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Impact of Nitrogen Application on Growth and Yield of Maize (*Zea mays* L.) Grown Alone and in Combination with Cowpea (*Vigna unguiculata* L.)

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Abstract: A field study was conducted to study the impact of nitrogen application on the growth and yield of maize grown alone and in a combination with cowpea at Agronomic Research Area, University of Agriculture Faisalabad during 'autumn', 2008. Experiment was laid out in randomized complete block design, comprised of following six treatments; maize alone (control), maize intercropped with cowpea and N at 250 kg ha^{-1}, cowpea alone with nitrogen 25 kg ha^{-1}, maize intercropped with cowpea and N at 225 kg ha^{-1}, maize intercropped with cowpea and N at 200 kg ha^{-1},maize intercropped with cowpea and N at 175 kg ha^{-1}. Results showed that, maize intercropped with cowpea and N at 225 kg ha^{-1} gave higher grain yield 6.65 t ha^{-1} and 1.26 t ha^{-1} of maize and cowpea, respectively. The maximum net farm income and cost benefit ratio was obtained from maize intercropped with cowpea and N at 225 kg ha^{-1}.

Key words: Nitrogen · Maize · Cowpea · Intercroppining

INTRODUCTION

Crop yield and its contributing factors are under the influence of different factors as use of a suitable and balanced use of fertilizer is one of these. Crop fertilizer needs can be met with the addition of an organic fertilizer, which is highly expensive and is cost effective. The use of legumes as an intercrop can serve a cheaper source as organic fertilizer.Inorganic sources of nitrogen are very expensive and their losses are more as compared to organic sources. Usually the crop uses 30 to 50% of the inorganic nitrogen fertilizer applied, the rest is lost by volatilization, denitrification, or leaching as nitrate into the groundwater [1]. Intercropping is practiced by majority of farmers in many regions of the world. Intercropping has since long been used as mean to cover the risk of failure of base crop and it can lead to increasing food supply without decreasing the sustainability of soil. This system of cropping suppresses weeds, reduces pest disease infestation, gives yield advantage and there is stable yield over time [2]. To re-introduce legumes into the system at large enough scale to enable farmers to capture potential benefits of biological nitrogen fixation, the legume technologies need to give a competitive rate of return on investment compared to alternative investment options [3]. When nitrogen fertilizer is added to the field, intercropped legumes use the inorganic nitrogen instead of fixing nitrogen from the air and thus compete with maize for nitrogen. However, when nitrogen fertilizer is not applied, intercropped legumes will fix most of their nitrogen from the atmosphere and not compete with maize for nitrogen resources [4, 5]. Maize (*Zea mays* L.) and cowpeas (*Vigna unguiculata* L.) are important components of traditional mixed cropping systems in many countries of the world [6].The yield advantage may be in terms of higher yield or higher net income. These advantages can occur as a result of complementary use of growth resources such as nutrients, water and light by the component crops [4]. Maintenance of the fertility status of the soil is also an important factor in order to obtain stable and sustainable agro ecosystem [7]. The advantages are greater stability of yield over different season, better use of growth resources, better control of weeds pests and diseases, erosion control through providing continuous leaf cover over the ground surface [8, 9]. One of the most important reasons to grow two or more crops together is the increase in productivity per unit of land. Researchers have designed several methods for assessing intercrop performance as compared to pure stand yield, but the use of the land equivalent ratio (LER)

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has become common practice in intercropping studies, because of its relatively simple concept [10]. Intercropping has been reported to have yield advantage over sole cropping. These advantages can occur as a result of complementary use of growth resources [11, 12].

MATERIALS AND METHODS

A field study to investigate the impact of nitrogen application on the growth and yield of maize grown alone and in combination with cowpea was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad, during autumn in 2008. The initial soil sample was taken to determined fertility level of soil before sowing the crop. Experiment was laid out in randomized complete block design (RCBD) with three replications having a net plot size 3.6 x 5m. For ready reference The experiment comprised of following treatments maize alone control (T_1), maize intercropped with cowpea and N at 250 kg ha^{-1} (T_2), cowpea alone with nitrogen 25 kg ha^{-1} (T_3), maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4), maize intercropped with cowpea and N at 200 kg ha^{-1} (T_5) maize intercropped with cowpea and N at 175 kg ha^{-1} (T_6). Whole phosphorus and one third of nitrogen were applied at sowing, while remaining nitrogen was applied in split doses at knee height and at flowering. All other agronomic practices except nitrogen rates were kept normal and uniform for all the treatments. Data of various yield parameters such as plant height (cm), number of grains per ear,1000-grain weight (g), grain yield (t ha^{-1}),biological yield (t ha^{-1}), harvest index (%), land equivalent ratio and benefit cost ratio were recorded. On the other hand, in case of cowpea 1000 seed weight, 1000 -seed yield, biological yield and harvest index were also recorded. Data collected on various growth and yield parameters were subjected to analysis of variance techniques using appropriate statistical package. The treatments means was separated using LSD test at 0.05 probabilities [13].

RESULTS AND DISCUSSION

Maize: Plant height is an important yield component, as more green area more will be photosynthetic activity more will be share to grain yield. Data regarding to plant height of maize presented in Table 1 which show significant differences among different treatments. The cultivation of maize alone with full dose of nitrogen (T_2) showed the maximum height (216.5cm), which was followed by maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4) having plant height (213.7 cm). The minimum plant height was recorded in maize alone, no fertilizer (T_1) with 184.5 cm plant height. All the fertilizer treatment increased the plant height over control. Increase plant height with increasing in nitrogen rate was also observed by Ashfaq [14] Khan *et al.* [15] and Maqsood *et al.* [16].

Ear length was influenced significantly by different nitrogen levels along with cowpea intercropped. All the treatments resulted in more ear length as compared to control. The maximum ear length (17.37cm) was observed in maize alone with full dose of nitrogen (T_2), which was followed by maize intercropped with cowpea and N at 225 kg ha^{-1} (17.23cm). However all the treatments were statistically at par with each other, having ear length 17.37, 17.23, 16.86 and 16.23 cm in T_2, T_4, T_5 and T6, respectively. While maize alone, without fertilizer (T_1) produced the minimum ear length (10.39 cm).). The increase in ear length was due to fertilizer application. The results are in confirmatory of Kushwaha and Chandel [17] and Santalla *et al.* [18] and Sahu [19] who reported significant increase in ear length.

Number of grains per ear have direct effect on grain yield of maize per unit area. Data regarding number of grains per ear (Table 1) showed that all the treatments affected significantly. The maximum number of grains (692.0) per ear were counted in maize alone with full dose of nitrogen (T_2) which was followed by maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4) in which 664.3 number of grains per ear were counted. In maize alone,

Table 1: Impact of nitrogen application on growth and yield of maize (*Zea mays* L.) grown alone and in combination with cowpea (*Vigna unguiculata* L.)
A) Maize

Treatment	Plant height at maturity (cm)	Ear length (cm)	No. of Grains per ear	1000 grains weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	LER	BCR
T_1)Maize alone (control)	184.5e	10.93b	386.e	220.0c	2.97d	9.30d	31.93c	1.00	0.75
T_2)Maize alone + N at 250 kg ha^{-1}	216.5 a	17.37a	692.0a	302.7a	6.71a	19.33a	34.71ab	1.00	1.18
T_3)Cowpea alone N at 25 kg ha^{-1}	----	----	----	----	----	----	----	1.00	1.28
T_4)Maize+N at 225 kg ha^{-1}+Cowpea	213.7b	17.23a	664.3b	296.7a	6.66ab	19.07b	34.72a	1.86	2.02
T_5) Maize + N at 200 kg ha^{-1} +Cowpea	209.8 c	16.87a	607.3c	289.7 b	6.55b	18.93b	34.61ab	1.78	1.95
T_6) Maize + N at 175 kg ha^{-1} + Cowpea	207.0d	16.23a	543.5d	288.7 b	6.15c	18.06c	34.05b	1.69	1.79
LSD value	1.69	1.574	23.28	6.31	0.12	0.19	0.75		

Any two means not sharing a letter in common differ significantly at 0.05 probability level

Table 2: Impact of nitrogen application on growth and yield of maize (*Zea mays* L.) grown alone and in combination with cowpea (*Vigna unguiculata* L.) B. Cowpea

Treatment	1000-grains weight (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Harvest index (%)
T_1)Maize alone (control)	----	----	----	----
T_2)Maize alone + N at 250 kg ha^{-1}	----	----	----	----
T_3)Cowpea alone N at 25 kg ha^{-1}	95.32 a	3..63 a	1.42 a	39.12a
T_4)Maize+N at 225 kg ha^{-1}+Cowpea	90.33 b	3.25 b	1.26 b	38.79a
T_5) Maize + N at 200 kg ha^{-1} + Cowpea	86.00 c	3.07 c	1.16 c	37.79a
T_6) Maize + N at 175 kg ha^{-1} + Cowpea	83.33 d	2.97 d	1. 12c	37.71a
LSD value	1.01	0.06	0.06	2.24

Any two means not sharing a letter in common differ significantly at 0.05 probability level

without fertilizer (T_1) the minimum numbers of grains (386.0) per ear were recorded. These results are in contrary with the findings of Raja and Reddy [20] who reported that nitrogen fertilizer did not affect number of grains per cob, these contradictory results can be attributed to differences, genetic makeup of crop plant and fertility status of the soils, while Kushwaha and Chandel [17] and Sahu [19] found the same results in maize legume intercropping system.

1000-grain weight is an important yield determining factor. It expresses the magnitude of seed development for deriving the grain quality and yield per hectare.The data of 1000-grain weight (g) revealed that all the treatments increased 1000-grain weight over control showed in (Table 1). In maize alone with full dose of nitrogen (T_2) the maximum1000-grain weight (302.7 g) was recorded which was statistically at par with maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4) having (296.7g). The minimum1000-grain weight (220.0g) was recoded in maize alone, no fertilizer. These results are in agreement with the findings of Ashfaq [14], Kushwaha and Chandel [17] and Kushwava and Sahu [19] while contrary with the findings of Raja and Reddy [20] who reported that nitrogen fertilizer did not affect the 1000-grain weight.

Grain yield of crop is the ultimate objective of all the grain crops. This factor is related with many factors such as plant density and nutrients availability. So increase or decrease in any of the factor may influence the crop yield. In this study the maximum grain yield (6.717 t ha^{-1}) was recorded in maize alone with full dose of nitrogen (T_2) which was statistically at par with cowpea and N at 225 kg ha^{-1} (T_4) producing 6.66 t ha^{-1} (Table I). The minimum grain yield was observed in maize alone, no fertilizer (T_1), which produced (2.697 t ha^{-1}). The increased in grain yield was probably due to the more number of rows per ear, number of grains per row and 1000-grain weight etc. These results are supported by the findings of Jayakumar *et al.* [21] and Oguzor [22].

Biological yield is a measure of total dry matter production of crop during its life span presented in (Table 1) which effected significant study. All the treatments enhanced the biological yield over control. The maximum biological yield (19.33 t ha^{-1}) was recorded in of maize alone with full dose of nitrogen (T_2) which was statistically at par with maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4) and maize intercropped with cowpea and N at 200 kg ha^{-1} (T_5) having biological yield 19.07 and 18.93 t ha^{-1}. The minimum biological yield (9.3 t ha^{-1}) was observed in maize alone, without fertilizer (T_1). The increase in biological yield was due to abundant nitrogen application and cowpea (legume) intercropping with maize. It is therefore, concluded that on increase in N levels increased in biological yield. These results are supported by the findings of [23].

Land equivalent ratio is the relative area of sole crop or crops required to produce the yield or yields achieved in intercropping. LER represent the extra advantages of intercropping system. The maximum LER (1.86) was recorded in maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4) which was followed by maize intercropped with cowpea and N at 200 kg ha^{-1} (1.78). On the contrary, the minimum LER (1.00) was recorded in maize and cowpea monoculture maize alone without fertilizer (T_1), maize alone with full dose of nitrogen (T_2) and cowpea alone with full dose of nitrogen (T_3). The results indicated that T_4 gave the higher land use efficiency than mono cropping of maize.

Cowpea: 1000-seed weight is an important yield contributing parameter. The data in table-2 showed that 1000-seed weight (g) increased over control and had affected significantly. In cowpea alone with nitrogen 25 kg ha^{-1} (T_3), 1000-seed weight 95.32 (g) was recorded which was the highest in all treatments. The minimum of 1000- seed weight (83.33g) was recorded in maize intercropped with cowpea and N at 175 kg ha^{-1} (T_6). Seed yield of crop is the ultimate objective of all the grain crops. This is the fact that, it is related with many factors

such as plant density. So increase or decrease in any of the factors may influence the crop yield. Data pertaining in (Table 2) showed the maximum seed yield (1.423 t ha^{-1}) in cowpea alone N at 25 kg ha^{-1}(T_3). The minimum seed yield (1.127 t ha^{-1}) was observed in maize + N at 175 kg ha^{-1}+ cowpea maize intercropped with cowpea and N at 175 kg ha^{-1} (T_6) which was followed by T_5 (1.167 t ha^{-1}) as shown in table 2. The increase in seed yield was due to nitrogen application and biological nitrogen fixation. Data regarding biological yield indicates significant effect in this study. All the treatments enhanced the biological yield over control. The maximum biological yield of (3.630 t ha^{-1}) was recorded in cowpea alone with full dose of nitrogen (T_3). The minimum biological yield 2.973 (t ha^{-1}) was recorded in maize intercropped with cowpea and N at 175 kg ha^{-1} (T_6). The efficiency of a crop variety to convert the dry matter into economic yield is determined by its harvest index value. The highest the value, higher will be dry matter conversion efficiency. A perusal of the data reveals non significant. The maximum harvest index (39.20) was observed in cowpea alone nitrogen at 25 kg ha^{-1}, (T_3) which was statistically at par with all the treatments maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4), maize intercropped with cowpea and N at 200 kg ha^{-1} (T_5) and maize intercropped with cowpea and N at 175 kg ha^{-1} (T_6) having 38.81, 38.06 and 37.89 harvest index, respectively.

Economic analysis of maize based intercropping system with cowpea at various nitrogen levels is reveals that the maximum net farm income of Rs. 128802 was obtained from maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4), which was followed maize intercropped with cowpea and N at 200 kg ha^{-1} (T_5), which has net farm income Rs.122742. While the minimum (Rs. 24925) was obtained (maize alone, no fertilizer (T_1). The higher benefit cost ratio of 2.02 was obtained in maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4), which was followed by BCR values of 1.95, 1.79, 1.28, 1.18 and 0.75 of T_5, T_6, T_3, T_2 and T_1, respectively. These results are supported by [5] obtained that higher net income in different maize based intercropping system than monocropping of maize. These results are supported by [27] and [19].

CONCLUSION

The finally augmented the crop yield crop yield and sustain soil fertility and identified low cost techniques for maize and substitute nitrogen fertilizer with leguminous crop as an organic sources with cowpea. It was concluded that maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4) gave higher grain yield 6.65 t ha^{-1} and 1.26 t ha^{-1} of maize and cowpea, respectively.The maximum net farm income was obtained from maize intercropped with cowpea and N at 225 kg ha^{-1} (T_4).

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