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Full Length Research Paper

Optimizing organic and inorganic fertilizers in rainfed region of Pothwar Pakistan: A case of wheat-sorghum and wheat-mungbean crop rotations

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The study describes the optimizing organic and inorganic fertilizers recommendations for wheat-sorghum and wheat-mung bean crop rotations under rainfed conditions. Optimization was based on returns to investment based on partial budget analysis using two years (2007-2009) trials data conducted at University Research Farm, PirMehr Ali Shah Arid Agriculture University, Rawalpindi, (Pakistan) under rainfed conditions. Five different treatments including T0 as Control, T1 with farmyard Manure (FYM) at 30 tons ha^{-1}, T2 include NPK at120-80-60 at kg ha^{-1}, T3 using poultry manure at 20 tons ha^{-1}, T4 included compost (Press mud) at 12.5 tons ha^{-1} and in T5, Inoculation by Phosphorus mobilizing microorganisms at 2.5 packets ha^{-1} was used only for wheat while, sorghum and mungbean were planted on the residual nutrients. Net benefits for the poultry manure were highest mainly due to high wheat 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 was 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: Organic farming, Inorganic fertilizers, cropping sequence.

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).Wheat is the main staple food for most of the population and largest grain source of the country. It occupies the central position in developing agricultural policies. It takes part 10.01% to the value added in agriculture and 2.2% to GDP (GoP 2013). About 12% of the total wheat production is harvested from rain-fed areas, which can be increased considerably with appropriate production technologies (Khan *et al*., 1986).

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 arid 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). Therefore the current study is done with specific

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Table 1: Partial budget of wheat-sorghum cropping sequence.

Treatments Dose	T_0	T_1	T_2	T_3	T_4	T_5
	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	10950	17754	9450	9675	650
Gross Benefits of grains	18549	43344	74694	69326	48236	24011
Gross Benefits of straw/stalk	5435	13826	12545	14550	11036	6360
Gross Field Benefits (Total)	23984	57170	87239	83876	59272	30371
NB from *wheat*	23984	46220	69485	74426	49597	29721
NB from *Sorghum*	14618	37855	56453	51656	33523	16801
Total NB with Wheat followed by Sorghum	38602	84075	125938	126082	83120	46522

Table 2: Partial budget of wheat-mungbean cropping sequence.

Treatments Dose	T_0	T_1	T_2	T_3	T_4	T_5
	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	0	10950	17754	9450	9675	650
Gross Benefits of grains	18549	43344	74694	69326	48236	24011
Gross Benefits of straw/stalk	5435	13826	12545	14550	11036	6360
Gross Field Benefits (Total)	23984	57170	87239	83876	59272	30371
NB from *wheat*	23984	46220	69485	74426	49597	29721
NB from *mungbean*	19322	41767	46578	43511	28911	21988
Total NB with *Wheat* followed by *mungbean* C. Pattern	43306	87987	116063	117937	78508	51709

objective to optimize input recommendation on economic parameters using technical parameters.

MATERIALS AND METHODS

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

Fertility Treatments

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

The above treatments were used during both years for wheat grown during winter season and no fertilizers were applied during summer season for the subsequent sorghum and mungbean.

The analytical techniques following CIMMYT (1988), Shah et al., (2009, 2011 and 2012) given below 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 wheat-sorghum cropping sequence is presented in table 1 and wheat-mungbean presented in Table-2. The Cost that Vary for the treatment NPK is highest followed by farmyard manure (FYM), compost, poultry manure (PM) and phosphorus solubilizing bacteria (PSB), respectively among the experimental treatments. However the net benefits for the

Table 3: Dominance Analysis for wheat sorghum cropping sequence.

Treatment	TCV	NB	
T0	0	38602	
T5	650	46522	
T3	9450	126082	
T4	9675	83120	D
T1	10950	84075	D
T2	17754	125938	D

Table 4: Dominance analysis for wheat mungbean cropping sequence.

Treatment	TCV	NB	
T0	0	43306	
T5	650	51709	
T3	9450	117937	
T4	9675	78508	D
T1	10950	87987	D
T2	17754	116063	D

Table 5: Marginal analysis for wheat-sorghum cropping sequence.

Treatment	TVC	NB	Change in TVC	Change in NB	MRR (%)
T0	0	38602			
T5	650	46522	650	7920	1218
T3	9450	126082	8800	79560	904

poultry manure were highest mainly due to better wheat yield with low cost that varies. The low returns from wheat are covered from better results from the following sorghum crop due to better residual effects. Wheat-Sorghum cropping sequence without fertility treatment gave net benefits Rs. 38602 ha^{-1}, while, wheat treated with FYM, NPK, PM, Compost and PSB gave net benefits Rs.84075, 125938, 126082, 83120 and 46522 per hectare, respectively. Poultry manure recommended for wheat and its residual effect on production of sorghum in summer gave maximum net benefits, so it was recommended for wheat-sorghum cropping sequence. In wheat-mungbeanthe net benefits for poultry manure were higher mainly due to better wheat yield with low cost that varies. Wheat-mungbean cropping sequence without fertility treatment gave net benefits Rs.43306 ha^{-1}, while, wheat treated with FYM, NPK, PM, Compost and PSB gave net benefits Rs. 87987, 116063, 117937, 78508 and 51709 per hectare, respectively. Poultry manure for wheat and its residual effect on production of mungbean in summer gave maximum net benefits, so it was recommended for wheat-mungbean cropping sequence.

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

The returns to investment for different experimental treatments are evaluated through marginal analysis as measured through Marginal Rate of Return (MRR). The results for Wheat-Sorghum sequence as depicted in table 5 indicated that the phosphorus solubilizing bacteria gave highest rate of return as the MRR was equal to 1218 percent which showed that one rupee invested in would give an additional 12.18 rupees to farmers when they moved from control to phosphorus solubilizing bacteria treatment. The returns by moving from phosphorus solubilizing bacteria to poultry manure were 904% which are in addition to the returns earlier achieved. Hence based on marginal analysis poultry manure was recommended. The results for Wheat-Mungbean sequence as depicted in Table 6 indicated that the phosphorus solubilizing bacteria gives highest rate of return as the MRR was equal to 1293 percent which showed that one rupee invested in poultry manure treatment would give an additional 12.93 rupees to the farmers when they moved from control to phosphorus solubilizing bacteria. The returns by moving from PSB to poultry manure were 753% which are in addition to the returns earlier achieved. Hence based on marginal analysis poultry manure better for wheat-mungbean cropping sequence was recommended.

The analysis using residual was conducted to confirm the results of marginal analysis. Through residual

Table 6: Marginal analysis for wheat-mungbean cropping sequence

Treatment	TCV	NB	Change in TCV	Change in NB	MRR (%)
T0	0	43306			
T5	650	51709	650	8404	1293
T3	9450	117937	8800	66228	753

Table 7: Residual analysis of wheat-sorghum cropping sequence.

Treatment	TVC	NB	Returns Required 100%×(TVC)	Residual=(NB-Returns Required)
T0	0	38602	0	38602
T5	650	46522	650	45872
T3	9450	126082	9450	116632

Table 8: Residual analysis for wheat mungbean cropping sequence.

Treatment	TCV	NB	Returns Required100% x(TCV)	Residual =(NB-Returns Required)
T0	0	43306	0	43306
T5	650	51709	650	51059
T3	9450	117937	9450	108487

Table 9: Comparison of sorghum and mungbean wheat based cropping sequences for the recommended treatments

Variables	Wheat-Sorghum	Wheat–Mungbean
Treatment	T3	T3
NB	126082	117937
MRR (%)	1218	1293
Residual Value	116632	108487

analysis (Table 7) value for poultry manure was the higher than PSB and as per procedures (CIMMYT 1988, Shah et al., 2011) the treatment with higher value poultry manure was recommended as it gave higher net income to the farmers. Poultry manure gave maximum residual return Rs. 116632 ha^{-1} in case of wheat-sorghum cropping sequence among the treatments because of low total cost that vary and high net benefits in that way poultry manure got recommended. Poultry manure gave maximum residual return Rs. 108487 ha^{-1} in case of wheat-mungbean cropping sequence among the treatments because of low total cost that vary and high net benefits in that way poultry manure recommended (Table-8).

Table-9 indicated that wheat-sorghum was better than wheat-mungbean cropping pattern due to high economic value of byproduct of sorghum than mungbean. Fertility effect of mungbean on soil required long period experiment.

CONCLUSION AND RECOMMENDATIONS

The study highlighted important discrepancies between technical and economic optimum as the yield of wheat was high for T2 (NPK) while the returns for T3 (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 in crop rotation being practiced by the farmers. Therefore, it was recommended that the input recommendation should be developed based on market factors (cost and benefits) and system aspects (cropping pattern).

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