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Optimizing organic and inorganic fertilizer recommendation in rainfed pothowar region of pakistan: a case of barley sorghum and barley mungbean crop rotations

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The paper describes the optimizing organic and inorganic fertilizers recommendations for barley-sorghum and barley-mungbean crop rotations under rainfed conditions. Optimization is based on returns to investment based on partial budget analysis using two years (2007-2009) trials data conducted at University Research Farm, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi under rain fed conditions. Five different treatments including T_0 as Control, T_1 with farmyard Manure (FYM) @ 30 tons ha^{-1}, T_2 include NPK @120-80-60 @ kg ha^{-1}, T_3 using poultry manure @ 20 tons ha^{-1}, T_4 included compost (Press mud) @ 12.5 tons ha^{-1} and in T_5, Inoculation by Phosphorus mobilizing microorganisms @ 2.5 packets ha^{-1} was used only for barley while sorghum and mungbean were planted on the residual nutrients. Net benefits for the T_3 were highest mainly due to high barley yield and marginal rate of return are also high. The results were also confirmed using residual analysis. The study concludes that cropping sequence tends to be low inputs and risk avoiding technique for fulfillment of subsistence objectives. Economic evaluation with Partial budgeting and profitability comparison is minimum extension to measure or compare different cropping sequences. Farmers could adopt the more economical inputs and technique to get the maximum returns from the market by using partial budget keeping in view the cost of production and net benefits.

Key words: Cropping pattern, fertilizer, Pothowar, Return to investment

Introduction

Pakistan is primarily an arid and semiarid country and agriculture is the basis of its economy of the total cropped area of 21.85 million ha in Pakistan, about 4 million ha are rainfed (Anonymous, 2012). In Pakistan barley was sown on an area of 71 thousands hectares with the total production of 62 thousands tones during the year 2012-13 (Anonymous,

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2013). The soil of rainfed areas are generally medium textured, with predominant textural classes of sandy loam, and loams, the soils are very low in natural fertility, deficient in nitrogen and phosphorus, however, potassium level is adequate. The soils are very deficient in organic content and ranging pH 7.5 to 8.5 (Ahmad *et al.,* 1990). Less production is the normal characteristic of aird agriculture due to irregular and insufficient rainfall, less soil organic matter %age, soils erosion, hardpan and other unwanted ecological conditions like dehydrated air and increased soil temperatures.

Farmers are utilizing synthetic fertilizers none sensibly to increase their farm production. Lands efficiency decline due to permanent addition of synthetic fertilizers has main bar to maintain crop yield. The price of synthetic fertilizer is very inflated that the deprived farmers not able to bear single bag to use in their crops as they lack capital. Furthermore the input recommendations normally static and are not dynamic to price changes (Shah *et al*., 2011).

Objective

To optimize input recommendation on economic parameters using technical parameters.

Material and methods

The experiment was conducted at University Research Farm, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi under rainfed conditions. The experiment was designed to study the effect of organic and inorganic fertilizers tested under different barley-sorghum and barley-mungbean cropping sequences on productivity for two year starting from November 2007 and ending in October 2009. The influence of five different organic and inorganic treatments and arrangement of cropping sequence was evaluated on the basis of crop productivity and economic returns using RCBD in Split Block Design. Subplot size was kept 3 x 5 m. Different cropping sequences and fertilizer levels were as under:

Fertility Treatments

T_0= Control
T_1 = Farmyard Manure (FYM) @ 30 tons ha^{-1}.
T_2 = NPK @ 120-80-60 @ kg ha^{-1}
T_3 = Poultry manure @ 20 tons ha^{-1}.
T_4 = Compost (Press mud) @ 12.5 tons ha^{-1}.
T_5 = Inoculation by Phosphorus mobilizing microorganisms @ 2.5 packets ha^{-1}.

No fertilizers were used during summer for sorghum and mungbean Analytical techniques following CIMMYT (1988), Shah *et al*. (2009, 2011 and 2012) were used to optimize the input on economic parameters:

Partial Budget Analysis

1. Gross field benefit
2. Net field benefit

Marginal analysis

1. Dominance analysis
2. Marginal rate of return
3. Analysis using Residual

Results and Discussion

Partial budget analysis of barley-sorghum and barley-mungbean cropping sequence is presented in Table 1 and 2. The Cost that Vary for the treatment farmyard manure was highest followed by compost, poultry manure, NPK and phosphorus solubilizing bacteria respectively among the experimental treatments. However the net benefits for the NPK were highest mainly due to better barley yield with low cost that varies. The low returns from barley are covered from better results from the following sorghum crop due to better residual effects. barley-sorghum cropping sequence without fertility treatment gave net benefits Rs. 33173 ha^{-1}, while, barley treated with FYM, NPK, PM, Compost and PSB gave net benefits Rs. 73542, 92305, 76428, 51713 and 36319 per hectare respectively. NPK recommended for barley and its residual effect on production of sorghum in summer gave maximum net benefits.Barley-mungbean cropping sequence without fertility treatment gave net benefits Rs. 34000 ha^{-1}, while, barley treated with FYM, NPK, PM, Compost and PSB gave net benefits Rs. 73914, 89777, 77811, 52117 and 37860 per hectare respectively. NPK recommended for barley and its residual effect on production of mungbean in summer gave maximum net benefits. PM was second best treatment for better economic returns for barley-sorghum and barley-mungbean cropping sequences.

Table 1. Partial Budget of Barley Sorghum Cropping Sequence

	T_0	T_1	T_2	T_3	T_4	T_5
Treatments Dose	Control	FYM(30 Tons ha^{-1})	NPK (120+80+60)	PM (20 Tons ha^{-1})	Compost (12.5 TON ha^{-1})	PSB(2.5 Pac. ha^{-1})
Total cost that vary	0	10900	6671	9350	9675	650
Gross Benefits of straw/stalk	4086	9302	7497	8302	6266	4615
Gross Field Benefits (Total)	14056	42396	48596	42842	31942	16078
NB from *Barley*	14056	31496	41924	33492	22267	15427
NB from *Sorghum* followed by Barley	19117	42046	50381	42936	29446	20892
Total Net Benefits	33173	73542	92305	76428	51713	36319

Table 2. Partial Budget of Barley Mungbean Cropping Sequence

	T_0	T_1	T_2	T_3	T_4	T_5
Treatments Dose	Control	FYM (30 Tons ha^{-1})	NPK (120+80+60)	PM (20 Tons ha^{-1})	Compost (12.5 tons ha^{-1})	PSB (2.5 Pac. ha^{-1})
TCV (total cost that vary)	0	10900	6671	9350	9675	650
Gross Benefits from Barley grains	9970	33094	41098	34540	25676	11463
Gross Benefits from Barley straw	4086	9302	7497	8302	6266	4615
Gross Field Benefits (Total)	14056	42396	48596	42842	31942	16078
NB from *Barley*	14056	31496	41925	33492	22267	15428
NB from *mungbean*	19944	42418	47852	44319	29850	22432
Total Benefits	34000	73914	89777	77811	52117	37860

Dominance Analysis was conducted as it is a prerequisite for further economic analysis to identify the dominated treatments for which the net benefits decreased while cost that varies increased. The results are presented in Table 3 and 4. Treatments poultry manure, compost and farmyard manure were dominated as there cost was high as compared to the previous one with higher net benefits. Hence these treatments would be excluded from the further analysis.

Table 3. Dominance Analysis for barley sorghum cropping sequenc

Treatment	TCV	NB	
T0	0	33173	
T5	650	36319	
T2	6671	92305	
T3	9350	76428	D
T4	9675	51713	D
T1	10900	73542	D

Table 4. Dominance analysis for barley mungbean cropping sequence

Treatment	TCV	NB	
T0	0	34000	
T5	650	37860	
T2	6671	89777	
T3	9350	77810	D
T4	9675	52117	D
T1	10900	73914	D

The returns to investment for different experimental treatments are evaluated through marginal analysis as measured through Marginal Rate of Return (MRR). The results for barley-sorghum and barley-mungbean sequence as depicted in Table 5and 6 indicated that the NPK gives highest rate of return as the MRR is equal to 930 percent which showed that one rupee invested in NPK treatment would give an additional 9.30 rupees to farmer when he moved from control to NPK. The returns by moving from NPK to phosphorus solubilizing bacteria were 484% which are in addition to the returns earlier achieved. The results for barley-mungbean sequence as depicted in Table 6 indicate that the NPK gave highest rate of return as the MRR is equal to 862 percent which showed that one rupee invested in NPK treatment would give an additional 8.62 rupees to farmer when he moved from control to phosphorus solubilizing bacteria. The returns by moving from NPK to PSB were 594% which are in addition to the returns earlier achieved. Hence based on marginal analysis NPK is recommended.

Table 5. Marginal Analysis for barley sorghum cropping sequence

Treatment	TVC	NB	Change in TVC	Change in NB	MRR (%)
T0	0	33173			
T5	650	36319	650	3146	484
T2	6671	92305	6021	55986	930

Table 6. Marginal analysis for barley mungbean cropping sequence

Treatment	TCV	NB	Change in TCV	Change in NB	MRR (%)
T0	0	34000			
T5	650	37860	650	3860	594
T2	6671	89777	6021	51916	862

The analysis using residual is conducted to confirm the results of marginal analysis. Through residual analysis Table 7and 8 different recommendations was proved as the residual value for NPK is the highest than PSB and as per procedures (CIMMYT 1988, Shah *et al*., 2011) the treatment with highest value NPK recommended as it gives heist net income to the farmer. PM gave maximum residual return Rs. 88869 ha^{-1} in case of barley-sorghum cropping sequence among the treatments because of low total cost that vary and high net benefits in that way NPK recommended. NPK gave maximum residual return Rs. 83106 ha^{-1} in case of barley-mungbean cropping sequence among the treatments because of low total cost that vary and high net benefits in that way NPK recommended.

Table 7. Residual Analysis of barley sorghum cropping sequence

Treatment	TVC	NB	Returns Required 100%×(TVC)	Residual=(NB-Returns Required)
T0	0	38540.03	0	38540
T5	650	41425.45	650	40775
T2	6671	95537.50	6671	88867

Table 8. Residual analysis for barley mungbean cropping sequence

Treatment	TCV	NB	Returns Required100% x(TCV)	Residual =(NB-Returns Required)
T0	0	34000	0	34000
T5	650	37860	650	37210
T2	6671	89777	6671	83106

Conclusion and recommendations

The study highlighted important discrepancies between technical and economic optimum as the yield of barley was high for T_2 (NPK) while, the returns for T_3 (PM) were higher. The same were confirmed by marginal analysis and analysis using residual. The higher returns are due to low cost of recommended treatment along with higher residual impact. This also highlighted the importance of residual effect and cropping pattern.

Therefore it is recommended that the input recommendation should be developed based on market factors (cost and benefits) and system aspects (cropping pattern).

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