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Productivity of Groundnut cum Blackgram based Intercropping System under Different Crop Ratios

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ABSTRACT

Background: To meet the requirements of sustainable growth for feeding the increasing population in a changing world, farmers and scientists have developed many eco-agricultural practices. Although researchers have developed many eco-agricultural techniques, there remain challenges in terms of integrating their advantages and overcoming their limitations. Here we advocate the intercropping of groundnut and blackgram with different crop ratios to study the production potential and economics of groundnut cum black-gram based intercropping system.

Methods: The experiment was laid out in 2020-2021 with random block design consisting twelve treatments comprising of groundnut as base crop and blackgram as intercrop in the replacement series or crop ratios of 3:1, 3:2, 4:1, 4:2, 5:1, 5:2, 6:1, 6:2, 7:1, 7:2 row proportions and their sole crops *viz*., groundnut and blackgram. Each treatment is replicated thrice.

Result: The productivity in terms of groundnut yield was significantly higher with 4:1 replacement series followed by 6:1 and 7:1 than other replacement series. The biological efficiency in terms of LER and ATER were also recorded maximum values and indicated a modest aggressivity and CR and gave a good value for the product of RCC with 4:1 followed by 6:1 and 7:1. The economics of the systems also indicates that groundnut + blackgram with replacement series of 4:1 was most profitable system in terms of gross return, net return, B:C ratio and MER followed by 6:1 and 7:1.

Key words: Blackgram, Crop ratio, Groundnut, Intercropping, Replacement series.

INTRODUCTION

Groundnut is one of the major oilseed crops of India accounting for 25% of total oilseed production in the country. India's vegetable oil requirement by 2022 is estimated 33.2 million tonnes and currently imports about 70% of the requirement accounting for about 73,000 crores per annum. Groundnut, a major oilseed of India, accounts for 25% of the total oilseed production of the country with yearly production of 6.73 million tonnes occupies an area of 4.59 m ha, with an average productivity of 1465 kg/ha (Chaudhari *et al*., 2017).

The global groundnut oil production in 2018-19 was 5.57 million MT out of which 0.99 million MT is from India. Though, India ranks second in the world with respect to area and production of groundnut, it is not self-sufficient in the production of edible oil. There is an imbalance between demand and supply in edible oil due to low productivity of oilseed crops.

India has the largest acreage under pulses and also is the largest producer, yet we are greatly dependent on imports to meet the demand of growing population. As per department of commerce, India's percentage share in black-gram export was 6.56% and percentage share in blackgram import was 22.71% in 2018-19. Pulse production can be increased by growing pulses on favourable lands that are occupied by cereals and cash crops by way of intercropping (Praharaj and Blaise, 2016). Experiments conducted over decades in the country established the feasibility of intercropping pulses in field crops. Studies have indicated benefits in terms of profitability, enhanced system productivity and yield stability of intercropping systems over sole cropping. By increasing area under intercropping, we can easily achieve the target production of besides accruing additional benefits of improved soil fertility through biological nitrogen fixation.

Further, the shortage of pulses and oilseeds has also aggravated the problem of malnutrition. Thus, introduction of crops in an intercropping system offers scope for maximizing and stabilizing return from oilseed crops rather than as a sole crop (Maitra *et al.,* 2021 and Willey, 1979).

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In order to exploit the production potential of pulses and oilseed crops, it is urgent need to increasing the area and the productivity of these crops (Hussainy *et al.,* 2020). But, the area under pulses and oilseeds does not seems likely to expand, as the land has become limiting factor due to rapid industrialization and urbanization. Therefore, increasing the productivity of the existing area can be achieved through adopting appropriate agronomic practices, of which intercropping system is one of the best ways to increase production. The yield advantages in intercropping systems are associated with full use of environmental resources over time and space (Willey *et al*., 1986; Bhuva *et al.,* 2017). Therefore, the present investigation was undertaken to study the production potential and economics of groundnut cum blackgram based intercropping system and also to find out the most productive and remunerative replacement series or crop ratio (Reddy, 1990).

MATERIALS AND METHODS

The field experiment was conducted at Central farm of AECRI, Tamil Nadu Agricultural University, Kumulur, India during Rabi season of 2020-21. The experimental area is located at 10.48 N. latitude 78.42 E. longitude and at an altitude of 88 meters. The climate of the region is classified as arid to semi-arid. The soil of the experimental site was clay loam in texture and receives an annual rainfall of 841.9 mm (June to rainy days which was lesser than the mean rainfall of Tamil Nadu (945 mm).

The experiment was laid out in random block design with twelve treatments comprising replacement series of 3:1, 3:2, 4:1, 4:2, 5:1, 5:2, 6:1, 6:2, 7:1, 7:2 row proportions and their sole crops *viz*., groundnut and blackgram. Each treatment was replicated thrice. The plot size of each treatment was taken as 8.0 m × 4.0 m. Details of treatments are given in Table 1. The seed rate for Sole groundnut and sole blackgram was 120 and 20 kg ha^{-1}. The amount of N applied for base and intercrop was 17 and 78 kg ha^{-1} also amount of P_2O_5 applied for base and intercrop was 25 and 50 kg ha^{-1} respectively (Rana *et al*., 2001). The date of sowing for both the crops was done on 03.02.2020. The date of harvesting for blackgram and groundnut was done on 06.04.2020 and 02.06.2020 respectively.

All the recommended dose of fertilizer for groundnut and blackgram as per sole and intercrops (Table 2) were applied at the time of sowing for sole and intercropping system. The seeds of groundnut and blackgram were sown by dibbling in fertilizered furrows and covered with the soil. Gap filling was done after establishment and the seedlings were thinned at 15 DAS to maintain required plant population. Plant protection practices were adopted to as when required. All other agronomic practices were followed as per recommended package of practices (Rani and Reddy, 2011).

Both sole and intercrops were harvested manually at their physiological maturity. The sun-dried crops were threshed manually. Observations on relevant parameters of all the component crops were recorded by following the standard procedures. The indices of competition and bio - economic efficiency of the component crops and intercropping systems were determined in terms of the relative crowding coefficient (Aasim *et al*., 2008), aggressivity (Taha and El-Mahdy, 2014), competitive ratio (Willey and Rao, 1980 and Doubi *et al.,* 2016), land equivalent ratio (Mead and Willey, 1980 and Adetiloye *et al*.,1983), area time equivalent ratio (Hiebsch and Mc Collum, 1987), crop performance ratio (Azam Ali *et al*.,1990) and monetary equivalent ratio (Adetioye and Adekunte, 1989 and Bhatt *et al.,* 2010). The gross return was worked out based on total equivalent yield of groundnut and intercrop (blackgram) from each treatment and the prices of the produces prevailing in the local market.

RESULTS AND DISCUSSION

Competition Indices

Relative crowding coefficient

Relative crowding coefficient (RCC) plays a significant role in determining the competition effects and advantages of intercropping. If the product of RCC (K) of two species is equal, less or greater than one, it means that the intercropping system has no advantage, disadvantage or advantage, respectively. RCC value in the intercropping system, showed higher value (1.23) with 4:1 replacement series and greater values in other replacement series than sole groundnut (K_{bc}) and sole blackgram (K_{ic}) indicating that intercrops had highly dominant over sole groundnut and sole blackgram in intercropping systems. It can be inferred that 4:1 ratio intercrop utilized the resources more efficiently than its base groundnut crop which appeared to be dominated. Among the intercropping system, significantly maximum value of RCC (K_{bc}, K_{ic} and K) was recorded in 4:1 intercropping system (Fig 1) indicating that maximum yield advantage was obtained by this intercropping system due to spatial and temporal complementary between both the component crops and also having distant difference in rooting pattern, growth habit and maturity periods and contrast nature of utilize natural resources efficiently. The results were in accordance with the findings of Sarkar *et al*. (1995) and Dutta and Bandhyopadhyay (2006).

Aggressivity

Aggressivity (A) is an important competition function to determine the competitive ability of a crop when grown in association with another crop. The value of aggressivity was recorded minimum for intercrops and maximum for groundnut and blackgram sole cropping systems (Fig 2). This shows that component crops did not compete equally and all the intercrops indicated dominant behaviour over the base groundnut and base blackgram. Among the intercropping systems, the highest value of aggressivity was observed in 5:1 replacement series (0.004) indicating greater difference in competitive ability between the component crops, resulting in wide variations between the actual and

Table 1: Details of treatments regarding row spacing number of rows in net plot, sown proportion of groundnut (Base crop) and blackgram (Inter crop).

Treatments	Cropping system ratio (groundnut: blackgram)	Area occupied (m^2/32 m^2)		Number of rows per 32 m^2		Sown proportion (%) of	
		BC	IC	BC	IC	BC	IC
T_1	3:1	24.6	7.4	20	6	77.0	23.0
T_2	3:2	19.7	12.3	16	10	61.5	38.5
T_3	4:1	25.8	6.2	21	5	80.7	19.3
T_4	4:2	22.1	9.9	18	8	69.2	30.8
T_5	5:1	27.1	4.9	22	4	84.6	15.4
T_6	5:2	24.6	7.4	20	6	77.0	23.0
T_7	6:1	28.3	3.7	23	3	88.5	11.5
T_8	6:2	24.6	7.4	20	6	77.0	23.0
T_9	7:1	28.3	3.7	23	3	88.5	11.5
T_{10}	7:2	25.8	6.2	21	5	80.7	19.3
T_{11}	Sole groundnut	32.0	-	26	-	100	-
T_{12}	Sole blackgram	-	32.0	-	26	-	100

Note: Row to row and plant to plant spacing was maintained as 30 cm and 10 cm respectively for all the treatments.

Table 2: Biological indices and groundnut pod equivalent yield of groundnut cum black gram based inter cropping systems.

Cropping system ratio (Groundnut: Blackgram)	Land equivalent ratio	Land equivalent coefficient	Area time equivalent ratio	Groundnut pod equivalent yield (kg ha^{-1})
3:1	0.9	0.07	0.77	2993
3:2	0.7	0.12	0.60	1602
4:1	1.1	0.11	0.96	3756
4:2	0.9	0.15	0.76	2439
5:1	0.9	0.04	0.84	3456
5:2	0.9	0.07	0.75	2931
6:1	1.0	0.04	0.87	3635
6:2	0.9	0.07	0.76	2979
7:1	1.0	0.04	0.84	3502
7:2	0.9	0.05	0.76	3050
Sole groundnut	1	1	1	3842
Sole blackgram	1	1	1	0.00
SD (σ)	0.09	0.36	0.11	1093
SEM±	0.02	0.10	0.03	316

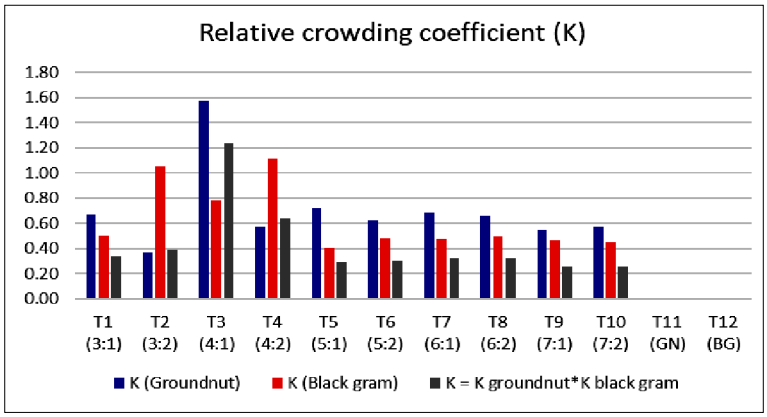

Fig1: Relative crowding coefficient of groundnut cum blackgram intercropping system

expected yields. While the lowest value of aggressivity was recorded in 4:1 (0.002) which indicated that 4:1 replacement series was least competitive replacement series among the groundnut cum blackgram based intercropping system.

These results were in close conformity with the findings of Sarkar *et al*. (1995) and Singh and Ahlawat (2011).

Competitive ratio

Competitive ratio (CR) gives better measure of competitive ability of the crops and can prove a better index over with K and A. The values of CR of intercrops were more than sole crops (1.00 to 3.36), indicating that intercrops were more competitive than sole crop under intercropping system (Fig 3). Among intercrops, the highest value of CR for groundnut as base crop was recorded by 5:1 (3.36) followed by 6:1 (2.99) and 7:1 (2.94) than 3:2 (1.00), 4:2 (1.21) and 4:1 (2.10) thus indicating that 5:1, 6:1 and 7:1 proved to be better competitor as compared to other replacement series when grown in groundnut cum blackgram association. It is also evident from the competitive ratio that 3:2, 4:2 and 4:1 was found to be least competitor crop ratios for intercropping groundnut cum blackgram. These results were in line with those reported by Dutta and Bandhyopadhyay (2006) and Singh and Ahlawat (2011).

Biological indices

Land equivalent ratio

Land equivalent ratio (LER) was used as criterion for evaluate efficiency of intercropping advantage in using the resources of the environment compared to sole crops. LER values greater than one in intercropping system (Table 2) indicating the yield advantage of intercropping over sole cropping of groundnut and blackgram for the effective use of environmental resources for plant growth. Among the intercropping system, the highest LER (1.1) was recorded in 4:1 which was on par with 6:1 and 7:1 and recorded significantly higher LER as compared to 4:2, 5:1, 5:2, 6:2, 7:2 which was significantly superior to 3:1 (0.9) and 3:2 (0.7). It might be attributed to better complementary relationship between component crop, leading to better use of growth resources. These results confirm the findings of Kumar *et al*. (2010).

Land equivalent coefficient

Land equivalent coefficient (LEC) is the product of individual LER of the component crops. Values of LEC in all the intercropping system were greater than 0, which indicate yield advantages in intercropping systems and each

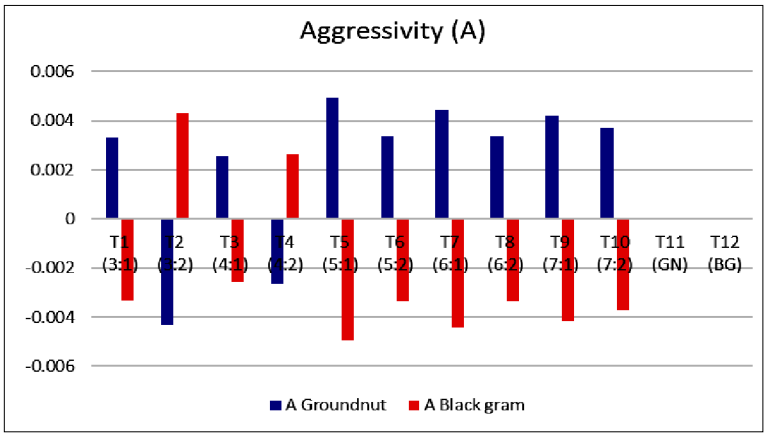

Fig 2: Aggressivity of groundnut cum blackgram intercropping system.

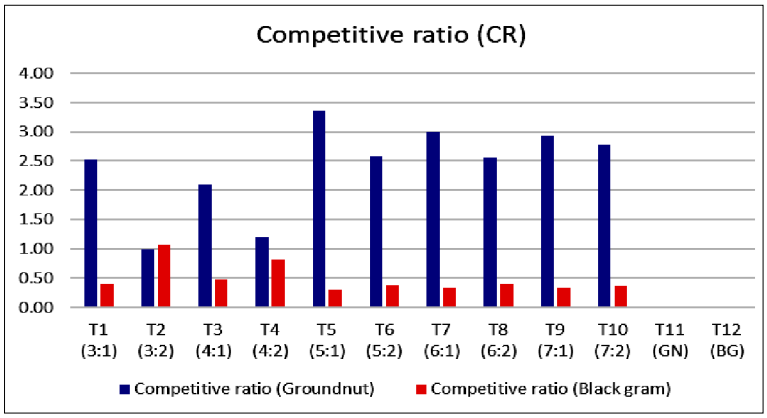

Fig 3: Competitive ratio of groundnut cum blackgram intercropping system.

component crop ratios in the system should give at least 50 per cent of their sole crop yield (Table 2). Among intercropping systems, significantly the highest value of LEC (0.15) was registered in 4:2, which was on par with 4:1 and 3:2 also recorded significantly higher compared to 3:1, 5:2 and 6:2 (0.07) which was significantly superior to 7:2 (0.05), 5:1, 6:1 and 7:1 (0.04) indicating better performance under inter cropping systems in groundnut cum blackgram intercropping proportion.

Area time equivalent ratio

Area time equivalent ratio (ATER) provides more a realistic comparison of the yield advantage of intercropping over that of sole cropping than LER as it considers variation in time taken by the component crops of different intercropping systems (Table 2). Significantly higher ATER was recorded in 4:1 (0.96) as compared to sole groundnut (0.89). This indicates that not only the efficient use of land but also efficient use of time to the extent of 7 per cent. While, significantly lowest ATER (0.87) was recorded in 6:1 which were on par with 5:1 and 7:1 (0.84) and 3:1(0.77) and 7:2 (0.76) also recorded ATER less than one indicating poor utility of resources. Similar observations were made by Kumar *et al.,* (2010).

Groundnut pod equivalent yield

Productivity in terms of groundnut pod equivalent yield (GPEY) is the best tool to determine the overall productivity potential of an intercropping system (Table 2). The highest GPEY (3756.38 kg ha^{-1}) was obtained significantly by 4:1 followed by 6:1 (3635.09 kg ha^{-1}) and 7:1 (3501 kg ha^{-1}) which were on par with sole groundnut (3841.75 kg ha^{-1}) due to better performance and yield of component crops as well as higher market price of intercrops (Table 3). While significantly lowest GPEY was recorded in 3:2 (1602.31 kg ha^{-1}), 5:2 (2930.81 kg ha^{-1}) and 6:2 (2978.94 kg ha^{-1}) compared to sole groundnut mainly due to low yield of component crop. This result showed that intercrops with replacement series *viz*., 4:1 was more compatible than other row proportions. Higher overall productivity in terms of GPEY of intercropping over sole cropping of groundnut has also been reported by Chandrika *et al*. (2001) and Prasad *et al*. (2007).

Economic indices

Gross and net returns and B:C ratio

Gross and net returns and B:C ratio was significantly influenced by intercropping systems (Table 3). The higher gross return, net return and B: C ratio was obtained significantly in 4:1 (Rs 232099.4, 152346.4 ha^{-1} and 2.91) followed by 6:1 (Rs 220583.4, 134668.4 ha^{-1} and 2.56) and 5:1 (Rs 210286.1, 127452.1 ha^{-1} and 2.53) and 7:1 (Rs 212527.6, 126612.6 ha^{-1} and 2.47) as compared to sole groundnut. Whereas less gross return, net return and B: C ratio was recorded by 3:2 (Rs 113064.5, 48479.54 ha^{-1} and 1.75) followed by 4:2 (Rs 160431, 89762.98 ha^{-1} and 2.27) and 5:2 (Rs 181162.9, 104332.9 ha^{-1} and 2.35) as compared to sole groundnut (Rs 230505, 135505 ha^{-1} and 2.42). The highest gross and net returns as well as B: C ratio might due to higher yield levels and higher market price of the component crops. Similar results were earlier reported by Solaiappan *et al*. (1994), Prasad *et al.* (2007) and Singh *et al.* (2011).

Monetary equivalent ratio

Monetary equivalent ratio (MER) was significantly influenced by intercropping systems (Table 3). Significantly highest MER (1.01) was recorded by 4:1 which is on par with 6:1 and 7:1 compared to sole groundnut (1.0). While significantly lowest MER (0.49) was recorded by 3:2 followed by 4:2 (0.7) and 5:2 (0.79) than sole groundnut. It suggested that 4:1, 6:1 and 7:1 would be the economic superiority replacement series among other series for groundnut cum blackgram intercropping system.

Table 3: Economic indices of groundnut cum blackgram based inter cropping systems.

Cropping system ratio (Groundnut: Blackgram)	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio	Monetary equivalent ratio
3:1	185155	108325	2.4	0.80
3:2	113065	48480	1.7	0.49
4:1	232099	152346	2.9	1.01
4:2	160431	89763	2.2	0.70
5:1	210286	127452	2.5	0.91
5:2	181163	104333	2.3	0.79
6:1	220583	134668	2.5	0.96
6:2	184205	107375	2.4	0.80
7:1	212528	126613	2.5	0.92
7:2	187133	107380	2.3	0.81
Sole groundnut	230505	135505	2.4	1.00
Sole blackgram	60272	44272	3.7	0.26
SD (σ)	50593	33170	0.5	0.2199
SEM±	14605	9575	0.1	0.0634

CONCLUSION

Blackgram (*Vigna mungo*) is a short duration legume crop with higher compatibility in intercropping system. The yield advantage of the companion crop was found owing towards effective utilization of growth resources and protection of soil health. From the results of groundnut based intercropping systems, it is concluded that intercropping with groundnut cum blackgram in 4:1 followed by 6:1 and 7:1 replacement series helps to bring additional income to farmers, also to get higher benefits and helps to utilize the growth resources, time (duration) very efficiently. Numerically the land usage can be intensified. Therefore, intercropping of groundnut cum blackgram with 4:1 row proportion is found biologically and economically sustainable intercropping system for all conditions.

Conflict of interest: None.

REFERENCES

Aasim, M., Umer, E.M. and Karim, A. (2008). Yield and competition indices of intercropping cotton (*Gossypium hirsutum* L.) using different planting patterns. Journal of Agricultural Sciences. 14(4): 326-333.

Adetiloye, P.O., Ezedinma, F.O.C. and Okigho, B.N. (1983). A land equivalent coefficient concept for the evaluation of competitive and productive interactions on simple complex mixtures. Annual Review of Ecology, Evolution and Systematics. 19: 27-39.

Adetioye, P.O. and Adekunte, A.A. (1989). Concept of monetary equivalent ratio and its usefulness in the evaluation of intercropping advantages. Journal of Tropical Agriculture. 66: 337-341.

Azam Ali, S.N., Mathews, R.B., Williams, J.H. and Peacock, J.M. (1990). Light use, water uptake and performance of individual components of sorghum/groundnut intercrop. Experimental Agriculture. 26: 413-427.

Bhatt, B.K., Dixit, S.K. and Darji, V.B. (2010). Monetary evaluation of sesame based intercropping systems. Indian Journal of Agricultural Research. 44(2): 146-149.

Bhuva, H.M., Kumawat, P.D., Mehta, A.C., Chaudhari, N.N. and Patel, P.R. (2017). Effect of groundnut (*Arachis hypogaea* L.)- based intercropping systems on yield and economics under rainfed condition. Indian Journal of Agricultural Research. 51(5): 448-452.

Chandrika, V., Sankara Reddy, K. and Soundararajan, M.S. (2001). Economic evaluation of groundnut (*Arachis hypogaea*) based cropping systems in rainfed alfisols. Indian Journal of. Agronomy. 46: 45-49.

Chaudhari, D.T., Vekariya, P.D., Vora, V.D., Talpada, M.M. and Sutaria, G.S. (2017). Enhancing productivity of groundnut based intercropping systems under rainfed conditions of Gujarat. Legume Research-An International Journal. 40(3): 520-525.

Doubi, B.T.S., Kouassi, K.I., Kouakou, K.L., Koffi, K.K., Baudoin, J.P. and Zoro, B.I.A. (2016). Existing competitive indices in the intercropping system of *Manihot esculenta* Crantz and Lagenaria siceraria (Molina) Standley. Journal of Plant Interactions. 11(1): 178-185.

Dutta, D. and Bandyopadhyay, P. (2006). Production potential of intercropping of groundnut (*Arachis hypogaea* L.) with pigeon pea (*Cajanus cajan*) and maize (*Zea mays*) under various row proportions in rainfed Alfisols of West Bengal. Indian Journal of Agronomy. 51: 103-106.

Hussainy, S.A.H., Brindavathy, R. and Vaidyanathan, R. (2020). Production potential of groundnut (*Arachis hypogaea* L.) under intercropping system-A review. Crop Research. 55: 36-47.

Hiebsch, C.K. and Mc Collum, R.E. (1987). Area time equivalent ratio, a method for evaluating productivity of intercrops. Indian Journal of Agronomy.79: 15-22.

Kumar, D.S., Reddy, D.S. and Yellamanda Reddy, T. (2010). Productivity of groundnut (*Arachis hypogaea* L.) based intercropping systems under rainfed conditions. Current Biotica. 3: 409-499.

Maitra, S., Hossain, A., Brestic, M., Skalicky, M., Ondrisik, P., Gitari, H., Brahmachari, K., Shankar, T., Bhadra, P., Palai, J.B. and Jena, J. (2021). Intercropping-A Low Input Agricultural Strategy for Food and Environmental Security. Agronomy. 11(2): 343.

Mead, R. and Willey, R.W. (1980). The concept of land equivalent ratio and advantages in yields for intercropping. Experimental Agriculture. 16: 217-228.

Praharaj, C.S. and Blaise, D. (2016). Intercropping: An approach for area expansion of pulses. Indian Journal of Agronomy. 61(4th IAC Special issue): S113-S121.

Prasad, T. V., Nandagopal, V., Gedia, M.V., Koradia, V. G. and Patel, H. V. (2007). Effect of intercropping on yield and yield parameters of groundnut (*Arachis hypogaea* L.). Indian Journal of Agricultural Sciences. 77: 515-518.

Rana, R.S., Singh, B., and Negi, S.C. (2001). Management of maize/legume intercropping under mid-hill sub-humid conditions. Indian Journal of Agricultural Research. 35(2): 100-103.

Rani, B.P., and Reddy, D.R. (2011). Performance of pigeonpea in sole and inter cropping system in vertisols of Krishna-Godavari zone in Andhra Pradesh. Indian Journal of Agricultural Science. 44(3): 225-228.

Reddy, B.N. (1990). Groundnut in intercropping and groundnut-based cropping systems. Journal of Oilseeds Research. 7: 31-40.

Sarkar, R.K., Chakraborty, A. and Mazumdar, R.C. (1995). Effect of intercropping oilseed and pulse crops in upland cotton (*Gossypium hirsutum*) for total productivity and monetary advantage in the system. Indian Journal of Agricultural Sciences. 65: 246-249.

Singh, R.J. and Ahlawat, I.P.S. (2011). Productivity, competition indices and soil fertility change of BT cotton (*Gossypium hirsutum*) groundnut (*Arachis hypogaea* L.) intercropping systems using different fertility levels. Indian Journal of Agricultural Sciences. 81: 606-611.

Singh, S., Ram, M., Singh, K., and Verma, B.S. (2011). Growth and yield of geranium (*Pelargonium graveolens*) and garlic (*Allium sativum*) in intercropping system. Indian Journal of Agricultural Research. 45(3).

Solaiappan, U., Kathiresan, G., Jayaraman, S. and Veerabadran, V. (1994). Profitable intercropping system based on groundnut (*Arachis hypogaea* L.) in Periyar Vaigai command area. Indian Journal of Agronomy. 39: 544-547.

Taha, E.M. and El-Mahdy, A.M. (2014). Land equivalent ratio as reference for relative crowding coefficient and aggressivity of intercropped plant species. Middle East Journal of Agriculture Research. 3(3): 576-585.

Willey, R.W. (1979). Intercropping its importance and Research needs competition and yield advantages, II. Agronomy of research approaches. Field Crop Abstract. 32: 1-10 and 73-85.

Willey, R.W. and Rao, M.R. (1980). A competitive ratio for quantifying competition between intercrops. Experimental Agriculture. 16: 117-125.

Willey, R.W., Natarajan, M., Reddy, M.S. and Rao, M.R. (1986). Cropping systems with groundnut resource use and productivity.In: Agro meteorology of groundnuts. Proceeding of an International Symposium, (21-26): 193-205.