Pak. J. Bot., 44(6): 2015-2019, 2012.

INTEGRATED MANAGEMENT OF CROP RESIDUE AND N FERTILIZER FOR WHEAT PRODUCTION

MOHAMMAD TARIQ JAN[1], MOHAMMAD JAMAL KHAN[2], FARHATULLAH[3*], MUHAMMAD ARIF[1], MOHAMMAD ZAHIR AFRIDI[1], AHMAD KHAN[1] AND HABIB AKBAR[1]

[1]Department of Agronomy, [2]Department of Soil and Environmental Sciences,[3]Department of Plant Breeding and Genetics, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan
[*]Corresponding author's e-mail: drfarhat@aup.edu.pk

Abstract

A field experiment was conducted at Agricultural Research Farm, KPK Agricultural University, Peshawar, Pakistan during winter 2005-2006. The treatments consisted of crop residue (stover & legume residue), two type of fertilizer-N (NH_4-N & NO_3-N) and their application time i.e. at sowing and 2nd node appearance stage. Higher spikes m^{-2} and grain yield were recorded for nitrate-N application in split at the rate of 100 kg ha^{-1} in combination with legume residue. Likewise, the highest grains spike^{-1} was recorded for legume and cereal residue application along with nitrate and ammonium N application at the rate of 100 kg ha^{-1}, respectively. However, 1000 grain weight was higher for legume residue along with split application of ammonium-N at the rate of 100 kg ha^{-1}. Planned mean comparisons showed that control plots produced significantly less spikes m^{-2}, grains spike^{-1}, 1000 grain weight and grain yield as compared to mean of the rest of the treatments. Likewise, legume alone enhanced spikes production as compared to cereal in combination with N. Similarly, legume alone also performed better than cereal alone for improving grain weight. In the same manner, residue plus nitrate-N produced higher grain yield as compared to residue plus ammonium-N.

Introduction

A need to increase food production to keep pace with an accelerating population growth while ensuring minimum environmental degradation has recently gained more attention. Agricultural production can only be sustained if productivity of land and other resources upon which agriculture is based are not allowed to deteriorate further. Alternative and renewable source of energy are needed in agriculture because of rising costs, potential shortage and injudicious use of fossil fuel. Nitrogen fertilizer represents the largest single input of the total energy required to produce a hectare of maize or wheat in Pakistan. More N is required in crop production than P and K, yet N has lower use efficiency, high losses and greater potential to pollute the environment (Jan *et al*., 2007).

Nitrogen fertilization plays an important role in improving soil fertility and increasing crop productivity (Habtegebrial *et al*., 2007). Nitrogen fertilization increases grain yield (43-68%) and biomass (25-42%) in maize (Ogola *et al*., 2002). It contributes 18-34% increase in soil residual N (Yang *et al*., 2007). Sole residue incorporation or in combination with N fertilizer have positive effects on plant growth and production (Jan *et al*., 2011) as well as on soil physiochemical properties (Khan *et al*., 2009). Synergistic effects of N with organic fertilizers (residue or FYM) accumulate more soil total N (Huang *et al*., 2007), but sole effects of FYM result in increasing yield (Anatoliy & Thelen, 2007), organic matter (44%) in soil (Rasool *et al*., 2007).

This study was conducted to study the integrated impact of crop residue (cereal and legume) and fertilizer N on wheat production.

Materials and Methods

Experimental site: Peshawar has a warm to hot, semi-arid, sub-tropical, continental climate with mean annual rainfall of about 360 mm. Summer (May–September) has a mean maximum temperature of 40°C and mean minimum temperature of 25°C. Winter (December to the end of March) has mean minimum temperature of 4°C and a maximum of 18.4°C. The average winter rainfall is higher than that of summer. The highest winter rainfall has been recorded in March, while the highest summer rainfall is in August. Soil of the experimental site is deficient in N, P and available Zn, but has adequate K. Canal water is available for irrigation. The physio-chemical properties of the experimental site are given in Table 2.

Experimental description: The field experiment was conducted at Agricultural Research Farm, KPK Agricultural University, Peshawar, Pakistan during winter 2005-2006. The experimental treatments were consisted of crop residue (cereal & legume residue), two type of fertilizer-N (NH_4-N & NO_3-N) and their application time i.e. at sowing and 2nd node appearance stage. Urea was used as mineral-N source for NH_4-N and calcium nitrate ($CaNO_3$) for NO_3-N. Crop residue was applied as sole or in mixture with NH_4 and NO_3 nitrogen. Cereal and legume residue were chopped into small pieces and was applied about 40 days before sowing at the rate of 5 and 2.5 t ha^{-1}, respectively. A 100 kg N ha^{-1} of both type of fertilizer-N was used in combination with cereal residue while two levels (50 & 100 kg N ha^{-1}) of both type of fertilizer-N were combined with legume residue. The entire crop residue (cereal & legume) was applied at sowing. A full dose of fertilizer-N was applied at pre boot stage or in a split (half dose at sowing with crop residue and half at pre boot stage). Details of the experimental treatments are given in Table 1. Wheat variety 'Fakhre Sarhad' was sown at the seed rate of 100 kg ha^{-1} with the help of a seed drill. Phosphorus was applied at the rate of 90 kg ha^{-1} at the time of sowing. Data were recorded on spikes m^{-2}, grains spike^{-1}, thousand grain weight and grain yield.

Table 1. Details of the experimental treatments.

	Source/Type of N		Plant Residue+Fertilizer-N	Fertilizer-N only
	S1	S2	S1	S2
T1	Control		0	0
T2	Cereal		5000	0
T3	Cereal	NH_4	5000	100
T4	Cereal + NH_4	NH_4	5000 + 50	50
T5	Cereal	NO_3	5000	100
T6	Cereal + NO_3	NO_3	5000 + 50	50
T7	Legume		2500	0
T8	Legume	NH_4	2500	50
T9	Legume + NH_4	NH_4	2500 + 25	25
T10	Legume	NO_3	2500	50
T11	Legume + NO_3	NO_3	2500 + 25	25
T12	Legume	NH_4	2500	100
T13	Legume + NH_4	NH_4	2500 + 50	50
T14	Legume	NO_3	2500	100
T15	Legume + NO_3	NO_3	2500 + 50	50

Cereal = Maize stover, Legume = Soybean residue, S1 = At sowing, S2 = At pre-boot stage

Table 2. Physico-chemical properties of the experimental site.

Sand (%)	8.7
Silt (%)	51.3
Clay (%)	40.0
Textural Class	Silty clay loam
Organic matter (g kg^{-1})	0.845
Total N (g kg^{-1})	0.04
$CaCO_3$ (%)	14.4
pH 1:1 Water	8.02
Electrical conductivity (dS m^{-1})	0.87
AB-DTPA extractible nutrients	
P (mg kg^{-1})	3.80
K (mg kg^{-1})	105
Zn (mg kg^{-1})	0.86

Data from Bhatti (2002) and Tariq *et al*., (2002) for Agricultural University Peshawar farm.

Statistical analysis: The data were analyzed statistically using analysis of variance technique appropriate for randomized complete block design. Means were compared using LSD test at 0.05 level of probability, when the F-values were significant (Jan *et al*., 2009).

Results

Spikes m^{-2}: Integrated N treatments significantly affected spikes m^{-2} in wheat. The highest spikes m^{-2} were recorded for nitrate-N application in split at the rate of 100 kg ha^{-1} in combination with legume residue and the lowest spikes m^{-2} was recorded for control plots. Generally, spikes m^{-2} was higher for legume residue application in combination with 100 kg N ha^{-1} as compared to cereal residue with the same N rate irrespective of type and method of N (Table 3).

Planned mean comparisons showed that control plots produced significantly less spikes m^{-2} as compared to mean of the rest of the treatments. Likewise, legume alone performed better than cereal in combination with N. However, legume alone did not result in higher spikes m^{-2} as compared to cereal residue alone. Moreover, ammonium-N also did not differ for spikes m^{-2} than nitrate-N in combination with residue in both cases (Fig. 1a).

Grains spike^{-1}: Grains spike^{-1} was significantly affected N treatments. Higher grains spike^{-1} was recorded for legume and cereal residue application along with nitrate and ammonium N application at the rate of 100 kg ha^{-1}, respectively. The lowest grains spike^{-1} was recorded for control plots. Grains spike^{-1} was infrequently higher for legume residue application in combination with 100 kg N ha^{-1} as compared to cereal residue with the same N rate irrespective of type and method of N (Table 3).

Planned mean comparisons showed that control plots produced significantly less grains spike^{-1} as compared to mean of the rest of the treatments. However, differences among cereal vs legume residue, cereal plus N vs legume alone and residue plus ammonium-N vs residue plus nitrate-N were not significant for grains spike^{-1} (Fig. 1b).

Thousand grain weight: Integrated N treatments significantly affected thousand grain weight of wheat. Grain weight was higher for legume residue along with split application of ammonium-N at the rate of 100 kg ha^{-1} and the lowest thousand grain weight was recorded for control plots. Generally, thousand grain weight was higher for legume residue application in combination with N at the rate of 100 kg ha^{-1} as compared to cereal residue with the same N rate irrespective of type and method of N (Table 3).

Planned mean comparisons showed that control plots produced significantly less thousand grain weight as compared to mean of the rest of the treatments. Legume alone performed better than cereal alone for improving grain weight. However, differences among cereal plus N vs legume alone and residue plus ammonium-N vs residue plus nitrate-N were not significant for thousand grain weight (Fig. 2a).

Grain yield: Grain yield was significantly affected by integrated N management treatments in wheat. Grain yield was higher for legume residue along with split nitrate N application at the rate of 100 kg ha^{-1} and the lowest grain yield was recorded for control plots. Usually, grain yield was higher in plots where legume residue was applied in combination with 100 kg N ha^{-1} as compared to cereal residue with the same N rate irrespective of type of and method of N.

Planned mean comparisons showed that control plots produced significantly less grain yield as compared to mean of the rest of the treatments. Likewise, residue plus nitrate-N produced higher grain yield as compared to residue plus ammonium-N. However, differences among cereal alone vs legume alone and cereal plus N vs legume alone were not significant for grain yield (Table 3).

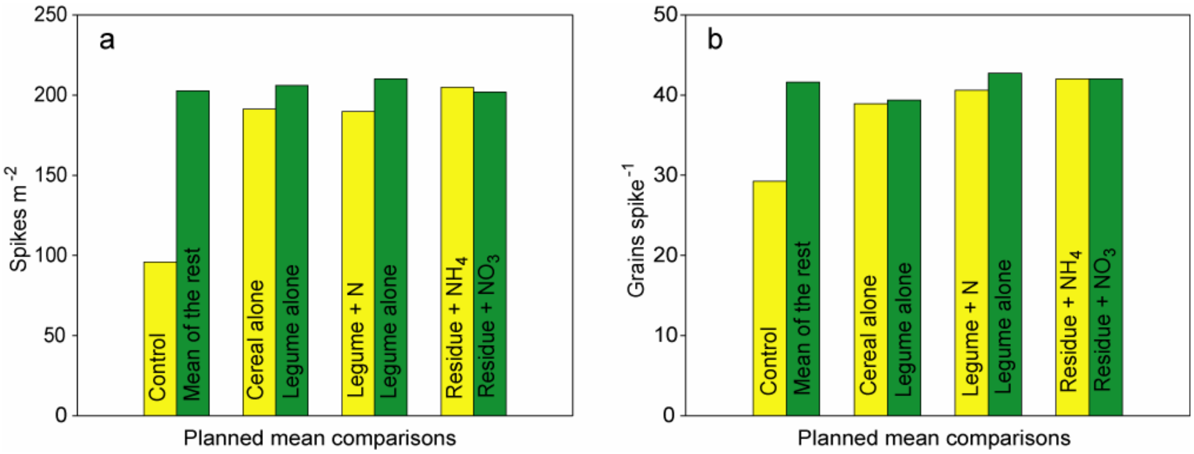

Fig. 1(a, b). Planned mean comparisons for spikes m^{-2} (a) and grains $spike^{-1}$ (b) as affected by integrated N management.

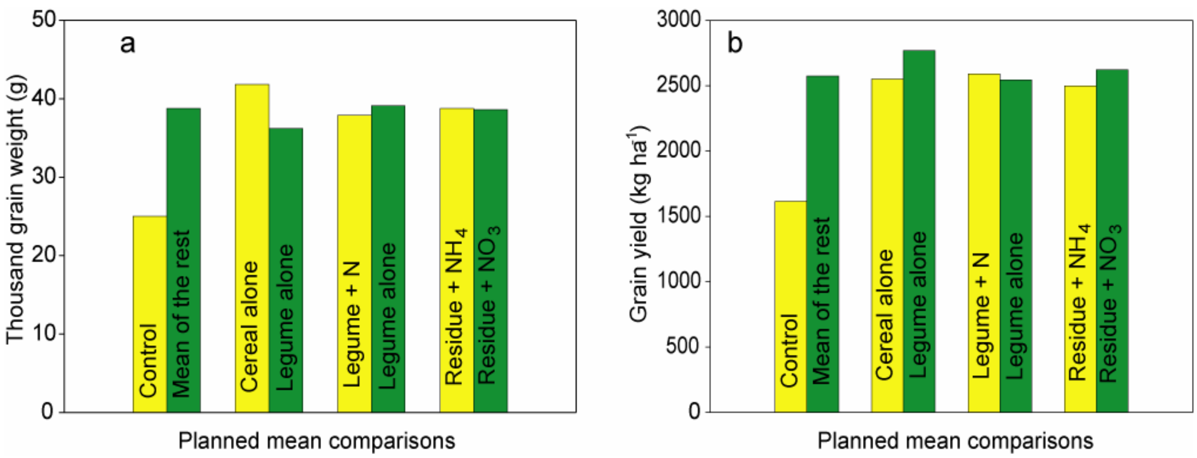

Fig. 2(a, b). Planned mean comparisons for thousand grain weight (a) grain yield (b) as affected by integrated N management.

Discussion

Yield and yield components responded positively to integration of organic and inorganic N-fertilizers. Generally, higher rates of N in mixture with legume resulted in higher yield and yield components than control and other treatments.

The better performance of N in mixture with legume residue is usually attributed to the synergistic effects of organic and inorganic fertilizers, which improve the efficiency of each other (Jan *et al.*, 2007). Likewise, higher nutrient use efficiency and recovery can be obtained with integration of organic and inorganic fertilizers (Kiani *et al*., 2005). The greater inorganic N

(Anatoliy & Thelen, 2007), total N availability in N amended plots (Dolan *et al.*, 2006; Jan *et al.*, 2010) may be the reasons for improved yield components in fertilized plots compared to control plots. The legume residue incorporation improves total N due to immediate decomposition (Malhi *et al.,* 2006) as compared to cereal residue which usually takes greater time to decompose and to release nutrient. The greater spike m^{-2} may be attributed to the adequate nitrogen availability, which facilitates tillering ability of the wheat crop (Jan & Khan, 2002). These results are line with Singh & Bhan (1998) who also obtained greater spike m^{-2} with higher fertilizer levels. Greater grain weight in fertilized plots can be attributed to the availability of N at grain formation stage. The results are in line with Tahir *et al.*, (2000) who recorded the highest grain weight with combine use of organic and inorganic in ratio of 50:50%. Our results are also similar to Khan *et al.*, (2005) who obtained heavier grains in fertilized plots.

Table 3. Effect of integrated N management on spikes m^{-2}, grains spike, thousand grain weight and grain yield (kg ha^{-1}) of wheat.

	Treatments/Details	Spikes m^{-2}	Grains spike^{-1}	Thousand grain weight (g)	Grain yield (kg ha^{-1})
T1	Control	96 h	29 d	25.00 d	1614 e
T2	Cereal	191 ef	39 c	41.82 ab	2552 a-d
T3	Cereal+100 NH4 S2	189f	40 c	35.70 c	2668 ab
T4	Cereal+100 NH4 (S1+S2)	213 bc	48 a	37.58 bc	2324 cd
T5	Cereal+100 NO3 S2	186 fg	38 c	39.03 abc	2790 a
T6	Cereal+100 NO3 (S1+S2)	172 g	37 c	39.18 abc	2577 a-d
T7	Legume	206 cde	39 c	36.20 c	2769 a
T8	Legume+50 NH4 S2	201 c-f	41 bc	38.28 abc	2436 bcd
T9	Legume+50 NH4 (S1+S2)	190 f	38 c	39.77 abc	2294 d
T10	Legume+50 NO3 S2	197 def	38 c	38.52 abc	2304 d
T11	Legume+50 NO3 (S1+S2)	188 f	39 c	39.38 abc	2607 abc
T12	Legume+100 NH4 S2	211 bcd	38 c	38.65 abc	2566 a-d
T13	Legume+100 NH4 (S1+S2)	225 b	47 ab	42.72 a	2696 ab
T14	Legume+100 NO3 S2	225 b	47 ab	37.87 abc	2621 abc
T15	Legume+100 NO3 (S1+S2)	243 a	53 a	37.77 bc	2834 a
	Least significant difference	15.93	6.382	4.030	300.3

Means in the same column followed by different letters are significantly different from one another at 5% level of probability

Higher grain yield was produced in plots amended with organic and inorganic N compared to control. Generally, combined applications of legume residue and higher rate of N resulted in greater yield. The higher yield in fertilized plots over control may be due to higher available N in fertilized plots (Halvorson *et al.,* 2001; Camara *et al.,* 2003; Malhi *et al.,* 2006). Most of the researchers attribute increase in grain yield due to an increase in residue decomposition, organic N mineralization and the availability of N for plant use (Halvorson *et al*., 2005; Sainju & Singh, 2001; Dinnes *et al*., 2002; Arif *et al*., 2011). The increase in grain yield may be due to the individual crop performance like spikelet number, grain per spike and 1000-grain weight (Zhai & Xiu LI, 2006) which may have improved grain yield. The increase in grain yield in fertilized plots can also be attributed to the increased tillers m^{-2}, spike m^{-2}, grains spike^{-1} and 1000 grains weight.

Acknowledgment

We acknowledge the financial support of Pakistan Agricultural Research Council under Agriculture Linkages Program for conduction of this research project.

References

Anatoliy, G.K. and K.D. Thelen. 2007. Effect of winter wheat crop residue on no-till corn growth and development. *Agron. J.,* 99: 549-555.

Arif, M., M.T. Jan, M.J. Khan, M. Saeed, I. Munir, Ziauddin, H. Akbar, Shahenshah and M.Z. Khan. 2011. Effect of cropping system and residue management on maize. *Pak. J. Bot*., 43(2): 915-920.

Bhatti, A.U. 2002. Soil Fertility Status of Malakandher Farm. Soil Bull. 6. Dept. Soil and Env. Sci., NWFP Agricultural University, Peshawar, Pakistan.

Camara, K.M., W.A. Payne, and P.E. Rasmussen. 2003. Long-term effects of tillage, nitrogen, and rainfall on winter wheat yields in the pacific northwest. *Agron. J*., 95: 828-835.

Dinnes, D.L., D.L. Karlen, D.B. Jaynes, T.C. Kasper, J.L. Hatfied, T.S. Colvin, and C.A. Cambardella. 2002. Nitrogen management strategies to reduce nitrate leaching in til-drained Midwestern soils. *Agron. J*., 94: 153-171.

Dolan, M.S., C.E. Clapp, R.R. Allmaras, J.M. Baker and J.A.E. Molina. 2006. Soil organic carbon and nitrogen in a Minnesota soil as related to tillage, residue and N management. *Soil and Tillage Res*., 89(2): 221-231.

Gangwar, K.S., K.K.Singh, S.K. Sharma and O.K. Tomar. 2006. Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gangetic plains. *Soil and Tillage Res.*, 88: 242-252.

Habtegebrial, K., B.R. Singh and M. Haile. 2007. Impact of tillage and nitrogen fertilization on yield, nitrogen use efficiency of tef *Eragrostis*, *Trotter* and soil properties. *Soil and Tillage Res.*, 94: 55-63.

Halvorson, A.D., B.J. Wienhold and A.L. Black. 2001. Tillage and nitrogen fertilization influence grain and soil nitrogen in an annual cropping system. *Agron. J*., 93: 836-841.

Halvorson, A.D., F.C. Schweissing, M.E. Bartula and C.A. Reule. 2005. Corn response to nitrogen fertilization in a soil with high residual nitrogen. *Agron. J*., 97: 1222-1229.

Huang, B., W.Z. Sun, Y.Z. Hao, J. Hu, R. Yang, Z. Zou, F. Ding and J. Su. 2007. Temporal and spatial variability of soil organic matter and total nitrogen in an agricultural ecosystem as affected by farming practices. *Geoderma*., 139: 336-345.

Jan, M.T., and S. Khan. 2002. Response of wheat yield components to type of N fertilizer, their levels and application time. *Pak. J. Biol. Sci*., 3: 1227-1230.

Jan, M.T., M.J. Khan, A. Khan, M. Arif, Farhatullah, D. Jan and M.Z. Afridi. 2011. Increasing wheat productivity through source and timing of nitrogen fertilization. *Pak. J. Bot*., 43(2): 905-913.

Jan, M.T., M.J. Khan, A. Khan, M. Arif, M. Shafi and Farmanullah. 2010. Wheat nitrogen indices response to nitrogen source and application time. *Pak. J. Bot*., 42(6): 4267-4278.

Jan, M.T., P. Shah, P.A. Hollington, M.J. Khan and Q. Shohail. 2009. Agriculture Research: Design and Analysis. 1st ed. Dept. of Agronomy, KPK Agric. Univ. Peshawar, Pakistan.

Jan, T., M.T. Jan, M. Arif, H. Akbar and S. Ali. 2007. Response of wheat to source, type and time of nitrogen application. *Sarhad Journal Agriculture*, 23: 871-879.

Khan, A., A. Jan and S. Alam. 2005. Effect of nitrogen and seed size on maize crop II: yield and yield components. *J. Agric. Soc. Sci*., 1: 18-23.

Khan, A., M.T. Jan, K.B. Marwat and M. Arif. 2009. Organic and inorganic nitrogen treatments effects on plant and yield attributes of maize in a different tillage systems. *Pak. J. Bot*., 41(1): 99-108.

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. *Archives Agronomy & Soil Science*, 51: 299-309.

Malhi, S.S., R. Lemke, Z.H. Wang and B.S. Chhabra. 2006. Tillage, nitrogen and crop residue effects on crop yield, nutrient uptake, soil quality, and greenhouse gas emissions. *Soil and Tillage Res*., 90: 171-183.

Ogola, J.B.O., T.R. Wheeler and P.M. Harris. 2002. Effects of nitrogen and irrigation on water use of maize crops. *Field Crop Res.*, 78: 105-117.

Rasool, R., S.S. Kukal and G.S. Hira. 2007. Soil physical fertility and crop performance as affected by long-term application of FYM and nitrogen fertilizers in rice-wheat system. *Soil and Tillage Res*., 96: 64-72.

Sainju, U.M. and B.P. Singh. 2001. Tillage, cover crop and kill-planting date effects on corn yield and soil nitrogen. *Agron. J*., 93: 878-886.

Singh, S., and V.M. Bhan. 1998. Response of wheat and associated weeds to irrigation regime, nitrogen and 2, 4-D. *Ind. J. Agron*., 43: 662-667.

Tahir, H., I. Ahmed, M.A. Haq, M. Jamil and M. JH. Zia 2000. EM Technology: From IPNM, Proceeding of symposium by National Fertilizer Development Centre. Islamabad, pp. 113-120.

Tariq, M., M.A. Khan, and S. Perveen. 2002. Response of maize to applied soil zinc. *Asian J. Plant Sci*., 1(4): 476-477.

Yang, J.Y., E.C. Huffman, R.D. Jong, V. Kirkwood, K.B. MacDonald and C.F. Drury. 2007. Residual soil nitrogen in soil landscapes of Canada as affected by land use practices and Agricultural policy scenarios. *Land Use Policy*, 24: 89-99.

Zhai, B. and S. Li. 2006. Study on the Key and Sensitive Stage of Winter Wheat Responses to Water and Nitrogen Coordination. *Agric. Sci. in China*, 5: 50-56.

(Received for publication 7 January 2011)