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Changes in wheat leaf phenology with the integrated application of organic and inorganic fertilizers

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Abstract

Leaf phenology is one of the most important traits in crop production. In this study the combine effect of manures and mineral fertilizers on various leaf parameters of wheat was investigated. We tested the response of leaf phonology to application of organic manure and inorganic fertilizer at Livestock Research and Development Station Surezai, Peshawar in two years filed trials in 2010-11 and 2011-12 in randomized complete block design with four replications. In this experiment three levels of poultry manure (2, 4 and 6 t ha^{-1}) three levels of farmyard manure (2, 4 and 6 t ha^{-1}) and two levels of nitrogen (60 and 90 kg ha^{-1}) along with control were applied to wheat crop. Certain traits of like leaf area, leaf area index, specific leaf area, leaf area ratio and leaf nitrogen content was investigated. Leaf area and others leaf transits were significantly affected by organic and inorganic fertilizers and in most cases increase in leaf traits were noted however decrease in leaf area and other traits were also noted in some cases. The increase or decrease in leaf area $tiller^{-1}$ and others leaf traits in different treatments may be a result of less or more number of leaves $tiller^{-1}$ and availability flow of nutrients from inorganic and organic sources of fertilizers. leaf area $tiller^{-1}$ increased with progressive increase in fertilizer level. The ratio of 6 t PM, 6 t FYM ha^{-1} and 90 kg N ha^{-1} is recommended for enhancing leaf architecture and leaf nitrogen content in wheat.

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Introduction

The arrangements of leaves in plants and its nitrogen content is very important factor in crops production because leaf plays a vital role in photosynthesis. It increase leaf area index by increasing leaf production and expansion rate that effect interception of photo-synthetically active radiation (PAR) and consequently the final dry matter production (Whitefield and Smith 1989). Insufficient availability of N to wheat plant results in low yield and significantly reduced profit compared to properly fertilized crop. Application of N from organic sources is better than inorganic sources.

Application of organic fertilizers to soil have been practiced for many centuries for increasing crop yield, improving soil fertility, increasing soil organic matter and improving soil structure in this way sustainable system of crop production is established. Various studies raveled that combine application of organic and inorganic fertilizers increased the yield of various wheat leaf parameters compared with sole organic or inorganic fertilizer (Mana *et al*., 2005).

Crops are produced in different environments because of change in morphological and physiological characteristics to environmental conditions (Lambers *et al*., 1990). In all environment light and nutrition affects growth which is determined by the available incident radiation, the pro-portion of radiation absorbed by the canopy and the efficiency by which absorbed radiation is converted into biomass (Barneix, 1990). Hirose and Werger (1987) showed direct relationship between photosynthetic rate and leaf N content. Increases in leaf N content increase photosynthetic rate and carbon gain. However, carbon gain can also be increased by nitrogen investments in canopy expansion resulting in more light interception. In several studies (Lambers *et al*., 1981; McDonald *et al*., 1986a), effect of nitrogen on growth was in fact through effects on leaf area. Photosynthesis was of secondary importance in the attainment of crop biomass (Grindlay, 1997). Two parameters important in the attainment of leaf area are the fraction of plant dry mass partitioned to the leaves and the amount of leaf area per leaf dry mass (McDonald, 1990).

These parameters which depend on the growth environment can describe plant morphological adaptation to this environment; therefore, they can be of importance in explaining growth. Novoa and Loomis (1981) proposed that the demand for nitrogen is determined by growth rate and the nitrogen composition of new tissue.

In view of the relation between nitrogen and photosynthesis, it has been suggested that the nitrogen content per leaf area is adjusted to the irradiance experienced during growth in order to make full use of the intercepted radiation (Grindlay, 1997). Nitrogen and radiation have direct relationship as differences in N content per leaf area effects photosynthesis due to different in irradiance levels. The effects of N and irradiance on growth it is important to ensure one can clearly distinguish between the effects of each factor. McDonald (1989) and McDonald(1990).

The objectives of the experiment were to study the effect of FYM, Poultry manure and nitrogenous fertilizer on leaf phenology of wheat yield contributing parameters and also to know the optimum levels of fertilizer concentration for enhancing crop yield.

Materials and methods

Experimental Site

The experiment was conducted at Livestock Research and Development Station Surezai Peshawar in in two year filed trials in 2010-11 and 2011-12. The experimental site is situated at South East of Peshawar city. It is situated at 34° N and 71.33° E with an altitude of 490 m above sea level in Khyber Pakhtunkhwa, Pakistan. Experimental site receives less than 350 mm annual rainfall and the climate of the site subtropical continental with worm to hot. Experimental site have fine silty with mixed clay loam soil. The soil pH is ranging from 7.7-8.0. The soil is very poor micro nutrients like NPK and contains less than one percent organic matter.

Experimental treatments

Following organic and inorganic fertilizers were used

1. Poultry manure (PM) t ha^{-1}

i) 2

ii) 4

iii) 6

2. Farm yard manure (FYM) t ha^{-1}

i) 2

ii) 4

iii) 6

3. Nitrogen fertilizer kg ha^{-1}

i) 60

ii) 90

4. Control

Experimental materials

Randomize Complete Block Design with four replications was used for conducting the experiment. Various ratios of organic and inorganic fertilizers were applied to wheat.

Each plot size was 1.8x4m. Wheat was cultivated 30 cm apart in six rows. Wheat variety Fakhri Sarhad was sown @ 100 kg ha^{-1}. Besides experimental treatments other inputs were applied uniformly which includes hoeing, weeding and irrigation. Nitrogen was applied in the farm of urea in two applications one at sowing and other after first irrigation.

Statistical analysis

Data collected during experiment was analyzed according to Randomized Complete Block design and upon obtaining significant F-value, least significant difference (LSD) test was employed (Steel and Torrie, 1980) .

Results and discussion

Leaf area (cm^2)

Leaf area tiller^{-1} was significantly affected by year (Y), poultry manure (PM), farm yard manure (FYM), nitrogen levels (N), and Control (C) Vs Rest (Table 01).

Table 1. Leaf area tiller^{-1} (cm^2) of wheat as affected by organic and inorganic fertilizers.

Year	Organic Sources	(t ha^{-1})	Nitrogen (kg ha^{-1})		Mean
			60	90	
2010-11	PM	2	117.43	120.17	118.80
		4	123.59	122.09	122.84
		6	127.37	130.71	129.04
	FYM	2	121.29	124.01	122.65
		4	123.53	116.92	120.23
		6	123.58	132.04	127.81
2011-12	PM	2	126.74	128.57	127.66
		4	132.10	135.14	133.62
		6	136.21	143.29	139.75
	FYM	2	125.51	135.12	130.32
		4	131.83	129.01	130.42
		6	137.71	142.87	140.29
2010-11			122.80	124.32	123.56b
2011-12			131.68	135.67	133.68a
	PM	2	122.08	124.37	123.23c
		4	127.84	128.61	128.23b
		6	131.79	137.00	134.40a
	FYM	2	123.40	129.57	126.48b
		4	127.68	122.97	125.32b
		6	130.64	137.45	134.05a
	Means		127.24	130.00	
	PM		134.04a		
	FYM		128.61b		
	Control Vs Rest				
2010-11	Control		79.07		
	Rest		123.56		
2011-12	Control		98.19		
	Rest		133.68		
	Control		88.63		
	Rest		128.62		

Means of the same category followed by different letters are significantly different (P≤0.05) using LSD test

LSD for FYM at P≤0.05= 3.12

LSD for PM at P≤0.05= 2.98

LSD for Year at P≤0.05= 9.08

All interactions were statistically non significant for leaf area. Mean values for years revealed that more leaf area tiller^{-1} (133.68 cm^2) was recorded in second year (2011-12) as compared to (123.56 cm^2) in first year (2010-11). More leaf area tiller^{-1} in year two may be due to more vegetative growth due to residual effect of organic sources in combination with inorganic nitrogen. These results are in agreement with Ahmad *et al.* (2011) who reported that combination of organic and inorganic fertilizers increased leaf area in wheat.

Table 2. Leaf area index of wheat as affected by organic and inorganic fertilizers.

Year	Organic Sources (t ha^{-1})		Nitrogen (kg ha^{-1})		Mean
			60	90	
2010-11	PM	2	3.84	4.01	3.93
		4	4.04	4.02	4.03
		6	4.14	4.14	4.14
	FYM	2	3.92	4.06	3.99
		4	4.10	3.96	4.03
		6	3.99	4.16	4.07
2011-12	PM	2	4.17	4.38	4.28
		4	4.37	4.44	4.41
		6	4.21	4.51	4.36
	FYM	2	4.15	4.28	4.22
		4	4.32	4.42	4.37
		6	4.27	4.63	4.45
2010-11			4.00	4.06	4.03
2011-12			4.25	4.44	4.35
	PM	2	4.00	4.20	4.10b
		4	4.21	4.23	4.22ab
		6	4.17	4.32	4.25a
	FYM	2	4.04	4.17	4.10b
		4	4.21	4.19	4.20ab
		6	4.13	4.39	4.26a
	Means		4.13b	4.25a	
	PM		4.46a		
	FYM		4.18b		
	Control Vs Rest				
2010-11	Control		3.23		
	Rest		4.03		
2011-12	Control		3.40		
	Rest		4.35		
	Control		3.31		
	Rest		4.19		

Means of the same category followed by different letters are significantly different (P≤0.05) using LSD test

LSD for FYM at P≤0.05= .11

LSD for Year at P≤0.05= .09

LSD for PM at P≤0.05= .12.

Means values for poultry manure shows that maximum leaf area tiller^{-1} (134.40 cm^2) was recorded for plots which received 6 t PM ha^{-1} while minimum leaf area tiller^{-1} (123.23 cm^2) was recorded in those plots which received 2 t PM ha^{-1}.

Similarly means values for FYM shows that maximum leaf area tiller^{-1} (134.05 cm^2) was recorded at 6 t FYM ha^{-1} while minimum leaf area tiller^{-1} (126.48 cm^2) was recorded at 2 and 4 t FYM ha^{-1}. The increase or decrease in leaf area

tiller^{-1} in different treatments may be a result of less or more number of leaves tiller^{-1} and availability flow of nutrients from inorganic and organic sources of fertilizers. These results are in accordance with the findings of Ayub *et al.* (2002) who reported that application of NP fertilizer significantly affected the leaf area tiller^{-1} of maize fodder while Haq and Jan (2001) concluded that leaf area tiller^{-1} increased with progressive increase in fertilizer level.

Table 3. Specific leaf area (cm^2 g^{-1}) of wheat as affected by organic and inorganic fertilizers.

Year	Organic Sources	(t ha^{-1})	Nitrogen (kg ha^{-1})		Mean
			60	90	
2010-11	PM	2	110.39	112.95	111.67
		4	117.29	115.47	116.38
		6	119.72	123.70	121.71
	FYM	2	115.33	115.13	115.23
		4	116.54	113.48	115.01
		6	115.53	123.51	119.52
2011-12	PM	2	121.75	123.11	122.43
		4	125.40	127.41	126.40
		6	127.61	132.66	130.13
	FYM	2	121.69	127.43	124.56
		4	124.76	124.73	124.74
		6	128.32	131.02	129.67
2010-11			115.80	117.37	116.59b
2011-12			124.92	127.72	126.32a
	PM	2	116.07	118.03	117.05c
		4	121.35	121.44	121.39b
		6	123.67	128.18	125.92a
	FYM	2	118.51	121.28	119.89c
		4	120.65	119.10	119.88b
		6	121.93	127.27	124.60a
	Means		120.36b	122.55a	
	PM		124.59a		
	FYM		121.45b		
	Control Vs Rest				
2010-11	Control		77.52		
	Rest		116.59		
2011-12	Control		103.47		
	Rest		126.32		
	Control		90.50		
	Rest		121.45		

Means of the same category followed by different letters are significantly different (P≤0.05) using LSD test
LSD for PM =0.4
LSD for N=0 .35.

Means values for nitrogen levels showed that maximum leaf area tiller^{-1} (130 cm^2) was recorded in plots which received 90 kg N ha^{-1} while minimum leaf area tiller^{-1} (127.24 cm^2) was recorded in plots which received 60 kg N ha^{-1} . These results indicate that increasing level of N increased leaf area tiller^{-1}. These results are in line with Gerri (1993) who reported that increasing level of N increased leaf area tiller^{-1}.Incase of control Vs rest higher leaf area (128.62 cm^2) was recorded for treated plots as compare to (88.63 cm^2) in control plots.

Leaf area index

Statistical analysis of the data reveled year (Y), poultry manure (PM), nitrogen levels (N) and Control (C) Vs Rest significantly affected leaf area index (Table 02). Non of the interaction was significant for leaf area index.

Mean values for years revealed that more leaf area index (4.35) was recorded in second year (2011-12) as compared to (4.03) in first year (2010-11). More leaf area index in year two may be due to more leaf area and more number of tillers m^{-2} due to more vegetative growth.

Table 4. Leaf area ratio ($cm^2\ g^{-1}$) of wheat as affected by organic and inorganic fertilizers.

Year	Organic Sources	(t ha^{-1})	Nitrogen (kg ha^{-1})	Mean	Year
			60	90	
2010-11	PM	2	26.10	26.70	26.40
		4	27.46	27.13	27.30
		6	28.31	29.05	28.68
	FYM	2	26.95	27.56	27.26
		4	27.45	25.98	26.72
		6	27.46	29.34	28.40
2011-12	PM	2	28.16	28.57	28.37
		4	29.36	30.03	29.69
		6	30.27	31.84	31.06
	FYM	2	27.89	30.03	28.96
		4	29.30	28.67	28.98
		6	30.60	31.75	31.18
2010-11			27.29	27.63	27.46b
2011-12			29.26	30.15	29.71a
	PM	2	27.13	27.64	27.38c
		4	28.41	28.58	28.50b
		6	29.29	30.45	29.87a
	FYM	2	27.42	28.79	28.11ab
		4	28.37	27.33	27.85b
		6	29.03	30.55	29.79a
	Means		28.28b	28.89a	
	PM		29.78a		
	FYM		28.58b		
	Control Vs Rest				
2010-11	Control		17.57		
	Rest		27.46		
2011-12	Control		21.82		
	Rest		29.71		
	Control		19.70		
	Rest		28.58		

Means of the same category followed by different letters are significantly different (P≤0.05) using LSD test

LSD for Year at P≤0.05= .34

LSD for PM=0 .41

LSD for N =0.31

LSD for FYM= 0.39.

Means values for PM shows that maximum leaf area index (4.25) was recorded for plots which received 6 t PM ha^{-1} while minimum leaf area index (4.10) was recorded in plots which received 2 t PM ha^{-1}. Similarly means values for FYM shows that maximum leaf area index (4.26) was recorded at6 t FYM ha^{-1} while minimum leaf area index (4.10) was recorded at 2 t FYM ha^{-1}. These results indicate that increasing level of PM and FYM increased increase leaf area index of wheat. As farm yard manure and PM increased vegetative growth due to which leaf area index of wheat increased. These results are in line with Kumar and Puri (2001) who reported that increasing level of FYM and PM increased leaf area index.

Table 5. Nitrogen (%) in leaves of wheat as affected by organic and inorganic fertilizers.

Year	Organic Sources	(t ha^{-1})	Nitrogen (kg ha^{-1})		Mean
			60	90	
2010-11	PM	2	1.35	1.59	1.47
		4	1.48	1.52	1.50
		6	1.55	1.70	1.62
	FYM	2	1.59	1.70	1.64
		4	1.46	1.47	1.47
		6	1.32	1.63	1.48
2011-12	PM	2	1.52	1.65	1.59
		4	1.67	1.74	1.70
		6	1.85	1.91	1.88
	FYM	2	1.56	1.68	1.62
		4	1.70	1.61	1.65
		6	1.77	2.01	1.89
2010-11			1.46	1.60	1.53b
2011-12			1.68	1.77	1.72a
	PM	2	1.43	1.62	1.53c
		4	1.57	1.63	1.60b
		6	1.70	1.80	1.75a
	FYM	2	1.57	1.69	1.63b
		4	1.58	1.54	1.56c
		6	1.55	1.82	1.69a
	Means		1.57b	1.68a	
	PM		1.68a		
	FYM		1.62b		
	Control Vs Rest				
2010-11	Control		1.28		
	Rest		1.53		
2011-12	Control		1.35		
	Rest		1.72		
	Control		1.31		
	Rest		1.63		

Means of the same category followed by different letters are significantly different (P≤0.05) using LSD test
LSD for PM=0 .14
LSD for N= 0.11.

Means values for Nitrogen levels showed that maximum leaf area index (4.25) was recorded in plots which received 90 kg N ha^{-1} while minimum leaf area index (4.13) was recorded in plots which received 60 kg leaf area index ha^{-1}. These results indicate that increasing level of N increased LAI. These results are in line with Gerri (1993) who reported that increasing level of N increased LAI. For control Vs rest higher leaf area index (4.19) was recorded for treated plots, while very low LAI (3.31) was recorded for control plots.

Specific Leaf area (cm^2 g^{-1})

Data on specific leaf area was significantly affected by year (Y), poultry manure (PM), Farm yard manure (FYM), nitrogen levels (N), FYMx N, PMxFYM, PMxFYMxN, Control (C) Vs Restand YxControl (C) Vs Rest (Table 03). Mean values for years revealed that more leaf area index (126.32 cm^2 g^{-1}) was recorded in second year (2011-12) as compared to (116.59 cm^2 g^{-1}) in first year (2010-11). More leaf area index in year two may be due to more leaf area and more number of tillers m^{-2} due to more vegetative growth.

Means values for PM showed that maximum specific leaf area (125.92 $cm^2 g^{-1}$) was recorded for plots which received 6 t PM ha^{-1} while minimum specific leaf area (117.05 cm^2 g^{-1}) was recorded in plots which received 2 t PM ha^{-1}. Means values for FYM showed that maximum specific leaf area (124.60 cm^2 g^{-1}) was recorded for plots which received 6 t FYM ha^{-1} while minimum specific leaf area (119.89 cm^2 g^{-1}) was recorded in plots which received 2 t FYM ha^{-1}.These results indicate that increasing level of PM increased increase specific leaf area of wheat. As PM increased vegetative growth due to high N content due to which specific leaf area of wheat increased.

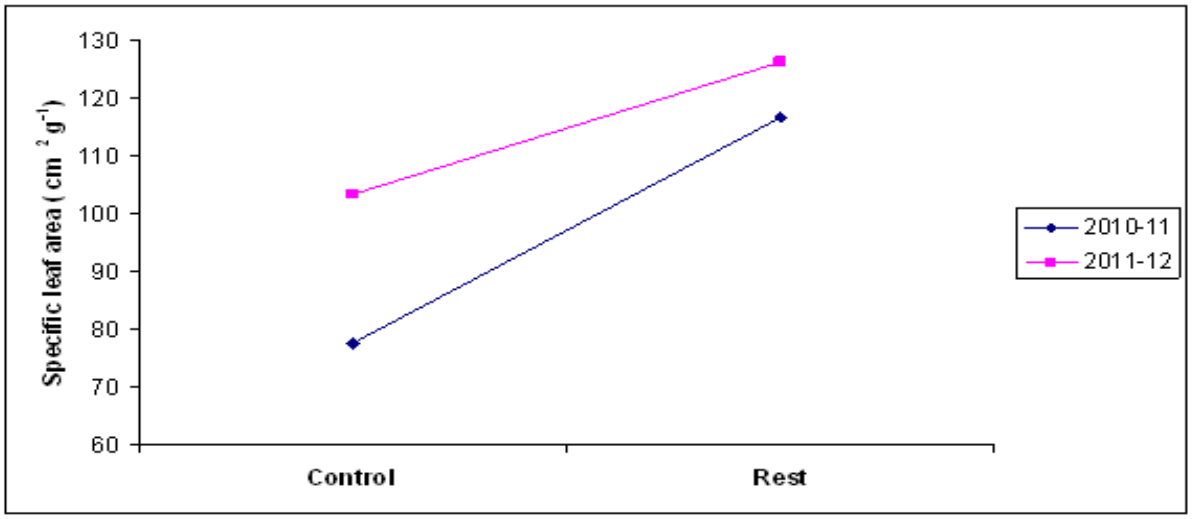

Fig. 1. Specific leaf area of wheat as affected by interactive effect of year x control Vs rest.

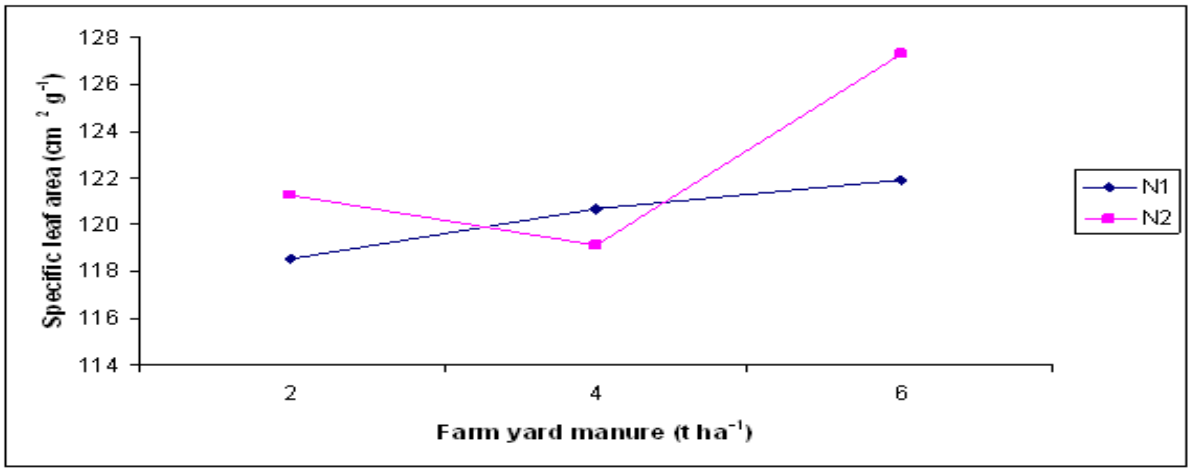

Fig. 2. Specific leaf area of wheat as affected by interactive effect of farm yard manure x nitrogen.

Similarly means values for nitrogen levels showed that maximum specific leaf area (122.55 cm^2 g^{-1}) was recorded in plots which received 90 kg N ha^{-1} while minimum leaf area index (120.36 cm^2 g^{-1}) was recorded in plots which received 60 kg N ha^{-1}. These results indicate that increasing level of N increased specific leaf area. These results are in agreement with Rich *et al.* (1998) who reported that increasing level of N increased specific leaf area. For control Vs rest higher leaf area index (121.45 $cm^2 g^{-1}$) was recorded for treated plots, while low specific leaf area (90.50 $cm^2 g^{-1}$) was recorded for control plots.

Interaction between FYMxN shows that increase of FYM and N levels linearly increased specific leaf area up to 6 t FYM ha^{-1} and 90 kg N ha^{-1}. Leaves $tiller^{-1}$

increased with increase in N from 60 to 90 kg N ha^{-1} in case of 2 t FYM ha^{-1} similar trend was observed for 6 t FYM ha^{-1}(fig. 2).

Leaf area ratio

Analysis of the data reveled year (Y), poultry manure (PM), FYM, nitrogen levels (N), Control (C) Vs Rest, Farm yard manure (FYM) x N, PMxFYM, PMxFYMxN (Table 04). Mean values for years revealed that more leaf area ratio (29.71) was recorded in second year (2011-12) as compared to (27.46) in first year (2010-11).

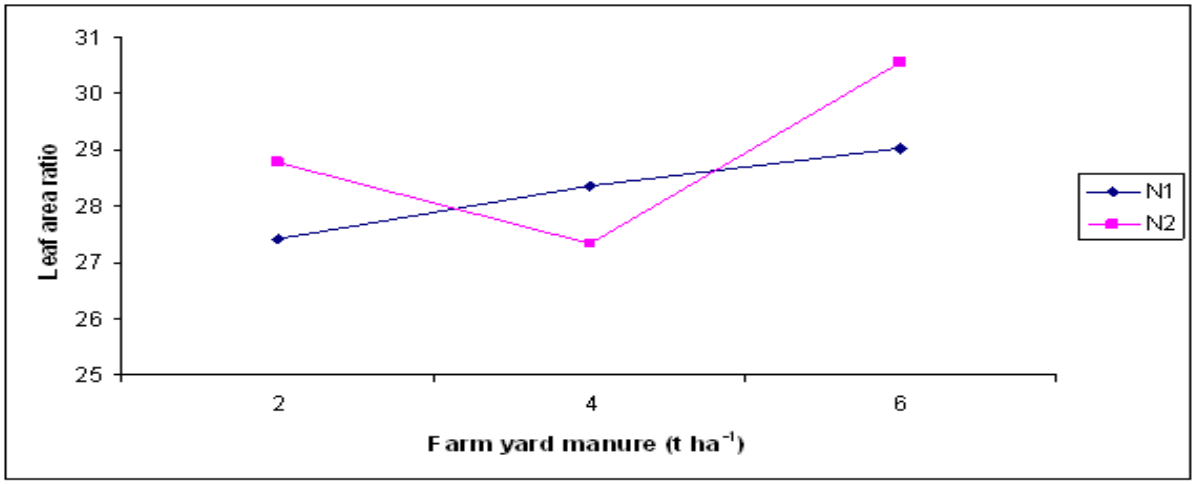

Fig. 3. Leaf area ratio of wheat as affected by interactive effect of farm yard manure x nitrogen.

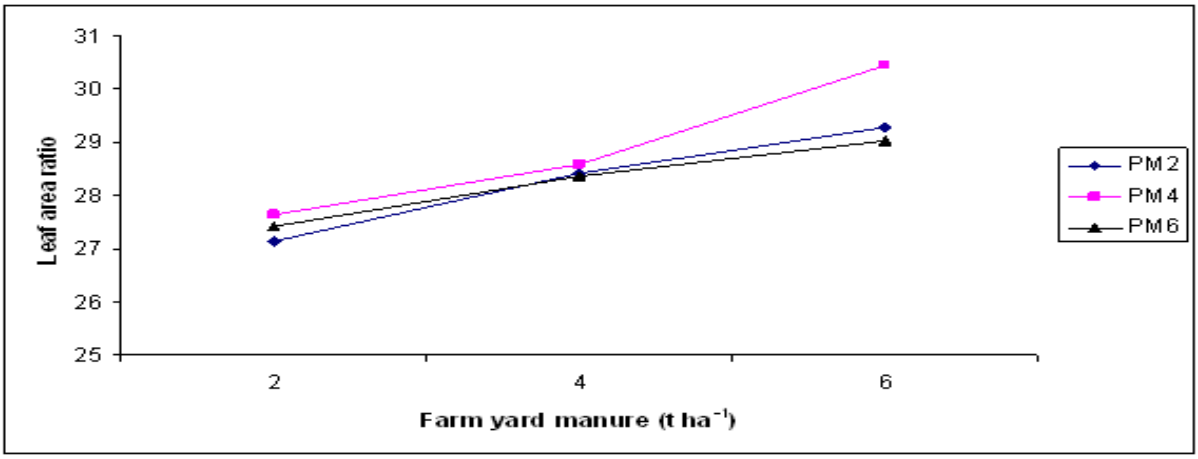

Fig. 4. Leaf area ratio of wheat as affected by interactive effect of farm yard manure x poultry manure.

More leaf area ratio in year two may be due to more leaf area and more number of tillers m^{-2} due to more vegetative growth.

Means values for PM shows that maximum leaf area ratio (29.87) was recorded for plots which received 6 t PM ha^{-1} while minimum leaf area ratio (27.38) was recorded in plots which received 2 t PM ha^{-1}. Means values for FYM shows that maximum leaf area ratio (29.89) was recorded for plots which received 6 t FYM ha^{-1} while minimum leaf area ratio (28.11) was recorded in plots which received 2 t FYM ha^{-1}.Similarly means values for Nitrogen levels showed that maximum leaf area ratio (28.89) was recorded in plots which received 90 kg N ha^{-1} while minimum leaf area ratio (28.28) was recorded in plots which received 60 kg N ha^{-1}. These results indicate that increasing level of N increased leaf area ratio. These results are in line with Gerri (1993) who reported that increasing level of N increased leaf area ratio.

For control Vs rest higher leaf area ratio (28.58) was recorded for treated plots, while very low leaf area ratio (19.70) was recorded for control plots. Interaction between FYMxN shows that increase of FYM and N levels linearly increased leaf area ratio up to 6 t FYM ha^{-1} and 90 kg N ha^{-1}(fig. 3).

Leaf nitrogen Content (%)

Year (Y), poultry manure (PM), nitrogen levels (N), PM x Farm Yard Manure, Y x treatments (YxT), Control (C) Vs Rest and Y x C Vs Rest significantly affected % N in leaves (Table 05). Mean values for years revealed that more N (1.72 %) was recorded in second year (2011-12) as compared to (1.53 %) in first year (2010-11). High nitrogen content in leaves in second year may be due to more vegetative growth because of carrying over effect of nitrogen from the organic sources applied to the previews wheat crop.

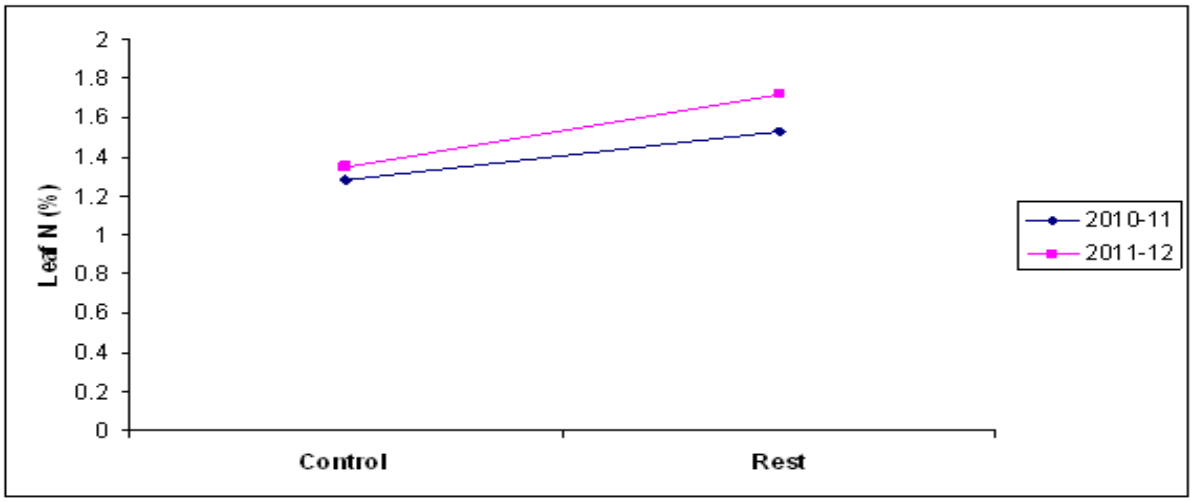

Fig. 5. Leaf area ratio of wheat as affected by interactive effect of Y x control Vs rest.

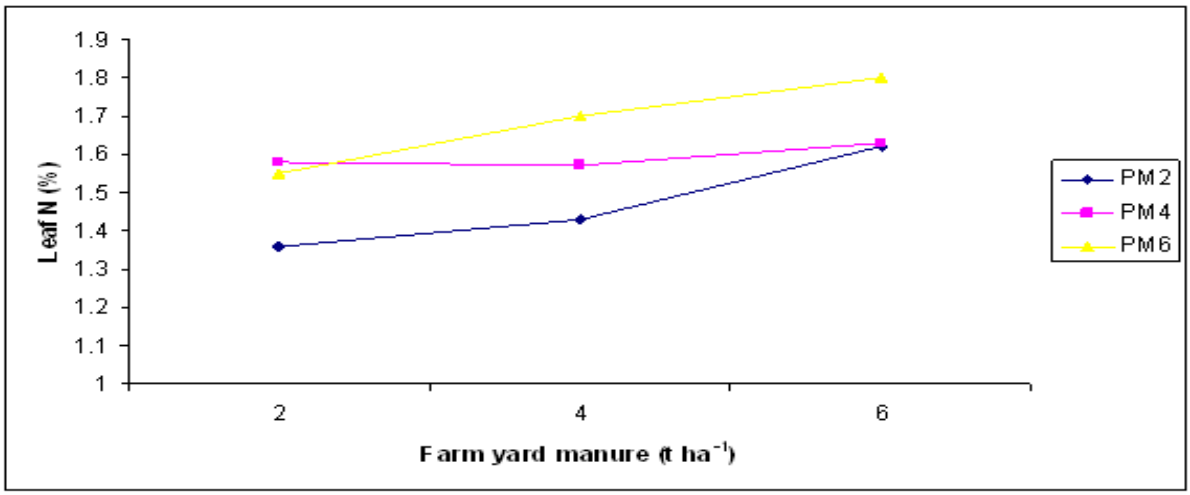

Fig. 6. Leaf area ratio of wheat as affected by interactive effect of farm yard manure x poultry manure.

Means values for PM shows that maximum % N in leaves (1.75 %) was recorded for plots which received 6 te PM ha^{-1} while minimum grains yield (1.53 %) was recorded in those plots which received 2 t PM ha^{-1}. These results indicate that increasing level of PM increased % N in plant tissues.

The results are in line with the findings of Safdar (1997) and Tariq (1998) who reported that by increasing the level of organic fertilizers % N in plant tissue was increased.

Nitrogen levels showed that maximum % N (1.68 %) was recorded in plots which received 90 kg N ha^{-1} while minimum % N (1.57 %) was recorded in plots which received 60 kg N ha^{-1}. These results indicate that increasing nitrogen levels increased % N in plant tissue. Ahmad (1999) reported that % N increased in tissue with increase in levels of nitrogen fertilizer. Mean values for control Vs rest revealed that higher % N (1.63 %) was recorded for treated plots while low % N (1.31 %) was recorded for control plots. Interaction between YxC Vs Rest shows that maximum % N (1.72 %) was recorded in second year (2011-12) in rest treatments while minimum (1.28 %) first year (2010-11) in control plots (fig. 5).

Recommendations

It is recommended that the integrated use of organic and inorganic fertilizers leaf area, leaf area index and leaf nitrogen content. The combined application of each six tons PM and FYM and 90 kg nitrogen ha^{-1} is recommended for higher leaf architecture in wheat.

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