Ecological intensification practices for enhancing productivity in greengram – maize cropping system

A.P. Sivamurugan, R. Ravikesavan

Department of Millets, Tamil Nadu Agricultural University, Coimbatore- 641003, Tamil Nadu, India

*Corresponding author: E-mail: apacsivamurugan@gmail.com

Keywords: *Greengram, Maize, Ecological Intensification (EI), growth and yield*

Abstract

Field experiments were carried out at Department of Millets, Tamil Nadu Agricultural University, Coimbatore during *kharif*, 2017, *rabi*, 2017-18, *kharif*, 2018 and *rabi*, 2018-19 in sandy clay loam soil to study the effect of ecological intensification practices on growth, yield attributes and yield of greengram- maize cropping system. Experimental results revealed that in greengram, Ecological Intensification (EI) practices recorded higher grain yield (846 kg ha^{-1}), net return (Rs. 24,782/ha) and BC ratio (1.84) in greengram- maize cropping system. In maize, Ecological Intensification (EI) practices recorded higher grain yield (5963 kg ha^{-1}), net return (Rs. 59,714/ha) and B:C ratio (2.48) in greengram- maize cropping system.

Abbreviations

Broad Leaved Weed (BLW)
Benefit Cost ratio(B:C)
Coimbatore(CO)
Critical Difference(CD)
Days After Sowing(DAS)
Di Ammonium Phosphate (DAP)
Ecological Intensification (EI)
Farm Yard Manure (FYM)
Hand Weeding(HW)
High yielding varieties programme (HYV)
Muriate of Potash(MOP)
Nitrogen(N)
Phosphorus(P)
Potassium(K)
Pre Emergence herbicide (PE)
Randomized Complete Block Design (RCBD)

Introduction

Conventional intensive agriculture after the introduction of high yielding varieties programme (HYV) in 1966 resulted in remarkable increase in productivity of crops. Nevertheless, this has led to deterioration in soil quality over the years and caused significant damage to the environment (Bender *et al.*, 2016). In recent years, there has been progressive and substantial depletion of soil reserves resulting in secondary and micronutrient deficiencies. Adoption of ecological intensification approach is necessary to solve these problems and to improve the crop productivity. This is proposed as a nature based alternative approach, which complements or replaces external inputs partially *viz.*, herbicides, pesticides, fungicides etc. with production supporting ecological processes, to sustain agricultural production while minimizing adverse effects on the environment (Cassman, 1999, Bommarco *et al.*, 2013, Tittonell, 2014).

Production and protection technologies like crop rotation, cover crop, intercropping, organic agriculture, minimum or no tillage, conservation agriculture etc. are being recommended for ecological intensification. (Hobbs *et al.*, 2008, Doltra and Olesen, 2013, Reganold and Wachter, 2016).The ecological intensification practices mentioned, sustain or enhance productivity of crops by ecosystem services thus minimizing negative impact on the environment. Hence, experiments were conducted to study the effect of ecological intensification practices on growth, yield attributes and yield of greengram - maize cropping system.

Material and methods

Experimental site

Field experiments were carried out at Department of Millets, Tamil Nadu Agricultural University, Coimbatore in Western Zone of Tamil Nadu during *kharif*, 2017, *rabi*, 2017-18, *kharif*, 2018 and *rabi*, 2018-19 to study the effect of ecological intensification practices on growth, yield attributes and yield of greengram- maize cropping system. The soil was low in available N and P and high in available K.

Experimental design

The experiments were laid out in a Randomized Complete Block Design (RCBD) with the following treatments for greengram and the whole experiment was replicated thrice.

	Treatments
T1	Farmer practice (No retention of residues, Broadcasting, CO 8 (variety), FYM at 5t/ha, 125 kg DAP/ha (basal) + 40 kg MOP/ ha (basal), Irrigation at critical stages, HW on 20-25 DAS, Dimethoate at 500 ml/ha for aphid and whitefly
T2	Ecological Intensification (EI) which includes retaining residue of previous crop, FYM at 12.5t/ha, CO 8 (variety) , 30 x 10 cm (line sowing), seed treatment with Trichoderma viride at 4g/ha and with Rhizobium and Phosphobacteria at 600g/ha,25:50:25 NPK kg/ha, spraying of pulse wonder @5kg/ha, irrigation at critical stages (Flowering and Pod formation), Pendimethalin at 3.3lit/ ha as pre emergence application, HW on 30 DAS, Dimethoate at 500 ml/ha for aphid and whitefly, Indoxacarb at 333 ml/ha for pod borer, Mancozeb at 1kg/ha for rust and leaf spot
T3	EI minus tillage practice (Conventional tillage without residue retention)
T4	EI minus Nutrient management (Farmer adopted nutrient management)
T5	EI minus Planting density (Farmer adopted genotype and density)
T6	EI minus Water management (Farmer's practice)
T7	EI minus Weed management (Farmer adopted weed management)
T8	EI minus Disease and insect management (Farmer adopted management)

After harvest of greengram, the following treatments were imposed for maize and the whole experiment was replicated thrice.

	Treatments
T1	Farmer practice (No retention of residues,60 x 20 cm,NK6240 (hybrid),FYM at 5t/ha,100 kg DAP/ha (basal) + 250 kg Urea/ha on 30-35 DAS, Irrigation at critical stages, PE Atrazine at 0.75 kg/ha + HW on 30-35 DAS, Chlorpyriphos or Monocrotophos at 500 ml/ha for sucking pest
T2	Ecological Intensification (EI) which includes retaining residue of previous crop, 60 x 25 cm, CO6 (hybrid) + FYM at 12.5t/ha + 110:61:90 NPK kg/ha, Irrigation at critical stages, PE Atrazine at 0.5kg/ha + HW on 30-35 DAS, Dimethoate at 660 ml/ha for sucking pest, phorate at10 kg/ha for stem borer and Mancozeb at 1kg/ha for blight
T3	EI minus tillage practice (Conventional tillage without residue retention)
T4	EI minus Nutrient management (Farmer adopted nutrient management)
T5	EI minus Planting density (Farmer adopted genotype and density)
T6	EI minus Water management (Farmer's practice)
T7	EI minus Weed management (Farmer adopted weed management)
T8	EI minus Disease and insect management (Farmer adopted management)

Measurements

Five plants in each plot were selected and tagged for recording plant height at harvest. Weed density in respect of grasses, sedges and BLW at 25 DAS was recorded by using quadrat. Yield attributes *viz.*, pods/plant, seeds/pod and100 seed weight (g) for greengram and 100 seed weight (g) for maize were recorded from the five randomly selected plants in each plot. The pods of greengram and cobs of maize from the net plot were harvested and threshed for calculating grain yield per plot and converted to kg per hectare. After the harvest of pods of greengram and cobs of maize, haulm and stover from the net plot was harvested and weighed .This was converted to kg per hectare.

Statistical analysis

The data on various characters studied during the investigation were statistically analyzed by Gomez and Gomez (2010) for Randomized Complete Block Design. Wherever the treatment difference was significant, critical differences were worked out at 5 per cent probability level.

Results and discussion

Effect of ecological intensification practices on growth and yield attributes of greengram in greengram – maize cropping system during kharif, 2017 and kharif, 2018.

Experimental results revealed that ecological intensification practices evinced significant influence on plant height and yield attributes of greengram in both the years. Among the different treatments, T_2 - Ecological Intensification (EI) recorded significantly higher plant height of 43.1 cm and 49.3 cm during *kharif*, 2017 and *kharif*, 2018, respectively at harvest which was comparable with T_3, T_6, T_8, T_1, T_4 and T_5. The lowest plant height was recorded in T_7 and T_1.This might be ascribed to more accumulation of photosynthates through effective utilization of nutrients, water and other resources. The results confirm the findings of Ihsanullah *et al.*, 2002. In respect of yield attributes, T_2 - Ecological Intensification (EI) recorded higher number of pods/ plant (26.1), seeds/pod (7.5), and 100 seed weight (3.93g) which was comparable with T_3, T_5, T_6 and T_8 during *kharif*, 2017. In kharif, 2018, T2 - Ecological Intensification (EI) recorded higher number of pods/plant (29.1), seeds/pod (7.5), and 100 seed weight (3.96 g) which was comparable with T_3, T_5, T_6, T_8 and T_7.The lowest number of pods/plant, seeds/pod and 100 seed weight were observed in T_7 and T_1. Ecological intensification practices *viz.*, recommended spacing, balanced nutrition, integrated weed, pest and disease manage-

Table 1 - Effect of ecological intensification practices on growth and yield attributes of greengram in greengram – maize cropping system during *kharif*, 2017 and *kharif*, 2018.

Treatments	Plant height (cm) at harvest		Pods/plant		Seeds/pod		100 seed weight (g)	
	Kharif, 2017	*Kharif*, 2018	*Kharif*, 2017	*Kharif*, 2018	*Kharif*, 2017	*Kharif*,2018	*Kharif*, 2017	*Kharif*, 2018
T1	38.2	43.6	21.7	24.1	6.6	6.2	3.51	3.57
T2	43.1	49.3	26.1	29.1	7.5	7.6	3.93	3.96
T3	41.3	47.2	24.6	27.9	7.3	7.3	3.82	3.89
T4	36.2	44.8	18.8	24.8	6.2	6.6	3.20	3.62
T5	38.3	45.4	22.0	26.1	7.0	7.0	3.62	3.71
T6	41.0	46.7	24.2	27.4	7.1	7.3	3.74	3.84
T7	34.3	43.9	12.3	24.4	5.9	6.3	3.43	3.59
T8	39.6	46.3	23.5	26.7	7.1	7.1	3.82	3.78
CD (p=0.05)	8.7	8.4	8.1	4.7	0.5	1.1	0.40	0.84

ment on adoption favoured better translocation of the accumulated photosynthates which resulted in more number of yield attributing characters. The results are in accordance with the findings of Naeem *et al.* (2006) and Hussain (1994).

Effect of ecological intensification practices on weed density in greengram - maize cropping system

Experimental results revealed that ecological intensification practices evinced significant influence on weed density in greengram – maize cropping system. In greengram, among the different practices, T_2 - Ecological Intensification (EI), recorded significantly lesser grassy weed count (14.7 No m^2) on 25 DAS and it was on par with T_6 and T_3 but was superior to other treatments. The highest grassy weed count was recorded in T_7. The treatments failed to exert any significant effect on Sedges. Nevertheless, T_5 - EI minus Planting density (Farmer adopted genotype and density) recorded significantly lesser weed count (0.7 No m^2). In respect of broad leaved weeds, T_4 - EI minus Nutrient management (Farmer adopted nutrient management) recorded lesser weed count (13.3 No m^2) which was comparable with T_8 and T_2. The highest weed count was recorded in T_5 during kharif, 2017. In greengram, during *kharif* 2018, T_2 - Ecological Intensification (EI), recorded significantly lesser grassy weed count (11.3 No m^2) on 25 DAS and it was on par with T_6 and T_3 but was superior to other treatments. The highest grassy weed count was recorded in T_1. The treatments failed to exert any significant effect on Sedges. Nevertheless, T_3 - EI minus tillage practice (Conventional tillage without residue retention) recorded significantly lesser weed count (2.0 No m^2). In respect of broad leaved weeds, T_2 - Ecological Intensification (EI) recorded lesser weed count (73.7 No m^2) which was comparable with T_6 and T_3. The highest weed count was recorded in T_1. The lesser weed count was ascribed to ideal plant geometry, appropriate nutrient, pest and disease management which favoured crop growth thus suppressing the dominance of weeds. Similar view has been expressed by Rana *et al.*, 2011.

In maize, among the different practices, T_2 - Ecological Intensification (EI), recorded significantly lesser grassy weed count (24.3 No m^2) on 25 DAS and it was on par with T_3, T_4, T_5 and T_6 but was superior to other treatments. The highest grassy weed count was recorded in T_7. The treatments evinced no significant effect on Sedges. Nevertheless, T_5 - EI minus Planting density (Farmer adopted genotype and density) recorded si-

Table 2 - Effect of ecological intensification practices on weed density in greengram - maize cropping system.

Treatments	Kharif, 2017 - Greengram			Kharif, 2018 - Greengram			Rabi, 2017-18- Maize			Rabi, 2018-19- Maize		
	Weed density (m^2) at 25 DAS			Weed density (m^2) at 25 DAS			Weed density (m^2) at 25 DAS			Weed density (m^2) at 25 DAS		
	Grasses	Sedges	BLW	Grasses	Sedges	BLW	Grasses	Sedges	BLW	Grasses	Sedges	BLW
T1	57.3	4.0	211.3	64.7	2.3	182.3	66.3	4.0	188.7	91.7	3.7	161.3
T2	14.7	6.0	67.3	11.3	3.7	73.7	24.3	7.7	86.3	30.3	9.7	94.3
T3	29.3	14.7	102.7	20.7	2.0	104.3	38.0	16.3	125.0	41.7	17.3	121.7
T4	42.0	12.7	13.3	54.3	5.3	150.3	53.7	13.3	31.3	61.7	16.7	44.7
T5	36.7	0.7	128.7	47.7	4.7	157.7	47.3	2.0	158.3	47.7	2.3	146.3
T6	21.3	8.0	106.0	27.7	4.0	112.3	32.3	9.7	128.7	39.3	8.3	97.3
T7	106.0	2.7	117.3	60.3	3.0	171.7	118.3	3.7	142.3	74.3	5.3	112.7
T8	45.3	2.7	44.0	38.3	3.0	134.3	58.33	3.7	66.3	54.3	4.7	70.7
CD (p=0.05)	20.5	NS	88.7	25.8	NS	55.2	30.2	NS	51.6	35.1	NS	55.6

Table 3 - Effect of ecological intensification practices on yield and economics of greengram in greengram – maize cropping system during *kharif* ,2017 and *kharif* ,2018.

Treatments	Grain yield (kg ha^{-1})		Haulm yield (kg ha^{-1})		Net return (Rs.ha^{-1})		B:C ratio	
	Kharif, 2017	***Kharif***, 2018	***Kharif***, 2017	***Kharif***, 2018	***Kharif***, 2017	***Kharif***,2018	***Kharif***, 2017	***Kharif***, 2018
T1	594	612	1525	1534	14971	16068	1.63	1.68
T2	832	859	1782	1976	23778	25786	1.80	1.87
T3	811	828	1703	1903	22360	23800	1.75	1.80
T4	512	644	1252	1604	7024	12126	1.27	1.41
T5	706	719	1521	1667	17866	18938	1.65	1.69
T6	796	804	1638	1854	21330	22282	1.72	1.75
T7	408	627	1071	1568	4149	11483	1.18	1.39
T8	772	761	1597	1757	19816	19456	1.67	1.65
CD (p=0.05)	104	117	235	NS				

gnificantly lesser weed count (2.0 No m^2). In respect of broad leaved weeds, T_4 - EI minus Nutrient management (Farmer adopted nutrient management) recorded lesser weed count (31.3 No m^2) which was comparable with T_8. The highest weed count was recorded in T_1 during rabi, 2017-18. In maize, during *rabi* 2018-19, T_2 - Ecological Intensification (EI), recorded significantly lesser grassy weed count (30.3 No m^2) on 25 DAS and it was on par with T_3, T_4, T_5, T_6 and T_8 but was superior to other treatments. The highest grassy weed count was recorded in T_1. The treatments failed to exert any significant effect on Sedges. Nevertheless, T_5 - EI minus Planting density (Farmer adopted genotype and density) recorded significantly lesser weed count (2.3 No m^2). In respect of broad leaved weeds, T_4 - EI minus Nutrient management (Farmer adopted nutrient management) recorded lesser weed count (44.7 No m^2) which was comparable with T_2, T_6 and T_8. The highest weed count was recorded in T_1. The results confirm the findings of Kamble *et al.*, 2005.

Effect of ecological intensification practices on yield and economics of greengram in greengram – maize cropping system during kharif, 2017 and kharif, 2018.

With respect to grain yield, T_2 - Ecological Intensification (EI) recorded higher grain yield of 832 kg ha^{-1} during kharif, 2017 and 859 kg ha^{-1} during kharif, 2018 which was comparable with T_3, T_6 and T_8 in both the seasons but was significantly superior to other treatments. The lowest yield of 408 kg ha^{-1} was recorded in T_7 during *kharif*, 2017 and 612 kg ha^{-1} was recorded in T_1 during *kharif*, 2018. This result might be ascribed to increased number of pods/plant, seeds/pod and 100 seed weight which enhanced the yield of greengram. Similar view has been expressed by Sultana *et al.* (2009). In respect of haulm yield, T_2 - Ecological Intensification (EI) recorded higher haulm yield of 1782 kg ha^{-1} during *kharif*, 2017 which was on par with T_3, T_6 and T_8 but was significantly superior to other treatments. During *kharif*, 2018 there was no significant influence of treatments in respect of haulm yield. The results are in accordance with the findings of Patel and Pramer, 1986. The highest net return of Rs. 23,778/ha and BC ratio of 1.80 was registered in T_2 (Ecological Intensification (EI) during *kharif*, 2017. In *kharif*, 2018 also T_2 (Ecological Intensification (EI) registered the highest net return (Rs. 25786/ha) and B:C (1.87) ratio.

Effect of ecological intensification practices on growth, yield and economics of maize in greengram – maize cropping system during rabi, 2017-2018 and rabi, 2018-2019.

The results obtained from this experimentation revealed that ecological intensification practices failed to exert significant influence on plant height and 100 seed weight of maize in both the years. Nevertheless, higher plant height and 100 seed weight was recorded in T_2 (Ecological Intensification (EI). The lowest plant height was recorded in T_7 and T_1. This might be ascribed to prolonged vegetative growth and effective utilization of resources which favoured the plant height and 100 seed weight. These results were in agreement with those of Khalil *et al.*, 1988 and Bakht *et al.*, 2006. With respect to yield, higher grain yield of 5892 kg ha^{-1} was recorded in T_2 (Ecological Intensification (EI), which was comparable with T_3 and T_8 but was significantly superior to other treatments during *rabi*, 2017-18. In *rabi*, 2018-19, T_2 (Ecological Intensification (EI) recorded higher grain yield of 6034 kg ha^{-1} which was comparable with T_3, T_4, T_5 and T_8 but was superior to other treatments. This might be due to favourable effect of ecological intensification practices, which were adopted in maize. Lower grain yield was observed in T_7 and T_1. The results are in accordance with the findings of Thakur *et al.* (1997) and Paramasivan *et al.* (2011). In respect of stover yield, T_2 (Ecological Intensification (EI) recorded higher stover yield which was comparable with T_3 and T_8 in both the years but was significantly superior to other treatments.

Table 4 - Effect of ecological intensification practices on growth, yield and economics of maize in greengram – maize cropping system during *rabi*, 2017-2018 and *rabi*, 2018-2019.

Treatments	Plant height (cm) at harvest		100 seed weight (g)		Grain yield(kg ha^{-1})		Stover yield (kg ha^{-1})		Net return (Rs.ha^{-1})		B:C ratio	
	Rabi, 2017-18	Rabi, 2018-19	Rabi, 2017-18	Rabi, 2018-19	Rabi, 2017-18	Rabi, 2018-19	Rabi, 2017-18	Rabi, 2018-19	Rabi, 2017-18	Rabi, 2018-19	Rabi, 2017-18	Rabi, 2018-19
T1	220.1	215.1	36.5	36.6	4904	4612	8547	7702	44657	38182	2.19	1.99
T2	231.3	235.7	37.8	38.6	5892	6034	10488	10619	59206	60222	2.49	2.47
T3	229.3	233.4	37.5	38.2	5714	5883	9885	10178	55933	57511	2.41	2.41
T4	212.7	223.4	35.9	37.2	4076	5198	7174	8785	35209	47760	2.06	2.22
T5	223.4	227.1	36.8	37.4	5257	5513	9159	9273	48352	51056	2.22	2.25
T6	216.7	196.7	36.1	36.2	4226	3976	7225	6561	33753	28089	1.92	1.74
T7	180.6	219.7	35.3	36.8	3591	4779	6394	8028	28542	40996	1.90	2.06
T8	225.8	229.7	36.9	37.7	5314	5562	9547	9567	52155	54145	2.41	2.39
CD(p=0.05)	NS	NS	NS	NS	626	856	1262	1259				

During *rabi*, 2017-18, higher net return and B:C ratio of Rs. 59206/ha and 2.49, respectively was registered in T_2 (Ecological Intensification (EI). In *rabi*, 2018-19 also, T_2 (Ecological Intensification (EI) registered higher net return and B:C ratio of Rs. 60222/ha and 2.47, respectively.

Conclusions

Based on the results of two years of experimentation, it is concluded that in greengram, Ecological Intensification (EI) practices recorded higher grain yield (846 kg ha^{-1}), net return (Rs. 24,782/ha) and BC ratio (1.84) in greengram- maize cropping system. In maize, Ecological Intensification (EI) practices recorded higher grain yield (5963 kg ha^{-1}), net return (Rs. 59,714/ha) and BC ratio (2.48) in greengram- maize cropping system.

Acknowledgement

The Researchers gratefully acknowledge ICAR-All India Coordinated Research Project on Maize for conducting the experiments and for the financial support and the facilities provided at Department of Millets, TNAU, Coimbatore, India.

References

Bakht JS, Ahmad M, Tariq H, Akber M, Shafi, 2006. Response of Maize to planting methods and fertilizer N. Journal of Agricultural and Biological Science 1:8-14.

Bender SF, Wagg C, Van Der Heijden MGA, 2016. An underground revolution: Biodiversity and soil ecological engineering for agricultural sustainability. Trends in Ecology and Evolution 31:440-452.

Bommarco R, Kleijn D, Potts SG, 2013. Ecological intensification: harnessing ecosystem services for food security. Trends in Ecology and Evolution 28:230-238.

Cassman KG, 1999. Ecological intensification of cereal production systems: Yield potential, soil quality, and precision agriculture. Proc. National Academy of Sciences of the United States of America 96:5952-5959.

Doltra J, Olesen JE, 2013. The role of catch crops in the ecological intensification of spring cereals in organic farming under Nordic climate. European J Agron 44:98-108.

Hobbs PR, Sayre K, Gupta R, 2008.The role of conservation agriculture in sustainable agriculture. Philosophical Transactions of the Royal Society B-Biological Sciences 363:543-555.

Hussain TA, 1994. Effect of NPK application on the growth and yield of mungbean (*Vigna radiata* L.). Agron J 37(3):549-551.

Ihsanullah, Taj FH, Akbar H, Basir A, Ullah N, 2002. Effect of Row Spacing on Agronomic Traits and Yield of Mungbean (*Vigna radiata* L. Wilczek). Asian J Plant Sci 1:328-329.

Khalil SK, Afridi MS, Iqbal M, 1988. Plant Height, Weeds Weight and Hay Yield of Maize and Mungbean in Mono and Associated Culture as Affected by NPK Application. Sarhad Journal of Agriculture 4:377-385.

Kamble TC, Kakade SU, Nemade SU, Pawar RV,Apotikar V, 2005.Integrated weed management in hybrid maize. Crop Res 29(3): 396-400.

Naeem M, Iqbal J, Maaha B, 2006. Comparative Study of Inorganic Fertilizers and Organic Manures on Yield and Yield Components of Mungbean (*Vigna radiata* L.). J Agric Social Sci 2: 227-229.

Paramasivan, M,Kumaresan KR,Malarvizhi S, Thiyageswari S,Mahimairaja, Velayudham K, 2011. Nutrient optimization strategy for sustainable productivity of hybrid maize (*Zea mays* L.) in palaviduthi (Pvd) series of soil of

Tamil Nadu. Res Crops 12(1): 39-44.
Patel TS, Pramer MT, 1986. Response of greengram to varying levels of nitrogen and phosphorus. Madras Agri J 73:355-356.
Reganold JP, Wachter JM, 2016. Organic agriculture in the twenty-first century. Nature Plants 2:15221.
Sultana S, Ullah J, Karim F, Asaduzzaman, 2009. Response of mungbean to integrated nitrogen and weed management. American Eurasian J Agron 2 (2):104-108.
Thakur, DR, Prakash O, Kharwara PC, Bhalla SK, 1997. Effect of nitrogen and plant spacing on yield, nitrogen uptake and economics in corn (*Zea mays* L.). Ind J Agron43(4): 668-671.
Tittonell P, 2014. Ecological intensification of agriculture - sustainable by nature. Current Opinion in Environmental Sustainability 8:53-61.