428 c-e	2462 c	2548 b
	B <sub>9</sub>	2399 de	2426 c-e	2438 cd	2648 a*

Where

BoZo=control, B<sub>3</sub>=biochar (3tons/ha), B<sub>6</sub>=biochar (6 tons/ha), B<sub>9</sub>=biochar (9 tons/ha), Z<sub>1</sub>=zeolite (1 tons/ha), Z<sub>3</sub>=zeolite (3 tons/ha), Z<sub>5</sub>=zeolite (5 tons/ha), B<sub>3</sub>Z<sub>1</sub>=biochar (3 tons/ha) + zeolite (1 tons/ha), B<sub>3</sub>Z<sub>3</sub>=biochar (3 tons/ha) + zeolite (3 tons/ha), B<sub>3</sub>Z<sub>5</sub>=biochar (3 tons/ha) + zeolite (5 tons/ha), B<sub>6</sub>Z<sub>1</sub>=biochar (6 tons/ha) + zeolite (1 tons/ha), B<sub>6</sub>Z<sub>3</sub>=biochar (6 tons/ha) + zeolite (3 tons/ha), B<sub>6</sub>Z<sub>5</sub>=biochar (6 tons/ha) + zeolite (5 tons/ha), B<sub>9</sub>Z<sub>1</sub>=biochar (9 tons/ha) + zeolite (1 tons/ha), B<sub>9</sub>Z<sub>3</sub>=biochar (9 tons/ha) + zeolite (3 tons/ha), B<sub>9</sub>Z<sub>5</sub>=biochar (9 tons/ha) + zeolite (5

tons/ha). \* Means not sharing a letter in common within column differ significantly at 5% probability level. Fertilizer use efficiency, which results in better growth and development of crop and increased its yield (Polat *et al.*, 2004). Malekian *et al.* (2011) found decrease in nitrate leaching and increase in grain yield of corn in zeolite (Clinoptilolite) amended soil. Zahedi *et al.* (2011) concluded that zeolite have the potential to conserve moisture during drought conditions and enhance plant growth and yield. Abbasieh *et al.* (2013) found that application of zeolite with potassium fertilizer has increased yield of sunflower by 70%.

Similarly, biochar addition increase organic matter content in the soil, which improves the crop yield (Chan *et al.*, 2007). Wheat yield was found to be increased by 18% with 6 tons/ha application of biochar along with half dose of recommended chemical fertilizer (Solaiman *et al.*, 2010). Addition of biochar changes the albedo and increase soil temperature. Increase in temperature at the time of germination can help in better crop stand and ultimately enhanced crop growth (Genesio *et al.*, 2012). Uses of biochar as a soil amendment have the potential to increase crop yield in rain fed areas where water is a central limiting factor crop production (Lehmann *et al.*, 2006). According to Albuquerque *et al.* (2012) biochar amendment to soil increase yield of wheat crop, mitigate climate change and maintain agricultural sustainability.

### Economic analysis

#### Benefit cost ratio

Economic analysis is a scientific approach to identify optimum use of available resources and enhance profit in term of money. In this regard BCR was calculated by keeping in view the cost of inputs (Soil bed preparation, application of biochar and zeolite, fertilizers, seeds, herbicides, use of agri-equipments/machinery, labor, harvesting and transportation charges) and outputs (Wheat straw and grains shown in table 1 and 2 in detail ) for two years. Table 3 and 4 shows the cost of all inputs and economical yield in Pakistani rupees.

The treatment B<sub>0</sub>Z<sub>0</sub> showed the highest benefit cost ratio of 2.7 and the lowest BCR (0.9) was found in B<sub>9</sub>Z<sub>5</sub> treatment during first year. All other sole and combine treatments with 3, 6 and 9 tons/ha of biochar and 1, 3 and 5 tons/ha of zeolite have low benefit cost ratio than control during first year. Extra cost of biochar and zeolite were responsible for low BCR in treated soil when compared to control (B<sub>0</sub>Z<sub>0</sub>). In second year highest benefit cost ratio (3.5) was observed in treatment B<sub>9</sub>Z<sub>5</sub> followed by treatment B<sub>9</sub>Z<sub>3</sub> and B<sub>9</sub>Z<sub>1</sub> and the lowest BCR (2.8) was found in control. Increase in BCR during second year was due to increase in economical yield and excluding the input cost of biochar and zeolite (Zeolite and biochar treatments were applied once in year 2013 before start of experiment). On the basis of this experiment, it was suggested that biochar and zeolite use is feasible for small to large scale farming to maximize crop production. Clinoptililite zeolite is widely used in agriculture due to its availability (huge deposits in nature), low price and unique physiochemical characteristics. Application of biochar and zeolite conserve moisture and nutrients. Which ultimately reduce cost of production and enhance economical yield of a crop. In this regard DeLuca and DeLuca, (1997) found that zeolite due to its physical and chemical properties help to retain nutrients in top soil and reduce nutrient leaching. It increases the fertilizer use efficiency and reduced (input) cost of crop production.

**Table 3.** Cost of all inputs and economic yield mention in Pakistani rupee(PKR) for 1<sup>st</sup> year.

Ents	Cost of sowing in PKR rupee/ Hactare Year 2013-14									Harvesting cost PKR rupee/Hactare			Benefit in PKR rupee/Hactare	
	Seed bed preparation/ha	Sowing with drill/hour	Fertilizers Urea &NPK /ha	Seed kg/ha	Zeolite ton/ha	Biochar ton/ha	Pesticide /ha	Labor/ (spray)	transportation (seed, fertilizer)	Harvester cost/hr	Labour (loading, unloading)	Transportation To local market	WHEAT SRTAW (kg/ha)	Grain yield (kg/ha)
B <sub>0</sub> Z <sub>0</sub>	6750	1050	14088	5805	0	0	1976	800	500	2500	2400	4000	47808.75	61087.5
B <sub>3</sub> Z <sub>0</sub>	6750	1050	14088	5805	0	30000	1976	800	500	2500	2400	4000	49247.25	64509.38
B <sub>6</sub> Z <sub>0</sub>	6750	1050	14088	5805	0	60000	1976	800	500	2500	2400	4000	49370.25	68718.75
B <sub>9</sub> Z <sub>0</sub>	6750	1050	14088	5805	0	90000	1976	800	500	2500	2400	4000	49643.25	72121.88
B <sub>0</sub> Z <sub>1</sub>	6750	1050	14088	5805	4000		1976	800	500	2500	2400	4000	48348.75	65809.38
B <sub>0</sub> Z <sub>3</sub>	6750	1050	14088	5805	12000		1976	800	500	2500	2400	4000	48478.5	66796.88
B <sub>0</sub> Z <sub>5</sub>	6750	1050	14088	5805	20000		1976	800	500	2500	2400	4000	48993.75	69793.75
B <sub>3</sub> Z <sub>1</sub>	6750	1050	14088	5805	4000	30000	1976	800	500	2500	2400	4000	49192.5	72259.38
B <sub>3</sub> Z <sub>3</sub>	6750	1050	14088	5805	12000	30000	1976	800	500	2500	2400	4000	49771.5	73859.38
B <sub>3</sub> Z <sub>5</sub>	6750	1050	14088	5805	20000	30000	1976	800	500	2500	2400	4000	51485.25	75750
B <sub>6</sub> Z <sub>1</sub>	6750	1050	14088	5805	4000	60000	1976	800	500	2500	2400	4000	50876.25	75403.13
B <sub>6</sub> Z <sub>3</sub>	6750	1050	14088	5805	12000	60000	1976	800	500	2500	2400	4000	52582.5	75840.63
B <sub>6</sub> Z <sub>5</sub>	6750	1050	14088	5805	20000	60000	1976	800	500	2500	2400	4000	55575	79306.25
B <sub>9</sub> Z <sub>1</sub>	6750	1050	14088	5805	4000	90000	1976	800	500	2500	2400	4000	54534.75	73234.38
B <sub>9</sub> Z <sub>3</sub>	6750	1050	14088	5805	12000	90000	1976	800	500	2500	2400	4000	56199	75634.38
B <sub>9</sub> Z <sub>5</sub>	6750	1050	14088	5805	20000	90000	1976	800	500	2500	2400	4000	57997.5	81296.88



**Table 4.** Cost of all inputs and economic yield mention in Pakistani rupee (PKR) for 2<sup>nd</sup> year.

Seed bed preparation/ha	Treatments Cost of sowing in PKR rupee / Hactare Year 2014							Harvesting cost PKR rupee/Hactare			Benefit in PKR rupee/Hactare			
	Sowing with drill/hour	Fertilizers Urea &NPK /ha	Seed kg/ha	Zeolite ton/ha	Biochar ton/ha	Pesticide /ha	Labor (spray)	transportation /seed, fertilizer)	Harvester cost/hr	Labour (loading, unloading)	Transportation To local market	WHEAT SRTAW (kg/ha)	Grain yield (kg/ha)	
B0Z0	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	46879.5	64418.75
B3Z0	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	49093.5	67178.13
B6Z0	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	49903.5	71087.5
B9Z0	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	50970.75	74978.13
BoZ1	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	48675.75	66690.63
BoZ3	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	49269	68050
BoZ5	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	49641	70143.75
B3Z1	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	50039.25	73387.5
B3Z3	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	51748.5	73303.13
B3Z5	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	51681	76443.75
B6Z1	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	52288.5	75871.88
B6Z3	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	53163.75	76943.75
B6Z5	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	55771.5	79637.5
B9Z1	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	55060.5	75800
B9Z3	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	56757	76196.88
B9Z5	5750	1050	14088	5805	-	-	1976	300	300	2500	2400	4000	58176.75	82746.88

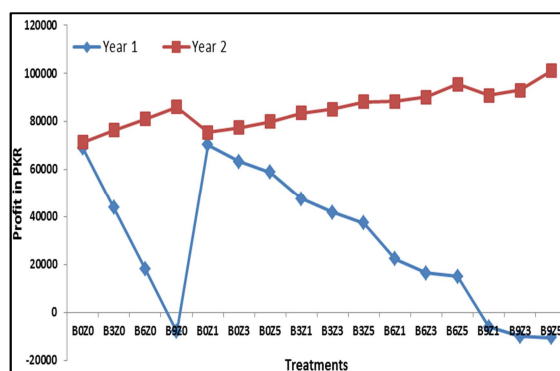
**Table 5.** Benefit cost ratio of wheat crop by using Biochar and zeolite soil amendments.

Treatments	Year 1			Year 2		
	Benefit in PKR	Cost In PKR	Benefit Cost Ratio	Benefit in PKR	Cost In PKR	Benefit Cost Ratio
B0Z0	39869	108896.3	2.73	39869	111298	2.79
B3Z0	69869	113756.6	1.63	39869	116272	2.92
B6Z0	99869	118089	1.18	39869	120991	3.03
B9Z0	129869	121765.1	0.94	39869	125949	3.16
BoZ1	43869	114158.1	2.60	39869	115366	2.89
BoZ3	51869	115275.4	2.22	39869	117319	2.94
BoZ5	59869	118787.5	1.98	39869	119785	3.00
B3Z1	73869	121451.9	1.64	39869	123427	3.10
B3Z3	81869	123630.9	1.51	39869	125052	3.14
B3Z5	89869	127235.3	1.42	39869	128125	3.21
B6Z1	103869	126279.4	1.22	39869	128160	3.21
B6Z3	111869	128423.1	1.15	39869	130108	3.26
B6Z5	119869	134881.3	1.13	39869	135409	3.40
B9Z1	133869	127769.1	0.95	39869	130861	3.28
B9Z3	141869	131833.4	0.93	39869	132954	3.33
B9Z5	149869	139294.4	0.93	39869	140924	3.53

More specifically when profit of using these biochar and zeolite treatments was calculated it was found that in control B<sub>0</sub>Z<sub>0</sub> treatment profit was minimum in first year but all other treatments show improvement in yield. Though the indicating line in graph is showing decreasing trend in profit because the initial costs of treatments lower the profit in first year.

In Treatment B<sub>9</sub>Z<sub>0</sub> B<sub>3</sub>Z<sub>5</sub>, B<sub>6</sub>Z<sub>5</sub> and B<sub>9</sub>Z<sub>5</sub> the cost of inputs was so high that there was no remarkable profit for the first year but when results of second year was calculated it was found that Treatment B<sub>9</sub>Z<sub>0</sub>, B<sub>3</sub>Z<sub>5</sub>, B<sub>6</sub>Z<sub>5</sub> and B<sub>9</sub>Z<sub>5</sub> have maximum profit. Biochar and zeolite treatments as a soil conditioner enhance water and fertilizer use efficiency which facilitate crop growth. Therefore Combine dose of Biochar and zeolite is highly profitable for use in

degraded soil in rainfed areas to improve soil health. Although these treatments have long term effect so further economic analysis are in process. This benefit cost ratio is helpful for farmers of rainfed areas to estimate their farm income.



**Fig. 1.** Two year impact of biochar and zeolite treatments on profit.

### Conclusion

It was observed that biochar and zeolite treatments along with NPK fertilizer enhance economical yield of wheat crop. On the bases of economic analysis of wheat crop it was found that by using biochar and zeolite amendments at the rate of 9 ton/ha and 5 ton/ha (sole and combine) for one time give beneficial economic return for two consecutive years. More research is needed to study long term economic benefit from these amendments.

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