International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(3): 3163-3166

Received: 10-03-2019
Accepted: 12-04-2019

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Relative performance of growth and yield of maize based cropping system

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Abstract
A field experiment was conducted at College of Agricultural Technology, Theni during summer 2019. The experiment was laid out in a randomized block design with nine treatments and replicated thrice. The effect of various row proportions on the relative performance of maize was studied. The experimental results revealed that, the grain yield and yield attributing components of maize, blackgram and soybean was significantly influenced by inter cropping pattern. The grain yield obtained under sole maize (5550 kg/ha) (T_1) was significantly higher than the maize + blackgram (2:1) intercropping system (5010 kg/ha) (T_5) which was closely followed by maize + blackgram (1:1) (5000 kg/ha) (T_4). Grain yield of sole blackgram (954 kg/ ha) (T_2) was significantly higher than the maize + blackgram (1:1) (724 kg/ha) (T_4). The higher LER (2.95) was recorded with maize + blackgram (2:1) intercropping system (T_5). Higher net return (Rs.88284) and B:C ratio (2.50) was recorded in intercropping of maize + blackgram (1:1) (T_4) which was followed by Maize + blackgram (2:1) (T_5).

Keywords: Black gram, equivalent yield, intercropping, maize, soybean

Introduction
Maize (*Zea mays*) Originated in Central Mexico. Maize is grown both as Sweet Corn for human consumption and as Field Corn for other uses such as animal feed and biofuels. Worldwide, only around 15% of maize production is used for food consumption with most production going to animal feed. The most abundant proteins in maize are known as Zeins. Maize is very nutritious, providing fiber, which aids in digestion, and folate, thiamin, phosphorus, vitamin C and magnesium are present in maize.

Blackgram (*Vigna mungo*) is one of the most highly prized pulse crop, cultivated in almost all parts of India. Its unique ability of biological nitrogen fixation, carbon sequestration and capacity to tolerate harsh climatic conditions. It also offers good scope for crop diversification (Ali and Gupta, 2012). It is perfect combination of all nutrients, which includes proteins (25-26%), Carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. It stands next to soybean in its dietary protein content. It is rich in vitamin A, B1, B3 and has small amount of thiamine, riboflavin, niacin and vitamin C in it.

Soybean (*Glycine max*) is a crop of multiple qualities as its both a pulse and oilseed crop. It is used in a variety of industries, providing products for human consumption, livestock feed and industrial purposes. Soybean seed consists of 35% carbohydrate, 5% ash, 40% protein and 20% oil.

Intercropping refers to growing of two or more generally dissimilar crops simultaneously on the same piece of land. Usually the base crop is grown in a distinct row arrangement. The recommended optimum plant population of the base crop is suitably combined with appropriate additional plant density of the associated crop, and there is crop intensification in both time and space dimensions. (Thayamini and Brintha, 2016)

The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources or ecological processes that would otherwise not be utilized by a single crop. Keeping these points in view, the present investigation was carried out in "Relative Performance of Growth and Yield of Maize based Cropping System".

Materials and Methods
Field experiment was conducted at College of Agricultural Technology, Theni, during January-April, 2019. The experiment was laid out in a randomized block design with nine

treatments with replicated thrice. The treatments consisted of sole maize - (T_1), sole Blackgram - (T_2), Sole soybean - (T_3), Maize + Blackgram (1:1) - T_4, Maize + Blackgram (2:1) - T_5, Maize + Blackgram (2:2), Maize + Soybean (1:1) - T_7, Maize + Soybean (2:1) - T_8, Maize + Soybean (2:2) - T_9.

The soil of the experiment field was sandy loam in texture classified taxonomically as *Typic Ustropept* and comes under Periyakulam series of soil series.

The individual gross plot was of 20 m^2 having the length of 5 m and width of 4 m. Maize crop was spaced at 45 x 15 cm^2, blackgram at 30 x 10 cm^2 and soybean at 30 x 10 cm^2. Observations are plant height, LAI (Puttasamy *et al.*, 1976) [8] yield attributes and yield, harvest index (Nichiporovich 1967) [6], maize equivalent yield (Singh *et al.*, 1990) [10], land equivalent ratio (Willey, 1985) and economics (Bhandari *et al*., 1988) [2] were worked out as per formula suggested from concerned author. Further crop management practices were followed as per crop production guide 2012.

Results and Discussion

Plant height

Growth in terms of plant height at all stages of development showed the significant variation due to the various row proportions during *summer* 2019. Among the different treatments, Sole maize (T1) recorded the tallest plant with the height of 48.5cm, 162cm, and 210 cm during *summer* 2019 at 20, 40 and 60 DAS respectively. The treatment Maize + Blackgram (2:1) (T_5) recorded the second best treatment recording the value 48 cm, 160 cm and 210 cm during *summe*r 2019 at 20, 40 and 60 DAS respectively.

Whereas, Maize + Soybean (1:1) (T7) recorded the lowest values of plant height of about 33.3 cm, 139.3 cm and 170 cm at 20, 40 and 60 DAS respectively. (Table. 1). Sharma and Behera (2009) [9], stated that the main reason for increase in plant height under sole maize treatment was due to the fact that the optimum space available in sole maize reduced the competition for light and nutrients, which probably provided favorable physical environment and helped the plants to grow taller. These findings were corroborated with our results.

Leaf area index

Leaf area index of maize was greatly influenced by the various treatments during *summe*r 2019. Among the different treatments, Sole maize (T_1) recorded the maximum leaf area index of about 1.86, 3, 3.6 at 20, 40, 60 DAS respectively. The treatment Maize + Blackgram (2:1) (T_5) was the second best treatment which recorded the value of 1.9, 2.8, 3.5 at 20, 40, 60 DAS respectively. The treatment Maize + Soybean (2:2) (T9) recorded the lowest values of leaf area index of about 1.5, 2.25, 3 at 20, 40, 60 DAS respectively during *summer* 2019. (Table. 2)

Number of grains per cob

The number of grains per cob of maize was greatly influenced by various treatments during *summer* 2019. Among the different treatments, Sole maize (T_2) recorded the maximum value (424.5) which was followed by Maize + Blackgram (2:1) (420.5) (T_5), where as Maize + Soybean (2:2) recorded lowest (362.80) (T_9). (Table.3).

Grain yield

Maize

Among the different treatments, Sole maize (T_2) recorded the maximum value (5550 kg per ha) which was followed by Maize + Blackgram (2:1) (5010 kg per ha) (T_5), where as Maize + Soybean (2:2) recorded lowest (3550 kg per ha) (T_9). (Table.3).

Stover yield

The number of grains per cob of maize was greatly influenced by various treatments during *summer* 2019. Among the different treatments, Sole maize (T_2) recorded the maximum value (8550 kg per ha) which was followed by Maize + Blackgram (2:1) (8020 kg/ha) (T_5), whereas Maize + Blackgram (2:2) recorded lowest (7008 kg per ha) (T_6). (Table.3).

Harvest Index

The harvest index (%) of maize was greatly influenced by various treatments during *summer* 2019. Among the different treatments, Maize + Blackgram (2:1) (T_5) recorded the maximum value (40.47%) which was followed by Sole maize (39.36%) (T_1), where as Maize + Soybean (2:2) recorded lowest (31%) (T_9). (Table.3).

Blackgram growth attributes

Plant height

No. of branches / plant:

No. of branches/ plant was greatly influenced by various treatments during *summer* 2019. Among the different treatments Sole Blackgram (T_2) recorded the maximum no of branches/ plant (6.80) which was followed by Maize + Blackgram (2:1) (6.5) (T_5), whereas Maize + Blackgram (2:2) recorded lowest (4.8) (T_6). (Table .4)

No. of pods/plant:

No. of pods/ plant was greatly influenced by various treatments during *summer* 2019. Among the different treatments Maize + Blackgram (2:1) (T_5) recorded the maximum no of pods/ plant (31) which was followed by Sole Blackgram (28) (T_2), whereas Maize + Blackgram (1:1) recorded lowest (25) (T_4). (Table.4).

Blackgram yield

Grain yield

Grain yield (kg/ha) was greatly influenced by various treatments during *summer* 2019. Among the different treatments Sole Blackgram (T_2) recorded the maximum grain yield (1429 kg/ha) which was followed by Maize + Blackgram (1:1) (954 kg/ha) (T_4), Whereas Maize + Blackgram (2:2) recorded lowest (585 kg/ha) (T_6). (Table.5). Sole blackgram (T_2) produced significantly more grain yield than intercropped with maize. Maize is usually taller with fast growing or more extensive root system particularly a large mass of fine roots and it is competitive for soil Nitrogen. The maize plant in the intercrop in the present study could have shadowed blackgram and soybean reducing the amount of light to carry out its physiological activities.

Haulm yield

Haulm yield (kg/ha) was greatly influenced by various treatments during *summer* 2019. Among the different treatments Sole Blackgram (T_2) recorded the maximum straw yield (1519 kg/ha) which was followed by Maize + Blackgram (1:1) (1420 kg/ha) (T_4), whereas Maize + Blackgram (2:2) recorded lowest (1229 kg/ha) (T_6). (Table.5)

Harvest index

Harvest index (%) was greatly influenced by various treatments during *summer* 2019. Among the different

treatments Sole blackgram (T_2) recorded the maximum harvest index (48.47), which was followed by Maize + Blackgram (2:1) (35.40) (T_5). Whereas, maize + blackgram (1:1) recorded the lowest (30.49) (T_4). (Table .5)

Soybean growth parameters

No. of branches per plant:

No. of branches/ plant was greatly influenced by various treatments during *summer* 2019. Among the different treatments Maize + Soybean (1:1) (T_7) recorded the maximum no of branches/ plant (5.5) which was followed by Maize + Soybean (2:1) (4.8) (T_9), whereas Maize +Soybean (2:2) recorded lowest (4.5) (T_9).(Table .6)

No. of pods per plant:

No. of pods/ plant was greatly influenced by various treatments during *summer* 2019. Among the different treatments Maize + Soybean (2:1) (T_8) recorded the maximum no of pods/ plant (14) which was followed by Sole Soybean (12) (T_3), whereas Maize + Soybean (2:2) recorded lowest (9) (T_9). (Table.6).

Soybean yield

Grain yield

Grain yield (kg/ha) was greatly influenced by various treatments during *summer* 2019. Among the different treatments Sole Soybean (T_3) recorded the maximum grain yield (956 kg/ha) followed by Maize + Soybean (1:1) (677 kg/ha) (T_7), whereas Maize + Soybean (2:1) recorded lowest (387 kg/ha) (T_8). (Table .7). Sole soybean (T_3) produced significantly more grain yield than intercropped with maize. Maize is usually taller with fast growing or more extensive root system particularly a large mass of fine roots and it is competitive for soil Nitrogen. The maize plant in the intercrop in the present study could have shadowed blackgram and soybean reducing the amount of light to carry out its physiological activities. (Pritee Aswathy., 2010) [7]

Haulm yield

Straw yield (kg/ha) was greatly influenced by various treatments during *summer* 2019. Among the different treatments Sole Soybean (T_3) recorded the maximum straw yield (1570 kg/ha) which was followed by Maize + Soybean (1:1) (1323 kg/ha) (T_7), whereas Maize + Soybean (2:2) recorded lowest (726 kg/ha) (T_9). (Table.7)

Harvest index

Harvest index was greatly influenced by various treatments during *summer* 2019. Among the different treatments Sole Soybean (T_3) recorded the maximum harvest index (37.84) which was followed by Maize + Soybean (2:2) (34.77) (T_9), whereas Maize + Soybean (2:1) recorded lowest (25.46) (T_8). (Table .7)

Maize Equivalent Yield

Maize grain equivalent yield was recorded to be higher in all the cases of intercropping .The highest maize grain equivalent yield was obtained in maize + blackgram (1:1) intercropping (7156 kg/ha) due to higher yield and price of blackgram. (Table.8). The maize equivalent yield was higher in Maize + Blackgram (1:1) (T_4) (7156 kg/ha) followed by maize + blackgram (2:1) (T_5) (6559 kg/ha). The increase was mainly due to additional yield advantage of intercropping as well as higher market price of grain legumes than maize. The findings are in agreement with Singh and Singh 2001.

Land equivalent ratio

LER values were always recorded to be higher than unity signifying yield advantages of intercropping over monoculture. Yield advantages occurred due to the development of both temporal and spatial complementarities. The highest value of LER (2.95) was obtained from maize + black gram (2:1) intercropping which was followed by maize + blackgram (1:1) intercropping (1.56). (Table.8) The land equivalent ratio indices were the greatest in maize component of the intercropping systems. The total LER values of Maize + Blackgram (1:1) (T_4) (2.95) were higher than one showing the advantage of intercropping over sole cropping in regard to the use of environmental resources for plant growth. Chen *et al*., (2004) [3] reported similar results.

Economics

Cost of cultivation of different treatments was ranged between Rs.49100 to Rs.59756 per ha. The cost of cultivation for the treatment Maize + Blackgram 2:2 (T_6) was Rs. 59756 and the treatment sole maize ($T_{1)}$ was Rs. 56556.

The highest gross income (Rs.147140 per ha) was observed with the treatment Maize + Blackgram 1:1(T4) where intercrop yield fetched higher gross income than other treatments. The highest net income (Rs.88284) and B:C ratio (2.50) were found with the treatment Maize + Blackgram (1:1) (T_4) followed by Maize + Blackgram (2:1) (T_5) with the net income (Rs. 75349) and B:C ratio (2.26). The increased yield in the main crop and the intercrop obtained in these treatment resulted in the higher net income. (Table. 9). Matusso *et al.*, (2014) [5]. Highest net return and marginal rate of return were obtained from maize-legumes intercrops. The intercrop system was economically feasible relative to sole crop maize and sole legumes as reported from different intercrop studies. Regardless of planting patterns, maize legumes intercropping had the highest yield advantages with optimum exploitation of the land and environmental resources. These led to higher profitability, suggesting potential increase in household incomes.

Table 1: Effect of treatments on plant height and Leaf area index of maize

	Plant Height (cm)			Leaf area index		
Treatment	**20DAS**	**40 DAS**	**60DAS**	**20DAS**	**40 DAS**	**60DAS**
T_1	48.5	162.3	210.4	1.82	3.02	3.65
T_4	41.6	150.4	186.6	1.63	2.73	3.47
T_5	48.0	160.8	210.7	1.84	2.93	3.58
T_6	44.0	143.9	200.5	1.75	2.64	3.29
T_7	33.3	139.5	170.9	1.47	2.57	3.14
T_8	39.6	146.6	176.6	1.59	2.49	3.13
T_9	37.5	137.1	168.3	1.53	2.34	3.05
SEd	1.07	3.68	3.35	0.08	0.06	0.08
CD (P=0.05)	2.13	8.03	7.31	0.19	0.14	0.17

Table 2: Effect of treatments on maize yield attributes and yield

Treatment	**Total no. of grains/cob**	**Grain yield (kg/ha)**	**Stover yield (kg/ha)**	**Harvest Index %**
T_1	424.5	5550	8550	39.4
T_4	402.8	5010	8020	38.4
T_5	420.5	4930	7250	40.5
T_6	386.2	4485	7008	39.0
T_7	399.4	4010	7630	34.0
T_8	377.3	3920	7050	35.0
T_9	362.8	3550	7600	31.0
SEd	9.20	109	167	0.8
CD(P=0.05)	20.05	239	364	1.7

Table 3: Effect of treatments on blackgram and soybean growth attributes and yield

Treatments	Blackgram					Treatments	Soybean				
	No. of branches/ plant	No. of pods/plant	Grain yield (kg/ha)	Haulm yield (kg/ha)	Harvest Index %		No. of branches/ plant	No. of pods/plant	Grain yield (kg/ha)	Haulm yield (kg/ha)	Harvest Index %
T_2	6.8	28	1429	1519	48.5	T_3	4.6	12.3	956	1570	37.8
T_4	5.3	25	954	1420	30.5	T_7	5.5	10.5	677	1323	33.8
T_5	6.5	31	724	1321	35.4	T_8	4.8	14.7	426	1247	25.5
T_6	4.8	26	585	1229	32.2	T_9	4.5	9.9	387	726	34.6
SEd	0.1	0.6	25	27	0.7	SEd	0.1	0.3	18	75	0.9
CD(P=0.05)	0.3	1.4	60	65	1.6	CD(P=0.05)	0.3	0.6	42	173	2.2

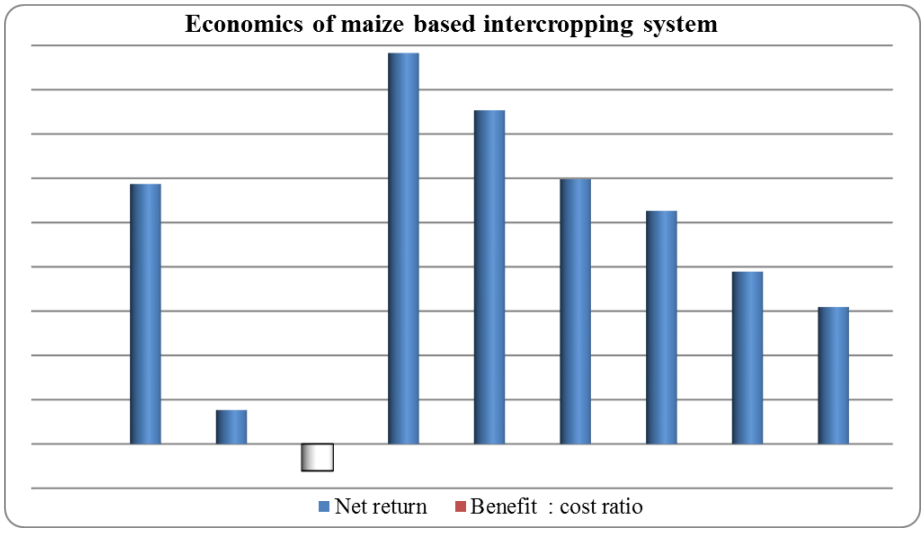

Fig 1: Effect of treatments on economics of maize based intercropping system

Conclusion

Small farm holders practice intercropping with cereals and legumes however on the basis of these findings, it is clear that sole cropping performed better than all intercrops. There are some benefits derived from intercropping systems such as nitrogen fixation by legumes and better land utilization and resource utilization.

Acknowledgement

We extend our sincere thanks department of agronomy, College of Agricultural Technology, Theni.

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