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Effect of Nitrogen and Preceding Cropping Pattern on Yield and Yield Components of Rainfed Wheat

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Abstract

Field experiment on carry over effect of preceding cropping pattern (millet, sorghum, mungbean and groundnut as sole and each in combination with groundnut repeated for two consecutive years 2007-2009) and current application of three doses of nitrogen (00, 45 and 90 kg ha^{-1}) on rainfed wheat was conducted at New Developmental Farm, Khyber Pakhtunkhwa Agricultural University Peshawar in rabi 2010. The experiment was laid out in randomized complete block design with split plot arrangement having three replications. Cropping pattern assigned to main plot while nitrogen levels to sub plot (5m x 1.8m). Soil analysis was carried out before sowing and after harvesting of crop. It showed that plots grown with mungbean (sole) had higher N content at both occasions (before sowing 0.41 g kg^{-1} and after harvest 0.38 g kg^{-1}) as compared with other cropping patterns. All parameters were significantly affected by cropping pattern and nitrogen application except number of unproductive tillers m^{-2} were not significantly affected by preceding cropping pattern. Groundnut and mungbean intercropping had significantly delayed anthesis and maturity. Mungbean (sole) or intercropped with groundnut as preceding crop had significantly produced taller plants, more: tillers m^{-2}, productive tillers m^{-2}, grains spike^{-1}, thousand grain weight, biological yield, grain yield and harvest index. Nitrogen application had significantly increase productive tillers m^{-2} (225), grains spike^{-1} (48), thousand grain weight (34g), grain yield (1448kg ha^{-1}), biological yield (6126kg ha^{-1}) and harvest index (23%) as compared to control. Combination of mungbean as sole and 90 kg N ha^{-1} produced significantly higher tillers m^{-2} (263), more productive tillers (234) and higher thousand grain weight (32g). Cropping system of mungbean as sole or intercropping with groundnut as preceding crop and nitrogen application at rate of 90 kg ha^{-1} seems to be the promising agronomic practices for growing wheat in rainfed areas.

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to the family Poaceae. It is an annual, Rabi, self pollinated and long day plant grown as winter crop in Pakistan. Its requirements in Pakistan are going to increase day by day. The present production of wheat is not sufficient to feed the existing population. The additional requirements will have to be met either by bringing more area under cultivation or increasing yield per unit area. During 2007-2008 total area under wheat cultivation was 8549.8 thousand ha, with a total production of 20958.8 thousand tones. Average yield per ha was 2451 kg ha^{-1}. In NWFP area under wheat cultivation during the same year was 747.4 thousand ha and with production of 1071.8 thousand tones. Average yield was 1434 kg ha^{-1}. (MINFAL, 2008)

Cropping system is the kind and sequence of crops grown on a given area of soil over a period of time, it may be a regular rotation of different crops in which the crops follow a definite order of appearance on the land or it may consist of only one crop grown year after year on the same area (Singh, 1972). Cropping system can be defined as the crop production enterprise used to derive benefits from a given resource and specific environmental conditions (Zandstra, 1997). Crop rotation or crop sequencing is the practice of growing a series of dissimilar types of crops in the same area in sequential seasons for various benefits such as to avoid the build up of pathogens and pests that often occurs when one species is continuously cropped. Crop rotation also seeks to balance the fertility demands of various crops to avoid excessive depletion of soil nutrients. A traditional component of crop rotation is the replenishment of nitrogen through the use of green manure in sequence with cereals and other crops. Crop rotation can also improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants (Carrol et al., 1997). The cropping system should increase farm productivity, better water distribution and to achieve maximum water use efficiency and best utilization of farm labour, machinery and other related resources (Sadiq, 2008).

In organic farming the replenishment of soil N mainly depends on biological nitrogen fixation (BNF) through legumes, ensuring sufficient nitrogen supply to cereal crops such as winter wheat and winter rye. Legumes are important components in cropping systems as soil ameliorants. They improve the physical structure, increase acquisition and mobility of macro and micronutrients and reduce soil-borne pests and pathogens (Lauren et al., 2001). In subsistence farming, it also makes good nutritional value to grow legumes and grain at the same time in different fields (Huang et al., 2003).

Nutritional stress, including widespread nutrient deficiencies (Rashid, 1994) and low and unbalanced use of fertilizers (NFDC, 1997) are one of the major limiting factors causing lower crop production in Pakistan. Among plant nutrients, nitrogen deficiency is one of the major yield limiting factor for cereals (Shah et al., 2003). Nitrogen being major nutrient is exposed to various losses like, leaching, volatilization, immobilization and denitrification and therefore its availability is always questioned, hence nitrogen fertilizer application is an essential input for crop productivity in most areas of the world (Evens et al., 1991). The recent trend for growing continuous cereals on all arable lands has further depleted the nutrients in soil which are already low (Rashid and Qayyum, 1991). There is a net negative balance of major nutrients even with the application of the recommended dose of 120 kg N ha^{-1} (Zia et al., 1992). A large number of fertilizer trails have shown that N is a major limitation to the yield of cereals (Khan et al. 1989). After water, among the plant nutrients, nitrogen deficiency is one of the major yield limiting factor of cereals (Shah et al., 2003).

Keeping in view the importance of crop rotation and nitrogen, the present experiment was conducted to study the carry over effect of cropping pattern and N levels on subsequent wheat crop.

MATERIALS AND METHODS

An experiment on ‘carry over effect of cropping pattern and nitrogen levels on subsequent rainfed wheat’ was conducted at New Developmental Farm of Agricultural University, Peshawar during winter 2009-10. The experiment was carried out in randomized complete block (RCB) design, with split plot arrangement, having three replications. Main plot size was 5m x 4.8m and Sub plot size of 5 m x 1.6 m was used in the experiment. Row to row distance was kept as 30 cm. Row orientation was east to west to minimize the effect of crop grown in intercropping. The crop was sown at proper moisture/vatter condition. Wheat variety Pirsabak-2005 was grown at the seed rate of 100 kg ha^{-1}. Phosphorous was applied at the rate of 60 kg ha^{-1} as basal dose at time of sowing.

Field History

Six crops i.e. Groundnut, Sorghum, Millet and Mungbean were grown as sole and in combination of Groundnut + Sorghum, Groundnut + Millet and Groundnut + Mungbean on the same field for two consecutive years (2008-2009) under rainfed conditions. For present experiment composite soil samples were taken for soil nitrogen analysis before sowing and after harvesting. Standard agronomic practices were carried out uniformly for all treatments.

The following factors and their level were studied

TREATMENTS

Main plot Factor (previous cropping pattern) is C_1:Groundnut (sole), C_2: Sorghum (sole), C_3: Millet (sole), C_4: Mungbean (sole), C_5:Groundnut + Sorghum, C_6: Groundnut + Millet, C_7:Groundnut + Mungbean. Where as sub plot Factor (N kg ha^{-1}) N_1:00, N_2:45, N_3: 90

Procedure for collection of data

The data on number of productive tillers m^{-2} was recorded in an area of one meter row in each sub plot at 3 places and were converted into m^2. The data on number of non productive tillers m^{-2} was recorded in an area of one meter row in each sub plot at three places and was converted into m^2. To record grains spike^{-1} ten earmarked spikes were randomly selected in each sub plot, threshed and then grain were counted and averaged**.** Biological yield was calculated after harvesting four central rows in each subplot, dried and weighed and then was converted into kg ha^{-1}. Grain yield from four central rows was recorded for each subplot after threshing and thoroughly cleaning the grain. Grain yield was then converted into kg ha^{-1}. For grains weight, thousand grains were counted from threshed clean grain of each sub plot having three samples and then were weighed with the help of sensitive electronic balance. Harvest index was recorded with the following formula:

$$\text{H.I. \%} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Nitrogen concentration in soil was determined by kjeldhal method of Bremnor and Mulvaney (1982). In this method, 0.2g of fairly grounded soil samples were digested with 3ml of concentrated H_2SO_4 in the presence of 1.1g digestion mixture containing $CuSO_4$ KSO_4 and selenium powder at 450 ^{0}C for 4-5 hours. After cooling, the digest was diluted to 100 ml with distilled water, 20 ml of which was distilled in the presence of 5 ml boric acid mixed indicator solution. The distillate was titrated against 0.005NHCl. The amount of N was calculated at 1 ml of 0.005 N HCl, which is equivalent to 70µgN.

EXPERIMENTAL RESULTS

Number of tillers m^{-2}

Data pertaining number of tillers m^{-2} is shown in Table 1. The statistical analysis of data showed that tillers m^{-2} was non-significantly affected by cropping pattern and was significantly affected by nitrogen levels and interactive effect of nitrogen and cropping pattern. Maximum numbers of tillers (296.3) were recorded for mungbean (sole) and minimum (211.48) were recorded for groundnut (sole). In terms of nitrogen, Maximum numbers of tillers (258.89) were recorded with the application of 90 kg N ha^{-1} and minimum (234.81) were recorded from control plots.

Number of unproductive tillers m^{-2}

The impact of cropping pattern and current nitrogen application on number of unproductive tillers m^{-2} is presented in Table 2. The statistical analysis of the data revealed that number of unproductive tillers m^{-2} were non-significantly ($P \leq 0.05$) affected by cropping pattern but significantly ($P \leq 0.05$) affected by nitrogen levels. The interactive effect of cropping pattern and nitrogen was found non-significant. Higher numbers of unproductive tillers m^{-2} (40.74) were recorded for mungbean (sole) and lower unproductive tillers m^{-2} (25.18) were recorded from groundnut and sorghum intercropping. In terms of nitrogen, maximum number of unproductive tillers m^{-2} (37.78) were recorded with the application of 90 kg N ha^{-1} and minimum unproductive tillers m^{-2} (32.22) were recorded from control plots.

Number of productive tillers m^{-2}

The influence of cropping pattern and current nitrogen application on number of productive tillers m^{-2} is shown in Table 3. The statistical analysis of the data revealed that number of productive tillers m^{-2} were significantly ($P \leq 0.05$) affected by cropping pattern and nitrogen levels. The interaction of cropping pattern and nitrogen was also significant. Maximum number of productive tillers m^{-2} (239.26) were recorded for mungbean (sole) and minimum productive tillers m^{-2} (195.93) were recorded from millet (sole). In terms of nitrogen, maximum number of productive tillers m^{-2} (225.13) were recorded with the application of 90 kg N ha^{-1} and minimum productive tillers m^{-2} (208.04) were recorded from control plots.

Grains $spike^{-1}$

The impact of cropping pattern and current nitrogen application on number of grains $spike^{-1}$ is presented in Table 4. The statistical analysis of the data revealed that grains $spike^{-1}$ were non-significantly ($P \leq 0.05$) affected by cropping pattern but significantly ($P \leq 0.05$) affected by nitrogen levels. The interactive effect of cropping pattern and nitrogen was found non-significant. Higher grains $spike^{-1}$ (48.11) were recorded for groundnut and mungbean intercropping and lower grains $spike^{-1}$ (35.89) were recorded from millet (sole). In terms of nitrogen, maximum grains $spike^{-1}$ (47.86) were recorded with the application of 90 kg N ha^{-1} and minimum grains $spike^{-1}$ (36) were recorded from control plots.

Thousand grain weight

The influence of cropping pattern and current nitrogen application on thousand grain weight is shown in Table 5. The statistical analysis of the data revealed that thousand grain weight was significantly ($P \leq 0.05$) affected by cropping pattern and nitrogen levels. The interaction of cropping pattern and nitrogen was not significant. Maximum thousand grain weight (34.4) was recorded for mungbean (sole) and minimum thousand grain weight (28.76) was recorded from millet (sole). In terms of nitrogen, maximum thousand grain weight (33.97) was recorded with the application of 90 kg N ha^{-1} and minimum thousand grain weight (28.78) was recorded from control plots.

Biological Yield

Data regarding biological yield as affected by cropping pattern and current nitrogen application is presented in Table 6. The statistical analysis of the data revealed that plant height was significantly ($P \leq 0.05$) affected by cropping pattern and nitrogen levels. The interactive effect of cropping pattern and nitrogen was found non-significant. Maximum biological yield (6293.33) was recorded for groundnut and mungbean intercropping and minimum biological yield (5682.22) was recorded from millet (sole) and intercropping of groundnut and sorghum. In terms of nitrogen, maximum biological yield (6126.19) was recorded with the application of 90 kg N ha^{-1} and minimum biological yield (5611.27) was recorded from control plots.

Grain yield

Data pertaining number of grain yield is shown in Table 7. The statistical analysis of data showed that grain yield was non-significantly affected by cropping pattern and was significantly affected by nitrogen levels and interactive effect of nitrogen and cropping pattern. Maximum grain yield (1519.83) was recorded for groundnut and mungbean intercropping and minimum (1004.45) was recorded for millet (sole). In terms of nitrogen, Maximum grain yield (1447.93) was recorded with the application of 90 kg N ha^{-1} and minimum (1008.36) was recorded from control plots.

Harvest Index (%)

The impact of cropping pattern and current nitrogen application on harvest index (%) is presented in Table 8. The statistical analysis of the data revealed that harvest index (%) was significantly ($P \leq 0.05$) affected by cropping pattern and nitrogen levels. The interactive effect of cropping pattern and nitrogen was found non-significant. Higher harvest index (24.11) was recorded for groundnut and mungbean (intercropping) and lower harvest index (17.61) was recorded from millet (sole). In terms of nitrogen, maximum harvest index (23.5) was recorded with the application of 90 kg N ha^{-1} and minimum harvest index (18.02) was recorded from control plots.

DISCUSSION

Number of tillers m^{-2} were non-significantly affected by cropping pattern but significantly affected by nitrogen levels. The tillers m^{-2} is the potential of crop and that's why it was non-significantly affected by previous cropping pattern. These results are against the results of Ryan et al. (1997) and Taa et al. (2004) who reported that number of tillers significantly affected by cropping pattern. In terms of nitrogen the higher dose of nitroegn i.e. 90 kg ha^{-1} produced more tillers m^{-2}. It might be due to the reason that the optimum nitrogen availability played an essential role in plant growth whereas low dose of nitrogen caused reduction in above ground vegetative growth of plant. The results are in confirmation with Golik et al. (2005) who concluded that number of tillers increased with incremental nitrogen.

Number of unproductive tillers m^{-2} was non significantly affected by cropping pattern but significantly affected by nitrogen levels. The non significant might be due to the reason that in terms of nitrogen the higher unproductive tillers were observed in control plots, as nitrogen is an integral part of plant so in case of its unavailability the plant is unable to produce the fertile tillers. The results are in confirmation with Dogar (1983) who reported that the presence of nitrogen increased the number of fertile tillers and vice versa.

Number of fertile tillers was significantly affected by both cropping pattern and nitrogen levels. The increase in number of productive tillers may be attributed to the fact that legumes as previous crop increased the nitrogen levels which ultimately affected the number of fertile tillers. The leguminous crop before the wheat had the added advantage over the cropping system where non-leguminous crop was planted before wheat. The results are in confirmation with Sadiq (2000). In terms of nitrogen, the number of fertile tillers increased with nitrogen application. The increase in number of fertile tillers with the increase in nitrogen levels can be attributed to the reduction in mortality of tillers and enabling the production of more tillers from the main stem. These results are in line with Ayoub et al. (1994) and Palta and Fillery (1995) who reported that number of fertile tillers increased with increase in nitrogen application in wheat.

Grains spike^{-1} was significantly affected by cropping pattern and nitrogen levels. The grains spike^{-1} were higher in plots in which preceding crop was legume. The results are in confirmation with Kumbhar et al., (2007) who reported that grains spike^{-1} of wheat were increased by the inclusion of legumes in crop rotation. In terms of nitrogen maximum grains spike^{-1} were recorded from highest dose of 90 kg ha^{-1}, followed by 45 kg N ha^{-1}. Similar results were observed by Sorour et al., (1998) that grains spike^{-1} were increased with incremental nitrogen.

Thousand grains weight is a genetically controlled trait, which is greatly influenced by environment during the process of grain filling. Thousand grains weight was significantly affected by both cropping pattern and nitrogen levels. It might be due to nitrogen fixation by preceding legumes and also the root biomass which contains nodules left in soil, which was slowly mineralized and become available to next wheat crop throughout its growth period. The results are in line with Evens et al., (1991) and Singh and Singh (2000) who reported that thousand grains weight increased after legumes. In terms of Nitrogen, The grain weight is a genetically controlled trait, which is greatly influenced by environment during the process of grain filling. It appears that the application of nitrogen increased the protein percentage which in turn increased the grain weight. Similar results were observed by Kausar et al., (1993) who reported that thousand grains weight increased with incremental nitrogen.

Biological yield is the net photosynthetic activity of any crop. Biological yield was significantly affected by cropping pattern and nitrogen levels. The biological yield is dependent on the nutrient supply of soil, therefore, legume crops due to their residual N directly increased the yield. These results are in confirmation with Ryan et al., (1997), Aslam et al., (2003) who reported that biological yield of wheat increased after legumes. In terms of nitrogen biological yield increased with every successive increase in the rate of nitrogen fertilizer. Increased rates of nitrogen induced vigorous vegetative growth, which in turn resulted in increased biological yield. Nitrogen increases leaf area of the crop and may result in increased dry matter production by intercepting more sun light (Wilhelm, 1998). Crop sequence with preceding crop as legume had additional benefit of residual fertility from the proceeding leguminous crop, which when utilized in addition to the applied inorganic nitrogen and resulted exuberant crop growth, which ultimately resulted in increased biological yield. Results are in confirmation with results of Nehra et al., (2001) that nitrogen is a nutrient which enhances vegetative growth of the crop and have positive relationship with biological yield. Grain yield was significantly affected by cropping pattern and nitrogen levels. It may be due to the reason that the residual nitrogen left after legumes. The results are in line with Simpson et al., (1992) who reported that grain yield increased after legumes. Kuswaha and ali (1988) reported that the wheat crop without N after cowpea fodder produced a similar yield to that of wheat with 80 kg N ha^{-1} after sorghum. Similarly unfertilized wheat after Mungbean gave the same yield as obtained with 80 kg N ha^{-1} after pearl millet. Lopez-Bellido et al., (1996) reported that wheat yield was highest for cereal-legume rotation but lowest for continuous wheat. Wheat yield after legumes was higher as compared to wheat after cereal due to nitrogen fixation (Singh et al., 1993) and other rotational benefits (Russelle et al., 1987) and due to improvement in soil physical, biological properties (Kundu and Ladha 1995 and Wani et al., 1995). Hossain et al., (1996) reported that leguminous crops inclusion in cropping system restored the soil fertility status and indirectly increased the wheat yield. Grain yield of wheat after legume was higher as compared to wheat grain yield after sorghum (Hayat et al., 2008). Grain yield of wheat increased with every successive increase in nitrogen level. It may be due to the fact that nitrogen increases grain filling (Eichenaur et al., 1986), increases net assimilation rate (Sage & Pearcy, 1987), higher number of tillers, higher grain weight and higher number of grains spike^{-1}. The results are in confirmation with Bellido et al., (2000), Fallahi et al., (2008) who reported that grain yield of wheat increased with application of nitrogen.

CONCLUSION

On the basis of experiment it is concluded that the intercropping of groundnut and mungbean and 90 kg ha^{-1} of nitrogen was found significant over most of the parameters and found that using of these treatments improve yield and yield components of rianfed wheat.

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Table 1. Number of tillers m^{-2} of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	211.48	259.63	280.37	250.49
Sorghum	217.41	261.48	245.56	241.48
Millet	233.70	254.07	213.70	233.83
Mungbean	261.11	274.44	296.30	277.28
Groundnut + Sorghum	215.18	225.19	248.15	229.51
Groundnut + Millet	223.70	238.15	259.26	240.37
Groundnut + Mungbean	281.11	275.93	268.89	275.31
Mean	234.81 c	255.56 b	258.89 a	

Mean value of the same category followed by different letters are significantly different from each other at $P \leq 0.05$ using LSD test.

LSD value at $P \leq 0.05$ for nitrogen = 2.432

Table 2. Number of unproductive tillers m^{-2} of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	36.30	31.85	34.07	34.07
Sorghum	31.85	36.67	39.63	36.05
Millet	31.85	41.48	37.78	37.04
Mungbean	34.44	40.74	35.93	37.04
Groundnut + Sorghum	25.18	28.15	36.30	29.88
Groundnut + Millet	35.19	30.37	41.48	35.68
Groundnut + Mungbean	30.74	48.89	39.26	39.63
Mean	32.22 b	36.88 a	37.78 a	

LSD value at $P \leq 0.05$ for nitrogen = 0.9338

Table 3. Number of productive tillers m^{-2} of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	171.85	228.52	246.67	215.68 bc
Sorghum	185.56	224.07	213.33	207.65 cd
Millet	199.63	212.22	175.93	195.93 e
Mungbean	226.67	233.70	257.41	239.26 a
Groundnut + Sorghum	236.30	198.52	231.85	222.22 b
Groundnut + Millet	185.92	207.78	217.41	203.70 de
Groundnut + Mungbean	250.37	224.45	233.33	236.05 a
Mean	208.04 c	218.47 b	225.13 a	

Mean value of the same category followed by different letters are significantly different from each other at $P \leq 0.05$ using LSD test.

LSD value at $P \leq 0.05$ for cropping pattern = 9.434

LSD value at $P \leq 0.05$ for nitrogen = 2.814

Table 4. Grains spike^{-1} of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	39.00	47.33	49.00	45.11 c
Sorghum	31.67	43.67	42.00	39.11 f
Millet	31.33	38.33	38.00	35.89 g
Mungbean	40.00	47.00	56.00	47.67 b
Groundnut + Sorghum	35.67	45.00	51.33	44.00 d
Groundnut + Millet	34.00	45.00	44.33	41.11 e
Groundnut + Mungbean	40.33	49.67	54.33	48.11 a
Mean	36.00 c	45.14 b	47.86 a	

LSD value at $P \leq 0.05$ for cropping pattern = 1.549

LSD value at $P \leq 0.05$ for nitrogen = 0.413

Table 5. Thousand grain weight of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	31.00	33.20	33.63	32.61 b
Sorghum	26.30	29.30	31.63	29.08 d
Millet	26.07	29.50	30.70	28.76 d
Mungbean	31.13	34.70	37.37	34.40 a
Groundnut + Sorghum	27.20	32.93	34.57	31.57 c
Groundnut + Millet	28.23	32.80	33.50	31.51 c
Groundnut + Mungbean	31.53	34.30	36.37	34.07 a
Mean	28.78 c	32.39 b	33.97 a	

Mean value of the same category followed by different letters are significantly different from each other at $P \leq 0.05$ using LSD test.

LSD value at $P \leq 0.05$ for cropping pattern = 0.484

LSD value at $P \leq 0.05$ for nitrogen = 0.124

Table 6. Biological yield of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	5388.89	6111.11	6270.00	5923.33 b
Sorghum	5583.33	5916.67	5888.89	5796.30 bc
Millet	5388.89	5991.11	5666.67	5682.22 c
Mungbean	5991.11	6166.67	6677.78	6278.52 a
Groundnut + Sorghum	5277.78	5833.33	5935.55	5682.22 c
Groundnut + Millet	5518.89	5861.11	6055.55	5811.85 b
Groundnut + Mungbean	6130.00	6361.11	6388.89	6293.33 a
Mean	5611.27 c	6034.44 b	6126.19 a	

Mean value of the same category followed by different letters are significantly different from each other at $P \leq 0.05$ using LSD test.

LSD value at $P \leq 0.05$ for cropping pattern = 135.672

LSD value at $P \leq 0.05$ for nitrogen = 39.055

Table 7. Grain yield of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	1101.42	1392.33	1521.27	1338.34 b
Sorghum	849.26	1109.59	1188.07	1048.97 cd
Millet	796.17	1081.29	1135.90	1004.45 d
Mungbean	1209.70	1465.37	1734.03	1469.70 a
Groundnut + Sorghum	928.86	1317.88	1438.22	1228.32 c
Groundnut + Millet	953.17	1275.65	1362.25	1197.02 c
Groundnut + Mungbean	1253.25	1550.47	1755.77	1519.83 a
Mean	1008.36 c	1313.22 b	1447.93 a	

LSD value at $P \leq 0.05$ for cropping pattern = 51.149
LSD value at $P \leq 0.05$ for nitrogen = 11.206

Table 8. Harvest Index (%) of wheat as affected by cropping pattern and current nitrogen application at New Developmental Farm, Rabi 2010

Cropping Pattern	*Nitrogen (kg ha^{-1})*			*Mean*
	00	*45*	*90*	
Groundnut	20.45	22.79	24.16	22.46 c
Sorghum	15.21	18.76	20.17	18.05 f
Millet	14.78	18.03	20.02	17.61 f
Mungbean	20.24	23.85	25.95	23.35 b
Groundnut + Sorghum	17.67	22.58	24.20	21.48 d
Groundnut + Millet	17.29	21.75	22.51	20.52 e
Groundnut + Mungbean	20.49	24.36	27.48	24.11 a
Mean	18.02 c	21.73 b	23.50 a	

Mean value of the same category followed by different letters are significantly different from each other at $P \leq 0.05$ using LSD test.
LSD value at $P \leq 0.05$ for cropping pattern = 0.473
LSD value at $P \leq 0.05$ for nitrogen = 0.157