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Research Article

INTER CROPPING SYSTEM: AN ALTERNATIVE PATHWAY FOR SUSTAINABLE PRODUCTIVITY AND ECONOMIC VIABILITY

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Abstract- A study was conducted on KVK instructional farm Sehore (M.P)during 2009-10 (*Kharif*) to evaluate the production potential, Land equivalent ratio, production efficiency, Relative crowding co-efficient and Economic viability of among inter cropping combination *viz.* Soybean, Green gram, Black gram + Maize and Pigeon pea with ratio (4:2). The grain yield was found higher 40.9 q/ha under sole Maize fallowed by sole soybean 17.6 q/ha than all inter cropping combination. But total system productivity was found highest under Soybean + Maize (4:2) combination (2720 kg/ha) followed by Soybean + Pigeon pea (4:2) 2310 kg /ha than other inter cropping combinations. Inter cropping of soybean with maize in 4:2 ratio gave maximum monetary advantage, income equivalent ratio, production efficiency and cost benefit ratio 35900, 22700, 359 and 1:2.9 respectively than other combinations. This treatment accounted maximum land equivalent ratio (1:1.4). Product of Relative crowding co-efficient K>4.2 which proved the most efficient system. Because the negative value of RCC indicates strong competitiveness of crop, while the positive value of RCC indicates, weak competitiveness of crop. Thus maize and pigeon pea crop was found dominant companion to intercrop of soybean along with enhanced economic viability and sustainable productivity in Sehore district of Madhya Pradesh.

Keywords- Yield (inter crop and sole crop)**,** Production potential LER, PE, RCC.

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Introduction

Soybean (*Glycine max* L. Merrill) is an important economic leguminous oil seed crop and is considered as a good source of protein and edible oil for human being. Soybean has been a predominant crop in Madhya Pradesh especially in Sehore district which accounts for 84% area (3, 25, 421 ha) under soybean cultivation during *kharif* season. The district Sehore falls under Vindhyan plateau zone of Madhya Pradesh and lies between 22^0, 31 to 23^0, 40 north and 76^0, 22 to 78^0, 08 east. It is established that soybean has been a predominant crop in Sehore district during kharif season and being used as mono cropping system that leads establishment of harmful dominated weeds flora and high infestation of insect pests, which significantly reduces the yield of soybean crop. Though control of weeds and insect pest infestation is possible by use of various chemical pesticides, however, it may gradually develop resistance in weeds and insect pest against these pesticides. In such situation, diversification of cropping system is necessary to get higher yield, net return, maintain soil health, preserve environment and meet daily food and fodder requirement of human and animals [1]. Thus, it is advised to change either the crop rotation or inclusion of short duration crop as an inter crop. The practice of intercropping explore efficient utilization of all given and available resources i..e. improves soil fertility through biological nitrogen fixation with the use of legume crops, increases soil conservation by more ground cover as compare to sole cropping and intercropping provides insurance against crop failure by any biotic or a biotic stress or against unstable market prices for a given commodity, especially in areas subject to extreme weather conditions such as frost, drought, and flood. Thus, it offers greater financial stability than sole cropping. Thus, through inter cropping we can maintain more stability in production and obtain higher net return accordingly, which is not possible through sole cropping system [2]. Apart from these, the practice of inter cropping also reducing the population density of insect pest as the inter crop may not be the host of insect pest [3]. Through inter cropping we can also manage weeds population over sole crops as intercrops are more effective than sole crops in conserving resources from weeds or suppressing weed growth through allelopathy [4]. In view of this, soybean, green gram, black gram with maize and pigeon pea as an intercrop was evaluated for productivity and economic benefits in Sehore district of Madhya Pradesh.

Materials and Methods

The field experiment was conducted during the *kharif* of 2009 at the instructional farm of KVK Sehore (M.P). The soil was well drained medium to black. Soil sample (0-15 cm deep) was taken from each plot before sowing of crop for analysis. The selected plot have low in nitrogen 225 kg/ha, medium in phosphorus 20.5 kg/ha and medium to high in potash 288 kg/ha and soil p^H and ^oC range of the 6.9 and 0.48%. And total precipitation received during the standing crop was 1190 mm. The size of each plot was 100 m^2 and soil of all the fields was medium to black and well drained. The experiment comprised of eleven treatments (five sole cropping i.e. Maize, Pigeon pea, Soybean, Green gram and Black gram) and six inter cropping i.e. Soybean+ Pigeon pea (4:2), Greenram+ pigeon pea (4:2),

Black gram+ Pigeon pea (4: 2), Soybean + Maize (4:2), Green gram+ Maize (4:2) and Black gram + Maize (4:2) was laid out in randomized block design with three replication. The varieties of crops were Soybean- JS-9305, Pigeon pea - JA-4, Maize- HQPM-1, Green gram- JM-21 and Black gram- JU-2 against the exiting variety of farmers JS-335, red tuar, Sathiya and local green & black gram respectively. The crop was sown in last week of June. Planting spacing for sole and intercropping system in maize & pigeon pea (70 cm × 30cm), soybean (45 cm ×7 cm), black gram and green gram crops (45 cm ×15 cm) and under intercrop system of maize& pigeon pea, soybean, green gram and black gram 60 cm× 30 cm, 40 cm × 7 cm and 40.5 cm × 12 cm was kept respectively. The pigeon pea, soybean, green gram, black gram and maize crops under sole cropping system were fertilized respectively with 20:60:20 and 120:60:50 kg N: P_2O_5:K_2O per ha. The crop under inter cropping system was fertilized with 25 kg N, 75 kg P_2O_5 and 25 kg K_2O/ hectare for both crops. For all sole crop and intercrop, full dose of phosphorus and potash and 1/3 dose of nitrogen was applied at the time of sowing and remaining dose of nitrogen was applied at knee height and teaselingstage of maize while entire quantities of recommended fertilizers were applied as basal at the time of sowing in soybean, green gram & black gram crop. The all crops a seed was treated with carbendazim + thiram (@ 1+2 g/kg seed) followed by *Rhizobium spp* and PSB culture @ 10 g/kg seed prior to sowing. Foliar spray of Profenofos @ 1 lit/ha (dissolved in 500 litre water) for the management of insect pests in soybean, green gram and black gram crops. Maize seed was treated with carbendazim + thiram (@ 1+2 g/kg seed), *Azotobacter* and PSB culture (@ 10 g/kg seed) before sowing. Observations on yield parameters (plant population/m^2, number of pods or cobs/ plant, number of grains/pod or cob, and seed index) of both the crops on randomly selected five plants from each quadrate ($1m^2$) and seed yield per plot were recorded at the time of harvest.

Crop equivalent yield was calculated by converting the seed yield of all intercrop to base crop (Soybean) on the basis of existing selling price in the market. Competition functions like land equivalent ratio (LER) (yield of base crop / yield of sole crop + yield of inter crop / yield of sole crop) and production efficiency (net monetary return of system / duration of system) were estimated as described [5]. Total system productivity was drawn from equivalent yield of system = (equivalent yield of inter crop + equivalent yield of sole crop) + equivalent yield of any one sole crop based on price of produce. Relative crowding co-efficient, area time equivalent ratio, monetary advantage and were calculated on pooled basis [5].

Results and Discussion

Performance of crop and their variety

Higher yield was noted under all sole crop of soybean, pigeon pea, maize, green gram and black gram over the intercrop combinations. Because improved variety of soybean, pigeon pea, maize, green gram and black gram JS-9305, JA-4, HQPM-1, JM-21 and JU-2 gave higher yield 17.3, 12.0, 40.9, 6.25 and 6.5 q/ha respectively over exiting cultivar i.e. JS-335, red tuar, sathiya, and local green gram and black gram 13.5,8.0, 16,4.3, and 4.0 q/ha respectively due to less inter specific competition of space water and nutrients [6]. It may be due to higher number of pods per plant and more number of grains per pod as compared to existing cultivar [Table-1]. Due to regular cultivation of existing variety of these crops since long time and use of higher seed rate than the recommended rates makes it highly susceptible against semi looper, girdle beetle, pod borer infestation, wilt and YMV diseases. Apart from these, premature shedding of flowers, pods and leaves also causes reduction in yield under stress conditions. While cultivar JS-9305 is resistant against diseases, insect-pest and shows tolerance to moisture stress, JA-4 tolerant to frost/cold, HQPM-1 resistant to maydis leaf blight and common rust, JM-21, resistant to YMV and JU-2 tolerant to Cercospora leaf spot and YMV.

Table -1 *Yield and cost benefit ratio under recommended practices and farmer practices*

Name of crop	Duration (days)	Production q/ha		Cost of cultivation		Gross income		Net return		Cost benefit ratio		Crop productivity Rs/ha/day	
		RP	FP	RP	FP	RP	FP	RP	FP	RP	FP	RP	FP
Soybean	90	17.6	13.59	16500.0	15000.0	35200.0	29898.0	18700.0	14808.0	1:2.1	1:1.9	207.7	135.4
Maize	100	40.9	16.4	16200.0	13000.0	40900.0	16400.0	24700.0	3400.0	1:2.5	1:1.3	247.0	34.0
Green gram	75	6.25	4.3	150000.0	1300.0	31250.0	21500.0	1650.0	8500.0	1:2.1	1:1.6	306.6	14.3
Black gram	75	6.5	4.0	15000.0	13000.0	32500.0	20000.0	17500.0	7000.0	1:2.2	1:1.5	326.6	118.7
Pigeon pea	180	12.0	8.0	16800.0	14400.0	36000.0	24000.0	21600.0	7200.0	1:2.1	1:1.7	120.0	60.0

FP- Recommended practices, FP-Farmers Practices

Soybean *Var.* RP-JS-9305,FP-JS-335, Pigeon pea *Var.* RP-JA-4, FP-Red tuar, Maize *Var.* RP-HQPM-1,FP-Satha, Green gram *Var.* RP- JM-21, FP- Local and Black gram *Var.* RP-JU-2 and FP-Local

Therefore, the genotypic combination of JS-9305, JA-4, HQPM-1, JM-21 and JU-2) recorded significantly higher system productivity than other systems. Besides these, JS 9305 and HQPM-1 are early maturing cultivars as compared to JS 335 and pigeon pea (if selected as an intercrop) that facilitate the timely sowing of wheat, gram and mustard during *rabi* season which is likely to give higher productivity.

Maximum cost benefit ratio and crop productivity Rs/ha/day was received under recommended practices in sole maize crop 1:2.5 fallowed by sole black gram 1:2.2 as compared to other sole cropping. Maximum crop productivity was observed in sole cropping of black gram Rs/ha/day 326.6 followed by green gram 306.6 as compared to other sole cropping system. Significantly lower cost benefit ratio and crop productivity Rs/ha/day 1:2.1 and 120 was noted under sole pigeon pea cropping system. This indicated that more profitability under short duration crop compared to long duration crops.

Crop equivalent yield

Maximum crop equivalent yield was found under soybean + maize (4:2) inter cropping combination 1420 +1300 kg/ha fallowed by Soybean +Pigeon pea (4:2) intercropping combination 1410 + 9000 kg/ha as compared to other combination.

Total system productivity

Maize and soybean cultivars 'HQPM-1' and 'JS-9305' recorded highest grain yield under both cropping system (2720 kg/ha) fallowed by soybean and pigeon pea cropping system (2310 kg/ha) as compared to other intercropping system. This might be accredited to lesser competition, temporal complementarities and better utilization of resources by the component crops having differential rooting pattern, canopy distribution and nutrient requirements [1].

Land equivalent ratio

Land equivalent ratio of soybean + maize intercropping system was recorded 1.4 fallowed by black gram + maize 1.34 as compared to other combination which clearly showed 40 and 34 percent increment in yield or to get same level of yield from sole crop, 1.4 and 1.3 ha area would be required. Other workers have also reported LER greater than 1 in soybean: maize intercropping system [7]. Maize + pigeon pea intercropping system, dry matter production per unit of photosynthetic active radiation (PAR) absorbed was higher than the sole crops. The higher PAR conversion efficiencies under intercropping systems may be attributed to greater spread and distribution of light over leaf area of intercrop canopies during early stage of growth [8].

Relative crowding co-efficient

The maximum relative crowding co-efficient values (4.2) was recorded in soybean + maize fallowed by soybean + pigeon pea (4.0) as compared to other intercropping system. The relative crowding co efficient values was noted > 1.0 in all above mention inter cropping combination, which indicated that more yield than expected. The positive value of RCC indicates weak competitiveness while

negative value of RCC indicates strong competitiveness of crop. Soybean + maize and soybean + pigeon pea indicated comparative yield advantage of this system over other inter cropping combination [8]. The product of relative crowding co-efficient indicated definite yield advantage to grow maize and pigeon pea.

Production efficiency

The higher production efficiency was obtained under soybean + maize inter cropping (359 %) fallowed by black gram + maize (250) than other inter or sole cropping system. The superior production efficiency from soybean + maize inter cropping could be due to spatial and temporal advantages as compared to sole cropping system [6].

Yield of inter crop

Yield variations and decreasing trends in the intercropping system depend on the row arrangements of component crop compared to sole crop [Table-2] due to shading and competition consequence of Maize plants on associated legumes crops under different inter cropping system [5].

Table-2 *Enhance the resource use efficiency through inter cropping for production efficiency and net return.*

Treatment Combinations	Average yield		Total system productivity(kg)	LER	EY in crop kg/ha		PE	RCC	
	BC	SC			BC	SC		BC	SC
Soybean: Pigeon pea (4:2) improved var.	14.1	6.0	2310.0	1.3	1410.0	900.0	153.9	4.0	1.0
Soybean: Maize (4:2) improved var.	14.2	26.0	2720.0	1.4	1420.0	1300.0	359.0	4.2	1.7
Green gram: Pigeon pea (4:2) improved var.	4.6	6.0	820.0	1.23	460.0	360.0	130.0	2.8	1.0
Black gram: Pigeon pea (4:2) improved var.	4.8	6.0	840.0	1.24	480.0	360.0	136.0	2.8	1.0
Green gram: Maize (4:2) improved var.	4.5	25	900.0	1.33	450	450.0	245.0	2.6	1.1
Black gram: Maize (4:2) improved var.	4.7	25.2	974.0	1.34	470	504.0	250.0	2.6	1.6
CD at 5%	0.91	2.99	304.3	0.053	85.75	139.8	90.6	1.1	0.35

LER-land equivalent ratio, AER-area equivalent ratio, EY-equivalent yield, PE-Production efficiency, BC-Base crop, SC-Sub crop.

Table-3 *Economic evaluation of different Intercropping combinations.*

Treatment Combinations	Cost of cultivation	Gross return		Total grass return	NMR in sequence	IER	B:C ratio
		BC	SC				
Soybean: Pigeon pea (4:2) improved var.	18500.0	28200.0	18000.0	46200	27700	21200.0	1:2.5
Soybean: Maize (4:2) improved var.	18500.0	28400.0	26000.0	54400	35900	32700.0	1:2.9
Green gram: Pigeon pea (4:2) improved var.	17500.0	23000.0	18000.0	41000	23500	14750.0	1:2.3
Black gram: Pigeon pea (4:2) improved var.	17500.0	24000.0	18000.0	42000	24500	15500.0	1:2.4
Green gram: Maize (4:2) improved var.	17500.0	2500.0	25000.0	50000.0	32500	27850	1:2.8
Black gram: Maize (4:2) improved var.	17500.0	23500.0	25200.0	48700.0	31200	24000	1:2.7

IER-Income equivalent ratio, NMR-Net monetary return, BC-Base crop, SC-Sub crop.

Economic evaluation

The monetary advantage based on land equivalent ratio indicated superior economic viability of soybean + maize inter cropping followed by green gram + maize in 4: 2 ratio over other cropping system [Table-3]. Soybean + maize intercropping system recorded highest net returns and benefit cost ratio (Rs. 35,900/ha &1:2.9) followed by Green gram + maize (Rs. 32,500/ha & 1:2.8), as compared to other inter cropping combination, which clearly indicated the superiority of this system over sole cropping systems.

Conclusion and recommendation

The results clearly revealed that intercropping of soybean + maize during *kharif* season enhanced the productivity and profitability under rainfed conditions. Application of recommended dose of fertilizers along with improved varietal combination is necessary for both sole and intercropping system. Since duration of life cycle of crops used in this intercropping system was within 100 days, farmers can efficiently utilize residual moisture through early sowing of few short duration *rabi* crops. Thus, the farmers of Sehore district could use maize crop as an intercrop with soybean for higher profits and economic benefits.

Conflict of Interest: None declared

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