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Impact of preceding legume and Nitrogen levels on Maize

ABSTRACT

An experiment on maize crop with preceding legumes and nitrogen levels were carried out in the Research Farm of Agronomy, the University of Agriculture, Peshawar during 2011-2012 using summer legumes-maize cropping pattern. The summer legumes were sown in the summer gap (60-65 days) for grain, fodder and green manure purposes. Mungbean for grain and cowpea for fodder purpose and Sesbania was for green manure purpose using fallow as control. After legumes experiment each plot was split into four sub plots to accommodate four levels of N (0, 90, 120 and 150 kg ha⁻¹) for maize. Data was recorded on emergence m⁻², plant height, grains ear⁻¹ and ear weight. Soil parameters after legumes experiment i.e. pH, total soluble salts (TSS), electrical conductivity (EC), and calcium carbonate (CaCO₃) measured and were found to be not significantly affected by preceding legumes. Soil pH was higher in case of fallow plots while lower in plots previously cultivated with mungbean. Similarly, higher soil TSS, EC and CaCO₃ were recorded in plots previously sown with mungbean while lower soil TSS, CaCO₃ and EC was noted in plots left fallow. All the parameters under investigation were significantly affected by nitrogen levels except emergence m⁻² of maize. The effect of legumes was significant for grain per ear and ear weight. Taller plants were produced in plots where N was applied at the rate of 150 kg ha⁻¹ followed by N application of 120 kg ha⁻¹ while control plots resulted in short stature plants. Plots fertilized with high N (150 kg ha⁻¹) had significantly higher ear weight which was at par with N application at the rate of 120 kg ha⁻¹. Higher grains per ear were found in ear collected from plots treated with N at the rate of 120 kg ha⁻¹ which was at par with plots fertilized with N at the rate of 150 kg ha⁻¹. Control plots resulted in fewer grains ear⁻¹. It is concluded from the results that summer legumes and nitrogen levels significantly improved the yield component of maize crop.

Key words: Maize, legumes, soil fertility and nitrogen levels,

I. INTRODUCTION

Cereal based cropping systems are predominantly practiced in Pakistan because of higher productivity and profitability, and for ensuring food security. Previously balanced fertilization with N, P and K was thought to be essential for achieving high levels of productivity. However, with the passage of time, there is a gradual decline in factor productivity and increasingly higher doses of nutrients are required to be applied to achieve the potential yields of these crops. This situation is associated with deteriorating fertility of the soils and consequent emergence of multiple nutrient deficiencies including those of micronutrients (Timsina and Connor, 2001). Organic matter is the life of soil, and the practices that support organic matter build-up also favor sustainable productivity (Katyalet al., 2001). Incorporation of plant residues is a useful means to sustain organic matter content and thereby enhance the biological activity, improve soil physical properties and increase nutrient availability. Organic manuring by way of direct application of conventional farmyard manure, mulching or green manuring, has declined over the years due to various operational constraints (Herridge et al.,1995). Cultivation of legumes for seed, fodder or green manure helps in sustaining the productivity of cereal based cropping systems and improves soil fertility through nutrient cycling (Herridge et al.,1995).

In most parts of Pakistan, there is a hot summer period of 70–80 days which occurs from last week of April to mid July, a period between after wheat harvesting and before maize planting. This period can be utilized by short duration legume crops for enhancing grain legumes production or fodder availability or green manuring. Green manuring with annual leguminous crops like Sesbania is a widely known practice has been found beneficial not only for realizing potential yields but also for N economy and improving soil fertility (Singh et al., 1991). Likewise, mungbean as well as cowpea have direct value in human diet and potential in adding N to the cropping system, especially when their residues with nodules are incorporated into the soil (Glasener et al., 2002).

It is not only desirable but quite possible to reduce the reliance on synthetic N fertilizers and move towards greater use of legumes to supply N for crop production. In fact, legume-based systems are likely to be more sustainable than cereal-based or fertilizer based systems. There are few studies quantifying the relative contribution of legumes in summer gap towards N economy, productivity, profitability and soil fertility in cereal based cropping system (Arif et al., 2014). Hence, a comprehensive study was undertaken to study the immediate and residual effects of legumes on increasing crop productivity, improving soil quality and getting sustainability in cereal based cropping system.

II. MATERIALS AND METHODS

The experiment was conducted at The Agronomy Research farm, the University of Agriculture Peshawar during 2011-2012 in kharif season. The experimental farm is located at 34.01° N latitude, 71.35° E longitude, at an altitude of 350 m above sea level in Peshawar valley. Peshawar (34.0167° N and 71.5833° E) is located about 1600 km North of the Indian Ocean and has continental type of climate. The research farm is irrigated by Warsak canal from river Kabul. Soil is clay loam, low in organic matter (0.87 %), phosphorus (6.57 mg kg⁻¹), potassium (121 mg kg⁻¹) and alkaline (pH 8.2) and is calcareous in nature (Amanullah et al., 2009). Summer legumes-maize cropping pattern was used for the experiments. The summer legumes were adjusted in planted during the period between after wheat harvesting and the planting of maize for grain, fodder and green manure purposes. Mungbean for grain, cowpea for fodder, and Sesbania was purely for green manure production. A fallow was included in the experiment as control. After the harvest of wheat crop, summer legumes i.e. mungbean, cowpea and Sesbania were sown in the first week of May according to the recommended agronomic practices. The biomass of Sesbania was incorporated into the field with a disc harrow in early July.

After thorough land preparation, each plot from the previous legumes experiment was split into four sub plots to accommodate four levels of N to maize crop. Maize was sown with four levels of N fertilizer (0, 90, 120 and 150 kg ha⁻¹) in mid July. Nitrogen was applied to maize as urea in two equal splits, half at sowing and another half at 30 days of growth. Similarly, the recommended rate of P fertilizer at the rate of 90 kg ha⁻¹ was applied to maize at sowing. For the legume experiment, a randomized complete block design (RCBD) with four replications was used in a plot size of 5 m x 16 m. For maize experiment, the plot (5 m x 16 m) was split into four plots to accommodate four levels of N to maize. In this way, each subplot size was 5 m x 4 m.

The data was recorded on emergence per meter square by counting total number of plants emerged in one meter row length at three randomly selected rows in each sub plot and then converted to emergence m^{-2} . Plant height of each crop was measured from base to the tip of the plant and five randomly selected plants in each sub-plot were used. Grains per ear of five randomly selected ears was counted and averaged.

For the analysis of soil physio-chemical characteristics, three soil samples were taken from each subplot at random and were mixed together for the determination of different physiochemical properties of soil (pH, EC, total soluble salts (TSS) and $CaCO_3$). Soil sampling was done after the harvest of legumes.

Statistical analysis

The data were analyzed according to analysis of variance technique appropriate for RCB design for legume experiment and RCB design with split plot arrangement for maize and wheat experiments using Genstat discovery software. The treatment means were compared at $P < 0.05$ level of probability using LSD test (Jan et al., 2009).

IV. RESULTS AND DISCUSSION

Soil parameters after legumes experiment

The values of the soil pH, total soluble salts (TSS), electrical conductivity (EC) and CaCO_3 content were not significantly affected by preceding legumes (Table 1). However, soil pH was higher in case of fallow plots. Similarly, higher soil TSS and EC were recorded in plots previously sown with mungbean. CaCO_3 content was higher in plots previously sown with Sesbania.

Emergence m^{-2}

Statistical analysis of the data showed that nitrogen levels (N) and legumes (L) had non-significant effects on emergence m^{-2} . The N x L interaction was also not significant. However, emergence was higher in N treated plots as compared to control. Likewise, plots previously sown with cowpea and mungbean or kept fallow resulted in higher emergence m^{-2} while emergence was lower in plots previously sown with Sesbania (Table 2).

Plant height (cm)

Different nitrogen levels significantly affected maize plant height while the effect on legume cropping system remained not significant (Table 2). The N x L interaction was not significant. Plant height steadily increased as nitrogen level increased from 0 to 150 kg ha^{-1} . The tallest maize plants (206 cm) were recorded in plots where N was applied at the rate of 150 kg ha^{-1} (Table 2b) followed by that 120 kg ha^{-1} (202 cm), while control plots recorded the shortest (188 cm) maize plants. This increase in plant height could be attributed to positive effect of N on vigorous vegetative growth the results are in agreement with the finding of Khan et al., (2009) who reported that maize growth increased with increasing nitrogen fertilizer.

Ear weight (g)

Ear weight of maize was significantly affected by nitrogen levels and previously grown legumes (Tables 2a and 2b). In the side of legumes alone, the highest maize ear weight was recorded after Cowpeas (77g) followed by that of Mungbean (74g), Sesbania (63g) and least in the fallow plots (60g). In the side of N application, plots fertilized with high N (150 kg ha⁻¹) had significantly higher ear weight (79 g) which was at par with nitrogen application at the rate of 120 kg ha⁻¹ as compared to control plots (54 g). Our finding are in line with Lopez et al. (2007) reported that nitrogen application have positive relation with yield of maize. Similarly, ear weight was higher in plots previously sown with cowpea or mungbean. Increase in ear weight is due to effect of preceding legumes which might increase the availability of essential nutrient for plant growth. Similar results are also reported by Sharma et al., (2009) that Sesbania green manuring and legumes in cropping system have favorable effect on maize yield and yield attributes.

Grains ear⁻¹

Data on grains ear⁻¹ is presented in Table 2. Statistical analysis of the data indicated that nitrogen levels significantly affected grain ear⁻¹ of maize while the effect of legumes were not significant. Similarly, N x L interaction remained not significant. Grains ear⁻¹ increased as N increased from 0 to 120 kg ha⁻¹. Higher grains ear⁻¹ were found in ears collected from plots treated with N at the rate of 120 kg ha⁻¹ which was at par with plots fertilized with N at the rate of 150 kg ha⁻¹. Control plots resulted in fewer grains ear⁻¹. All N amended plots resulted in higher grain ear⁻¹ over control. Timely availability of nutrient mainly N in N amended plots increase in dry matter accumulation and better crop growth that could positively change the physiological functions of the maize crop (Ali et al., 1999).

Table1. Soil pH, TSS, EC and CaCO₃ as affected by preceding legumes.

Legumes	pH	TSS (%)	EC (dsm ⁻¹)	CaCO ₃ (ppm)
Cowpea	8.200	0.060	0.187	12.833
Mungbean	8.167	0.066	0.207	12.917
Sesbania	8.167	0.059	0.183	13.250
Fallow	8.233	0.053	0.167	12.000
LSD(0.05)	ns	ns	ns	ns

Means of the same category followed by different latter are significantly different from one another at 5% level of probability.

ns = non-significant

Table 2a. Emergence m⁻², plant height (cm), ear weight (g) and grains ear⁻¹ of maize as affected by preceding legumes.

	Emergence m ⁻²	Plant height (cm)	Ear weight (g)	Grains ear ⁻¹
Legumes				
Cowpea	11	205	77a	259 a
Mungbean	11	201	74a	263 a
Sesbania	10	191	63b	242 b
Fallow	11	193	60b	244 b
LSD (0.05)	ns	ns	9.23	13.54

Table 2b. Emergence m⁻², plant height (cm), ear weight (g) and grains ear⁻¹ of maize as affected by different nitrogen levels.

	Emergence m ⁻²	Plant height (cm)	Ear weight (g)	Grains ear ⁻¹
Nitrogen (kg ha⁻¹)				
0	10	188 d	54c	234 c
90	11	195 c	64b	252 b
120	11	202 b	77a	264 a
150	11	206 a	79a	257ab
LSD (0.05)	ns	3.54	4.12	14.68

Means of the same category followed by different letter(s) are significantly different from one another at 5% level of probability.

ns = non-significant

Conclusions and recommendation

It is concluded from the above results that summer legumes increase ear weight and grains per ear as compared to fallow plots similarly nitrogen at the rate of 120 kg per ha produce higher grains per ear and ear weight as compared to 150 kg per ha it show that inclusion of summer legumes in cropping system improve soil fertility due which the availability of soil nutrient is sufficient for growth at lower rates (120 kg ha⁻¹) as compared to recommended (150 kg ha⁻¹) rate which gradually reduce cost of production, reduce excess nutrient losses, reduce fertilizer cost and thus have to improve the yield of maize crop on sustainable bases.

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