Ann. Agric. Res. New Series Vol. 35 (1) : 32-36 (2014)

Growth and yield of soybean as influenced by maize + soybean intercropping systems and nitrogen levels

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Received : July 2012; Revised accepted : October 2013

Abstract

A field investigation was conducted at Amar Singh College, Lakhaoti, Bulandshahr during *kharif* seasons of 2009 and 2010 to study the growth and yield performance of soybean under maize + soybean intercropping systems and nitrogen levels. Soybean grown as intercrop registered significantly higher growth and yield up to application of 40 kg N/ha to maize crop. The higher levels at 80 kg and 120 kg N/ha failed to produce significant effect. Similarly, the grain and stover yield showed significant improvement up to 80 kg N/ha. Increase in nitrogen upto 80 kg N/ha to maize crop did not show any adverse effect on soybean since except basal dose, the fertilizers were applied only to maize crop row zone. Maize + soybean intercropping led to efficient use of land and higher economic return. Interaction effect between cropping systems and N levels was not significant. The benefit : cost ratio was enhanced with maize + soybean intercropping in additive series and was superior as soybean improved the fertility status of soil.

Key words : Cropping systems, nitrogen, yield, maize, soybean.

Soybean is known as the 'Golden bean' of twentieth century. It is the largest oilseed in India followed by groundnut. Several countries, such as Japan, China, Indonesia, Philippines and European countries are importing soybean to supplement their diet for human consumption and cattle feed. In India, the production of soybean is restricted mainly to Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Uttarakhand, Maharashtra and Gujarat and on small acreage in Himachal Pradesh and Punjab also. Soybean is rich in protein and contains 40-45 % protein of superior quality and almost all essential amino acids, particularly glycine, tryptophan and lysine. It contains about 18-20 % oil with important fatty acids, lecithin and vitamins A and D, besides its sprouts contain a considerable amount of vitamin C.

The leguminous crops are rich in protein and improve human nutrition.These crops improve the soil fertility through the process of nitrogen fixation in the root nodules and also through the leaffall on the ground at maturity. The cereal - pulse crop intercropping is important for enhancing national food production without causing any loss to the soil structure and health. Intercropping is one of the means of cropping intensification and has been traditionally practiced to create enough photosynthetic surface area (crop canopy) during initial growth phase to capture solar radiation to a maximum extent. It also helps in proper nutrition, water and light utilization from different soil zones as cereals are surface feeder and soybean has a deeper tap root system. Soybean and maize intercropping is a traditional and typical farming system and has many advantages, besides increasing yield which include greater stability of production and, therefore, minimum risk and more equal distribution of labor throughout the growing season with greater diversity of food and income sources. This also provides biological insurance, improvement in physico-chemical properties of soil, better control of weeds, pests and diseases (Chatterjee and Mandal, 1992). Intercropping of maize with pulse crops and soybean saved 30 to 60 kg N/ha (Sharma and Chaubey, 1991; Shivay *et al*., 2001, and Meena *et al*., 2006). Intercropping systems involve the simultaneous cultivation of legumes and cereals in various adaptable combinations though the legume association is, usually, expected to contribute towards the nitrogen needs of the associated non- legume components, nutritional requirement of such a system deserve careful consideration. The current availability of pulses in India is 32 g/day/capita as against 80g/day/capita, and India has to import lots of pulses which affect the foreign reserves of the country. Since, the present and future aspects of bringing more area under pulses appear no brighter, spatial and or temporal intensification of cropping, particularly intercropping provides an alternative of immense relevance and potential. Hence, the present experiment was conducted to study the growth, yield performance and economics of soybean as influenced by maize + soybean cropping system and levels of nitrogen.

Materials and Methods

A field investigation was conducted at Research Farm, A.S. (P.G) College, Lakhaoti, Bulandshahr, during *kharif* seasons of 2009 and 2010 to study the growth and yield performance of soybean under maize + soybean intercropping systems and nitrogen levels. The treatments consisted of combinations of five cropping systems (C_1) Maize sole crop, (C_2) Soybean sole crop, (C_3) Maize + soybean (1:1 replacement series), (C_4) Maize + soybean (1:1 additive series), (C_5), Maize + soybean (1 : 1 mixed seed) in main-plots; four nitrogen levels (N_0) Control, (N_1) 40 kg N /ha, (N_2) 80 kg N /ha, (N_3) 120 kg N /ha in sub-plots in factorial randomized block design replicated thrice during the kharif seasons. The maize variety 'Uttam Azad' and soybean variety 'Alankar' were used in the cropping systems. Soil of the experimental site was sandy loam in texture. The weather during the both years of the experiment was normal and devoid of any extreme conditions. The experiment was conducted as per the standard procedures and all the pre-and post-harvest observations were recorded and analyzed as per the prescribed statistical procedures.

Results and Discussion

Growth parameters of soybean

The inter cropping systems had no significant influence on the plant height of soybean, however, nitrogen application upto 80 kg/ha showed a little more plant height over control, but N level at 80 kg and 120 kg N/ha did not show significant differences between them. The branch number/plant increased upto 90 DAS and slightly reduced at final harvest in both the years. Cropping system did not show significant difference on number of branches/plant Nitrogen levels 80 kg and 120 kg N/ha were distinctly superior to control and 40kg N/ha. The total dry matter production by the soybean continued to increase up to harvesting, but the influence of intercropping systems was not significant during both seasons. The dry matter accumulation was faster in additive series as compared to replacement series or mixed seed in maize-soybean intercropping system.The nitrogen level increased with the nitrogen applied and was the highest in 120 kg N/ha followed by N80, N40 and control treatments. The lowest drymatter accumulation was observed in control. Increasing nitrogen level (0-120 kg N/ha) brought increased soybean growth parameters *viz*. plant height, number of branches/plant and total dry matter production in both the years of experimentation. The nitrogen application enhanced the number of branches and total dry matter production where as it was lowest when nitrogen was not applied. It can be presumed that the nitrogen application favorably influenced the plant metabolic activities and finally resulted in improved growth, development and productivity in soybean. The additive series was relatively better than replacement series and mixed series. This might have been because of light penetration and root development might have affected the plant dry matter production and branch number. The results are in conformity with those of Balyan, (2002) and Kavil *et al.* (2003).

Yield attributes and yield of soybean

The number of pods/plant, seeds/pod and pod length and even seed weight were not significantly affected by different cropping systems during both the years.

Table 1. Growth attributes of soybean as influenced by inter-cropping systems and levels of nitrogen

Treatment	Plant height (cm) at 30 DAS		Plant height (cm) at harvest		Number of branches/ plant at 30 DAS		Number of branches/ plant at harvest		Dry matter accumul-ation (g/plant) at 30 DAS		Dry matter accumul-ation (g/plant) at harvest	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Cropping systems												
C_2	58.9	57.5	96.0	96.2	4.3	4.4	8.2	8.0	29.5	28.7	92.0	95.0
C_3	59.1	59.2	95.8	95.9	4.2	4.3	8.0	8.2	28.6	27.5	91.0	82.0
C_4	58.8	59.3	96.0	96.1	4.3	4.4	8.5	7.8	29.2	28.2	92.0	87.5
C_5	59.2	59.3	95.0	96.2	4.4	4.3	8.4	7.9	29.8	26.5	87.5	83.0
SEm ±	0.50	0.54	1.17	1.17	0.21	0.26	0.61	0.53	0.21	0.52	0.79	0.85
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels (kg/ha)												
N_1	50.5	51.5	92.0	93.5	3.5	3.0	7.5	7.8	28.0	29.0	65.0	72.1
N_2	54.6	56.6	96.0	95.2	4.4	4.4	8.2	8.2	32.0	33.4	74.3	79.2
N_3	59.5	59.2	95.0	96.0	4.6	4.7	8.9	8.5	36.5	37.5	80.0	84.3
N_4	60.0	61.0	96.2	97.2	5.0	4.9	9.0	9.1	38.0	39.2	92.5	94.8
SEm ±	0.57	0.62	0.48	1.07	0.21	0.20	0.23	0.71	0.04	0.05	0.39	0.35
CD (P=0.05)	2.51	2.81	1.62	3.04	0.61	0.58	1.01	1.07	0.12	0.14	1.25	0.87

C_2: Sole soybean
C_3: Maize + soybean 1:1 ratio (Replacement series)
C_4: Maize + soybean 1:1 ratio (Additive series)
C_5: Maize + soybean 1:1 ratio (Seed Mixed)

N_0: Control
N_1: 40 kg N/ha
N_3: 80 kg N/ha
N_4: 120 kg N/ha

Nitrogen levels had significant effect on pod number, test weight, but pod length and number of seeds/pod did not show any significant variation amongst these treatments in both the years. The grain yield was found to be significantly influenced by different cropping systems used in the maize + soybean intercropping; however, it was minimum in mixed seed than other systems. The additive series enhanced the grain yield and stover yield over mixed seed and replacement series and were almost at par among themselves in both the years. The grain yield and stover yield increased significantly with the application of nitrogen. The grain and stover yield were found to be at par at N80 and N120 kg/ha.

The data on harvest index revealed that there were non-significant differences due to different treatments of cropping systems and nitrogen levels. The pod length, number of pods/plant, number of seeds /pod and test-weight were relatively lower when nitrogen was not applied and nitrogen application showed positive results on grain yield and yield contributing characters. The higher yield may be attributed to pod number, grains /pod and seed size and lack of N might have reduced the pod setting per cent and poor retention of pods and poor seed size. The grain and stover yields increased with increased dose of nitrogen. Application of higher dosage of nitrogen did not show any adverse effect on soybean, since the applications of fertilizer dosage were restricted to the maize row only (Balyan, 2002).

A significant variation in maize equivalent due to intercropping system was recorded in both the years. The increase in maize equivalent yield was mainly due to the additional yield

Table 2. Yield attributes & yields of soybean as influenced by inter-cropping systems and levels of nitrogen

Treatment	Seeds /pod		Pods /plant		Test weight (g)		Grain yield (t/ha)		Stover yield (t/ha)		Harvest Index (%)	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Cropping systems												
C_2	2.26	2.27	94.6	94.7	95.3	95.4	1.68	1.70	2.88	2.89	33.1	33.4
C_3	2.30	2.25	94.5	94.6	95.4	95.4	1.65	1.68	2.78	2.88	33.3	33.1
C_4	2.28	2.29	94.6	94.7	95.4	95.4	1.67	1.70	2.85	2.90	33.2	33.0
C_5	2.22	2.24	94.0	94.5	95.3	95.3	1.58	1.62	2.75	2.85	32.4	32.2
SEm±	0.47	0.29	0.31	0.27	0.28	0.29	0.14	0.15	0.11	0.17	0.12	0.14
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.43	0.52	0.48	NS	NS	NS
Nitrogen levels (kg/ha)												
N_1	2.15	2.18	93.2	93.6	94.3	94.5	1.40	1.45	2.60	2.65	30.0	30.6
N_2	2.20	2.21	94.8	94.9	94.8	94.8	1.50	1.57	2.73	2.85	32.0	34.3
N_3	2.29	2.30	95.2	95.3	95.3	95.3	1.65	1.66	2.86	2.88	32.8	32.7
N_4	2.30	2.35	95.6	95.8	95.6	95.4	1.72	1.72	2.95	2.98	33.3	33.0
SEm±	0.08	0.09	0.23	0.47	0.37	0.27	0.24	0.27	0.78	0.32	0.10	0.11
CD (P=0.05)	NS	NS	0.75	1.10	1.02	0.92	0.92	0.95	2.24	1.24	NS	NS

C_2: Sole soybean
C_3: Maize + soybean 1:1 ratio (Replacement series)
C_4: Maize + soybean 1:1 ratio (Additive series)
C_5: Maize + soybean 1:1 ratio (Seed Mixed)

N_0: Control
N_1: 40 kg N/ha
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N_4:120 kg N/ha

advantage of intercropping as well as higher market price of soybean than that of maize alone. Rana *et al*. (2008) has suggested that in intercropping system the pulse produces additional quantities of commodities required by the country and benefit : cost ratio was enhanced with maize + soybean intercropping. Hayder *et al*. (2003) reported that maize + soybean intercropping in narrow strip can provide forage quality advantage without affecting yield. He also suggested that intercropping with legumes enhanced land equivalent ratio (LER). Sharma and Behara (2009) also support this view and reported that the incorporation of residue of different legumes in intercropping system added variable amounts of N that influenced the productivity of preceding crop too. Addition of residues and nitrogen was much higher with soybean and groundnut than any other intercrop. Hayder *et al*. (2003) reported greater LER and higher economic returns as compared to monoculture of all the seed rates of soybean and concluded that soybean can successfully be intercropped with maize for an efficient use of land and higher economic returns. The net return was relatively more in maize + soybean intercropping system when compared to maize (mono-crop) or without nitrogen. Hence intercropping has edge over any mono-culture in terms of grain yield, quality and LER and MEY (maize equivalent yield) and net return and farmers with limited resources have greater advantage to grow maize + soybean intercrop for less cost and higher net return with eco-friendly atmosphere because intercropping with soybean does not pollute the environment and add nitrogen to the soil as a naturally biological nitrogen fixing factory.

On the basis of results obtained from the present investigation, it could be concluded that soybean grown as intercrop registered significantly higher growth and yield parameters up to application of 40 kg N/ha to maize crop.

Similarly, the grain and stover yields showed significant improvement up to 40 kg N/ha and 80 kg N/ha. Maize + soybean intercropping led to the efficient use of land and higher economic return. The benefit:cost ratio was enhanced with maize + soybean intercropping in additive series.

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