Appraising economic dimension of maize production under coherent fertilization in Azad Kashmir, Pakistan

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Abstract

Pakistan is ranked seventh biggest country where climate change has imparted drastic impacts on crops productivity and profitability along with seriously disturbing the agro-ecological systems. Environmental pollution caused by chemical fertilizers along with their high prices which deplete economic turn-outs necessitates the utilization of organic materials for boosting the profitability of rainfed crops. A field trial was executed to investigate the response of maize to organic manures applied solely and conjunction with reduced doses of chemical fertilizers. The field trial was comprised of three nutrient sources including urea nitrogen, poultry manure, compost manure applied solely and in conjunction with each other. The productivity and profitability of maize under coherent fertilization regimes were taken as response variables. The research findings indicated that urea nitrogen remained superior to solo and co-application organic manures as far as grain yield of maize was concerned. The

highest crop value was generated by urea nitrogen (US$2375) and it was followed by poultry manure applied in combination with urea nitrogen (US$2365). The coherent application of urea nitrogen and poultry manure gave the maximum net returns (US$2265), incremental income (US$513) and value-cost ratio (5.13), while among fertilization treatments, poultry manure and compost applied coherently generated the minimum net returns ($1765) and incremental income (US$31). Thus, coherently applied urea nitrogen and poultry manure is inferred as the most profitable fertilization regime under rainfed conditions.

Keywords: Integrated fertilization. Value-cost ratio. Net income. Organic manures. *Zea mays* L.

1. Introduction

Climate change has threatened crops productivity and livelihood of millions of farmers in developing countries like Pakistan. As Pakistan entails an agrarian economy, thus crops productivity imparts significant influence on various economic indicators (GDP, exports volume, trade deficit, balance of payments, fiscal deficit, foreign exchange reserves etc.) of the country (Ahmad *et al.*, 2015). Maize is world's leading crop with respect to area under cultivation and production, while maize flour, meals, flakes, porridge, poultry and fish meals, bran feed, gluten meal and stalk fodder are some of its products. Although maize production in Pakistan has surged to over 6.10 million tons with an area of 1.33 m ha in 2017 from 5.27 million tons (1.19 m ha) in 2016 with total export of over 0.1 million tons (US$ 15 million), but still maize yield (4.59 t ha^{-1}) remained below par to varietal potential (Iqbal *et al.*, 2017). Among many factor responsible for lower yield of maize, poor plant nutrition constitutes as a major reason (Iqbal and Mian, 2015) owing to non-availability at critical growth stages of crop and precarious economic conditions of small landholders. The sub-optimal plant nutrition decreases maize yield sharply which slashes economic turn outs which has forced the farmers of rainfed areas to live below the poverty line.

Environmental pollution, high prices, sub-optimal yields and low profitability has necessitated the utilization of alternate sources of plant nutrients for maize production. Different organic materials of plant and animal origin have the potential to supply essential nutrients for crops production, restoration and preservation of soils along with boosting economic turn outs generated through plummeted input costs on one hand and surged yields on the other hand. However, organic manures applied as a sole of pant nutrients recorded significantly lesser yields and net income compared to chemical fertilizers (Sahoo and

Mahapatra, 2015). The performance of organic manures was reported to be mainly linked to their chemical composition, decomposition level and provision of nutrients as per crop requirements. It was suggested that organic material such as farm yard manure, poultry litter, municipal sewdge and sludge, vermicompost etc. also result in polluting environment and water bodies owing to inappropriate disposal (Adamtey *et al.,* 2016). An advantage associated with organic manures was their potential to supply nutrients over a longer period of time compared to chemical fertilizers which led to higher nutrient use efficiency and ultimately maize yield along with net returns were doubled (Ali *et al.*, 2015).

There exists a knowledge and research gap regarding the performance of organic manures of plant and animal origin for maize productivity and profitability under rainfed conditions. Thus, it was hypothesized that organic manures have potential to generate higher or at least comparable economic returns as that of chemical fertilizers. Thus, the primary objective of this field trial was to determine the influence of organic manures applied solely and coherently with each other and reduced doses of chemical fertilizers on productivity and profitability of maize under rainfed conditi0ns of Azad Kashmir, Pakistan.

2. Literature Review

The significantly lower cost of production and higher profitability of organic materials have the potential to make them popularize among the farming community. Singh et al., (2010) conducted a field trial to determine the influence of coherent application of farm yard manure and chemical fertilizers on economic returns and benefit-cost ratio (BCR) of baby corn (pre-mature, unfertilized and de-husked maize ear which is consumed as vegetable). It was concluded that solo chemical fertilizers resulted in the highest net income (US$ 1174 ha^{-1}) and benefit-cost ratio (3.45), while coherent application of farm yard manure (FYM) and chemical fertilizer followed it with net profit and BCR of US$ 970 ha^{-1} and 3.31 respectively. It was also reported that combined application of FYM and chemical fertilizers resulted in higher cost of production (US$ 123 ha^{-1}) compared to chemical fertilizers alone. Sahoo and Mahapatra (2005) also reported that integrated fertilization was effective in boosting economic returns of baby corn under agro-environmental conditions of India. However, this study lacked integration of organic manures from plant origin for decreasing cost of production and increasing profit. In another field investigation Sahoo and Mahapatra (2007)

reported that coherent application of organic manures has the potential to reduce fertilizers cost and yielded comparable grain yield of maize.

Ramachandrappa et al. (2004) reported that baby corn productivity and profitability was influenced by coherent fertilization (synthetic fertilizers + organic composed manures). It was concluded that organic manures was found to be inferior to chemical fertilizers as far as grain yield and net income (US$191 ha^{-1}) of baby corn was concerned. It was recommended to apply organic manures with reduced doses of chemical fertilizers for obtaining better yield and economic returns. However, this study was limited in scope for being under irrigated conditions. Otinga et al. (2013) reported that substitution of inorganic phosphorous with farm yard resulted in higher productivity of maize which generated 33% higher net income compared to sole synthetic fertilizers. It was also concluded that 25% substitution of sulphate of potash with farm yard manure gave significantly higher benefit-cost ratio (4.5) than sole sulphate of potash. Thus, it was recommended to replace synthetic potash fertilizers with farm yard manure to increase the productivity as well as net earnings of maize. Sheahan et al. (2013) concluded that integration of organic manures with chemical fertilizers resulted in increased cost of production owing to higher labor needed to apply organic manures as well heavy subsidies provided by government on chemical fertilizers. Similarly, Kipsat et al. (2004) reported that in Kenya, using organic inputs resulted in higher labor cost which constituted 75% of total production cost and recommended to find out the ways and techniques to reduce labor cost in organic farming.

The net earnings of maize under organic manures continue to remain one of the biggest concerns of small landholder especially in developing countries of Asia and Africa. Adamty et al. (2016) evaluated maize-bean intercrops under integrated fertilization regimes in Kenya. The findings revealed that organic manures applied in conjunction with chemical fertilizers generated 1.3-4.1 times higher income and benefit-cost ratio (2.4) compared to chemical fertilizers alone. Thus, it was demonstrated that coherent application imparted sustainability to maize-bean farming along with boosting economic returns. Delbridge et al. (2011) demonstrated that organic manures applied in co-application with synthetic fertilizers incurred significantly higher cost than synthetic fertilizers alone; however it resulted in fertility build-up along with improved economic turn outs. In contrast, Mahoneya et al. (2004) reported that organic systems recorded lesser cost compared to chemical fertilizers and suggested to switch to organic farming to impart sustainability to seriously degraded soils. Clark et al. (1999) and Setboonsarng et al. (2008) opined that using organic inputs could not

get desired attention of farmers owing to lack of premium for organic products and significantly higher cost of production under organic farming compared to conventional farming systems. In contrast, Welsh (1999) argued that organic products could not and should not be compared with traditional farming products in terms of price rather comparatively better quality of organic products must be highlighted to fetch higher prices.

The fertility status of agricultural soil is pivotal in determining the performance of organic manures in terms of productivity and economic viability. Shrestha et al. (2013) demonstrated that organic manures and chemical fertilizers remained similar on marginal soils and seriously eroded soils as far as productivity and net earnings were concerned. Forster et al., (2013) evaluated organic manures and synthetic fertilizers for cotton production in India and reported that organic manures could fulfill nutritional requirement of cotton on their own and suggested that addition of organic manures improved soil fertility status along with generating higher income. Mucheru-Muna et al. (2014) also reported similar findings where addition of organic inputs with mineral fertilizers proved to be superior in increasing soil fertility status, maize yield and economic returns compared to sole application of mineral fertilizers.

3. Materials and Methods

A field trial was conducted at Rawalakot (Azad Kashmir, Pakistan) which is situated in the foothills of great Himalayas. Its soil is classified as Thermic Lithic Eutrudepts. The climate of the area is humid to sub-humid having quite varying annual rainfall (500-2000 mm) (Khaliq et al., 2006). Pre-sowing random sampling of the soil samples from the selected field was carried out up to depth of 15 cm to determine important physico-chemical parameters. The soil was of silt loam type. The experiment was comprised of treatments including compost manure alone, poultry manure alone, compost manure + poultry manure, urea alone, half dose of urea, urea + compost manure, urea + poultry manure, urea + compost manure + poultry manure, while a control treatment containing no fertilization was maintained for comparison purpose.

Economic analysis on the recorded data was performed at the end of the study. The prevailing costs of added amendments (urea fertilizer, poultry manure and compost) and the income from the grain and stalk yields were used to assess the economic feasibility of different applied amendments as described earlier by Khaliq et al. (2006) using the formula;

Total income (revenue) for each treatment = Summation of the individual income of the marketable products (grains+ straw) of maize

(1)

Incremental income = Value of additional yield obtained due to specific inputs - Cost of applied inputs

(2)

Value-cost ratio (VCR) = incremental income/cost of added inputs

(3)

Value Cost Ratio (VCR) is the income obtained from the increased yield per unit cost of applied amendment i.e. chemical fertilizers and organic amendments and other expenditures involved in the applications of treatments. The VCR of > 2.0 indicates satisfactory risk coverage against investment in inputs with respect to fertilizers.

4. Results and Discussion

The highest grain yield of rainfed maize was recorded by compost manure applied as a sole source of plant nutrients, while coherent application of urea + compost manure and urea + compost manure + poultry manure followed it (Table 1). The maximum stalk yield was recorded by coherent application of urea + compost manure, while coherently applied of urea + compost manure + poultry manure followed it.

Table 1: Yield (grain + stalk) and gross earning of rainfed maize under coherent application of fertilization in Azad Kashmir, Pakistan.

Treatments	Crop yields (t ha^{-1})		Crop value ($ ha^{-1})		
	Grain	Stalk	Grain	Stalk	Total
Control	2.61	4.97	1254	498	1752
Compost manure alone	3.70	5.95	1780	595	2375
Poultry manure alone	3.14	5.62	1508	563	2070
Compost manure + Poultry manure	2.90	5.35	1393	535	1929
Urea alone	3.11	5.56	1496	556	2053
Half dose of urea	2.80	5.03	1346	504	1849
Urea + Compost manure	3.54	6.01	1702	601	2303
Urea + Poultry manure	3.65	6.09	1756	609	2365
Urea + Compost manure + Poultry manure	3.65	6.05	1754	605	2359

Maize grain market price = US$ 0.48 kg^{-1}, Maize stalk price = US$ 0.10 kg^{-1}

The maximum crop value (grain + stalk) was recorded by compost manure (US$ 2365), while coherent application of urea and poultry manure (US$ 2375) followed it (Table

1). Data regarding the economics of amendments (compost manure, poultry manure and urea along with their combinations) applied to maize under rainfed conditions showed that coherent application of amendments increased the financial returns and income relative to the control treatment. The financial returns differed among different amendments (Table 2). The manure compost applied as a sole source of nutrients recorded the maximum cost (US$130), it was followed by urea alone, while coherent application of compost manure and poultry manure recorded the lowest input cost (US$ 61) (Table 2). The increase in total income varied between 5.54-35.56% under different amendments. The highest net returns (US$ 2275) were generated by urea and it was closely followed by urea + poultry manure (US$ 2207), showing close match of coherent application of urea and poultry manure to urea alone as far as economical and financial effectiveness were concerned (Table 2).

Table 2: Economic analysis of rainfed maize under coherent application of fertilization in Azad Kashmir, Pakistan.

Treatments	**Input cost (US$)**	**Net returns (US$)**	**Incremental Income (US$)**	**Value-cost ratio (VCR)**
Control	-------	1752	--------	------
Compost manure alone	130	2245	493	3.79
Poultry manure alone	65	2005	253	3.90
Compost manure + Poultry manure	61	1868	116	1.89
Urea alone	70	1983	231	3.30
Half dose of urea	66	1783	31	0.48
Urea + Compost manure	96	2207	455	4.74
Urea + Poultry manure	100	2265	513	5.13
Urea + Compost manure + Poultry manure	100	2259	507	5.07

Mineral nitrogen fertilizer rate = US$ 0.85 kg^{-1}, Poultry manure rate = US$ 13.75 $tone^{-1}$ Compost manure rate = US$ 7.

Among all the amendments, the coherent use of compost manure and poultry manure remained inferior by recording the lowest net returns of US$ 1783, with the corresponding lowest value-cost ratio of 0.48. The net returns (US$ 2259) calculated for urea + compost manure + poultry manure was higher next to urea alone and coherently applied urea and poultry manure and the relative increase in total income was 28.9% over the control. Similar research findings were also reported by Mucheru-Muna *et al.* (2014), where sole use of organic manures generated less economic turn outs owing to significant decrease in crops productivity compared to mineral fertilizers. However, it was concluded that reduced doses of mineral fertilizers applied coherently with organic manures recorded the highest profit as input cost was decreased and yield was improved.

Regarding the value cost ratio (VCR), the highest VCR of 5.13 was recorded by co-application of urea + poultry manure an it was closely followed by coherent application of urea + compost manure + poultry manure (5.07). These findings demonstrated that applying the organic amendments with half mineral N was an economically and financially more valuable approach than the urea fertilizer alone. The VCR calculated for urea (3.79) was significantly lower than treatments receiving half dose of urea (3.90). Similarly, the benefits (in terms of VCR) from poultry manure were 74% higher compared to compost manure alone. These results are comparable with the findings of Yaduvanshi (2003) and Adamtey *et al.* (2016), where it was concluded that 50% substitution of chemical fertilizers with farm yard manure or green manure in rice-wheat cropping system generated significantly higher income compared to chemical fertilizers alone owing to lesser cost of production despite heavy subsidies on chemical fertilizers. Gosh *et al.* (2004) conducted a field experiment on wheat-soybean cropping and suggested the combined use of poultry manure with 75% of the recommended NPK fertilizers for higher yields and profitability compared to the full recommended NPK fertilizers, thereby diminishing 25% fertilizer requirement of both the crops.

5. Conclusions

The increasing prices of mineral fertilizers and environmental concerns have necessitated the utilization of organic materials for crops production. The research findings proved in contrast to postulated hypothesis as organic manures applied solely as a source of plant nutrients generated below-par net returns, however coherently applied urea and poultry manure recorded the maximum economic turn outs and value-cost ratio, thus this combination can be recommended for general adaptation in the locality. However, it is also suggested to conduct more in-depth field investigations for evaluation the performance of coherently applied fertilization regimes in terms of cost of production and net revenues under varied pedo-climatic conditions.

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