Int.J.Curr.Microbiol.App.Sci (2019) *8*(3): 2246-2254

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 03 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.803.268

Availability of Mineral Nitrogen in Soil under Maize + Soybean Intercropping System

Pragya Pandey[1]* and R.K. Bajpai[2]

[1]Krishi Vigyan Kendra, Bemetara (Chhattisgarh), India
[2]Directorate of Research, Indira Gandhi Agricultural University, Raipur (Chhattisgarh), India

**Corresponding author*

Keywords

Crop arrangement, Nutrient management, Ammonical nitrogen, Nitrate nitrogen

Article Info

Accepted:
20 February 2019
Available Online:
10 March 2019

ABSTRACT

This field experiment was conducted during the *kharif* season of 2014 and 2015 at the Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) to find out the effect of crop arrangement and nutrient management on availability of nutrients under maize and soybean intercropping system. Treatments comprised of six cropping arrangements *viz.* sole maize (C_1), sole soybean (C_2), two replacement series of maize + soybean (2:2, C_3 and 2:4, C_4), two additive series in which two rows (C_5) and one row (C_6) of soybean were added in-between two rows of maize and four fertility levels *viz.* 125% recommended dose of fertilizer (RDF) (F_1), 100% RDF (F_2), 75% RDF (F_3) and 50% RDF (F_4). Two control plots; control$_1$ and control$_2$ (From the two additive series plots soybean rows were omitted and the space between paired row of maize were left fellow) were planted in order to calculate the amount of mineral nitrogen supplemented by soybean to maize. Results of this experiment show the higher availability of nutrients in soil under intercropping over sole plantation. Out of six crop arrangements 2:4 replacement series of maize and soybean showed the highest availability of NH_4^+-N and NO_3^--N in soil and this was closely followed by maize + soybean 2:2 crop arrangement. However, the lowest availability of mineral nitrogen was observed from the sole soybean. Among different nutrient management the highest and lowest availability of aforesaid nutrients were reported in the treatment fertilized with 125% and 50% RDF, respectively. Intercropped treatments exhibited 10.76 and 8.39 per cent higher availability of NH_4^+-N and 13.13 and 7 per cent higher availability NO_3^--N in soil in comparison to control$_1$ and control$_2$, respectively. Around 17.09 kg ha^{-1} higher available mineral nitrogen (NH_4^+-N + NO_3^--N) was reported under intercropping treatments than control plots. This additional amount of available NH_4^+-N and NO_3^--N was supplied by the soybean through biological nitrogen fixation.

Introduction

Economic constraints among small scale farmers in India limit sole inorganic fertilizer use. Further, the use of fertilizer, pesticides and various synthetic chemicals leads to the degradation of cultivable land and natural resources. Thus it is necessary to find additional sources of N that would embrace the smallholder socio-economic status. Cereal + grain legume intercropping is one of them. Growing of cereal with grain legume has not only gives higher yield but also has the potential to address the soil nutrient depletion on smallholder farms (Sanginga and Woomer, 2009). Maize and soybean are promising crops in aerable lands of Chhattisgarh besides rice as main crop in medium and low land situation. Intercropping of legumes in maize was found productive economically and energetically viable (Pandey *et al.,* 2003) compared to either of the sole crops. Soybean is considered as an ideal crop for intercropping with maize owing to its comparative tolerance for shade and drought, efficient light utilization and less competitiveness for soil moisture (Wright *et al.,* 1988).

Intercropping is a viable agronomic practice for stepping up the production of these crops from a unit of land besides sustaining the soil health through biological nitrogen fixation by soybean during a cropping period. Sustainable production of these crops requires a careful management of all nutrient sources available in a farm, particularly in maize based cropping systems. These include inorganic fertilizers and integration of legume crops in cereal based mono cropping (Wakene *et al.,* 2007). Maize being an exhaustive crop requires high quantity of fertilizers, particularly nitrogenous. In intercropping systems, legumes can provide N for intercropped cereals through N transfer. Thus being a legume crop soybean is capable of supplying nitrogen for its growth and intercropped cereals through symbiotic nitrogen fixation, and hence reduces the need for expensive and environment polluting nitrogen fertilizer (Ning *et al.,* 2012).

Transformation of added nitrogen through fertilizers, manures or biological nitrogen fixation into different forms of nitrogen in soil and their availability to crops depends on soil properties and nature of nitrogen sources added to soils. According to the research reports, more than 90 per cent of nitrogen in the soil is present in organic form and concentrations of inorganic form *viz.,* nitrate nitrogen and ammonical nitrogen in soil at any given time is influenced by several soil factors. So to maintain the higher availability of nutrients in order to obtain the optimum yield from the intercropping system, there is need to take care of different types of competitions between the intercrops. Therefore, this experiment is an attempt to study the proper arrangement of component crops in order to avoid limitation of reduced plant population of base crop under traditional intercropping system and a careful management of all nutrient sources which includes inorganic fertilizers as well as the biologically fixed nitrogen provided by soybean to maize so that higher production unit^{-1} of land could be achieved.

Materials and Methods

Field experiment was conducted during the *kharif* season (July to October) of 2014 and 2015 at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur situated in central parts of Chhattisgarh and lies at latitude, longitude and altitude of 21^{o}4′ N, 81^{o}35′ E and 290.20 metres above mean sea level, respectively. The hybrid maize variety Hishell and soybean variety Jawahar Soybean 97-52 (JS 97-52) were used in the experiment. Soil of experimental site was caly (*Vertisol*) with neutral pH (7.50) and 0.26 dSm EC. Soil was low in nitrogen (175.61 kg ha^{-1}) and phosphorus (10.74 kg ha^{-1}) and potassium availability was medium (330.74 kg ha^{-1}). The experiment was laid out in Factorial Randomised Block Design with one additional plot design. There were 3 replications and all of them were divided into 24 + 2 experimental treatments and each treatment was applied to a plot had an area of 38.4 m^{2}. Maize and soybean were spaced at a spacing of 60×20 cm^2 and 5x30 cm^2, respectively. Treatments comprised of six cropping arrangements *viz*. sole maize (C_1), sole soybean (C_2), maize + soybean in 2:2 (C_3) and 2:4 (C_4) rows in replacement series and two additive series (two rows of soybean (C_5) and one row of soybean (C_6) planted in-between two rows of maize and four fertility levels viz. 125% recommended dose of fertilizer (RDF) (F_1), 100% RDF (F_2), 75% RDF (F_3) and 50% RDF (F_4). Recommended dose of fertilizer used for maize was 110 kg N ha^{-1}, 60 P_2O_5 kg ha^{-1} and 40 K_2O kg ha^{-1} and for soybean was 20 N kg ha^{-1}, 60 P_2O_5 kg ha^{-1} and 40 K_2O kg ha^{-1}. Analysis of availability of ammonium and nitrate nitrogen was done by Steam distillation method as suggested by Bremner and Keeney (1965). To find out the amount of nitrogen supplemented by soybean to maize we compared the mean availability of mineral nitrogen (Ammonium and nitrate) from 24 treatments and this was compared with control plots. For this comparison two control plots were taken in which the soybean rows planted in between paired maize rows (Under two additive series i.e. 2M + 2S and 2M + 4S) were omitted and space occupied by the soybean rows were left fellow. So two paired row of maize (row x row spacing, 60 cm) were planted at 90 cm distance in $control_1$ and 150 cm distance in $control_2$. 100% RDF was applied to both the control plots. The experimental data were statistically analyzed for analysis of variance and test of significance as described by Gomez and Gomez (1984).

Results and Discussion

Availability of nitrogen in soil

Availability of nitrogen in soil was significantly influenced by the treatments imposed. Observations were taken at periodic interval of 20 days till harvest *i.e.* at 20, 40, 60, 80 DAS and at harvest. Availability of the mineral nitrogen increase upto 60 DAS but after that till harvest decreasing trend was reported. This was due to the three reasons: (1) Side placement of fertilizer to the crops was done at the critical growth stages (between 40-60 DAS) of crop, application of fertilizer at this stage/duration has increased the availability of nutrients in soil (2) Maximum uptake of nutrients take place at major growth period of crop i.e. during 40-80 DAS and as the crop has already taken up the majority of nutrients from the soil during this time period, the availability of nutrient later on was decreased. (3) As the crop advances to harvesting, especially during 80 DAS to harvesting, the moisture level in the soil of the field goes down and this drastically reduces the availability of ammonium nitrogen. This is in agreement with Li *et al.*, (2001).

Availability of ammonium-N

Among six crop arrangements, 2 maize + 4 soybean replacement series (C_4) showed the highest value of available NH_4^+-N from 20 DAS till harvest except at 80 DAS when paired row replacement series (C_3) recorded the highest available NH_4^+-N in soil (Table 1). However, these two treatments were reported at par at all the observational stages except at 60 DAS. This finding is in line with the result explained by Matusso *et al.*, (2014).

On the other hand, comparatively lower availability NH_4^+-N was observed from sole maize (C_1) and sole soybean (C_2). Further sole soybean (C_2) recorded the lowest value throughout the crop growth period. Higher availability of NH_4^+-N in intercropping than sole planting is due to the contribution of biological nitrogen fixed by intercropped soybean in addition to the applied synthetic fertilizers. Among different nutrient management, treatments fertilized with 125% RDF (F_1) and 50% RDF (F_4) showed significantly higher and lower value of available NH_4^+-N, respectively, in soil over remaining nutrient managements. The reason behind this was increasing amount of nitrogen fertilizer application rates from 50% to 125% RDF. Kebeney *et al.,* (2015) also reported the same.

Availability of nitrate -N

Throughout the crop growth stage highest availability of NO_3^--N in soil was reported from C_4 i.e. 2 maize + 4 soybean intercropping system and this was found comparable with the additive series C_5 (Two rows of soybean added in between two rows of maize) at all the observational stage except at - harvest. Increase in NO_3-N content may be ascribed to nitrification of NH_4-N to NO_3-N by soil microorganisms (Santhy *et al.,* 1998).

On the other hand, the lowest available NO_3^--N in soil was recorded from sole soybean (C_2), however, this found comparable with sole maize throughout the crop growth period (Table 2). Regarding nutrient management maximum available NO_3^--N in soil was obtained under highest amount of fertilizer applied soil i.e. 125% RDF. With the decrease in fertility levels from 125% RDF to 50% RDF significant decrease in NO_3^--N availability in soil was reported.

Mineral nitrogen (Ammonium and nitrate) supplemented by soybean to maize

Legumes enrich soil by fixing the atmospheric nitrogen converting it from an inorganic form to forms that are available for plants uptake. Biological fixation of atmospheric nitrogen can replace nitrogen fertilization wholly or in part.

Biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems when nitrogen fertilizer is limited. Moreover, because inorganic fertilizers have much environmental damage such as nitrate pollution, legumes grown in intercropping are regarded as a sustainable and alternative way of introducing N into lower input agro ecosystems (Fustec *et al.,* 2010).

In Table 3 mean data related to the availability of NH_4^+-N (mg kg^{-1} of soil) of the 24 treatment combinations of crop arrangements and nutrient managements (Rest) is presented which were compared to the two control treatments i.e. $control_1$ (Paired row maize planted at 60 cm and spacing between two pairs of rows was 90 cm + 100% RDF) and $control_2$ (Paired row maize were planted at 60 cm and spacing between two pairs was 150 cm + 100% RDF).

In case of availability of NH_4^+-N, non - significant difference between rest and controls were reported at 20 DAS, but later on mean availability of NH_4^+-N in soil of 24 treatments (Combinations of the crop arrangement and nutrient management) showed significant higher availability over both the controls (Table 3). Significant variation in the availability of NH_4^+-N in soil of $control_1$ and rest (Mean availability from 24 treatments) was recorded at all the observational stages.

But in case of $control_2$, the availability of NH_4^+-N was found comparable with rest upto 40 DAS of crop growth and afterward till harvest the mean availability from the 24 treatments i.e. rest was reported significantly superior over $control_2$. But the highest availability of NO_3^--N in soil was reported from rest and this was followed by $control_2$ (two paired row of maize spaced at 60 cm planted at a distance of 150 cm with each other) throughout the crop growth stage (Table 4). Osunde *et al.,* (2004) also found higher nitrogen availability in intercropping and observed that the proportion of nitrogen derived from atmosphere fixation was about 40 percent in the intercropped soybean and 30 percent in the sole crop without the addition of fertilizer.

At harvest stage the 6.63 and 5.17 kg higher mean availability of NH_4^+-N ha^{-1} was reported from the intercroping in comparison to $control_1$ and $control_2$, respectively and in case of NO_3^--N this additional availability was 16.47 and 9.02 kg ha^{-1} higher than $control_1$ and $control_2$, respectively.

Between the two controls, $control_2$ proved to be more advantageous over $control_1$ and showed higher availability of mineral nitrogen in soil, however the difference between the two controls was non-significant at all the observational stages.

Grain yield

The grain yield was significantly influenced by different cropping system and nutrient levels. Among crop arrangements C_3, Maize + soybean (2:2, replacement series) produced significantly higher grain yield over rest of the crop arrangement (Table 5).

This was followed by additive series C_5 (two rows of soybean added in between two rows of maize). The significantly lower producer was sole soybean. Under maize + soybean intercropping systems, soybean yield tends to be lower and maize yield tends to be higher (Ghaffarzaeh *et al.*, 1994). The increase in the total grain production of intercropping system obviously was the result of additional yield of soybean as bonus by utilization of inter-row space of maize crop.

Table.1 Availability of NH4+- N in soil as influenced by the crop arrangement and nutrient management under maize + soybean intercropping system (Mean data of 2014 and 2015)

Available ammonium-N (mg kg^{-1} of soil)					
Treatments	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
Crop arrangement					
C_1	16.61	31.66	44.43	34.44	26.71
C_2	16.20	30.24	43.15	33.10	26.13
C_3	17.45	33.13	46.07	37.18	28.09
C_4	17.66	33.75	47.22	36.68	28.86
C_5	17.20	32.54	45.52	35.72	27.55
C_6	16.91	31.87	44.45	35.00	27.14
SEm±	0.21	0.50	0.63	0.44	0.40
CD (P=0.05)	0.50	1.18	1.49	1.05	0.94
Nutrient management					
F_1	19.00	35.65	49.57	38.83	30.34
F_2	17.33	32.93	46.43	35.97	28.32
F_3	16.24	31.14	43.66	34.02	26.40
F_4	15.43	29.07	40.89	32.59	24.58
SEm±	0.17	0.40	0.51	0.36	0.32
CD (P=0.05)	0.41	0.96	1.22	0.86	0.77

Table.2 Availability of NO3-- N in soil as influenced by the crop arrangement and nutrient management under maize + soybean intercropping system (Mean data of 2014 and 2015)

Available ammonium-N (mg kg^{-1} of soil)					
Treatments	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
Crop arrangement					
C_1	53.50	66.26	92.48	73.00	55.04
C_2	53.11	65.60	92.47	72.33	54.43
C_3	56.13	68.54	95.40	75.31	56.24
C_4	57.41	69.52	96.97	76.78	57.52
C_5	55.25	67.87	94.28	74.49	55.97
C_6	54.45	66.67	93.66	73.51	55.19
SEm±	0.66	0.55	0.73	0.73	0.43
CD (P=0.05)	1.56	1.29	1.73	1.73	1.02
Nutrient management					
F_1	59.65	73.37	101.67	80.36	60.49
F_2	56.20	68.66	96.66	76.22	56.85
F_3	53.06	65.28	91.46	71.61	54.00
F_4	51.00	62.34	87.05	68.75	51.58
SEm±	0.54	0.45	0.59	0.59	0.35
CD (P=0.05)	1.27	1.06	1.41	1.41	0.83

C_1-Sole maize, C_2-Sole soybean, C_3-Maize+ soybean, 2:2, C_4-Maize+ soybean, 2:4, C_5- Two rows of soybean planted in between two rows of maize, C_6 -One row of soybean planted in between two rows of maize, F_1-125% RDF, F_2 -100% RDF, F_3 -75% RDF, F_4 -50% RDF

Table.3 Status of NH4+ - N in the soil under maize + soybean intercropping system and control plots (Mean data of 2014 and 2015)

Available ammonium-N (mg kg^{-1} of soil)					
Control vs. rest	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
Rest	17.00	32.20	45.14	35.35	27.41
$Control_1$	16.53	28.95	41.40	32.03	24.46
SEm±	0.43	1.01	1.28	0.91	0.82
SEd±	0.60	1.40	1.78	1.25	1.14
CD (P=0.05)	NS	2.82	3.57	2.52	2.28
$Control_2$	17.29	31.11	41.67	32.56	25.11
SEm±	0.43	1.30	1.30	0.90	0.81
SEd±	0.59	1.42	1.25	1.25	1.12
CD (P=0.05)	NS	2.87	3.61	2.50	2.25
Con_1vs.Con_2	NS	NS	NS	NS	NS

Table.4 Status of NO3- - N in soil under maize + soybean intercropping system and control plots (Mean data of 2014 and 2015)

Available nitrate-N (mg kg^{-1} of soil)					
Control vs. rest	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
Rest	54.98	67.41	94.21	74.24	55.73
$Control_1$	49.96	55.64	81.12	60.37	48.41
SEm±	1.34	1.11	1.48	1.50	0.87
SEd±	1.86	1.54	2.05	2.06	1.21
CD (P=0.05)	3.74	3.10	4.13	4.14	2.43
$Control_2$	51.16	59.95	89.48	60.69	51.72
SEm±	1.12	0.87	1.49	1.38	0.94
SEd±	1.55	1.21	2.06	1.91	1.30
CD (P=0.05)	3.12	2.43	4.14	3.84	2.61
Con_1vs.Con_2	NS	NS	NS	NS	NS

Rest- Mean availability of NH_4^+ - N in soil from 24 combination of crop arrangement and nutrient management, $Control_1$ - Paired row planting of maize at 60 cm and spacing between two pairs was 90 cm + 100% RDF, $Control_2$ - Paired row planting of maize at 60 cm and spacing between two pairs was 150 cm + 100% RDF

Table.5 Effect of cropping arrangement and fertility levels on light interception (%) and grain maize equivalent yield (q ha-1) of maize under maize + soybean intercropping system (Mean data of 2014 and 2015)

Treatment	Grain maize equivalent yield (q ha^{-1})
Cropping arrangement	
C_1 (Sole maize)	60.30
C_2 (Sole soybean)	27.80
C_3 (Maize + soybean, 2:2)	71.90
C_4 (Maize + Soybean, 2:4)	49.00
C_5 (Two row of soybean planted in between two row of maize)	64.60
C_6 (One row of soybean planted in between two row of maize)	63.20
SEm±	0.84
CD (P=0.05)	2.36
Nutrient management	
F_1(125% RDF)	62.50
F_2 (100% RDF)	59.10
F_3 (75% RDF)	53.70
F_4 (50% RDF)	49.20
SEm±	0.69
CD (P=0.05)	1.93

Htet *et al.,* (2016) indicated that, legume contribution to corn in mixtures was significant and increased the total biomass yield of mixtures. Our findings are in accordance with these researches. Among four nutrient levels, the grain yield obtained from F_1 (125% RDF) was highest and significantly superior because of the superior yield attributing characters. Panhwar *et al.*, (2004) concluded that fertilizer levels exhibited highly significant effect on grain yield of maize. However, the lowest grain yield was reported from the treatment with 50% RDF (F_4).

References

Bremner, J.M. and Keeney, D.R. 1965. Steam distillation methods for determination of ammonium, nitrate, and nitrite. Anal. Chem. Acta., 32: 485-495.

Fustec, J., Lesuffleur, F., Mahieu, S. and Cliquet, J. B. 2010. Nitrogen rhizodeposition of legumes- A Review. *Agron Sustain Dev*, 30: 57-66.

Ghaffarzaeh, M., Prechac, F.G. and Cruse, R.M. 1994. Grain yield response of corn, soybean and oat grown under strip intercropping systems. Am. Altern. Agric., 9:171-177.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedure for agricultural research. John Wiley and Sons Publication 2nd edition. NewYork, p. 680.

Htet, M.N., Soomro, N.S. and Jiang, b.O.H. 2016. Effect of Intercropping of maize (*Zea mays* L.) and soybean (*Glycine max* L.) on green forage yield and quality evaluation. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 9(12):59-63.

Kebeney, S. J., Semoka, J. M. R., Msanya, B. M., Ng'etich, W. K. and Chemei, D. K. 2015. Effects of nitrogen fertilizer rates and soybean residue management on nitrate nitrogen in sorghum-soybean intercropping system. Internation//al Journal of Plant and Soil Science, 4(3):212-229.

Li, L., Sun, J., Zhang, F., Li, X., Yang, S., and Rengel, Z. 2001. Wheat-maize or wheat-soybean strip intercropping I yield advantage and interspecific interaction on nutrients. Field Crop Res., 71: 123-137.

Matusso, J.M.M. 2014. Effects of maize (*Zea mays*L.)- soybean (*Glycine max* L. *Merrill*) Intercropping patterns on yields and soil properties in two contrasting sites of Embu and Counties, Kenya. PhD thesis, Kenyatta University, Kenya, p.29

Ning T, Zheng Y, Han H, Jiang G, Li Z. 2012. Nitrogen Uptake, Biomass Yield and Quality of Intercropped Spring- and Summer-Sown Maize at Different Nitrogen Levels in the North China Plain. Biomass Bioenergy, 47:91-98.

Osunde, A.O., Tsado, P.A., Bala, A. and Sanginga, N. 2004. Productivity of maize promiscuous soybean intercrop as affected by the fertilizer in the Southern Guinea Sawanna Zone of Nigeria. West African Journal of Applied Ecology, 5: 51-62.

Pandey, Z.B., Bharati, Y. and Mishra, S.S. 2003. Effect of maize (*Zea mays*)-based intercropping systems on maize yield and associated weeds under rainfed condition. Indian Journal of Agronomy, 48(1): 30–33.

Panhwar, M.A., Memon, F.H., Kalhoro, M.A. and Soomro, M.I. 2004. Performance of maize in intercropping system with soybean under different planting pattern and nitrogen levels. *Journal of Applied Sciences*, 4(2): 201-204.

Sanginga N and Woomer P.L. 2009. Integrated soil Fertility management in Africa: Principles, Practices and Development Process. (Eds.). Tropical

Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture. Nairobi, pp. 263.

Santhy, P., Jayasree, S., Muthuvel, P. and Selvi, D. 1998. Long-term fertilizer experiments. Status of N, P and K fractions in soil. *J. Indian Soc. Soil Sci.* 46: 395-98.

Singh, M., Singh, P. and Nepalia, V. 2005. Integrated weed management studied in maize based intercropping system. *Indian Journal of Weed Science* 37(3-4): 205-208.

Wakene, N., Fite G., Abdena and Birhanu, D. 2007. Integrated use of organic and inorganic fertilizers for maize production. *In utilization diversity in land use systems: Sustainable and organic approaches to meet human needs.* Conference Tropentag, October 9-12, Witzenhousen, Kassel, Germany.

Wright, G.C., Smith, C.J. and Nelson, I.B. 1988. Growth and yield of soybean under wet soil culture and conventional furrow irrigation in South-Eastern Australia. Irrigation Science, 9: 127–192.

How to cite this article:

Pragya Pandey and Bajpai, R.K. 2019. Availability of Mineral Nitrogen in Soil under Maize + Soybean Intercropping System. *Int.J.Curr.Microbiol.App.Sci.* 8(03): 2246-2254. doi: https://doi.org/10.20546/ijcmas.2019.803.268