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Evaluation of intercropping efficiency and profitability on Okra-Cowpea based cropping system in Chitwan district, Nepal

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Abstract**—** *A field experiment was conducted in vegetable research farm of Agriculture and Forestry University, Chitwan to study the intercropping efficiency of okra and cowpea. The experiment was arranged in Randomized Complete Block Design (RCBD) with four replications. One row of okra and two rows of okra was intercropped with cowpea. Data collected was subjected to analysis of variance (ANOVA) and the least significant difference (LSD) test was carried out at the 5% probability level. Intercropping efficiency was measured using Total okra yield equivalent, Land Equivalent Ratio, Percentage land saved and Land Equivalent Coefficient. Result revealed that 1:1 intercropping system as most efficient one that gave highest yield of 21.15 ton/ha with LER of 1.48 saving 32.43% of land. Economic analysis was also carried out using benefit to cost ratio analysis. Sole cowpea gave highest B: C ratio of 1.47 followed by 1:1 intercropping with the value of 1.37 and least B: C ratio was found in sole okra. This study suggested that 1:1 intercropping as beneficial and is recommended for okra growers while sole cropping is recommended for cowpea growing farmers.*

Keywords**— Cowpea, Intercropping, Land Equivalent Ratio, Okra, Yield Equivalent.**

I. INTRODUCTION

Intercropping is a multiple cropping practice. It is an agronomic strategy where two or more plant species are grown together for at least a period of their life cycle and planted nearer and closer so that inter specific competition can occur (Usman, 2001). It involvesintensification in terms of time and space (Andrew & Kassam, 1976)so may be row or mixed or strip or relay intercropping. Growing in proximity allows interaction among crops and is practiced with the aim of maximizing cooperation rather than competition (Sullivan, 2001). It plays vital role in subsistence farming system (Adeoye, 2005) especially in cropping system with limited external inputs (Adesogan, Salawu, & Deaville, 2000). This approach is advantageous owing to increased production, efficient use of environmental resources, stable yield and reduction of disease, pest (Mousavi & Eskandari, 2011).

In Nepal most of the farmers practice subsistence farming where variety of agricultural commodities are grown and consumed. This strategy is long adopted by marginalized smallholder farmers in hills and mountains. So, multiple cropping is not a new form of agriculture technology, instead is an ancient means of intensive farming (Paudel, 2016).In developing nations more than 60% of food sources is produced by smallholder farms through intercropping system particularly cereals with legumes (Paudel, 2016). Combination of cereals and legumes has become popular as legumes fixes atmospheric nitrogen and improves soil fertility (Matusso, Mugwe, & Mucheru-Muna, 2014). Success of an intercropping system depends upon adoption of planting pattern and compatibility of component crops (Seran & Brintha, 2009). Both Okra and Cowpea are familiar in intercropping system and the combination of these two have been practiced (Ajayi, Adeoye, & Shittu, 2017).

Okra is one of the most important crop widely cultivated in terai region of Nepal. It was cultivated in the area of 10,781.4ha with the productivity of 11.3t/ha (MoAD 2015-16). Similarly, cowpea is an important legume crop normally grown as intercrop with cereals. Both Okra and cowpea are summer season crops but Okra can be grown late up to rainy season. Similarity in agro-climatic condition makes them more compatible in intercropping system. However, the combination of these two crops has not been practiced yet in Nepal. Moreover, no any research activities have been

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conducted to find out the compatibility and yield performance of mixed stand of these crops. Therefore the present study was carried out to determine the performance of okra and cowpea in an intercrop system.

II. MATERIALS AND METHOD

The experiment was conducted in olericulture farm of Agriculture and Forestry University, Bharatpur Metropolitan City, Rampur, Chitwan from May 8 to July 15 of 2019. Geographic location is $27^0$38'50.92"N, $84^0$20'49.43"E with the elevation of 228 meters above sea level. The area is characterized by subtropical climate with unimodalrainfall pattern. Soil type is sandy loam and acidic. Cowpea (*Vignaunguiculata*var. Karma Stickless) and Okra (*Abelmoschusesculentus*var.ArkaAnamika) were used in the study.Cowpea were sown at the spacing of 60cm*60cm while Okra were sown at the spacing of 60cm*40cm. The experimental design was Randomized Complete Block Design (RCBD) with four replications. The experimental unit area was 15.12m^2 (3.6m*4.2m). The four treatments were used in this study as following:

T_1= Sole Cowpea

T_2= Sole Okra

T_3= Okra and Cowpea (One row of okra: One row of Cowpea)

T_4= Okra and Cowpea (Two row of Okra: One row of Cowpea)

Six okra plants were chosen randomly from each experimental unit and the following measurements were taken: Plant height (cm), Canopy (cm^2), Branches per plant, number of Node per plant, Internode Length (cm), Fruit length (cm), Fruit diameter (mm) and Total fruit weight(ton/ha). Similarly, six cowpea plants were chosen randomly from each experimental unit and following measurements were taken: Plant height (cm), Canopy (cm^2), Branches per plant, Number of Node per plant, Internode Length (cm), Cluster per plant, Fruit diameter (mm) and Total fruit weight(ton/ha).

Land Equivalent Ratio:

It is simply the relative land area under sole cropping required to produce the yield that is achieved in intercropping(Willey, 1979). Mathematically, it can be calculated as:

Land Equivalent Ratio= $L_a+L_b = Y_a/S_a+Y_b/S_b$

Where,

L_a and L_b are the LER of individual crop

Y_a and Y_b are the individual crop yield in intercropping

S_a and S_b are their yield as sole cropping

B: C Ratio:

Benefit Cost ratio is the ratio of gross return to cost of cultivation, so it can also be expressed as returns per rupee invested. This index is an estimate of the benefit a farmer derives from the expenditure he incurs in adopting a particular cropping system. Mathematically, it can be calculated by dividing gross return with the cost of cultivation as

B: C Ratio = Gross Return/Cost of cultivation

To determine the feasibility of cowpea okra intercropping system, economic analysis was carried out through B/C Ratio. The farmingis economically and financially convenient if the gross B/C value is >1.

Okra Equivalent Yield:

Since Okra and Cowpea were involved in intercropping system, it is not logical to compare total yield of 2 crops in one system with others. Thus, this index is used to evaluate the biological suitability of intercropping system.

It is yield of intercrop converted into equivalent yield of any one crop based on market price of produce(Reddy & Reddi, 2002). Numerically, it can be computed as

Okra Yield Equivalent= $Y_O + Y_C * P_C/P_O$

Where, Y_O= Yield of Okra, Y_C= Yield of Cowpea

P_O= Price of Okra, P_C= Price of Cowpea

This value of LER give percentage land saved as

Percentage land saved= (1-1/LER)*100%

Land Equivalent Coefficient (LEC): It is simply the product of the multiplication of LERs of component crops and determined as

LEC= $L_a * L_b$ where L_a and $L_b$are Land equivalent ratio of individual crop.

It assess the nature of interaction and evaluate mixture productivity. The value greater than 0.25 indicate the yield advantage as interaction becomes complementary and the value becomes less than 0.25 under competitive or inhibitory interaction(Adetiloye, Ezedinma, & Okigbo, 1983)

III. RESULT AND DISCUSSION

Table I and II shows the effect of intercropping on height of Okra and Cowpea respectively. Result indicatesthat there is no any significant difference in height among different cropping pattern early in the season. But later in 30^{th} days after planting, cropping pattern of 1:1 shows significant increase in height compared to sole cropping. This may be due to the fact that there is peak levelofcompetition for resources especially light during this period resulting in increase in height of both the crops. But this doesn't remain

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up to 40 days or later period in cowpea while significant difference remains in okra. As cowpea matures rapidly, the competition reduces with time thus okra utilizes the remaining resources and grow taller(Ofosu-Anim & Limbani, 2007). Similarly, intercropping has the effect on branching of component crops. Table III shows that sole cropping system favors branching in okra. There is significantly higher number of branches in sole cropping system compared to intercropping (1:1) but not significantly higher compared to another intercropping system (1:2). Similar pattern is observed in cowpea branching (Table IV). There is relatively higher number of branches in sole cropping system compared to intercropping but the significant difference isn't observed.

Table I. Effect of intercropping on height(cm) of Okra

Treatment	Days after planting		
	20	30	40
Sole okra	24.64	46.17[b]	74.58[b]
Cowpea + Okra (1:1)	28.78	65.17[a]	97.08[a]
Cowpea + Okra (1:2)	24.92	55.54[ab]	85.79[ab]
F.sig. (P< 0.05)	ns	*	*

Note: ns indicates non-significant and * denotes significant at 5% level of significance

Table II. Effect of intercropping on height(cm) of Cowpea

Treatment	Days after planting			
	20	30	40	50
Sole cowpea	38.88	56.04[b]	85.04	75.62
Cowpea + Okra (1:1)	42.29	64.71[a]	91.5	91.75
Cowpea + Okra (1:2)	40.21	59.58[ab]	89.17	79.25
F.sig. (P< 0.05)	ns	*	ns	ns

Table III.Effect of intercropping on branching of Okra

Treatment	Days after planting		
	20	30	40
Sole okra		1.5417[a]	3.417[a]
Cowpea + Okra (1:1)		0.7917[ab]	1.708[b]
Cowpea + Okra (1:2)		1[ab]	2.458[ab]
F.sig.(P< 0.05)		*	*

Table IV. Effect of intercropping on branching of Cowpea

Treatment	Days after planting			
	20	30	40	50
Sole cowpea	1.1250	3.625	4.708	5.125
Cowpea + Okra (1:1)	0.333	3.125	3.875	4.375
Cowpea + Okra (1:2)	0.75	3.208	4.125	4.875
F.sig. (P< 0.05)	Ns	Ns	Ns	Ns

Table V and VI revealed that there is significant effect of intercropping on yield attributing characters causing significant yield difference of each crop in different cropping system. Table V depicts that okra in sole cropping system has significantly higher fruit length compared to intercropping (1:2) and relatively higher but not significantly higher than another intercropping system (1:1). Exactly similar pattern is observed in the case of fruit diameter in okra amongdifferent cropping system. Higher fruit length, larger fruit diameter along with higher plant population contributed higher fruit

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yield of okra in sole cropping system compared to intercropping.

Table VI shows yield component of cowpea where there is no any significant difference in fruit length and diameter but relatively higher value is obtained in sole cropping system. Moreover, there is significant difference in important yield component i.e. number of cluster per plant. Significantly higher number of cluster per plant is observed in sole cropping while it is not significantly different among two intercropping system. Such higher number of cluster and higher plant population resulting into significantly higher yield of sole cropping system compared to intercropping. Within mixed cropping system, 1:1 system has significantly higher yield compared to 1:2 system, this is due to lower population on later treatment.

Table V. Effect of intercropping on yield component of Okra

Treatment	Fruit Length(cm)	Fruit Diameter(cm)	Fruit Yield(ton/ha)
Sole okra	20.3[a]	2.113[a]	12.552[a]
Cowpea + Okra (1:1)	18.89[ab]	1.984[ab]	10.706[ab]
Cowpea + Okra (1:2)	17.63[b]	1.858[b]	8.747[b]
LSD (P< 0.05)	*	*	*

Table VI. Effect of intercropping on yield component of Cowpea

Treatment	Fruit length(cm)	Fruit diameter(cm)	No. of clusters	Yield
Sole cowpea	29.23	0.9306	30.92[a]	10.511[a]
Cowpea + Okra (1:1)	28.38	0.8599	22.54[b]	7.459[b]
Cowpea + Okra (1:2)	28.03	0.8627	21.58[b]	3.867[c]
F.Sig. (P< 0.05)	ns	ns	*	*

The index okra yield equivalent is used to compare the yield performance of different cropping system. According to Table VII okra yield equivalent varied significantly due to treatment establishment in the experiment. Significantly higher yield equivalent was obtained in 1:1 intercropping system. It was due to higher yield of okra and higher yield of intercrop cowpea. In addition to that cowpea had higher existing market price (Rs 75 per Kg), while the existing market price of okra was Rs 50 per Kg. Individually, each component crop has higher yield on sole cropping but as a cropping system 1:1 intercropping system was superior on yield performance. This is followed by sole cowpea which has significantly higher yield than sole okra system. Also 1:2 intercropping system has relatively lower yield than sole cowpea system, this is due to lower population of cowpea in this system. This indicates that equivalent yield is greatly affected by market price and yield of component crops in intercropping. Moreover significantly higher okra yield equivalent in intercropping system illustrated that this type of intercropping was more profitable over sole panting of okra in Rampur Chitwan.

Land Equivalent Ratio (LER) is an indicator of biological efficiency of intercropping system (Yildirim & Guvenc, 2005). When the value LER is greater than one, it indicates the system is superior then sole cropping system (Vandermeer, 1989). In current study intercropping system has LER value greater than 1, signifying that the association of these two crops is advantageous. This is because of efficient utilization of inputs giving higher yield compared to sole cropping system. Highest LER value 1.48 was obtained in 1:1 intercropping system while LER value of 1.1 was obtained in 1:2 intercropping system. This indicates 1:1 intercropping system has better utilization of limited land area than 1:2 intercropping system. Also, with these LER value percentage land saved can be extrapolated and found as 32.43%, 9.09% in 1:1 and 1:2 intercropping system respectively. This saved land can be used for other agricultural activities. The LER value of individual crop is extrapolated into Land Equivalent Coefficient (LEC). This LEC value for 1:1 intercropping is 0.527 followed by another intercropping system of 1:2 with the value of 0.26. Both of the values are greater than 0.25 signifies that intercropping of cowpea and okra has complementary type interaction.

Comparing these two system in terms of LEC, 1:1 intercropping system has more yield advantage than 1:2 indicating former treatment as more efficient.

Table VII. Effect of Okra-Cowpea intercropping on Okra yield equivalent

Treatments	Okra Yield Equivalent (ton/ha)			Land Equivalent Ratio
	Okra	Intercrop	Total	
Sole Cowpea		16.89[a]	16.89[b]	1.00
Sole Okra	12.55[a]		12.55[c]	1.00
Cowpea + Okra (1:1)	10.71[a]	10.44[b]	21.15[a]	1.48
Cowpea+ Okra (1:2)	8.74[b]	6.55[c]	15.29[bc]	1.10
F.sig.(P<0.05)	*	*	*	

Table VIII. Calculation of Land Equivalent Ratio, Percentage Land Saved and Land Equivalent Coefficient

Treatment	LER	% land saved	LEC
Sole cowpea	1.00	-	-
Sole Okra	1.00	-	-
Cowpea + Okra (1:1)	1.48	0.324	0.527
Cowpea+ Okra (1:2)	1.10	0.09	0.26

Table IX. Economic analysis of okra intercropping with cowpea

Treatments	Gross return (Rs 000 ha^{-1})	Cultivation Cost (Rs 000 ha^{-1})	Net Return (Rs 000 ha^{-1})	Benefit cost ratio
Sole cowpea	844.5	575.6	2,68,897	1.47
Sole Okra	637.5	624.47	46,974	1.02
Cowpea + Okra (1:1)	1057.5	769.51	2,87,986	1.37
Cowpea+ Okra (1:2)	764	668	95,993	1.14

Above table shows that 1:1 intercropping system incurred the highest cultivation cost of Rs.7,69,510 followed by another intercropping pattern1:2 which incurred the cost of 6,68,000. In sole cropping okra has higher cultivation cost than cowpea. Thus it is clear that intercropping is more costly than sole cropping due to more input requirements and difficulty in agronomic practices. Likewise, highest net return was obtained in 1:1 intercropping followed by sole cowpea followed by 1:2 intercropping system and finally sole okra. Cowpea + Okra (1:1) which incurred highest cultivation cost gave highest net return followed by sole cowpea which incurred least cultivation cost. Thus sole cowpea has highest B:C ratio of 1.47 while 1:1 intercropping system has 1.37, second highest B: C ratio. This is due to the reason that greater yield, higher market price and least cultivation cost. Similarly, B: C ratio for 1:2 intercropping and sole okra is 1.14 and 1.02 respectively. If calculated value of benefit to cost ratio is greater than 1 for any cropping system, the system is viable and advantageous to practice (Ajayi, Adeoye, & Shittu, 2017). Thus from above analysis it can be recommended that sole cropping is economical if farmers have main purpose of raising cowpea while intercropping is best suited for okra growers.

IV. CONCLUSION

This study indicates intercropping has significant effect on okra in terms of height and branching pattern while little effect was observed in cowpea. Okra gave the higher fruit yield in sole cropping with longer and greater fruit diameter. Similar pattern was observed in cowpea which gave higher fruit yield on sole cropping with highest number of clusters per plant, longer fruit length and greater fruit diameter. However, analyzing all the observed data 1:1 intercropping system gave significantly higher okra yield equivalent compared to others indicating efficient utilization of available resources. This is also supported by highest LER value of 1:1 intercropping system which is 1.48.Also, this treatment saved 32.43% of land that can be used for other

agricultural purpose. Moreover, this system gave highest LEC value which is 0.527indicating complementary association between these two crops. Considering all these information of okra yield equivalent, LER, percentage land saved and LEC, it can be mentioned that 1:1 intercropping system is more efficient. Likewise economic analysis shows sole cowpea has highest B: C ratio of 1.47 followed by 1:1 intercropping which has the value of 1.37. Thus for economically sustainable production of okra, one row of okra should be altered with one row of cowpea while for cowpea sole cropping is beneficial.

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