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Production and Profitability of Integrated Nutrient Management Practices on Intensive Diversified Cropping System

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Abstract Field investigations were carried out in farmers field at Dharmapuri, during 2017-18 and 2018-19, to assess the production and profitability of five intensive diversified cropping systems in order to identify the suitable crop based rotations and owning maximum profitability for North Western Agro climatic Zones of Tamil Nadu. During *kharif* season, among the different intensive intercropping system higher groundnut equivalent yield was recorded in brinjal with onion intercropping system with 8.82 t ha^{-1} and 9.67 t ha^{-1} during 2017-18 and 2018-19 respectively, which was followed by bhendi with coriander intercropping system of 5.62 t ha^{-1} and 6.34 t ha^{-1}. Higher nutrient uptake was recorded in maize with fodder cowpea intercropping system followed by groundnut intercropped with redgram cropping system. Application of vermicompost @ 5 t ha^{-1} along with 100% inorganic fertilizer recorded higher groundnut equivalent yield and nutrient uptake followed by farm yard manure @ 12.5 t ha^{-1} along with 100% inorganic fertilizer applied plot. Higher B:C ratio was recorded in brinjal intercropped with onion cropping system and among the nutrient management practices farm yard manure @ 12.5 t ha^{-1} along with 100% inorganic fertilizer applied plot registered higher B:C ratio during both the years.

Keywords Cropping systems, Nutrient management, Vermicompost, Farm yard manure, Production and profitability.

Introduction

Intercropping is an age old practice in India, especially under rainfed conditions, which aims to increase total productivity through equitable and judicious use of land resource and farming inputs including labors. Intercropping system meets the various requirements of a farmer and also harness the farmer resources efficiently. Development of feasible and economically viable intercropping system which largely depends upon the adoption of proper planting time, planting geometry, selection of compatible crop and adoption of nutrient management techniques. Thus, the objectives of intercropping system aims at augmenting the total productivity per unit time of the land by growing more than one crop in same field, diversification of

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cropping system is necessary to get higher yield and returns, to maintain soil health, preserve environment and meet daily food and fodder requirement of human and animal, respectively (Padhi and Panigrahi 2006).

Inclusion of legumes in cereal based intercropping system help to increase productivity by extracting moisture and nutrient from the deeper soil layers. Fodder cowpea is a heavy forage yielder it enrich their nutritive value due to its higher protein content. Besides, it also improves the fertility status of soil and reduce the nitrogen requirement of companion or succeeding crop in rotation, by fixing atmospheric nitrogen through their nodules (Bisht et al. 2001). Inclusion of fodder cowpea in maize not only provide nutritional security but also it improve yield, economics and environmental stability to maize belt in future. North Western Agroclimatic zone normally receives sufficient rainfall and is well distributed. It provides enough moisture for growing crops in a year successfully. Hence, there is a possibility of taking a compatible intercrop with diversity in growth habit and duration during *kharif* season.

Presently, the production of oil seeds and pulses is sub-optimal leading to low per capita availability. The scope for further increase in production through expansion of area is very much limited and alternatively the production can be increased through different cropping systems. Groundnut and pigeonpea intercropping proved advantageous bacause groundnut is a short duration crop which utilizes resources effectively in the early season and pigeonpea being long duration, slow-growing and indeterminate type can utilize the resources effectively during post monsoon season.

Short duration vegetables grown in between the agricultural crops is the recent advancement to fulfill the requirement of vegetable without any reduction in agricultural area. Judicious combination of organic manures (Nanjundappa et al. 2000) along with inorganic fertilizers not only reduces the quantity of chemical fertilizers to be applied but also improve the yield and quality of crops. Identification of suitable intercropping system to a particular region to explore available resources, for higher income per unit area and unit time and effect of organic manures in combination with inorganic fertilizers on intercropping system is meager. Hence, the present investigation was planned and undertaken.

Materials and Methods

Experiment location

An experiment was conducted on intensive diversified cropping systems in farmer field at Dharmapuri (latitudes N $11^0$47` and $12^0$13` and longitudes E $77^0$02` and $78^0$40` at an elevation of 457 m above Mean Sea Level (MSL), Tamil Nadu during *kharif, rabi* and summer seasons of 2017-18 and 2018-19. A uniformity trial on sorghum was undertaken during *rabi* 2016-17 to ensure uniform soil physico-chemical status in the entire field. The soil (0-15 cm layer), taken after the uniformity trial, of the experimental site was sandy clay loam in texture (Piper 1996) with pH 7.8 (1:2.5 soil and water ratio), EC 0.4 ds m^{-1} (conductivity bridge), organic carbon 0.4% (Walkley and Black 1934), low in available nitrogen with 263 kg ha^{-1} (Subbiah and Asija 1956), medium in available phosphorus with 20.17 kg ha^{-1} (Olsen et al. 1954) and potassium with 234 kg ha^{-1} (Stanford and English 1949).

Experimental details

The experiment was laid-out in strip plot design replicated thrice in fixed plots. Five treatments comprised of five intensive diversified cropping systems viz., cropping systems were taken in main-plots and five nutrient management practices treatments viz., farm yard manure 12.5 t ha^{-1} and vermicompost at 2.5, 5 and 7.5 t ha^{-1} along with fertilizers at variable level 100, 75 and 50% were imposed in sub-plots. On an average, manure used in the experiment contains nutrient content of 0.4% N, 0.2% P_2O_5, 0.3% K_2O in FYM and vermicompost contain 2.3%N, 0.9% P_2O_5, 1.2% K_2O.The details of crops, genotype, seed rate and fertilizers used in cropping systems are given in Table 1. The nutrient management practices were imposed on *kharif, rabi* and summer season crops where organic manures was applied only in *kharif* season. Before crop sowing vermicompost, FYM and inorganic fertilizers were broadcasted uniformly as per the treatment schedule. Nitrogen, phosphorus and

Table 1. Details of agronomic practices followed for different crops in field experiment during 2017-18 and 2018-19.

kharif crop	Genotypes	Seed rate (kg ha^{-1})	Fertilizer (NPK kg ha^{-1})
Groundnut	VRI –2	120	25:50:75
Redgram	CO (RG)-7	15	
Maize	CO (HM)-6	20	250:75:75
Fodder cowpea	CO –9	25	
Bhendi	OH 102	10	100:100:100
Coriander	CO2	12	
Brinjal	Dhuruva	200 g	100:150:100
Onion	CO5	8	

potassium were applied, through urea, single superphosphate and muriate of potash respectively. All the intercultural operations were followed as per standard agronomic practices precisely mentioned in crop production guide. Plant samples collected at harvest stage from individual plots were dried under shade and then oven dried, powdered in a Willy mill and separately analyzed as per the standard procedures for N it is Micro Kjeldhal digestion (Humphries 1956), P and K with Triple acid digestion i.e. Colorimeter (Jackson 1973) and the nutrient content in the plant samples were multiplied with their respective dry matter to estimate the nutrient uptake and expressed in kg ha^{-1}. Cost of cultivation and gross return for all the treatments were worked out on the basis of prevailing input cost and market price of the grain at the time of experimentation. The net income was calculated by deducting the cost of cultivation from the gross return. The benefit cost ratio (BCR) was worked out as dividing gross return by cost of cultivation. The data on various characters studied during the course of investigation were statistically analyzed as suggested by Gomez and Gomez (1984). Wherever the treatment differences were significant (F test), critical differences were worked out at five percent probability level and the values were furnished. Crop equivalent yield of cropping system was calculated by taking into account the yield of component crop multiplied with prevailing price of intercrop.

Results and Discussion

Groundnut equivalent yield

Among the different diversified intensive cropping systems in *kharif* season, higher groundnut equivalent yield was recorded in brinjal intercropped with onion recorded 8.82 t ha^{-1} and 9.67 t ha^{-1} which was followed by 5.62 t ha^{-1} and 6.34 t ha^{-1} in bhendi intercropped with coriander system during 2017-18 and 2018-19, respectively (Table 2). The lowest groundnut equivalent yield was recorded in groundnut based cropping system with 2.15 t ha^{-1} and 2.18 t ha^{-1} during 2017-18 and 2018-19, respectively. The most common advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of available growth resources using a mixture of crops of different rooting ability, canopy structure, height and nutrient requirements based on complimentary utilization of growth resources by the component crops compared to monocrop alone (Lithourgidis et al. 2011). Higher production potential of brinjal and higher price of onion, were the possible reasons for getting higher groundnut equivalent yield in *kharif* season. Vegetable based cropping systems are also more productive and profitability than cereal and oilseed based cropping system resulting in better remuneration.

Table 2. Groundnut equivalent yield (t/ha) of *kharif* crops influenced by different nutrient management practices on intensive cropping system during 2017-18 and 2018-19. RDF- Recommended fertilizer to each crop, FYM-Farm yard manure, V- Vermicompost. *GEY- Groundnut equivalent yield.

Treatments	*GEY of *kharif* crops (t/ha) 2017-18	2018-19
Cropping systems		
M_1 : Groundnut - chillies - greengram	2.15	2.18
M_2 : Groundnut + redgram - sorghum - blackgram	2.76	2.78
M_3 : Maize + fodder cowpea - sunflower - greengram	2.19	2.06
M_4 : Bhendi + coriander - tomato - blackgram	5.62	6.34
M_5 : Brinjal + onion - cowpea - sunnhemp	8.82	9.67
SEm	0.02	0.04
CD (p = 0.05)	0.11	0.10
Nutrient Management practices		
S_1 : FYM @ 12.5 t/ha + 100% RDF	4.48	4.83
S_2 : VC @ 2.5 t/ha + 100% RDF	4.39	4.70
S_3 : VC @ 5 t/ha + 100% RDF	4.66	5.09
S_4 : VC @ 5 t/ha + 75% RDF	4.07	4.28
S_5 : VC @ 7.5 t/ha + 50% RDF	3.94	4.12
SEm	0.03	0.06
CD (p = 0.05)	0.10	0.13

Table 3. Total nutrient uptrike (kg ha^{-1}) of *kharif* crops influenced by different nutrient management practices on intensive cropping system during 2017-18. RDF - Recommended fertilizer to each crop, FYM-Farm yard manure, VC-Vermicompost.

Treatments	Total NPK uptake (kg ha^{-1}) (2017-18) N	P	K
Cropping systems			
M_1 : Groundnut - chillies - greengram	136	28	88
M_2 : Groundnut + redgram - sorghum - blackgram	170	33	103
M_3 : Maize + fodder cowpea - sunflower-greengram	300	50	253
M_4 : Bhendi + coriander - tomato - blackgram	54	10	29
M_5 : Brinjal + onion- cowpea - sunnhemp	107	12	59
SEm	1.98	0.44	1.31
CD (p = 0.05)	4.58	1.03	3.03
Nutrient management			
S_1 : FYM @ 12.5 t/ha + 100% RDF	164	30	117
S_2 : VC @ 2.5 t/ha + 100% RDF	159	28	109
S_3 : VC @ 5 t/ha + 100% RDF	167	31	120
S_4 : VC @ 5 t/ha + 75% RDF	150	23	100
S_5 : VC @ 7.5 t/ha + 50% RDF	126	20	85
SEm	1.87	0.33	1.24
CD (p = 0.05)	3.79	0.67	2.52

Table 4. Total nutrient uptake (kg ha^{-1}) of *kharif* erops influenced by different nutrient management practices on intensive cropping system during 2018-19. RDF - Recommended fertilizer to each crop, FYM-farm yard manure, VC-Vermicompost.

Treatments	Total NPK uptake (kg ha^{-1}) (2018-19) N	P	K
Cropping systems			
M_1 : Groundnut - chillies greengram	145	32	92
M_2 : Groundnut+redgram - sorghum - blackgram	190	36	106
M_3 : Maize + fodder cowpea - sunflower - greengram	305	54	266
M_4 : Bhendi + coriander - tomato - blackgram	56	10	46
M_5 : Brinjal + onion - cowpea - sunnhemp	119	12	63
SEm	1.69	0.28	1.10
CD (p = 0.05)	3.90	0.66	2.53
Nutrient management			
S_1 : FYM @ 12.5 t/ha + 100% RDF	174	33	125
S_2 : VC @ 2.5 t/ha + 100% RDF	170	30	118
S_3 : VC @ 5 t/ha + 100% RDF	178	34	134
S_4 : VC @ 5 t/ha + 75% RDF	155	26	104
S_5 : VC @ 7.5 t/ha + 50% RDF	138	22	93
SEm	2.09	0.32	1.23
CD (p = 0.05)	4.23	0.66	2.48

Among the different nutrient management practices application of vermicompost at 5 t ha^{-1} along with 100% fertilizer recorded higher groundnut equivalent yield with 4.66 t ha^{-1} and 5.09 t ha^{-1} which was followed by FYM at 12.5 t ha^{-1} along with 100% fertilizer plot. Application of vermicompost at 7.5 t ha^{-1} along with 50% fertilizer recorded lowest groundnut equivalent yield of 3.94 t ha^{-1} and 4.12 t ha^{-1} during both the years. Vermicompost is a rich source of macro and micro nutrients along with growth hormones which not only supplies essential nutrients to the soil but also improves the physico-chemical and biological properties of the soil (Pooniya et al. 2017).

Total nutrient uptake (kg ha^{-1})

During *kharif* season, higher nutrient uptake was noticed in maize intercropped with fodder cowpea cropping system with N of 300 kg ha^{-1} and 305 kg ha^{-1}, P of 50 kg ha^{-1} and 54 kg ha^{-1} and K of 264 kg ha^{-1} and 273 kg ha^{-1} which was followed by groundnut with redgram intercropping system with N of 170 kg ha^{-1} and 190 kg ha^{-1}, P of 33 kg ha^{-1} and 36 kg ha^{-1} and K of 103 kg ha^{-1} and 106 kg ha^{-1} during 2017-18 and 2018-19, respectively (Tables 3 and 4). Lower nutrient uptake was recorded in bhendi intercropped with coriander cropping system. Higher the dry matter production, higher will be the nutrient uptake.

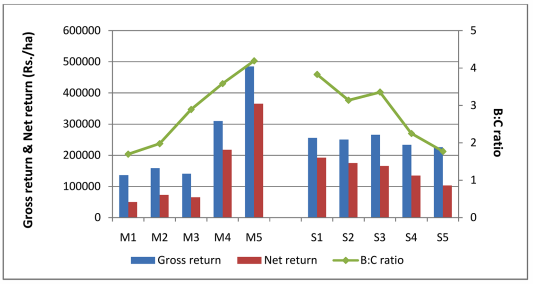

Fig. 1. Economics of *kharif* crops influenced by different nutrient management practices on intensive cropping system during 2017-18.

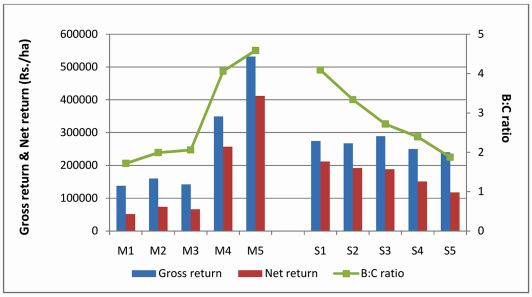

Fig. 2. Economics of *kharif* crops influenced by different nutrient management practices on intensive cropping system during 2018-19.

Among the nutrient management practices, vermicompost application of 5 t ha^{-1} along with 100% fertilizer plot recorded higher N uptake (167 kg ha^{-1} and 178 kg ha^{-1}). P uptake (31 kg ha^{-1} and 34 kg ha^{-1}) and K uptake (120 kg ha^{-1} and 134 kg ha^{-1}) during both the years. Application of vermicompost at 7.5 t ha^{-1} along with 100% fertilizer plot recorded lower N uptake (126 kg ha^{-1} and 138 kg ha^{-1}), P uptake (20 kg ha^{-1} and 22 kg ha^{-1}) and K uptake (85 kg ha^{-1} and 93 kg ha^{-1}) during 2017-18 and 2018-19, respectively. Vermicompost could release nutrients slowly and steadily into the system and enables the plants to absorb these nutrients over time (Sharma 2003) as earthworms stimulate microbial activities, metabolism and also it influence microbial populations in soil (Joshi and Vig 2010).

Economics

Economics was calculated for *kharif* cropping system alone i.e. gross return, net return and B : C ratio and presented in Figs.1 and 2 for 2017-18 and 2018-19, respectively. During 2017-18 and 2018-19, the economic analysis revealed that among the different intensive cropping system maximum gross return (Rs 4,85,248 ha^{-1} and Rs 5,32,011 ha^{-1}), net return (Rs 3,65,212 ha^{-1} and Rs 5,32,011 ha^{-1}) and B:C ratio (4.19 and 4.59) was obtained from brinjal intercropped with onion (1:2 ratio) cropping system. This might be due to higher productivity and higher price fetched by brinjal and onion. Among the nutrient management practices, application of vermicompost at 5 t ha^{-1} along with 100% fertilizer plot recorded higher gross return (Rs 2,65,866 ha^{-1} and Rs 2,88,882 ha^{-1}) during both the years. But, higher net return (Rs 1,92,805 ha^{-1} and Rs 2,11,904 ha^{-1}) and B:C ratio (3.83 and 4.09) was registered in farm yard manure at 12.5 t ha^{-1} along with 100% fertilizer plot during 2017-18 and 2018-19, respectively. Even though, vermicompost registered higher gross return due to higher yield recorded in that treatment. But higher net return and B:C ratio was recorded in FYM as it was less cost when compared to vermicompost.

Conclusion

From the above conducted research, it could be concluded that during *kharif* season, brinjal intercropped with onion (1:2) along with application of vermicompost at 5 t ha^{-1} with 100% fertilizer recorded higher groundnut equivalent yield and nutrient uptake. But the farm yard manure at 12.5 t ha^{-1} along with 100% fertilizer registered higher Benefit: Cost ratio that will be profitable to farmers in North Western Zones of Tamil Nadu.

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