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EFFECT OF CROPPING SYSTEM AND RESIDUE MANAGEMENT ON MAIZE

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Abstract

Concern for the sustainability of yield and soil fertility has led to a renewed interest in crop rotation and incorporation of crop residues. The objective of this experiment was to study the effects of cropping system and residues management on the yield and yield components of maize. The experiment was conducted at KPK Agricultural University, Peshawar during summer 2002 and was laid out in RCB design with split plot arrangement having four replications. Higher ear length and weight, grains ear^{-1}, grain weight and grain and biological yields were recorded for legume-cereal (chickpea-maize) cropping system followed by cereal-cereal (wheat-maize) cropping system with nitrogen application at the rate of 160 kg N ha^{-1} to the previous as well as current crops in both cases. However, these parameters were minimal for cereal-cereal (wheat-maize) cropping system with no nitrogen application either in the previous crop or in the current crop. Higher ear length and weight, grain ear^{-1}, grain weight, grain and biological yields were recorded for the plots applied with FYM followed by the plots in which residues were incorporated. The plots in which no residues were incorporated performed poorly and resulted in least values of these parameters. It is concluded that application of farmyard manure at the rate of 10 tons ha^{-1} in legume cereal cropping system resulted in higher yield and yield component of maize.

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop after wheat and rice in Pakistan. It is a dominant crop in the farming system because it is a staple food crop for most of the rural population. Due to short growing period, maize is grown twice a year both for grain and fodder purposes (Harris *et al*., 2007). Low soil fertility is one of the major yield limiting factors for cereal production in many developed and developing countries including Pakistan. The developed countries are capable to deal with low soil fertility through supply of nutrients in sufficient amounts as chemical fertilizers. In the majority of countries, however, this is not possible because of the high costs of fertilizers. As a result, farmers use both the available organic sources and the affordable amount of chemical fertilizers to cut down the high cost of chemical fertilizers for higher crop yields. However, due to energy shortages, increased fertilizer cost, deterioration of soil health and environmental concerns, the use of organic manures has again become important (Yaduvanshi, 2003). The organic matter or crop residue helps to recycle the nutrients to correct their deficiencies. Studies indicated that use of organic sources can help maintain a better N:P ratio and higher yield (Bakhtiar *et al*., 2002, Khanam *et al*., 2001). Incorporation of organic sources at much higher rates had been found useful but may not be affordable by small or low-income farmers (Ahmad, 2000; Alam *et al*., 2000).

The supply of essential plant nutrients in soil is a growth-limiting factor towards production. Among all the nutrients required by a plant, nitrogen (N) is of prime importance that improves growth and yield parameters. However, because of the implications of long-term and continuous use of mineral fertilizers, particularly in decreasing soil productivity due to soil mining, creating environmental pollution and their high costs compel farmers to think about recycling of organic manures (Kiani *et al*., 2005).

The incorporation of organic N in soil as organic matter or crop residue improve the soil fertility that substantially reduce the requirements of fertilizer N and increase crop yield (Singh *et al*., 2004). Judicious use of mineral, organic and microbial fertilizer will not only improve the crop yield, but will also lead to sustainable higher crop yield. The combined use of organic and chemical fertilizers will help to maintain soil productivity even under intensive cropping system.

The purpose to develop and promote the use of legumes for enhanced production of cereal crops, and to understand the role of crop residues in the legume based cereal cropping system, the instant experiment was designed to study the effects of cropping systems and management of crop residues on the performance of subsequent crop.

Materials and Methods

The field experiment was conducted at KPK Agricultural University Peshawar during 2000-2002 and was laid out in RCB design with split plot arrangement and four replications.

Experimental Site: Peshawar has a continental climate. The experimental site is located at 34° N, 71.3° E and an altitude of 450 meters above sea level. The soil of the experimental field was silty clay loam with a clay type montmorillonite, low in nitrogen (0.03-0.04%), low in organic matter (0.7-0.9%) and alkaline in reaction (pH 8.0-8.2).

Experimental Details:
The experiment consisted of the following treatments:

I. Residues Management (Main plot)

i. Residues (non-incorporated)
ii. Residues (incorporated)
iii. Farm Yard Manure

II. Cropping systems (Sub-plot)

Previous crops and N levels (2001-2002)	Test crops and N levels (2002)
Wheat (0 N)	Maize (0 N)
Wheat (0 N)	Maize (120 N)
Wheat (120 N)	Maize (0 N)
Wheat (120 N)	Maize (120 N)
Chickpea (0 N)	Maize (0 N)
Chickpea (0 N)	Maize (120 N)

Table 1. Chronological order of the crops sown in the experimental field during 2000-2002.

Summer (2000)	Winter (2000-2001)	Summer (2001)	Winter (2001-2002)	Summer (2002) test crop
Maize (0N)	Wheat (0N)	Maize (0N)	Wheat (0N)	Maize (0N)
Maize (+N)	Wheat (0N)	Maize (+N)	Wheat (0N)	Maize (+N)
Maize (0N)	Wheat (+N)	Maize (0N)	Wheat (+N)	Maize (0N)
Maize (+N)	Wheat (+N)	Maize (+N)	Wheat (+N)	Maize (+N)
Maize (0N)	Chickpea	Maize (0N)	Chickpea	Maize (0N)
Maize (+N)	Chickpea	Maize (+N)	Chickpea	Maize (+N)

The cropping systems were cereal-cereal and cereal-legume with supplementation of fertilizer-N (+N) or no fertilizer-N (0N). Site history (Table 1) was developed in such manner that half of the wheat was given nitrogen and the rest was left without adding nitrogen. Maize was sown on the same field which was previously occupied by wheat and chickpea.

For residue management treatment, grain yield from each plot of the previous crop was taken and was divided into three parts for residue management and FYM application. In two parts residue of the previous crop was put in a manner that residue was incorporated in one part, while residue was not incorporated in the other part. In third part, FYM (well rotten animal dung) was applied at the rate of 10 t ha^{-1}. Residue incorporation and FYM application were done on 26th April 2002 about 40 days before sowing of the maize crop.

A subplot size of 3 m by 3.5 m was used. Maize variety Kisan-90 was included in the experiment. Plant to plant distance of 30 cm was maintained by thinning. Row to row distance was kept 70 cm. Seed rate of 40 kg ha^{-1} was used. Nitrogen was applied at the rate of 160 kg ha^{-1} in two splits i.e. at the time of sowing and at 8-10 leaf stage. Urea was used as a source of nitrogen. Phosphorus was applied at the rate of 100 kg ha^{-1}. Single superphosphate (SSP) was used as a source of phosphorus. The crop was sown on June 05, 2002 and was harvested on October 03, 2002. Data were recorded on ear length, ear weight, grains ear^{-1}, hundred grain weight, grain yield and biological yield.

Statistical analysis: The data were statistically analyzed using analysis of variance appropriate for randomized complete block design with split plot arrangement. Means were compared using LSD test at 0.05 level of probability, when the F-values were significant (Steel & Torrie, 1984).

Results and Discussion

Cropping systems significantly affected ear length and weight, grains ear^{-1}, grain weight and grain and biological yields (Tables 2, 3). Higher ear length and weight, grains ear^{-1}, grain weight and grain and biological yields were recorded for legume-cereal (chickpea-maize) cropping system followed by cereal-cereal (wheat-maize) cropping system with nitrogen application at the rate of 160 kg N ha^{-1} to the previous as well as current crops in both cases. However, these parameters were minimal for cereal-cereal (wheat-maize) cropping system with no nitrogen application either in the previous crop or in the current crop. In most of the cases, the cereal-cereal (wheat-maize) cropping system with N application to the current crop only got third rank and the legume-cereal (chickpea-maize) cropping system with no application of N to the previous as well as current crop obtained fourth rank.

Table 2. Ear length, ear weight and grains ear^{-1} of maize as affected by residues management and cropping systems.

Cropping systems (CS)	Ear length (cm)	Ear weight (g)	Grains ear^{-1}
W(0N)-M(0N)	11 e	232 f	306 f
W(0N)-M(+N)	14 b	250 d	346 c
W(+N)-M(0N)	12 d	242 e	321 e
W(+N)-M(+N)	14 b	262 b	367 b
Cp(0N)-M(0N)	13 c	252 c	334 d
Cp(0N)-M(+N)	15 a	291 a	381 a
LSD	0.2296	0.9691	3.273
Residues management (RM)			
Non-incorporated	12 c	213 c	306 c
Incorporated	14 b	261 b	346 b
FYM	15 a	290 a	375 a
LSD	0.5769	0.8325	3.166
Interaction CS × RM			
Significance level	NS	*	*

Means of the same category followed by the different letters are significantly different from one another using LSD test (p≤0.05%).
M = Maize, W = Wheat, Cp = Chickpea, 0N = No fertilizer N, +N = 160 kg N ha^{-1}

Table 3. Hundred grain weight, grain yield and biological yield of maize as affected by residues management and cropping systems.

Cropping systems (CS)	Hundred grain weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})
W(0N)-M(0N)	22.83 f	2381 e	7405 f
W(0N)-M(+N)	27.25 c	2951 c	8807 c
W(+N)-M(0N)	23.83 e	2475 e	7936 e
W(+N)-M(+N)	27.83 b	3081 b	9392 b
Cp(0N)-M(0N)	25.83 d	2620 d	8364 d
Cp(0N)-M(+N)	29.83 a	3299 a	10259 a
LSD	0.4844	100.7	292.0
Residues management (RM)			
Non-incorporated	23.04 c	2358 c	7586 c
Incorporated	26.83 b	2864 b	8705 b
FYM	28.83 a	3182 a	9791 a
LSD	0.416	97.54	239.6
Interaction CS × RM			
Significance level	NS	NS	NS

Means of the same category followed by the different letters are significantly different from one another using LSD test (p≤0.05%).
M = Maize, W = Wheat, Cp = Chickpea, 0N = No fertilizer N, +N = 160 kg N ha^{-1}

Greater ear length and weight, grain ear^{-1}, grain weight, grain and biological yields were recorded for the plots applied with FYM followed by the plots in which residues were incorporated (Tables 2, 3). The plots in which no residues were incorporated performed poorly and resulted in least values of these parameters. Our results are in line with Shafi *et al*., (2007) who reported that crop residues incorporation significantly increased grain yield of maize compared with the residues removed treatment. Similarly, Kouyate *et al*., (2000) also reported an increase in cereal grain and stover yields by 37 and 49%, respectively when crop residues were incorporated as compared to no residues incorporation treatment. In our results, the maize grain yield and yield components were mostly higher in legume-cereal (chickpea-maize) cropping system supplemented with N which shows the residual advantage of the legume crop on the following crop. The rotational payback of legume (chickpea) on subsequent crop is in line with the results reported by Kuo & Jellum, (2002) and Shah *et al*., (2003). Similarly, many researchers have reported that N is a key factor in the response of cereals following legumes compared with cereals following non-legumes (Evans *et al*., 1991; Chalk *et al*., 1993; Smiley *et al*., 1994).

Fertilizer N applied to previous wheat showed carry over effect on the following maize comparing with treatments which received no fertilizer N in the previous season. Likewise, the application of fertilizer N to the current maize significantly increased its grain yield compared with un-fertilized control treatments in both sort of cropping systems. The effect of fertilizer N on maize yields is consistent with the low organic matter and chemical fertility of the soil. Similarly, Tejada & Gonzalez (2003) also reported that increasing N fertilizer rate increased the number of grains per spike, which resulted in higher grain yield compared with their control (no N application). Similar results were also reported by Heison & Collum (1990) who found that plots treated with residue incorporation produced heavy cobs.

Our results revealed that FYM and crop residue incorporation significantly increased yield and yield components of maize as compared with the residues removed treatment. Similar results were obtained by Kumar & Puri (2001) who reported that the application of 90 kg N ha^{-1} and 15 tons FYM ha^{-1} resulted in higher grain and straw yields of maize. The results are also supported by Suri & Puri (1997) who reported that application of FYM increased grain yield of maize. These results are in agreement with Shafi *et al*., (2007) who reported that crop residues incorporation significantly increased grain yield of maize during both 2000 and 2001 compared with the residues removed treatment. They further added that on average, crop residues increased the grain yield of maize by 23.7%. Similarly, Kouyate *et al*., (2000) also reported an increase in cereal grain and stover yields by 37 and 49%, respectively, when crop residues were incorporated compared with untreated controls (no residues incorporation). Our results regarding yield components of maize are in line with Kumar & Puri (2001) who reported that application of 90 kg N and 15 tones FYM ha^{-1} resulted in maximum ear length, grains ear^{-1} and grain weight.

Conclusion

This experiment has shown that application of FYM and retention of crop residues, inclusion of legumes in the cropping systems and application of fertilizer N significantly increased yield and yield components of maize. Legume-cereal cropping system performed better than cereal-cereal cropping system with and without addition of N. Nitrogen applied to previous wheat showed carry over effect on the subsequent maize crop.

References

Ahmad, N. 2000. Integrated plant nutrition management in Pakistan-status and opportunities. In: *Proc. Symposium on Integrated Plant Nutrition Management*. NFDC, Islamabad. pp. 18-39.

Alam, S.M., R. Ansari and M.A. Khan. 2000. Incorporation of FYM and inorganic fertilizers on the growth of rice. In: *Proc. Symposium on Integrated Plant Nutrition Management*. NFDC, Islamabad. pp. 231-234.

Bakhtiar, S.M., M.J. Alam, K. Mahmood and M.H. Rahman. 2002. Integrated nutrient management under three agro-ecological zones of Bangladesh. *Pak. J. Biol. Sci*., 5: 390-393.

Chalk, P.M., C.J. Smith, S.D. Hamilton and P. Hopmans. 1993. Characterization of the N benefit of a grain legume (*Lupinus angustifolius* L.) to a cereal (*Hordeum vulgare* L.) by an in situ ^{15}N isotope dilution technique. *Biol. Fertil. Soils,* 15: 39-44.

Evans, J., N.A. Fettell, D.R. Coventry, G.E. O'Connor, D.N. Walsgott, J. Mahoney and E.L. Armstrong. 1991. Wheat response after temperate crop legumes in South-eastern Australia. *Aust. J. Agric. Res*., 42: 31-43.

Harris, D., A. Rashid, G. Miraj, M. Arif and H. Shah. 2007. 'On-farm' seed priming with zinc sulphate solution—A cost-effective way to increase the maize yields of resource-poor farmers. *Field Crops Res*., 102: 119-127.

Heison, C.H. and S.K. Collum. 1990. The effect of different residues on maize yield. J. Agron. and Crop Sci. 166(5): 326-337. *Field Crop Abst*., 44: 854.

Khanam, M., M.M. Rahman and M.R. Islam. 2001. Effect of manures and fertilizers on the growth and yield of BRRI Dhan 30. *Pak. J. Biol. Sci*., 4: 172-174.

Kiani, M.J., M.K. Abbasi and N. Rahim. 2005. Use of organic manure with mineral N fertilizer increases wheat yield at Rawalakot Azad Jammu and Kashmir. *Arch. Agron. & Soil Sci*., 51: 299-309.

Kouyate, Z., K. Franzluebbers, A.S.R. Juo and L. Hossner. 2000. Tillage, crop residue, legume rotation, and green manure effects on sorghum and millet yields in the semiarid tropics of Mali. *Plant and Soil,* 225: 141-151.

Kumar, A. and U.K. Puri. 2001. Effect of nitrogen and farmyard manure application on maize (*Zea mays* L.) varieties. *Ind. J. Agron*., 46: 255-259.

Kuo, S. and E.J. Jellum. 2002. Influence of winter cover crop and residue management on soil nitrogen availability and corn. *Agron. J*., 94: 501-508.

Shafi, M. J. Bakht, M.T. Jan and Z. Shah. 2007. Soil C and N dynamics and maize (*Zea may* L.) yield as affected by cropping systems and residue management in North-western Pakistan. *Soil & Tillage Res*., 94: 520-529.

Shah, Z., S.H. Shah, M.B. Peoples, G.D. Schwenke and D.F. Herriedge. 2003. Crop residue and fertilizer N effects on nitrogen fixation and yields of legume–cereal rotations and soil organic fertility. *Field Crops Res*., 83: 1-11.

Singh, Y., B. Singh, J.K. Ladha, C.S. Khind, T.S. Khera and C.S. Bueno. 2004. Effect of residue decomposition on productivity and soil fertility in rice-wheat rotation. *Soil Sci. Soc. Am. J*., 68: 854-864.

Smiley, R.W., R.E. Ingham, W. Uddin and G.H. Cook. 1994. Crop sequences for managing cereal cyst nematode and fungal pathogens of winter wheat. *Plant Dis*., 78: 1142-1149.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and procedures of statistics, 2nd ed., p.172-177. McGraw Hill Book Co., Singapore.

Suri, V.K. and U.K. Puri. 1997. Effect of phosphorus application with and without farmyard manure on rainfed maize-wheat-maize cropping sequence in an acid alficsol. *Himachal J. Agric. Res*., 25: 13-18.

Tejada, M. and J.L. Gonzalez. 2003. Effects of the application of a compost originating from crushed

cotton gin residues on wheat yield under dry land conditions. *Eur. J. Agron*., 19: 357-368.
Yaduvanshi, N.P.S. 2003. Substitution of inorganic fertilizers by organic manures and the effect of on soil fertility in rice-wheat rotation on reclaimed sodic soil in India. *J. Agric. Sci*., 140: 161-168.

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