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Effect of Legume Intercrops and Nitrogen Levels on the Yield Performance of Maize

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Abstract: This experiment was conducted to study the beneficial effect of legumes and inorganic quantities of N on maize crop. Different levels of nitrogen i.e. 0, 40, 80 and 120 kg ha^{-1} were used. Besides maize alone, intercrops were; maize+mungbean, maize+pigeon pea and maize+janter. Maize @ 40, mungbean 20, pigeon pea 50 and janter at 25 kg ha^{-1} were used respectively. Maximum seedlings emerged m^{-2} (40.20) was obtained at 120 kg N ha^{-1} in maize alone. Maximum days (61.7) to earing were taken by maize intercropped with janter. Maximum days (67.50) to silking were taken by maize+janter intercrop at 0 kg N ha^{-1}. Maximum plant height (165.50 cm) was observed in maize alone at 120 kg N ha^{-1}. Maximum cob length (12.55 cm) was noticed in maize and mungbean intercrop under 40 kg N ha^{-1}. Maximum biological yield (28429.63 kg ha^{-1}) was obtained from maize alone by 40 kg N ha^{-1}. Maximum number of grains cob^{-1} (309) was obtained from maize and pigeon pea intercropping at 120 kg N ha^{-1}. For maximum yield potential maize alone and maize+mungbean intercropping was at par statistically at 80 and 40 kg N ha^{-1} by giving 3463 and 3444 kg ha^{-1} yield respectively. Overall legume intercrop was superior by decreasing less yield of maize crop in addition to legume seed yield and N cost minimization.

Key words: Legumes, intercrop, N levels, maize

Introduction

Maize is an important edible starchy grain crop in the world after wheat and rice. It is extensively grown in the temperate, sub-tropical region of the world. It is also an important dual purpose grain and forage crop of irrigated and barani tracts of Pakistan. It constitutes 6.4% of the total grain production of the country. Its kernels are valuable and consumable source of protein (10.4%), fat (4.5%), starch (71.8%), vitamins and minerals. It also provides raw materials to starch industry for preparing different products. Mungbean (*Vigna radiata* L.), pigeon pea (*Cajanus cajan* L.) and janter (*Susbenia jancia* L.) are important grain legumes belong to family leguminosae. Pulses are excellent and inexpensive source of plant protein, when eaten in combination with wheat, rice and other cereals. They provide a balanced diet for millions of people. Pulses as 'poor man's meat' in the developing world, while in the developed world they are perceived as 'health food'. Being leguminous, they maintain soil fertility by converting and fixing atmospheric nitrogen in available form through symbiosis with rhizobial strains. Pulses are also an important component of animal feeds and their dry straw is used as hay. As regards composition, legumes account 40% of protein, digestible carbohydrate mainly starch about 50% but have fewer lipids i.e. about 1-2 %. Low yield factors responsible in Pakistan are imbalanced fertilization and improper intercropping. Yield of maize can be increased horizontally land expansion, vertically more inputs, intensificative unit $area^{-1}$ and potentially. Legume intercropping is an effective technique for increasing production unit $area^{-1}$ with suitable farm management practices. The main reason behind this practice is high return in yield and offers defense against the risk involved in mono cropping. There is also a much lower probability of income falling below a disaster level in intercrops than an equivalent mono crop. Small farmers of limited means are highly benefited from intercropping. Intercropping could narrow down and bridge the gaps in between actual and potential yield and could increase the land utilization efficiency and gains. Maize is an exhaustive crop. So, along with intercropping it also needs balanced fertilization, especially nitrogenous fertilizer. Nitrogen is one of the essential ingredients for increasing maize yield kg ha^{-1}. But unfortunately excessive nitrogen increment reduces yield instead of increasing it. Nitrogen effect is less on root growth than on shoot growth. Increased nitrogen supply results in an increased shoot:root ratio, which is conducive to lodging. Nitrogen is required for synthesis of protein, chlorophyll and nucleic acid metabolism enzymatic function and for core yield components. Samad *et al.* (1984) who reported that balanced proportion of NP took less number of days

to tasseling and silking. Mohammad *et al.* (1993) stated that the highest grains were recorded with 100% N level. Sharma (1993) stated that intercropping with soybeans or *Vigna radiata* did not reduce maize grain or fodder yields. He also concluded that the increase in maize yield with intercropping compared with sole cropping was greatest at lower levels of N application. Increasing rates of applied N increased yield component that is grain yield (Nunes *et al.*, 1996). Kushwaha and Chandel (1997) reported that maize-equivalent grain yield increased up to 50 kg N in the intercrop and was higher than that of the sole crop receiving 120 kg N ha^{-1}. Sachan and Gangawar (1996) also observed that yield was increased with N increment, being at a maximum with 90 kg N ha^{-1}. Shivay and Singh (2000) reported that plant height was significantly increased with 120 N kg ha^{-1} in maize.

The present experiment was designed to study the beneficial combined effect by legumes and inorganic quantities of N fertilizer on maize crop in the field.

Materials and Methods

This experiment was carried out at Malakandher Research Farm, NWFP Agricultural University, Peshawar, during the Summer 2001. The experiment was laid down in randomized complete block design (RCBD) with split plot arrangement replicated four times in subplot of 3x4.5 m^2 and it included the following treatments:

Nitrogen levels kg ha^{-1} (main plots)

$N_1 = 0$ $N_2 = 40$ $N_3 = 80$ $N_4 = 120$

Intercrops (sub-plots)

I_1	Maize (alone)
I_2	Maize + Mungbean
I_3	Maize + Pigeon pea
I_4	Maize + Janter

A basal dose of single super phosphate @ 100 kg P ha^{-1} was applied during land preparation. Maize seed of variety kisan 91 @ 40 kg ha^{-1} was used. As regards legumes seeds, mungbean, pigeon pea and janter @ 20, 50 and 25 kg ha^{-1} were used respectively.

In each sub-plot maize was planted at row distance of 75 cm and in between two rows of maize legume was intercropped. Observations were recorded about; seedlings emergence m^{-2}, days to earing, days to silking, plant height (cm), cob length (cm), biological yield (kg ha^{-1}), number of grains cob^{-1} and grain yield kg ha^{-1}.

Emergence data was recorded by counting the number of seedlings per meter length of row in three representative spots in each sub-plot. And then this data was converted into seedling m^{-2}. Days to earing was found by counting the days from the date of sowing to the date of 75% ear appearance in each treatment. Days to silking were recorded by calculating the days from the date of sowing to the date of 75% silk appearance in each subplot. For the determination of plant height, three representative plants were chosen in each subplot and their height from ground level to the tip of tassel was recorded and averaged. Cob length was recorded by measuring the length of three cobs i.e. small, medium and large size, chosen randomly in each sub-plot and averaged. For biological yield, the whole plots were harvested. Bundles were made and weighed with the help of balance. For finding the number of grains cob^{-1}, three cobs of different sizes i.e. small, medium and large size cobs were chosen randomly in each subplot, number of grains were counted in each cob and then averaged. Grain yield and biological yield was calculated as:

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Grain yield (kg)}}{\text{Sub plot area}} \times 10000$$

$$\text{Biological yield (kg ha}^{-1}) = \frac{\text{Biological yield (kg)}}{\text{Sub plot area}} \times 10000$$

The data collected during the experiment was statistically analyzed accordingly to Steel and Torrie (1980).

Results and Discussion

Various N levels had significantly ($P \leq 0.05$) affected emergence of seedling m^{-2} in maize (Table 1). Mean value of the data indicated that emergence of 34.36, 34.23 and 34.09 seedlings m^{-2} were recorded with control, 40 and 80 kg N ha^{-1} respectively which were at par statistically, followed by 33.55 seedlings m^{-2} with 120 kg N ha^{-1}. In case of intercropping had also significantly affected emergence of seedlings m^{-2} in maize. Maize sown alone recorded maximum of 37.68 seedlings m^{-2} followed by maize+pigeon pea

Table 1: Emergence m^{-2} as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	36.15c	35.38cd	39.00ab	40.20a	37.68a
Maize+Mungbean	33.28ef	31.38gh	32.98f	29.03I	31.66c
Maize+Pigeon pea	33.00f	32.13fg	38.93b	30.53h	33.64b
Maize+Janter	35.00cd	38.05b	25.45j	34.45de	33.24b
Mean	34.36a	34.23a	34.09a	33.55b	-

LSD value for nitrogen levels=0.4839, LSD value for intercropping=0.6251, LSD value for interaction=1.2500

Table 2: Days to earing as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	58.00	56.75	54.25	53.25	55.56d
Maize+Mungbean	60.00	59.25	57.00	55.50	57.94c
Maize+Pigeon pea	62.00	60.50	59.75	57.00	59.81b
Maize+Janter	64.50	63.50	60.75	58.25	61.75a
Mean	61.13a	60.0b	57.94c	56.00d	

LSD value for nitrogen levels=0.8899, LSD value for intercropping= 0.5385

Table 3: Days to silking as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	61.00fg	59.00hi	57.25j	56.25j	58.38d
Maize+Mungbean	63.00cd	62.25de	60.00gh	58.50I	60.94c
Maize+Pigeon pea	65.00b	63.50c	62.75cd	60.00gh	62.81b
Maize+Janter	67.50a	66.50a	63.75c	61.25ef	64.75a
Mean	64.13a	62.81b	60.94c	59.00d	

LSD value for nitrogen levels= 0.9258, LSD value for intercropping= 0.6080, LSD value for interaction=1.1180

Table 4: Plant height (cm) as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	139.50h	149.00f	158.00d	165.50a	153.0a
Maize+Mungbean	137.00i	148.75f	155.75e	164.00b	151.4b
Maize+Pigeon pea	133.50j	146.50g	154.50e	161.25c	148.9c
Maize+Janter	130.25k	139.75h	149.75f	154.75e	143.6d
Mean	135.1d	146.0c	154.5b	161.4a	-

LSD value for nitrogen levels=1.189, LSD value for intercropping=0.6413, LSD value for interaction=1.283

Table 5: Cob length (cm) as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	11.13cd	11.18c	11.45c	12.33ab	11.52a
Maize+Mungbean	9.00g	12.55a	11.45c	11.23c	11.06b
Maize+Pigeon pea	9.55fg	9.80fg	11.50bc	11.20c	10.51c
Maize+Janter	10.30d-f	9.68fg	10.8c-e	10.00ef	10.19c
Mean	9.99c	10.80b	11.29a	11.19a	

LSD value for nitrogen levels=0.3726, LSD value for intercropping=0.4212, LSD value for interaction= 0.8423, Mean of the same category followed by different letters are significantly different from one another using LSD test

Table 6: Biological yield (kg ha^{-1}) as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	25096.3c	28429.6a	25651.9bc	25837b	26251.9a
Maize+Mungbean	9074.1k	26022.2b	20555.5e	25837b	20370.4b
Maize+Pigeon pea	9911.1j	19911.1f	18703.7g	22222d	17688.9c
Maize+Janter	6296.3l	11948.1i	14074.1h	11763I	11022.2d
Mean	12592.6c	21577.8a	19748.1b	21415a	

LSD value for nitrogen levels=0.6081, LSD value for intercropping=0.4254, LSD value for interaction=0.8508

Table 7: Number of grains cob^{-1} as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	248i	270f	280c	272e	268b
Maize+Mungbean	188m	288b	288b	280c	261c
Maize+Pigeon pea	274d	268g	258h	309a	277a
Maize+Janter	199l	225j	188m	209k	205d
Mean	227d	263b	254c	268a	

LSD value for nitrogen levels=0.7625, LSD value for intercropping=0.7238, LSD value for interaction=1.448

Table 8: Grain yield (kg ha^{-1}) as affected by legume intercropping and nitrogen levels in maize

	Nitrogen levels (kg ha^{-1})				
Intercropping	0	40	80	120	Mean
Maize	1704f	2389d	3463a	2722c	2569a
Maize+Mungbean	954g	3444a	2898bc	3046b	2586a
Maize+Pigeon pea	852g	2056e	2370d	1981ef	1815b
Maize+Janter	463h	435h	518h	704gh	530c
Mean	993c	2081b	2312a	2113b	

LSD value for nitrogen levels=157, LSD value for intercropping=155, LSD value for interaction=309, Mean of the same category followed by different letters are significantly different from one another using LSD test

and maize+janter intercropping with 33.64 and 33.24 seedlings m^{-2} and these two intercropping were statistically at par. Maize + mungbean intercropping gave the lowest emergence of 33.24 seedlings m^{-2}. As regards interaction of N-levels x intercropping, significant differences had been recorded. Highest emergence of 40.20 seedlings m^{-2} was recorded with 100 kg N ha^{-1} x maize alone followed by 39.00, 38.93 and 38.05 seedlings m^{-2} with 80 kg N ha^{-1} x maize alone, maize+pigeon pea with same N level and 40 kg N ha^{-1} with maize+janter, while the lowest or minimum emergence of seedlings m^{-2} was observed with 80 kg ha^{-1} N level in maize+janter intercropping.

Various N levels and intercropping had significantly ($P \leq 0.05$) affected days to earing in maize. Mean value of the data indicated that highest of 61.13 days to earing were taken by control plots, while lowest of 56.00 days were taken by plots applied with 120 kg ha^{-1} nitrogen. As regards intercropped plots where janter was intercropped with maize had taken highest of 61.75 days to earing while plots with maize alone with lowest of 55.56 days to earing (Table 2). Similar results were also reported by Pandey *et al.* (2000). Various N levels, intercropping and their interaction (i.e. N x I) had significantly ($P \leq 0.05$) affected days to silking in maize. It can be inferred from the data that highest of 64.13 days to silking were taken by control plots, while lowest of 59.00 days were taken by plots applied with 120 kg N ha^{-1}. As regards intercropping,

highest of 64.75 days were taken by maize + janter intercropping while lowest of 58.38 days were taken by those plots where maize was sown alone. As regards interaction, highest of 67.50 days were taken by maize + janter intercropping with 0 kg ha^{-1} nitrogen while lowest of 56.25 and 57.25 days were taken by plots where maize was sown alone and 80 and 120 kg ha^{-1} N which were at par statistically were applied (Table 3). This observation is in line with Samad *et al.* (1984) who reported that balanced proportion of NP took less number of days to tasseling and silking.

Various N levels, intercropping and their interaction (N x I) were significantly ($P \leq 0.05$) affected plant height in maize (Table 4). Mean value of the data indicated that taller plants of 161.4 cm were observed in plots treated with 120 kg N ha^{-1}, while shorter plants of 135.1 cm were in plots treated with zero nitrogen application. In case of intercropping, maximum height of 153.0 cm was observed in plots where maize was sown alone, while minimum plant height of 143.60 cm was observed in plots where maize + janter intercropping was done. As regards interaction, maximum plant height of 165.50 cm was noted in plots where maize was sown alone and nitrogen was applied @ 120 kg ha^{-1} while minimum plant height of 130.25 cm was recorded in plots where maize + janter was intercropped and 0 kg N ha^{-1} was applied. This finding is in similarity with Shivay and Singh (2000) who reported that plant height was significantly increased with increasing N levels and the highest plant height was recorded with 120 N kg ha^{-1} in maize.

N levels, intercropping and their interaction had significantly ($P \leq 0.05$) affected cob length. Eighty and 120 kg N ha^{-1} were at par statistically, gave 11.29 and 11.19 cm length of cob, followed by 10.80 cm with 40 kg N ha^{-1} (Table 5). Lowest of 9.99 cm cob length was given by plots where 0 kg ha^{-1} nitrogen was applied. As regards intercropping, maximum of 11.52 cm cob length was observed in plots where maize was sown alone, followed by 11.06 cm with maize + mungbean intercropping. Maize + pigeon pea and maize + janter intercropping were at par statistically and gave 10.51 and 10.19 cm cob length respectively. Regarding the interaction between N x I, maize + mungbean intercropping gave maximum of 12.55 cm cob length with 40 kg ha^{-1} N level. While lowest cob length of 9.00 cm was observed in maize + mungbean with control level of N kg ha^{-1} (0 N kg ha^{-1}). These observations, especially for N-levels, were supported by Nunes *et al.* (1996) who stated that increasing rates of applied N increased grain yield and all components. N levels, intercropping and their interaction had significantly ($P \leq 0.05$) affected biological yield. It can be inferred from the data (Table 6) that both 40 and 120 kg ha^{-1} N levels gave maximum biological yield of 21577.8 and 21415 kg ha^{-1} respectively and these both levels of N were at par statistically, followed by 80 kg N ha^{-1} with 19748.1 kg ha^{-1} biological yield. Lowest biological yield of 12592.6 kg ha^{-1} was in plots with no N fertilizer application. In case of intercropping maximum of 26251.9 kg ha^{-1} biological yield was given by those plots where maize was sown alone followed by maize + mungbean intercropping with 20370.4 kg ha^{-1} biological yield and the lowest biological yield of 11022.2 kg ha^{-1} was given by maize + janter intercropping. This result is in agreement with that of Ali (1960) who obtained the highest grain and stalk yield with an application of 112 kg N ha^{-1}. As regards interaction between nitrogen levels and intercropping (N x I), maximum biological yield of 28429.6 kg ha^{-1} was given by those plots where maize was sown alone and applied with 40 kg ha^{-1} nitrogen while minimum of 6296.3 kg ha^{-1} biological yield was given by those plots where maize + janter intercropping was done and applied with 0 N kg ha^{-1} (Table 6). Data revealed that N levels, intercropping and their interaction had significantly ($P \leq 0.05$) affected number of grains cob^{-1}. Maximum of 268 gains cob^{-1} were recorded in plots, treated @120 kg N ha^{-1}, while minimum of 227 grains cob^{-1} were observed in control plots. In case of intercropping, maximum of 277 grains cob^{-1} was given by maize + pigeon pea intercropping while minimum of 205 grains cob^{-1} was observed in maize + janter intercropping (Table 7). These results were in line with Mohammad *et al.* (1993) who stated that the highest grains were recorded with 100% N levels. These results were also similar to Sachan and Gangawar (1996) who observed that yield attributes were increased with increasing levels of nitrogen. Regarding interaction (N x I) maximum of 309 grains cob^{-1} was recorded in maize + pigeon pea intercropping applied with 120 kg ha^{-1} N while minimum of 188 grains cob^{-1} were observed in both maize + mungbean and maize + janter intercropping with 0 and 80 kg ha^{-1} N respectively. These both intercropping were at par statistically at these levels of N.

Nitrogen levels, intercropping and their interaction (N x I) had significantly ($P \leq 0.05$) affected maize yield (kg ha^{-1}). Maximum of 2312 kg ha^{-1} yield of maize was recorded in those plots where nitrogen was applied @ 80 kg ha^{-1} while minimum of 993 kg ha^{-1} yield was observed with 0 kg ha^{-1} nitrogen level. As regards intercropping maize alone and maize + mungbean had highest yield of 2569 and 2586 kg ha^{-1} respectively as these both intercropping

were at par statistically (Table 8). Minimum of 530 kg ha^{-1} yield was recorded by maize + janter intercropping. This observation regarding nitrogen levels is also in line with Sachan and Gargawar (1996) who concluded that crop yield, yield attributes and net return were increased with increasing levels of nitrogen, being at a maximum with 90 kg N ha^{-1}. Regarding interaction (NxI), maize alone and maize + mungbean were statistically at par at 40 and 80 kg ha^{-1} N level, with 3463 and 3444 kg ha^{-1} yield as maximum while minimum yield kg ha^{-1} was shown by maize + janter intercropping with all N levels as these levels were at par statistically. Lowest yields kg ha^{-1} given by maize + janter intercropping at these 4 levels of nitrogen were 993, 2081, 2312 and 2113 kg ha^{-1} respectively. Sharma (1993) who stated that intercropping with soybeans or *Vigna radiata* did not reduce maize grain or fodder yields. He also concluded that the increase in maize yield with intercropping compared with sole cropping was greatest at lower levels of N application. This observation is in line with Samad *et al.* (1984) who reported that balanced proportion of NP took less number of days to tasseling and silking. This finding was in similarity with Shivay and Singh (2000) who reported that plant height was significantly increased with increasing N levels and the highest plant height was recorded with 120 N kg ha^{-1} in maize. These observations, especially for N levels, were supported by Nunes *et al.* (1996) who stated that increasing rates of applied N increased grain yield and all components. This result was in agreement with that of Ali (1960) who obtained the highest grain and stalk yield with an application of 112 kg N ha^{-1}. Our results were in line with Mohammad *et al.* (1993) who stated that the highest grains were recorded with 100% N levels. These results are also similar to Sachan and Gangawar (1996) who observed that yield attributes were increased with increasing levels of nitrogen. This observation regarding nitrogen levels was also in line with Sachan and Gargawar (1996) who concluded that crop yield, yield attributes and net return were increased with increasing levels of nitrogen, being at a maximum with 90 kg N ha^{-1}.

At the end it was recommended to intercrop mungbean (*Vigna radiata* L.) with maize and applied with N fertilizer @ of 40 kg ha^{-1} for maximum yield potential of maize because from this research it is concluded that overall legume intercrop was superior by decreasing less yield of maize crop in addition to legume seed yield and N cost minimization.

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