SUMMARY AND CONCLUSION

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Two field trials were carried out at Zarzoora Experiment Station, El-Behaira governorate during 1999 and 2000 seasons to study the effect of biofertilizer application at different level of nitrogen fertilization on growth, yield, yield components and of maize and soybean in pure stand and intercropping. Twenty four treatments were the combinations of two cropping systems, i.e., pure stand and intercropping maize three way cross 320 and soybean cv. Giza 82 and inoculating maize or soybean with *Azospirillum brasilense* and *Brady rhizobium japonicum* and mineral fertilizer application at levels 0, 60, 90 and 120 Kg N/fed.. The following are the summary of the results obtained.

Soybean.

1. Effect of cropping system on :

I. Average number of nodules/plant.

Cropping system had a significant effect on number of nodules/plant. Active, unactive and total number of nodules/plant when soybean was intercropped with maize were significantly lower than those calculated in the root of pure stand soybean.

II. Growth characters.

Data indicate that soybean height and number of leaves/plant when plants were intercropped with maize significantly exceeded those grown in pure stand.

A tendency to branch more was associated with soybean grown in pure stand was observed.

III. Yield and yield components.

The average number of pods/plant, weight of pods/plant, average number of seeds/plant and weight of 100 seeds of soybean grown in pure stand were significantly higher than those of the intercropped soybean.

Seeds and straw yield of intercropped soybean plants were significantly less than those obtained of pure stand soybean.

Significant reductions in seed oil as well as seed protein contents were also observed when soybean was intercropped with maize as compared with pure stand.

2. Effect of nitrogen fertilizer levels on :

I. Average number of nodules/plant.

The effect of nitrogen fertilization rate on the average number of nodules/plant was distinctive. Values increased with increasing the rate of nitrogen fertilizer up to 60 Kg N/fed.. in case of the active and total nodules/plant. Thereafter, a slow down was observed up to the heaviest rate.

II. Effect on growth characters :

There were significant gradient and consistent increases in plant height of soybean plant with increasing the rate of nitrogen fertilizer up to the heaviest rate i.e., 120 Kg N/fed..

Increasing the rate of nitrogen fertilizer rate up to the heaviest rate had a similar effect on the average number of leaves/plant as well as the average number of

branches/plant. Where the number of leaves and branches/plant was the maximum.

III. Yield and yield components.

There were significant and gradual increases in the values of number of pods/plant, weight of pods/plant, number of seeds/plant and weight of 100 seeds with increasing nitrogen fertilizer rate up to 60 Kg N/fed., there after a regular decline in all traits were observed at 90 Kg N/fed., then another increases were recorded up to the heaviest dose, i.e., 120 Kg N/fed. Seed and straw yields /fed. followed the same course of change and significancy.

Nitrogen fertilization rate had the same effect on seed oil as well as seed crude protein contents.

3. Effect of bacterial inoculation on :

I. Average number of nodules/plant.

Inoculating soybean plants with the Rhizobia inoculant significantly increased the average active, unactive and total number of nodules/plant.

II. Growth characters.

Inoculating soybean with Rhizobium had favorable and significant effects on growth traits; plant height, the average number of leaves/plant and the average number of branches/plant. Data revealed that all values of these traits were significantly higher than those left without inoculation with the Rhizobia.

III. Yield and yield components.

Inoculating soybean with Rhizobia caused a significant increase in the average number of pods/plant, weight of pods/plant, number of seeds/plant and the weight of 100 seeds.

Seed yield/plant, seed yield fed., straw yield/fed. and the biological yield followed the same trend as the effect on yield components. The values of these traits were higher in inoculated soybean than the uninoculated one. Same trend and course of significancy were also observed on seed oil and seed protein contents which were higher in inoculated soybean as compared with uninoculated.

4. Interaction effect of cropping system with nitrogen fertilizer levels on :

I. Average number of nodules/plant.

The active and total number of nodules/plant significantly increased with increasing the rate of nitrogen fertilizer up to 60 Kg N/fed., thereafter a gradual slow down was observed up to the heaviest rate (120 Kg N/fed.) under both cropping systems. Nodulation was little higher within pure stand system as compared with the intercropping system. The highest number of nodules/plant was obtained from pure stand planting given 60 Kg N/fed..

II. Growth characters.

There were increases in plant height with increasing the rate of nitrogen fertilizer up to the heaviest whether soybean was grown in pure stand or intercropped with maize. Same results were observed on the average number of leaves and average

number of branches/plant. The highest number of leaves and branches/plant was obtained in intercropped and pure stand of soybean given 120 Kg N/fed. respectively.

III. Yield and yield components.

No. of pods and seeds/plant, weight of pods/plant and 100 seeds as well as seed yield/plant significantly increased up to 60 Kg N/fed., thereafter a slow down was observed in these values at 90 Kg N/fed.. Another increases were observed when soybean plants received 120 Kg N/fed.. These trends were observed under both cropping systems.

Values of these traits when soybean was grown in pure stand were always higher than those grown in the intercrop under the same treatment of N fertilizer. The highest values of yield component were obtained when soybean was grown in pure stand and given 120 Kg N/fed..

Resemblance to the effect of interaction on yield components traits was the effect on yield of seeds per plant and per feddan, yield of straw/fed. and biological yield/fed.. The highest values were obtained in pure stand grown soybean fertilized with 120 Kg N/fed..

Seed oil and seed crude protein contents behaved the same as the interaction effect on the yield parameter or yield components.

5. Interaction effect of cropping system and bacterial inoculation on:

I. Average number of nodules/plant.

Inoculating soybean plants with Rhizobia increased the number of active and total number of nodules/plant. It is also evident that there were ever increases in nodulation in pure stand rather than the intercropped soybean. Inoculated soybean grown in pure stand gave the highest number of nodules/plant.

II. Growth characters.

Inoculation with the Rhizobia stimulated plant height and average number of leaves/plant than plant left without inoculation under both cropping system. On other hand, plants were ever shorter in pure stand system as compared with those in the intercrop.

Soybean branching followed a reversal trend. The average number of branching when plants were grown in pure stand exceeded that of the intercropped plants whether soybean was inoculated or left uninoculated.

III. Yield and yield components.

Yield and yield components of soybean grown in pure stand were significantly always higher than those obtained when soybean was intercropped with maize. Whether plants were inoculated with the Rhizobia or left uninoculated.

Values of these traits when soybean was inoculated with the Rhizobia were ever significantly higher than those obtained from the uninoculated plants whether plants were grown sole or intercropped with maize. Inoculated soybean seeds grown in

pure stand gave the highest values of No. of pods and seeds/plant, weight of pods and 100 seed, seed yield/plant and fed. as well as straw and biological yield.

Both seed oil and crude protein contents followed the same trend, with same course of significance where the highest value was recorded in inoculated pure stand soybean.

6. Interaction effect of nitrogen fertilizer levels with bacteria inoculation with Rhizobia on :

I. Average number of nodules/plant.

Nodulation was severely affected by bacterial inoculation with the Rhizobia at different rates of nitrogen fertilizer. Sharp increases in nodulation was observed when plants were inoculated with the bacteria.

There were increases in the average number of nodules/plant with increasing nitrogen fertilizer rate up to 60 Kg N/fed., thereafter a decline in nodulation was observed. The highest number of nodules/plant was recorded in inoculated plants fertilized with 60 Kg N/fed..

II. Growth characters.

Data revealed consistent and gradient increases in soybean height with increasing nitrogen fertilizer rate up to 120 Kg N/fed. whether soybean was inoculated with the Rhizobia or left uninoculated. An exception was observed between plants received 90 Kg N/fed. and inoculated with Rhizobia and those received 60 Kg N/fed. and inoculated with the bacteria, where a reversal trend was observed. Soybean plant inoculated with the Rhizobia was always higher than the uninoculated under any

level of nitrogen fertilization. The tallest plants were obtained from inoculated plants and given 60 Kg/fed..

The interaction effect on soybean branching and the average number of leaves followed the same trend as in case of plant height. Same exception between 60 and 90 Kg N treatment was also evident. Inoculated plants fertilized with 60 Kg N/fed. produced the highest number of branches whereas the highest number of leaves/plant was obtained from inoculated plants fertilized with 120 Kg N/fed..

III. Yield and yield components.

Yield and yield components values significantly increased with increasing nitrogen fertilizer rate up to 60Kg N/fed., then their values decreased at 90 Kg N/fed.. Another increases were observed at 120 Kg N/fed.. Whether plants were inoculated with the Rhizobia or left uninoculated.

These traits were always higher when plant were inoculated with inocula as compared with plants left uninoculated at any respective treatment of nitrogen fertilization. Inoculating soybean plants gave the highest values of No. of pods and seeds/plant, weight of pods and 100 seed, seed yield/plant and fed. straw and biological yield when the plants were fertilized by 120 Kg N/fed..

Similar trend was noticed on seed oil content and seed protein content.

7. **Interaction effect of cropping system, nitrogen fertilizer levels and bacterial inoculation with the Rhizobia on :**

I. Average number of nodules/plant.

Number of nodules/plant was significantly affected by cropping system, nitrogen and bacterial inoculation. The highest value of active and total nodules/plant was obtained in inoculated plants grown in pure stand and give 60 Kg N/fed..

II. Growth characters.

Plant height, number of branches and leaves/plant were significantly affected by cropping system, nitrogen and inoculation. The tallest plants were produced from inoculating soybean seeds, grown with maize and given 60 Kg N/fed..

Inoculated intercropped plants fertilized with 120 Kg N/fed. had the highest number of leaves/plant. The highest number of branches were in inoculated plants grown in pure stand and given 60 Kg N/fed..

III. Yield and yield components.

Yield and yield components were tenaciously governed by the general tendencies of the three main variables.

The highest values of yield components as well as seed, straw and biological yield were obtained when pure stand soybean plants were inoculated with Rhizobia and received 120 Kg N/fed.

Maize.

1. Effect of cropping system on :

I. Number of active bacteria in maize root rhizospher.

The number of active bacteria in the rhizospere of maize root when maize was grown in pure stand was significantly higher than in maize intercropped with soybean.

II. Growth characters.

Intercropping had a depressive effect on maize height, topmost ear height, stalk diameter, leaf area of topmost ear and percent of plants with double ears where pure standing surpassed intercropping in these traits.

Number of days to 50% tasseling and silking was significantly lower when maize was intercropped with soybean than pure stand.

III. Yield and yield components.

Ear length, ear diameter, number of rows/ear, 100-kernel weight and shelling percent were insignificantly influenced by cropping system, although values of pure stand were relatively higher than those recorded in case of intercropped maize. On other hand, number of kernels/row, ear weight and kernels weight/ear followed the same trend, but with significant differences.

Intercropping had significant diminishing effects on grain, straw and the biological yields. Similar effects were observed on crude protein and oil percents in maize grains. Grain, straw and biological yield of maize in pure stand surpassed that in intercropping.

2. Effect of nitrogen fertilizer levels on :

I. Number of active bacteria in maize root rhizospher.

Addition of 60 Kg N/fed. increased number of active bacteria, thereafter gradual decreases were observed up to the heaviest rate (120 Kg N/fed.).

II. Growth characters.

Growth characters of maize, i.e., plant height, topmost ear height, leaf area of topmost ear, stem diameter and with double ears were positively responsive to increasing nitrogen fertilizer up to the heaviest rate (120 Kg N/fed.) in most cases.

Increasing nitrogen fertilizer level decreased both tasseling and silking except in case of the effect of the heaviest dose on tasseling where number of days were little lower than plant received 90 Kg N/fed..

III. Yield and yield components.

Most yield components of maize plants significantly increased with increasing N fertilizer level up to the heaviest, except number of rows/ear, 100-kernel weight and shelling percent.

Grain, straw and the biological yields/fed. followed same trend and course of significancy. These traits increased with the increase in n application up to 120 Kg N/fed.. Crude protein and oil percents in maize grain followed also same trend. Protein and oil percentage significantly increased with increasing nitrogen application up to the highest level.

3. Effect of Azospirilla inoculation on :

I. Number of active bacteria in maize root rhizospher.

The average number of Azospirilla in maize root rhizosphere increased with artificial inoculation with Azospirilla inocula.

II. Growth characters.

Plant height, leaf area of topmost ear and plants with double ears were positively and significantly affected by inoculation with the associative N_2-fixer bacteria.

Inoculating maize seeds with Azospirillum inocula had a significant and diminishing effect on number of days to 50% silking but insignificant effect on number of days to 50% tasseling was noticed.

III. Yield and yield components.

Inoculating maize seeds with Azospirilla had favorable effects on maize yield components. Significant differences were recorded in cases of ear length, ear weight and kernels weight/ear.

Same pattern of change and the course of significancy were observed on yield parameters as well as crude protein and oil percents of maize grains. Grain, straw and biological yield of maize in inoculated plants were higher than uninoculated ones

4. Effect of interaction of nitrogen fertilizer levels and cropping system on :

I. Number of active bacteria in maize root rhizospher.

The interaction effect of nitrogen fertilizer with cropping system was governed by both main variables.

Azospirillum count reached its maximal when maize was grown in pure stand and received 60 Kg N/fed..

II. Growth characters.

Values of plant height, topmost ear height, stem diameter leaf area of topmost ear and plants with double ears of pure stand maize were relatively higher than those recorded when maize was intercropped with soybean. Values of growth traits increased with increasing nitrogen level up to the heaviest under the two cropping system.

The highest values of these traits were recorded in pure stand maize received 120 Kg N/fed.

Values of number of days to 50% tasseling decreased up to the heaviest rate of N whatever the cropping system used, except, between 90 Kg N/fed. and 120 Kg N/fed. where the effect was reversed. The lowest value was in intercropped maize given 90 Kg N/fed.

Number of days to 50% silking decreased consistently with increasing N fertilizer rate up to the heaviest in both cropping systems.

Intercropped maize produced the lowest number when received 120 Kg N/fed.

III. Yield and yield components.

Most traits of yield components improved with increasing nitrogen fertilizer level up to the heaviest, except in case of number of rows/ear.

Relative increases in the values of these traits when maize was grown in pure stand. The highest values of ear length and diameter, number of rows, ear, kernel, ear weight and kernel weight/ear were obtained in pure stand maize given 120 Kg N/fed.

Yield parameters as well as crude protein and oil percents in maize grain followed same patterns and course of significance.

The highest grain, straw and biological yield as well as oil and protein content were recorded in pure stand growing given 120 Kg N/fed..

5. Effect of cropping system and inoculation with Azospirilla on :

I. Number of active bacteria in maize root rhizospher.

Inoculating maize seeds with Azospirilla inocullum had an activating effect on Azospirilla count under pure stand and intercropped maize. Maize inoculated with Azospirilla and grown in pure stand had the highest value of active and total bacteria in its root rhizospher

II. Growth characters.

Values of growth characters of maize grown in pure stand were relatively higher than those grown in association with soybean at any level of inoculation.

Growth traits of inoculated maize with Azospirilla and grown in pure stand were superior to those recorded on the untreated and intercropped maize.

Tasseling as well as silking when maize was inoculated with Azospirilla appeared earlier as compared with plant left without inoculation under the two cropping system.

The earliest maize plants were recorded from those intercropped with soybean and inoculated with Azosperilla.

III. Yield and yield components.

Yield components of pure stand maize were always higher than those of maize intercropped with soybean, and when maize was inoculated with Azospirilla than those remained uninoculated.

The highest yield of seed, straw and biological as well as yield component were obtained in inoculated plants grown in pure stand.

Crude protein and oil percents of maize grain were similarly affected by both variable (cropping system and inoculating maize seeds with Azospirilla).

6. Interaction effect of nitrogen fertilizer levels with inoculation with Azospirilla on :

I. Number of active bacteria in maize root rhizospher.

Number of active bacteria of inoculated maize treatments exceeded the untreated maize treatments under the different levels of nitrogen. The highest number of active bacteria in the soil was recorded in inoculated plants which received 60 Kg N/fed.

II. Growth characters.

Growth characters of maize gradually increased up to 60 Kg N/fed., then a slow down was observed at 90 Kg N/fed.. Rather

increase was associated with the heaviest level whether plants were inoculated or uninoculated. Values of growth characters of maize were the highest when seeds were inoculated with Azospirilla and given 120 Kg N/fed..

There were gradual decreases in number of days to 50% silking with increasing nitrogen fertilizer level up to the heaviest (120 Kg N/fed.) in inoculated and uninoculated plants. Inoculated maize plants with Azospirilla fertilized with 120 Kg N/fed. were the earliest ones in tasseling and silking.

III. Yield and yield components.

All yield components as well as yield parameters, crude protein and oil percents of maize grains increased with increasing nitrogen fertilizer level up to the heaviest (120 Kg N/fed.) whether maize was inoculated or left uninoculated. Inoculated maize fertilized with 120 Kg N/fed. gave the highest grain, straw and biological yield as well as yield components.

The results also revealed that all values of these traits when maize was inoculated with the bacteria exceeded those uninoculated.

7. The interaction effect of cropping system, nitrogen fertilizer levels and inoculation with Azospirilla on :

I. Number of active bacteria in maize root rhizospher.

Inoculation with Azospirilla raised the number of active bacteria under any level of nitrogen whether maize was grown alone or in the intercrop. Inoculated maize plants received 60 Kg N/fed. and grown in pure stand produced the highest number of active bacteria in the soil.

II. Growth characters.

The effect of the combined interaction of the three main variables, i.e., cropping system, inoculation with Azospirilla and nitrogen fertilization level on growth characters followed the general tendency of the three main variables when behaved individually. The highest values of growth characters were recorded in inoculated plants grown in pure stand and given 120 Kg N/fed..

The interaction effect on the number of days to 50% tasseling or silking was also significant. Inoculated plants grown with soybean and given 90 Kg N/fed. were the earliest in silking and tasseling.

III. Yield and yield components.

Yield components of maize, yield parameter and crude protein and oil percents of maize grains were governed by the course of change of the three main variables (inoculation with Azospirilla, nitrogen fertilizer level and the cropping system) as they behaved individually.

Maximum values of grain, straw and biological yield as well as protein and oil percentage were obtained when maize was grown alone with seeds inoculated with Azospirilla and received heaviest dose of nitrogen fertilizer (120 Kg N/fed.).

Competitive relationships.

Results evidenced that while LER_s of soybean never exceeded 50% of sole planting. Productivity under all nitrogen fertilizer levels and whether plants were inoculated with the bacteria or left uninoculated (were going round 40%) LER_s of

maize exceeded half the sole planting productivity (were going round 60%).

Results on total LER evidenced that the effect was more appreciable by inoculation state rather than nitrogen fertilize. Values of total LER_s increased with increasing nitrogen fertilizer and by inoculation with N-fixer bacteria. The data revealed also that all values obtained were higher than the unit; nevertheless, yield advantage never exceeded 13%. Maximum values of Land Equivalent Ratio were obtained when plants received 60 Kg N/fed. and were inoculated with N-fixer bacteria.

Relative Crowding Coefficient parameters followed the same pattern of change as the LER were influenced. Maximum values were obtained when plants were fertilized with 60 Kg N/fed. and inoculated with N-fixer bacteria.

Agressivity data indicate that in all levels of N fertilizer whether plants were inoculated with N-fixer bacteria, maize was the dominant components and soybean was the dominated. All values obtained were not high enough to exert heavy competitive pressure on both components in the intercrop.

Competitive Ratio value revealed that CR of maize was ever higher than that of soybean under any level of nitrogen or whether plants were inoculated with N_2-fixer bacteria or left uninoculated.

Area Time Equivalent Ratio values were lower than those recorded on LER. Increases with increasing N-fertilizer level up to 60 Kg N/fed. was observed thereafter a slow down was observed at 90 Kg N/fed. another increase was evident at the

heaviest dose (120 Kg N/fed.). There were also ever higher values when plants were inoculated with N-fixer bacteria as compared with uninoculated plants under same respective level of nitrogen fertilizer

Cereal Units (CUs).

Data revealed that none of the interaction treatments of the intercropped maize could produce more cereal units than the pure stand maize at the same respective treatment.

All values under any level of N-fertilizer were higher when maize was inoculated with the bacteria as compared with the uninoculated maize.

Cereal units produced from intercropped soybean were always lower than those produced from pure stand soybean under same respective treatment of N fertilizer or state of inoculation.

Cereal units produced from soybean increased with first dose of N fertilizer (60 Kg N/fed.) thereafter a slow down was observed at 90 Kg N/fed.. then another increase was also observed with the heaviest dose (120 Kg N/fed.) under each of the cropping system and inoculated state.

All values of Cereal units of soybean when plants were inoculated with N_2-fixer bacteria were always higher than those obtained from uninoculated under any level of N fertilizer.

Data also revealed that the total cereal unit resulted from the intercrop system (soybean/maize) was at maximal when both crops were inoculated with N_2fixer bacteria and received 120 kg N/fed. And exceed total cereal unit produced from maize pure stand by 6.13% in 1999 season. Total cereal units produced from

pure stand soybean by 26.78, 52.08% in 1999 and 2000 seasons, respectively.

Conclusion:

It could be concluded that inoculating maize with Azosprilla and soybean with Rhizobia and supplying the intercrop system with 60 Kg N/fed. (as Urea) resulted in maximum land equivalent ratio. In addition this system could save any more of the nitrogen fertilization (i.e up to 120 Kg N/fed.).