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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

Awais Ali*[1], Irfan Aziz[1], Mehmood-Ul-Hassan[1], Shehzada Sohail Ejaz[2]

[1]*Department of Agronomy, Faculty of Crop & Food Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan*

[2]*Department of Soil Science and Water Conservation, Faculty of Crop & Food Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, 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.

* **Corresponding Author:** Awais Ali ✉ awaisshah12@hotmail.com

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 in organic 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˚Ċ) 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_4^+ and N-NO_3^- ions) and reduced leaching of exchangeable cations, especially K^+ (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 24m². 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 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). 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 planker 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_2O_5:100, and k_2O: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: 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 crop yield and economic analysis parameters

Seed Yield

Three samples of 1m² from each plot was harvested manually and threshed after sun drying manually and the seed yield plot^{-1} so obtained was converted into seed yield hectare^{-1} (SYH).

Total biomass

Three samples of 1m² 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.

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

Where,

P_V = present value of benefit

P_V cost= present value of cost

Profit calculation

Profit was calculated by using the following formula

Profit= SP- 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_3, B_6 and B_9 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_1, Z_3 and Z_5 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_9Z_5 treatment over control followed by treatment B_9Z_3 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_3	6657 c	6793 c		
	B_6	6947 b	7038 b		
	B_9	7279 a*	7366 a*		
Zeolite	Control	6536 d	6562 d		
	Z_1	6765 c	6887 c		
	Z_3	6901 b	7037 b		
	Z_5	7135. a*	7192 a*		
Biochar*Zeolite	Year 1	Z_0	Z_1	Z_3	Z_5
	B_0	6375 i	6446 hi	6464 g-i	6533 f-h
	B_3	6566 fg	6559 fg	6636 f	6865 e
	B_6	6582 f	6783. e	7011 d	7410 b
	B_9	6619 f	7271 c	7493 b	7733 a*
Biochar*zeolite	Year 2	Z_0	Z_1	Z_3	Z_5
	B_0	6251 k	6490 j	6569 h-j	6619 hi
	B_3	6546 ij	6745 fg	6922 e	6958 e
	B_6	6654 gh	6972 e	7089 d	7436 c
	B_9	6796 f	7341 c	7567 b	7757 a*

Where

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). * 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 nd 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_9 followed by $B_6$with 14% and $B_{3v}$with 9% increase during first year over control. While maximum increase of 32% was observed B_9 in 2nd year following by treatment B_6 and B_3 with 26% and 16% increase, respectively. In sole zeolite treatment maximum increase of 15% and 22% was observed in treatment Z_5 while treatment Z_3has increase grain yield by 10 to 20% and treatment Z_1 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_9Z_5 with 41% increase in first year and 48% increase in second year with respect to control followed by treatment B_9Z_3.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_3	2291 b		2344 c	
	B_6	2394 a		2428 b	
	B_9	2418 a*		2479 a*	
Zeolite	Control	2132 d		2221 c	
	Z_1	2294 c		2341 b	
	Z_3	2337 b		2365 b	
	Z_5	2449 a*		2477 a*	
Biochar*Zeolite	Year 1	Z_0	Z_1	Z_3	Z_5
	B_0	1955 h	2106 fg	2138 ef	2233 d
	B_3	2064 g	2312 c	2363 bc	2424 b
	B_6	2199 de	2413 b	2427 b	2538 a
	B_9	2308 c	2344 c	2420 b	2602 a*
Biochar*zeolite	Year 2	Z_0	Z_1	Z_3	Z_5
	B_0	2061 h	2134 g	2178 g	2245 f
	B_3	2150 g	2377 e	2380 e	2468 c
	B_6	2278 f	2428 c-e	2462 c	2548 b
	B_9	2399 de	2426 c-e	2438 cd	2648 a*

Where

B0Z0=control, B3=biochar (3tons/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. 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 Alburquerque *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 calcuated by keeping in view the cost of inputs (Soil bed prepration, application of biochar and zeolite, fertilizers, seeds, herbicides, use of agri-equipments/machinary, 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_0Z_0 showed the highest benifit cost ratio of 2.7 and the lowest BCR (0.9) was found in B_9Z_5 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 benifit cost ratio than control during first year. Extra cost of biochar and zeolite were responsiblfor low BCR in treated soil when compared to control (B_0Z_0). In second year highest benefit cost ratio (3.5) was observed in treatment B_9Z_5 followed by treatment B_9Z_3 and B_9Z_1 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 fesible for small to large scale farming to maximize crop production. Clinoptililite zeolite is widely used in agriculture due to its availibility (huge deposits in nature), low price and unique physiochemical chracteristics. 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 n utrient 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 1st 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)
B0Z0	6750	1050	14088	5805	0	0	1976	800	500	2500	2400	4000	47808.75	61087.5
B3Z0	6750	1050	14088	5805	0	30000	1976	800	500	2500	2400	4000	49247.25	64509.38
B6Z0	6750	1050	14088	5805	0	60000	1976	800	500	2500	2400	4000	49370.25	68718.75
B9Z0	6750	1050	14088	5805	0	90000	1976	800	500	2500	2400	4000	49643.25	72121.88
B0Z1	6750	1050	14088	5805	4000		1976	800	500	2500	2400	4000	48348.75	65809.38
B0Z3	6750	1050	14088	5805	12000		1976	800	500	2500	2400	4000	48478.5	66796.88
B0Z5	6750	1050	14088	5805	20000		1976	800	500	2500	2400	4000	48993.75	69793.75
B3Z1	6750	1050	14088	5805	4000	30000	1976	800	500	2500	2400	4000	49192.5	72259.38
B3Z3	6750	1050	14088	5805	12000	30000	1976	800	500	2500	2400	4000	49771.5	73859.38
B3Z5	6750	1050	14088	5805	20000	30000	1976	800	500	2500	2400	4000	51485.25	75750
B6Z1	6750	1050	14088	5805	4000	60000	1976	800	500	2500	2400	4000	50876.25	75403.13
B6Z3	6750	1050	14088	5805	12000	60000	1976	800	500	2500	2400	4000	52582.5	75840.63
B6Z5	6750	1050	14088	5805	20000	60000	1976	800	500	2500	2400	4000	55575	79306.25
B9Z1	6750	1050	14088	5805	4000	90000	1976	800	500	2500	2400	4000	54534.75	73234.38
B9Z3	6750	1050	14088	5805	12000	90000	1976	800	500	2500	2400	4000	56199	75634.38
B9Z5	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 2nd year.

Treatments	Cost of sowing in PKR rupee / Hactare Year 2014									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)
B0Z0	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	46879.5	64418.75
B3Z0	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	49093.5	67178.13
B6Z0	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	49903.5	71087.5
B9Z0	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	50970.75	74978.13
B0Z1	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	48675.75	66690.63
B0Z3	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	49269	68050
B0Z5	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	49641	70143.75
B3Z1	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	50039.25	73387.5
B3Z3	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	51748.5	73303.13
B3Z5	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	51681	76443.75
B6Z1	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	52288.5	75871.88
B6Z3	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	53163.75	76943.75
B6Z5	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	55771.5	79637.5
B9Z1	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	55060.5	75800
B9Z3	6750	1050	14088	5805	-	-	1976	800	500	2500	2400	4000	56757	76196.88
B9Z5	6750	1050	14088	5805	-	-	1976	800	500	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
B0Z1	43869	114158.1	2.60	39869	115366	2.89
B0Z3	51869	115275.4	2.22	39869	117319	2.94
B0Z5	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 theses biochar and zeolite treatments was calculated it was found that in control B_0Z_0 treatment profit was minimum in first year but all other treatments show improvement in yield. Though the indicating line in graph is showing decreaing trend in profit because the initial costs of treatments lower the profit in first year.

In Treatment B9Z0 B_3Z_5, B_6Z_5 and B_9Z_5 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 B9Z0, B_3Z_5, B_6Z_5 and B_9Z_5 have maximum profit. Biochar and zeolite treatments as a soil conditioner enhance water and fertilizer use efficiency which facilitate crop growth. Therefor 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.

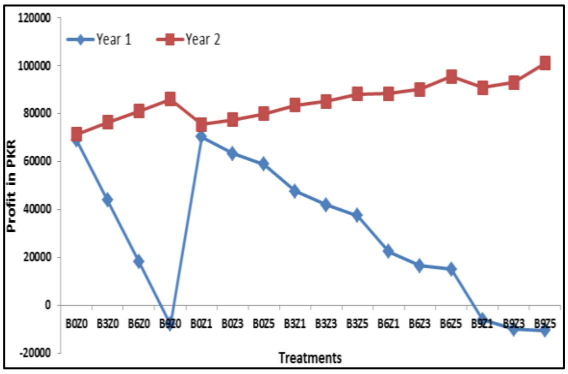

Fig. 1. Two year impact of biochar and zeolite treatments on profit.

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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