Research Article

Effect of Pigeon Pea Green Manuring and Nitrogen on Performance of Wheat Crop

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Abstract | An experiment was conducted at Newly Developed Research Farm of the University of Agriculture Peshawar to observe the effect of pigeon pea green manuring on performance and subsequent nitrogen fertilizer requirement of wheat crop during 2013 and 2014. The experiment was carried out in randomized complete block design with split plot arrangements having four replications. Pigeon pea green manuring treatments as 0, 30, 60, 90 and 120 days post emergence were allotted to main plots, where crop was incorporated in soil at different days after emergence (DAE), this was done in previous season before sowing of wheat crop, whereas nitrogen levels as 0, 30, 60, 90 and 120 kg N ha^{-1} were allotted to sub plots in the field where wheat crop was sown. Data were recorded on emergence m^{-2}, days to maturity, plant height, thousand grains weight, biological yield and grain yield of wheat. The integration of pigeonpea green manuring with nitrogen levels significantly increased wheat growth, yield and yield components. In case of green manuring, plots in which pigeon pea crop was incorporated at the age of 90 days showed maximum plant height (103.3 cm), thousand grains weight (45.2 g), biological yield (10199 kg ha^{-1}) and grain yield (3641 kg ha^{-1}) of wheat. The application of nitrogen at the rate of 120 kg N ha^{-1} significantly increased plant height (102.5 cm), thousand grains weight (43.8 g), biological yield (10674 kg ha^{-1}) and grain yield (3766 kg ha^{-1}) of wheat. The incorporation of green manures 90 days posts emerged pigeon pea with 90 and 120 kg N ha^{-1} produced taller plants with height of 104.4 and 104.0 cm, heavier grains with 52.0 and 50.8 g weight per thousand grains, higher biological yield 11986 and 11859 kg ha^{-1} and optimum grain yield 4161 and 4147 kg ha^{-1}. Results indicated that the integration of 90 days older pigeon pea green manuring with 90 kg nitrogen ha^{-1} can be the best recipe for better and sustainable wheat production.

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Introduction

Wheat (*Triticum aestivum* L.) as belongs to the family Graminae (Poaceae) is considered as an enormous food grain and an essential diet of the people of Pakistan and that's the reason that it is grown approximately in every part of the country (Ilyas et al., 2006). Area and production target of wheat for the year 2009-10 had been set at 9045 thousand hectares and 25 million tons, respectively. Wheat was cultivated on an area of 9042 thousand hectares, showing a decrease of 0.04 % over last year's area of 9046 thousand hectares (MINFAL, 2010). With increased prices of commercial fertilizers, the alternative ways of adding fertilizer with organic fertilizers has been realized. Residues incorporation as pigeonpea green manures

have been demonstrated to augment crop yields with uphold probability and economically gorgeous to farmers. Thus, farmers left the crop residue in the field because of economic concerns and sustainability issues (Kumar and Goh, 2002).

Pigeon pea (*Cajanus cajan*) is a hardy perennial legume crop but occasionally annual shrub and its growing periods are different depending on cultivar. It can be intercropped with cereals like wheat and used as a shade crop for young trees and also can use for green manuring. Green manuring enhances the soil incorporation of several fields or scavenge crop while green or rapidly later than flowering for the reason of soil improvement (Sullivan, 2003). They are also considered as effective alternatives to compound fertilizers in the organization and conservation of soil fertility and productivity. Uniqueness of green manures includes a crop that is quick rising with fast decomposition and rapid nutrient release (Leinonen, 2000). Green manuring is mainly the inexpensive means of mounting up organic matter content of the soil. It may be applied in a straight line, leaving it on the soil as mulch or composted before function and can serve up a dual point as a source of green manure and food. Some green manures can be utilized as animal feed by means of resulting animal manure employed as fertilizer. A new focal point is the production of fibers or forages allowing for greater in addition to different uses of green manure and an increase in its advantages (Talgre et al., 2009).

The meaning of nitrogen for privileged yield has long been predictable in Pakistan wherever most soils are deficient in nitrogen for the cause so as to great outflow. Shortage of nitrogen directs to reduce protein combination, chlorophyll and nucleic acid formation (Shah et al., 2003). Nitrogen is one of the important plant nutrients; it is continuously a limiting issue of plant growth and yields. Its vulnerability to losses is intimately associated to manage the vegetative growth of plant and therefore settle on the chance of reproductive sequence and ultimately yield. The production of the crop significantly affected by optimum method, time and level of nitrogen application. The lower crop yield and poor growth resulted because of the higher nitrogen requirement than soil supply in Pakistan, improper application method and, its sub-optimal application level by farmers (Ahmad, 2006).

The release of nitrogen from green manures could be utilized by means of subsequent wheat crops right through their mounting stage. Consequently, the nitrogen received in a while mounting stage enhances grain protein contents Majid et al. (2010). Considerable quantities of nitrogen are practiced into soil via green manures, but nitrogen is on the rampage steadily with long-standing breakdown of natural material, as a result lessening the hazard of escape nutrients. Keeping in view the importance of green manuring and N application current study plan was made to evaluate the pigeonpea green manuring effect on performance and subsequent N fertilizer requirement of wheat crop.

Materials and Methods

Two years field experiments titled to evaluate the effect of pigeonpea green manuring on performance and subsequent nitrogen fertilizer requirement of wheat crop were conducted at Newly Developed Research Farm of the University of Agriculture Peshawar in 2013-2014. The soil was silty clay loam with pH of 8.02 and low organic matter contents of 0.844%. The trials in both years were carried out in RCB design with split-plot arrangements having four replicates. Pigeon pea green manuring treatments were allotted to main plots, where crop was incorporated in soil at different days after emergence (DAE), this was done in previous season before sowing of wheat crop, whereas the nitrogen levels were allotted to sub plots as:

Pigeonpea green manuring	Nitrogen levels
M_1 = Control	N_1 = Control
M_2 = 30 days after emergence	N_2 = 30 kg ha^{-1}
M_3 = 60 days after emergence	N_3 = 60 kg ha^{-1}
M_4 = 90 days after emergence	N_4 = 90 kg ha^{-1}
M_5 = 120 days after emergence	N_5 = 120 kg ha^{-1}

Statistical analysis

The analysis of the data was done using RCBD design under split plot arrangement. Significant differences in mean data were separated by LSD test (Steel and Torrie, 1980).

Results and Discussion

Emergence m^{-2} of wheat

Data regarding the wheat emergence m^{-2} showed that the green manuring significantly affect the wheat emergence rate, whereas the nitrogen levels and the

interaction between the green manuring and nitrogen levels did not affect the plant emergence significantly (Table 1). The plots integrated with green manuring at 60 and 90 and 120 days post appearance showed significantly higher and statistically same emergence (118.0, 117.4 and 118.1) m^{-2} but different then 30 days and control that produced the similar results. Application of nitrogen at different levels and their interaction with green manuring did not significantly increase the wheat seedlings emergence rate. The same emergence m^{-2} was noted during both years. Equal emergence may be because of the identical soil temperature throughout germination period during both years. The plots integrated with more green manures showed increase in emergence m^{-2} of wheat. This may be due to the pleasant effect of green manuring on physiochemical properties of soil which eventually enhanced emergence m^{-2} of wheat crop. The incorporation of 60, 90 and 120 days post emerged green manures enhance the emergence m^{-2} however, year as source of variation and nitrogen application treatments showed non-significant effect to emergence m^{-2}. Contrasting results are reported by Islam et al. (2002) who stated that high levels of nitrogen (140 kg ha^{-1}) significantly increased germination percentage and ultimately emergence of seedlings.

Days to maturity

Data regarding days to maturity as affected by green manuring and nitrogen levels are presented in Table 2. Statistical analysis of the data revealed that both the green manuring and nitrogen levels affect the maturity of the wheat. Green manuring and nitrogen interaction had substantial effects on days to maturity. Incorporation of older pigeon pea green manure increased days to maturity of wheat crop. The plots integrated with no and 30 days post emerged green manures took fewer days (157) to maturity, followed by days (159) to maturity in plots which were treated with 60 days post emerged pigeon pea green manuring. More days (160) to maturity occurred in plots in which 90 and 120 days post emerged green manures were incorporated. Application of nitrogen fertilizer with higher rates delayed maturity of the wheat crop as well. Wheat crop took more days (160) to maturity in plots which were fertilized with 120 kg N ha^{-1}, followed by (159) plots in which 60 and 90 kg N ha^{-1} was applied. Early (157 days) maturity was observed in control plots. Integration of green manuring and nitrogen levels showed that wheat crop took more days to maturity with increase in nitrogen

Table 1: *Emergence m^{-2} of wheat as affected by pigeonpea green manuring and nitrogen fertilizer application during 2013-14 and 2014-15.*

Green manuring	Nitrogen Levels	Year (Y)		Gm × N
(DAE)	(kg ha^{-1})	2013-14	2014-15	
No green manuring	0 (control)	110.2	110.2	110.2
	30	110.0	110.0	110.0
	60	108.1	108.1	108.1
	90	108.4	105.4	106.9
	120	107.7	104.5	106.1
30 DAE	0 (control)	107.5	106.4	107.0
	30	107.5	108.9	108.2
	60	109.4	108.3	108.9
	90	111.9	110.8	111.4
	120	108.6	107.5	108.1
60 DAE	0 (control)	115.8	115.8	115.8
	30	118.9	118.9	118.9
	60	116.4	116.4	116.4
	90	120.3	120.3	120.3
	120	118.6	118.6	118.6
90 DAE	0 (control)	117.9	115.6	116.7
	30	118.1	115.8	117.0
	60	117.5	115.3	116.4
	90	121.0	118.6	119.8
	120	118.4	116.1	117.3
120 DAE	0 (control)	120.1	120.3	120.2
	30	119.9	119.9	119.9
	60	118.7	118.7	118.7
	90	116.4	116.4	116.4
	120	115.5	115.5	115.5
	0 (control)	114.3	113.7	114.0
	30	114.9	114.7	114.8
	60	114.0	113.4	113.7
	90	115.6	114.3	114.9
	120	113.8	112.5	113.1
No green manuring		108.9	107.6	108.3 b
30 DAE		109.0	108.4	108.7 b
60 DAE		118.0	118.0	118.0 a
90 DAE		118.6	116.3	117.4 a
120 DAE		118.1	118.1	118.1 a
Mean		114.5	113.7	
Interactions	**Significance levels**			
Y × GM	NS.			
GM × N	NS.			
Y × N	NS.			
Y × GM × N	NS.			

LSD at 0.05% for GM = 2.35; DAE = Days after emergence; NS = Non-significant; Means having same letters are not significantly different from each other at (P ≤ 0.05).

Table 2: *Days to maturity of wheat crop as affected by pigeonpea green manuring and nitrogen fertilizer application during 2013-14 and 2014-15.*

Green manuring	Nitrogen Levels	Year (Y)		GM × N
(DAE)	(kg ha^{-1})	2013-14	2014-15	
No green manuring	0 (control)	156	155	156
	30	156	156	156
	60	157	156	156
	90	157	157	157
	120	158	158	158
30 DAE	0 (control)	156	156	156
	30	156	157	156
	60	158	157	157
	90	158	158	158
	120	159	158	159
60 DAE	0 (control)	156	158	157
	30	157	158	157
	60	159	159	159
	90	159	160	159
	120	160	161	160
90 DAE	0 (control)	160	159	159
	30	160	160	160
	60	160	161	161
	90	161	162	161
	120	161	161	161
120 DAE	0 (control)	160	160	160
	30	160	160	160
	60	160	160	160
	90	160	160	160
	120	160	162	161
	0 (control)	157	157	157 d
	30	158	158	158 c
	60	159	158	159 b
	90	159	159	159 b
	120	159	160	160 a
No green manuring		**157**	**156**	**157 b**
30 DAE		157	157	157 b
60 DAE		158	159	159 a
90 DAE		160	161	160 a
120 DAE		160	160	160 a
Mean		158	159	
Interactions	**Significance levels**			
Y × GM	NS			
GM × N	**			
Y × N	*			
Y × GM × N	NS			

*LSD at 0.05% for GM = 1.56; N = 0.28; Y × N = 0.39 and GM × N = 0.63; DAE = Days after emergence; * = Significant and ** = highly significant.*
Means having same letters are not significantly different from each other at (P ≤ 0.05).

rates and green manures. With 90 days post emerged green manures and 60, 90 and 120 kg N ha^{-1} crop took maximum days to maturity. Minimum days to maturity were counted in control plots where no green manuring with no or less amount of nitrogen fertilizer was applied. A slight increase in days to maturity was observed in second year but that was not statistically significant. Increase in days to maturity by wheat crop could be due the higher doses of nitrogen and its release during the decomposition of green manures which have increase the vegetative growth of crop. These findings can be supported by Shah and Ishaq (2006) and Berecz et al. (2005) who suggested that combined use of organic and inorganic sources of nitrogen had a significant improvement for the vegetative growth of crops.

Plant height (cm)

In case of plant height, plants during the second year were found to have more height (99.9 cm) as compared to first year i.e. 99.3 cm (Table 3). The plots integrated with 90 days post emerged green manures produced wheat plants with maximum plant height (103.3 cm), followed by (101.7 cm) plots integrated with 120 days older green manure. Minimum plant height (94.4 cm) was produced by wheat crop in plots where no green manuring was done. Highest plant height (102.6 cm) was recorded in plots fertilized with 120 kg N ha^{-1}, while lowest plant height (95.4 cm) was recorded in control plots. The plots treated with amalgamated integration of green manures 90 days post emergence along with 90 kg N ha^{-1} showed maximum plant height (104.4 cm), while minimum plant height (89.2 cm) was recorded in control plots. The excellence confirmation of green manures 90 days post emergence along with 90 kg N ha^{-1} was recorded with taller plants of wheat. Berecz et al. (2005) reported that biomass production and vegetative plant growth were significantly higher when farmyard manure and nitrogen were mutually applied.

Thousand grains weight (g)

Data pertaining to thousand grains weight of wheat as affected by years, green manures and nitrogen levels are presented in Table 4. Statistical analysis of data showed that green manuring and nitrogen had a significant effect on thousand grain weight of wheat. With the incorporation of green manures 90 and 120 days post emerged pigeon pea, 1000 grains weight improved up to 45.2 and 45.3 g respectively indicating that the incorporation of pigeon pea green

Table 3: *Plant height (cm) of wheat as affected by pigeonpea green manuring and nitrogen fertilizer application during 2013-14 and 2014-15.*

Green manuring	Nitrogen Levels	Year (Y)		GM × N
(DAE)	(kg ha^{-1})	2013-14	2014-15	
No green manuring	0 (control)	89.2	89.2	89.2
	30	90.8	90.5	90.6
	60	94.3	93.5	93.9
	90	99.4	99.6	99.5
	120	98.0	100.0	99.0
30 DAE	0 (control)	93.6	91.1	92.4
	30	95.1	94.5	94.8
	60	99.5	99.9	99.7
	90	99.7	102.4	101.1
	120	102.1	102.8	102.4
60 DAE	0 (control)	95.3	95.3	95.3
	30	99.6	100.1	99.8
	60	101.2	102.1	101.6
	90	101.8	103.1	102.5
	120	103.2	103.3	103.3
90 DAE	0 (control)	100.9	101.9	101.4
	30	102.5	103.2	102.9
	60	103.1	104.4	103.7
	90	104.7	104.2	104.4
	120	103.9	104.2	104.0
120 DAE	0 (control)	97.4	100.1	98.8
	30	98.5	101.2	99.9
	60	100.9	102.9	101.9
	90	103.6	104.2	103.9
	120	103.8	104.3	104.0
	0 (control)	95.3	95.5	95.4 d
	30	97.3	97.9	97.6 c
	60	99.8	100.5	100.2 b
	90	101.9	102.7	102.3 a
	120	102.2	102.9	102.5 a
No green manuring		94.3	94.5	94.4 d
30 DAE		98.0	98.1	98.1 c
60 DAE		100.2	100.8	100.5 b
90 DAE		103.0	103.6	103.3 a
120 DAE		100.8	102.5	101.7 b
Mean		99.3	99.9	
Interactions	**Significance levels**			
Y × GM	NS			
GM × N	**			
Y × N	NS			
Y × GM × N	NS			

*LSD at 0.05% for GM = 2.02; N = 0.89 and GM ×N = 2.09; DAE = Days after emergence; ** = highly significant; NS = Non-significant. Means having same letters are not significantly different from each other at (P ≤ 0.05).*

Table 4: *Thousand grains weight (g) of wheat as affected by pigeonpea green manuring and nitrogen fertilizer application during 2013-14 and 2014-15.*

Green manuring	Nitrogen Levels	Year (Y)		GM × N
(DAE)	(kg ha^{-1})	2013-14	2014-15	
No green manuring	0 (control)	27.1	29.0	28.0
	30	26.3	29.1	27.7
	60	30.7	30.6	30.6
	90	31.6	31.3	31.4
	120	36.3	37.3	36.8
30 DAE	0 (control)	30.9	31.1	31.0
	30	31.1	31.3	31.2
	60	34.2	33.9	34.0
	90	37.4	35.1	36.2
	120	40.4	35.9	38.2
60 DAE	0 (control)	31.6	32.4	32.0
	30	32.7	35.3	34.0
	60	38.1	35.8	37.0
	90	41.5	35.5	38.5
	120	45.2	38.6	41.9
90 DAE	0 (control)	37.1	38.9	38.0
	30	36.5	44.0	40.3
	60	42.8	47.0	44.9
	90	51.5	52.6	52.0
	120	50.6	51.1	50.8
120 DAE	0 (control)	38.8	41.0	39.9
	30	38.6	42.5	40.5
	60	40.3	48.0	44.1
	90	50.8	50.9	50.8
	120	51.2	51.2	51.2
	0 (control)	33.1	34.5	33.8 e
	30	33.0	36.5	34.7 d
	60	37.2	39.1	38.1 c
	90	42.6	41.1	41.8 b
	120	44.7	42.8	43.8 a
No green manuring		30.4	31.4	30.9 d
30 DAE		34.8	33.5	34.1 c
60 DAE		37.8	35.5	36.7 b
90 DAE		43.7	46.7	45.2 a
120 DAE		43.9	46.7	45.3 a
Mean		38.1	38.8	
Interactions	**Significance levels**			
Y × GM	NS			
GM × N	**			
Y × N	**			
Y × GM × N	NS			

*LSD at 0.05% for GM = 1.93; N = 1.27; GM × N = 2.86 and Y × N= 1.80; DAE = Days after emergence; ** = highly significant and NS = Non-significant.*
Means having same letters are not significantly different from each other at (P ≤ 0.05).

manuring should be done after 90 days rather delaying it up to 120 days. In case of nitrogen, healthiest grains having thousands grain weight of 43.8 g were produced by the plots which were given higher dose of nitrogen 120 kg N ha^{-1}, followed by plots fertilized with 90, 60 and 30 kg N ha^{-1} resulting in 41.8, 38.1 and 34.7g respectively. However, lowest 1000 grains weight (33.8 g) was recorded in control plots. Interaction between green manure and nitrogen (GM × N) showed significant effect on thousand grain weight of wheat indicating that maximum 1000 grains weight (50.8 g) were recorded in plots integrated with green manures 90 days post emergence fertilized with 120 kg N ha^{-1}. Without green manures plots gave minimum 1000 grain weight (27.7g) fertilized with 30 kg N ha^{-1}. Same results were confirmed by Malik et al. (2002) who stated that the higher 1000 grain weight can be produced by the combine application of nitrogen at the rate of 90/120 kg ha^{-1} and green manures. Alam et al. (2005) also reported increase in weight of wheat grains with the integration of chemical and organic fertilizers.

Biological yield (kg ha^{-1})

Green manuring and nitrogen fertilizer application significantly affected the biological yield of wheat crop (Table 5). Mean values of the data indicated that biological yield increased to 10199 and 10260 kg ha^{-1}, respectively, with 90 and 120 days post emerged pigeon pea green manuring, followed by 60 days post emerged pigeon pea green manuring (9801 kg ha^{-1}). Lowest biological yield (6889 kg ha^{-1}) was recorded from plots that received no green manuring. In case of nitrogen fertilizer higher biological yield (10674 kg ha^{-1}) was recorded in plots that were given nitrogen fertilizer at the rate of 120 kg ha^{-1}, followed by plots fertilized with 90 kg N ha^{-1} resulting biological yield of 10248 kg ha^{-1}. However, the lowest biological yield (7175 kg ha^{-1}) was recorded in control plots. All the interactions except GM × N showed non-significant effects on biological yield of wheat. The plots treated with combined integration of 90 days post emerged pigeon pea green manures and 90 kg N ha^{-1} showed highest biological yield of 11986 kg ha^{-1}. The lowest biological yield (4893 kg ha^{-1}) was recorded in control plots where neither manures nor nitrogen were applied. The results indicated that the treatment of green manures after 90 days of emergence combined with 90 kg N ha^{-1} enhanced biological yield of wheat during both years compared to the rest of applied green manures and nitrogen rates. Increase in

Table 5: *Biological yield (kg ha^{-1}) of wheat as affected by pigeonpea green manuring and nitrogen fertilizer application during 2013-14 and 2014-15.*

Green manuring	Nitrogen Levels	Year (Y)		GM × N
(DAE)	(kg ha^{-1})	2013-14	2014-15	
No green manuring	0 (control)	4959	4828	4893
	30	6251	6147	6199
	60	6751	6828	6789
	90	7806	7758	7782
	120	8626	8936	8781
30 DAE	0 (control)	6912	7020	6966
	30	7703	7990	7847
	60	8564	7875	8220
	90	8801	8932	8866
	120	9481	9744	9613
60 DAE	0 (control)	7946	8210	8078
	30	8661	8967	8814
	60	9773	10036	9904
	90	10773	11036	10904
	120	11259	11351	11305
90 DAE	0 (control)	8023	7460	7741
	30	9064	9328	9196
	60	10078	10342	10210
	90	12037	11935	11986
	120	11884	11835	11859
120 DAE	0 (control)	8064	8328	8196
	30	9287	9339	9313
	60	10148	10411	10279
	90	11530	11868	11699
	120	11745	11882	11814
	0 (control)	7181	7169	7175 e
	30	8193	8354	8274 d
	60	9063	9098	9081 c
	90	10189	10306	10248 b
	120	10599	10750	10674 a
No green manuring		6878	6899	6889 d
30 DAE		8292	8312	8302 c
60 DAE		9682	9920	9801 b
90 DAE		10217	10180	10199 a
120 DAE		10155	10366	10260 a
Mean		9045	9135	
Interactions	**Significance levels**			
Y × GM	NS			
GM × N	**			
Y × N	NS			
Y × GM × N	NS			

*LSD at 0.05% for GM = 298.03; N = 226.74 and GM × N = 507.01; DAE = Days after emergence; ** = Highly significant; NS = Non-significant.*

Means having same letters are not significantly different from each other at (P ≤ 0.05).

Table 6: *Grain yield (kg ha^{-1}) of wheat as affected by pigeonpea green manuring and nitrogen fertilizer application during 2013-14 and 2014-15.*

Green manuring	Nitrogen Levels	Year (Y)		GM × N
(DAE)	(kg ha^{-1})	2013-14	2014-15	
No green manuring	0 (control)	1819	1922	1871
	30	2306	2280	2293
	60	2521	2549	2535
	90	2938	2764	2851
	120	3153	3211	3182
30 DAE	0 (control)	2444	2481	2463
	30	2785	2780	2782
	60	2958	2961	2959
	90	3069	3127	3098
	120	3389	3433	3411
60 DAE	0 (control)	2771	2815	2793
	30	3153	3200	3176
	60	3542	3625	3584
	90	3750	3787	3768
	120	3917	3974	3946
90 DAE	0 (control)	2875	2961	2918
	30	3250	3322	3286
	60	3660	3724	3692
	90	4139	4183	4161
	120	4139	4155	4147
120 DAE	0 (control)	2861	2947	2904
	30	3361	3419	3390
	60	3701	3849	3775
	90	4098	4155	4126
	120	4149	4141	4145
	0 (control)	2554	2625	2590 e
	30	2971	3000	2985 d
	60	3276	3342	3309 c
	90	3599	3603	3601 b
	120	3749	3783	3766 a
No green manuring		2547	2545	2546 d
30 DAE		2929	2956	2943 c
60 DAE		3426	3480	3453 b
90 DAE		3612	3669	3641 a
120 DAE		3634	3702	3668 a
Mean		3230	3271	
Interactions	**Significance levels**			
Y × GM	NS.			
GM × N	NS.			
Y × N	NS.			
Y × GM × N	NS.			

LSD at 0.05% for GM = 146.3 and N = 102.6; DAE = Days after emergence; NS = Non-significant.
Means having same letters are not significantly different from each other at (P ≤ 0.05).

biological yield with green manuring is related to the fact that during the decomposition of green manures it may provide many essential nutrients which enhance the growth of plant biomass. Same findings were also reported by Nicole et al. (2018) and Hayat et al. (2008) who reported that considerable improvement in biological yield of crops is related to the efficient supply of nutrients from organic and inorganic sources to the plants during the entire vegetative life spam of the plants which ultimately produced healthy plants.

Grain yield (kg ha^{-1})

Grain yield of wheat crop was significantly affected by green manuring and nitrogen levels, while all the interactions were found non-significant (Table 6). Results showed that plots integrated with 90 and 120 days post emerged pigeon pea green manures produced 3641 and 3668 kg grain yield ha^{-1} respectively, which are statistically similar, followed by grain yield 3453 kg ha^{-1} produced by plots in which 60 days post emerged pigeon pea was green manured. Lowest grain yield of 2546 kg ha^{-1} was recorded in plots that received no green manures. In case of nitrogen application, an increasing trend was found in grain yield with increase in nitrogen rates. Higher grain yield (3766 kg ha^{-1}) was recorded in plots that were given nitrogen fertilizer at the rate of 120 kg N ha^{-1}, while, lower grain yield (2590 kg ha^{-1}) was recorded in control plots. Wheat crop on average, produced 3230 kg ha^{-1} grain yield during first year and 3271 kg ha^{-1} during second year, which was almost similar. Results indicated that incorporation of 90-day older pigeon pea crop combined with 90 kg N ha^{-1} enhanced grain yield of wheat crop (4161 kg ha^{-1}). Increasing the nitrogen levels produced higher yield but when combing with green manures the fertilizers use can be reduced without compromising on environmental risk and it can lead towards the sustainable agriculture. Same results were given by Nawab et al. (2011), Javaid (2011) and Aulakh et al. (2000) who described that the incorporation of green manure legumes with chemical fertilizers especially nitrogenous fertilizers increased the grain yield of crops.

Conclusions and Recommendations

Based on the results obtained, it is concluded that the incorporation of green manures 90 and 120 days post emerged pigeon pea improved plant growth and yields of wheat crop during both the years. Application of N fertilizers at the rate of 120 kg N ha^{-1} improved the growth of wheat while some parameters were also

similar when 90 kg ha^{-1} N was used. In case of combine use of green manuring and nitrogen fertilizer results showed that wheat crop performed very well in those plots which were treated with 90 days post emerged pigeon pea and 90 kg nitrogen ha^{-1}. Results indicating that synthetic nitrogen requirement can be reduced with the use of green manuring, which is a good approach towards batter and sustainable agriculture.

Author's Contribution

Saqib Bashir conducted the experiment, collect the data, analyze it and wrote the manuscript. Bashir Ahmad provided technical inputs and help in writing manuscript.

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