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Residual effect of preceding legumes and nitrogen levels on subsequent maize

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Abstract

An experiment entitled "Residual effect of preceding legumes and nitrogen levels on subsequent maize" was carried out at Agronomy Research Farm, The University of Agriculture, Peshawar during summer 2014. The experiment was laid out in RCB Design with split plot arrangement having three replications. A plot size of (5 m × 4 m) having five rows with row to row distance of 70 cm and maize variety "Azam" was sown at seed rate of 30 kg ha^{-1} during the experiment. Four nitrogen levels (0, 90, 120, 150 kg ha^{-1}) and four legumes (cowpea, Sesbania, mung bean and fallow) were included in the experiment. Legume was allotted to the main plots while nitrogen was allotted to sub plots. Data were recorded on plant height, leaf area plant^{-1}, number of grains cob^{-1}, thousand grains weight and grain yield. The result showed that legumes as preceding crop had significantly affected leaf area plant^{-1} (319.99 cm^2), number of grains ear^{-1} (412), grain weight (268.33 g) and grain yield (5104 ka ha^{-1}) while its effect on plant height was not significant. Fallow as preceding practice had significantly lowest number of grains ear^{-1} (301), grain weight (205 g) and grain yield (3185 kg ha^{-1}) as compared with legumes as preceding crops. Among legumes maximum number of grains ear^{-1} and grain yield obtained with Sesbania as preceding crop. Sesbania as preceding crop and application of 120 ka N ha^{-1} is recommended for higher yield of maize crop.

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Introduction

Maize (*Zea mays* L.) belongs to Poaceae family, is an important cereal crop grown in various agro-ecological zones, as a single crop or in mixed cropping. It plays an important role in farmer's economy, livestock feeding and poultry production throughout the world. Maize is used as a raw material in industries to produce biodegradable plastics, biofuel, and alcohol (Harris *et al.,* 2007). Maize contains 72% starch, 10% protein, 4.8% oil, 5.8% fiber, 3.0% sugar and 1.7% ash (Zilic *et al.,* 2011). Maize yield in Pakistan is lower as compared to its neighboring countries, China and India. Numerous factors are accountable for low yield performance of maize among which poor nutrients management techniques are predominant. Similarly imbalance use of chemical fertilizers further spoiled the situation (Khattak *et al*., 2004). Nitrogen fertilization plays significant role in enhancing soil fertility, increasing grain yield, biomass and improving crop productivity (Ogola *et al.,* 2002). Ideal N management optimizes grain yield, farm profit, and N use efficiency while it minimizes the potential for leaching of N beyond the crop rooting zone (Raun and Johnson, 1999). Although maize crop is highly responsive to nitrogen fertilization however constant or excessive application of these nitrogenous fertilizers degrades soil quality, decrease production and several other environmental issues such as nitrate leaching and soil water contamination are evolved. Therefore there is a need to replace the high use of synthetic nitrogenous fertilizers by organic sources of nutrients. Organic matter is considered as life of the soil, and also favors sustainable productivity (Katyal *et al*., 2001; Behera *et al*., 2007). Incorporation of plant residues particularly N_2- fixing legumes is a useful means to sustain organic matter content and thereby enhance the biological activity, improve soil fertility and increase nutrient availability (Giller *et al.,* 1997, Kumar and Goh, 2000; Palm *et al*., 2001). Legumes are grown for their food grain seed, for livestock forage and silage, and as soil-enhancing green manure. Legumes are noteworthy in that most of them have symbiotic nitrogen-fixing bacteria in structures called root nodules (Sanginga *et al.,* 1996). Well-known legume crops include alfalfa, clover, peas, beans, lentils, lupins, mesquite, carob, soybeans, peanuts, tamarind, and the woody climbing vine wisteria. Legume trees like the Locust trees (*Gleditsia*, *Robinia*) or the Kentucky coffeetree (*Gymnocladus dioicus*) can be used in permaculture food forests (Stefan and Christian 2002).

Unfortunately Legumes incorporation in the soil has been slowly eliminated from cropping systems, and has led to serious consequences on soil fertility. Despite their great potential for making significant N contributions and improving productivity, the adoption of legumes is poor due to wide range of socio economic and physical constraints (Shah *et al*., 2003; Chikowo *et al*., 2006; Ojiem *et al*., 2006). Cultivation of legumes for seed, fodder or green manure Legumes can positively influence the structure and functioning of the agro-ecosystem (Pierce and Rice, 1988). Several studies have shown that crop yield and product quality are usually improved when legume are grown as a preceding crop (Campiglia *et al*., 1999). Keeping in view the importance of nutrient management sources (organic and inorganic) the present experiment was designed to study the residual effects of incorporated legumes on soil physio-chemical properties and maize productivity.

Materials and methods

Field Experiment

A field experiment entitled "Residual effect of preceding legumes and nitrogen levels on subsequent maize crop" was carried out at Agronomy Research Farm, The University of Agriculture Peshawar, Pakistan during Kharif 2014.

The experiment was conducted in randomized complete block design (RCBD) with split plot arrangements having three replications. Legumes (Cowpea, Sesbania, Mungbean) as proceeding legume crops and fallow was allotted to main plot while nitrogen levels (0 kg ha^{-1}, 90 kg ha^{-1},120 kg ha^{-1},150 kg ha^{-1}) were allotted to the subplot. Plot size was 5m x 4m. Planting was done on flat beds in rows spaced 0.75m.

Nitrogen was applied to maize through urea in two equal splits, half each at sowing and 30 days of growth. Similarly, the recommended rate of P fertilizer (90 kg ha^{-1}) also applied to maize at sowing. First irrigation was given 12 days after sowing while the subsequent irrigation were adjusted according to the need of the crop and avoiding the over irrigation strictly. All the other agronomic practices were kept normal and uniform for all the treatments.

Data were collected on the following parameters

1. Leaf area $plant^{-1}$ (cm^2)
2. Plant height (cm)
3. Thousand grains weight (g)
4. Number of grains ear^{-1}
5. Grain yield (kg ha^{-1})

Leaf area $plant^{-1}$

Leaf area $plant^{-1}$ (cm^{-2}) was calculated by measuring the length and width of all leaves of the three randomly selected plants from each plot and then average was worked out to calculate the leaf area $plant^{-1}$ by using the formula:

Leaf area $plant^{-1}$ = Leaf length x leaf width x 0.75

Plant height

Plant heights (cm) of five randomly selected plants were measured from the ground level to the top of tassel in each plot and then their means were calculated.

Thousand grains weight (g)

A random sample of thousand grains were taken from the grain yield of each plot and weighed with an electronic balance to record weight for thousand grains.

Number of grains ear^{-1}

To record the number of grains ear^{-1}, grains of five randomly selected ears in each plot were counted and then averaged.

Grain yield (kg ha^{-1})

For recording grain yield data, three central rows were harvested in each plot with the help of a sickle. Ears were removed from the harvested plants, dried, threshed and weighed with the help of an electronic balance and the data will then be converted into kg ha^{-1}.

Statistical analysis

Analysis of variance procedure was followed for the statistical analysis of data based on RCBD with split plot arrangement. Means were compared using least significant differences (LSD) test at $P \leq 0.05$ upon significant F-test (Jan *et al.,* 2009).

Results and discussion

Leaf area $plant^{-1}$

Mean value of Table 1 shows that leaf area $plant^{-1}$ (cm^2) was significantly affected by preceding legumes (L) crops and nitrogen (N) applied. The interaction between L x N was not significant for leaf area $plant^{-1}$. Among the legumes cowpea and Sesbania had significantly more leaf area $plant^{-1}$ compared with mung bean. While the lower leaf area $plant^{-1}$ (189.73 cm^2) was recorded from fallow land. The affect of N level was significant on leaf area $pant^{-1}$. Plots grown with 120 kg N ha^{-1} had significantly more leaf area $plant^{-1}$ (313.28 cm^2). The leaf area $plant^{-1}$ increased with increase in N from 0 to 120 kg ha^{-1} but no significant differences were recorded among 0, 90 and 150 kg ha^{-1} N application. Higher leaf area $plant^{-1}$ (cm^2) was observed in the plots where Sesbania was incorporated and nitrogen was applied at the rate of 120 kg ha^{-1} while lower leaf area $plant^{-1}$ (cm^2) was recorded from control plots. This is might be the residual soil nitrogen contents by the legumes incorporation and decomposition. The results are in consistent with that of Arif *et al.,* (2011) whose study was to check the effect of residues on the yield and yield components of maize crop.

Plant height

Mean value of Table 2 shows that plant height (cm) was significantly affected by preceding legume crops (L) and nitrogen (N) applied. The interaction between L x N was not significant for plant height. All the legumes had significantly taller plants as compared with fallow land where dwarf plant (162.55 cm) was observed.

The difference within the legumes was not statistically significant. The affect of N levels was significant on plant height. Plots grown without N fertilizer had significantly dwarf plants (175.60 cm). The plant height significantly increased with increase in N from 0 to 90 kg ha^{-1} but no significant difference was recorded between 90, 120, 150 kg ha^{-1} N application. Significantly taller plant was recorded from the plots where Sesbania was incorporated and nitrogen was applied at the rate of 120 kg ha^{-1} whereas dwarf plants were recorded in control plots. The performance of maize plant might be the result of residual soil fertility improved by the legumes or the nodule formation by the roots of Sesbania compared to other legumes. These results are in line with those of Balasubramaniyan and Palaniappan, 2001.

Table 1. Leaf area $plant^{-1}$ (cm^2) of maize as affected by preceding legumes and nitrogen levels.

	Nitrogen (kg ha^{-1})				Mean
Preceding Legumes	0	90	120	150	
Cowpea	276.63	282.65	356.97	317.82	308.29 a
Sesbania	281.65	285.77	378.91	333.62	319.99 a
Mungbean	196.04	247.99	290.27	237.03	242.83 b
Fallow	154.46	218.86	227.86	157.72	189.73 c
Mean	227.69 b	258.83 b	313.28 a	261.55 b	

LSD value ($P \leq 0.05$) for Legumes (L) = 41.0

LSD value ($P \leq 0.05$) for Nitrogen (N) = 42.11

LSD value ($P \leq 0.05$) for L x N = ns.

Table 2. Plant height (cm) of maize as affected by preceding legumes and nitrogen levels.

	Nitrogen (kg ha^{-1})				Mean
Preceding Legumes	0	90	120	150	
Cowpea	186.83	187.17	199.53	190.97	190.97 a
Sesbania	193.33	194.20	200.73	186.40	193.67 a
Mungbean	174.13	184.33	194.40	194.27	186.78 a
Fallow	148.07	168.47	170.07	163.60	162.55 b
Mean	175.60 b	183.54 ab	191.18 a	183.65 a	

LSD value ($P \leq 0.05$) for Legumes (L) = 15.30

LSD value ($P \leq 0.05$) for Nitrogen (N) = 8.02

LSD value ($P \leq 0.05$) for L x N = ns.

Thousand grains weight

Mean value of Table 3 shows that thousand grains weight (g) was significantly affected by preceding legumes (L). While nitrogen application and interaction between L x N both were found not significant. Among the legumes plots grown with Sesbania had higher thousand grains weight (268.33 g). There were no significant differences between cowpea and mung bean. While the lower thousand grains weight was obtained from fallow land (205 g). Significantly heavy grains were recorded for the plots where nitrogen was applied at the rate of 120 kg ha^{-1} and Sesbania incorporated while the minimum grain weight was noted from the control plots. The increase in thousand grain weight with N application and legumes in corn might be due to the organic sources of nitrogen in addition with inorganic fertilizers. The results are in agreement with Muhammad *et al.* (2005), who reported that yield contributing characters such as thousand grain weight, number of grains ear^{-1} with higher doses of inorganic fertilizer in combination with manure resulting in higher yield.

Number of grains ear^{-1}

Mean value of Table 4 shows that number of grains ear^{-1} was significantly affected by preceding legumes (L) crops. Though not significantly affected by nitrogen (N) applied.

The interaction between L x N was statistically significant for number of grains ear^{-1}. Among the legumes higher number of grains cob^{-1} were recorded from the plots grown with Sesbania (412) followed by cowpea and mung bean, respectively whereas the lower number of grains ear^{-1} were recorded from fallow land (301).

Table 3. Thousand grains weight (g) as affected by preceding legumes and nitrogen levels.

	Nitrogen (kg ha^{-1})				Mean
Preceding Legumes	0	90	120	150	
Cowpea	223.00	242.67	273.67	244.33	245.92 b
Sesbania	243.33	274.00	287.00	269.00	268.33 a
Mungbean	222.67	245.33	268.00	235.67	242.92 b
Fallow	190.33	201.33	228.67	199.67	205.00 c
Mean	219.83 c	240.83 b	264.33 a	237.17 b	

LSD value ($P \leq 0.05$) for Legumes (L) = 22.39

LSD value ($P \leq 0.05$) for Nitrogen (N) = ns

LSD value ($P \leq 0.05$) for L x N = ns.

The interaction between N x L shows that fallow plot had minimum number of grains ear^{-1} as compared with legumes plots and number of grains ear^{-1} remain consistent irrespective of nitrogen application whereas in case of legumes number of grains ear^{-1} slightly increases from 0 kg ha^{-1} to 120 kg ha^{-1} and then deceases at 150 kg nitrogen ha^{-1}. Maximum number of grains ear^{-1} were noted in Sesbania incorporated plots with nitrogen applied at the rate of 120 kg ha^{-1} whereas the minimum grain yield was recorded from the control plots. The more number of grains ear^{-1} might be due to more photo-assimilates production in Sesbania incorporated plots having 120 kg ha^{-1} nitrogen applied. Optimum supply of nitrogen had affected yield components. In control plots the lower number of grains ear^{-1} were reported by Muhammad *et al.* (2005), and the possible reason was unavailability of nitrogen and less dry matter accumulation.

Table 4. Number of grains ear^{-1} as affected by preceding legumes and nitrogen levels.

	Nitrogen (kg ha^{-1})				Mean
Preceding Legumes	0	90	120	150	
Cowpea	337	396	437	384	388 ab
Sesbania	346	431	466	353	412 a
Mung bean	335	344	453	353	371 b
Fallow	276	284	324	321	301 c
Mean	323 c	364 b	420 a	366 b	

LSD value ($P \leq 0.05$) for Legumes (L) = 84

LSD value ($P \leq 0.05$) for Nitrogen (N) = ns

LSD value ($P \leq 0.05$) for L x N = *.

Grain yield

Mean value of Table 5 shows that grain yield (ka ha^{-1}) was significantly affected by preceding legumes (L) and nitrogen (N) applied. The interaction between N x L was not significant for grain yield. Among the legumes plots grown with Sesbania had higher grain yield (5104 kg ha^{-1}) followed by cowpea and mung bean. Whereas the lower grain yield (3184) was observed in Fallow plots. The affect of N level was significant on grain yield.

Plots grown without nitrogen had lower grain weight (3878 kg ha^{-1}). The grain weight slightly increased with increase in nitrogen application from 0 to 90 kg ha^{-1} but no significant differences found between 90 and 120 kg ha^{-1} while further increase in nitrogen decrease the grain yield. Grain yield was observed to be higher in the plots where nitrogen was applied at the rate of 120 kg ha^{-1} and Sesbania was incorporated whereas the lower grain yield was noted in control plots. This increase might be due to the liter and leaf biomass on the soil in Sesbania incorporated plots. The leaf biomass of Sesbania is of high quality, it decompose more rapidly and supply more nitrogen.

Table 5. Grain yield (kg ha^{-1}) as affected by preceding legumes and nitrogen levels.

	Nitrogen (kg ha^{-1})				Mean
Preceding Legumes	0	90	120	150	
Cowpea	4213	5287	5549	4667	4962 ab
Sesbania	4413	5387	5749	4867	5104 a
Mungbean	3896	3930	4743	4204	4193 b
Fallow	2990	3236	3412	3101	3185 c
Mean	3878 c	4460 ab	4863 a	4210 bc	

LSD value ($P \leq 0.05$) for Legumes (L)= 737

LSD value ($P \leq 0.05$) for Nitrogen (N) = 410

LSD value ($P \leq 0.05$) for L x N = ns.

The results are in argument with those of Niringiye *et al.* 2005 who argued that the good quality of leaf biomass compared with other components, leaf decomposed rapidly to supply more N to the growing maize plots.

These findings are also in agreement with the results of Malik *et al.* (1991) who conducted an experiment on residual effect of legumes such as pigeon pea, mungbean and cowpea on cereals(Maize, wheat) and found increasing total grain yield and monetary returns. Intercropping pigeon pea with cowpea and mungbean expressed an excellent response. Increasing total grain yield significantly followed by wheat. Abate *et al.* (1992) carried out an experiment of the forage legumes and revealed that forage legumes improve soil fertility, increase crop yields, improve yields suppress weeds and combat erosion. Drinkwater *et al.* (2000) observed that legume based cropping patterns increase the organic matter content consequently result in sustainable yields of crops. Gadgil *et al.* (2002) reported that high benefit cost ratio and effective net returns can be obtained with the introduction of legume based cropping patterns.

Conclusion

It can be concluded that Sesbania as preceding legume having 120 kg N ha^{-1} ,have significantly increased the yield and yield components of succeeding maize crop then the other legumes in agro-climatic conditions of Peshawar and is therefore recommended.

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