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Productivity of *Sesbania* alley cropping system with sequentially cropped berseem and maize at different moisture regimes and fertilizers

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ABSTRACT

An investigation was undertaken in hot sub-humid region at Indian Grassland and Fodder Research Institute, Jhansi, India, to assess the productivity of *Sesbania sesban* hedgerows and its effect on berseem (*Trifolium alexandrinum* L.)-maize (*Zea mays* L.) cropping sequence at different moisture regimes and fertilizers levels. The experiment was laid out in a randomized complete block design with 4 replications. Three levels of phosphorus (40, 80 and 120 kg P_2O_5 ha^{-1}) and 4 levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) were applied on berseem in *rabi* (November-March). The treatments imposed on maize in *kharif* (July-September) were 3 moisture regimes (rainfed, irrigation at canopy air temperature difference (CATD), values of 0^{o} and -2°C) and 4 levels of nitrogen (0, 40, 80 & 120 kg N ha^{-1}). The increase in biomass production of *Sebania* was associated with reduction of berseem productivity in subsequent years. However, *Sesbania* alley did not significantly affect yield of maize crop over the years. The system produced maximum yield with the application of 120 kg P_2O_5 and 60 kg S ha^{-1}on berseem, and irrigation at -2°C CATD and 120 kg N ha^{-1}on maize grown under 4 m apart *Sesbania* alley.

Key words: Alley cropping, *Sesbania, Trifolium alexandrinum*, moisture regime, fertilizer, *Zea mays*

INTRODUCTION

In alley cropping system, food or fodder crops are grown between hedgerows of shrubs and trees, preferably leguminous species. Hedgerows, are periodically pruned to prevent shading of companion crops and these prunings, are used as feed for livestock and to supplement soil nutrients (Atta-Krah and Sumberg 1988; Kang *et al.* 1981; 1984; Rosecrance *et al.* 1992; Ssekabembe 1985). Over the past three decades, research on agroforestry has recognised alley cropping as a sustainable, intensive system that would radically improve long-term prospects of resource poor farmers. In spite of the potential of alley cropping for sustainable agricultural development, the adoption of this technology by farmers is poor (Carter 1995; David 1995; Young 1997). However, on the basis of results to date, it has been proposed that this technology might prove acceptable to livestock owners (Young 1997). The inclusion of fast growing hedgerow species such as *Sesbania* in alley cropping along with fodder based cropping sequences in the alleys can provide fodder round the year even during lean period of hot summer.

A wide range of hedgerow species has been tested in various trials in different climates and soils. Much work has been carried out on species like *Leucaena, Gliricidia* and *Cassia* (Dugma *et al.* 1988; Kang *et al.* 1981; Lal 1991; Lawson and Kang 1990; Wilson *et al.* 1986). In contrast, research on *Sesbania* as a potential hedge species has been scarce. *Sesbania* is very rich in essential nutrients. Magoon and Shankernarayan (1974) found that *Sesbania aegyptica* fodder contains 25% crude protein, 2.62% calcium, 2.41% potassium and 0.43% P_2O_5. Likewise Rekib and Shukla (1997) reported 38.1 % dry matter, 16.9 % crude protein, 32.5 % crude fibre, 41.8% NFE, 5.8% ash and 94.2% organic matter in *Sesbania sesban* leaves. In addition to the supply of good quality fodder, *Sesbania* is a promising shrub for alley cropping as it is very easy to establish, fast growing and supplies green manure, fodder and wood (Chapman and Myers 1987; Evans and Rotar 1987; Anon 1984; Tothill 1987; Tran van Nao 1983; Yamoah 1988). However, further investigations are needed on its suitability for alley cropping and its effects on companion crops.

In India, agriculture is oriented towards mixed farming in which livestock rearing forms an integral part of rural living. Low productivity of livestock is a matter of great concern because of poor fodder and feed resources. The overall availability of forage is to the extent of 60% of requirements (Hazra 1995). In view of increasing fodder and feed resources various fodder based cropping systems have been adopted by farmers. Berseem-maize is one of the very common cropping systems practiced in various agroclimatic regions to supply green fodder and concentrate to livestock. The incorporation of this cropping system in *Sesbania* alley cropping can supply fodder and feed in the form of green fodder, concentrate and crop residue throughout the year.

Phosphorus is an essential nutrient for leguminous crops such as berseem. In leguminous fodder, phosphorus increases crude protein, digestibility and P content (Dhar *et al.* 1977). In berseem, response to applied P has been found up to 80-150 kg P_2O_5 ha^{-1} in various production systems (Tripathi and Hazra 1995). Sulphur is also an important nutrient for increasing crop productivity as well as for maintaining nutritional quality of fodder crops. It maintains desired level of protein, sugar, amino acid, crude fibre and mineral ratio *viz.* N:S, Ca:P, Zn:S and Cu:Mo *etc.* in crop plants (Tripathi & Hazra 1995). In India, S deficiency in the soils is widespread. S deficiency (<22.5 kg S ha^{-1}) has been found in 41% of soils (Singh 2001). Therefore, the addition of S-fertilizer is essential to achieve higher productivity particularly in soil deficient in S. The response of S fertilizer varies in different crops. In berseem crop, it is reported as 71 kg dry fodder kg^{-1} S (Hazra and Tripathi 1995). Responses of P and S have been studied on berseem as sole crop. However, no information is available on the response of these nutrients on berseem planted in alley cropping.

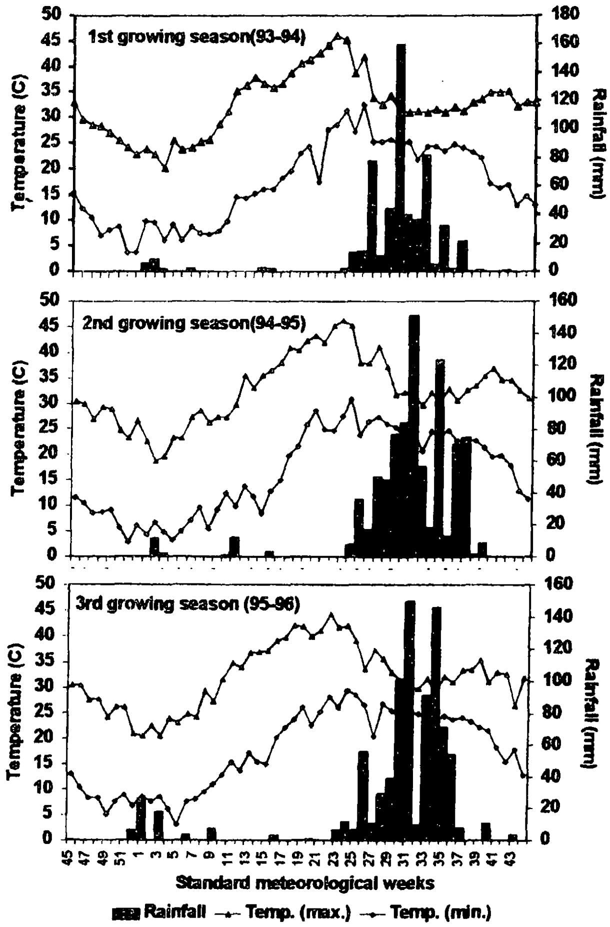
Central India falls under hot-subhumid agroecological zone. This zone is characterized by erratic distribution of rainfall. The *kharif* season (July-September) that receives 90% of total annual rainfall, often experiences long dry spells and thus crop productivity is declined due to soil water scarcity during this period. The most critical growth stages for moisture stress in maize i.e., tasseling and silking stages generally coincide with the dry period at the end of *kharif* season. The productivity will decline unless water is supplied through irrigation. Therefore, working out of irrigation schedule is also important to optimize the maize crop productivity. Along with soil moisture status, yield of maize is influenced by N-fertilizer. Maize can respond up to 120 kg N ha^{-1}. The information on irrigation and fertilizer requirement in *Sesbania* alley cropping system is meager.

Keeping in view the potential of berseem-maize cropping sequences along with management practices like fertilizers and irrigation in *Sesbania* alley cropping system for supplying the fodder and feed resources to the livestock, the present study was undertaken to find out the productivity of *Sesbania* hedgerows and its impact on berseem-maize (grain) cropping sequence practiced within alleys at different moisture regimes and fertilizer levels.

MATERIALS AND METHODS

The field experiment was conducted for three years (1993-94 to 95-96) in hot sub-humid region at Indian Grassland and Fodder Research Institute, Jhansi (25°27'N and 78°35'E), India. The average annual rainfall in the region is 938 mm. About 90% of the total rainfall is received in *kharif* (July to September) with occasional showers during *rabi* (November to March) season. The distribution of precipitation is often erratic and even in wet months, (July-August), which received about 70% of annual total, experience long dry spells many times. During the study period of three years, the precipitation was 430.6, 726.4, and 708.8 mm, respectively during *kharif* and 17.8, 33.7 and 60.8 mm, respectively in *rabi*. May and June were the hottest months and recorded maximum temperatures of 43 to 46°C and minimum temperature reached 3 to 4°C during winter months. Annual potential evapotranspiration (PET) value in the region ranged from 1300-1500 mm. The mean weekly maximum and minimum temperature, and rainfall during study periods are given in Fig. 1.

The soil type of the experimental site was upland sandy clay loam, with a pH of 7.5. It was



medium in organic carbon (0.54%) and available P (21.8 kg P ha^{-1}), and high in potassium (490 kg K ha^{-1}). S content of soil was low (16.9 kg S ha^{-1}). The field capacity, permanent wilting point and bulk density were 24.4 %, 8.5% and 1.4 g cm^{-3}, respectively.

The experiment was laid out in a randomized complete block design with four replications. The blocks were established on a gentle slope (0.5%) with 12 plots of 24 x 5m in each block. The distances between individual plots and blocks were 1 and 2 m, respectively. *Sesbania sesban* hedgerows were established in August 1993 using 4 m inter-row spacing with 50 cm intra-row spacing between seedlings. Berseem (*Trifolium alexandrinum* L.) for fodder in *rabi* and maize (*Zea mays* L.) for grain in *kharif* season were grown as alley crops. Berseem crop was sown by broadcast method using 25 kg seed ha^{-1}. Berseem was sown during 1st week of November and harvested in middle of April. In *kharif*, plots were seeded with maize at a spacing of 10 X 25 cm (50 kg seed ha^{-1}) during middle of July. The crop was harvested during 2nd week of October.

Twelve treatment combinations composed of different factors were imposed separately during separate growing seasons, i.e., during *rabi* 3 levels of phosphorus (*viz.* 40, 80 and 120 kg P_2O_5 ha^{-1}) and 4 levels of sulphur (*viz.* 0, 20, 40 and 60 kg S ha^{-1}), and in *kharif* 3 moisture regimes (rainfed, Canopy Air Temperature Difference [CATD] values of 0°C and -2°C) and 4 levels of nitrogen (0, 40, 80 and 120 kg N ha^{-1}). Phosphorus and sulphur were supplied to berseem as diammonium phosphate (DAP) and gypsum, respectively. The N-fertilizer was applied as urea to maize in two equal splits, half at sowing and other half top-dressed 25 days after sowing. Along with various levels of N, uniform recommended doses of P (60 kg P_2O_5 ha^{-1}) and K (40 kg K_2O ha^{-1}) were applied to all plots in the form of single super phosphate and muriate of potash, respectively. Irrigation was supplied to maize on the basis of CATD. The use of CATD for detecting crop water stress or irrigation scheduling is based on the assumption that transpired water evaporates and thus cools the canopy below the air temperature. If the water becomes limiting, evaporation will be reduced and canopy temperature will be warmer than air temperature. The CATD is found to be an important index for crop water stress detection and irrigation scheduling (Jackson 1982). The CATD was determined by infrared thermometer. Irrigation was applied to recharge the soil water up to field capacity (60 mm water per irrigation). The water was measured through Parshall flume. Berseem crop was fertilized with phosphorus and sulphur at the time of sowing. The recommended dose of N-fertilizer (20 kg N ha^{-1} as basal) was also applied in all berseem plots. Four cuttings were taken from the crop. Uniform moisture regimes were maintained in all berseem plots by supplying water through irrigation.

During initial year of experiment, *Sesbania* hedges were planted during August 1993 and pruning started 10 months after planting. *Sesbania* was pruned 1 week before sowing and harvest of alley crops and during lean period (May-June) at height of 75 cm. Four prunings were taken in each year.

The yields of alley crops along with Sesbania were reported for different seasons to find out the seasonal as well as annual output of the system. The maize crop during *Kharif* 1994-95 was damaged due to continuous and high rainfall (Fig.1). Therefore, results of the maize crop are reported only for 2 years. The alley cropped maize and berseem were harvested from 23 x 4 m net plot and yield was expressed on a per hectar basis. To work out the total productivity of the alley cropping system, grain and stover yield of maize, green forage yield of *Sesbania* were expressed in terms of berseem green forage yield equivalent (BFE) using the following formula (Rawat 1997):

$$BFE = (Gy \times Gp) / Fp$$

Where, Gy = grain, stover yield of maize; green forage yield of Sesbania in q, Gp = Sale price of grain, stover of maize; sale price of green forage yield of *Sesbania* in Rs.q^{-1}, Fp = Sale price of berseem green forage in Rs.q^{-1}

The data were analysed following two factorial randomized complete block design (Gomez and Gomez 1984). As the interaction between levels of factors was found to be non-significant, only main effects of various factors are presented and discussed. The relationship between yield of berseem and maize with fertilizers was established by quadratic equations. The optimum agronomic and economic levels of fertilizers were worked out by following equations (Tripathi *et al.* 1977):

$$\text{Agronomic optimum} = -b / 2c$$

$$\text{Economic optimum} = (q/p - b) / 2c$$

Where, q = cost of one unit of input (Rs. kg^{-1}), p = price of one unit of output (Rs. q^{-1}), and b & c are constants of quadratic equation i.e., $y = a + bx + cx^2$

RESULTS AND DISCUSSION

Yields during *rabi* season

Increasing level of phosphorus from 40 to 80 through to 120 kg P_2O_5 ha^{-1}significantly increased the green and dry fodder yield of berseem (Table 1). Significantly higher green fodder (8.2%) and dry matter (11.9%) yields of berseem were observed at 120 kg P_2O_5 ha^{-1}over 40 kg P_2O_5 ha^{-1}. The higher green fodder yield of berseem grown as sole crop in loam soil at 120 kg P_2O_5 ha^{-1}was recorded by Hukkeri *et al.* (1976). The optimum agronomic and economic levels of P_2O_5 for berseem were 102.3 and 69.8 kg P_2O_5 ha^{-1}, respectively (Table 2). Research carried out in India indicated that *Sesbania* species are quite efficient in P uptake (Hussain 1990). In the present experiment, it was recorded that phosphorus applied on berseem alley crop increased green fodder yield of *Sesbania* significantly (Table1). Almost 16% increase in yield was observed from lowest to highest level of P_2O_5. In an experiment, growth response of *Sesbania* to phosphorus application was studied in sandy loam soil in India by Dutta and Pathanai (1984). Out of various P levels applied to *Sesbania*, higher growth response was observed at highest level of P i.e. 80 kg P_2O_5 ha^{-1}.

Subsequent increase in the levels of sulphur from 0-20, 20-40 and 40-60 kg ha^{-1}significantly increased green fodder and dry matter yield of berseem (Table 1). The yields at 20, 40 and 60 kg S ha^{-1} were higher over control by 5.25, 10.84 and 15.19% in terms of green fodder, and 7.82, 14.35 and 21.24% in terms of dry matter, respectively. Significant response of S in berseem productivity as a result of addition of S fertilizer could be due to the reason that S content in the soil of the experimental site was low (16.9 kg ha^{-1}). It has been shown that crop responds significantly to addition of S fertilizer in the soil containing available S less than 22.5 kg S ha^{-1} (Tomer *et al.* 1995). No significant response in the productivity of perennial shrub *Sesbania* was recorded at various levels of added sulphur (Table 1).

The yearly mean data during *rabi* season revealed that there was a significant reduction in yield of berseem in the subsequent years. The green fodder yield reduced by 8.5% and 8.3% while the decrease in dry matter yield were 16.7% and 17.4% in the 2nd and 3rd years, respectively. In contrast, nearly two times increase in yield of *Sesbania* was observed in the 3rd year in comparison to productivity of 2nd year. *Sesbania* yield was not computed in the 1st year of establishment because during establishment growth was not uniform. Like berseem, due to continuous cultivation reduction in yield was reported for cowpea, sorghum and castor and maize grown in association with *Leucaena* hedgerows (Singh *et al.* 1990; Lawson and Kang 1990). In a six-year trial, 31% reduction of initial yield of cowpea was recorded during sixth year in *Leucaena* alley cropping systems (Lal 1989).

The yield reduction of berseem is presumably due to shading and root competition. *Sesbania* hedgerows were pruned before sowing of berseem and subsequent pruning was done during end of the crop growth season. In between no pruning was done as *Sesbania* does not withstand frequent pruning especially during winter months because of slower growth rate in cold weather. At the end of the season it reached a height of 2m. Due to this short stature of crop, berseem that grew beneath pruning height of *Sesbania* may have been affected by shading of hedgerows. Reduction in productivity of other short

Table 1.Green fodder yield of berseem and *Sesbania* during *rabi* season at different levels of phosphorous and sulphur

Treatment	Berseem								Sesbania		
	Green fodder yield (t ha^{-1})				Dry matter yield (t ha^{-1})				Green fodder yield (t ha^{-1})		
	1993-94	1994-95	1995-96	Pooled	1993-94	1994-95	1995-96	Pooled	1994-95	1995-96	Pooled
P_2O_5 (kg ha^{-1})											
40	82.53	73.15	68.77	74.81	11.80	8.72	7.39	8.97	15.13	30.27	22.70
80	85.17	79.16	72.07	78.80	11.52	9.73	7.74	9.67	15.78	31.55	23.66
120	87.85	81.52	73.48	80.95	11.60	9.80	8.71	10.04	17.59	35.17	26.33
LSD 0.05	1.97	1.30	1.99	1.04	0.39	0.16	0.31	0.16	1.57	3.11	1.75
S (kg ha^{-1})											
0	80.57	69.73	67.03	72.54	10.52	8.07	7.11	8.57	15.87	31.74	23.69
20	83.82	74.73	69.73	76.35	11.03	9.18	7.52	9.24	16.10	32.20	24.15
40	86.74	81.41	73.07	80.40	11.68	9.91	7.82	9.80	16.56	33.13	24.85
60	89.61	82.21	75.87	83.56	12.03	10.50	8.67	10.39	16.12	32.25	24.19
LSD 0.05	2.28	1.51	2.32	1.17	0.45	0.18	0.37	0.20	NS	NS	NS
Mean (Year)	85.18	77.94	71.44	-	11.31	9.42	7.78	-	18.70	32.33	-
LSD (Year) 0.05		1.01				0.18				1.40	

(Interaction effect between various levels of P and S was non-significant, NS - Non-significant) stature crops like cowpea was also recorded in *Leucaena* alley cropping system (Lawson and Kang 1990). Instead of repeated pruning of *Leucaena* at beginning of cowpea growing season and twice more subsequently, hedgerow shading has been to have a more pronounced effect on cowpea yield. The relationship between the changes in yield of *Sesbania* and berseem in 2[nd] and 3[rd] year of experiment shows decline in berseem yield with increased biomass of pruning from *Sesbania* (Fig.2). Lawson and Kang (1990) also concluded from the experiment on *Leucaena* alley cropping that a larger amount of hedgerow biomass production was associated with significant decrease in crop yields owing to increase of hedgerow shading.

In addition to competition for incident light by above ground biomass of hedgerows, below ground hedgerow roots can compete with crop roots for available water and nutrients in the top soil. The berseem yield reduction can be explained in the light of competition of roots of perennial components of ally cropping for growth inputs. It is observed that root growth of hedgerows is prompted when inputs are supplied to alley crops (Femandes 1990). The root competition was studied in alley cropping system by various researchers (Sigh *et al.* 1989; Femanades 1990). The reduction in yield of cowpea and sorghum was eliminated by using root barriers separating hedge and crop to a depth of 50 cm (Singh *et al.* 1987). Femandes (1990) studied the effect of root pruning of *Inga edulis* hedgerows on yield of alley cropped rice. Root pruning by trenching 25 cm from the base of hedgerow and to a depth of 20 cm, immediately after sowing and ageing just prior to tillering, resulted an increase in grain yield of rice by 30% in the row closest to the hedgerow and 15% towards the centre of alley. The above studies

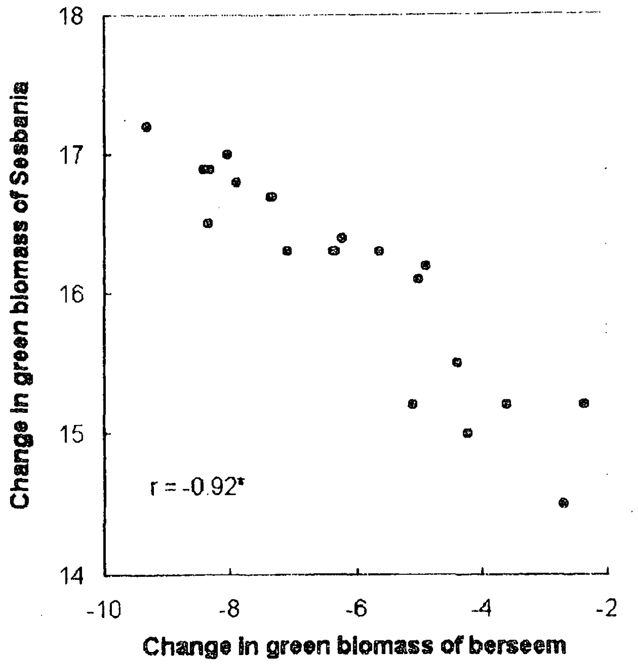


Fig.2 Relationship between changes in productivity of Sesbania and berseem over the years

indicated that hedgerow roots compete with alley crops. However, in the present experiment no root study was conducted. However, future investigation on competition of *Sesbania* hedgerow roots with berseem may justify the reduction of yield of alley crop.

Yields during *kharif* season

The irrigation at different levels of moisture regimes on maize revealed that grain and stover yield increased significantly from rainfed to CATD value - 2°C (Table 2). In comparison to rainfed treatment higher yields of grain (20.4%) and stover (13.5%) were recorded when irrigation was given at CATD

Table 2. Yield of maize and *Sesbania* at different moisture regimes and N-fertilizer levelsl during *kharif* season

Treatment	Maize						*Sesbania*			
	Grain yield (t ha^{-1})			Stover yield (t ha^{-1})			Green fodder yield (t ha^{-1})			
	1993-94	1995-96	Pooled	1993-94	1995-96	Pooled	1993-94	1994-95	1995-96	Pooled
Moisture regimes										
Rainfed	2.30	2.41	2.35	9.94	9.87	9.91	19.18	21.37	23.97	21.51
CATD 0°C	2.53	2.35	2.44	10.27	9.66	9.93	19.84	22.28	25.43	22.69
CATD-2°C	2.87	2.79	2.83	11.27	11.24	11.25	22.41	24.68	28.90	25.33
LSD 0.05	0.12	0.16	0.10	0.61	0.57	0.53	0.67	1.01	1.14	0.65
N (kg ha^{-1})										
0	1.62	1.40	1.51	6.99	6.29	6.64	18.07	19.03	20.95	19.35
40	2.47	2.45	2.46	10.27	10.01	10.14	20.16	21.62	23.83	21.87
80	2.93	2.79	2.86	11.35	11.22	11.29	20.85	24.02	26.68	23.85
120	3.26	3.43	3.35	13.13	13.50	13.32	22.84	28.12	32.80	27.92
LSD 0.05	0.13	0.19	0.11	0.71	0.66	0.47	0.77	1.12	1.32	0.76
Mean (Year)	2.57	2.52	-	10.43	10.26	-	20.48	23.09	26.09	-
LSD (Year) 0.05		0.04			0.19			0.71		

value -2°C (Table 2). The green fodder yield of *Sesbania* alley also increased significantly with increase in soil moisture regimes. The higher green fodder (17.76%) was recorded at wet moisture regime (irrigation at CATD -2°C) over rainfed. The poor distribution of rainfall (Fig.1) during its growing season resulted in lowest yield of rainfed treatment. The most critical growth stages for moisture stress of maize i.e. tasselling and silking received only 4.8% and 8.3% of total annual rainfall during September-October in 1993-94 and 1995-96, respectively. Supply of water through irrigation at CATD value 0 and 20°C increased the productivity of maize over rainfed crop. Like maize, *Sesbania* also responded to moisture regimes and higher productivity was obtained at wet moisture regime. In another experiment on clay loam soil in hot-subhumid region in India, fodder production potential of *Sesbania* alley cropping system with sorghum was reported to be higher with irrigation at -2°C CATD and it was followed by irrigation at 0°C CATD and rainfed condition (Shukla and Shiva Dhar 2000).

Successive increase of N levels from 0 to 40, 40 to 80 and 80 to 120 kg N ha^{-1} increased the yield of maize crop significantly (Table 2). The pooled data over the years revealed that more than twofold increase in grain and stover yield of maize resulted at 120 kg N ha^{-1} over control. Gichuru and Kang (1989) also found that maize yields under alleys were substantially increased with the application of nitrogenous fertilizer. A review of alley cropped maize showed that the application of inorganic N-fertilizer considerably increases yield of maize (Szott and Kass 1993). The response of N on yield of maize crop was predicted through quadratic relationship (Table 3). The optimum agronomic and

Table 3. Relationship between yield of berseem and maize with fertilizers and optimum agronomic and economic levels of fertilizers

Crop	Fertilizer	Relationship	R^2	Agronomic Optimum (kg ha^{-1})	Economic optimum (kg ha^{-1})
Berseem Green forage Yield (y)	P_2O_5 (X)	$Y = 74.81 + 0.1228X - 0.0006X^2$	0.91	102.3	69.8
Berseem dry matter yield (Y)	P_2O_5 (X)	$Y = 8.97 + 0.022X - 0.0001X^2$	0.99	-	-
Maize grain Yield (Y)	Nitrogen (X)	$Y = 1.55 + 0.023X - 0.0004X^2$	0.96	115.0	101.8
Maize stover Yield (Y)	Nitrogen (X)	$Y = 6.80 + +0.081X - 0.0004X^2$	0.92	111.3	81.4

economic levels of N-fertilizer for maize grain were 115.0 and 101.8 kg N ha^{-1} and for maize stover were 111.3 and 81.4 kg N ha^{-1}, respectively. The response due to application of nitrogenous fertilizer on maize was also observed on *Sesbania*. The green fodder yield of *Sesbania* was significantly higher at 120 kg N ha^{-1}, when compared to all other nitrogen levels. It was 44.3% higher over control. Mungikar *et al.* (1976) also found that yield of *Sesbania* increased by application of fertilizer nitrogen.

The yield of maize over the years revealed that there was no significant reduction of grain and stover yield. However, 12.7% and 12.9% increase in yield of *sesbania* were recorded in 2nd and 3rd year of experiment over preceding year. Overall, 27.3% higher yield was observed in final year in comparison to 1st year.

Yield of the system

The seasonal and yearly total yield of the system is expressed in terms of berseem green fodder yield equivalent (BFE) (Table 4). The overall increase in seasonal and annual yield of the system was recorded at different fertilizer levels and moisture

Table 4. Productivity of *Sesbania* alley cropped with berseem and maize in terms of Berseem Green Fodder Equivalent (BFE)

Treatment*	Rabi			Kharif			Lean period	Total
	Berseem green fodder (t ha^{-1})	*Sesbania* green fodder (t ha^{-1})	Total (t ha^{-1})	Maize grain & stover (t ha^{-1})	Sesbania green fodder (t ha^{-1})	Total (t ha^{-1})	*Sesbania* green fodder (t ha^{-1})	BFE (t ha^{-1})
40 P_2O_5-rainfed	74.81	13.62	88.43	24.03	12.91	36.94	2.51	127.88
80 P_2O_5-0°C CATD	78.80	14.20	93.00	25.58	13.61	39.19	3.49	135.68
120 P_2O_5-2°C CATD	80.95	15.83	96.78	28.26	15.20	43.46	3.63	144.17
LSD 0.05	0.04	4.05	1.57	1.06	0.39	1.72	0.21	2.71
0S - 0N	72.45	14.21	86.66	15.66	11.61	27.27	2.49	116.42
20S - 40N	76.35	14.49	90.94	24.91	13.12	38.03	2.85	131.82
40S - 80N	80.40	14.75	95.15	28.46	14.31	42.77	3.44	141.36
60S - 120N	83.56	14.51	98.07	33.39	16.75	50.14	4.55	152.76
LSD 0.05	1.17	NS	1.81	1.96	0.46	3.04	0.35	5.32

(* - various levels of P and S were applied during *rabi*, and moisture regimes and N levels were applied during *Kharif.* Interaction effect between various levels of P and S was non-significant, N - non-significant) regimes. Successive increase in the levels of phosphorus and sulphur increased the total yield of berseem. Although green fodder yield of *Sesbania* increased, the effect of S on *Sesbania* was not significant. The highest yield of the system during *rabi* season was 96.78 t BFE ha^{-1} at 120 kg P_2O_5 ha^{-1}, similarly at higher level of S (60 kg ha^{-1}) the system produced higher yield of 98.07 t BFE ha^{-1}. Irrigation at different moisture regimes and application of N fertilizer on maize increased the total yield in the *kharif* season. Total yield of 43.46 t BFE $ha^{-1}$was recorded when irrigation was given at CATD of -2°C. The maximum yield of *kharif* season was 50.14 t BFE ha^{-1}at 120 kg N ha^{-1}. The residual effect of seasonal treatments was found in yield of *Sesbania* during lean period. The seasonal and total productivity of system revealed that at highest level of phosphorus (120 kg P_2O_5 ha^{-1}) in *rabi* and wet moisture regime (CATD -2°C) in *kharif* the alley cropping system produced highest yield (144.17 t BFE ha^{-1}) in comparison to other treatments of phosphorus and irrigation. The system produced maximum yield (152.76 t BFE ha^{-1}) with the application of highest level of sulphur (60 S ha^{-1}) and nitrogen (120 kg N ha^{-1}) in *rabi* and *kharif* seasons, respectively.

CONCLUSIONS

The experimental results revealed that berseem produced maximum yield at highest level of phosphorus and sulphur application. The agronomic and economic optimum levels of phosphorus fertilizer for berseem green fodder production were 102.3 and 69.8 kg P_2O_5 ha^{-1}, respectively, The maximum yield of maize was recorded at wet moisture regime and highest doses of nitrogen fertilizer. The agronomic and economic optimum doses of N-fertilizer were 115.0 and 101.8 kg N ha^{-1} for grain, and 111.3 and 81.4 kg N ha^{-1}, respectively, for stover production of maize crop. The response to treatments imposed on alley crops also influenced on *Sesbania* productivity. The green fodder production in alleys increased with increase of moisture regimes and fertilizers except sulphur application. The reduction of berseem yield was recorded in subsequent years and this was associated with increase in biomass production of *Sesbania* alley. However, no significant reduction in maize productivity was observed. Thus, in *Sesbania* alley cropping system, yield reduction was more for low stature crop like berseem. From the results on productivity of the system, it could be concluded that intercropping of berseem with 120 kg P_2O_5 and 60 kg S ha^{-1} in *rabi*, followed by maize with 120 kg N ha^{-1} and irrigation at -2°C CATD in 4m wide alleys of *Sesbania*, produced the highest yield.

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